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20 August 2002

<u>RTCA Special Committee 186, Working Group 3</u>

<u>ADS-B 1090 MOPS, Revision A</u>

<u>Meeting #13</u>

Draft 1 of Sections 1 thru 4 of DO-260A

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SUMMARY
Following is the first draft of the combined Sections 1 through 4 of DO-260A for review by WG-3. This draft includes (1) all of the changes that have been agreed to by WG-3 since Meeting #1 and that are documented in the Table of Changes posted on the ADS-B/1090 web site, (2) updates to §2.2.4.4 and §2.4.4.4 for the addition of Enhanced Processing, (3) addition of §2.2.17 and 2.4.17 for TIS-B, (4) integration of Intent Reporting changes presented in 1090-WP-12-01R2, and changes to §2.4 as a result of those changes, (5) integration of changes to SV, MS and On-Condition Report Formats presented in 1090-WP-12-02R3, and changes to §2.4 as a result of those changes, (6) integration of proposed changes to NIC/NAC/SIL and CC & OM Codes as presented in 1090-WP-12-13R2, and changes to §2.4 as a result of those changes, plus (7) some initial removal of major sections dealing with the Aircraft Coordination Message, (8) removal of §2.2.5 and §2.4.5 sections dealing with TCP/TCP+1, and last, but not least, (9) all of hundreds of editorial changes that have been made since DO-260 was published.

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1.0 PURPOSE AND SCOPE

1.1 Introduction

This document contains Minimum Operational Performance Standards (MOPS) for airborne equipment for Automatic Dependent Surveillance-Broadcast (ADS-B) utilizing 1090 MHz Mode-S Extended Squitter. The supporting hardware can be a stand-alone ADS-B unit, or alternatively, ADS-B may be incorporated within other on-board equipment.

Compliance with these standards by manufacturers, installers and users is recommended as one means of assuring that the equipment will satisfactorily perform its intended functions under conditions encountered in routine aeronautical operations. The regulatory application of these standards is the responsibility of appropriate government agencies. In the United States, the Federal Aviation Administration (FAA) plans to publish a Technical Standard Order (TSO) for ADS-B equipment to reference the requirements and bench test procedures in Section 2 of this document.

Since the equipment implementation includes a computer software package, RTCA/DO-178B, *Software Considerations in Airborne Systems and Equipment Certification*, is applicable. When determining the level of software requirements, as defined in RTCA/DO-178B, the equipment manufacturer should consider the criticality appropriate for the installation certification, equipment failure analysis, and the fault monitoring being accomplished.

In addition, since the measured values of equipment performance characteristics may be a function of the measurement method, standard test conditions and methods of test are recommended in this document.

Section 1 of this document provides information and assumptions needed to understand the rationale for equipment characteristics and requirements stated in the remaining sections. It describes typical equipment applications and operational goals and, along with RTCA/DO-242A, *Minimum Aviation System Performance Standards for ADS-B*, forms the basis for the standards stated in Sections 2 and 3.

Section 2 contains the minimum operational performance standards for the equipment. These standards define required performance under standard operating conditions and stressed physical environmental conditions. Also included are recommended bench test procedures necessary to demonstrate equipment compliance with the stated minimum requirements.

Section 3 describes the performance required of the installed equipment. Tests for the installed equipment are included when performance cannot be adequately determined through bench testing.

Section 4 describes the operational characteristics of the installed equipment, self test features, and controls.

Appendix A is *normative* whereas Appendices B through I are *informative.* The following is a short description of each of the appendices contained in this document:

- Appendix A defines the formats and coding for extended squitter ADS-B Messages, expanding upon the requirements of Section 2.2.
- Appendix B contains a list of acronyms and definition of terms used in this document.
- Appendix C discusses aircraft antenna performance characteristics and identifies references to obtain additional information on the subject.
- Appendix D defines a ground architecture that can support surveillance for ATC using extended squitter ADS-B reports.
- Appendix E contains air-to-air link budgets for each class of ADS-B equipment and summarizes the relationships between transmitter power, receiver sensitivity, and range under worst case and practical implementation conditions.
- Appendix F presents a traceability matrix to the ADS-B MASPS (RTCA Document DO-242A).
- Appendix G discusses transition issues for ADS-B avionics.
- Appendix H discusses ADS-B report assembly and provides additional guidance on the subject.
- Appendix I identifies and discusses various enhanced reception techniques for extended squitter that might be used to improve performance in future updates to this document.
- Appendix J discusses determining the navigation uncertainty category for velocity (NAC_V) and describes the rationale for the tables used in §2.2.5.1.22, "NAC_V Data."
- Appendix K discusses and provides the results of an analysis that determined the affect of report assembly on velocity accuracy.
- Appendix L discusses and provides a table showing, by equipage class, the impact of radio frequency interference on extended squitter report integrity.

1.2 System Overview

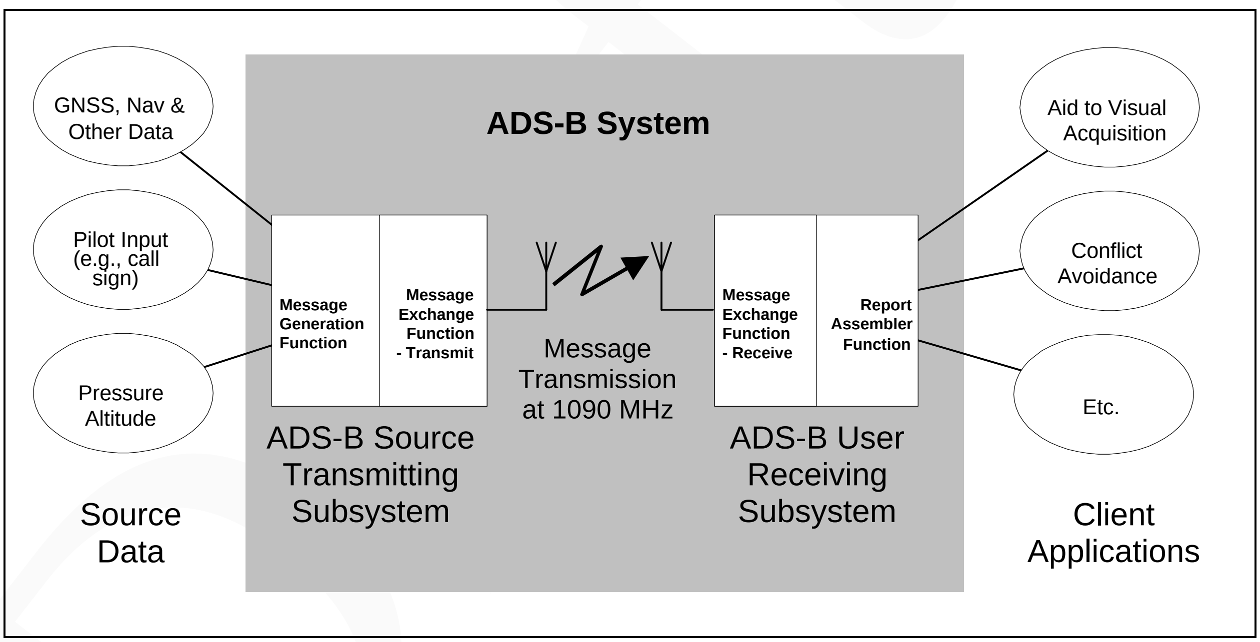
1.2.1 Definition of Automatic Dependent Surveillance - Broadcast

ADS-B is a system for aircraft or surface vehicles operating within the airport surface movement area that periodically transmits its state vector (horizontal and vertical position, horizontal and vertical velocity) and other information. ADS-B is *automatic* because no external stimulus is required; it is *dependent* because it relies on on-board navigation sources and on-board broadcast transmission systems to provide surveillance information to other users. The aircraft or vehicle originating the broadcast may or may not have knowledge of which users are receiving its broadcast; any user, either aircraft or ground-based, within range of this broadcast, may choose to receive and process the ADS-B surveillance information. ADS-B supports improved use of airspace, reduced ceiling/visibility restrictions, improved surface surveillance, and enhanced safety such as conflict management.

For the purposes of this document, the term *aircraft/vehicle* (A/V) will refer to either 1) a machine or device capable of atmospheric flight, or 2) a vehicle on the airport surface movement area (i.e., runways and taxiways). For simplicity, the word *aircraft* is used to refer to aircraft and vehicles, where appropriate.

Figure 1-1 shows the extent of the 1090 MHz ADS-B system and its major components. This figure is adapted from the ADS-B MASPS, RTCA/DO-242A.

As indicated in the figure, the ADS-B system includes the following components: message generation/transmission by the source A/V, propagation medium, and message reception/report assembling by the user. The ADS-B system does *not* include the sources of the data to be sent by the source subsystem on board the transmitting aircraft. Neither does it include the client applications, which use the information received by the ADS-B user subsystem on board the receiving aircraft. Some ADS-B participants may be able to transmit but not receive. In addition, some ground-based users may be able to receive but not to transmit.



<u>Figure 1-1:</u> The Scope of the 1090 MHz ADS-B System.

1.2.2 1090 MHz ADS-B System

In the 1090 MHz system that is the topic of this document, the "propagation medium", as shown in Figure 1-1, is the 1090 MHz downlink frequency used by the Secondary Surveillance Radar (SSR) and other systems such as IFF Mode 4. The "ADS-B Messages" transmitted on 1090 MHz are the Mode S extended squitters (airborne position squitter, airborne velocity squitter, surface position squitter, etc.) described in the *Manual on Mode S Specific Services*, ICAO document 9688, and Appendix A of this document.

The source 1090 MHz transmitting subsystem may or may not be implemented in conjunction with a Mode S transponder.

The user 1090 MHz receiving subsystem may or may not be implemented in conjunction with a TCAS (Traffic Alert and Collision Avoidance System).

1.2.3 ADS-B Avionics Integrity

The integrity requirements for the total system to support ADS-B related applications are determined for a particular airborne architecture by conducting a functional hazard assessment and system safety assessment. For each application, the classification (typically expressed in terms of a category such as hazardous/minor, hazardous major, etc.) of unannunciated and unmitigated failure conditions of ADS-B avionics that cause out-of-tolerance error conditions will be derived from these assessments.

Guidance on the above assessments can be found in:

- SAE ARP4761 -- Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment;
- SAE ARP4754/ED79 -- Certification Considerations for Highly-Integrated or Complex Aircraft Systems;
- JAA AMJ 25.1309 -- Advisory Material Joint, System Design and Analysis;
- FAA AC 25.1309-1A -- Advisory Circular, System Design and Analysis.

Presuming that all 24 parity check bits are employed for error detection, the 1090 MHz ADS-B Message formats have been designed to support an undetected error rate of less than 1 undetected error per 10^7 ADS-B Messages.

1.2.4 1090 MHz ADS-B Subsystem Implementations

Figure 1-2 shows the 1090 MHz ADS-B subsystems in more detail.

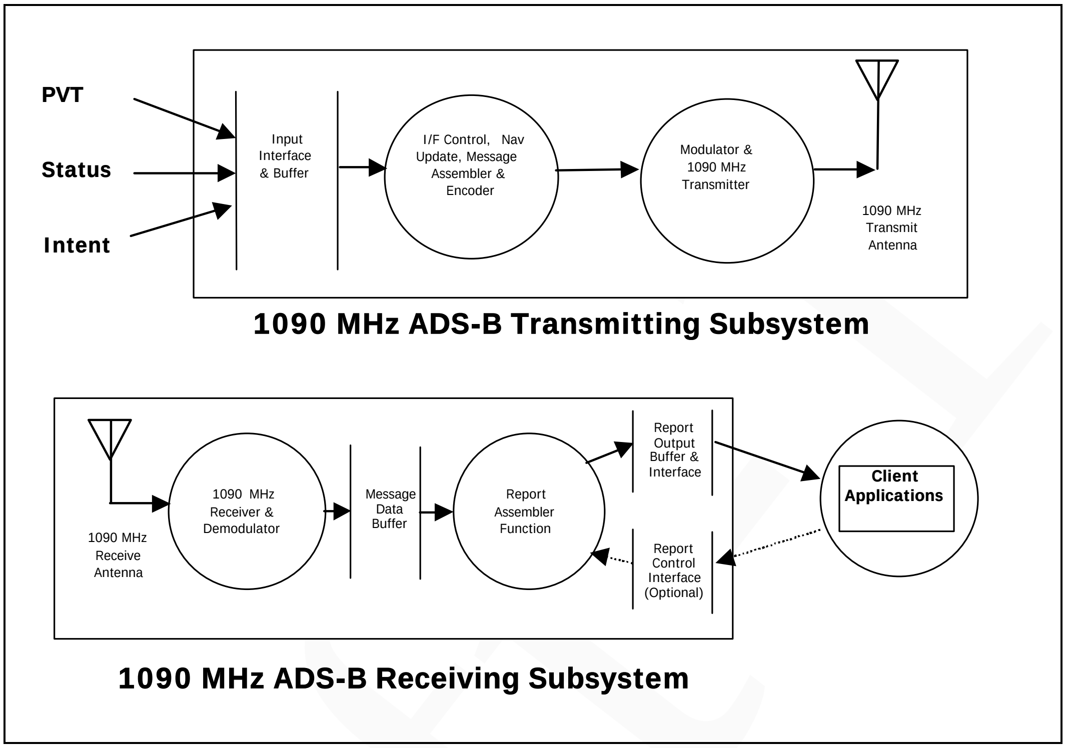


Figure 1-2: 1090 MHz ADS-B Subsystems.

1.2.4.1 Source 1090 MHz ADS-B Transmitting Subsystem

The source subsystem consists of a message generation function and a transmitting message exchange function. The 1090 MHz ADS-B transmitting subsystem takes PVT (Position, Velocity, Time), status, and intent inputs from other systems onboard the aircraft and transmits this information on the 1090 MHz frequency as Mode S extended squitter messages. The message generation function includes the input interface, message assembly, and encoding subfunctions. The message exchange function includes the radio equipment (modulator/transmitter) and 1090 MHz transmitting antenna subfunctions.

The transmitting subsystem may be implemented either (a) using a Mode S secondary surveillance radar transponder, or (b) using non-transponder-based 1090 MHz transmitting equipment.

1.2.4.1.1 Transponder-Based Subsystems

In a Mode S transponder based subsystem, the ADS-B Message generation function and the modulator and 1090 MHz transmitter are present in the Mode S transponder itself. The transmit antenna subfunction consists of the Mode S antenna(s) connected to that transponder.

1.2.4.1.2 Non-Transponder-Based Subsystems

Non-transponder based ADS-B subsystems might be installed in general aviation aircraft that have Mode A/C ATCRBS transponders rather than Mode S transponders. In such non-transponder-based ADS-B subsystems, the message generation function and the modulator and 1090 MHz transmitter will be housed together in the transmitting unit. The transmitting antenna subfunction may be separate from the transmitter unit or may also be incorporated in the unit.

1.2.4.2 User 1090 MHz ADS-B Receiving Subsystem

The user subsystem consists of a receiver message exchange function and a report assembler function. The 1090 MHz ADS-B receiving subsystem takes ADS-B Mode S extended squitter messages and outputs information to other systems onboard the aircraft. The message exchange function includes the 1090 MHz receiving antenna and radio equipment (receiver/demodulator) subfunctions. The report assembler function includes the message decoding, report assembly, and output interface subfunctions. Several configurations of ADS-B receiving subsystems, which include the reception portion of the ADS-B Message Exchange Function and the ADS-B Report Assembly Function, are defined:

- Type 1 ADS-B receiving subsystems receive ADS-B Messages and produce application-specific subsets of ADS-B reports. Type 1 ADS-B receiving subsystems are customized to the particular applications using ADS-B reports. Type 1 ADS-B receiving subsystems may additionally be controlled by an external entity to produce installation-defined subsets of the reports that those subsystems are capable of producing.
- Type 2 ADS-B receiving subsystems receive ADS-B Messages and are capable of producing complete ADS-B reports in accordance with the ADS-B equipment class. Type 2 ADS-B receiving subsystems may be controlled by an external entity to produce installation-defined subsets of the reports that those subsystems are capable of producing.
- The ADS-B Message reception function may be physically partitioned into separate avionics from those that implement the ADS-B report assembly function.

1.2.4.2.1 Type 1 Report Assembler Function

In *Type 1* the assembler function may be closely coupled to the client application using the information provided by the ADS-B system. In this case, the ADS-B report assembler function might reside together with the associated client application in one piece of equipment.

An advantage of a closely coupled assembler and application is that the report assembler function can be customized for the needs of the particular client application with which it is associated. If the client application does not require all of the State Vector elements listed in the MASPS (RTCA/DO-242A), then its associated report assembler function can customize the report by not providing the unneeded SV elements. Again, if the client application is only concerned with certain targets, then its report assembler function can optimize performance by filtering out targets that have no relevance to that application.

In a Type 1 configuration, any further control of output reports (beyond the customization) would require a control interface by which the client application(s) can specify which and how reports are to be assembled or output.

The Type 1 configuration has the advantage that it places only minimal processing requirements on the ADS-B receiving subsystem.

1.2.4.2.2 Type 2 Report Assembler

In *Type 2* the assembler function is of a general nature and is capable of supporting the needs of a variety of applications.

An advantage of Type 2 is that it can support the needs of a variety of client applications, as it includes a generalized report assembler function that can output reports that contain *all* the elements of the SV, MS, and OC reports as described in RTCA/DO-242A.

In a Type 2 configuration, any control of output reports would require a control interface by which the client application(s) can specify which and how reports are to be assembled or output.

1.2.4.3 Major Operating Characteristics

The 1090 MHz ADS-B System uses the Mode S extended squitter defined in the ICAO Document 9688 to broadcast the aircraft/vehicle position, intent and other relevant information over the RF medium. ICAO Document 9688 provides the Mode S transponder register definitions as well as the 56-bit data formats required for the ADS-B Messages. Appendix A to this document specifies the formats contained in ICAO Document 9688, plus those event-driven messages that are now defined. The transmission rate for each of the defined broadcast messages is defined in Appendix A and in the MOPS for Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode-S) Airborne Equipment (RTCA/DO-181C).

The ADS-B extended squitters sent from a Mode S transponder use Downlink Format 17. Each squitter contains 112 bits, of which 56 bits contain the various navigation, intent, and other data comprising the ADS-B information. The other 56 bits include the 5-bit DF (Downlink Format) field, the 3-bit CA (Capability) field, the 24-bit AA (Announced Address) field, and the 24-bit PI (Parity/Interrogator ID) field.

For non-transponder-based ADS-B source subsystems, the 112 bit message will use DF = 18. By using this format instead of DF = 17, a receiving system will know that this is non-transponder-based system that cannot be interrogated.

The transmitter power is based on the classification of the ADS-B equipment. For example, ADS-B class A0 equipment, which is intended to support only the “aid to visual acquisition” application, may transmit at a lower power than class A3 equipment, which is capable of supporting the “flight path de-confliction planning” application.

The operating range of the extended squitter receiver is tailored to the classification of the equipment as well. Class A0 equipment, intended to support only the “aid to visual acquisition" application, may have a less sensitive receiver and thus support a comparatively short operating range. Class A3 equipment, which is capable of supporting the "flight path de-confliction planning" operation, requires a more sensitive receiver, in order to receive ADS-B Messages from aircraft that are farther away.

The operation of the 1090 MHz ADS-B System must not have an adverse effect on other on-board systems. The ADS-B System may be used in conjunction with these other systems for increased accuracy and integrity of an aircraft's current navigational position and/or intent information.

1.2.5 Typical System Operation

A departing aircraft on the ground begins broadcasting its position and velocity via the 1090 MHz ADS-B System. This broadcast is received by other aircraft and the ground based receivers. The broadcasting aircraft also receives other aircraft broadcasts. The aircraft processes this information for use by applications that may involve CDTI. As the aircraft taxis to its holding area, it monitors the movement of other aircraft on the surface as well as those in final approach. The aircraft on approach can also monitor the ground traffic and watch for a potential runway incursion and/or a blunder on a parallel approach area.

Once in the en route airspace, the aircraft broadcasts not only its position and velocity, but depending on the equipment classes, additional intent information. The aircraft performs various applications with the received broadcasts from other aircraft within range. These applications may include the use of CDTI, situational awareness, and de-confliction planning.

As the aircraft approaches its destination (terminal area), it monitors other proximate aircraft in order to maintain the desired separation for approach and landing.

1.2.6 ADS-B Message Content

The ADS-B Message refers to the transfer of data via 1090 MHz. An ADS-B Message is formatted data that conveys information used in the development of ADS-B reports. SV source data is provided by the platform dynamic navigation systems and sensors.

For the transponder case, the information for the state vector is contained in various registers. When broadcast, the contents of a register are inserted in the 56-bit message field of a 112-bit squitter transmission. The remaining 56 bits contain the aircraft address as well as required forward error correcting parity information. Appendix A to this document defines the contents of the various transponder registers.

1.2.7 ADS-B Report Content

The ADS-B Report refers to the restructuring of ADS-B Message data received from a 1090 MHz broadcast into various reports that can be used directly by other on-board applications. Three report types are defined for ADS-B outputs to applications. These reports types are State Vector (SV), Mode Status (MS), and TCP+1.

1.2.7.1 State Vector Report

The state vector report contains information about an aircraft or vehicle's current kinematic state as well as a measure of the accuracy of the state vector. Specific requirements for the customization of this type of report may vary according to the needs of the client applications of each participant. The state vector data is the most dynamic of the three ADS-B reports; hence, the applications require frequent updates of the state vector to meet the required accuracy for the operational dynamics of the typical flying aircraft or ground operations of aircraft and surface vehicles.

1.2.7.2 Mode Status Report

The mode status report contains current operational information about the transmitting participant. This information may include current intent (trajectory change point), call sign, address, and other information that may be needed at a lower update rate than the information in the state vector. Specific requirements for a participant to transmit data for, and/or customize, this report type will vary according to the ADS-B equipage class of each participant.

1.2.7.3 TCP+1 Report

The TCP+1 report contains information that will be broadcast (in Aircraft Trajectory Intent messages) when the broadcasting aircraft approaches the current trajectory change point (TCP). (See §2.2.8.3 for the format of this report.)

Note: *The MASPS (RTCA DO-242A) describes a more general "On Condition" report of which the TCP+1 Report is the only instance that has so far been defined.*

1.3 Operational Applications

The various equipment classes defined within this document are intended to provide a level of capability appropriate to a set of expected operational applications. Operational approval for specific applications should consider the total capability of all associated equipment installed in the aircraft. All airborne equipment will require a source of state vector data, such as a GNSS (GPS) receiver, an inertial/multisensor navigation system, or FMS**.** Additional concepts, algorithms, procedures, and standards not defined within this document will also be required. This section describes several examples of applications which make use of ADS-B supplied information. Further examples may be found in RTCA DO-242A.

1.3.1 General Support for Surveillance

ADS-B is a cooperative system. All participating aircraft/vehicles are required, at a minimum, to broadcast ADS-B Messages as defined in Section 2.2 of this document for each applicable equipment class. The broadcast of these messages provides the basic surveillance data necessary to support all other ADS-B applications.

1.3.2 Cockpit Display of Traffic Information (CDTI)

The CDTI provides the pilot with awareness of proximate traffic. A minimum system provides only the relative position and velocity vector of nearby traffic. Displays to support advanced applications may be required to supply additional information, pilot cues, or advanced alerting functions.

1.3.2.1 Aid to Visual Acquisition

An aid to visual acquisition application provides the pilot with information that supports visual acquisition as part of the normal see-and-avoid operations. Visual acquisition is applicable under visual meteorological conditions (VMC) regardless of whether the operations are being conducted under IFR or VFR.

1.3.2.2 Enhanced Traffic Situational Awareness

With the ability to display the full population of proximate aircraft, the CDTI may be used as an overall situational awareness tool. The CDTI is also seen as a key element to Free Flight operations. With mature Free Flight, and mutual controller/pilot agreement, separation responsibility may be delegated to the pilot. In this case, the ability to electronically "see and avoid" proximate aircraft becomes a necessary technology to enable the Free Flight concept. For example, the CDTI may be used for "Electronic VFR," with pilots applying "Rules of the Air" (as stated in ICAO Annex 2 to the Convention of International Aviation) to maintain safe separation.

1.3.3 Improvements to Aircraft-based Collision Avoidance

ADS-B is seen as a valuable technology to enhance operation of the Airborne Collision Avoidance System (ACAS). ADS-B data may be used to improve surveillance performance. It may also be used within the collision avoidance logic to reduce the number of unnecessary alerts and improve the Resolution Advisory maneuver selection process, for example, by eliminating alerts for aircraft that will pass with large lateral separation and by enabling more accurate trajectory prediction.

1.3.4 Conflict Management and Airspace De-confliction

Conflict management and airspace de-confliction functions may be provided both by ground and aircraft automation systems. Aircraft conflict management functions will be used to support cooperative separation during the periods that separation responsibility has been delegated to the aircraft, such as in Free Flight. Ground conflict management functions will also be in place, both as a backup and as the primary tool to monitor aircraft for conflict detection. Airspace de-confliction based on the exchange of intent information will be used for strategic separation.

1.3.5 ATS Conformance Monitoring

ADS-B may be used to support and enhance ATS conformance monitoring, which is the process of ensuring that an aircraft maintains conformance to its agreed-to trajectory. The degree of deviation from the trajectory, or the conformance bounds, is based on factors such as the aircraft's navigation capability and the separation standards in place. Conformance monitoring occurs for all controlled aircraft or airspace, and applies to all operational airspace domains. In the case of protected airspace or Special Use Airspace (SUA), conformance monitoring is performed to ensure that an aircraft does not enter or leave a specific airspace. Conformance monitoring includes monitoring of simultaneous approaches to multiple runways, and surface operations.

1.3.5.1 Simultaneous Approaches

A specific example of conformance monitoring is the monitoring of simultaneous instrument approaches, a task that enables closer separation between aircraft on adjacent approach courses due to monitoring of each approach path by an ATS controller.

Parallel approaches that are not individually monitored require a stagger between aircraft on adjacent approaches, thus reducing arrival rates. Conformance monitoring of simultaneous approaches using a dedicated ATS controller for each approach stream allows simultaneous approaches to be flown. No stagger is required and the potential arrival rate can be 40 percent higher than for staggered approaches. Simultaneous approaches can be flown as close as 5,000 ft (three runways) and 4,300 ft (dual runways) with controllers using conventional sensors and displays, and as close as 3400 ft when controllers use PRM, which is a specialized sensor for simultaneous approaches. Simultaneous approaches may also be flown to converging runways, and in the future may be flown along curved or segmented courses that are tailored for local airport noise and arrival procedures. ADS-B may offer a viable alternative to expensive PRM technology to support simultaneous approaches, and may allow simultaneous approaches at airports that cannot currently justify the cost of a PRM or conventional equipment for simultaneous approach monitoring.

1.3.5.2 Incursion Monitoring

ADS-B information may be used to support incursion monitoring for both airborne and surface operations. Specific zones may be defined including:

- special use airspace,
- restricted airspace,
- hazardous weather locations,
- runways and taxiways,
- lighting control areas (areas where lighting is under ATS control)
- weight limited or wingspan limited areas, and
- other operational control zones such as noise sensitive areas.

Projected position information based on ADS-B state vectors, when used in combination with zone incursion monitoring, can provide early warnings to ATS and the pilot.

1.3.6 Other Applications

Other applications for ADS-B may not be directly related to ground-based surveillance, CDTI, or a Traffic Situation Display (TSD), but still offer many users a direct economic or operational benefit. These should be developed and exploited as a means to encourage users to promptly and voluntarily equip with ADS-B systems. Some examples of these other applications are as follows:

- Improved Search and Rescue
- Enhanced Flight Following
- Lighting Control and Operation
- Aircraft Rescue and Fire Fighting (ARFF) Vehicle Operations
- General Aviation Operations Control

Further details on these and other potential ADS-B applications can be found in the ADS-B MASPS, RTCA Document DO-242A.

1.4 ADS-B Functions

The 1090 MHz ADS-B System can be viewed as being comprised of three major functions. These functions are the ADS-B Message Generation Function, the ADS-B Message Exchange Function, and the ADS-B Report Assembler Function.

The ADS-B Message Generation Function is responsible for assembling and structuring the data to be delivered via the 1090 MHz extended squitter. The ADS-B Message Exchange Function is then responsible for transferring this data at the required rate across the 1090 MHz frequency link. This function encompasses both the transmission and reception of the data. The ADS-B Report Assembler Function is responsible for structuring the received data into the appropriate ADS-B Reports for use by onboard applications.

1.4.1 ADS-B Message Generation Function

1.4.1.1 Avionics Input Bus

The information required for the various ADS-B reports are provided to the message generation function via avionics digital communication buses or a General Aviation interface. The majority of the information for air carrier installations may be obtained from avionics buses that contain ARINC 429 data labels for the required information.

1.4.1.2 Input Interface

For the transponder case, the Mode S transponder will provide the input interface for the required ADS-B Message data. This input may come directly from the source that supplies the data, i.e. an FMS unit, or from a data concentrator. The data concentrator would serve as the input for all source data and transfer this data to the transponder in the case of the 1090 MHz ADS-B System.

1.4.1.3 Message Assembly/Encoder

These subfunctions **shall** accept input data from other avionics sources and process this data into the appropriate format. For a Mode S transponder-based ADS-B system, this formatted data will then be inserted into Downlink Format =17 for transmission over the 1090 MHz frequency link. For a non-transponder-based ADS-B system, the formatted data will be inserted into Downlink Format = 18 for transmission.

1.4.2 ADS-B Message Exchange Function

The ADS-B Message Exchange Function provides for transmission and reception of the ADS-B Message over the 1090 MHz medium. The message exchange function also provides suitable integrity for ADS-B Messages.

1.4.2.1 Modulation/Transmission Subfunction

The modulation of the ADS-B Message transmission is Pulse Position Modulation (PPM) as specified in RTCA/DO-181C. This modulation scheme is inherently resistant to ATCRBS interference. The information content of the transmission is further protected by parity check bits generated by a cyclic coding algorithm.

The transmitter subfunction generates the 1090 MHz carrier frequency and impresses the ADS-B information onto the carrier frequency. For Mode S transponder-based implementations, the transmitter requirements for transmission of the ADS-B data are defined in ICAO Annex 10, Volume IV, and also RTCA/DO-181C. For non-transponder based implementations, transmitter requirements are contained in this document.

1.4.2.2 Transmit/Receive/Antenna Subfunction

The ADS-B transmit and receive subfunctions should be supported by one or two antennas depending upon aircraft installation for the operational unit. Two antennas are required if the transponder is coupled with an on-board TCAS, or if the aircraft's weight or maximum airspeed is such that diversity is specified in ICAO Annex 10. The diversity installation should be such that one antenna is mounted on the top of the fuselage and the other on the underside. The antennae should be capable of receiving and transmitting the 1090 MHz frequency (D-Band).

For best coverage in the yaw plane, the ADS-B antennas should be designed to radiate and receive vertically polarized RF signals. The antennas should be designed such that the ADS-B System is capable of performing its intended functions. This includes all azimuth headings with respect to any radial direction from another ADS-B System receiver when in the transmit mode or to another ADS-B transmitter when in the receive mode.

Note: *For the transponder case, the antenna should also be capable of receiving the 1030 MHz frequency for use in the ATCRBS/Mode S environment.*

These subfunctions should be designed to receive the RF signals of airborne aircraft and aircraft/vehicles operating on the ground. Detailed requirements are given in Section 2.2 to establish a receive antenna suitable for the ADS-B function.

1.4.2.3 Receiver/Demodulator Subfunction

The ADS-B Message is received over the 1090 MHz frequency link, demodulated, and output to the report assembler function. The minimum trigger level (MTL) defines the minimum input power that results in reliable reception and is suitable for receiving the information necessary for an ADS-B report. The MTL may vary to effectively increase or reduce the range depending on the phase of flight. Dynamic MTL may be used to reject low level multipath and interference.

1.4.3 ADS-B Report Assembler Function

1.4.3.1 Decoder/Report Assembly

Once the ADS-B Message is received, the decoder and message assembly subfunctions provide all control, decoding, and formatting functions needed to convert the received messages into the appropriate formatted reports for use by client applications. These subfunctions may be performed in the 1090 MHz receiver unit itself or an external processing unit that interfaces to the receiver.

Since the ADS-B information will be transmitted in multiple messages, the message assembler may require the use of a tracker. The message assembly and tracking processor will structure the received messages into the appropriate output data reports. It also verifies that the output data reports are valid prior to delivery to the Output Interface subfunction.

1.4.3.2 Output Interface

The report assembler function will output information through the interface for use by client applications that may involve CDTI. The report assembly/output processor serves as the output control for ADS-B Message data and transfers this data to client applications.

1.4.3.3 Avionics Output Bus

The information required for the various client applications is provided by the report assembler function, via avionics digital communication buses or a General Aviation interface. The majority of the information for air carrier installations may be delivered with avionics buses that contain ARINC 429 data labels for the required information.

1.5 Operational Goals

The aviation industry has articulated the goal of levering ADS-B equipage, in conjunction with technologies/services such as GPS, Traffic Information Service—Broadcast (TIS-B), Flight Information Service—Broadcast (FIS-B), and two-way digital aeronautical data link, to support operational enhancements leading toward free flight [Joint Government/Industry Plan for Free Flight Operational Enhancements, August 1998, RTCA Flight Select

Committee]. A number of the operational applications cited in Section 1.3 are involved in this effort, most notably to support Improved Terminal Operations in Low Visibility Conditions, Enhanced Visual Operations and Situational Awareness, Enhanced Operations for En Route and Oceanic Air-to-Air, Improved Surface/Approach Operations, a Surface and Airport Vicinity Display for the Controller, Use of ADS-B in Non-Radar Airspace, and Use of ADS-B to Enhance Radar and Automation Performance. ADS-B is a technical linchpin for supporting seven of the ten identified operational enhancements.

Operational scenarios have been developed for each of the above Free Flight Enhancements, and more detailed operational concepts are being completed. The detailed operational concepts are being used to develop a comprehensive roadmap for surveillance airborne and ground system development and interoperability.

1.6 Assumptions and Rationale

Throughput requirements for ADS-B Message reception have been developed so that the equipment can process the maximum number of messages that can be supplied on the 1090 MHz medium. The ADS-B report assembler function, whether or not physically collocated with the ADS-B Message reception function, will similarly be required to be capable of accepting this number of messages as output by the ADS-B receiver function.

1.7 Test Procedures

The test procedures specified in Sections 2 and 3 are intended to be used as recommended means of demonstrating compliance with the minimum acceptable performance parameters specified herein. Although specific test procedures are cited, it is recognized that other methods may be suitable. These alternate procedures may be used if they provide at least equivalent information. In such cases, the procedures cited herein should be used as one criterion in evaluating the acceptability of the alternate procedures.

1.7.1 1.7.1 Environmental Tests

Environmental tests are specified in Section 3. These tests, like bench tests, are performed at the equipment level. The procedures and their associated requirements provide a laboratory means of determining the electrical and mechanical performance of the equipment under conditions expected to be encountered in actual aeronautical operations. Test results may be used by equipment manufacturers as design guidance, in preparation of installation instructions and, in certain cases, for obtaining formal approval of equipment design and manufacture.

1.7.2 Qualification Tests

The test procedures specified in Section 2.4 provide a means to demonstrate equipment performance in a simulated environment. Test results may be used as design guidance for monitoring manufacturing compliance and, in certain cases, for obtaining formal approval of equipment design and manufacture.

Test procedures contained in Section 2.4 apply to the minimum system requirements in accordance with the minimum performance parameters specified in this standard.

1.7.3 Installed Tests

The installed test procedures and their associated limit requirements are in Section 3. Although bench and environmental test procedures are not a part of installed tests, their successful completion is normally a precondition to the completion of the installed tests. Installed tests are normally performed on the ground and in flight.

The test results may be used to demonstrate equipment functional performance in the environment in which it is intended to operate and with the minimum service to be provided.

1.8 MASPS Compliance

Certain points concerning MASPS compliance are presented here. A detailed listing of compliance is contained in Appendix F. The following points are listed by their MASPS requirement reference number:

- R3.17- This MOPS requires a source data update rate of 5 Hz in order for subsystems reporting a Navigation Uncertainty Category of 8 or greater to meet the specified latency requirement.

- R3.24- This MOPS levies this availability requirement at the aircraft installed system level (as addressed in Section 3) not at the subsystem level as indicated in the MASPS.

- R3.35- This MOPS does not require the velocity field to be estimated when a state vector report is updated using a position message; instead the most recent velocity and its time of applicability will be reported along with the time of applicability of the rest of the state vector report.

1.9 Definition of Terms

Appendix B provides a glossary of the terms used in this document. This section expands upon the definitions of key terms in order to increase document clarity and establish a common foundation of terminology.

<u>ADS-B Broadcast and Receive Equipment</u> - Equipment that can transmit and receive ADS-B Messages. Defined as Class A equipment.

<u>ADS-B Broadcast Only Equipment</u> - Equipment that can transmit but not receive ADS-B Messages. Defined as Class B equipment. Includes transponder based equipment that is capable of receiving 1030 MHz SSR interrogations.

<u>ADS-B Message</u> - A modulated packet of formatted data which conveys information used in the development of ADS-B reports.

ADS-B Receiver or 1090 MHz Receiver - An ADS-B receiving subsystem that is not part of a TCAS 1090 MHz receiver.

ADS-B Report - Specific Information provided by the ADS-B user participant subsystem to external applications. Reports contain identification, state vector, and status/intent information. Elements of the ADS-B Report that are used and the frequency with which they must be updated will vary by application. The portions of an ADS-B Report that are provided will vary by the capabilities of the transmitting participant.

Non-Transponder-Based Implementation - An ADS-B transmitting subsystem that is not part of a Mode S transponder.

TCAS Implementation – An ADS-B receiving subsystem implemented as part of a TCAS receiver.

Transponder-Based Implementation - An ADS-B transmitting subsystem implemented as part of, or added capability to, a Mode S transponder.

2.0 Equipment Performance Requirements and Test Procedures

2.1 General Requirements

2.1.1 Airworthiness

In the design and manufacture of the equipment, the manufacturer **shall** provide for installation so as not to impair the airworthiness of the aircraft.

2.1.2 Intended Function

The equipment **shall** perform its intended function(s), as defined by the manufacturer, and its proper use **shall** not create a hazard to other users of the National Airspace System.

2.1.3 Federal Communications Commission Rules

All equipment **shall** comply with the applicable rules of the Federal Communications Commission.

2.1.4 Fire Protection

All materials **shall** be self-extinguishing except for small parts (such as knobs, fasteners, seals, grommets and small electrical parts) that would not contribute significantly to the propagation of a fire.

***Note**: One means of showing compliance is contained in Federal Aviation Regulations (FAR), Part 25, Appendix F.*

2.1.5 Operation of Controls

The equipment **shall** be designed so that controls intended for use in flight cannot be operated in any position, combination or sequence that would result in a condition detrimental to the reliability of the equipment or operation of the aircraft.

2.1.6 Accessibility of Controls

Controls that do not require adjustment during flight **shall** not be readily accessible to flight personnel.

2.1.7 Equipment Interfaces

The interfaces with other aircraft equipment **shall** be designed such that, properly installed with adequately designed other equipment, normal or abnormal ADS-B equipment operation **shall** not adversely affect the operation of other equipment nor **shall** normal or abnormal operation of other equipment adversely affect the ADS-B equipment except as specifically allowed.

2.1.8 Effects of Test

The equipment **shall** be designed so that the application of specified test procedures **shall** not be detrimental to equipment performance following the application of these tests, except as specifically allowed.

2.1.9 Design Assurance

The equipment **shall** be designed to the appropriate design assurance level(s) based on the intended application of the equipment and aircraft class in which it is to be installed. The appropriate design assurance level(s) are determined by an analysis of the failure modes of the equipment and a categorization of the effects of the failure on the operation of the aircraft. For the purpose of this analysis, a failure is defined as either a loss of function or the output of misleading information. Additional guidance is contained in Advisory Circulars AC 23.1309-1C and AC 25.1309-1A.

Software included as part of the equipment **shall** be developed in compliance with the appropriate software level as defined in RTCA/DO-178B Software Considerations in Airborne Systems and Equipment Certification.

2.1.10 Integration and Interoperability with a Mode S Transponder

If the ADS-B equipment is integrated into a Mode S transponder, the transponder functions **shall** meet the appropriate requirements specified in the MOPS for Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment (RTCA/DO-181C).

If the ADS-B equipment is designed as a stand-alone system, it **shall** be interoperable within the Mode S environment.

2.1.11 Equipage Class Application Coverage

ADS-B equipment is categorized into aircraft system equipage classes as defined in the ADS-B MASPS (RTCA document #DO-242A) and as summarized in Table 2-1. These class categories are based on both the aircraft's on-board transmitter and receiver capabilities. The system classes are then broken down into subsystem equipment classes that are based on the individual unit specifications (refer to §2.1.11.1 and §2.1.11.2). Table 2-2 lists the different types of ADS-B Messages in the 1090 MHz ADS-B system.

<u>Table 2-1:</u> ADS-B Aircraft System Classes
(adapted from RTCA DO-242A, Table 3-1)

CLASS	SUBSYSTEM	CAPABILITIES	FEATURES	COMMENTS
Interactive Aircraft/Vehicle Participant Systems (Class A)				
A0	Minimum Interactive Aircraft/Vehicle	Aid to Visual Acquisition.	Lower transmit power and less sensitive than Class A1.	Minimum interactive capability with CDTI.
A1	Basic Interactive Aircraft	A0 Plus Conflict Avoidance.	Standard Tx and Rx. Antenna Diversity (Note)	Provides ADS-B based conflict avoidance and interface to current TCAS surveillance algorithms/displays.
A2	Enhanced Interactive Aircraft	A1 Plus Separation Assurance and Sequencing.	Standard transmit power and more sensitive receiver. Interface with avionics source required for aircraft trajectory intent data. Antenna Diversity (Note)	Baseline for separation management employing intent information.
A3	Extended Interactive Aircraft	A2 Plus Flight Path Deconfliction Planning.	More sensitive receiver. Interface with avionics source required for aircraft trajectory intent data. Antenna Diversity (Note)	Extends planning horizon for strategic separation employing intent information.
Broadcast-Only Participant Systems (Class B)				
B0	Aircraft Broadcast Only	Supports visual acquisition and conflict avoidance for other participants.	Transmit power may be matched to coverage needs. Nav data input required.	Enables aircraft to be seen by Class A and Class C users.
B1	Aircraft Broadcast Only	Supports visual acquisition and conflict avoidance for other participants.	Transmit power may be matched to coverage needs. Nav data input required.	Enables aircraft to be seen by Class A and Class C users.
B2	Ground Vehicle Broadcast Only	Supports visual acquisition and conflict avoidance on airport surface.	Transmit power matched to surface coverage needs. High accuracy Nav dat input required.	Enables vehicle to be seen by Class A and Class C users.
B3	Fixed Obstruction	Supports visual acquisition and conflict avoidance.	Fixed coordinates. No Nav data input required. Collocation with obstruction not required with appropriate broadcast coverage.	Enables Nav hazard to be detected by Class A users.
Ground Receive Systems (Class C)				
C1	ATS En route and Terminal Area Operations	Supports ATS cooperative surveillance.	Requires ATS certification and interface to ATS sensor fusion system.	En route coverage out to 200 NM. Terminal coverage out to 60 NM
C2	ATS Parallel Runway and Surface Operation	Supports ATS cooperative surveillance.	Requires ATS certification and interface to ATS sensor fusion system.	Approach coverage out to 10 NM. Surface coverage out to 5 NM
C3	Flight Following Surveillance	Supports private user operations planning and flight following.	Does not require ATS interface. Certification requirements determined by user application.	Coverage determined by application.

<u>Note:</u> *See subparagraph 3.3.1 for Antenna Diversity.*

Table 2-2: ADS-B MESSAGE TO REQUIREMENT CROSS-REFERENCE TABLE

MESSAGE	REFERENCE SECTION
AIRBORNE POSITION	§2.2.3.2.3
SURFACE POSITION	§2.2.3.2.4
AIRCRAFT IDENTIFICATION and TYPE	§2.2.3.2.5
AIRBORNE VELOCITY (Subtype 1, 2, 3, & 4)	§2.2.3.2.6.1- §2.2.3.2.6.4
AIRCRAFT TRAJECTORY INTENT AND SYSTEM STATUS	§2.2.3.2.7.1
AIRCRAFT OPERATIONAL STATUS	§2.2.3.2.7.2
EVENT DRIVEN MESSAGE FOR TEST	§2.2.3.2.7.3
EVENT DRIVEN	§2.2.3.2.7.4– §2.2.3.2.7.7
EXTENDED SQUITTER AIRCRAFT STATUS	§2.2.3.2.7.8

2.1.11.1 Transmitting Subsystem

An ADS-B transmitting subsystem is classified according to the unit's range capability and the set of parameters that it is capable of transmitting. Manufacturers should take into consideration the equipment's intended operation when determining the minimum set of messages that the unit will be required to transmit (refer to Table 2-3 and Table 2-4).

Table 2-3: ADS-B CLASS A TRANSMITTER EQUIPMENT TO MESSAGE COVERAGE

Transmitter Class	Minimum Range / Minimum Transmit Power (at Antenna Port)	Operation	MASPS Requirement (RTCA/DO-242A)	Minimum Message Capability Required (From Table 2-2)
A0 (Minimum)	10 NM / 70 W	♦ Aid to Visual Acquisition ♦ Conflict Avoidance	SV MS	Airborne Position A/C Identification & Type Airborne Velocity A/C Operational Status Extended Squitter A/C Status
A0 (Minimum)	10 NM / 70 W	♦ Airport Surface	SV MS	Surface Position A/C Identification & Type A/C Operational Status
A1 (Basic)	20 NM / 125 W	♦ Aid to Visual Acquisition ♦ Conflict Avoidance ♦ Simultaneous Approaches	SV MS	Airborne Position A/C Identification & Type Airborne Velocity A/C Operational Status Extended Squitter A/C Status
A1 (Basic)	20 NM / 125W	♦ Airport Surface	SV MS	Surface Position A/C Identification & Type A/C Operational Status
A2 (Enhanced)	40 NM / 125 W	♦ Aid to Visual Acquisition ♦ Conflict Avoidance ♦ Separation Assurance and Sequencing ♦ Flight Path Deconfliction Planning ♦ Simultaneous Approaches	SV MS	Airborne Position A/C Identification & Type Airborne Velocity A/C Operational Status Extended Squitter A/C Status A/C Trajectory Intent and System Status
A2 (Enhanced)	40 NM / 125 W	♦ Airport Surface	SV MS	Surface Position A/C Identification & Type A/C Operational Status
A3 (Extended)	90 NM / 125 W	♦ Aid to Visual Acquisition ♦ Conflict Avoidance ♦ Separation Assurance and Sequencing ♦ Flight Path Deconfliction Planning ♦ Simultaneous Approaches	SV MS OC	Airborne Position A/C Identification & Type Airborne Velocity A/C Operational Status Extended Squitter A/C Status A/C Trajectory Intent and System Status Event Driven
A3 (Extended)	90 NM / 125 W	♦ Airport Surface	SV MS	Surface Position A/C Identification & Type A/C Operational Status

Table 2-4: ADS-B Class B Transmitter Equipment To Message Coverage

Transmitter Class	Minimum Range / Minimum Transmit Power (at Antenna Port)	Operation	MASPS Requirement (RTCA/DO-242A)	Minimum Message Capability Required (From Table 2-2)
B0	10 NM / 70 W [1]	⬩ Aid to Visual Acquisition ⬩ Conflict Avoidance	SV MS	Airborne Position A/C Identification & Type Airborne Velocity A/C Operational Status Extended Squitter A/C Status
B1 (Aircraft)	10 NM / 70 W [1]	⬩ Aid to Visual Acquisition ⬩ Conflict Avoidance	SV MS	Airborne Position A/C Identification & Type Airborne Velocity A/C Operational Status Extended Squitter A/C Status
B1 (Aircraft)	10 NM / 70 W [1]	⬩ Airport Surface	SV MS-P	Surface Position A/C Identification & Type A/C Operational Status
B2 (Ground Vehicle)	10 nmi / 70 W [1]	⬩ Aid to Visual Acquisition ⬩ Conflict Avoidance	SV_{B2} $MS\text{-}P_{B2}$	Surface Position A/C Identification & Type (See Note 14)
B2 (Ground Vehicle)	10 nmi / 70 W [1]	⬩ Airport Surface	SV_{B2} $MS\text{-}P_{B2/B3}$	Surface Position A/C Identification & Type (See Note 14)
B3 (Fixed Obstruction)	10 nmi / 70 W [1]	⬩ Aid to Visual Acquisition ⬩ Conflict Avoidance	SV_{B3} $MS\text{-}P_{B2/B3}$	Airborne Position A/C Identification & Type (See Note 14)
B3 (Fixed Obstruction)	10 nmi / 70 W [1]	⬩ Airport Surface	SV_{B3} $MS\text{-}P_{B2/B3}$	Airborne Position A/C Identification & Type (See Note 14)

[1] – May be increased based upon application specific needs.

Notes: *(Tables 2-3 and 2-4):*

1. *SV = State Vector, MS = Mode Status, OC = On-Condition*

2. *SV elements are as follows:*

   - *Address (the ICAO 24 Bit Address)*
   - *Latitude and Longitude*
   - *Altitude, Geometric*
   - *Position Component of Navigation Uncertainty Category (NUC_P)*
   - *Geometric Position Valid (Horizontal/Vertical)*
   - *N and E Velocity*

- *Vertical Rate*
- *Velocity Component of Navigation Uncertainty Category (*NUC_V*)*
- *Barometric Pressure Altitude*
- *Barometric Pressure Altitude Rate*
- *Airspeed (True or Indicated)*
- *Ground Speed, Ground Track (True or Magnetic Heading)*
- *Turn Indication*

3. *MS elements are as follows:*

- *Address (the ICAO 24 Bit Address)*
- *Call Sign (Up to 8 Alpha-numeric Characters)*
- *Participant Category*
- *Surveillance Support Code*
- *Emergency/Priority Status*
- *Class Codes*
- *Operational Mode Specific Data*

4. *OC reports is a category that includes multiple report types. Each specific OC report type includes the following elements:*

- *Air Referenced Velocity Report*
  - *Address (the ICAO 24 Bit Address)*
  - *Time of Applicability*
  - *Airspeed*
  - *Heading*
- *Target State Reports*
  - *Time of Applicability*
  - *Horizontal Short Term Intent*
  - *Vertical Short Term Intent*
- *Reserved for Trajectory Change Reports*

5. SV_{B2} *elements are as follows:*

- *Address (the ICAO 24 Bit Address)*
- *Latitude*
- *Longitude*
- *Position Component of Navigation Uncertainty Category (*NUC_P*)*
- *N Velocity*
- *E Velocity*

6. $MS\text{-}P_{B2\text{-}B3}$ *elements are as follows:*

- *Address (the ICAO 24 Bit Address)*
- *Participant Category*
- *Surveillance Support Code*

7. SV_{B3} *elements are as follows:*

- *Address (the ICAO 24 Bit Address)*
- *Latitude*
- *Longitude*

- *Altitude, Geometric*
- *Position Component of Navigation Uncertainty Category (NUC$_P$)*
- *Geometric Position Valid (Horizontal/Vertical)*

8. *If the formats for these categories are changed in the future, then they will be required to transmit the message that contains the Version Number.*

2.1.11.2 Receiving Subsystem

An ADS-B receiving subsystem is classified by the sensitivity and the set of parameters that it is capable of formatting into reports. Manufacturers should take into consideration the equipment's intended operation when determining the minimum set of reports that the unit will be required to develop (refer to Table 2-5 and Table 2-6).

Table 2-5: ADS-B Class A Receiver Equipment To Report Coverage

Receiver Class	Minimum Trigger Threshold Level (MTL)	Reception Technique	Operation	MASPS Requirement (RTCA/DO-242A)	Minimum Report Required
A0 (Basic VFR)	-72 dBm	Standard	♦ Aid to Visual Acquisition ♦ Airport Surface	SV	ADS-B State Vector Report (per §2.2.8.1)
A1 (Basic IFR)	-74 dBm	Enhanced (per §2.2.4.4)	♦ Aid to Visual Acquisition ♦ Conflict Avoidance ♦ Simultaneous Approaches ♦ Airport Surface	SV MS	ADS-B State Vector Report (per §2.2.8.1) AND ADS-B Mode Status Report (per §2.2.8.2)
A2 (Enhanced IFR)	-79 dBm	Enhanced (per §2.2.4.5)	♦ Aid to Visual Acquisition ♦ Conflict Avoidance ♦ Separation Assurance and Sequencing ♦ Simultaneous Approaches ♦ Airport Surface	SV MS OC	ADS-B State Vector Report (per §2.2.8.1) AND ADS-B Mode Status Report (per §2.2.8.2) AND ADS-B Target State Report (OC Report per §2.2.8.3) AND Reserved for ADS-B Target Change Reports
A3 (Extended Capability)	-84 dBm	Enhanced (per §2.2.4.5)	♦ Aid to Visual Acquisition ♦ Conflict Avoidance ♦ Separation Assurance and Sequencing ♦ Flight Path Deconfliction Planning ♦ Simultaneous Approaches ♦ Airport Surface	SV MS OC	ADS-B State Vector Report (per §2.2.8.1) AND ADS-B Mode Status Report (per §2.2.8.2) AND ADS-B Target State Report (OC Report per §2.2.8.3) AND Reserved for ADS-B Target Change Reports §2.2.8.3)

Table 2-6: ADS-B Class C Receiver Equipment To Report Coverage

Receiver Class	Minimum Trigger Threshold Level (MTL)	Operation	MASPS Requirement (RTCA/DO-242A)	Minimum Report Required
C1 (ATS En Route and Terminal)	Not Specified in this MOPS	• Aid to Visual Acquisition • Conflict Avoidance • Separation Assurance and Sequencing • Flight Path Deconfliction Planning	SV MS OC	ADS-B State Vector Report (per §2.2.8.1) AND ADS-B Mode Status Report (per §2.2.8.2) AND ADS-B Target State Report (per §2.2.8.3) AND Reserved for ADS-B Trajectory Change Report(s)
C2 (Approach and Surface)	Not Specified in this MOPS	• Aid to Visual Acquisition • Conflict Avoidance • Separation Assurance and Sequencing • Simultaneous Approaches • Airport Surface	SV MS OC	ADS-B State Vector Report (per §2.2.8.1) AND ADS-B Mode Status Report (per §2.2.8.2) AND ADS-B Target State Report (per §2.2.8.3) AND Reserved for ADS-B Trajectory Change Report(s)
C3 (Flight Following)	Not Specified in this MOPS	• Aid to Visual Acquisition • Separation Assurance and Sequencing • Airport Surface	SV MS OC	ADS-B State Vector Report (per §2.2.8.1) AND ADS-B Mode Status Report (per §2.2.8.2) AND ADS-B Target State Report (per §2.2.8.3) AND Reserved for ADS-B Trajectory Change Report(s)

Notes: *(Tables 2-5 and 2-6):*

1. *SV = State Vector;*
2. *MS = Mode Status;*
3. *OC = On-Condition.*

2.2 Minimum Performance Standards - Standard Conditions and Signals

2.2.1 Definition of Standard Conditions

Unless otherwise noted, the signal levels specified for transmitting devices in this subsection exist at the antenna end of a transmitter to antenna transmission line of loss equal to the maximum for which the transmitting function is designed.

Likewise, unless otherwise noted, the signal levels specified for receiving devices in this subsection exist at the antenna end of an antenna to receiver transmission line of loss equal to the maximum for which the receiving function is designed.

Note: *Transmitting or receiving equipment may be installed with less than the designed maximum transmission line loss. Nevertheless, the standard conditions of this document are based on the maximum design value. Insertion losses internal to the antenna should be included as part of the net antenna gain.*

2.2.2 ADS-B Transmitter Characteristics

2.2.2.1 Transponder Based Transmitters

a. Transmitters for Class A1, A2, and A3 systems **shall** be based on Mode S transponders with RF Peak Output Power levels as specified in §2.2.2.1.1.2, §2.2.2.1.1.3, or §2.2.2.1.1.4, respectively, for the class of equipment.

b. Transmitters for Class A0 and Class B systems may also be based on Mode S transponders with RF Peak Output Power levels as specified in §2.2.2.2.10.

c. If the ADS-B transmitter is based on Mode S transponders, then it **shall** comply with RTCA Document No. DO-181C (EUROCAE ED-73A) for each class of transponder defined in FAA TSO-C112A.

   Note: *TSO-C112A is pending. TSO-C112* ***shall*** *be used in lieu of TSO-C112A until it is superseded by TSO-C112A.*

2.2.2.1.1 RF Peak Output Power (minimum)

The minimum RF peak output power of each pulse of each transmitted message at the terminals of the antenna **shall** be as provided in the following subparagraphs for each class of equipment addressed.

2.2.2.1.1.1 Class A0 ADS-B Transponder Based Transmitter Power

The minimum RF peak output power for Class A0 ADS-B Transponder Based equipment **shall** be 18.5 dBW (70 W).

2.2.2.1.1.2 Class A1 ADS-B Transponder Based Transmitter Power

The minimum RF peak output power for Class A1 ADS-B Transponder Based equipment **shall** be 21.0 dBW (125 W).

2.2.2.1.1.3 Class A2 ADS-B Transponder Based Transmitter Power

The minimum RF peak output power for Class A2 ADS-B Transponder Based equipment **shall** be 21.0 dBW (125 W).

2.2.2.1.1.4 Class A3 ADS-B Transponder Based Transmitter Power

The minimum RF peak output power for Class A3 ADS-B Transponder Based equipment **shall** be 21.0 dBW (125 W).

Note: *Future versions of these MOPS may require that Class A3 1090 MHz ADS-B systems have a transmission capability with a minimum RF peak power of 23 dBW (200 Watts) measured at the antenna terminals. This 2 dB increase from the 21 dBW minimum RF peak power specified by this MOPS and DO-181C may be required in order to support the longer range air-to-air applications (e.g., flight path de-confliction), especially when over-flying moderate to high traffic density airspace.*

2.2.2.1.1.5 Class B ADS-B Transponder Based Transmitter Power

The minimum RF peak output power for Class B ADS-B Transponder Based equipment **shall** be 18.5 dBW (70 W).

2.2.2.1.2 RF Peak Output Power (maximum)

The maximum RF peak output power of each pulse of each transmitted message at the terminals of the antenna **shall** be fixed at 27.0 dBW (500 W) for all classes of Transponder based equipment.

2.2.2.2 Stand Alone Transmitters

Transmitters for Class A0 and Class B equipment may be implemented independent of a Mode S transponder. Such transmitters **shall** meet the requirements specified in the following subparagraphs.

Note: *A 1090 MHz non-transponder device (NTD) is intended to provide the lowest cost implementation of Extended Squitter for low-end General Aviation (GA) users. A NTD implementation does not use the 1090 MHz spectrum as efficiently nor provide all of the system benefits as a transponder implementation. For this reason, its use is restricted to class A0 operation in order to limit the number of such devices. Examples of the spectrum efficiency and system benefit issues related to NTDs are as follows:*

1. *TCAS will not be able to benefit from the ADS-B information from the NTD. TCAS will only monitor ADS-B data reported in DF=17 squitters (as emitted by a Mode S transponder). DF=18 squitters from NTDs are not monitored since TCAS must assume that it cannot interrogate the aircraft (via Mode S) to validate the range and approximate bearing via active interrogations through a process called hybrid surveillance.*

2. *Mode S interrogators will not be able to benefit from the ADS-B information from the NTD. Mode S interrogators will not be able to read Extended Squitter messages via direct air-ground readout. Such readout requires that the ADS-B data is available in the transponder registers. This will not be the case for a NTD.*

3. *More interference is generated. An aircraft equipped with a NTD and a Mode A/C transponder will generate more interference than a Mode S transponder implementation of Extended Squitter. Examples are as follows: (a) For a transponder implementation, TCAS will (after validation) maintain an aircraft on passive surveillance unless it becomes a near threat or a threat. For the NTD case, the aircraft will emit Extended Squitters and be regularly interrogated by TCAS. (b) A Mode S transponder implementation of Extended Squitter offers a surface surveillance system the possibility of controlling the squitter rate to reduce un-necessary transmissions.*

2.2.2.2.1 Transmission Frequency

The carrier frequency of ADS-B Message transmissions **shall** be 1090 $\pm$ 1 MHz.

Note: *This requirement is consistent with ICAO Annex 10, Volume IV, second edition, July 1998, §3.1.2.2.1, and RTCA Document No. DO-181C, §2.2.3.1 (EUROCAE ED-73A, §3.3.1).*

2.2.2.2.2 Transmission Spectrum

Spectrum requirements for the ADS-B transmitted message are provided in §2.2.3.1.3 and Table 2-7 of this document.

Note: *The requirements provided are consistent with requirements of ICAO Annex 10, Volume IV, second edition, July 1998, § 3.1.2.2.2 and Figure 3-5, as well as with the requirements of RTCA Document No. DO-181C (EUROCAE ED-73A).*

2.2.2.2.3 Modulation

The ADS-B transmitted message **shall** consist of a preamble and a data block. The preamble **shall** be a 4-pulse sequence and the data block **shall** be binary pulse-position modulated at a 1 megabit per second data rate.

Note: *This requirement is consistent with ICAO Annex 10, Volume IV, second edition, July 1998, §3.1.2.2.4. Requirements consistent with RTCA Document No. DO-*

181C, §2.2.4.2.1 (EUROCAE ED-73A, §3.6.1 and §3.6.2) are provided in §2.2.3.1.1 of this document.

2.2.2.2.4 Pulse Shapes

Pulse shape requirements of the ADS-B transmitted message are provided in §2.2.3.1.3 of this document.

Note: *The requirements provided are consistent with the requirements of ICAO Annex 10, Volume IV, second edition, July 1998, §3.1.2.2.4.1 and Table 3-2, as well as with the requirements of RTCA Document No. DO-181C, §2.2.4.2.3 (EUROCAE ED-73A, §3.3.2 and §3.6.4).*

2.2.2.2.5 Message Structure

Message structure requirements of the ADS-B transmitted message are provided in §2.2.3.1 and Figure 2-1 of this document.

Note: *The requirements are consistent with the requirements of ICAO Annex 10, Volume IV, second edition, July 1998, §3.1.2.2.5 and Figure 3-6, as well as with the requirements of RTCA Document No. DO-181C, §2.2.4.2 and Figure 2-3 (EUROCAE ED-73A, §3.6.1 and Figure 3-2).*

2.2.2.2.6 Pulse Intervals

Pulse interval requirements of the ADS-B transmitted message are provided in §2.2.3.1.4 of this document.

Note: *The requirements are consistent with the requirements of ICAO Annex 10, Volume IV, second edition, July 1998, §3.1.2.2.5.1, as well as with the requirements of RTCA Document No. DO-181C, §2.2.4.2.4 (EUROCAE ED-73A, §3.6.5).*

2.2.2.2.7 Preamble

Preamble requirements of the ADS-B transmitted message are provided in §2.2.3.1.1 of this document.

Note: *The requirements are consistent with the requirements of ICAO Annex 10, Volume IV, second edition, July 1998, § 3.1.2.2.5.1.1, as well as with the requirements of RTCA Document No. DO-181C, § 2.2.4.2.1 (EUROCAE ED-73A, §3.6.1).*

2.2.2.2.8 Data Pulses

Requirements for data pulses of the ADS-B transmitted message are provided in §2.2.3.1.2 of this document.

Note: *The requirements are consistent with the requirements of ICAO Annex 10, Volume IV, second edition, July 1998, §3.1.2.2.5.1.2, as well as with the requirements of RTCA Document No. DO-181C, §2.2.4.2.2 (EUROCAE ED-73A, §3.6.2).*

2.2.2.2.9 Pulse Amplitude

Pulse amplitude requirements of the ADS-B transmitted message are provided in §2.2.3.1.3 of this document.

Note: *The requirements are consistent with the requirements of ICAO Annex 10, Volume IV, second edition, July 1998, §3.1.2.2.5.2, as well as with the requirements of RTCA Document No. DO-181C, §2.2.4.2.3 (EUROCAE ED-73A, §3.3.2 and §3.6.4b).*

2.2.2.2.10 RF Peak Output Power

The RF peak output power of each pulse of each transmitted message at the terminals of the antenna **shall** be as provided in the following subparagraphs for each class of equipment addressed.

2.2.2.2.10.1 Class A0 Equipment RF Peak Output Power

The minimum RF peak output power for Class A0 equipment **shall**:

a. not be less than 18.5 dBW (70 W) for aircraft (or other installations) not capable of operating at altitudes exceeding 15,000 feet (4,570 meters);

b. not be less than 21.0 dBW (125 W) for aircraft (or other installations) capable of operating above 15,000 feet (4,570 meters);

c. not be less than 21.0 dBW (125 W) for aircraft (or other installations) with a maximum cruising speed exceeding 175 knots (324 km/h).

Note: *These requirements are consistent with the requirements of ICAO Annex 10, Volume IV, second edition, July 1998, §3.1.2.10.2, as well as with the requirements of RTCA Document No. DO-181C, §2.2.3.2 (EUROCAE ED-73A, §3.3.3).*

2.2.2.2.10.2 Class B Equipment RF Peak Output Power

The minimum RF peak output power for Class B equipment **shall**:

a. not be less than 18.5 dBW (70 W) for aircraft (or other installations) not capable of operating at altitudes exceeding 15,000 feet (4,570 meters);

b. not be less than 21.0 dBW (125 W) for aircraft (or other installations) capable of operating above 15,000 feet (4,570 meters);

c. not be less than 21.0 dBW (125 W) for aircraft (or other installations) with a maximum cruising speed exceeding 175 knots (324 km/h).

<u>***Note:***</u> *These requirements are consistent with the requirements of ICAO Annex 10, Volume IV, second edition, July 1998, §3.1.2.10.2, as well as with the requirements of RTCA Document No. DO-181C, §2.2.3.2 (EUROCAE ED-73A, §3.3.3).*

2.2.2.2.10.3 RF Peak Output Power (maximum)

The maximum RF peak output power of each pulse of each transmitted message at the terminals of the antenna **shall** be fixed at 27.0 dBW (500 W) for all classes of stand alone transmitter based equipment.

<u>***Note:***</u> *These requirements are consistent with the requirements of ICAO Annex 10, Volume IV, second edition, July 1998, §3.1.2.10.2, as well as with the requirements of RTCA Document No. DO-181C, §2.2.3.2 (EUROCAE ED-73A, §3.3.3).*

2.2.2.2.11 Unwanted Output Power

When the ADS-B transmitter is in the inactive state, the RF output power at 1090 ± 3.0 MHz at the terminals of the antenna **shall** not exceed -70 dBm.

<u>***Notes:***</u>

1. *The inactive state is defined to include the entire period between ADS-B Message transmissions less 10-microsecond transition periods, if necessary, preceding and following the extremes of the transmissions.*

2. *This unwanted power requirement is necessary to insure that the ADS-B transmitter does not prevent closely located 1090 MHz receiver equipment from meeting its requirements. It assumes that the isolation between the ADS-B transmitter antenna and the 1090 MHz receiver equipment antenna exceeds 20 dB. The resultant interference level at the 1090 MHz receiver equipment antenna should then be below -90 dBm.*

3. *This unwanted power requirement is consistent with the requirements provided in:*

a. ICAO, Annex 10, Volume 4, Second Edition, July 1998, §3.1.2.10.2.1.

b. RTCA Document No. DO-181C, §2.2.3.3 and §2.2.20.f (EUROCAE ED-73A, §3.3.4 and §3.23.f), and

c. RTCA Document No. DO-185A, §2.2.3.2.

2.2.2.2.12 Broadcast Rate Capability

The ADS-B Transmitting Subsystem must be capable of the broadcast rates specified for each message type in §2.2.3.3. These rates must be maintained along with whatever other transmit functions that the transmitting device may be required to perform.

2.2.3 Broadcast Message Characteristics

2.2.3.1 ADS-B Message Characteristics

The ADS-B Message data block is formed by Pulse Position Modulation (PPM) encoding of the message data. A pulse transmitted in the first half of the interval represents a ONE while a pulse transmitted in the second half represents a ZERO (see Figure 2-1).

Note: *These requirements are consistent with the requirements of ICAO Annex 10, Volume IV, second edition, July 1998, §3.1.2.3.1.2, as well as with the requirements of RTCA Document No. DO-181C, §2.2.4.2 (EUROCAE ED-73A, §3.6.1).*

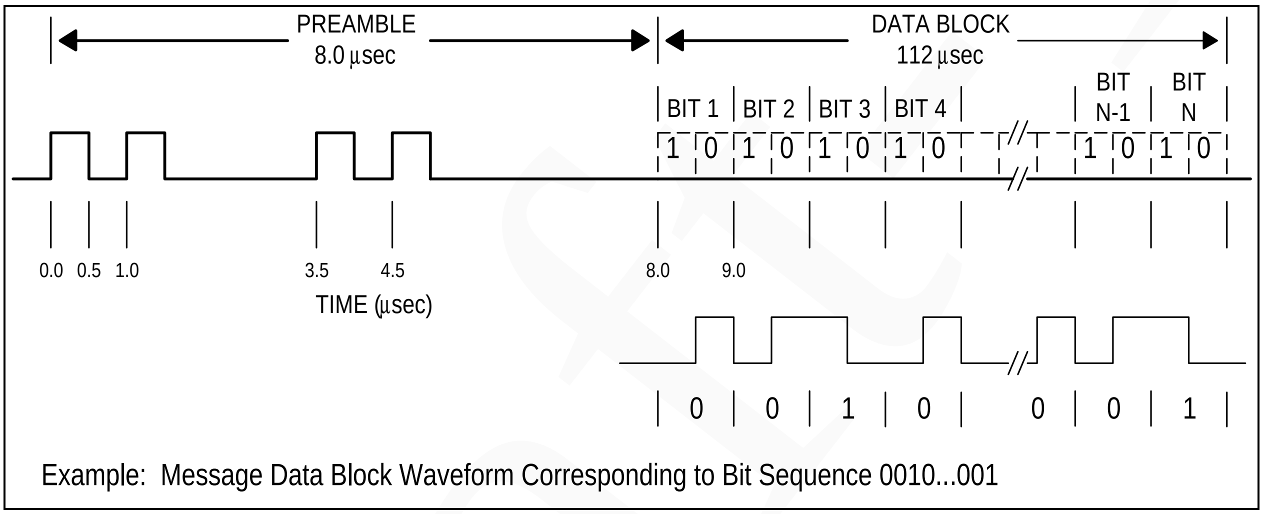


Figure 2-1: ADS-B Message Transmission Waveform

2.2.3.1.1 ADS-B Message Preamble

The preamble **shall** consist of 4 pulses, each having duration of 0.5 ± 0.05 microseconds. The second, third and fourth pulses **shall** be spaced 1.0, 3.5 and 4.5 microseconds, respectively, from the first transmitted pulse. The spacing tolerance **shall** be in accordance with §2.2.3.1.4.

Note: *These requirements are consistent with the requirements of ICAO Annex 10, Volume IV, second edition, July 1998, §3.1.2.2.4 and §3.1.2.2.5, as well as with the requirements of RTCA Document No. DO-181C, §2.2.4.2 (EUROCAE ED-73A, §3.6.1).*

2.2.3.1.2 ADS-B Message Data Pulses

The block of message data pulses **shall** begin 8.0 microseconds after the first transmitted pulse. 112 one-microsecond intervals **shall** be assigned to each ADS-B Message transmission. A pulse with a width of 0.5 ± 0.05 microseconds **shall** be transmitted either in the first or the second half of each interval. If a pulse transmitted in the second half of one interval is followed by another pulse transmitted in the first half of the next interval, the two pulses **shall** merge and a 1.0 ± 0.05 microsecond pulse **shall** be transmitted.

Note: *These requirements are consistent with the requirements of ICAO Annex 10, Volume IV, second edition, July 1998, §3.1.2.2.5.1.2, as well as with the requirements of RTCA Document No. DO-181C, §2.2.4.2.2 (EUROCAE ED-73A, §3.6.2).*

2.2.3.1.3 ADS-B Message Pulse Shape

a. The pulse amplitude variation between one pulse and any other pulse in a message transmission **shall** not exceed 2 dB.

b. The pulse rise time **shall** not be less than 0.05 microseconds or greater than 0.1 microsecond.

c. The pulse decay time **shall** not be less than 0.05 microseconds or greater than 0.2 microseconds.

d. The spectrum of the message transmission **shall** not exceed the bounds in Table 2-7:

Table 2-7: ADS-B Transmission Message Spectrum

Frequency Difference (MHz from 1090 MHz)	**Maximum Relative Response** (dB Down From Peak)
> 1.3 and ≤ 7	3
> 7 and ≤ 23	20
> 23 and ≤ 78	40
> 78	60

Note: *These requirements are consistent with the requirements of ICAO Annex 10, Volume IV, second edition, July 1998, §3.1.2.2, Table 3-2, and Figure 3-5, as well as with the requirements of RTCA Document No. DO-181C, §2.2.4.2.2 (EUROCAE ED-73A, §3.6.4).*

2.2.3.1.4 ADS-B Message Pulse Spacing

ADS-B Message transmission pulses **shall** start at a defined multiple of 0.5 microsecond from the first transmitted pulse. The pulse position tolerance **shall** be ± 0.05 microseconds, measured from the first pulse of the transmission.

Note: *These requirements are consistent with the requirements of ICAO Annex 10, Volume IV, second edition, July 1998, §3.1.2.2.5.1, as well as with the requirements of RTCA Document No. DO-181C, §2.2.4.2.4 (EUROCAE ED-73A, §3.6.5).*

2.2.3.2 ADS-B Message Format Structure

Formats for the ADS-B Messages are defined in detail in the following subparagraphs. Additional format information is provided in Appendix A of this document. Descriptive material relative to message formats is provided in Appendix A of this document.

2.2.3.2.1 ADS-B Message Baseline Format Structure

The baseline format structure to be used for ADS-B Message transmissions is provided in Figure 2-2.

ADS-B MESSAGE BASELINE FORMAT STRUCTURES					
BIT #	1 --- 5	6 - 8	9 ---------------32	33 --88	89 ----------- 112
DF=17 FIELD NAME	DF [5]	CA [3]	AA [24]	ME [56]	PI [24]
	MSB LSB	MSB LSB	MSB LSB	MSB LSB	MSB LSB
DF=18 FIELD NAME	DF [5]	CF [3]	AA [24]	ME [56]	PI [24]
	MSB LSB	MSB LSB	MSB LSB	MSB LSB	MSB LSB
DF=19 FIELD NAME	DF [5]	AF[4] [3]	AA [24]	ME [56]	PI [24]
	MSB LSB	MSB LSB	MSB LSB	MSB LSB	MSB LSB
DF=19 FIELD NAME	DF [5]	AF[4] [3]	9 --------------- RESERVED FOR MILITARY APPLICATIONS-----------------112 [104]		
	MSB LSB	MSB LSB	MSB LSB		

Notes:

1. *"[#]" provided in the Field indicates the number of bits in the field.*
2. *"CA" field shown above is used in DF=17 messages, while "CF" is used for DF=18 messages.*
3. *DF=19 mesages are intended for Military Application systems only.*
4. *For DF=19, if the AF field is equal to 000 then bits 9-32 shall be used for the AA field, bits 33-88 shall be used for the ME field, and bits 89-112 shall be used for the PI field. If the AF field is equal to 001 - 111 then bits 9 - 112 shall be used for the "RESERVED FOR MILITARY APPLICATIONS" field (Note: this format is reserved for military use only.*

Figure 2-2: ADS-B Message Baseline Format Structure

2.2.3.2.1.1 ADS-B Message Baseline Field Descriptions

Baseline fields used in ADS-B Message transmissions are described in alphabetical order in the following subparagraphs.

2.2.3.2.1.1.1 "AA" Address Field, Announced

The "AA" field is a 24-bit (bits 9 through 32) field that **shall** contain the ICAO 24-bit Address of the transmitting installation in the clear. This provides unambiguous identification of the transmitting installation.

<u>Note 1:</u> *These requirements are consistent with the requirements of ICAO Annex 10, Volume IV, second edition, July 1998, §3.1.2.5.2.2.2, as well as with the requirements of RTCA Document No. DO-181C, §2.2.14.4.1 (EUROCAE ED-73A, §3.18.4.1).*

The ADS-B transmitter **shall** declare a transmitter failure in the event that its own ICAO 24-bit Address is all "ZEROs" or all "ONEs."

<u>Note 2:</u> *This requirement is consistent with the requirements of RTCA Document No. DO-181C, §2.2.10.3.*

2.2.3.2.1.1.2 "CA" Capability Field (used in DF=17)

a. <u>Definition:</u> **--** The "CA" field is a 3-bit (bits 6 through 8) field used to report the capability of the transponder based transmitting installation. For the most part, the "CA" field is used to report the capability of a transponder and is used in Mode-S downlink format DF=11, i.e., the Mode-S All Call reply and short squitter. Therefore, the codes used in the "CA" field are defined in Table 2-8:

<u>Table 2-8:</u> "CA" Field Code Definitions

Coding	Meaning
0	Signifies no communications capability (surveillance only, no ability to set code 7, either on the ground or airborne
1	NOT USED
2	NOT USED
3	NOT USED
4	Signifies at least Comm-A and Comm-B capability, ability to set code 7, on the ground
5	Signifies at least Comm-A and Comm-B capability, ability to set code 7, airborne
6	Signifies at least Comm-A and Comm-B capability, ability to set code 7, either on the ground or airborne
7	Signifies "DR" field is NOT equal to zero, or "FS" field equals 2, 3, 4, 5, either on the ground or airborne.

When the conditions for Code 7 are not satisfied, installations that have communications capability but do not have automatic means to set on-the-ground condition **shall** use Code 6. Aircraft with automatic on-the-ground determination **shall** use "CA" codes 4 and 5. Data Link capability reports (RTCA Document No. DO-

181C, §2.2.17.1.12.5) (EUROCAE ED-73A, §3.21.1.12.e) **shall** be available for "CA" codes 4, 5, 6 and 7.

Notes:

1. *"CA" codes 1 to 3 were used by earlier Mode S transponders that did not use "CA" code 7.*

2. *These requirements are consistent with the requirements of ICAO Annex 10, Volume IV, second edition, July 1998, §3.1.2.5.2.2.1, as well as with the requirements of RTCA Document No. DO-181C, §2.2.14.4.5 (EUROCAE ED-73A, §3.18.4.5).*

b. Transponder Use -- The "CA" code definitions provided herein are intended for use when implemented with the Mode-S Transponder functions.

c. Air/Ground Broadcast Format Selection:

(1). If there is a means to automatically determine the vertical status of the ADS-B emitter category (as defined in §2.2.3.2.1.1.2.d), then such information **shall** be used to determine whether to report the Airborne Position Message (see §2.2.3.2.3) or the Surface Position Message (see §2.2.3.2.4).

(2). If there is no means to automatically determine the vertical status of the ADS-B emitter category, then the Airborne Position Message (see §2.2.3.2.3) **shall** be broadcast except under the conditions given for each of the ADS-B emitter category types given in Table 2-9A. If the conditions given in Table 2-9A are met for the given ADS-B emitter category, then the Surface Position Message (see §2.2.3.2.4) **shall** be broadcast.

Table 2-9A: Determination Of Surface Position Message Broadcast when there is no means to automatically determine vertical status

ADS-B Emitter Category Set "A"						
Coding	**Meaning**	**Ground Speed**		**Airspeed**		**Radio Altitude**
0	No ADS-B Emitter Category Information	Always report Airborne Position Message (see §2.2.3.2.3)				
1	Light (<15,500 lbs.)	Always report Airborne Position Message (see §2.2.3.2.3)				
2	Small (15,500 to 75,000 lbs.)	< 100 knots	***or***	< 100 knots	***or***	< 50 feet
3	Large (75,000 to 300,000 lbs.)	< 100 knots	***or***	< 100 knots	***or***	< 50 feet
4	High-Vortex Large (aircraft such as B-757)	< 100 knots	***or***	< 100 knots	***or***	< 50 feet
5	Heavy (> 300,000 lbs.)	< 100 knots	***or***	< 100 knots	***or***	< 50 feet
6	High Performance (> 5g acceleration and >400 knots)	< 100 knots	***or***	< 100 knots	***or***	< 50 feet
7	Rotorcraft	Always report Airborne Position Message (see §2.2.3.2.3) (See Note 1)				
ADS-B Emitter Category Set "B"						
Coding	**Meaning**	**Ground Speed**		**Airspeed**		**Radio Altitude**
0	No ADS-B Emitter Category Information	Always report Airborne Position Message (see §2.2.3.2.3)				
1	Glider / Sailplane	Always report Airborne Position Message (see §2.2.3.2.3)				
2	Lighter - than- Air	Always report Airborne Position Message (see §2.2.3.2.3) (See Note 2)				
3	Parachutist / Skydiver	Always report Airborne Position Message (see §2.2.3.2.3)				
4	Ultralight / hang-glider / paraglider	Always report Airborne Position Message (see §2.2.3.2.3)				
5	Reserved	Reserved				
6	Unmanned Aerial Vehicle	Always report Airborne Position Message (see §2.2.3.2.3)				
7	Space / Trans - Atmospheric vehicle	< 100 knots	***or***	< 100 knots	***or***	< 50 feet
ADS-B Emitter Category Set "C"						
Coding	**Meaning**					
0	No ADS-B Emitter Category Information	Always report Airborne Position Message (see §2.2.3.2.3)				
1	Surface Vehicle - Emergency Vehicle	Always report Surface Position Message (see §2.2.3.2.4)				
2	Surface Vehicle - Service Vehicle	Always report Surface Position Message (see §2.2.3.2.4)				
3	Fixed Ground or Tethered Obstruction	Always report Airborne Position Message (see §2.2.3.2.3) (See Note 3)				
4 - 7	Reserved	Reserved				
ADS-B Emitter Category Set "D"						
Coding	**Meaning**					
0	No ADS-B Emitter Category Information	Always report Airborne Position Message (see §2.2.3.2.3)				
1 - 7	Reserved	Reserved				

Notes:

1. *Because of the unique operating capabilities of rotorcraft, i.e., hover, etc., an operational rotorcraft* ***shall*** *always report the "Airborne" state unless the "Ground" state is specifically declared in compliance with subparagraph "c.(1)" above.*

2. *Because of the unique operating capabilities of "Lighter-than-Air" vehicles, i.e., balloons, and operational "Lighter-than-Air" vehicle **shall** always report the "Airborne" State unless the "Ground" state is specifically declared in compliance with subparagraph "c.(1)" above.*

3. *Because of the fact that it is important for fixed ground or tethered obstructions to report altitude, such objects **shall** always report the "Airborne" State.*

d. <u>Validation of Ground Status:</u>

<u>Note:</u> *For aircraft with an automatic means of determining vertical status (i.e., weight-on-wheels, strut switch, etc.) the "CA" field reports whether the aircraft is airborne or on the ground. TCAS acquires aircraft using the short or long squitters, both of which contain the "CA" field. If an aircraft reports that it is on the ground, that aircraft will not be interrogated by TCAS in order to reduce unnecessary interrogation activity. The 1090 MHz ADS-B Message formatter may have information available to validate that an aircraft reporting "on-the-ground" is actually on the surface.*

If the automatically determined Air/Ground status is not available or indicates that the Airborne Position Message (see §2.2.3.2.3) **shall** be broadcast, then the Airborne Position Message **shall** be broadcast in accordance with subparagraph c.

If one of the conditions in Table 2-9B is satisfied, the Air/Ground status **shall** be changed to "Airborne" and the Airborne Position Message (see §2.2.3.2.3) **shall** be broadcast irrespective of the automatically determined Air/Ground status.

<u>Table 2-9B:</u> Validation Of "ON-GROUND" Status

AIRBORNE POSITION MESSAGE BROADCAST						
ADS-B Emitter Category Set "A"						
Coding	**Meaning**	**Ground Speed**		**Airspeed**		**Radio Altitude**
0	No ADS-B Emitter Category Information	No Change to "On-the-Ground" status				
1	Light (<15,500 lbs.)	No Change to "On-the-Ground" status				
2	Small (15,500 to 75,000 lbs.)	> 100 knots	***or***	> 100 knots	***or***	> 50 feet
3	Large (75,000 to 300,000 lbs.)	> 100 knots	***or***	> 100 knots	***or***	> 50 feet
4	High-Vortex Large (aircraft such as B-757)	> 100 knots	***or***	> 100 knots	***or***	> 50 feet
5	Heavy (> 300,000 lbs.)	> 100 knots	***or***	> 100 knots	***or***	> 50 feet
6	High Performance (> 5g acceleration and >400 knots)	> 100 knots	***or***	> 100 knots	***or***	> 50 feet
7	Rotorcraft	No Change to "On-the-Ground" status				

2.2.3.2.1.1.3 "CF" and "AF", (used in DF=18 and DF=19)

The "CF" field of DF=18 messages is a 3-bit field (bits 6 through 8) used by Non-Transponder based installations. The "AF" ("Application Field") field of DF=19 messages is a 3-bit field (bits 6 through 8) used by all ADS-B Message transmissions from transmission devices that are Military Application based systems. Coding of the "CF" and "AF" field is specified in Table 2-10. Refer to §2.2.3.2.1.1.2 for determining On Ground Status.

Table 2-10: "CF" and "AF" Field Code Definitions

Coding	DF=18 Meaning "CF" Field	DF=19 Meaning "AF" Field
0	ADS-B	ADS-B Message Structure
1 - 7	Reserved	Reserved for future Military Applications

2.2.3.2.1.1.4 "DF" Downlink Format Field

a. The "DF" field is the first field in all downlink formats and provides the transmission descriptor coded in accordance with RTCA Document DO-181C, Figure 2-5 (EUROCAE ED-73A, Figure 3-4).

b. The "DF" field **shall** be set to DF=17 (1 0001 binary) for all ADS-B Message transmission devices that are Mode-S transponder based systems.

c. The "DF" field **shall** be set to DF=18 (1 0010 binary) for all ADS-B Message transmissions from transmission devices that are not Mode-S transponder based systems.

d. The "DF" field **shall** be set to DF=19 (1 0011 binary) for all ADS-B Message transmissions from transmission devices that are Military Application based systems.

Note: *Encoding of the "DF" field is consistent with §3.1.2.3.2 and Figure 3-8 in ICAO ANNEX 10, Volume IV, Second Edition, July 1998.*

2.2.3.2.1.1.5 "ME" Message, Extended Squitter

The "ME" field is a 56-bit (bits 33 through 88) downlink field used to transmit extended squitter Automatic Dependent Surveillance - Broadcast (ADS-B) and Aircraft Identification messages in DF = 17, DF = 18 and DF = 19 messages.

2.2.3.2.1.1.6 "PI" Parity / Identity

The "PI" field is a 24-bit (bits 89 through 112) downlink field that contains the parity overlaid on the Code Label ("CL") and Interrogator Code ("IC") fields, in accordance with §2.2.14.4.22 and §2.2.16.2.1 of RTCA Document DO-181C (EUROCAE ED-73A, §3.18.4.27 and §3.20.2.1).

Note: *In ADS-B Messages (those transmitted with downlink format DF=17 or DF=18) both the "CL" = 0 and "IC" = 0. In other words, in ADS-B Messages, the parity is overlaid with a 24-bit pattern of ALL ZEROs.*

2.2.3.2.2 DF=17 and 18 Format Structures

All DF=17 and 18 ADS-B transmissions have the baseline structure defined in §2.2.3.2.1. The "ME" field is defined for each of the ADS-B Message types in the following subparagraphs.

2.2.3.2.3 ADS-B Airborne Position Messages

Format for the Airborne Position Message "ME" field contents is defined in Figure 2-3. Each of the subfields is defined in the following subparagraphs.

AIRBORNE POSITION MESSAGE "ME" FIELD									
MSG BIT #	33--37	38 --------------- 39	40	41 ------ 52	53	54	55 --------- 71	72 --------- 88
"ME" BIT #	1 --- 5	6 ----------------- 7	8	9 ------- 20	21	22	23 --------- 39	40 --------- 56
FIELD NAME	TYPE [5]	SURVEILLANCE STATUS [2]	SINGLE ANTENNA [1]	ALTITUDE [12]	TIME (T) [1]	CPR FORMAT (F) [1]	ENCODED LATITUDE [17]	ENCODED LONGITUDE [17]
	MSB LSB	MSB LSB	MSB LSB	MSB LSB			MSB LSB	MSB LSB

Note: *"[#]" provided in the Field indicates the number of bits in the field.*

Figure 2-3: ADS-B Airborne Position Message Format

2.2.3.2.3.1 "TYPE" Subfield in ADS-B Airborne Position Messages

The "TYPE" subfield is a 5-bit ("ME" bits 1 through 5, Message bits 33 through 37) field that is used to identify the ADS-B Message and to differentiate the messages several message types.

1. Airborne Position Message (§2.2.3.2.3)
2. Surface Position Message (§2.2.3.2.4)
3. Aircraft Identification (ID) and Type Message (§2.2.3.2.5)
4. Airborne Velocity Message (§2.2.3.2.6)
5. Airborne Trajectory Intent and System Status Message (§2.2.3.2.7.1)
6. Aircraft Operational Status Message (§2.2.3.2.7.2)
7. Aircraft Status Message (Type=28) (§2.2.3.2.7.8)

In the case of Airborne Position Messages (§2.2.3.2.3), the Message TYPE subfield also encodes the Navigation Integrity Category (NIC, §***TBD***) and the altitude type (barometric pressure altitude, §***TBD***, or geometric altitude, §***TBD***). For Surface Position Messages (§2.2.3.2.4), the TYPE subfield encodes NIC – but not altitude type, since altitude is not reported in Surface Position Messages.

Detailed definition of the “TYPE” subfield encodings that **shall** be used for all ADS-B Messages are provided in Table 2-11.

The ADS-B Airborne Position Messages **shall** use only “TYPE” codes 0, 9 through 18 and codes 20 through 22 as indicated in Table 2-11.

Table 2-11: **"TYPE" Subfield Code Definitions (DF = 17 or 18)**

Type Code	Format (Message Type)	Horizontal Containment Limit (R_C) and Navigation Integrity Category (NIC)	Altitude Type	Notes
0	No Position Information (**Airborne Position Message** or **Surface Position Message**)	R_C unknown NIC = 0	Baro Altitude *or* No Altitude Information	1, 2, 3
1	**Aircraft Identification and Type Message** (§2.2.3.2.5)	*Not Applicable*	*Not Applicable*	Category Set D
2		*Not Applicable*	*Not Applicable*	Category Set C
3		*Not Applicable*	*Not Applicable*	Category Set B
4		*Not Applicable*	*Not Applicable*	Category Set A
5	**Surface Position Message** (§2.2.3.2.4)	R_C < 7.5 m NIC = 11	No Altitude Information	
6		R_C < 75 m NIC = 9 or 10		6
7		R_C < 0.1 NM (185.2 m) NIC = 8		
8		R_C = 0.1 NM (185.2 m) or unknown NIC = 0		
9	**Airborne Position Message** (§2.2.3.2.3)	R_C < 7.5 m *and* VPL < 11 m NIC = 11	Baro Altitude	5
10		R_C < 75 m *and* VPL < 112 m NIC = 9 or 10		5, 6
11		R_C < 0.1 NM (185.2 m) NIC = 8		
12		R_C < 0.2 NM (370.4 m) NIC = 7		
13		R_C < 0.6 NM (1111.2 m) NIC = 6		
14		R_C < 1.0 NM (1852 m) NIC = 5		
15		R_C < 2 NM (3.704 km) NIC = 4		
16		R_C < 8 NM (14.816 km) NIC = 2 or 3		7
17		R_C < 20 NM (37.04 km) NIC = 1		
18		R_C = 20 NM (37.04 km) or unknown NIC = 0		
19	**Airborne Velocity Message** (§2.2.3.2.6)	*Not Applicable*	*Difference between "Baro Altitude" and "GNSS Height (HAE)"*	
20	**Airborne Position Message** (§2.2.3.2.3)	R_C < 7.5 m *and* VPL < 11 m NIC = 11	GNSS Height (HAE)	2, 5
21		R_C < 25 m *and* VPL < 37.5 m NIC = 10		2, 5
22		R_C = 25 m *or* VPL = 37.5 m *or* R_C or VPL unknown NIC = 0		2
23	**Reserved for Test Purposes (§2.2.3.2.7.4)**			
24	**Reserved for Surface System Status (§2.2.3.2.7.5)**			
25 - 27	**Reserved (§2.2.3.2.7.6 to §2.2.3.2.7.8)**			
28	**Aircraft Status Message (§2.2.3.2.7.9)**			
29	**Aircraft Trajectory Intent Message (§2.2.3.2.7.1)**			
30	**Aircraft Operational Coordination Message** (§2.2.3.2.7.2)			
31	**Aircraft Operational Status Message** (§2.2.3.2.7.4)			

Notes for Table 2-11:

1. *"Baro Altitude" means barometric pressure altitude, relative to a standard pressure of 1013.25 millibars (29.92 in.Hg.). It does* **not** *mean baro corrected altitude.*

2. *Type codes 20 to 22 or Type Code 0 are to be used when valid "Baro Altitude" is not available.*

3. *After initialization, when horizontal position information is not available but altitude information is available, the Airborne Position Message is transmitted with a type code of zero in bits 1-5, the barometric pressure altitude in bits 9 to 20, and bits 22 to 56 set to zero. If neither horizontal position nor barometric altitude information is available, then all 56 bits of register 0,5 are set to zero. The zero type code field indicates that latitude and longitude information is not available, while the zero altitude field indicates that altitude information is not available. (See Appendix A).*

4. *If the position source is an ARINC 743A GNSS receiver, then the ARINC 429 data "label 130" data word from that receiver is a suitable source of information for R_C, the horizontal integrity containment radius. (The label 130 data word is variously called HPL (Horizontal Protection Limit) or HIL (Autonomous Horizontal Integrity Limit) in different documents.*

5. *This TYPE code value implies limits for both R_C (horizontal containment limit) and VPL (Vertical Protection Limit). If* <u>*either*</u> *of these limits is not satisfied, then a different value for the TYPE code should be selected.*

6 *The "NIC supplement" field in the Aircraft Operational Status message (§2.2.3.2.7.3.6) enables the report assembly function in ADS-B receiving equipment to determine whether the transmitting ADS-B subsystem is announcing NIC = 9 (R_C < 75 m and VPL < 112 m) or NIC = 10 (R_C < 25 m and VPL < 37.5 m).*

7 *The "NIC supplement" field in the Aircraft Operational Status message (§2.2.3.2.7.3.6) enables the report assembly function in ADS-B receiving equipment to determine whether the transmitting ADS-B subsystem is announcing NIC = 2 (R_C < 8 NM) or NIC = 3 (R_C < 4 NM).*

2.2.3.2.3.1.1 Airborne Position Message Type Code if Containment Radius is Available

Note: *If the position information comes from a GNSS receiver that conforms to the ARINC 743A characteristic, a suitable source of information for the containment radius (R_C), is ARINC 429 label 130 from that GNSS receiver.*

If R_C (containment radius) information is available from the navigation data source, then the transmitting ADS-B subsystem **shall** determine the Type Code (the value of the TYPE subfield) of Airborne Position Messages as follows.

a. If current valid horizontal position information is not available to the ADS-B transmitting subsystem, then the TYPE subfield of Airborne Position Messages **shall** be set to ZERO (0) as described in §2.2.3.2.3.1.3.2 below.

b. If valid horizontal position and barometric pressure altitude information are both available to the ADS-B transmitting subsystem, then the ADS-B transmitting subsystem **shall** set the TYPE subfield of Airborne Position Messages to a value in the range from 9 to 18 in accordance with Table 2-11.

c. If valid horizontal position information is available to the ADS-B transmitting subsystem, but valid barometric pressure altitude information is ***not*** available, and valid geometric altitude information ***is*** available, the ADS-B transmitting subsystem **shall** set the TYPE subfield of Airborne Position Messages to a value in the range from 20 to 22 depending on the containment radius R_C and vertical protection limit VPL in accordance with Table 2-11.

d. If valid horizontal position information is available to the ADS-B transmitting subsystem, but neither valid barometric altitude information nor valid geometric altitude information is available, the ADS-B transmitting subsystem **shall** set the TYPE subfield in Airborne Position Messages to a value in the range from 9 to 18 depending on the containment radius R_C in accordance with Table 2-11. (In that case, the ALTITUDE subfield of the Airborne Position Messages would be set to all ZEROs in accordance with §2.2.3.2.3.4.3 below, in order to indicate that valid altitude information is ***not*** available.)

2.2.3.2.3.1.2 Airborne Position MessageType Code if Containement Radius is Not Available

If R_C (containment radius) information is NOT available from the navigation data source, then the ADS-B transmitting subsystem **shall** indicate NIC = 0 by selecting a Type Code of 0, 18, or 22 in the Airborne Position Messages, as follows:

a. The ADS-B transmitting subsystem **shall** set the TYPE subfield to ZERO (0) if valid horizontal position information is ***not*** available, as described in §2.2.3.2.3.1.3.2 below.

b. The ADS-B transmitting subsystem **shall** set the TYPE subfield to 18 if valid pressure altitude information is available, or if neither valid pressure altitude nor valid geometric altitude information is available.

If valid pressure altitude is not available, but valid geometric altitude information is available, the ADS-B transmitting subsystem **shall** set the TYPE subfield to 22.

2.2.3.2.3.1.3 Special Processing for Type Code ZERO

2.2.3.2.3.1.3.1 Significance of Type Code Equal to ZERO

As shown in Table 2-11, Type Code equal to ZERO (0) is labeled "No Position Information." This type of message is intended to be used when horizontal position information is not available or is invalid, and still permit the reporting of barometric altitude, when it is available and valid. As such, the principal use of this message case is to provide TCAS the ability to passively receive altitude information.

Airborne position messages may be transmitted with a Type Code of "0" under the following condition:

An Airborne Position Message with a Type Code of "0" **shall** set all 56 bits of the "ME" field bits to ZERO (0) if NO barometric pressure Altitude data is available. If valid pressure Altitude data is available, then the "Altitude" subfield, "ME" bits 9 - 20, Message bits 41 - 52, **shall** report the altitude in accordance with §2.2.3.2.3.4.3.

Note: *Special processing is required for Airborne Position Messages because a CPR encoded value of all ZEROs in the latitude and longitude field is considered to be a valid encoding.*

2.2.3.2.3.1.3.2 Broadcast of Type Code Equal to ZERO

The Type Code Equal to ZERO message may be required as a consequence of the following events:

a. An ADS-B Airborne Position or Surface Position Message register has not been loaded with data in the last 2 seconds. In this case, the ADS-B Message register **shall** be cleared (i.e., all 56 bits set to ZERO) once it has timed out. Transmission of the ADS-B Message that broadcasts the contents of the register **shall** be terminated if the ADS-B Message register has not been loaded in 60 seconds. Broadcast of the ADS-B Airborne Position or Surface Position Message **shall** resume once data has been loaded into the ADS-B Message register.

b. The data management function responsible for loading the ADS-B Message registers determines that all navigation sources that can be used for the airborne or surface position message are either missing or invalid. In this case the data management function **shall** clear (set all data fields to all ZEROs) the Type Code and all other fields of the airborne or surface position message and insert the ZEROed message into the appropriate ADS-B Message register. This should only be done once in support of the detection of the loss of data insertion and **shall** result in the suppression of the broadcast of the related ADS-B Message.

c. Note that in all of the cases discussed above, a Type Code of ZERO infers a message of all ZEROs. The only exception is that the airborne position message format **shall** contain barometric altitude code as set by the transponder when so implemented. There is no analogous case for the other extended squitter message types, since a ZERO value in any of the fields indicates that no valid information is available.

2.2.3.2.3.1.4 Type Code based on Horizontal Position and Altitude Data

a. If valid horizontal position information is available, and valid pressure altitude information is available, then the "TYPE" code in the Airborne Position Message **shall** be set in the range from "9" to "18."

b. If valid horizontal position information is available, valid pressure altitude is NOT available, and GNSS Height Above the Ellipsoid (HAE) data is available, then the "TYPE" code in the Airborne Position Message **shall** be set in the range from "20" to "22."

c. If valid horizontal position information is available, but neither valid pressure altitude information nor valid GNSS Height Above Ellipsoid (HAE) information is available, then the "TYPE code in the airborne position message **shall** be set in the range from "9" to "18."

d. In all three cases, "a," "b," and "c" the "TYPE" coding **shall** be selected in accordance with the Containment Radius (R_C) given in Table 2-11.

   Alternatively, the "TYPE" coding may be selected in accordance with the Horizontal Protection Limits (HPL) given in Table 2-11.

2.2.3.2.3.2 "SURVEILLANCE STATUS" Subfield in ADS-B Airborne Position Messages

The "SURVEILLANCE STATUS " subfield is a 2-bit ("ME" bits 6 and 7, Message bits 38 and 39) field used to encode information from the aircraft's Mode-A transponder code as provided in Table 2-12.

Table 2-12: "SURVEILLANCE STATUS" Subfield Code Definitions

Coding	Meaning
0	No Condition Information
1	Permanent Alert Condition (Emergency)
2	Temporary Alert Condition (change in Mode-A Identity Code other than emergency condition)
3	Special Position Identification (SPI) Condition

Note: *Codes 1 and 2 take precedence over code 3.*

The setting of the Surveillance Status is a transponder function and is appropriately defined in RTCA Document No. DO-181C, §2.2.16.2.7 (EUROCAE ED-73A, §3.21.2.6.8).

When not implemented in a Mode-S Transponder based system, the ADS-B function **shall** set the Surveillance Status to ZERO.

2.2.3.2.3.3 "SINGLE ANTENNA" Subfield in ADS-B Airborne Position Messages

The "SINGLE ANTENNA" subfield is a 1-bit ("ME" bit 8, Message bit 40) field used to indicate that the ADS-B transmitting function is operating with a single antenna. The following conventions **shall** apply both to Transponder Based and Stand Alone ADS-B Transmitting functions:

a. Non-Diversity, i.e., those transmitting functions that use only one antenna, **shall** set the Single Antenna subfield to "ONE" at all times.

b. Diversity, i.e., those transmitting functions designed to use two antennas, **shall** set the Single Antenna subfield to "ZERO" at all times that both antenna channels are functional.

At any time that the diversity configuration cannot guarantee that both antenna channels are functional, then the Single Antenna subfield **shall** be set to "ONE."

Note: *Certain applications may require confirmation that each participant has functioning antenna diversity for providing adequate surveillance coverage.*

2.2.3.2.3.4 "ALTITUDE" Subfield in ADS-B Airborne Position Messages

The "ALTITUDE" subfield is a 12-bit ("ME" bit 9 through 20, Message bit 41 through 52) field that **shall** contain the altitude of the ADS-B transmission device as provided in the following subparagraphs.

2.2.3.2.3.4.1 "BAROMETRIC ALTITUDE" in ADS-B Airborne Position Messages

Barometric Pressure Altitude relative to a standard pressure of 1013.25 millibars (29.92 in.Hg.) **shall** be reported in the "Altitude" Subfield of Airborne Position Messages having "Type" codes 9 through 18 (see §2.2.3.2.3.1 and Table 2-11) under the following condition:

Barometric Pressure Altitude is selected for reporting via a control selection process and such Barometric Pressure Altitude data is valid.

Note: *"Barometric Pressure Altitude" specifically **DOES NOT** refer to "Barometric Corrected Altitude."*

Encoding of the Barometric Pressure Altitude data into the "Altitude" subfield **shall** be in accordance with §2.2.3.2.3.4.3.

2.2.3.2.3.4.2 "GNSS Height Above the Ellipsoid (HAE)" in ADS-B Airborne Position Messages

GNSS Height Above the Ellipsoid (HAE) **shall** be reported in the "Altitude" Subfield of the Airborne Position Message having "Type" codes 20 through 22 (see §2.2.3.2.3.1 and Table 2-11) under the following condition:

GNSS Height Above the Ellipsoid (HAE) is selected for reporting via a control selection process and such GNSS Height Above the Ellipsoid (HAE) data is valid.

Encoding of the GNSS Height Above the Ellipsoid (HAE) data into the "Altitude" subfield **shall** be in accordance with §2.2.3.2.3.4.3.

Note: *GNSS height may be useful for integrity checking of altitude and in future ATC concepts.*

2.2.3.2.3.4.3 "ALTITUDE ENCODING" in ADS-B Airborne Position Messages

Altitude data **shall** be encoded into the "Altitude" subfield as follows:

a. Bit 16 (i.e., Message bit 48) **shall** be designated as the **Q** bit. **Q** equals ZERO **shall** be used to indicate that the altitude is reported in 100 foot increments as defined in paragraph b. below. **Q** equals ONE **shall** be used to indicate that the altitude is reported in 25 foot increments as defined in paragraph c. below.

b. If **Q** is equal to ZERO, then the altitude **shall** be coded in 100 foot increments by selection of pulses in accordance with ICAO ANNEX 10, Volume IV, second edition, July 1998, Appendix 1 to Chapter 3, (see RTCA Document No. DO-181C, §2.2.13.1.2.a.(2).(c)) (EUROCAE ED-73A, §3.17.1.a and 3.18.4.2). The appropriate mapping for the sequence of pulses **shall** be as shown in Figure 2-4.

ALTITUDE SUBFIELD ENCODING FOR "Q" = "0"												
MSG BIT #	41	42	43	44	45	46	47	48	49	50	51	52
"ME" BIT #	9	10	11	12	13	14	15	16	17	18	19	20
CODE BIT	C1	A1	C2	A2	C4	A4	B1	"Q"	B2	D2	B4	D4

<u>Figure 2-4:</u> Altitude Subfield Encoding For "Q" = Zero

c. If **Q** is equal to ONE, then the altitude **shall** be coded such that bits 9 through 15, and 17 to 20 (Message bits 41 through 47, and 49 through 52) represent a binary - coded field whose least significant bit has a value of 25 feet. The binary value of the decimal number "N" **shall** be used to report pressure altitudes in the range (25 * N - 1000 ± 12.5 feet).

<u>Note 1:</u> *The most significant bit of this field is bit 9. This code is able to provide code values only between -1000 feet and +50,175 feet. The coding used for altitudes that are greater than 50, 175 feet* ***shall*** *conform to the coding principles described in paragraph b. above.*

d. If altitude data is not available, then all bits of the Altitude subfield **shall** be set to ZERO.

<u>Note 2:</u> *These requirements are consistent with the requirements of ICAO Annex 10, Volume IV, second edition, July 1998, §3.1.2.6.5.4, as well as with the requirements of RTCA Document No. DO-181C, §2.2.13.1.2 (EUROCAE ED-73A, §3.17.1.b).*

2.2.3.2.3.5 "TIME" (T) Subfield in ADS-B Airborne Position Messages

The "TIME" (T) subfield is a 1-bit ("ME" bit 21, Message bit 53) field which indicates whether or not the epoch of validity for the horizontal position data in an Airborne Position Message is an exact 0.2 second UTC epoch. If the time of applicability of the position data is synchronized to an exact 0.2 second UTC epoch, the "TIME" (T) subfield **shall** be set to "1"; otherwise, the "TIME" (T) subfield **shall** be set to "0."

Notes:

1. *An ADS-B Transmitting Subsystem that sets the "TIME" (T) subfield to "1" must accept a GNSS TIME MARK input from the navigation data source in order to be able to update the position data from the navigation data source to an exact 0.2 second UTC epoch (See §2.2.5.1.6).*

2. *An arithmetic description of the intended synchronization implementation is provided in the **"Commentary"** paragraphs provided in §2.2.3.2.3.7.2 for precision Latitude Position Extrapolation and in §2.2.3.2.3.8.2 for precision Longitude Position Extrapolation.*

2.2.3.2.3.6 "CPR FORMAT" (F) Subfield in ADS-B Airborne Position Messages

The "CPR Format" (F) subfield is a 1-bit ("ME" bit 22, Message bit 54) field used to indicate which Compact Position Reporting (CPR) format type ("**even**" or "**odd**") is used to encode the latitude and longitude data (See §2.2.3.2.3.7 and §2.2.3.2.3.8). The bit **shall** be set to "ZERO" to indicate the "**even**" encoding of such data, or to "ONE" to indicate the "**odd**" encoding of such data.

a. When "TIME" (T) = 0:

The "CPR Format" (F) subfield functions ONLY to indicate the "**even**" or "**odd**" CPR encoding. In this case, the CPR encoding type **shall** alternate between "**even**" and "**odd**," and the "CPR Format" (F) subfield **shall** alternate between "0" and "1" respectively, each time the Airborne Position Message register is updated with new position data.

Note: *When the "TIME" (T) subfield is "ZERO," the Airborne Position Message register must be updated at least as frequently as every 200 milliseconds: however, it may be updated more frequently, for example, every 100 milliseconds, etc. In such cases, the CPR encoding should alternate between "**even**" and "**odd**" each time that the register is updated with new position data.*

b. When "TIME" (T) = 1:

The "CPR Format" (F) subfield functions to indicate the "**even**" or "**odd**" CPR encoding and also indicates whether the epoch of applicability of the position data is an "**even**" or "**odd**" 0.2 second UTC epoch.

Notes:

1. *Although the Airborne Position Message register may be updated more frequently than five times per second, the "CPR Format" (F) subfield* ***shall*** *alternate between "0" and "1" only as the epoch of applicability of the data being loaded into the register alternates between "even" and "odd" 0.2 second UTC epochs.*

2. *An "even 0.2 second UTC epoch" is defined as that moment on the UTC time scale that occurs at an even number of 200-millisecond intervals after an exact even-numbered UTC second. Likewise, an "odd 0.2 second UTC epoch" is defined as that moment on the UTC time scale that occurs at an odd number of 200 millisecond intervals after an even numbered UTC second. Examples of even 0.2 second epochs are 12.0 seconds, 12.4 seconds, 12.8 seconds, 13.2 seconds, 13.6 seconds, etc. Examples of odd 0.2 second epochs are 12.2 seconds, 12.6 seconds, 13.0 seconds, 13.4 seconds, 13.8 seconds, etc.*

2.2.3.2.3.7 "ENCODED LATITUDE" Subfield in ADS-B Airborne Position Messages

The "ENCODED LATITUDE" subfield is a 17-bit ("ME" bit 23 through 39, Message bit 55 through 71) field containing the encoded latitude of the airborne position.

2.2.3.2.3.7.1 Airborne Latitude Data Encoding

The airborne latitude position data **shall** be encoded in accordance with §A.1.4.2.2 and §A.1.7 of Appendix A.

2.2.3.2.3.7.2 Airborne Latitude Position Extrapolation/Estimation (Precision Case, Type Codes 9, 10, 20 and 21)

The following subsections apply to Airborne Position Messages in which the TYPE Code is 9, 10, 20 and 21 (see §2.2.3.2.3.1).

2.2.3.2.3.7.2.1 GPS/GNSS Time Mark Coupled Case (Extrapolation, "TIME" (T) = "1")

If "TIME" (T) = 1 (see §2.2.3.2.3.5) in an Airborne Position Message, then the time of applicability of the latitude and longitude fields in that message **shall** be an exact 0.2 second UTC epoch.

a. Specifically, the position data in the latitude and longitude fields **shall** be extrapolated forward from the time of validity of the position fix to the time of applicability of the Airborne Position Message.

b. The Airborne latitude data registers and the encoded latitude subfield **shall** be updated every 200 milliseconds to the next 0.2 UTC Epoch using the velocity data provided for the position fix.

Notes:

1. *The time of validity of the fix is provided with the fix data from the navigation data source and is indicated by the leading edge of the GNSS Time Mark (see §2.2.5.1.6). The time of applicability of the position message is the exact 0.2 second UTC Epoch to which the position data is extrapolated.*

2. *The latitude position registers and encoded latitude subfield should be updated at a time about 100 milliseconds before the time of applicability of the data being loaded into that register (see §2.2.5.3.1 and Appendix A, §A.1.4.2.3.1).*

3. *One method of estimating the position to an exact 0.2 second UTC Epoch is described in the following "Commentary."*

COMMENTARY:

The following example provides one method (not the only method!) that latitude given in the Airborne Position Message may be extrapolated from the time of validity of the fix (included with the fix from the navigation data source) to the time of applicability of the Airborne Position Message. In the example, it is assumed that the "TIME" (T) subfield (see §2.2.3.2.3.5) is "ONE," indicating that the time of applicability of the extrapolated position is an exact 0.2 second UTC Epoch.

Let:

t_{fix}	=	*time of the leading edge of the last received GNSS Time Mark (see §2.2.5.1.6), which is also the time of validity included with the fix from the navigation data source.*
$t_{message}$	=	*time of applicability of the Airborne Position Message, which is an exact 0.2 second UTC Epoch.*
Dt	=	$t_{message} - t_{fix}$*, in milliseconds*
f_{fix}	=	*last known latitude position, at time* t_{fix}*, in degrees*
$f_{message}$	=	*latitude, extrapolated forward to the time of applicability of the Airborne Position Message,* $t_{message}$
Df	=	$f_{message} - f_{fix}$*, in degrees*
n_{NS}	=	*North / South Velocity*

The earth may be modeled as a sphere with radius such that one nautical mile equals one minute of arc along a great circle. Using that approximation, yields:

$$f_{message} = f_{fix} + Df$$

$$= f_{fix} + (n_{NS}/60)(Dt/3600000)$$

$$= f_{fix} + (n_{NS}\,Dt) / (2.16 \times 10^8)$$

(We divide n_{NS} *by 60 to convert from knots in the N-S direction to degrees of latitude per hour, and divide Dt by 3600 x 1000 to convert from milliseconds to hours.)*

The result, $f_{message}$, is to be encoded in the latitude field of the Airborne Position Message using the CPR algorithm described in Appendix A, §A.1.7.

2.2.3.2.3.7.2.2 Non-Coupled Case (Estimation, "TIME" (T) = "0")

ADS-B Airborne Position Messages with TYPE Codes of 9, 10, 20 and 21 (see §2.2.3.2.3.1) may implement estimation techniques such as alpha-beta trackers or Kalman filters to satisfy the intent of the position update requirements given in §2.2.3.2.3.7.2.1. Such techniques provide the capability to decouple the position computation from the message transmission timing provided that the sampled data rate is sufficient to satisfy minimum Nyquist criterion. Likewise such techniques may be necessary in order to provide velocity compensation and/or acceleration estimation in the future.

a. If sampled data estimation techniques, e.g., alpha-beta trackers, alpha-beta-gamma trackers, or Kalman filters, are used to periodically update position data, then the maximum sampled data time **shall** not exceed 100 milliseconds.

b. Sampled data implementations **shall** update the airborne latitude data registers and encoded latitude data subfield at intervals not to exceed 100 milliseconds

Note: *The 100 millisecond requirement is necessary in order to insure that the 200 millisecond performance required in §2.2.3.2.3.7.2.1 is not degraded.*

2.2.3.2.3.7.3 Airborne Latitude Position Extrapolation/Estimation (non - precision)

2.2.3.2.3.7.3.1 Airborne Latitude Position Extrapolation Case (non - precision)

ADS-B Airborne Position Messages with TYPE Codes other than 9, 10, 20 or 21 (see §2.2.3.2.3.1) **shall** contain an estimate of the latitude position at a time of applicability that is within 200 milliseconds of the time that the Airborne Position Message is transmitted. Essentially, the original data and the encoded latitude **shall** be updated at least as frequently as every 200 milliseconds.

COMMENTARY:

The only difference between latitude position extrapolation in the non-precision case and that of the precision case (§2.2.3.2.3.7.2.1) is the interpretation of what "Dt" means. In the non-precision case, Dt is the elapsed time from the last received position update to the expected time of transmission of an Airborne Position Message that is based on the last position update.

(In the precision case, Dt is the time interval from the last received leading edge of the GNSS Time Mark to the 0.2 second UTC Epoch which is to be the time of applicability of the Airborne Position Message).

Let:

t_{fix}	=	*time validity included with the PVT (position, velocity, time) data from the navigation data source.*
t_{update}	=	*time when the transmitting ADS-B subsystem receives the most recent PVT (position, velocity, time) data from a navigation data source.*
$t_{message}$	=	*time of applicability of the Airborne Position Message*
Dt	=	$t_{message} - t_{update}$, *in milliseconds*
f_{fix}	=	*last known latitude position, at time* t_{fix}, *in degrees*
$f_{message}$	=	*latitude, extrapolated forward to the time of applicability of the Airborne Position Message,* $t_{message}$
Df	=	$f_{message} - f_{fix}$, *in degrees*
n_{NS}	=	*North / South Velocity*

The earth may be modeled as a sphere with radius such that one nautical mile equals one minute of arc along a great circle. Using that approximation, yields:

$$
\begin{aligned}
f_{message} &= f_{fix} + Df \\
&= f_{fix} + (n_{NS}/60)(D_t/3600000) \\
&= f_{fix} + (n_{NS}\, D_t) / (2.16 \times 10^8)
\end{aligned}
$$

(We divide n_{NS} *by 60 to convert from knots in the N-S direction to degrees of latitude per hour, and divide* D_t *by 3600 x 1000 to convert from milliseconds to hours.)*

The result, $f_{message}$, *is to be encoded in the latitude field of the Airborne Position Message using the CPR algorithm described in Appendix A, §A.1.7.*

<u>Note:</u> *In order not to introduce excessive error in the estimated latitude,* $f_{message}$, *the latency,* $t_{update} - t_{fix}$, *in the delivery of PVT data from the navigation data source should not be excessive.*

2.2.3.2.3.7.3.2 Airborne Latitude Position Estimation Case (non - precision)

ADS-B Airborne Position Messages with TYPE Codes other than 9, 10, 20 and 21 (see §2.2.3.2.3.1) may implement estimation techniques such as alpha-beta trackers or Kalman filters to satisfy the intent of the position update requirements given in §2.2.3.2.3.7.3.1. Such techniques provide the capability to decouple the position computation from the message transmission timing provided that the sampled data rate is sufficient to satisfy minimum Nyquist criterion. Likewise such techniques may be necessary in order to provide velocity compensation and/or acceleration estimation in the future.

a. If sampled data estimation techniques, e.g., alpha-beta trackers, alpha-beta-gamma trackers, or Kalman filters, are used to periodically update position data, then the maximum sampled data time **shall** not exceed 100 milliseconds.

b. Sampled data implementations **shall** update the airborne latitude data registers and encoded latitude data subfield at intervals not to exceed 100 milliseconds

Note: *The 100 millisecond requirement is necessary in order to insure that the 200 millisecond performance required in §2.2.3.2.3.7.3.1 is not degraded.*

2.2.3.2.3.7.4 Airborne Latitude Position Data Retention

In the event that the latitude position data is no longer available, the extrapolation or estimation of, and update of latitude data and fields defined in §2.2.3.2.3.7.2 through §2.2.3.2.3.7.3.2 **shall** be limited to no more than two seconds.

At the end of two seconds, the latitude data registers and the encoded latitude field **shall** be set to ALL ZEROs.

2.2.3.2.3.8 "ENCODED LONGITUDE" Subfield in ADS-B Airborne Position Messages

The "ENCODED LONGITUDE" subfield is a 17-bit ("ME" bit 40 through 56, Message bit 72 through 88) field containing the encoded longitude of the airborne position.

2.2.3.2.3.8.1 Airborne Longitude Data Encoding

The airborne longitude position data **shall** be encoded in accordance with §A.1.4.2.2 and §A.1.7 of Appendix A.

2.2.3.2.3.8.2 Airborne Longitude Position Extrapolation/Estimation (Precision Case, Type Codes 9, 10, 20 and 21)

2.2.3.2.3.8.2.1 GPS/GNSS Time Mark Coupled Case (Extrapolation, "TIME" (T) = "1")

If "TIME" (T) = 1 (see §2.2.3.2.3.5) in an Airborne Position Message, then the time of applicability of the latitude and longitude fields in that message **shall** be an exact 0.2 second UTC epoch.

a. Specifically, the position data in the latitude and longitude fields **shall** be extrapolated forward from the time of validity of the position fix to the time of applicability of the Airborne Position Message.

b. The Airborne longitude data registers and the encoded longitude subfield **shall** be updated every 200 milliseconds to the next 0.2 UTC Epoch using the velocity data provided for the position fix.

Notes:

1. *The time of validity of the fix is provided with the fix data from the navigation data source and is indicated by the leading edge of the GNSS Time Mark (see*

§2.2.5.1.6). The time of applicability of the position message is the exact 0.2 second UTC Epoch to which the position data is extrapolated.

2. *The longitude position registers and encoded longitude subfield should be updated at a time about 100 milliseconds before the time of applicability of the data being loaded into that register (see §2.2.5.3.1 and Appendix A, §A.1.4.2.3.1).*

3. *One method of estimating the position to an exact 0.2 second UTC Epoch is described in the following "Commentary."*

<u>COMMENTARY</u>:

The following example provides one method (not the only method!) that longitude given in the Airborne Position Message may be extrapolated from the time of validity of the fix (included with the fix from the navigation data source) to the time of applicability of the Airborne Position Message. In the example, it is assumed that the "TIME" subfield (see §2.2.3.2.3.5) is "ONE," indicating that the time of applicability of the extrapolated position is an exact 0.2 second UTC Epoch.

Let:

t_{fix}	=	*time of the leading edge of the last received GNSS Time Mark (see §2.2.5.1.6), which is also the time of validity included with the fix from the navigation data source.*
$t_{message}$	=	*time of applicability of the Airborne Position Message, which is an exact 0.2 second UTC Epoch.*
Dt	=	$t_{message} - t_{fix}$*, in milliseconds*
l_{fix}	=	*last known longitude position, at time* t_{fix}*, in degrees*
$l_{message}$	=	*longitude, extrapolated forward to the time of applicability of the Airborne Position Message,* $t_{message}$
Dl	=	$l_{message} - l_{fix}$*, in degrees*
f	=	*approximate latitude (the latitude,* f_{fix}*, at the time of the fix may be used)*
n_{EW}	=	*last known E-W velocity at time* t_{fix}*, in knots (positive for easterly velocity)*

The earth may be modeled as a sphere with radius such that one nautical mile equals one minute of arc along a great circle. Using that approximation, yields:

$$l_{message} = l_{fix} + Dl$$

$$= l_{fix} + [(n_{EW})/(60 \cos(f))]\,(Dt/3600000)$$

$$= l_{fix} + (n_{EW}\,Dt) / [(2.16 \times 10^{8}) \cos(f)]$$

(We divide n_{EW} by *60 cos (f) to convert from knots in the E-W direction to degrees of longitude per hour, and divide Dt by 3600 x 1000 to convert from milliseconds to hours.)*

The result, $l_{message}$, is to be encoded in the longitude field of the Airborne Position Message using the CPR algorithm described in Appendix A, §A.1.7.

2.2.3.2.3.8.2.2 Non-Coupled Case (Estimation, "TIME" (T) = "0")

ADS-B Airborne Position Messages with TYPE Codes of 9, 10, 20 and 21 (see §2.2.3.2.3.1) may implement estimation techniques such as alpha-beta trackers or Kalman filters to satisfy the intent of the position update requirements given in §2.2.3.2.3.8.2.1. Such techniques provide the capability to decouple the position computation from the message transmission timing provided that the sampled data rate is sufficient to satisfy minimum Nyquist criterion. Likewise such techniques may be necessary in order to provide velocity compensation and/or acceleration estimation in the future.

a. If sampled data estimation techniques, e.g., alpha-beta trackers, alpha-beta-gamma trackers, or Kalman filters, are used to periodically update position data, then the maximum sampled data time **shall** not exceed 100 milliseconds.

b. Sampled data implementations **shall** update the airborne longitude data registers and encoded longitude data subfield at intervals not to exceed 100 milliseconds

Note: *The 100 millisecond requirement is necessary in order to insure that the 200 millisecond performance required in §2.2.3.2.3.8.2.1 is not degraded.*

2.2.3.2.3.8.3 Airborne Longitude Position Extrapolation/Estimation (non - precision)

2.2.3.2.3.8.3.1 Airborne Longitude Position Extrapolation Case (non - precision)

ADS-B Airborne Position Messages with TYPE Codes other than 9, 10, 20 or 21 (see §2.2.3.2.3.1) **shall** contain an estimate of the longitude position at a time of applicability that is within 200 milliseconds of the time that the Airborne Position Message is transmitted. Essentially, the original data and the encoded longitude **shall** be updated at least as frequently as every 200 milliseconds.

COMMENTARY:

The only difference between longitude position extrapolation in the non-precision case and that of the precision case (§2.2.3.2.3.7.2.1) is the interpretation of what "Dt" means. In the non-precision case, Dt is the elapsed time from the last received position update to the expected time of transmission of an Airborne Position Message that is based on the last position update. (In the precision case, Dt is the time interval from the last received leading edge of the GNSS Time Mark to the 0.2 second UTC Epoch which is to be the time of applicability of the Airborne Position Message).

Let:

t_{fix} = *time validity included with the PVT (position, velocity, time) data from the navigation data source.*

t_{update} = *time when the transmitting ADS-B subsystem receives the most recent PVT (position, velocity, time) data from a navigation data source.*

$t_{message}$	=	*time of applicability of the Airborne Position Message*
Dt	=	$t_{message}$ - t_{update}, *in milliseconds*
l_{fix}	=	*last known longitude position, at time* t_{fix}, *in degrees*
$l_{message}$	=	*longitude, extrapolated forward to the time of applicability of the Airborne Position Message,* $t_{message}$
Dl	=	$l_{message}$ - l_{fix}, *in degrees*
f	=	*approximate latitude (the latitude,* f_{fix}, *at the time of the fix may be used)*
n_{EW}	=	*last known E-W velocity at time* t_{fix}, *in knots (positive for easterly velocity)*

The earth may be modeled as a sphere with radius such that one nautical mile equals one minute of arc along a great circle. Using that approximation, yields:

$$l_{message} = l_{fix} + Dl$$

$$= l_{fix} + [(n_{EW})/(60 \cos(f))] (Dt/3600000)$$

$$= l_{fix} + (n_{EW} Dt) / [(2.16 \times 10^{8}) \cos(f)]$$

(We divide n_{EW} by *60 cos* (f) *to convert from knots in the E-W direction to degrees of longitude per hour, and divide Dt by 3600 x 1000 to convert from milliseconds to hours.)*

The result, $l_{message}$, *is to be encoded in the longitude field of the Airborne Position Message using the CPR algorithm described in Appendix A, §A.1.7.*

Note: *In order not to introduce excessive error in the estimated longitude,* $l_{message}$, *the latency,* t_{update} - t_{fix}, *in the delivery of PVT data from the navigation data source should not be excessive.*

2.2.3.2.3.8.3.2 Airborne Longitude Position Estimation Case (non - precision)

ADS-B Airborne Position Messages with TYPE Codes other than 9, 10, 20 and 21 (see §2.2.3.2.3.1) may implement estimation techniques such as alpha-beta trackers or Kalman filters to satisfy the intent of the position update requirements given in §2.2.3.2.3.8.3.1. Such techniques provide the capability to decouple the position computation from the message transmission timing provided that the sampled data rate is sufficient to satisfy minimum Nyquist criterion. Likewise such techniques may be necessary in order to provide velocity compensation and/or acceleration estimation in the future.

a. If sampled data estimation techniques, e.g., alpha-beta trackers, alpha-beta-gamma trackers, or Kalman filters, are used to periodically update position data, then the maximum sampled data time **shall** not exceed 100 milliseconds.

b. Sampled data implementations **shall** update the airborne longitude data registers and encoded longitude data subfield at intervals not to exceed 100 milliseconds

> ***Note:*** *The 100 millisecond requirement is necessary in order to insure that the 200 millisecond performance required in §2.2.3.2.3.8.3.1 is not degraded.*

2.2.3.2.3.8.4 Airborne Longitude Position Data Retention

The extrapolation or estimation, and update of longitude data and fields defined in §2.2.3.2.3.8.2 through §2.2.3.2.3.8.3.2 **shall** be limited to no more than two seconds, in the event that the longitude position data is no longer available.

At the end of two seconds, the longitude data registers and the encoded longitude field **shall** be set to ALL ZEROs.

2.2.3.2.4 ADS-B Surface Position Messages

The format for the Surface Position Message "ME" field contents is defined in Figure 2-5. Each of the subfields is defined in the following subparagraphs.

SURFACE POSITION MESSAGE "ME" FIELD								
MSG BIT #	33--37	38 --------- 44	45	46 --------- 52	53	54	55 --------- 71	72 --------- 88
"ME" BIT #	1 --- 5	6 ---------- 12	13	14 --------- 20	21	22	23 --------- 39	40 --------- 56
FIELD NAME	TYPE [5]	MOVEMENT [7]	GROUND TRACK STATUS [1]	GROUND TRACK [7]	TIME (T) [1]	CPR FORMAT (F) [1]	ENCODED LATITUDE [17]	ENCODED LONGITUDE [17]
	MSB LSB	MSB LSB		MSB LSB			MSB LSB	MSB LSB

Note: *"[#]" provided in the Field indicates the number of bits in the field.*

Figure 2-5: ADS-B Surface Position Message Format

2.2.3.2.4.1 "TYPE" Subfield in ADS-B Surface Position Messages

The "TYPE" subfield was previously defined for the Airborne Position Message in §2.2.3.2.3.1 and remains the same for the ADS-B Surface Position Message, which **shall** use Type Codes 5, 6, 7 and 8 only.

Detailed definition of the "TYPE" subfield encodings that **shall** be used for all ADS-B Messages are provided in Table 2-11.

2.2.3.2.4.1.1 Surface Position Message Type Code if Containment Radius is Available

If R_C (horizontal containment radius) information is available from the navigation data source, then the ADS-B transmitting subsystem **shall** use R_C to determine the Type Code used in the Surface Position Message in accordance with Table 2-11.

Note: *If the position information comes from a GNSS receiver that conforms to the ARINC 743A characteristic, a suitable source of information for the containment radius (R_C), is ARINC 429 label 130 from that GNSS receiver.*

2.2.3.2.4.1.2 Surface Position Message Type Code if Containment Radius is Not Available

If R_C (horizontal containment radius) information is NOT available from the navigation data source, then the ADS-B transmitting subsystem **shall** indicate NIC = 0 by selecting a Type Code of 0 or 8 in the Surface Position Messages, as follows:

a. The ADS-B transmitting subsystem **shall** set the TYPE subfield to ZERO if valid horizontal position information is not available, as described in §2.2.3.2.3.1.3.2 above.

b. The ADS-B transmitting subsystem **shall** set the TYPE subfield to 8 if valid horizontal position information is available. (This Type Code indicates that containment radius, R_C, is either unknown or greater than or equal to 0.1 NM.)

2.2.3.2.4.1.3 Special Processing for Type Code ZERO

2.2.3.2.4.1.3.1 Significance of Type Code Equal to ZERO

As shown in Table 2-11, Type Code equal to ZERO (0) is labeled “No Position Information.” This type of message is intended to be used when the latitude and/or longitude information is not available or is invalid.

A surface position message with a Type Code of “0” **shall** have all 56 bits of the “ME” field set to ZERO.

Special processing is required for surface position messages because a CPR encoded value of all ZEROs in the latitude and longitude field is considered to be a valid encoding.

2.2.3.2.4.1.3.2 Broadcast of Type Code Equal to ZERO

The requirements provided in §2.2.3.2.3.1.3.2 apply equally to the surface position message except that subparagraph “c” is modified to read as follows:

Note that in all of the cases, a Type Code of ZERO infers a message of all ZEROs.

2.2.3.2.4.1.4 Type Code based on Horizontal Protection Level or Estimated Horizontal Position Accuracy

a. If valid horizontal position information is available, then the “TYPE” code in the Airborne Position Message **shall** be set in the range from “5” to “8.”

b. If R_C (Horizontal Containment Radius) information is available from the navigation data source, the “TYPE” coding **shall** be selected according to the R_C value, in accordance with Table 2-11.

c. If R_C is not available from the navigation data source, then the "TYPE" coding **shall** be set to 8.

2.2.3.2.4.2 "MOVEMENT" Subfield in ADS-B Surface Position Messages

The "MOVEMENT " subfield is a 7-bit ("ME" bits 6 through 12, Message bits 38 through 44) field that is used to encode information regarding the status of "Movement" of the ADS-B Transmitting Subsystem in accordance with the coding provided in Table 2-13.

Table 2-13: "MOVEMENT" Subfield Code Definitions

Encoding	Meaning	Quantization
0	No Movement Information Available	
1	Aircraft Stopped (Ground Speed < 0.2315 km/h (0.125 knots))	
2 - 8	0.2315 km/h (0.125 kt) ≤ Ground Speed < 1.852 km/h (1 kt)	0.2315 km/h (0.125 kt) steps
9 - 12	1.852 km/h (1 kt) ≤ Ground Speed < 3.704 km/h (2 kt)	0.463 km /h (0.25 kt) steps
13 - 38	3.704 km/h (2 kt) ≤ Ground speed < 27.78 km/h (15 kt)	0.926 km/h (0.50 kt) steps
39 - 93	27.78 km/h (15 kt) ≤ Ground Speed < 129.64 km/h (70 kt)	1.852 km/h (1.00 kt) steps
94 - 108	129.64 km/h (70 kt) ≤ Ground Speed < 185.2 km/h (100 kt)	3.704 km/h (2.00 kt) steps
109 - 123	185.2 km/h (100 kt) ≤ Ground Speed < 324.1 km/h (175 kt)	9.26 km/h (5.00 kt) steps
124	324.1 km/h (175 kt) ≤ Ground Speed	
125	Reserved for Aircraft Decelerating	
126	Reserved for Aircraft Accelerating	
127	Reserved for Aircraft Backing-Up	

Notes:

1. *The data encoding represented in Table 2-13 represents a non-linear encoding: therefore, encoding **shall** be performed exactly as defined in the table.*

2. *The last three movement encodings (125, 126, 127) are reserved to indicate high levels of ground speed change, etc. The precedence of the codes is not defined yet as inputs that would be required are not currently available.*

2.2.3.2.4.3 "STATUS BIT FOR HEADING" Subfield in ADS-B Surface Position Messages

The "Status Bit for Heading " subfield is a 1-bit ("ME" bit 13, Message bit 45) field that **shall** be used to indicate the validity of the Heading as defined in Table 2-14.

Table 2-14: "STATUS BIT FOR HEADING" Encoding

Coding	Meaning
0	Heading data is NOT VALID
1	Heading data is VALID

Note: *If a source of A/V heading **is not** available to the ADS-B transmitting subsystem, but a source of ground track angle **is** available, ground track angle may be used instead of heading,, provided that the STATUS BIT FOR HEADING subfield is set to ZERO whenever the ground track angle is not a reliable indication of the A/V's heading. (The ground track angle is not a reliable indication of the A/V's heading when the A/V's ground speed is close to ZERO.)*

2.2.3.2.4.4 "HEADING" Subfield in ADS-B Surface Position Messages

The "HEADING" subfield is a 7-bit ("ME" bit 14 through 20, Message Bit 46 through 52) field that **shall** be used to report the Heading, or motion of the ADS-B transmitting subsystem, Clockwise from North (i.e., Heading Sign Bit = 0). Encoding of the Heading Subfield is defined in Table 2-15.

<u>Table 2-15:</u> "HEADING" Encoding

Coding (binary)	**Coding** (decimal)	**Meaning** (Heading in degrees)
000 0000	0	Heading is ZERO
000 0001	1	Heading = 2.8125 degrees
000 0010	2	Heading = 5.6250 degrees
000 0011	3	Heading = 8.4375 degrees
***	***	***
011 1111	63	Heading = 177.1875 degrees
100 0000	64	Heading = 180.00 degrees
100 0001	65	Heading = 182.8125 degrees
***	***	***
111 1111	127	Heading = 357.1875 degrees

<u>Notes:</u>

1. *The encoding shown in the table represents an angular weighted binary encoding in degrees clockwise from true north. The MSB represents a bit weighting of 180 degrees, while the LSB represents a bit weighting of 360/128 degrees.*

2. *Raw data used to establish the Heading subfield will normally have more resolution (i.e., more bits) than that required by the Heading Subfield. When converting such data to the Heading Subfield, the accuracy of the data must be maintained such that it is not worse than +/- ½ LSB where the LSB is the weight of the least significant bit of the Heading subfield.*

3. *The reference direction for Heading (whether True North or Magnetic North) is indicated in the Horizontal Reference Direction (HRD) field of the Aircraft Operational Status Message (§2.2.3.2.7.2).*

2.2.3.2.4.5 "TIME" (T) Subfield in ADS-B Surface Position Messages

The "TIME" (T) subfield is a 1-bit ("ME" bit 21, Message bit 53) field which may be used to indicate whether or not the epoch of validity for the horizontal position data in a Surface Position Message is an exact 0.2 second UTC epoch. If the time of applicability of the position data is synchronized to an exact 0.2 second UTC epoch, the "TIME" (T) subfield **shall** be set to "1"; otherwise, the "TIME" (T) subfield **shall** be set to "0."

The "TIME" (T) subfield may be set to "1" only for Type Codes 5 and 6 (see §2.2.3.2.3.1 and Table 2-11) when used to indicated synchronization as discussed in the previous paragraph.

Notes:

1. *An ADS-B Transmitting Subsystem that sets the "TIME" (T) subfield to "1" must accept a GNSS TIME MARK input from the navigation data source in order to be able to update the position data from the navigation data source to an exact 0.2 second UTC epoch (See §2.2.5.1.6).*

2. *An arithmetic description of the intended synchronization implementation is provided in the "Commentary" paragraphs provided in §2.2.3.2.4.7.2 for precision Latitude Position Extrapolation and in §2.2.3.2.4.8.2 for precision Longitude Position Extrapolation.*

2.2.3.2.4.6 "CPR FORMAT" (F) Subfield in ADS-B Surface Position Messages

The "CPR Format" (F) subfield is a 1-bit ("ME" bit 22, Message bit 54) field used to indicate which Compact Position Reporting (CPR) format type ("**even**" or "**odd**") is used to encode the latitude and longitude data (See §2.2.3.2.4.7 and §2.2.3.2.4.8). The bit **shall** be set to "ZERO" to indicate the "**even**" encoding of such data, or to "ONE" to indicate the "**odd**" encoding of such data.

a. When "TIME" (T) = 0:

The "CPR Format" (F) subfield functions ONLY to indicate the "**even**" or "**odd**" CPR encoding. In this case, the CPR encoding type **shall** alternate between "**even**" and "**odd**," and the "CPR Format" (F)" subfield **shall** alternate between "0" and "1" respectively, each time the Surface Position Message register is updated with new position data.

Note: *When the "TIME" (T) subfield is "ZERO," the Surface Position Message register must be updated at least as frequently as every 200 milliseconds: however, it may be updated more frequently, for example, every 100 milliseconds, etc. In such cases, the CPR encoding should alternate between "**even**" and "**odd**" each time that the register is updated with new position data.*

b. When "TIME" (T) = 1:

The "CPR Format" (F) subfield functions to indicate the "**even**" or "**odd**" CPR encoding and also indicates whether the epoch of applicability of the position data is an "**even**" or "**odd**" 0.2 second UTC epoch.

Notes:

1. *Although the Surface Position Message register may be updated more frequently than five times per second, when T=1, the "CPR Format" (F) subfield **shall** alternate between "0" and "1" only as the epoch of applicability of the data*

*being loaded into the register alternates between "**even**" and "**odd**" 0.2 second UTC epochs.*

2. *An "even 0.2 second UTC epoch" is defined as that moment on the UTC time scale that occurs at an even number of 200-millisecond intervals after an exact even-numbered UTC second. Likewise, an "odd 0.2 second UTC epoch" is defined as that moment on the UTC time scale that occurs at an odd number of 200 millisecond intervals after an even numbered UTC second. Examples of even 0.2 second epochs are 12.0 seconds, 12.4 seconds, 12.8 seconds, 13.2 seconds, 13.6 seconds, etc. Examples of odd 0.2 second epochs are 12.2 seconds, 12.6 seconds, 13.0 seconds, 13.4 seconds, 13.8 seconds, etc.*

2.2.3.2.4.7 "ENCODED LATITUDE" Subfield in ADS-B Surface Position Messages

The "ENCODED LATITUDE" subfield is a 17-bit ("ME" bit 23 through 39, Message bit 55 through 71) field containing the encoded latitude of the Surface position.

2.2.3.2.4.7.1 Surface Latitude Data Encoding

The surface latitude position data **shall** be encoded in accordance with §A.1.4.2.2 and §A.1.7 of Appendix A.

2.2.3.2.4.7.2 Surface Latitude Position Extrapolation/Estimation (Precision Case, Type Codes 5 and 6)

The following subsections apply to Surface Position Messages with TYPE Codes of 5 and 6 (see §2.2.3.2.3.1).

2.2.3.2.4.7.2.1 GPS/GNSS Time Mark Coupled Case (Extrapolation, "TIME" (T) = "1")

If "TIME" (T) = 1 (see §2.2.3.2.3.5) in a Surface Position Message, then the time of applicability of the latitude and longitude fields in that message **shall** be an exact 0.2 second UTC epoch.

a. Specifically, the position data in the latitude and longitude fields **shall** be extrapolated forward from the time of validity of the position fix to the time of applicability of the Surface Position Message.

b. The Surface latitude data registers and the encoded latitude subfield **shall** be updated every 200 milliseconds to the next 0.2 UTC Epoch using the velocity data provided for the position fix.

<u>Notes:</u>

1. *The time of validity of the fix is provided with the fix data from the navigation data source and is indicated by the leading edge of the GNSS Time Mark (see §2.2.5.1.6). The time of applicability of the position message is the exact 0.2 second UTC Epoch to which the position data is extrapolated.*

2. *The latitude position registers and encoded latitude subfield should be updated at a time about 100 milliseconds before the time of applicability of the data being loaded into that register (see §2.2.5.3.1 and Appendix A, §A.1.4.2.3.1).*

3. *One method of estimating the position to an exact 0.2 second UTC Epoch is described in the following "Commentary."*

<u>COMMENTARY</u>:

The following example provides one method (not the only method!) that latitude given in the Surface Position Message may be extrapolated from the time of validity of the fix (included with the fix from the navigation data source) to the time of applicability of the Surface Position Message. In the example, it is assumed that the "TIME" (T) subfield (see §2.2.3.2.3.5) is "ONE," indicating that the time of applicability of the extrapolated position is an exact 0.2 second UTC Epoch.

Let:

t_{fix}	=	*time of the leading edge of the last received GNSS Time Mark (see §2.2.5.1.6), which is also the time of validity included with the fix from the navigation data source.*
$t_{message}$	=	*time of applicability of the Surface Position Message, which is an exact 0.2 second UTC Epoch.*
Dt	=	$t_{message} - t_{fix}$, *in milliseconds*
f_{fix}	=	*last known latitude position, at time* t_{fix}, *in degrees*
$f_{message}$	=	*latitude, extrapolated forward to the time of applicability the Surface Position Message,* $t_{message}$
Df	=	$f_{message} - f_{fix}$, *in degrees*
n_{NS}	=	*North / South Velocity*

The earth may be modeled as a sphere with radius such that one nautical mile equals one minute of arc along a great circle. Using that approximation, yields:

$$f_{message} = f_{fix} + Df$$

$$= f_{fix} + (n_{NS}/60)(Dt/3600000)$$

$$= f_{fix} + (n_{NS}\,Dt) / (2.16 \times 10^{8})$$

(We divide n_{NS} *by 60 to convert from knots in the N-S direction to degrees of latitude per hour, and divide Dt by 3600 x 1000 to convert from milliseconds to hours.)*

The result, fmessage, is to be encoded in the latitude field of the Surface Position Message using the CPR algorithm described in Appendix A, §A.1.7.

2.2.3.2.4.7.2.2 Non-Coupled Case (Estimation, "TIME" (T) = "0")

ADS-B Surface Position Messages corresponding to precision categories 5 and 6 (see §2.2.3.2.3.1) may implement estimation techniques such as alpha-beta trackers or Kalman filters to satisfy the intent of the position update requirements given in §2.2.3.2.4.7.2.1. Such techniques provide the capability to decouple the position computation from the message transmission timing provided that the sampled data rate is sufficient to satisfy minimum Nyquist criterion. Likewise such techniques may be necessary in order to provide velocity compensation and/or acceleration estimation in the future.

a. If sampled data estimation techniques, e.g., alpha-beta trackers, alpha-beta-gamma trackers, or Kalman filters, are used to periodically update position data, then the maximum sampled data time **shall** not exceed 100 milliseconds.

b. Sampled data implementations **shall** update the surface latitude data registers and encoded latitude data subfield at intervals not to exceed 100 milliseconds.

Note: *The 100 millisecond requirement is necessary in order to insure that the 200 millisecond performance required in §2.2.3.2.4.7.2.1 is not degraded.*

2.2.3.2.4.7.3 Surface Latitude Position Extrapolation/Estimation (non - precision)

2.2.3.2.4.7.3.1 Surface Latitude Position Extrapolation Case (non - precision)

ADS-B Surface Position Messages with TYPE Codes other than 5 or 6 (see §2.2.3.2.3.1) **shall** contain an estimate of the latitude position at a time of applicability that is within 200 milliseconds of the time that the Surface Position Message is transmitted. Essentially, the original data and the encoded latitude **shall** be updated at least as frequently as every 200 milliseconds.

COMMENTARY:

The only difference between latitude position extrapolation in the non-precision case and that of the precision case (§2.2.3.2.4.7.2.1) is the interpretation of what "Dt" means. In the non-precision case, Dt is the elapsed time from the last received position update to the expected time of transmission of a Surface Position Message that is based on the last position update.

(In the precision case, Dt is the time interval from the last received leading edge of the GNSS Time Mark to the 0.2 second UTC Epoch which is to be the time of applicability of the Surface Position Message).

Let:

t_{fix}	=	*time validity included with the PVT (position, velocity, time) data from the navigation data source.*
t_{update}	=	*time when the transmitting ADS-B subsystem receives the most recent PVT (position, velocity, time) data from a navigation data source.*
$t_{message}$	=	*time of applicability of the Surface Position Message*

Dt	=	$t_{message}$ - t_{update}, *in milliseconds*
f_{fix}	=	*last known latitude position, at time* t_{fix}, *in degrees*
$f_{message}$	=	*latitude, extrapolated forward to the time of applicability of the Surface Position Message,* $t_{message}$
Df	=	$f_{message}$ - f_{fix}, *in degrees*
n_{NS}	=	*North / South Velocity*

The earth may be modeled as a sphere with radius such that one nautical mile equals one minute of arc along a great circle. Using that approximation, yields:

$$f_{message} = f_{fix} + Df$$

$$= f_{fix} + (n_{NS}/60)(D_t/3600000)$$

$$= f_{fix} + (n_{NS}\, D_t) / (2.16 \times 10^8)$$

(We divide n_{NS} *by 60 to convert from knots in the N-S direction to degrees of latitude per hour, and divide* D_t *by 3600 x 1000 to convert from milliseconds to hours.)*

The result, $f_{message}$*, is to be encoded in the latitude field of the Surface Position Message using the CPR algorithm described in Appendix A, §A.1.7.*

Note: *In order not to introduce excessive error in the estimated latitude,* $f_{message}$*, the latency,* t_{update} - t_{fix}*, in the delivery of PVT data from the navigation data source should not be excessive.*

2.2.3.2.4.7.3.2 Surface Latitude Position Estimation Case (non - precision)

ADS-B Airborne Position Messages that do not correspond to precision categories 5 and 6 (see §2.2.3.2.3.1) may implement estimation techniques such as alpha-beta trackers or Kalman filters to satisfy the intent of the position update requirements given in §2.2.3.2.4.7.3.1. Such techniques provide the capability to decouple the position computation from the message transmission timing provided that the sampled data rate is sufficient to satisfy minimum Nyquist criterion. Likewise such techniques may be necessary in order to provide velocity compensation and/or acceleration estimation in the future.

a. If sampled data estimation techniques, e.g., alpha-beta trackers, alpha-beta-gamma trackers, or Kalman filters, are used to periodically update position data, then the maximum sampled data time **shall** not exceed 100 milliseconds.

b. Sampled data implementations **shall** update the surface latitude data registers and encoded latitude data subfield at intervals not to exceed 100 milliseconds.

Note: *The 100 millisecond requirement is necessary in order to insure that the 200 millisecond performance required in §2.2.3.2.4.7.3.1 is not degraded.*

2.2.3.2.4.7.4 Surface Latitude Position Data Retention

The extrapolation and update of latitude data and fields defined in §2.2.3.2.4.7.2 through §2.2.3.2.4.7.3.2 **shall** be limited to no more than two seconds, in the event that the latitude position data is no longer available. At the end of two seconds, the latitude data registers and the encoded latitude field **shall** be set to ALL ZEROs.

2.2.3.2.4.8 "ENCODED LONGITUDE" Subfield in ADS-B Surface Position Messages

The "ENCODED LONGITUDE" subfield is a 17-bit ("ME" bit 40 through 56, Message bit 72 through 88) field containing the encoded latitude of the Surface position.

2.2.3.2.4.8.1 Surface Longitude Data Encoding

The airborne longitude position data **shall** be encoded in accordance with §A.1.4.2.2 and §A.1.7 of Appendix A.

2.2.3.2.4.8.2 Surface Longitude Position Extrapolation/Estimation (Precision Case, Type Codes 5 and 6)

2.2.3.2.4.8.2.1 GPS/GNSS Time Mark Coupled Case (Extrapolation, "TIME" (T) = "1")

If "TIME" (T) = 1 (see §2.2.3.2.3.5) in a Surface Position Message, then the time of applicability of the latitude and longitude fields in that message **shall** be an exact 0.2 second UTC epoch.

a. Specifically, the position data in the latitude and longitude fields **shall** be extrapolated forward from the time of validity of the position fix to the time of applicability of the Surface Position Message.

b. The Surface longitude data registers and the encoded longitude subfield **shall** be updated every 200 milliseconds to the next 0.2 UTC Epoch using the velocity data provided for the position fix.

Notes:

1. *The time of validity of the fix is provided with the fix data from the navigation data source and is indicated by the leading edge of the GNSS Time Mark (see §2.2.5.1.6). The time of applicability of the position message is the exact 0.2 second UTC Epoch to which the position data is extrapolated.*

2. *The longitude position registers and encoded longitude subfield should be updated at a time about 100 milliseconds before the time of applicability of the data being loaded into that register (see §2.2.5.3.1 and Appendix A, §A.1.4.2.3.1).*

3. *One method of estimating the position to an exact 0.2 second UTC Epoch is described in the following "Commentary."*

<u>***COMMENTARY:***</u>

The following example provides one method (not the only method!) that longitude given in the Surface Position Message may be extrapolated from the time of validity of the fix (included with the fix from the navigation data source) to the time of applicability of the Surface Position Message. In the example, it is assumed that the "TIME" subfield (see §2.2.3.2.3.5) is "ONE," indicating that the time of applicability of the extrapolated position is an exact 0.2 second UTC Epoch.

Let:

t_{fix}	=	*time of the leading edge of the last received GNSS Time Mark (see §2.2.5.1.6), which is also the time of validity included with the fix from the navigation data source.*
$t_{message}$	=	*time of applicability of the Surface Position Message, is an exact 0.2 second UTC Epoch.*
Dt	=	$t_{message} - t_{fix}$*, in milliseconds*
l_{fix}	=	*last known longitude position, at time* t_{fix}*, in degrees*
$l_{message}$	=	*longitude, extrapolated forward to the time of applicability of the Surface Position Message,* $t_{message}$
Dl	=	$l_{message} - l_{fix}$*, in degrees*
f	=	*approximate latitude (the latitude,* f_{fix}*, at the time of the fix may be used)*
n_{EW}	=	*last known E-W velocity at time* t_{fix}*, in knots (positive for easterly velocity)*

The earth may be modeled as a sphere with radius such that one nautical mile equals one minute of arc along a great circle. Using that approximation, yields:

$$l_{message} = l_{fix} + Dl$$

$$= l_{fix} + [(n_{EW})/(60 \cos(f))] \times (Dt/3600000)$$

$$= l_{fix} + (n_{EW}\, Dt) / [(2.16 \times 10^{8}) \cos(f)]$$

(We divide n_{EW} *by 60 cos (*f*) to convert from knots in the E-W direction to degrees of longitude per hour, and divide Dt by 3600 x 1000 to convert from milliseconds to hours.)*

The result, $l_{message}$*, is to be encoded in the longitude field of the Surface Position Message using the CPR algorithm described in Appendix A, §A.1.7.*

2.2.3.2.4.8.2.2 Non-Coupled Case (Estimation, "TIME" (T) = "0")

ADS-B Surface Position Messages with TYPE Codes of 5 and 6 (see §2.2.3.2.3.1) may implement estimation techniques such as alpha-beta trackers or Kalman filters to satisfy the intent of the position update requirements given in §2.2.3.2.4.8.2.1. Such techniques provide the capability to decouple the position computation from the message transmission timing provided that the sampled data rate is sufficient to satisfy minimum Nyquist criterion. Likewise such techniques may be necessary in order to provide velocity compensation and/or acceleration estimation in the future.

a. If sampled data estimation techniques, e.g., alpha-beta trackers, alpha-beta-gamma trackers, or Kalman filters, are used to periodically update position data, then the maximum sampled data time **shall** not exceed 100 milliseconds.

b. Sampled data implementations **shall** update the surface longitude data registers and encoded longitude data subfield at intervals not to exceed 100 milliseconds.

Note: *The 100 millisecond requirement is necessary in order to insure that the 200 millisecond performance required in §2.2.3.2.4.8.2.1 is not degraded.*

2.2.3.2.4.8.3 Surface Longitude Position Extrapolation/Estimation (non - precision)

2.2.3.2.4.8.3.1 Surface Longitude Position Extrapolation Case (non - precision)

ADS-B Surface Position Messages with TYPE Codes other than 5 or 6 (see §2.2.3.2.3.1) **shall** contain an estimate of the longitude position at a time of applicability that is within 200 milliseconds of the time that the Surface Position Message is transmitted. Essentially, the original data and the encoded longitude **shall** be updated at least as frequently as every 200 milliseconds.

COMMENTARY:

The only difference between longitude position extrapolation in the non-precision case and that of the precision case (§2.2.3.2.3.7.2.1) is the interpretation of what "Dt" means. In the non-precision case, Dt is the elapsed time from the last received position update to the expected time of transmission of an Surface Position Message that is based on the last position update. (In the precision case, Dt is the time interval from the last received leading edge of the GNSS Time Mark to the 0.2 second UTC Epoch which is to be the time of applicability of the Surface Position Message).

Let:

t_{fix}	=	*time validity included with the PVT (position, velocity, time) data from the navigation data source.*
t_{update}	=	*time when the transmitting ADS-B subsystem receives the most recent PVT (position, velocity, time) data from a navigation data source.*
$t_{message}$	=	*time of applicability of the Surface Position Message*
Dt	=	$t_{message} - t_{update}$*, in milliseconds*
l_{fix}	=	*last known longitude position, at time* t_{fix}*, in degrees*
$l_{message}$	=	*longitude, extrapolated forward to the time of applicability of the Surface Position Message,* $t_{message}$
Dl	=	$l_{message} - l_{fix}$*, in degrees*

f	=	*approximate latitude (the latitude, f_{fix}, at the time of the fix may be used)*
n_{EW}	=	*last known E-W velocity at time t_{fix}, in knots (positive for easterly velocity)*

The earth may be modeled as a sphere with radius such that one nautical mile equals one minute of arc along a great circle. Using that approximation, yields:

$$l_{message} = l_{fix} + Dl$$

$$= l_{fix} + [(n_{EW})/(60 \cos(f))] \times (Dt / 3600000)$$

$$= l_{fix} + (n_{EW}\, Dt) / [(2.16 \times 10^{8}) \cos(f)]$$

(We divide n_{EW} by *60 cos (f) to convert from knots in the E-W direction to degrees of longitude per hour, and divide Dt by 3600 x 1000 to convert from milliseconds to hours.)*

The result, $l_{message}$, is to be encoded in the longitude field of the Surface Position Message using the CPR algorithm described in Appendix A, §A.1.7.

Note: *In order not to introduce excessive error in the estimated longitude, $l_{message}$, the latency, t_{update} - t_{fix}, in the delivery of PVT data from the navigation data source should not be excessive.*

2.2.3.2.4.8.3.2 Surface Longitude Position Estimation Case (non - precision)

ADS-B Surface Position Messages with TYPE Codes other than 5 and 6 (see §2.2.3.2.3.1) may implement estimation techniques such as alpha-beta trackers or Kalman filters to satisfy the intent of the position update requirements given in §2.2.3.2.4.8.3.1. Such techniques provide the capability to decouple the position computation from the message transmission timing provided that the sampled data rate is sufficient to satisfy minimum Nyquist criterion. Likewise such techniques may be necessary in order to provide velocity compensation and/or acceleration estimation in the future.

a. If sampled data estimation techniques, e.g., alpha-beta trackers, alpha-beta-gamma trackers, or Kalman filters, are used to periodically update position data, then the maximum sampled data time **shall** not exceed 100 milliseconds.

b. Sampled data implementations **shall** update the surface longitude data registers and encoded longitude data subfield at intervals not to exceed 100 milliseconds.

Note: *The 100 millisecond requirement is necessary in order to insure that the 200 millisecond performance required in §2.2.3.2.3.8.3.1 is not degraded.*

2.2.3.2.4.8.4 Surface Longitude Position Data Retention

The extrapolation and update of longitude data and fields defined in §2.2.3.2.4.8.2 through §2.2.3.2.4.8.3.2 **shall** be limited to no more than two seconds, in the event that the longitude position data is no longer available. At the end of two seconds, the longitude data registers and the encoded longitude field **shall** be set to ALL ZEROs.

2.2.3.2.5 ADS-B Aircraft Identification and Type Messages

Format for the Aircraft Identification and Type Message "ME" field contents is defined in Figure 2-6. Each of the subfields is defined in the following subparagraphs.

AIRCRAFT IDENTIFICATION AND TYPE MESSAGE "ME" FIELD										
MSG BIT #	33--37	38 --------- 40	41 -46	47-52	53 -58	59 -64	65 -70	71 -76	77 -82	83 -88
"ME" BIT #	1 --- 5	6 ------------- 8	9 -- 14	15 -20	21--26	27- 32	33 -38	39 -44	45 -50	51 -56
FIELD NAME	TYPE [5]	ADS-B EMITTER CATEGORY [3]	Ident Char. #1 [6]	Ident Char. #2 [6]	Ident Char. #3 [6]	Ident Char. #4 [6]	Ident Char. #5 [6]	Ident Char. #6 [6]	Ident Char. #7 [6]	Ident Char. #8 [6]
	MSB LSB	MSB LSB	MSB LSB	MSB LSB	MSB LSB	MSB LSB	MSB LSB	MSB LSB	MSB LSB	MSB LSB

Note: *"[#]" provided in the Field indicates the number of bits in the field.*

Figure 2-6: ADS-B Aircraft Identification And Type Message Format

2.2.3.2.5.1 "TYPE" Subfield in ADS-B Aircraft Identification and Type Message

The "TYPE" subfield was previously defined for the Airborne Position Message in §2.2.3.2.3.1 and remains the same for the ADS-B Aircraft Identification and Type Message which uses Type Codes 1, 2, 3 and 4 only.

2.2.3.2.5.2 "ADS-B EMITTER CATEGORY" Subfield in ADS-B Aircraft Identification and Type Message

The "ADS-B EMITTER CATEGORY" subfield is a 3-bit ("ME" bits 6 through 8, Message bits 38 through 40) field used to identify particular aircraft or vehicle types within the ADS-B Emitter Type Sets A, B, C or D identified by Message Format Type codes 4, 3, 2 and 1 respectively. Each of the ADS-B Emitter Type sets are defined in Table 2-16:

Table 2-16: "ADS-B EMITTER CATEGORY SET" Code Definitions

ADS-B EMITTER CATEGORY SET "A"	
Coding	**Meaning**
0	No ADS-B Emitter Category Information
1	Light (<15,500 lbs.)
2	Small (15,500 to 75,000 lbs.)
3	Large (75,000 to 300,000 lbs.)
4	High-Vortex Large (aircraft such as B-757)
5	Heavy (> 300,000 lbs.)
6	High Performance (>5g acceleration and > 400 knots)
7	Rotorcraft

ADS-B EMITTER CATEGORY SET "B"	
Coding	**Meaning**
0	No ADS-B Emitter Category Information
1	Glider / Sailplane
2	Lighter-than-Air
3	Parachutist / Skydiver
4	Ultralight / hang-glider / paraglider
5	Reserved
6	Unmanned Aerial Vehicle
7	Space / Trans-atmospheric vehicle

ADS-B EMITTER CATEGORY SET "C"	
Coding	**Meaning**
0	No ADS-B Emitter Category Information
1	Surface Vehicle - Emergency Vehicle
2	Surface Vehicle - Service Vehicle
3	Fixed Ground or Tethered Obstruction
4 - 7	Reserved

ADS-B EMITTER CATEGORY SET "D"	
Coding	**Meaning**
0	No ADS-B Emitter Category Information
1 - 7	Reserved

Notes:

1. *The category codes 1 to 5 in category set "A" are intended to advise other aircraft of the transmitting aircraft's wake vortex characteristics, and not necessarily the transmitting aircraft's actual maximum takeoff weight. In case of doubt, the next higher aircraft category code should be used.*

2. *The following category code assignments should be considered for the aircraft operating in the United States national air space (NAS).*

Set	*Code*	*Meaning*
A	*1*	*less than 7,000 kg (15,500 lb)*
A	*2*	^{3} *15,500 and < 41,000 lb*
A	*3*	^{3} *41,000 and < 255,000 lb and not in Code 4*
A	*4*	*certain other aircraft, including B-757*
A	*5*	^{3} *255,000 lb*

2.2.3.2.5.3 "CHARACTER" Subfield in ADS-B Aircraft Identification and Type Message

Each of the 8 "CHARACTER" subfields is a 6-bit field as shown in Figure 2-6.

The 8 "Character" subfields **shall** encode the following information:

a. If the flight identification used in the aircraft flight plan is available (e.g. an airline flight number), then the flight identification used in the flight plan **shall** be encoded.

b. If the flight identification used in the aircraft flight plan is not available, then the Aircraft Registration Marking **shall** be encoded.

The character in each of the "Character" subfields is encoded as a 6-bit subset of the International Alphabet Number 5 (IA-5) in accordance with the following documents:

a. ICAO, Annex 10, Volume IV, second edition, July 1998, §3.1.2.9.1.2 and Table 3-6.

Note: *The international reference version of International Alphabet No. 5 (IA-5) is defined in full in ICAO, Annex 10, Volume III, Part 1, Amendment No. 71, dated 07/11/96, Table 8-2.*

b. RTCA Document No, DO-181C, §2.2.17.1.13, (EUROCAE ED-73A, §3.21.1.13) and

c. §A.1.4.4 of Appendix A.

2.2.3.2.6 ADS-B Airborne Velocity Information Messages

Formats for the various Airborne Velocity Information Messages are further classified by subtype as identified in the following subparagraphs and Figure 2-7a and Figure 2-7b.

AIRBORNE VELOCITY INFORMATION MESSAGE_SUBTYPE_"1" and "2"_ "ME" FIELD															
MSG BIT #	33-37	38 ------ 40	41	42	43 -- 45	46	47 --- 56	57	58 --- 67	68	69	70 - 78	79 - 80	81	82 --- 88
"ME" BIT #	1 --- 5	6 --------- 8	9	10	11 -- 13	14	15 --- 24	25	26 --- 35	36	37	38 - 46	47 - 48	49	50 --- 56
FIELD NAME	TYPE [5]	SUBTYPE [3]	INTENT CHANGE FLAG [1]	IFR Capability FLAG [1]	NUC_R [3]	E/W Direction Bit [1]	E/W Velocity [10]	N/S Direction Bit [1]	N/S Velocity [10]	Vert. Rate Source [1]	Vert. Rate Sign [1]	Vert. Rate [9]	Turn Indicator [2]	Diff. from Baro. Alt. Sign [1]	Difference from Baro. ALT [7]
	MSB LSB	MSB LSB			MSB LSB		MSB LSB		MSB LSB			MSB LSB	MSB LSB		MSB LSB

Note: *"[#]" provided in the Field indicates the number of bits in the field.*

Figure 2-7a: ADS-B Airborne Velocity Information Message_Subtype _"1&2"

AIRBORNE VELOCITY INFORMATION MESSAGE_SUBTYPE_"3" and "4"_ "ME" FIELD															
MSG BIT #	33-37	38 ----- 40	41	42	43 --- 45	46	47 --- 56	57	58 --- 67	68	69	70 --- 78	79 --- 80	81	82 ----- 88
"ME" BIT #	1 --- 5	6 -------- 8	9	10	11 --- 13	14	15 --- 24	25	26 --- 35	36	37	38 --- 46	47 --- 48	49	50 ----- 56
FIELD NAME	TYPE [5]	SUBTYPE [3]	INTENT CHANGE FLAG [1]	IFR Capability FLAG [1]	NUC_R [3]	Magnetic Heading Status Bit [1]	Magnetic Heading [10]	Airspeed Type [1]	Airspeed [10]	Vertical Rate Source [1]	Vertical Rate Sign [1]	Vertical Rate [9]	Turn Indicator [2]	Diff. from Baro. Alt. Sign [1]	Difference from Baro. ALT [7]
	MSB LSB	MSB LSB			MSB LSB		MSB LSB		MSB LSB			MSB LSB	MSB LSB		MSB LSB

Note: *"[#]" provided in the Field indicates the number of bits in the field.*

Figure 2-7b: ADS-B Airborne Velocity Information Message_Subtype _"3&4"

2.2.3.2.6.1 ADS-B Airborne Velocity Message - Subtype "1"

a. The Airborne Velocity Information Message - Subtype "1" is illustrated in Figure 2-7a and **shall** be transmitted by the Airborne ADS-B Transmitting Subsystem when Velocity Over Ground information is available, and the transmitting device is installed in an environment having *NON*-supersonic airspeed capability.

b. The Supersonic Version of the velocity message (i.e., Subtype "2") **shall** be used if either the East – West velocity OR the North - South velocity exceeds 1022 knots. A switch to the normal velocity message (i.e., Subtype "1") **shall** be made if both the East - West and the North - South velocities drop below 1000 knots.

c. This message **shall** not be broadcast if the only valid data are the Intent Change and the IFR Capability Flags.

   (1). Transponder based ADS-B Transmitting Subsystems **shall** suppress the broadcast by loading register 0,9 with all "ZEROs" and then discontinuing updating of the register until data input is available again.

   (2). Non-transponder based ADS-B Transmitting Subsystems **shall** simply suppress the broadcast.

Each of the subfields of the Subtype "1" message is defined in the following subparagraphs.

2.2.3.2.6.1.1 "TYPE" Subfield in Aircraft Velocity - Subtype "1" Messages

The "TYPE" subfield was previously defined in §2.2.3.2.3.1 and remains the same for ADS-B Airborne Velocity Information - Subtype "1" Messages which use Type Code 19 only.

2.2.3.2.6.1.2 "SUBTYPE" Subfield in Aircraft Velocity - Subtype "1" Messages

The "SUBTYPE" subfield is a 3-bit ("ME" bit 6 through 8, Message bit 38 through 40) field used to identify the types of Airborne Velocity Information Messages as defined in Table 2-17.

Table 2-17: Airborne Velocity Information Message "SUBTYPE" Field Encoding

Coding	Primary Message Contents
0	NOT USED
1	Velocity Over Ground (i.e., Ground Speed) under normal airspeed, i.e., non-supersonic, conditions
2	Velocity Over Ground (i.e., Ground Speed) under supersonic conditions
3	Airspeed and Heading Information when Velocity Over Ground information is not available and airspeed conditions are normal, i.e., non-supersonic
4	Airspeed and Heading Information when Velocity Over Ground information is not available and airspeed conditions are supersonic
5	Not Assigned
6	Not Assigned
7	Not Assigned

The ADS-B Airborne Velocity Information - Subtype "1" Messages **shall** use a subtype encoding of "1."

2.2.3.2.6.1.3 "INTENT CHANGE FLAG" Subfield in Aircraft Velocity - Subtype "1" Messages

The "INTENT CHANGE FLAG" subfield is a 1-bit ("ME" bit 9, Message bit 41) field used to indicate a change in intent as defined in Table 2-18.

Table 2-18: "INTENT CHANGE FLAG" Encoding

Coding	Meaning
0	No Change in Intent
1	Intent Change

a. Mode-S Transponder Implementations

An Intent Change event is triggered 4 seconds after the detection of new information being inserted in GICB registers 4,0 to 4,2. This results in the "Intent Change Flag" being set to "1" and the code remains set for 18 +/- 1 seconds following the intent change.

Notes:

1. *GICB register 4,3 is not included since it contains dynamic data which will be continuously changing.*

2. *A four second delay is required to provide for settling time for intent data derived from manually set devices.*

b. Non-Transponder Implementations

Non-Transponder transmission devices do not implement GICB registers and therefore do not set the "Intent Change Flag." Therefore, such devices **shall** set the "Intent Change Flag" to ZERO at all times.

2.2.3.2.6.1.4 "IFR Capability Flag" Subfield in Aircraft Velocity - Subtype "1" Messages

The "IFR Capability Flag " subfield is a 1-bit ("ME" bit 10, Message bit 42) field that **shall** be used to indicate IFR capability by being encoded as defined in Table 2-19.

Table 2-19: "IFR CAPABILITY FLAG" Encoding

Coding	Meaning
0	Transmitting aircraft has no capability for applications requiring ADS-B equipage class "A1" or above
1	Transmitting aircraft has capability for applications requiring ADS-B equipage class "A1" or above

2.2.3.2.6.1.5 "NAC_V" Subfield in Aircraft Velocity - Subtype "1" Messages

Note: *The following preliminary requirements for NAC_V are included in the first version of the 1090 MHz ADS-B MOPS to provide the best possible guidance to avionics manufacturers with regard to this ADS-B Message/report field. This information has been developed through discussions with manufacturers of GPS equipment to be used in conjunction with the Wide Area Augmentation System (WAAS) and Local Area Augmentation System (LAAS). A subsequent version of this document will specify final NAC_V requirements, based upon further ADS-B/WAAS/LAAS experience and analysis.*

The ADS-B Transmitting Subsystem **shall** accept, via an appropriate data interface, data from which the own-vehicle Navigation Uncertainty Category for Velocity (NAC_V) may be inferred, and it **shall** use such data to establish the NAC_V subfields in transmitted ADS-B airborne velocity messages as follows:

a. If the external data source provides 95% accuracy figures of merit for horizontal and vertical velocity [$HFOM_R$ (Horizontal Figure of Merit for Velocity) and $VFOM_R$ (Vertical Figure of Merit for Velocity)], then the ADS-B Transmitting Subsystem **shall** determine the value of the NAC_V field in the Airborne Velocity Messages, subtypes 1, 2, 3 and 4 (§2.2.3.2.6.1, §2.2.3.2.6.2, §2.2.3.2.6.3 and §2.2.3.2.6.4, respectively) according to Table 2-20:

Table 2-20: Determining NAC_V If $HFOM_R$ and $VFOM_R$ Are Provided.

$HFOM_R$ value		$VFOM_R$ value	NAC_V value
$HFOM_R$ < 0.3 m/s (0.984 fps)	AND	$VFOM_R$ < 0.46 m/s (1.5 fps)	4
$HFOM_R$ < 1 m/s (3.28 fps)	AND	$VFOM_R$ < 1.5 m/s (5.0 fps)	3
$HFOM_R$ < 3 m/s (9.84 fps)	AND	$VFOM_R$ < 4.6 m/s (15.0 fps)	2
$HFOM_R$ < 10 m/s (32.8 fps)	AND	$VFOM_R$ < 15.2 m/s (50 fps)	1
$HFOM_R$ unknown <u>or</u>	OR	$VFOM_R$ unknown <u>or</u>	0

$HFOM_R \geq 10$ m/s (32.8 fps)		$VFOM_R \geq 15.2$ m/s (50 fps)	

Notes:

1. *The tests in the table are to be applied in the order shown, from the most stringent test (for $NAC_V = 4$) to the least stringent (for $NAC_V = 0$). That is, if $HFOM_R$ and $VFOM_R$ do not satisfy the conditions for $NAC_V = 4$, then they are tested against the conditions for $NAC_V = 3$. If they do not satisfy the conditions for $NAC_V = 3$, they are tested against the conditions for NAC_V = 2; and so on.*

2. *The $HFOM_R$ and $VFOM_R$ thresholds in this table are based upon the definitions of the NAC_V values in Table 2-1b of RTCA/DO-242A, the ADS-B MASPS.*

b. If the external data source does not provide $HFOM_R$ and $VFOM_R$, the 95% accuracy figures of merit for horizontal and vertical velocity, but it does provide 95% accuracy figures of merit for the horizontal and vertical positions [HFOM, Horizontal Figure of Merit for position, and VFOM, Vertical Figure of Merit for position], then the following tables may be used to determine the NAC_V value to be inserted in the Airborne Velocity message. The first of these tables **shall** be used if the position and velocity are obtained from a GNSS/LAAS or GNSS/WAAS receiver (Global Navigation Satellite System with Local Area Augmentation System or with Wide Area Augmentation System) when that receiver is operating in LAAS or WAAS mode. The second table **shall** be used if the position and velocity are obtained from a GNSS receiver operating in autonomous mode (that is, without LAAS or WAAS differential corrections).

<u>Table 2-21:</u> Determining NAC_V From a GNSS Receiver Operating in LAAS or WAAS Mode.

HFOM and VFOM values	NAC_V value
HFOM ≤ 1 m and VFOM ≤ 5.85 ft	4
(HFOM > 1 m or VFOM > 5.85 ft) and HFOM ≤ 4.5 m, and VFOM ≤ 23.3 ft	3
(HFOM > 4.5 m or VFOM >23.3 ft) and HFOM ≤ 14.5 m, and VFOM ≤ 73.3 ft	2
(HFOM > 14.5 m or VFOM >73.3 ft) and HFOM ≤ 49.5 m, and VFOM ≤ 248 ft	1
HFOM > 49.5 m or VFOM > 248 ft	0

<u>Table 2-22:</u> Determining NAC_V When Differential GNSS Corrections Are Not Available

HFOM and VFOM values	NAC_V value
HFOM ≤ 125 m, and VFOM ≤ 585 ft	2
HFOM > 475 m or VFOM > 2335 ft	0
(HFOM > 125 m or VFOM >585 ft) and HFOM ≤ 475 m, and VFOM ≤ 2335 ft	1

Note: *The rationale for the HFOM and VFOM thresholds in these tables is to be found in Appendix J of this MOPS.*

c. If the external source of position and velocity data provides neither 95% bounds on the accuracy of the velocity data ($HFOM_R$ and $VFOM_R$) nor 95% bounds on the accuracy of the position data (HFOM and VFOM), then the transmitting ADS-B device **shall** set the value of the NAC_V field in the Airborne Velocity messages to ZERO.

2.2.3.2.6.1.6 "EAST / WEST DIRECTION BIT" Subfield in Aircraft Velocity - Subtype "1" Messages

The "EAST / WEST DIRECTION BIT" subfield is a 1-bit ("ME" bit 14, Message bit 46) field is used to indicate the direction of the East / West Velocity Vector as defined in Table 2-23.

Table 2-23: "EAST / WEST DIRECTION BIT" Encoding

Coding	Meaning
0	EAST
1	WEST

2.2.3.2.6.1.7 "EAST / WEST VELOCITY" Subfield in Aircraft Velocity - Subtype "1" Messages

The "EAST / WEST VELOCITY" subfield is a 10-bit ("ME" bit 15 through 24, Message bit 47 through 56) field is used to report the East / West sub-sonic Velocity (in knots) of the ADS-B transmission device.

Range, Resolution, and No Data encoding of the "EAST / WEST VELOCITY" subfield **shall** be as shown in Table 2-24.

Table 2-24: "EAST / WEST VELOCITY" (sub-sonic) Encoding

Coding (binary)	**Coding** (decimal)	**Meaning** (E/W Velocity in knots)
00 0000 0000	0	No E/W Velocity information available
00 0000 0001	1	E/W Velocity is ZERO
00 0000 0010	2	E/W Velocity = 1 knot
00 0000 0011	3	E/W Velocity = 2 knots
***	***	***
11 1111 1110	1022	E/W Velocity = 1021 knots
11 1111 1111	1023	E/W Velocity > 1021.5 knots

Notes:

1. *The encoding shown in the table represents Positive Magnitude data only. Direction is given completely by the East/West Direction Bit.*

2. *Raw data used to establish the East/West Velocity Subfield will normally have more resolution (i.e., more bits) than that required by the East/West Velocity Subfield. When converting such data to the East/West Velocity Subfield, the*

*accuracy of the data **shall** be maintained such that it is not worse than +/- ½ LSB where the LSB is that of the East/West Velocity subfield.*

2.2.3.2.6.1.8 "NORTH / SOUTH DIRECTION BIT" Subfield in Aircraft Velocity - Subtype "1" Messages

The "NORTH / SOUTH DIRECTION BIT" subfield is a 1-bit ("ME" bit 25, Message bit 57) field is used to indicate the direction of the North / South Velocity Vector as shown in Table 2-25.

Table 2-25: "NORTH /SOUTH DIRECTION BIT" Encoding

Coding	Meaning
0	NORTH
1	SOUTH

2.2.3.2.6.1.9 "NORTH /SOUTH VELOCITY" Subfield in Aircraft Velocity - Subtype "1" Messages

The "NORTH / SOUTH VELOCITY" subfield is a 10-bit ("ME" bit 26 through 35, Message bit 58 through 67) field is used to report the North / South sub-sonic Velocity (in knots) of the ADS-B transmission device.

Range, Resolution, and No Data encoding of the "NORTH / SOUTH VELOCITY" subfield **shall** be as shown in Table 2-26.

Table 2-26: "NORTH / SOUTH VELOCITY" (sub-sonic) Encoding

Coding (binary)	**Coding** (decimal)	**Meaning** (N/S Velocity in knots)
00 0000 0000	0	No N/S Velocity information available
00 0000 0001	1	N/S Velocity is ZERO
00 0000 0010	2	N/S Velocity = 1 knot
00 0000 0011	3	N/S Velocity = 2 knots
***	***	***
11 1111 1110	1022	N/S Velocity = 1021 knots
11 1111 1111	1023	N/S Velocity > 1021.5 knots

Notes:

1. *The encoding shown in the table represents Positive Magnitude data only. Direction is given completely by the North/South Direction Bit.*

2. *Raw data used to establish the North/South Velocity Subfield will normally have more resolution (i.e., more bits) than that required by the North/South Velocity Subfield. When converting such data to the North/South Velocity Subfield, the accuracy of the data **shall** be maintained such that it is not worse than +/- ½ LSB where the LSB is that of the North/South Velocity subfield.*

2.2.3.2.6.1.10 "SOURCE BIT FOR VERTICAL RATE" Subfield in Aircraft Velocity - Subtype "1" Messages

The "SOURCE BIT FOR VERTICAL RATE " subfield is a 1-bit ("ME" bit 36, Message bit 68) field that **shall** be used to indicate the source of Vertical Rate information by being encoded as defined in Table 2-27.

Table 2-27: "SOURCE BIT FOR VERTICAL RATE" Encoding

Coding	Meaning
0	Vertical Rate information from Geometric Source (GNSS or INS)
1	Vertical Rate information from Barometric Source

2.2.3.2.6.1.11 "SIGN BIT FOR VERTICAL RATE" Subfield in Aircraft Velocity - Subtype "1" Messages

The "VERTICAL RATE SIGN BIT" subfield is a 1-bit ("ME" bit 37, Message bit 69) field used to indicate the direction of the Vertical Rate Vector as shown in Table 2-28.

Table 2-28: "SIGN BIT FOR VERTICAL RATE" Encoding

Coding	Meaning
0	UP
1	DOWN

2.2.3.2.6.1.12 "VERTICAL RATE" Subfield in Aircraft Velocity - Subtype "1" Messages

The "VERTICAL RATE" subfield is a 9-bit ("ME" bit through 38 through 46, Message bit 70 through 78) field is used to report the Vertical Rate (in feet/minute) of the ADS-B transmission device.

Range, Resolution, and No Data encoding of the "VERTICAL RATE" subfield **shall** be as shown in Table 2-29.

Table 2-29: "VERTICAL RATE" Encoding

Coding (binary)	**Coding** (decimal)	**Meaning** (VERTICAL RATE in feet / minute)
0 0000 0000	0	No Vertical Rate information available
0 0000 0001	1	Vertical Rate is ZERO
0 0000 0010	2	Vertical Rate = 64 feet / minute
0 0000 0011	3	Vertical Rate = 128 feet / minute
***	***	***
1 1111 1110	510	Vertical Rate = 32,576 feet / minute
1 1111 1111	511	Vertical Rate > 32,608 feet / minute

Note: *The encoding shown in the table represents **Positive Magnitude data only**. Direction is given completely by the Vertical Rate Sign Bit.*

2.2.3.2.6.1.13 "TURN INDICATOR" Subfield in Aircraft Velocity - Subtype "1" Messages

The "TURN INDICATOR" subfield is a 2-bit ("ME" bits 47 - 48, Message bits 79 - 80) field that **shall** be used to indicate that the vehicle is turning as shown in Table 2-30.

Table 2-30: "TURN INDICATOR" Encoding

Coding	Meaning
0	No Turn Information Available
1	Aircraft is NOT Turning
2	Aircraft is Turning Right at a rate of at least ***TBD*** degrees per second
3	Aircraft is Turning Left at a rate of at least ***TBD*** degree per second

Note: *Various international and domestic committees responsible for establishing Aviation related standards have not agreed upon the thresholds that should be used to determine if an aircraft is turning. Until such time that firm agreement is reached and standards established, the conventions provided in the following paragraphs **shall** be adhered to.*

a. ADS-B Transmitting Subsystems **shall** set the Turn Indicator coding to "**0.**"

b. ADS-B receiving devices **shall** ignore all Turn Indicator Codings other than "**0.**"

The ADS-B receiving devices **shall** set the Turn Indicator Coding to "**0**" for all applicable cases until further definition is provided in this document.

2.2.3.2.6.1.14 "DIFFERENCE FROM BAROMETRIC ALTITUDE SIGN BIT" Subfield in Aircraft Velocity - Subtype "1" Messages

The "DIFFERENCE FROM BAROMETRIC ALTITUDE SIGN BIT" subfield is a 1-bit ("ME" bit 49, Message bit 81) field used to indicate the direction of the GNSS Altitude Source data as shown in Table 2-31.

Table 2-31: "DIFFERENCE FROM BAROMETRIC ALTITUDE SIGN BIT" Encoding

Coding	Meaning
0	Geometric (GNSS or INS) Altitude Source data is greater than (above) Barometric
1	Geometric (GNSS or INS) Altitude Source data is less than (below) Barometric

2.2.3.2.6.1.15 "DIFFERENCE FROM BAROMETRIC ALTITUDE" Subfield in Aircraft Velocity - Subtype "1" Messages

The "DIFFERENCE FROM BAROMETRIC ALTITUDE" subfield is a 7-bit ("ME" bit through 50 through 56, Message bit 82 through 88) field is used to report the difference between Geometric (GNSS or INS) Altitude Source data and Barometric Altitude when both types of Altitude Data are available and valid. The difference between barometric altitude and GNSS Height Above Ellipsoid (HAE) is preferred. However, GNSS Altitude (MSL) may be used when airborne position is being reported using Type Codes 11 through 18. If airborne position is being reported using Type Codes 9 or 10, only GNSS Height Above the Ellipsoid (HAE) may be used. For Type Codes 9 and 10, if

GNSS Height Above the Ellipsoid (HAE) is not available, then the Difference from Barometric Altitude subfield **shall** be set to ALL ZEROs.

Note: *The basis for the barometric altitude difference (either GNSS HAE or Altitude MSL) must be used consistently for the reported difference.*

Range, Resolution, and No Data encoding of the "DIFFERENCE FROM BAROMETRIC ALTITUDE" subfield **shall** be as shown in Table 2-32.

Table 2-32: "DIFFERENCE FROM BAROMETRIC ALTITUDE" Encoding

Coding (binary)	**Coding** (decimal)	**Meaning** (Geometric (GNSS or INS) Altitude Source data Difference in feet)
000 0000	0	No GNSS Altitude Source data Difference information available
000 0001	1	GNSS Altitude Source data Difference is ZERO
000 0010	2	GNSS Altitude Source data Difference = 25 feet
000 0011	3	GNSS Altitude Source data Difference = 50 feet
***	***	***
111 1110	126	GNSS Altitude Source data Difference = 3,125 feet
111 1111	127	GNSS Altitude Source data Difference > 3,137.5 feet

Note: *The encoding shown in the table represents **Positive Magnitude data only**. Direction is given completely by the Difference From Barometric Altitude Sign Bit.*

2.2.3.2.6.2 ADS-B Airborne Velocity Message - Subtype "2"

a. The Airborne Velocity Information Message - Subtype "2" is illustrated in Figure 2-7a and **shall** be transmitted by the Airborne ADS-B Transmitting Subsystem when Velocity Over Ground information is available, and the transmitting device is installed in an environment having a Supersonic airspeed capability.

b. The Supersonic Version of the velocity message (i.e., Subtype "2") **shall** be used if either the East - West velocity OR the North - South velocity exceeds 1022 knots. A switch to the normal velocity message (i.e., Subtype "1") **shall** be made if both the East - West and the North - South velocities drop below 1000 knots.

c. This message **shall** not be broadcast if the only valid data are the Intent Change and the IFR Capability Flags.

(1). Transponder based ADS-B Transmitting Subsystems **shall** suppress the broadcast by loading register 0,9 with all "ZEROs" and then discontinuing updating of the register until data input is available again.

(2). Non-transponder based ADS-B Transmitting Subsystems **shall** simply suppress the broadcast.

Each of the subfields of the Subtype "2" message is defined in the following subparagraphs.

2.2.3.2.6.2.1 "TYPE" Subfield in Aircraft Velocity - Subtype "2" Messages

The "TYPE" subfield was previously defined in §2.2.3.2.3.1 and remains the same for ADS-B Airborne Velocity Information - Subtype "2" Messages which use Type Code 19 only.

2.2.3.2.6.2.2 "SUBTYPE" Subfield in Aircraft Velocity - Subtype "2" Messages

The "SUBTYPE" subfield was previously defined in §2.2.3.2.6.1.2 and remains the same for ADS-B Airborne Velocity Information - Subtype "2" Messages which **shall** use a subtype encoding of "2."

2.2.3.2.6.2.3 "INTENT CHANGE FLAG" Subfield in Aircraft Velocity - Subtype "2" Messages

The "INTENT CHANGE FLAG" subfield was previously defined in §2.2.3.2.6.1.3 and remains the same for ADS-B Airborne Velocity Information - Subtype "2" Messages.

2.2.3.2.6.2.4 "IFR Capability Flag" Subfield in Aircraft Velocity - Subtype "2" Messages

The "IFR Capability Flag" subfield was previously defined in §2.2.3.2.6.1.4 and remains the same for ADS-B Airborne Velocity Information - Subtype "2" Messages.

2.2.3.2.6.2.5 "NAC_V" Subfield in Aircraft Velocity - Subtype "2" Messages

The "Navigation Uncertainty Category - Velocity" (NAC_V) subfield was previously defined in §2.2.3.2.6.1.5 and remains the same for ADS-B Airborne Velocity Information - Subtype "2" Messages.

2.2.3.2.6.2.6 "EAST / WEST DIRECTION BIT" Subfield in Aircraft Velocity - Subtype "2" Messages

The "EAST / WEST Direction Bit" subfield was previously defined in §2.2.3.2.6.1.6 and remains the same for ADS-B Airborne Velocity Information - Subtype "2" Messages.

2.2.3.2.6.2.7 "EAST / WEST VELOCITY" Subfield in Aircraft Velocity - Subtype "2" Messages

The "EAST / WEST VELOCITY" subfield is a 10-bit ("ME" bit 15 through 24, Message bit 47 through 56) field is used to report the East / West supersonic Velocity (in knots) of the ADS-B transmission device.

Range, Resolution, and No Data encoding of the "EAST / WEST VELOCITY" subfield **shall** be as shown in Table 2-33.

Table 2-33: "EAST / WEST VELOCITY" (supersonic) Encoding

Coding (binary)	**Coding** (decimal)	**Meaning** (E/W Velocity in knots)
00 0000 0000	0	No E/W Velocity information available
00 0000 0001	1	E/W Velocity is ZERO
00 0000 0010	2	E/W Velocity = 4 knots
00 0000 0011	3	E/W Velocity = 8 knots
***	***	***
11 1111 1110	1022	E/W Velocity = 4,084 knots
11 1111 1111	1023	E/W Velocity > 4,086 knots

Notes:

1. *The encoding shown in the table represents Positive Magnitude data only. Direction is given completely by the East/West Direction Bit.*

2. *Raw data used to establish the East/West Velocity Subfield will normally have more resolution (i.e., more bits) than that required by the East/West Velocity Subfield. When converting such data to the East/West Velocity Subfield, the accuracy of the data **shall** be maintained such that it is not worse than +/- ½ LSB where the LSB is that of the East/West Velocity subfield.*

2.2.3.2.6.2.8 "NORTH / SOUTH DIRECTION BIT" Subfield in Aircraft Velocity - Subtype "2" Messages

The "NORTH / SOUTH Direction Bit" subfield was previously defined in §2.2.3.2.6.1.8 and remains the same for ADS-B Airborne Velocity Information - Subtype "2" Messages.

2.2.3.2.6.2.9 "NORTH / SOUTH VELOCITY" Subfield in Aircraft Velocity - Subtype "2" Messages

The "NORTH / SOUTH VELOCITY" subfield is a 10-bit ("ME" bit 26 through 35, Message bit 58 through 67) field is used to report the North / South Supersonic Velocity (in knots) of the ADS-B transmission device.

Range, Resolution, and No Data encoding of the "NORTH / SOUTH VELOCITY" subfield **shall** be as shown in Table 2-34.

Table 2-34: "NORTH / SOUTH VELOCITY" (supersonic) Encoding

Coding (binary)	**Coding** (decimal)	**Meaning** (N/S Velocity in knots)
00 0000 0000	0	No N/S Velocity information available
00 0000 0001	1	N/S Velocity is ZERO
00 0000 0010	2	N/S Velocity = 4 knots
00 0000 0011	3	N/S Velocity = 8 knots
***	***	***
11 1111 1110	1022	N/S Velocity = 4,084 knots
11 1111 1111	1023	N/S Velocity > 4,086 knots

Notes:

1. *The encoding shown in the table represents Positive Magnitude data only. Direction is given completely by the North/South Direction Bit.*

2. *Raw data used to establish the North/South Velocity Subfield will normally have more resolution (i.e., more bits) than that required by the North/South Velocity Subfield. When converting such data to the North/South Velocity Subfield, the accuracy of the data **shall** be maintained such that it is not worse than +/- ½ LSB where the LSB is that of the North/South Velocity subfield.*

2.2.3.2.6.2.10 "SOURCE BIT FOR VERTICAL RATE" Subfield in Aircraft Velocity - Subtype "2" Messages

The "Source Bit for Vertical Rate" subfield was previously defined in §2.2.3.2.6.1.10 and remains the same for ADS-B Airborne Velocity Information - Subtype "2" Messages.

2.2.3.2.6.2.11 "SIGN BIT FOR VERTICAL RATE" Subfield in Aircraft Velocity - Subtype "2" Messages

The "Sign Bit for Vertical Rate" subfield was previously defined in §2.2.3.2.6.1.11 and remains the same for ADS-B Airborne Velocity Information - Subtype "2" Messages.

2.2.3.2.6.2.12 "VERTICAL RATE" Subfield in Aircraft Velocity - Subtype "2" Messages

The "Vertical Rate" subfield was previously defined in §2.2.3.2.6.1.12 and remains the same for ADS-B Airborne Velocity Information - Subtype "2" Messages.

2.2.3.2.6.2.13 "TURN INDICATOR" Subfield in Aircraft Velocity - Subtype "2" Messages

The "Turn Indicator" subfield was previously defined in §2.2.3.2.6.1.13 and remains the same for ADS-B Airborne Velocity Information - Subtype "2" Messages.

2.2.3.2.6.2.14 "DIFFERENCE FROM BAROMETRIC ALTITUDE SIGN BIT" Subfield in Aircraft Velocity - Subtype "2" Messages

The "DIFFERENCE FROM BAROMETRIC ALTITUDE SIGN BIT" subfield was previously defined in §2.2.3.2.6.1.14 and remains the same for ADS-B Airborne Velocity Information - Subtype "2" Messages.

2.2.3.2.6.2.15 "DIFFERENCE FROM BAROMETRIC ALTITUDE" Subfield in Aircraft Velocity - Subtype "2" Messages

The "DIFFERENCE FROM BAROMETRIC ALTITUDE" subfield was previously defined in §2.2.3.2.6.1.15 and remains the same for ADS-B Airborne Velocity Information - Subtype "2" Messages.

2.2.3.2.6.3 ADS-B Airborne Velocity Message - Subtype "3"

a. The Airborne Velocity Information Message - Subtype "3" is illustrated in Figure 2-7b and **shall** be transmitted by the Airborne ADS-B Transmitting Subsystem when Velocity Over Ground information is not available, and the transmitting device is installed in an environment having *NON*-supersonic airspeed capability.

b. The Supersonic Version of the velocity message (i.e., Subtype "4") **shall** be used if the airspeed exceeds 1022 knots. A switch to the normal velocity message (i.e., Subtype "3") **shall** be made if the airspeed drops below 1000 knots.

c. This message **shall** not be broadcast if the only valid data is the Intent Change and the IFR Capability Flags.

   (1). Transponder based ADS-B Transmitting Subsystems **shall** suppress the broadcast by loading register 0,9 with all "ZEROs" and then discontinuing updating of the register until data input is available again.

   (2). Non-transponder based ADS-B Transmitting Subsystems **shall** simply suppress the broadcast.

Each of the subfields of the Subtype "3" message is defined in the following subparagraphs.

2.2.3.2.6.3.1 "TYPE" Subfield in Aircraft Velocity - Subtype "3" Messages

The "TYPE" subfield was previously defined in §2.2.3.2.3.1 and remains the same for ADS-B Airborne Velocity Information - Subtype "3" Messages which use Type Code 19 only.

2.2.3.2.6.3.2 "SUBTYPE" Subfield in Aircraft Velocity - Subtype "3" Messages

The "SUBTYPE" subfield was previously defined in §2.2.3.2.6.1.2 and remains the same for ADS-B Airborne Velocity Information - Subtype "3" Messages which **shall** use a subtype encoding of "3."

2.2.3.2.6.3.3 "INTENT CHANGE FLAG" Subfield in Aircraft Velocity - Subtype "3" Messages

The "INTENT CHANGE FLAG" subfield was previously defined in §2.2.3.2.6.1.3 and remains the same for ADS-B Airborne Velocity Information - Subtype "3" Messages.

2.2.3.2.6.3.4 "IFR Capability Flag" Subfield in Aircraft Velocity - Subtype "3" Messages

The "IFR Capability Flag" subfield was previously defined in §2.2.3.2.6.1.4 and remains the same for ADS-B Airborne Velocity Information - Subtype "3" Messages.

2.2.3.2.6.3.5 "NUC-R" Subfield in Aircraft Velocity - Subtype "3" Messages

The "Navigation Uncertainty Category - Velocity" (NUC-R) subfield was previously defined in §2.2.3.2.6.1.5 and remains the same for ADS-B Airborne Velocity Information - Subtype "3" Messages.

2.2.3.2.6.3.6 "MAGNETIC HEADING STATUS BIT" Subfield in Aircraft Velocity - Subtype "3" Messages

The "MAGNETIC HEADING STATUS BIT " subfield is a 1-bit ("ME" bit 14, Message bit 46) field is used to indicate the availability of Magnetic Heading information as shown in Table 2-35.

Table 2-35: "MAGNETIC HEADING STATUS BIT" Encoding

Coding	Meaning
0	Magnetic Heading Data is NOT Available
1	Magnetic Heading Data is Available

2.2.3.2.6.3.7 "MAGNETIC HEADING" Subfield in Aircraft Velocity - Subtype "3" Messages

The "MAGNETIC HEADING" subfield is an 10-bit (ME bits 15 through 24, Message bits 47 through 56) field is used to report the Magnetic Heading (in degrees) of the ADS-B transmission device.

Range, Resolution, and No Data encoding of the "MAGNETIC HEADING" subfield **shall** be as shown in Table 2-36.

Table 2-36: "MAGNETIC HEADING" (MHDG) Encoding

Coding (binary)	**Coding** (decimal)	**Meaning** (Magnetic Heading in degrees)
00 0000 0000	0	Magnetic Heading is ZERO
00 0000 0001	1	Magnetic Heading = 0.3515625 degrees
00 0000 0010	2	Magnetic Heading = 0.703125 degrees
00 0000 0011	3	Magnetic Heading = 1.0546875 degrees
***	***	***
01 1111 1111	511	Magnetic Heading = 179.6484375 degrees
10 0000 0000	512	Magnetic Heading = 180.0 degrees
10 0000 0001	513	Magnetic Heading = 180.3515625 degrees
10 0000 0010	514	Magnetic Heading = 180.703125 degrees
***	***	***
11 1111 1110	1022	Magnetic Heading = 359.296875 degrees
11 1111 1111	1023	Magnetic Heading = 359.6484375 degrees

Notes:

1. *The encoding shown in the table represents an angular weighted binary encoding in degrees clockwise from Magnetic North. The MSB represents a bit weighting of 180 degrees, while the LSB represents a bit weighting of 360/1024 degrees.*

2. *Raw data used to establish the Magnetic Heading Subfield will normally have more resolution (i.e., more bits) than that required by the Magnetic Heading Subfield. When converting such data to the Magnetic Heading Subfield, the accuracy of the data **shall** be maintained such that it is not worse than +/- ½ LSB where the LSB is that of the Magnetic Heading subfield.*

2.2.3.2.6.3.8 "AIRSPEED TYPE" Subfield in Aircraft Velocity - Subtype "3" Messages

The "AIRSPEED TYPE" subfield is a 1-bit ("ME" bit 25, Message bit 57) field used to indicate the type of subsonic airspeed data provided in the "Airspeed" Subfield (see §2.2.3.2.6.3.9) and is coded as defined in Table 2-37.

Table 2-37: "AIRSPEED TYPE" (subsonic) Encoding

Coding	Meaning
0	Airspeed Type is Indicated Airspeed (IAS)
1	Airspeed Type is True Airspeed (TAS)

2.2.3.2.6.3.9 "AIRSPEED" Subfield in Aircraft Velocity - Subtype "3" Messages

The "AIRSPEED" subfield is an 10-bit ("ME" bit 26 through 35, Message bit 58 through 67) field is used to report the subsonic Airspeed, either Indicated or True, of the ADS-B transmission device.

Range, Resolution, and No Data encoding of the "AIRSPEED" subfield **shall** be as shown in Table 2-38.

Table 2-38: "AIRSPEED" (IAS or TAS) (subsonic) Encoding

Coding (binary)	Coding (decimal)	Meaning (Airspeed in knots) (subsonic)
00 0000 0000	0	No Airspeed information available
00 0000 0001	1	Airspeed is ZERO
00 0000 0010	2	Airspeed = 1 knot
00 0000 0011	3	Airspeed = 2 knots
***	***	***
11 1111 1110	1022	Airspeed = 1,021 knots
11 1111 1111	1023	Airspeed > 1,021.5 knots

Note: *The encoding shown in the table represents **Positive Magnitude data only**, since Airspeed Data (IAS or TAS) is always considered to be positive.*

2.2.3.2.6.3.10 "SOURCE BIT FOR VERTICAL RATE" Subfield in Aircraft Velocity - Subtype "3" Messages

The "Source Bit for Vertical Rate" subfield was previously defined in §2.2.3.2.6.1.10 and remains the same for ADS-B Airborne Velocity Information - Subtype "3" Messages.

2.2.3.2.6.3.11 "SIGN BIT FOR VERTICAL RATE" Subfield in Aircraft Velocity - Subtype "3" Messages

The "Sign Bit for Vertical Rate" subfield was previously defined in §2.2.3.2.6.1.11 and remains the same for ADS-B Airborne Velocity Information - Subtype "3" Messages.

2.2.3.2.6.3.12 "VERTICAL RATE" Subfield in Aircraft Velocity - Subtype "3" Messages

The "Vertical Rate" subfield was previously defined in §2.2.3.2.6.1.12 and remains the same for ADS-B Airborne Velocity Information - Subtype "3" Messages.

2.2.3.2.6.3.13 "TURN INDICATOR" Subfield in Aircraft Velocity - Subtype "3" Messages

The "Turn Indicator" subfield was previously defined in §2.2.3.2.6.1.13 and remains the same for ADS-B Airborne Velocity Information - Subtype "3" Messages.

2.2.3.2.6.3.14 "DIFFERENCE FROM BAROMETRIC ALTITUDE SIGN BIT" Subfield in Aircraft Velocity - Subtype "3" Messages

The "DIFFERENCE FROM BAROMETRIC ALTITUDE SIGN BIT" subfield was previously defined in §2.2.3.2.6.1.14 and remains the same for ADS-B Airborne Velocity Information - Subtype "3" Messages.

2.2.3.2.6.3.15 "DIFFERENCE FROM BAROMETRIC ALTITUDE" Subfield in Aircraft Velocity - Subtype "3" Messages

The "DIFFERENCE FROM BAROMETRIC ALTITUDE" subfield was previously defined in §2.2.3.2.6.1.15 and remains the same for ADS-B Airborne Velocity Information - Subtype "3" messages.

2.2.3.2.6.4 ADS-B Airborne Velocity Message - Subtype "4"

a. The Airborne Velocity Information Message - Subtype "4" is illustrated in Figure 2-7b and **shall** be transmitted by the Airborne ADS-B Transmitting Subsystem when Velocity Over Ground information is ***NOT*** available, and the transmitting device is installed in an environment having Supersonic airspeed capability.

b. The Supersonic Version of the velocity message (i.e., Subtype "4") **shall** be used if the airspeed exceeds 1022 knots. A switch to the normal velocity message (i.e., Subtype "3") **shall** be made if the airspeed drops below 1000 knots.

c. This message **shall** not be broadcast if the only valid data is the Intent Change and the IFR Capability Flags.

   (1). Transponder based ADS-B Transmitting Subsystems **shall** suppress the broadcast by loading register 0,9 with all "ZEROs" and then discontinuing updating of the register until data input is available again.

   (2). Non-transponder based ADS-B Transmitting Subsystems **shall** simply suppress the broadcast.

Each of the subfields of the Subtype "4" message is defined in the following subparagraphs.

2.2.3.2.6.4.1 "TYPE" Subfield in Aircraft Velocity - Subtype "4" Messages

The "TYPE" subfield was previously defined in §2.2.3.2.3.1 and remains the same for ADS-B Airborne Velocity Information - Subtype "4" Messages which use Type Code 19 only.

2.2.3.2.6.4.2 "SUBTYPE" Subfield in Aircraft Velocity - Subtype "4" Messages

The "SUBTYPE" subfield was previously defined in §2.2.3.2.6.1.2 and remains the same for ADS-B Airborne Velocity Information - Subtype "3" Messages which **shall** use a subtype encoding of "4."

2.2.3.2.6.4.3 "INTENT CHANGE FLAG" Subfield in Aircraft Velocity - Subtype "4" Messages

The "INTENT CHANGE FLAG" subfield was previously defined in §2.2.3.2.6.1.3 and remains the same for ADS-B Airborne Velocity Information - Subtype "4" Messages.

2.2.3.2.6.4.4 "IFR Capability Flag" Subfield in Aircraft Velocity - Subtype "4" Messages

The "IFR Capability Flag" subfield was previously defined in §2.2.3.2.6.1.4 and remains the same for ADS-B Airborne Velocity Information - Subtype "4" Messages.

2.2.3.2.6.4.5 "NAC_V" Subfield in Aircraft Velocity - Subtype "4" Messages

The "Navigation Uncertainty Category - Velocity" (NAC_V) subfield was previously defined in §2.2.3.2.6.1.5 and remains the same for ADS-B Airborne Velocity Information - Subtype "4" Messages.

2.2.3.2.6.4.6 "MAGNETIC HEADING STATUS BIT" Subfield in Aircraft Velocity - Subtype "4" Messages

The "Magnetic Heading Status Bit" subfield was previously defined in §2.2.3.2.6.3.6 and remains the same for ADS-B Airborne Velocity Information - Subtype "4" Messages.

2.2.3.2.6.4.7 "MAGNETIC HEADING" Subfield in Aircraft Velocity - Subtype "4" Messages

The "Magnetic Heading" subfield was previously defined in §2.2.3.2.6.3.7 and remains the same for ADS-B Airborne Velocity Information - Subtype "4" Messages.

2.2.3.2.6.4.8 "AIRSPEED TYPE" Subfield in Aircraft Velocity - Subtype "4" Messages

The "AIRSPEED TYPE" subfield is a 1-bit ("ME" bit 25, Message bit 57) field used to indicate the type of supersonic airspeed data provided in the "Airspeed" Subfield (see §2.2.3.2.6.4.9) and is coded as defined in Table 2-39.

Table 2-39: "AIRSPEED TYPE" (supersonic) Encoding

Coding	Meaning
0	Airspeed Type is Indicated Airspeed (IAS)
1	Airspeed Type is True Airspeed (TAS)

2.2.3.2.6.4.9 "AIRSPEED" Subfield in Aircraft Velocity - Subtype "4" Messages

The "AIRSPEED" subfield is an 10-bit ("ME" bit 26 through 35, Message bit 58 through 67) field is used to report the subsonic Airspeed, either Indicated or True, of the ADS-B transmission device.

Range, Resolution, and No Data encoding of the "AIRSPEED" subfield **shall** be as shown in Table 2-40.

Table 2-40: "AIRSPEED" (IAS or TAS) (supersonic) Encoding

Coding (binary)	**Coding** (decimal)	**Meaning** (Airspeed in knots) (subsonic)
00 0000 0000	0	No Airspeed information available
00 0000 0001	1	Airspeed is ZERO
00 0000 0010	2	Airspeed = 4 knot
00 0000 0011	3	Airspeed = 8 knots
***	***	***
11 1111 1110	1022	Airspeed = 4,084 knots
11 1111 1111	1023	Airspeed > 4,086 knots

Note: *The encoding shown in the table represents* ***Positive Magnitude data only****, since Airspeed Data (IAS or TAS) is always considered to be positive.*

2.2.3.2.6.4.10 "SOURCE BIT FOR VERTICAL RATE" Subfield in Aircraft Velocity - Subtype "4" Messages

The "Source Bit for Vertical Rate" subfield was previously defined in §2.2.3.2.6.1.10 and remains the same for ADS-B Airborne Velocity Information - Subtype "4" Messages.

2.2.3.2.6.4.11 "SIGN BIT FOR VERTICAL RATE" Subfield in Aircraft Velocity - Subtype "4" Messages

The "Sign Bit for Vertical Rate" subfield was previously defined in §2.2.3.2.6.1.11 and remains the same for ADS-B Airborne Velocity Information - Subtype "4" Messages.

2.2.3.2.6.4.12 "VERTICAL RATE" Subfield in Aircraft Velocity - Subtype "4" Messages

The "Vertical Rate" subfield was previously defined in §2.2.3.2.6.1.12 and remains the same for ADS-B Airborne Velocity Information - Subtype "4" Messages.

2.2.3.2.6.4.13 "TURN INDICATOR" Subfield in Aircraft Velocity - Subtype "4" Messages

The "Turn Indicator" subfield was previously defined in §2.2.3.2.6.1.13 and remains the same for ADS-B Airborne Velocity Information - Subtype "4" Messages.

2.2.3.2.6.4.14 "DIFFERENCE FROM BAROMETRIC ALTITUDE SIGN BIT" Subfield in Aircraft Velocity - Subtype "4" Messages

The "DIFFERENCE FROM BAROMETRIC ALTITUDE SIGN BIT" subfield was previously defined in §2.2.3.2.6.1.14 and remains the same for ADS-B Airborne Velocity Information - Subtype "3" Messages.

2.2.3.2.6.4.15 "DIFFERENCE FROM BAROMETRIC ALTITUDE" Subfield in Aircraft Velocity - Subtype "4" Messages

The "DIFFERENCE FROM BAROMETRIC ALTITUDE" subfield was previously defined in §2.2.3.2.6.1.15 and remains the same for ADS-B Airborne Velocity Information - Subtype "4" Messages.

2.2.3.2.6.5 ADS-B Aircraft Velocity Message - Subtype "5, 6, & 7"

ADS-B Airborne Velocity Information Messages are not defined for Subtypes 5, 6 and 7 and **shall** be considered to be reserved for future expansion of Velocity Information Type Messages.

2.2.3.2.7 ADS-B Intent and Operational Status Messages

Type Codes 29 and 31 **shall** be used for Aircraft Intent and Aircraft Operational Status Messages. The structure of these messages is provided in detail in the subsequent paragraphs.

2.2.3.2.7.1 "Aircraft Trajectory Intent and System Status" (ATISS) Message

The "Aircraft Trajectory Intent and System Status" (ATISS) Message is used to provide the current state of an airborne aircraft in navigating to its intended trajectory and the status of the aircraft's navigation data source, CDTI and TCAS/ACAS systems. For this version of these MOPS the ATISS Message is defined to convey information on the aircraft's target heading and altitude (i.e. Target State information) as well as information on the status of the navigation data being used by ADS-B and the status of the aircraft CDTI and TCAS systems. The format of the ATISS Message **shall** be as defined in Figure 2.2.3.2.7.1, while further definition of each of the subfields **shall** be as defined in the subsequent paragraphs.

Notes:

1. *Future editions of these MOPS may include provisions for additional subtypes of ATISS Messages supporting broadcast of trajectory change information. An overview of such messages is provided in Appendix **TBD**.*

2. *At the time of the adoption of RTCA DO-260, it was decided by RTCA SC-186 Plenary that insufficient information was known about Trajectory Change Points and their usage to broadcast a TCP Valid Flag ("ME" bit 11) set equal to ONE (1), indicating that the following TCP Data was "Valid," without a clear understanding of what that data represented. It was agreed that the TCP Valid Flag be set to ZERO (0), until the issue of TCP was resolved by changes to the ADS-B MASPS, RTCA DO-242A. This would result in the TCP/TCP+1 Messages not being broadcast from a RTCA DO-260 compliant airborne implementation.*

   It was further agreed by the RTCA SC-186 Plenary, which approved DO-260 that all remaining text in DO-260 regarding TCP and TCP+1 was to remain as written, without modification, except for the test procedure in subparagraph 2.4.3.2.7.1.4, which deals specifically with the TCP Valid Flag in subparagraph 2.2.3.2.7.1.4.

   In these revised MOPS (RTCA DO-260A) the provisions of RTCA DO-260 related to TCP/TCP+1 have been removed and provisions for a ATISS Message has been defined using the same message Type Code value (i.e, Type Code = 29) as previously defined by RTCA DO-260 for the Aircraft Trajectory Intent Messages that conveyed TCP/TCP+1 information. It is not expected that any implementation based on RTCA DO-260 would have implemented the messages for TCP and TCP+1. However, for purposes of backward compatibility these MOPS require for a Type Code = 29 message that "ME" bit 11 always be set to ZERO (0), which would result in a RTCA DO-260 conformant ADS-B receiver not attempting to make use of the remaining contents of the message. Likewise, any Type Code = 29 message transmitted by an implementation based on DO-260 that has incorrectly set "ME" bit 11 set to ONE (1) (i.e., indicating a valid TCP/TCP+1 Message is being transmitted) should be discarded.

Aircraft Trajectory Intent and System Status (ATISS) Message			
MSG Bit #	33 ----------- 37	38 --------- 39	40 --------------------------- 88
ME Bit #	1 -------------- 5	6 ------------ 7	8 ----------------------------- 56
Field Name	Type Code = 29 (11101) [5]	Subtype Code [2]	Intent/Status Information (see §2.2.3.2.7.1.2) [49]
	MSB LSB	MSB LSB	MSB LSB

<u>Figure 2.2.3.2.7.1:</u> "Aircraft Trajectory Intent and System Status" (ATISS) Message Format

2.2.3.2.7.1.1 "TYPE Code" Subfield in ATISS Messages

The "TYPE Code" subfield was previously defined for the Airborne Position Message in §2.2.3.2.3.1 and **shall** use the same subfield format for the ATISS Message, which uses a TYPE Code of 29.

2.2.3.2.7.1.2 "SUBTYPE" Subfield in ATISS Messages

The "SUBTYPE" subfield is a 2-bit ("ME" bits 6 and 7, Message bits 38 and 39) field used to identify if the format of the remainder of the ATISS Message. The "SUBTYPE" subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.2.

Table 2.2.3.2.7.1.2: "SUBTYPE" Subfield Encoding

Encoding		Meaning
(binary)	(decimal)	
00	0	Target State and Status Information provided in the subsequent subfields of the message (see 2.2.3.2.7.1.3)
01	1	Reserved for Trajectory Change information to be conveyed in the subsequent subfields of the message
10	2	Reserved for Trajectory Change information to be conveyed in the subsequent subfields of the message
11	3	Reserved for Trajectory Change information to be conveyed in the subsequent subfields of the message

2.2.3.2.7.1.3 Target State and Status Information (SUBTYPE = 0 Format)

"Target State and Status Information" is conveyed by the ATISS Message (TYPE = 29) when the SUBTYPE = ZERO (0). The format of the Target State and Status Information **shall** as be in accordance with Figure 2.2.3.2.7.1.3.

MSG Bit #	33 ----- 37	38 ----- 39	40 ----- 41	42	43	44 ----- 45
ME Bit #	1 ----- 5	6 ----- 7	8 ----- 9	10	11	12 ----- 13
Field Name	TYPE Code =29 (1 1 1 0 1) [5]	SUBTYPE = 0 (0 0) [2]	Vertical Data Available/Source Indicator [2]	Target Altitude Type [1]	Backward Compatibility Flag = 0 [1]	Target Altitude Capability [2]
	MSB LSB	MSB LSB	MSB LSB			MSB LSB

MSG Bit #	46 --- 47	48 --- 57	58 --- 59	60 --- 68	69	70 --- 71
ME Bit #	14 --- 15	16 --- 25	26 --- 27	28 --- 36	37	38 --- 39
Field Name	Vertical Mode Indicator [2]	Target Altitude [10]	Horizontal Data Available/Source Indicator [2]	Target Heading /Track Angle [9]	Target Heading /Track Indicator [1]	Horizontal Mode Indicator [2]
	MSB LSB	MSB LSB	MSB LSB	MSB LSB		MSB LSB

MSG Bit #	72 --- 75	76	77 --- 78	79 --- 83	84 --- 85	86 --- 88
ME Bit #	40 --- 43	44	45 --- 46	47 --- 51	52 --- 53	54 --- 56
Field Name	NAC_P [4]	NIC_{BARO} [1]	SIL [2]	Reserved [5]	Capability /Mode Codes [2]	Emergency / Priority [3]
	MSB LSB		MSB LSB	MSB LSB	MSB LSB	MSB LSB

<u>Figure 2.2.3.2.7.1.3:</u> "Target State and Status Information" (SUBTYPE = 0 Format)

2.2.3.2.7.1.3.1 "Vertical Data Available/Source Indicator" Subfield in ATISS Messages

The "Vertical Data Available/Source Indicator" subfield is a 2-bit ("ME" bits 8 and 9, Message bits 40 and 41) field used to identify if aircraft vertical state information is available and present as well as the data source for the vertical data when present in the subsequent subfields ("ME" bits 10 through 25, Message bits 42 through 57) of the ATISS Message. The "Vertical Data Available/Source Indicator" subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.3.1. If the "Vertical Data Available/Source Indicator" subfield is encoded with a value of ZERO (0), the target altitude related data in the subsequent subfields **shall** be ignored.

Table 2.2.3.2.7.1.3.1: "Vertical Data Available/Source Indicator" Subfield Encoding

Encoding (binary)	Encoding (decimal)	Meaning
00	0	No valid Vertical Target State data is available
01	1	Autopilot control panel selected value, such as Mode Control Panel (MCP) or Flight Control Unit (FCU)
10	2	Holding Altitude
11	3	FMS/RNAV System

2.2.3.2.7.1.3.2 "Target Altitude Type" Subfield in ATISS Message

The "Target Altitude Type" subfield is a 1-bit ("ME" bit 10, Message bit 42) field used to identify whether the altitude reported in the "Target Altitude" subfield is referenced to mean sea level (MSL) or to a flight level (FL). The "Target Altitude Type" subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.3.2.

Table 2.2.3.2.7.1.3.2: "Trajectory Type" Subfield Encoding

Encoding	Meaning
0	Target Altitude referenced to Pressure Altitude (Flight Level)
1	Target Altitude referenced to Baro-Corrected Altitude (Mean Sea Level)

2.2.3.2.7.1.3.3 "Backward Compatibility Flag" Subfield in ATISS Message

The "Backward Compatibility Flag" subfield is a 1-bit ("ME" bit 11, Message bit 43) field used to provide backward compatibility for version 0 (zero) 1090 MHz ADS-B systems based on the initial version of these MOPS (i.e., in RTCA DO-260). RTCA DO-260 designated message TYPE = 29 for TCP and TCP+1 Messages. RTCA DO-260 required the "TCP/TCP+1 DATA VALID" subfield ("ME" bit 11) to be encoded with a value of ZERO (0), indicating the TCP/TCP+1 information in the message is not valid. For the current version of these MOPS where message TYPE = 29 is no longer being used for TCP/TCP+1 Messages, backward capability is provided by always setting "ME" bit 11 to a value of ZERO (0) in order to ensure that any receiving system based on the first version of these MOPS (i.e., based on RTCA DO-260) will ignore the contents of this message. Any TYPE = 29 message received with the "Backward Compatibility Flag" set to ONE (1) **shall** be discarded. The "Backward Compatibility Flag" subfield **shall** be encoded in accordance Table 2.2.3.2.7.1.3.3.

Table 2.2.3.2.7.1.3.3: "Backward Compatibility Flag" Subfield Encoding

Encoding	Meaning
0	Required Value
1	Invalid Message (discard entire Aircraft Trajectory Intent and System Status Message)

2.2.3.2.7.1.3.4 "Target Altitude Capability" Subfield in ATISS Message

The "Target Altitude Capability" subfield is a 2-bit ("ME" bits 12 and 13, Message bits 44 and 45) field used to describe the aircraft's capabilities for providing the data reported in the "Target Altitude" subfield. The "Target Altitude Capability" subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.3.4.

Table 2.2.3.2.7.1.3.4: "Target Altitude Capability" Subfield Encoding

Encoding		Meaning
(binary)	(decimal)	
00	0	Capability for reporting holding altitude only
01	1	Capability for reporting either holding altitude or autopilot control panel selected altitude
10	2	Capability for reporting either holding altitude, autopilot control panel selected altitude, or any FMS/RNAV level-off altitude
11	3	Reserved

2.2.3.2.7.1.3.5 "Vertical Mode Indicator" Subfield in ATISS Message

The "Vertical Mode Indicator" subfield is a 2-bit ("ME" bits 14 and 15, Message bits 46 and 47) field used to indicate whether the target altitude is in the process of being acquired (i.e., aircraft is climbing or descending toward the target altitude) or whether the target altitude has been acquired/being held. The "Vertical Mode Indicator" subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.3.5.

Table 2.2.3.2.7.1.3.5: "Vertical Mode Indicator" Subfield Encoding

Encoding		Meaning
(binary)	(decimal)	
00	0	Unknown Mode or Information Unavailable
01	1	"Acquiring" Mode
10	2	"Capturing" or "Maintaining" Mode
11	3	Reserved

2.2.3.2.7.1.3.6 "Target Altitude" Subfield in ATISS Message

The "Target Altitude" subfield is a 10-bit ("ME" bits 16 through 25, Message bits 48 through 57) field used to provide aircraft's next intended level-off altitude if in a climb or descent, or the aircraft current intended altitude if it is intending to hold its current altitude. It is intended that the reported "Target Altitude" be the operational altitude recognized by the aircraft's guidance system. The reported "Target Altitude" **shall** be consistent with the reported "Target Altitude Capability" as defined in 2.2.3.2.7.1.3.4. The "Target Altitude" subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.3.6.

Table 2.2.3.2.7.1.3.6: "Target Altitude" Subfield Encoding

Coding (binary)	Coding (decimal)	Meaning
00 0000 0000	0	Target Altitude = -1000 feet
00 0000 0001	1	Target Altitude = -900 feet
00 0000 0010	2	Target Altitude = -800 feet
***	***	***
00 0000 1011	11	Target Altitude = zero (0) feet
00 0000 1100	12	Target Altitude = 100 feet
***	***	***
11 1111 0010	1010	Target Altitude = 100,000 feet
11 1111 0011 - 11 1111 1111	1011 - 1023	Invalid (out of range)

2.2.3.2.7.1.3.7 "Horizontal Data Available/Source Indicator" Subfield in ATISS Message

The "Horizontal Data Available/Source Indicator" subfield is a 2-bit ("ME" bits 26 and 27, Message bits 58 and 59) field used to identify if aircraft horizontal state information is available and present as well as the data source for the horizontal target data when present in the subsequent subfields ("ME" bit 28 through 39, Message bit 60 through 71) of the ATISS Message. The "Horizontal Data Available/Source Indicator" subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.3.7. If the "Horizontal Data Available/Source Indicator" subfield is encoded with a value of ZERO (0), the target heading related data in the subsequent subfields **shall** be ignored.

Table 2.2.3.2.7.1.3.7: "Horizontal Data Available/Source Indicator" Subfield Encoding

Encoding		Meaning
(binary)	(decimal)	
00	0	No valid horizontal Target State data is available
01	1	Autopilot control panel selected value, such as Mode Control Panel (MCP) or Flight Control Unit (FCU)
10	2	Maintaining current heading or track angle (e.g., autopilot mode select)
11	3	FMS/RNAV System (indicates track angle specified by leg type)

2.2.3.2.7.1.3.8 "Target Heading/Track Angle" Subfield in ATISS Message

The "Target Heading/Track Angle" subfield is a 9-bit ("ME" bits 28 through 36, Message bits 60 through 68) field used to provide aircraft's intended (i.e., target or selected) heading or track. The "Target Heading/Track Angle" subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.3.8.

Table 2.2.3.2.7.1.3.8: "Target Heading/Track Angle" Subfield Encoding

Coding (binary)	Coding (decimal)	Meaning
0 0000 0000	0	Target Heading/Track = Zero degrees
0 0000 0001	1	Target Heading/Track = 1 degrees
0 0000 0010	2	Target Heading/Track = 2 degrees
***	***	***
1 0110 0111	359	Target Heading/Track = 359 degrees
1 0110 1000 through 1 1111 1111	360 through 511	Invalid

2.2.3.2.7.1.3.9 "Target Heading/Track Indicator" Subfield in ATISS Message

The "Target Heading/Track Indicator" subfield is a 1-bit ("ME" bit 37, Message bit 69) field used to indicate whether a heading angle or a track angle is being reported in the "Target Heading/Track Angle" subfield. The "Target Heading/Track Indicator" subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.3.9.

Table 2.2.3.2.7.1.3.9: "Target Heading/Track Indicator" Subfield Encoding

Encoding	Meaning
0	Target Heading Angle being reported
1	Target Track Angle being reported

2.2.3.2.7.1.3.10 "Horizontal Mode Indicator" Subfield in ATISS Message

The "Horizontal Mode Indicator" subfield is a 2-bit ("ME" bits 38 and 39, Message bits 70 and 71) field used to indicate whether the target heading/track is being acquired (i.e., lateral transition toward the target direction is in progress) or whether the target heading/track has been acquired and is currently being maintained. The "Horizontal Mode Indicator" subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.3.10.

Table 2.2.3.2.7.1.3.10: "Horizontal Mode Indicator" Subfield Encoding

Encoding		Meaning
(binary)	(decimal)	
00	0	Unknown Mode or Information Unavailable
01	1	"Acquiring" Mode
10	2	"Capturing" or "Maintaining" Mode
11	3	Reserved

2.2.3.2.7.1.3.11 "NAC_P" Subfield in ATISS Message

The "NAC_P" subfield is a 4-bit ("ME" bits 40 through 43, Message bits 72 through 75) field used to indicate the Navigational Accuracy Category of the navigation information used as the basis for the aircraft reported position. The "NAC_P" subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.3.11.

Table 2.2.3.2.7.1.3.11: "NAC_P" Subfield Encoding

Encoding (binary)	Encoding (decimal)	Meaning = 95% Horizontal and Vertical Accuracy Bounds (EPU and VEPU)
0000	0	EPU ≥ 18.52 km (10 NM) - Unknown accuracy
0001	1	EPU < 18.52 km (10 NM) - RNP-10 accuracy
0010	2	EPU < 7.408 km (4 NM) - RNP-4 accuracy
0011	3	EPU < 3.704 km (2 NM) - RNP-2 accuracy
0100	4	EPU < 1852 m (1NM) - RNP-1 accuracy
0101	5	EPU < 926 m (0.5 NM) - RNP-0.5 accuracy
0110	6	EPU < 555.6 m (0.3 NM) - RNP-0.3 accuracy
0111	7	EPU < 185.2 m (0.1 NM) - RNP-0.1 accuracy
1000	8	EPU < 92.6 m (0.05 NM) - e.g., GPS (with SA)
1001	9	EPU < 30 m and VEPU < 45 m - e.g., GPS (SA off)
1010	10	EPU < 10 m and VEPU < 15 m - e.g., WAAS
1011	11	EPU < 3 m and VEPU < 4 m - e.g., LAAS
1100 - 1111	12 - 15	Reserved

2.2.3.2.7.1.3.12 "NIC_{BARO}" Subfield in ATISS Message

The "NIC_{BARO}" (Barometric Altitude Integrity Code) subfield is a 1-bit ("ME" bit 44, Message bit 76) field used to indicate whether or not the barometric pressure altitude being reported in the Airborne Position Message (§2.2.3.2.3) has been cross-checked against another source of pressure altitude. The "NIC_{BARO}" subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.3.12.

Table 2.2.3.2.7.1.3.12: "NIC_{BARO}" Subfield Encoding

Encoding	Meaning
0	The barometric altitude that is being reported in the Airborne Position Message is based on a Gilham coded input (ARINC 572???TBD) that has not been cross-checked against another source of pressure altitude
1	The barometric altitude that is being reported in the Airborne Position Message is either based on a Gilham code input that has been cross-checked against another source of pressure altitude and verified as being consistent, or is based on a non-Gilham coded source

Notes:

1. *The NIC value itself is conveyed within the ADS-B Position Message.*

2. *The NIC_{BARO} subfield provides a method of indicating a level of data integrity for aircraft installed with Gilham encoding barometric altitude sources (ARINC 572???TBD). Because of the potential of an undetected error when using a Gilham encoded altitude source, a comparison will be performed with a second source and only if the two sources agree will the NIC_{BARO} subfield be set to a value of "1". For other barometric altitude sources (Synchro or DADC) the integrity of the data is indicated with a validity flag or SSM. No additional checks or comparisons are necessary. For these sources the NIC_{BARO} subfield will be set to a value of "1" whenever the barometric altitude is valid.*

3. *The use of Gilham type altimeters is strongly discouraged because of the potential for undetected altitude errors.*

2.2.3.2.7.1.3.13 "SIL" Subfield in ATISS Message

The "SIL" (Surveillance Integrity Level) subfield is a 2-bit ("ME" bits 45 and 46, Message bits 77 and 78) field used to define the probability of the integrity containment radius used in the NIC subfield being exceeded, without alerting, including the effects of the airborne equipment condition, which airborne equipment is in use, and which external signals are used by the navigation source. The "SIL" subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.3.13.

Table 2.2.3.2.7.1.3.13: "SIL" Subfield Encoding

Encoding		Meaning
(binary)	(decimal)	(Probability of Exceeding the Integrity Containment Radius Reported in the NIC Subfield Without Detection)
00	0	Unknown
01	1	1×10^{-3} per flight hour or per operation
10	2	1×10^{-5} per flight hour or per operation
11	3	1×10^{-7} per flight hour or per operation

2.2.3.2.7.1.3.14 "Capability/Mode Codes" Subfield in ATISS Message

The "Capability/Mode Codes" subfield is a 2-bit ("ME" bits 52 and 53, Message bits 84 and 85) field used to indicate the current operational status of TCAS/ACAS systems/functions. The "Capability/Mode Codes" subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.3.14 as two individual 1-bit length data elements that each indicates the status of a specific system or function on the transmitting aircraft.

Table 2.2.3.2.7.1.3.14: "Capability/Mode Codes" Subfield Encoding

Encoding	Meaning
ME bit 52 = 0	TCAS/ACAS operational or unknown
ME bit 52 = 1	TCAS/ACAS not operational
ME bit 53 = 0	No TCAS/ACAS Resolution Advisory active
ME bit 53 = 1	TCAS/ACAS Resolution Advisory active

2.2.3.2.7.1.3.15 "Emergency/Priority Status" Subfield in ATISS Message

The "Emergency/Priority Status" subfield is a 3-bit ("ME" bits 54 through 56, Message bits 86 through 88) field used to provide additional information regarding aircraft status. The "Emergency/Priority Status" subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.3.15.

Table 2.2.3.2.7.1.3.15: "Emergency/Priority Status" Subfield Encoding

Encoding		Meaning
(binary)	(decimal)	
000	0	No emergency
001	1	General emergency
010	2	Lifeguard/medical emergency
011	3	Minimum fuel
100	4	No communications
101	5	Unlawful interference
110	6	Downed Aircraft
111	7	Reserved

2.2.3.2.7.1.4 Trajectory Change Information (TYPE = 29 and SUBTYPE > 0) Format

This section is reserved for future editions of these MOPS to define Trajectory Change Information to be conveyed by the Aircraft Trajectory Intent and System Status Message with TYPE Code equal to 29 and the SUBTYPE greater than ZERO (0).

2.2.3.2.7.2 "AIRCRAFT OPERATIONAL STATUS" Messages

The "Aircraft Operational Status Message" is used to provide the current status of the aircraft. The format of the message is provided in Figure 2-10, while further definition of each of the subfields is provided in the subsequent paragraphs.

	"AIRCRAFT OPERATIONAL STATUS" MESSAGE "ME" FIELD												
Msg Bit #	33 37	38 40	41 52	53 56	57 72	73 75	76	77 80	81 82	83 84	85	86	87 88
"ME" Bit #	1 5	6 8	9 20	21 24	25 40	41 43	44	45 48	49 50	51 52	53	54	55 56
Field Name	**Type = 31** [5]	**Subtype** = 0 [3]	**Capability Class (CC) Codes** [16]		**Operational Mode (OM) Codes** [16]	**Version No.** [3]	**NIC Supp.** [1]	**NAC_P** [4]	**BAQ = 0** [2]	**SIL** [2]	**NIC_{baro}** [1]	**HRD [1]**	**Reserved** [2]
		Subtype = 1 [3]	**CC Codes** [12]	**L/W Codes** [4]					**Reserved** [2]		**TRK/HDG** [1]		
	MSB LSB	MSB LSB	MSB LSB	MSB LSB	MSB LSB	MSB LSB	MSB	MSB LSB	MSB LSB	MSB LSB	MSB	MSB	LSB

Note: Subfields that are relevant only for Airborne Participants are allocated to Subtype ZERO (binary 000), while those that pertain only to surface participants are allocated to Subtype ONE (binary 001).

<u>Figure 2-10:</u> "Aircraft Operational Status" ADS-B Message Format

2.2.3.2.7.2.1 "TYPE" Subfield in Aircraft Operational Status Messages

The "TYPE" subfield was previously defined for the Airborne Position Message in §2.2.3.2.3.1 and remains the same for the Aircraft Operational Status Message that uses Type Code 31.

2.2.3.2.7.2.2 "SUBTYPE" Subfield in Aircraft Operational Status Messages

The "SUBTYPE" subfield is a 3-bit ("ME" bits 6 through 8, Message bits 38 through 40) subfield used to indicate various types of Aircraft Operational Status Messages as defined in Table 2-53.

Table 2-53: "SUBTYPE" Subfield in Aircraft Operational Status Messages Encoding

Subtype Coding	Meaning
0	Message contains Aircraft Operational Status data as shown in Figure 2-10 for Airborne Participants
1	Message contains Aircraft Operational Status data as shown in Figure 2-10 for Surface Participants
2 - 7	Reserved for future Growth

2.2.3.2.7.2.3 "CAPABILITY CLASS (CC)" Subfield in Aircraft Operational Status Messages

The Capability Codes (CC) subfield of the Aircraft Operational Status Message occupies 16 bits in the "airborne" format of that message and 12 bits in the "surface" format of the message. In the airborne format (message with Type = 31, Subtype = 0), the CC codes occupy "ME" bits 9 through 24 (Message bits 41 through 56). In the surface format (Type Code = 31, Subtype = 1), the CC codes occupy "ME" bits 9 through 20 (Message bits 41 through 52). The format of this subfield depends on the Version Number subfield (§2.2.3.2.7.3.5). Moreover, for messages transmitted from a "Version 1" ADS-B transmitting subsystem, the CC format depends on whether the message Subtype field is has a value of 0 or 1.

If the Version Number subfield (§2.2.3.2.7.3.5) is 0, the format of the CC subfield is as defined in the initial version of this MOPS (RTCA DO-260). This is summarized in Table 2.2.3.2.7.3.3A below.

Table 2.2.3.2.7.3.3A: Capability Class (CC) Code Format in Version 0 Transmitting Susbystems

Msg Bit #	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
"ME" Bit #	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Content	0	0	~TCAS	CDTI	Unused											

Notes for Table 2.2.3.2.7.3.3A:

1. *~TCAS = "TCAS/ACAS Not Installed Or Not Operational"*
2. *CDTI = "CDTI Traffic Display Capability"*
3. *Reserved = "Reserved for standardization in future versions of this MOPS"*

If the Version Number subfield (§2.2.3.2.7.3.4) is 1 (for ADS-B Transmitting Subsystems conformant to RTCA DO-260A, and the Subtype subfield is 0, the format of the CC subfield **shall** be as defined in Table 3.3.4.3.7.3.3B below.

Table 2.2.3.2.7.3.3B: Airborne Capability Class (CC) Code Format in Version 1 Transmitting Subsystems.

Msg Bit #	41	42	43	44	45	46	47	48	49	50	51	53 -- 56
"ME" Bit #	9	10	11	12	13	14	15	16	17	18	19	21 -- 24
Content	**Service Level** MSBs = 0 0		**~TCAS**	**CDTI**	**Service Level** LSBs = 0 0		**ARV**	**TS**	**TC**		**POA**	Reserved

Notes for Table 2.2.3.2.7.3.3B:

1. *~TCAS = "TCAS/ACAS Not Installed Or Not Operational"*
2. *CDTI = "CDTI Traffic Display Capability"*
3. *ARV = "ARV Report Capability"*
4. *TS = "TS Report Capability"*
5. *TC = "TC Report Capability Level"*
6. *POA = "Position Offset Applied"*
7. *Reserved = "Reserved for standardization in future versions of this MOPS"*

If the Version Number subfield (§2.2.3.2.7.3.4) is 1 and the Aircraft Operational Status Message Subtype subfield is 1, then the format of the CC subfield **shall** be as defined in Table 3.3.4.3.7.3.3C below.

<u>Table 2.2.3.2.7.3.3C</u>: Surface Capability Class (CC) Code Format in Version 1 Transmitting Subsystems.

Msg Bit #	41	42	43	44	45	46	47	48	49	50	51	52
"ME" Bit #	9	10	11	12	13	14	15	16	17	18	19	20
Content	**Service Level** MSBs = 0 0		**POA**	**CDTI**	**Service Level** LSBs = 0 0		**Reserved**					

<u>Notes for Table 2.2.3.2.7.3.3C:</u>

1. CDTI = "CDTI Traffic Display Capability"
2. POA = "Position Offset Applied"
3. Reserved = "Reserved for standardization in future versions of this MOPS"

2.2.3.2.7.2.3.1 "Reserved for Service Level" CC Code Subfield in Aircraft Operational Status Message

Within the CC Code subfield, a four-bit subfield ("ME" bits 41-42 and 45- 46, Message bits 9-10 and 13-14) is reserved for the "Service Level" of the ADS-B transmitting subsystem. ADS-B equipment conforming to Version 1 (DO-260A) of these MOPS **shall** set the Service Level code to ALL ZEROs.

<u>Note:</u> *When Service Levels are defined in the ASA MASPS, future versions of these MOPS will define values other than zero for this CC code subfield.*

2.2.3.2.7.2.3.2 "~TCAS" CC Code Subfield in Aircraft Operational Status Messages

The "~TCAS" (pronounced "not Tee Cass") subfield of the CC Codes subfield in Aircraft Operational Status Messages is so called because it is encoded with the opposite sense from that of the "TCAS/ACAS Installed and Operational" field in Mode Status reports (§***<u>TBD</u>***). This subfield is available if the Version Number subfield is ZERO (indicating that the message comes from a DO-260 conformant ADS-B Transmitting Subsystem), or if the Version Number subfield is ONE and the Subtype subfield is ZERO (indicating that the message comes from a DO-260A conformant ADS-B Transmitting Subsystem that is airborne).

The coding of "~TCAS" CC Code subfield, and of the corresponding subfield in Mode Status reports, **shall** be as specified in Table 2.2.3.2.7.2.3.2 below.

<u>Table 2.2.3.2.7.2.3.2:</u> Encoding of "~TCAS" CC Subfield in Aircraft Operational Status Messages.

"~TCAS" CC Code Encoding in Aircraft Operational Status Message	**"TCAS/ACAS Installed and Operational" CC Code Encoding in MS Report**	**Meaning**
0	1	TCAS operational or unknown
1	0	TCAS not installed or not operational

The "~TCAS" CC Code in Aircraft Operational Status Messages **shall** be set to ZERO in Aircraft Operational Status Messages if the transmitting aircraft is fitted with a TCAS II or ACAS computer and that computer is turned on and operating in a mode that can generate Resolution Advisory (RA) alerts. Likewise, this CC Code Subfield in Aircraft Operational Status Messages **shall** be set to ZERO if the ADS-B transmitting subsystem cannot ascertain whether or not a TCAS II or ACAS computer is installed, or cannot ascertain whether that computer, if installed, is operating in a mode that can generate RA alerts. Otherwise, this CC Code Subfield in Aircraft Operational Status Messages **shall** be set to ONE.

Notes:

1. *The corresponding "TCAS/ACAS Operational" CC code in Mode Status Reports (§**TBD**) has opposite sense: a ONE in the CC Code in the Mode Status Report means "TCAS/ACAS operational or unknown," while a ZERO in that part of the Mode Status Report means "TCAS/ACAS not installed or not operational."*

2. *The encoding of this CC Code subfield in the Aircraft Operational Status Message is chosen for compatibility with the initial (DO-260) version of these MOPS. The coding of the corresponding subfield in the Mode Status Report (§**TBD**) is chosen for compliance with the current version (DO-242A) of the ADS-B MASPS.*

3. *It is the responsibility of the Report Assembly Function (§**TBD**) to invert the "~TCAS" CC Code as received in Aircraft Operational Status Messages to form the "TCAS/ACAS Installed and Operational" CC code in Mode Status Reports.*

2.2.3.2.7.2.3.3 "CDTI Traffic Display Capability" CC Code Subfield in Aircraft Operational Status Messages

The CC Code for "CDTI Traffic Display Capability" in Aircraft Operational Status Messages (Type = 31, Subtype = 0 or 1) that **shall** be set to ONE if the transmitting aircraft has a Cockpit Display of Traffic Information (CDTI) installed and that display is currently operating in a mode capable of displaying nearby ADS-B traffic. Otherwise, this CC code **shall** be ZERO.

2.2.3.2.7.2.3.4 "ARV Report Capability" CC Code Subfield in Aircraft Operational Status Messages

The "ARV Report Capability" subfield of the CC Codes subfield is a one-bit Boolean flag that **shall** be encoded as defined in Table 2.2.3.2.7.2.3.4:

Table 2.2.3.2.7.2.3.4: ARV Report Capability Encoding.

ARV Report Capability Flag	Meaning
0	No capability for Air Referenced Velocity Reports
1	Capability of sending messages to support Air-Referenced Velocity

ARV Report Capability Flag	Meaning
	Reports.

2.2.3.2.7.2.3.5 "TS Report Capability" CC Code Subfield in Aircraft Operational Status Messages

The "Target State (TS) Report Capability" subfield of the CC Codes subfield is a one-bit Boolean flag in the "airborne" format of the Aircraft Operational Status Message (Type = 31, Subtype = 0) that **shall** be encoded as defined in Table 2.2.3.2.7.2.3.5:

Table 2.2.3.2.7.2.3.5: TS Report Capability Encoding.

TS Report Capability Flag	Meaning
0	No capability for Target State Reports
1	Capability of sending messages to support Target State Reports.

2.2.3.2.7.2.3.6 "TC Report Capability" CC Code Subfield in Aircraft Operational Status Messages

The "Trajectory Change (TC) Report Capability" subfield of the CC Code subfield is a two-bit subfield in the "airborne" format of the Aircraft Operational Status Message (Type = 31, Subtype = 0) that **shall** be encoded as defined in Table 2.2.3.2.7.2.3.6:

Table 2.2.3.2.7.2.3.6: TC Report Capability Encoding.

TC Report Capability Flag	Meaning
0	No capability for Target State Reports
1	Capability of sending messages to support TC+0 Report only.
2	Capability of sending information for multiple TC reports.
3	(Reserved for future use.)

2.2.3.2.7.2.3.7 "Position Offset Applied" CC Code Subfield in Aircraft Operational Status Messages

The "Position Offset Applied"(POA) subfield of the CC Code subfield of the "surface" format Aircraft Operational Status Message (Type = 31, Subtype = 1) is a one-bit Boolean flag that the ADS-B transmitting subsystem **shall** set to ONE if the position that it is transmitting (in Airborne Position Messages (§2.2.3.2.3) and Surface Position Messages (§2.2.3.2.4)) is known to be the position of the ADS-B participant's ADS-B position reference point (§***TBD***) rather than, for example, the position of the antenna of the navigation receiver. Otherwise, the ADS-B transmitting subsystem **shall** set this flag to ZERO.

2.2.3.2.7.2.4 "OPERATIONAL MODE (OM)" Subfield in Aircraft Operational Status Messages

The "Operational Mode (OM)" subfield is a 16-bit subfield ("ME" bits 25 through 40, Message bits 57 through 72) that indicates operational modes that are active on board the A/V in which the ADS-B transmitting subsystem resides. The format of the OM subfield in Aircraft Operational Status Messages **shall** be as defined in Table 2.2.3.2.7.2.4.

Table 2.2.3.2.7.2.4: Operational Mode (OM) Subfield Format.

<table>
<tr><th>Msg Bit #</th><th>57</th><th>58</th><th>59</th><th>60</th><th>61</th><th>62 -- 72</th></tr>
<tr><th>"ME" Bit #</th><td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30 -- 40</td></tr>
<tr><td rowspan="4">OM Format</td><td colspan="2">0 0</td><td>RA Active</td><td>IDENT Switch Active</td><td>Receiving ATC Services</td><td>Reserved</td></tr>
<tr><td colspan="2">0 1</td><td colspan="4">Reserved</td></tr>
<tr><td colspan="2">1 0</td><td colspan="4">Reserved</td></tr>
<tr><td colspan="2">1 1</td><td colspan="4">Reserved</td></tr>
</table>

2.2.3.2.7.2.4.1 OM Subfield Format Code in Aircraft Operational Status Messages

The first two bits of the OM subfield ("ME" bits 25 and 26) are reserved for selecting one of up to four OM subfield formats. For this version of these MOPS (DO-260A), the OM subfield format code **shall** be set to ZERO.

2.2.3.2.7.2.4.2 "TCAS/ACAS Resolution Advisory Active" OM Code Subfield in Aircraft Operational Status Message

The "TCAS/ACAS Resolution Advisory Active" (RA Active) Operational Mode Code is a one-bit subfield ("ME" bit 11, Message bit 43) of the OM subfield in Aircraft Operational Status Messages. The ADS-B transmitting subsystem **shall** set this code to ONE so long as a TCAS II or ACAS resolution advisory is known to be in effect; otherwise, it **shall** set this OM code to ZERO.

Note: *The requirement for an interface by which the ADS-B transmitting subsystem may be informed when a TCAS/ACAS resolution advisory is active is specified in §**TBD**.*

2.2.3.2.7.2.4.3 "IDENT Switch Active" OM Code Subfield in Aircraft Operational Status Message

The "IDENT Switch Active" Operational Mode code is a one-bit subfield ("ME" bit 12, message bit 44) of the OM Code subfield in Aircraft Operational Status Messages. Initially, the "IDENT Switch Active" OM Code **shall** be set to ZERO. Upon activation of the IDENT switch, the ADS-B transmitting subsystem **shall** set this code to ONE for a period of 20 ± 3 seconds; thereafter, the ADS-B transmitting subsystem **shall** set this OM Code to ZERO.

Note: *The requirement for an interface by which the ADS-B transmitting subsystem may be informed when the IDENT switch is active is given in §**TBD** below.*

2.2.3.2.7.2.4.4 "Receiving ATC Services" OM Code Subfield in Aircraft Operational Status Message

The "Receiving ATC Services" Operational Mode Code is a one-bit subfield ("ME" bit 13, Message bit 45) of the OM Code subfield in Aircraft Operational Status Messages. The ADS-B transmitting subsystem **shall** set this OM Code to ONE when the ADS-B transmitting subsystem is receiving ATC services, as indicated by an appropriate interface on board the transmitting aircraft. Otherwise, this OM Code **shall** be set to ZERO.

Note: *The requirement for an interface by which the ADS-B transmitting subsystem may be informed when the aircraft is receiving ATC services is given in §**TBD.***

2.2.3.2.7.2.5 Version Number Subfield in Aircraft Operational Status Message

The "Version Number" (VN) subfield is a 3-bit ("ME" bits 41 through 43, Message bits 73 through 75) field used to indicate the Version Number of the formats and protocols in use on the aircraft installation. Encoding of the Version Number subfield **shall** be as shown in Table 2.2.3.2.7.2.5. Airborne ADS-B systems conformant to the initial version of the 1090 MHz ADS-B MOPS (RTCA DO-260) do not broadcast an explicit Version Number. Therefore, ADS-B Receiving Subsystems conformant with this version of the 1090 MHz MOPS (RTCA DO-260A) will initially assume a Version Number of ZERO (binary 000), until received Version Number data indicates otherwise.

Future versions of these MOPS are expected to maintain backward compatibility with RTCA DO-260A. Messages originating from 1090 MHz ADS-B aircraft reporting a MOPS Version Number value that is indicated in Table A-21 as "Reserved" are to be considered valid. However, all message types and all subfields within messages that are currently "Unassigned" or are indicated as being "Reserved" by these MOPS **shall** be ignored and not used for ADS-B Report Generation.

Table 2.2.3.2.7.2.5: Version Number Encoding

VERSION NUMBER SUBFIELD		
Coding		**Meaning**
(binary)	**(decimal)**	
000	0	Conformant to DO-260
001	1	Conformant to DO-260A
010 – 111	2 – 7	Reserved

2.2.3.2.7.2.6 "NIC Supplement" Subfield in Aircraft Operational Status Messages

The NIC Supplement subfield in the Aircraft Operational Status message is a one-bit subfield ("ME" bit 44, Message bit 76) that, together with the TYPE subfield in

Airborne Position and Surface Position Messages, is used to encode the Navigation Integrity Category (NIC) of the transmitting ADS-B participant.

Note: *The Navigation Integrity Category (NIC) is reported so that surveillance applications may determine whether the reported geometric position has an acceptable level of integrity for the intended use. See §2.1.2.12 of RTCA DO-242A, the ADS-B MASPS, for a fuller description of the Navigation Integrity Category.*

Table 2.2.3.2.7.2.6 lists the possible NIC codes and the values of the Position Message Type codes, and of the NIC Supplement subfield that **shall** be used to encode those NIC Modes in messages on the 1090 MHz ADS-B data link.

Table 2.2.3.2.7.2.6: Navigation Integrity Category (NIC) Encoding.

NIC Value	Containment Radius (R_C) and Vertical Protection Limit (VPL)	Airborne		Surface	
		Airborne Position Type Code	NIC Supplement Code	Surface Position Type Code	NIC Supplement Code
0	R_C unknown	0, 18, 22	0	0, 8	0
1	R_C < 20 NM (37.04 km)	17	0	N/A	N/A
2	R_C < 8 NM (14.816 km)	16	0	N/A	N/A
3	R_C < 4 NM (7.408 km)	16	1	N/A	N/A
4	R_C < 2 NM (3.704 km)	15	0	N/A	N/A
5	R_C < 1 NM (1852 m)	14	0	N/A	N/A
6	R_C < 0.6 NM (1111.2 m)	13	0	N/A	N/A
7	R_C < 0.2 NM (370.4 m)	12	0	N/A	N/A
8	R_C < 0.1 NM (185.2 m)	11	0	7	0
9	R_C < 75m *and* VPL < 112 m	10	0	6	0
10	R_C < 25m *and* VPL < 37.5 m	10	1	6	1
		21	0		
11	R_C < 7.5m *and* VPL < 11 m	9, 20	0	5	0

Note: *"N/A" means "This NIC value is not available in the Surface Position Message formats."*

2.2.3.2.7.2.7 "Navigation Accuracy Category for Position (NAC_P) Subfield in Aircraft Operational Status Messages

The Navigation Accuracy Category for Position (NAC_P) is a four-bit subfield of the Aircraft Operational Status Message ("ME" bits 45 to 48, Message bits 77 to 80) that announces 95% accuracy limits for the horizontal position (and for some NAC_P values, the vertical position) that is being currently broadcast in airborne position and surface position messages. Table 2.2.3.2.7.2.7 defines the accuracy limits for each NAC_P value.

Note: *The Navigation Accuracy Category for Position (NAC_P) is reported so that surveillance applications may determine whether the reported geometric position has an acceptable level of accuracy for the intended use. See §2.1.2.13 of the ADS-B MASPS, RTCA DO-242A, for a fuller description of NAC_P.*

Table 2.2.3.2.7.2.7: Encoding of Navigation Accuracy Category for Position (NAC_P)

NAC_P	95% Horizontal and Vertical Accuracy Bounds (EPU and VEPU)	Comment	Notes
0	EPU ≥ 18.52 km (10 NM)	Unknown accuracy	1
1	EPU < 18.52 km (10 NM)	RNP-10 accuracy	1, 3
2	EPU < 7.408 km (4 NM)	RNP-4 accuracy	1, 3
3	EPU < 3.704 km (2 NM)	RNP-2 accuracy	1, 3
4	EPU < 1852 m (1 NM)	RNP-1 accuracy	1, 3
5	EPU < 926 m (0.5 NM)	RNP-0.5 accuracy	1, 3
6	EPU < 555.6 m (0.3 NM)	RNP-0.3 accuracy	1, 3
7	EPU < 185.2 m (0.1 NM)	RNP-0.1 accuracy	1, 3
8	EPU < 92.6 m (0.05 NM)	e.g., GPS (with SA on)	1
9	EPU < 30 m and VEPU < 45 m	e.g., GPS (SA off)	1, 2, 4
10	EPU < 10 m and VEPU < 15 m	e.g., WAAS	1, 2, 4
11	EPU < 3 m and VEPU < 4 m	e.g., LAAS	1, 2, 4

Notes for Table 2.2.3.2.7.2.7:

1. *The Estimated Position Uncertainty (EPU) used in the table is a 95% accuracy bound on horizontal position. EPU is defined as the radius of a circle, centered on the reported position, such that the probability of the actual position lying outside the circle is 0.05. When reported by a GPS or GNSS system, EPU is commonly called HFOM (Horizontal Figure of Merit).*

2. *Vertical Estimated Position Uncertainty (VEPU) is a 95% accuracy limit on the vertical position (geometric altitude). VEPU is defined as a vertical position limit, such that the probability of the actual geometric altitude differing from the reported geometric altitude by more than that limit is 0.05. When reported by a GPS or GNSS system, VEPU is commonly called VFOM (Vertical Figure of Merit).*

3. *RNP accuracy includes error sources other than sensor error, whereas horizontal error for NAC_P only refers to horizontal position error uncertainty.*

4. *If geometric altitude is not being reported, then the VEPU tests are not assessed.*

2.2.3.2.7.2.8 "Reserved for Barometric Altitude Quality (BAQ)" Subfield in Aircraft Operational Status Messages

The "Reserved for Barometric Altitude Quality (BAQ)" subfield of "subtype 0" Aircraft Operational Status Message is a two-bit field ("ME" bits 51-52, Message bits 83-84) that **shall** be set to ZERO by ADS-B Transmitting Subsystems that conform to these MOPS (RTCA DO-260A).

Note: *Non-zero versions of the BAQ subfield will be defined in future version of this MOPS. One possible future encoding for this subfield is described in a Note in §2.1.2.16 of RTCA DO-242A, the ADS-B MASPS.*

2.2.3.2.7.2.9 "Surveillance Integrity Level (SIL)" Subfield in Aircraft Operational Status Messages

The Surveillance Integrity Level (SIL) is a two-bit subfield of "subtype 0" Aircraft Operational Status Messages ("ME" bits 49 and 50, message bits 83 and 84) by which a ADS-B transmitting subsystem announces the integrity level associated with the containment radius (R_C) being broadcast in the NIC parameter. Table 2.2.3.2.7.2.9 defines the meaning of each SIL value.

Notes:

1. *The NIC parameter is broadcast partly in the TYPE subfield of Airborne Position and Surface Position Messages, and partly in the NIC Supplement subfield of Aircraft Operational Status Messages (§2.2.3.2.7.2.6).*

2. *The Surveillance Integrity Level (SIL) defines the probability of the integrity containment radius, R_C, used in the NIC parameter without being detected at the transmitting ADS-B participant. See §2.1.2.15 of the ADS-B MASPS, RTCA DO-242A, for a fuller description of SIL.)*

Table 2.2.3.2.7.2.9: Surveillance Integrity Level (SIL) Encoding.

SIL	Probability of Exceeding the R_C Containment Radius Without Detection
0	1×10^{-3} per flight hour or per operation
1	1×10^{-3} per flight hour or per operation
2	1×10^{-5} per flight hour or per operation
3	1×10^{-7} per flight hour or per operation

2.2.3.2.7.2.10 "Barometric Altitude Integrity Code (NIC_{BARO}) Subfield in Aircraft Operational Status Messages

See the description of the Barometric Altitude Integrity Code, NIC_{BARO}, in 2.2.3.2.7.1.3.12.

2.2.3.2.7.2.11 "Aircraft Length and Width Codes" Subfield in Aircraft Operational Status Messages

The Aircraft Length and Width Codes Subfield is a four-bit field ("ME" bits 21 to 24, Message bits 53 to 56) of "subtype 1" Aircraft Operational Status Messages. This field describes the amount of space that an aircraft or ground vehicle occupies. The length and width codes are based on the actual dimensions of the transmitting aircraft or surface vehicle as specified in Table 2.2.3.2.7.2.11. Each aircraft or vehicle **shall** be assigned the smallest length and width codes for which its overall length and width qualify it.

Note: *For example, consider a powered glider with overall length of 24 m and wingspan of 50 m. Normally, an aircraft of that length would be in length category 1 (that is, have a length code of 1). But since the wingspan exceeds 34 m, it does not qualify for even the "wide" subcategory (width code = 1) of length category 1. Such an aircraft would be assigned length code = 4 and width code = 1, meaning "length less than 55 m and width less than 52 m."*

Table 2.2.3.2.7.2.11: Aircraft Length and Width Encoding

A/V - L/W Code (decimal)	Length Code			Width Code	Length Category (meters)	Width Category (meters)
	ME Bit 49	ME Bit 50	ME Bit 51	ME Bit 52		
0	0	0	0	0	0 < L < 15	0 < W < 11.5
1				1		11.5 ≤ W < 23
2	0	0	1	0	15 ≤ L < 25	23 ≤ W < 28.5
3				1		28.5 ≤ W < 34
4	0	1	0	0	25 ≤ L < 35	28 ≤ W < 33
5				1		33 ≤ W < 38
6	0	1	1	0	35 ≤ L < 45	34 ≤ W < 39.5
7				1		39.5 ≤ W < 45
8	1	0	0	0	45 ≤ L < 55	38 ≤ W < 45
9				1		45 ≤ W < 52
10	1	0	1	0	55 ≤ L < 65	52 ≤ W < 59.5
11				1		59.5 ≤ W < 67
12	1	1	0	0	65 ≤ L < 75	65 ≤ W < 72.5
13				1		72.5 ≤ W < 80
14	1	1	1	0	L ≥ 75	W < 80
15				1		W ≥ 80

Each A/V for which the length code is 2 or more (that is, for which Length/Width Code is 4 or more) **shall** broadcast its length/width code while it is on the surface. For this purpose, the determination of when an aircraft is on the surface **shall** be as described in §***TBD***.

2.2.3.2.7.2.12 "Track Angle/Heading" Subfield in Aircraft Operational Status Messages

The Track Angle/Heading subfield is a one-bit field ("ME" bit 53, Message bit 85) of the Aircraft Operational Status Message. This field ***TBD***

2.2.3.2.7.2.13 "Horizontal Reference Direction (HRD)" Subfield in Aircraft Operational Status Messages

The Horizontal Reference Direction (HRD) subfield of "subtype 1" Aircraft Operational Status Messages is a one-bit field ("ME" bit 53, message bit 85) that indicates the reference direction (true north or magnetic north) for horizontal directions such as heading, track angle, selected heading, selected track angle, etc. The Horizontal Reference Direction subfield **shall** be encoded as specified in Table 2.2.3.2.7.2.13.

Table 2.2.3.2.7.2.13: Horizontal Reference Direction (HRD) Encoding.

HRD Value	Meaning
0	True North
1	Magnetic North

2.2.3.2.7.2.14 "NOT ASSIGNED" Subfield in Aircraft Operational Status Message

The "NOT ASSIGNED" subfield is a 13-bit ("ME" bits 44 through 56, Message bits 76 through 88) field reserved for future application.

2.2.3.2.7.3 RESERVED TYPE "23" ADS-B Event - Driven Messages for "TEST"

TYPE "23" ADS-B Message are Reserved Exclusively for Test Purposes.

2.2.3.2.7.4 RESERVED TYPE "24" ADS-B Event - Driven Messages for Surface System Status

TYPE "24" ADS-B Messages are Reserved for Surface System Status.

2.2.3.2.7.5 RESERVED TYPE "25" ADS-B Event - Driven Messages

TYPE "25" ADS-B Messages are Reserved for Future Expansion.

2.2.3.2.7.6 RESERVED TYPE "26" ADS-B Event - Driven Messages

TYPE "26" ADS-B Messages are Reserved for Future Expansion.

2.2.3.2.7.7 RESERVED TYPE "27" ADS-B Event - Driven Messages

TYPE "27" ADS-B Messages are Reserved for Future Expansion.

2.2.3.2.7.8 Extended Squitter Aircraft Status Messages (TYPE “28”)

The Extended Squitter Aircraft Status Message (TYPE “28”) is used to provide additional information regarding aircraft status. Subtype “1” is used specifically to provide Emergency / Priority status.

Specific formatting of the TYPE “28,” Subtype “1” is provided in Appendix A, Figure A-9.

2.2.3.3 ADS-B Message Update Rates

2.2.3.3.1 Transmission Rates for Transponder - Based Transmitters

2.2.3.3.1.1 Transmission Rates compliant with RTCA Document No. DO-181C (EUROCAE ED-73A)

ADS-B transmitters based on Mode S transponders **shall** comply with the Message Update Rates specified in RTCA Document No. DO-181C (EUROCAE ED-73A), for each class of transponder defined in FAA TSO-C112.

Note: *The requirements of RTCA Document No. DO-181C (EUROCAE ED-73A) are consistent with the requirements of ICAO Annex 10, Volume IV, second edition, July 1998, §3.1.2.8.6.4.*

2.2.3.3.1.2 Transmission Rates that are not specified in RTCA Document No. DO-181C (EUROCAE ED-73A)

When the transmission rate of a particular message type is not specified in RTCA Document No. DO-181C (EUROCAE ED-73A), then the Mode S transponder based ADS-B transmitters **shall** deliver those messages at the rates specified in the following subparagraphs for Stand - Alone Transmitters. If there is conflict between the requirements of RTCA/DO-181C (EUROCAE ED-73A) and this document, then the requirements of RTCA/DO-181C (EUROCAE ED-73A) **shall** be adhered to.

Note: *The possible transmission time epochs should not be correlated with UTC to preclude inadvertent synchronization of transmissions from different aircraft.*

2.2.3.3.1.3 Maximum Transmission Rates for Transponder - Based Transmitters

The maximum ADS-B Message transmission rate **shall** not exceed 6.2 transmitted messages per second, distributed as required by RTCA Document No. DO-181C, §2.2.16.2.6.2.3.

Notes:

1. *Transponders are limited to no more than 2 Event Driven messages per second. Therefore, the average of 2 Airborne Position, 2 Airborne Velocity, 0.2 Identification, and 2 Event Driven messages per second yields a maximum of 6.2 messages per second.*

2. *This MOPS contains a limited capability to adjust event-driven message rates to stay within the Event-Driven budget of 2 transmissions per second (2.2.3.3.2.10). If additional Event-Driven message types are defined, a later version of this document may define a more fully featured scheduling function that assigns rates based upon the relative priority of the Event-Driven messages.*

2.2.3.3.1.4 ADS-B Event-Driven Message Broadcast Rates

2.2.3.3.1.4.1 ADS-B Aircraft Trajectory Intent and System Status (ATISS) Message Broadcast Rates

a. The Aircraft Trajectory Intent and System Status (ATISS) Message(s) (message TYPE = 29, §2.2.3.2.7.1) **shall** be initiated only when the aircraft is airborne and when vertical and/or horizontal trajectory intent information is available and valid as a minimum.

b. The ATISS Message with a SUBTYPE value of ZERO (0) **shall**, for the nominal case, be broadcast at random intervals that are uniformly distributed over the range of 1.2 to 1.3 seconds relative to the previous Aircraft Trajectory Intent Message and System for as long as data is available to satisfy the requirements of subparagraph “a.” above.

c. The broadcast rates for ATISS Messages with a SUBTYPE subfield value of other than ZERO (0) are not defined by this version of these MOPS.

Notes:

1. *Future versions of these MOPS may require unique broadcast update intervals for each Aircraft Trajectory Intent and System Status Message SUBTYPE (i.e., unique for each value of the SUBTYPE subfield).*

2. *Future versions of these MOPS may require that the broadcast rate for Aircraft Trajectory Intent and System Status Messages be temporarily increased (e.g., for 24 seconds) following any change in intent or status information.*

2.2.3.3.1.4.2 ADS-B Aircraft Operational Status Message Broadcast Rates

The rate at which the Aircraft Operational Status Messages (message TYPE = 31 and SUBTYPE = ZERO (0), §2.2.3.2.7.3) **shall** be broadcast varies depending on the following conditions:

Condition 1: Aircraft Trajectory Intent and System Status message (§2.2.3.2.7.1) for Target State and System Information (i.e., TYPE = 29 and SUBTYPE = 0) is not being broadcast versus being broadcast.

Condition 2: There has been a change within the past 24 seconds in the value of one or more of the following parameters included in the Operational Status Message

a. TCAS/ACAS Operational

b. ACAS/TCAS resolution advisory active

c. NAC_p

d. SIL

a. For the two cases where:

i. The Aircraft Trajectory Intent and System Status Message (§2.2.3.2.7.1) with SUBTYPE = ZERO (0) is not being broadcast and Condition 2 above is not applicable (nominal condition); or

ii. The Aircraft Trajectory Intent and System Status message with SUBTYPE = ZERO (0) is being broadcast regardless of the applicability of Condition 2 above;

The Aircraft Operational Status Message **shall** be broadcast at random intervals uniformly distributed over the range of 2.4 to 2.6 seconds.

b. For the case where the Aircraft Trajectory Intent and System Status Message (§2.2.3.2.7.1) with SUBTYPE = ZERO (0) is not being broadcast and Condition 2 above is applicable, the Aircraft Operational Status Message broadcast rate **shall** be increased for a period of 24 seconds (+/- 1 second) such that the broadcasts occur at random intervals that are uniformly distributed over the range of 0.75 to 0.85 seconds.

2.2.3.3.1.4.3 "Extended Squitter Aircraft Status" ADS-B Event-Driven Message Broadcast Rate

The rate at which the "Extended Squitter Aircraft Status" (TYPE = 28), "Emergency/Priority Status" ADS-B Event - Driven Message (SUBTYPE = 1) **shall** be broadcast, varies depending on whether the "Aircraft Trajectory Intent and System Status Message" (§2.2.3.2.7.1) with SUBTYPE = ZERO (0) is not being broadcast versus being broadcast.

a. In the case where the "Aircraft Trajectory Intent and System Status Message" with SUBTYPE = ZERO (0) is not being broadcast, the "Emergency/Priority Status" **shall** be broadcast at random intervals that are uniformly distributed over the range of 0.75 to 0.85 seconds relative to the previous Emergency/Priority Status Message for the duration of the emergency condition established in accordance with Appendix A, Figure A-9, Note 2.

b. In the case where the "Aircraft Trajectory Intent and System Status Message" with SUBTYPE = ZERO (0) is being broadcast, the "Emergency/Priority Status" **shall** be broadcast at random intervals that are uniformly distributed over the range of 2.4 to 2.6 seconds relative to the previous Emergency/Priority Status Message for the duration of the emergency condition established in accordance with Appendix A, Figure A-9, Note 2.

2.2.3.3.1.4.4 "TYPE 23 (TEST) ADS-B Event-Driven Message Broadcast Rate

The "TEST" ADS-B Event - Driven Messages **shall** be broadcast NOT MORE THAN ONCE each time the Event Driven Test Information is updated to the transponder.

2.2.3.3.1.4.5 "TYPE 24 – 27 ADS-B Event-Driven Message Broadcast Rate

In general, TYPE 24 - 27 ADS-B Event-Driven Messages **shall** be broadcast ONCE each time the Event-Driven TYPE 24 - 27 information is updated to the transponder.

2.2.3.3.1.4.6 ADS-B Message Transmission Scheduling

An ADS-B Message scheduling function **shall** be used to determine the sequence of ADS-B Messages to be broadcast and to control the overall transmission rate of event-driven messages. ADS-B systems that are not capable of supporting the broadcast of Aircraft Trajectory Intent and System Status Messages (§2.2.3.2.7.1) **shall** be permitted to use a simplified scheduling function for Event-Driven messages (i.e., the subset of the defined Event-Driven Message Scheduling function that is applicable to the specific messages types that are supported) in lieu of the full scheduling function described in §2.2.3.3.1.4.6.1.

2.2.3.3.1.4.6.1 Event-Driven Message Scheduling Function

Note: *This version of these MOPS do not define the message format for the broadcast of trajectory change information (§2.2.3.2.7.1.4). However it is anticipated that future versions of these MOPS will require the broadcast of trajectory change information for all Class A2 and Class A3 airborne systems and will be optional for Class A1 airborne systems. The following requirements for the Event-Driven Message Scheduling Function include provisions to accommodate the future addition of messages conveying trajectory change information (i.e., message TYPE = 29 and SUBTYPE = 0).*

The Event-Driven Message Scheduling Function **shall** ensure that the total Event-Driven message rate does not exceed 2 transmitted messages per second. This is consistent with the required overall maximum allowed transmission rate specified in §2.2.3.3.1.3.

The Event-Driven Message Scheduling Function **shall** apply the following rules as a means of prioritizing the Event-Driven Message transmissions and limited the transmission rates:

a. The Event-Driven Message scheduling function **shall** reorder, as necessary, pending Event-Driven Messages according to the following message priorities, listed below in descending order from highest to lowest priority:

   i. When an Extended Squitter Status Message (§2.2.3.2.7.9) is active for the broadcast of an Emergency/Priority Condition (message TYPE = 28 and SUBTYPE = 1), that message **shall** continue to be transmitted at the rate specified in §2.2.3.3.1.4.3 for the duration of the emergency/priority condition.

   ii. Reserved for future use.

Note: This priority level may be used in a future version of these MOPS for the case when an Aircraft Trajectory Intent and System Status Message (§2.2.3.2.7.1) is active for the broadcast of trajectory change information (message TYPE = 29 and SUBTYPE = 0) and there has been a change in one or more of the message parameters that results in a higher update rate reporting requirement.

iii. Reserved for future use.

Note: This priority may be used in a future version of these MOPS for the case when an Aircraft Trajectory Intent and System Status Message (§2.2.3.2.7.1) is active for the broadcast of trajectory change information (message TYPE = 29 and SUBTYPE > 0) and there has been a change in one or more of the message parameters that results in a higher update rate reporting requirement.

iv. When an Aircraft Operational Status Message (§2.2.3.2.7.3) is active (message TYPE = 31 and SUBTYPE = 0) and there has been a change in one or more of the message parameters within the past 24 seconds that results in a higher update rate reporting requirement, the Aircraft Operational Status Message **shall** be transmitted at the nominal rate specified in §2.2.3.3.1.4.2.

v. When an Aircraft Trajectory Intent and System Status Message (§2.2.3.2.7.1) is active for the broadcast of trajectory state information (message TYPE = 29 and SUBTYPE = 0) the Aircraft Trajectory Intent and System Status message **shall** be transmitted at the nominal rate specified in §2.2.3.3.1.4.1.

vi. Reserved for future use.

Note: This priority level may be used in a future version of these MOPS for the case when an Aircraft Trajectory Intent and System Status Message (§2.2.3.2.7.1) is active for the broadcast of trajectory change information (message TYPE = 29 and SUBTYPE > 0) at a nominal rate.

vii. When an Aircraft Operational Status Message (§2.2.3.2.7.3) is active (message TYPE = 31 and SUBTYPE = 0) and is being broadcast at a nominal rate, the Aircraft Operational Status Message s**hall** be transmitted at the rate specified in §2.2.3.3.1.4.2.

viii. This priority level applies as a default to any event-driven message TYPE and SUBTYPE combination not specifically identified at a higher priority level above. Event-Driven messages of this default priority level **shall** be delivered to the transponder on a first-in-first-out basis at equal priority.

b. The Event-Driven Message scheduling function **shall** limit the number of Event-Driven messages provided to the transponder to two (2) messages per second.

Note: *It is possible that future versions of these MOPS, and requiring a complementary change to the Mode S transponder MOPS, will allow for Event-Driver messages to be transmitted at a rate of greater than the current limit of* *two (2) messages per second. Therefore, a means should be provided to allow for a future adjustment to the value used for the message rate limit in the Event-Driven Message scheduling function.*

c. If (b) results in a queue of messages awaiting delivery to the transponder, the higher priority pending messages, according to (a) above **shall** be delivered to the transponder for transmission before lower priority messages.

d. If (b) results in a queue of messages awaiting delivery to the transponder, new Event-Driven messages **shall** directly replace older messages of the same exact Type and Subtype (where a Subtype is defined) that are already in the pending message queue. The updated message **shall** maintain the same position in the message queue as the pending message that is being replaced.

e. If (b) above results in a queue of messages awaiting delivery to the transponder, then pending message(s), **shall** be deleted from the message transmission queue if not delivered to the transponder for transmission, or not replaced with a newer message of the same message Type and Subtype, within the Message Lifetime value specified in the Table 2.2.3.3.1.4.6.1 below:

Table 2.2.3.3.1.4.6.1: Event-Drive Message Lifetime

Message TYPE	Message SUBTYPE	Message Lifetime (seconds)
23		Reserved (see Note)
24		Reserved (see Note)
25		Reserved (see Note)
26		Reserved (see Note)
27		Reserved (see Note)
28	=1	5.0 seconds (+/- 0.2 sec.)
	0, >1	Reserved (see Note)
29		Reserved (see Note)
30	=0	2.5 seconds (+/- 0.2 sec.)
	>0	Reserved (see Note)
31	=0	5.0 seconds (+/- 0.2 sec.)
	>0	Reserved (see Note)

Note: *A default message lifetime of 20 seconds shall be used for queue management unless otherwise specified.*

2.2.3.3.2 Transmission Rates for Stand - Alone Transmitters

a. Transmitters for Class A0 and Class B equipment may be implemented independent of a Mode S transponder. Such transmitters **shall** meet the transmission rate requirements of §2.2.3.3.1.3 and the message update rate requirements specified in the following subparagraphs.

b. Extended squitter messages **shall** be transmitted at random intervals that are uniformly distributed over the specified time interval using a time quantization no greater than 15 milliseconds.

Note: *The possible transmission time epochs should not be correlated with UTC to preclude inadvertent synchronization of transmissions from different aircraft.*

2.2.3.3.2.1 Power-On Initialization and Start Up

2.2.3.3.2.1.1 Power-On Initialization

a. At power-up initialization, the ADS-B transmission device **shall** start operations in a mode in which it transmits **NO** messages.

b. Given that appropriate message data is provided to the ADS-B transmission device, the transmission device **shall** be capable of transmitting ADS-B Messages no later than 2.0 seconds after Power-On.

c. After a power-up initialization exceeding the momentary power interruption capability of the equipment, the total set of BITE tests that check all necessary functions of the ADS-B device **shall** be completed within 20 seconds. As a minimum, the BITE tests **shall** include RAM, ROM, I/O, Timing, CPU instruction integrity, and any associated RF hardware tests necessary to ensure proper functioning of the ADS-B device.

2.2.3.3.2.1.2 Start Up

a. The ADS-B transmission device **shall** initiate broadcast transmissions of the Airborne Position, Surface Position, Aircraft Identification and Type, Velocity, Trajectory Intent, Operational Coordination, Aircraft Status, and/or Event - Driven messages only once it has received appropriate data to structure at least one variable data field of the respective message. As such, each message **shall** be initiated individually and independently of the other messages.

   The single exception is presented by Altitude data in the Airborne Position message which **shall** be processed as follows:

   The ADS-B transmission device **shall** not initiate broadcast of the Airborne Position message until horizontal position data has been received. That is, that altitude data alone **shall** not be sufficient to initiate broadcast of the Airborne Position Message.

b. Once ADS-B Message transmission has been initiated the transmission rate of each type of ADS-B Message **shall** be as provided in the following paragraphs.

2.2.3.3.2.2 ADS-B Airborne Position Message Broadcast Rate

Once started, ADS-B Airborne Position Messages **shall** be broadcast by the transmission device when in the Airborne state at random intervals that are uniformly distributed over the range of 0.4 to 0.6 seconds relative to the previous Airborne Position Message, with the exceptions as specified in §2.2.3.3.2.9.

2.2.3.3.2.3 ADS-B Surface Position Message Broadcast Rate

a. Once started, ADS-B Surface Position Messages **shall** be broadcast by the transmission device when in the On-Ground state using either the "High" or "Low" rate, which has been selected as follows:

(1). Switching from "High" rate to "Low" Rate:

(a). The broadcast rate **shall** be changed from "High" to "Low" when the navigation source position data has not changed more than 10 meters in a 30 second sampling interval.

Note: *It is acceptable to compute the 10 meter distance using either rectangular or polar coordinates.*

(b). Upon selecting the "Low" rate, the transmission device **shall** save the Position data at the time that the "Low" rate was selected.

(2). Switching from "Low" rate to "High" Rate:

The broadcast rate **shall** be changed from "Low" to "High" when the position of the transmission device has changed by 10 meters or more since the "Low" rate was selected.

Note: *It is acceptable to compute the 10 meter distance using either rectangular or polar coordinates.*

b. If the "High" rate is selected, then the Surface Position Message **shall** be transmitted at random intervals that are uniformly distributed over the range of 0.4 to 0.6 seconds relative to the previous Surface Position Message.

c. If the "Low" rate is selected, then the Surface Position Messages **shall** be transmitted at random intervals that are uniformly distributed over the range of 4.8 to 5.2 seconds relative to the previous Surface Position Message.

Note: *Pending further study and analysis of surface broadcast rates and their triggering mechanisms by regulatory authorities, it is widely assumed that the "Low" rate will be raised to a nominal rate approaching once per second.*

d. In the event that the transmission device cannot determine the required transmission rate, then the "High" rate **shall** be used as the default transmission rate.

e. Exceptions to these transmission rate requirements are defined in §2.2.3.3.2.9.

2.2.3.3.2.4 ADS-B Aircraft Identification and Type Message Broadcast Rate

a. Once started, ADS-B Aircraft Identification and Type Messages **shall** be broadcast by the transmission device at random intervals that are uniformly distributed over the range of 4.8 to 5.2 seconds relative to the previous Identification and Type Message, when the ADS-B Transmitting Subsystem is reporting the Airborne Position Message, or when reporting the Surface Position Message at the high rate.

b. When the Surface Position Message is being reported at the low surface rate, then the Aircraft Identification and Type Message **shall** be broadcast at random intervals that are uniformly distributed over the range of 9.8 to 10.2 seconds relative to the previous Identification and Type Message.

c. When neither the Airborne Position Message nor the Surface Position Message is being transmitted, then the Aircraft Identification and Type Message **shall** be broadcast at the rate specified in subparagraph a.

d. Exceptions to these transmission rate requirements are defined in §2.2.3.3.2.9.

2.2.3.3.2.5 ADS-B Velocity Information Message Broadcast Rate

a. Once started, ADS-B Velocity Information Messages **shall** be broadcast by the transmission device at random intervals that are uniformly distributed over the range of 0.4 to 0.6 seconds relative to the previous Velocity Information Message.

b. Exceptions to these transmission rate requirements are defined in §2.2.3.3.2.9.

2.2.3.3.2.6 ADS-B Trajectory Intent, Operational Coordination, and Status Message Broadcast Rates

2.2.3.3.2.6.1 ADS-B Aircraft Trajectory Intent and System Status Message Broadcast Rates

a. The requirements of §2.2.3.3.1.4.1 are applicable.

b. The Aircraft Trajectory Intent and System Status Message (TYPE = 29, SUBTYPE = 0, §2.2.3.2.7.1) **shall** be broadcast at random intervals that are uniformly distributed over the range of 1.2 to 1.3 seconds relative to the previous Aircraft Trajectory Intent and System Status Message for as long as data is available to satisfy the requirements of subparagraph “a.” above.

c. Exceptions to these transmission rate requirements **shall** be as defined in §2.2.3.3.2.9.

2.2.3.3.2.6.2 ADS-B Aircraft Operational Status Message Broadcast Rates

a. The Aircraft Operational Status Message (TYPE = 31 and SUBTYPE = 0) (§2.2.3.2.7.2) **shall** be broadcast at varying rates as defined in §2.2.3.3.1.4.2.

b. Exceptions to these transmission rate requirements **shall** be as defined in §2.2.3.3.2.9.

2.2.3.3.2.6.3 "Extended Squitter Aircraft Status" ADS-B Event - Driven Message Broadcast Rate

a. The rate at which the "Extended Squitter Aircraft Status" (Type = 28), "Emergency/Priority Status" ADS-B Event-Driven Message (SUBTYPE = 1) **shall** be broadcast varies as defined in Section 2.2.3.3.1.4.3.

b. The exceptional conditions specified in §2.2.3.3.2.9 **shall** be observed.

2.2.3.3.2.7 "TYPE 23 (TEST)" ADS-B Event - Driven Message Broadcast Rate

The "TEST" ADS-B Event - Driven Messages **shall** be broadcast ***NOT MORE Than*** ONCE each time the Event Driven Test Information is updated to the ADS-B transmission device. The delay conditions specified in §2.2.3.3.2.9 **shall** be observed.

2.2.3.3.2.8 "TYPE 24 - 27" ADS-B Event - Driven Message Broadcast Rate

In general, TYPE 24 - 27 ADS-B Event - Driven Messages **shall** be broadcast ONCE each time the Event Driven TYPE 24 - 27 Information is updated to the ADS-B transmission device. The delay conditions specified in §2.2.3.3.2.9 **shall** be observed.

2.2.3.3.2.9 ADS-B Message Transmission Scheduling

An ADS-B Message scheduling function **shall** be used to determine the sequence of ADS-B Messages to be broadcast and to control the overall transmission rate of event-driven messages.

As an exception to the general requirement for the transmission of ADS-B Messages, the scheduled message transmission **shall** be delayed if a Mutual Suppression interface is active.

2.2.3.3.2.9.1 Position, Velocity and Identification Message Scheduling

The priority for transmission (from highest to lowest) for the message types that are not event-driven **shall** be:

a. Position Message (either Airborne Position Message, as defined in §2.2.3.2.3, or Surface Position Message, as defined in §2.2.3.2.4)

b. Airborne Velocity Message (§2.2.3.2.6.3)

c. Aircraft Identification and Type Message (§2.2.3.2.5)

2.2.3.3.2.9.2 Event-Driven Message Scheduling

An Event-Driven Message Scheduling function **shall**:

a. Ensure that the total Event-Driven Message rate does not exceed 2 transmitted messages per second. This is consistent with the required overall maximum allowed transmission rate specified in §2.2.3.3.2.10.

> ***Note:*** *It is possible that future versions of these MOPS may allow for Event-Driven messages to be transmitted at a rate of greater than the current limit of two (2) messages per second. Therefore a means should be provided to allow for a future adjustment to the value used for the message rate limit in the Event-Driven Message scheduling function.*

b. The Event-Driven Message scheduling requirements of §2.2.3.3.1.4.6 **shall** be used as the means of ensuring the Event-Driven message broadcast limit of 2 messages per second is not exceeded.

2.2.3.3.2.10 Maximum ADS-B Message Transmission Rates

The maximum ADS-B Message transmission rate of non-transponder ADS-B Transmitter implementations **shall** not exceed 6.2 transmitted messages per second.

Note: *It is possible that future versions of these MOPS may allow for ADS-B Messages to be transmitted at a rate of greater than the current limit of 6.2 messages per second. Therefore a means should be provided to allow for a future adjustment to the value used for the message rate limit in the message scheduling function.*

2.2.3.3.2.11 ADS-B Message Timeout

The ADS-B Transmission Device **shall** clear all 56-bits of the airborne position, surface position and velocity message if no new data is received within two seconds of the previous input data update. This timeout requirement **shall** be applied individually for each of the three message types identified.

Notes:

1. *These messages are cleared to prevent the reporting of outdated position and velocity information.*

2. *During a register timeout event, the "ME" field of the ADS-B Broadcast Message may contain all zeroes, except for those fields that may be updated due to the receipt of new data.*

b. The ADS-B transmission device **shall** not clear the Aircraft Identification Message (see §2.2.3.2.5) if no new data (neither aircraft type, emitter category, nor identification data) is received within up to 60 seconds of the previous input data update.

Note: *The identification message, is not cleared since it contains data that rarely changes in flight and is not frequently updated.*

c. The ADS-B transmission device **shall** not clear the Intent, Operational Coordination, Operational Status, or Event-Driven Messages (see §2.2.3.2.7) if no new data is received within up to 60 seconds of the previous input data update.

Note: *The event-driven messages do not need to be cleared since contents of such messages are only broadcast once each time that new data is received.*

2.2.3.3.2.12 ADS-B Message Termination

a. The ADS-B transmission device **shall** terminate broadcast transmissions of the Airborne Position, Surface Position, Aircraft Identification and Type, Velocity, Trajectory Intent, Operational Coordination, Aircraft Status, and/or Event - Driven messages if input data necessary to update the particular ADS-B Message type is not available for a period of 60 seconds.

Notes:

1. *For the Airborne Position Message, specifically, Altitude Data alone **shall** be considered necessary and sufficient to maintain broadcast of the message once the message has been initiated.*

2. *For the Surface Position Message, the receipt of new Position (i.e., Latitude and Longitude, combined), Movement, or Ground Track data **shall** be considered necessary and sufficient to maintain broadcast of the message once the message has been initiated.*

3. *For all other ADS-B Messages, the receipt of new data necessary to update any single parameter of the message **shall** be considered necessary and sufficient to maintain broadcast of the message once the message has been initiated.*

b. Each ADS-B Message type **shall** be terminated individually and independently of all other ADS-B Messages.

2.2.3.4 ADS-B Transmitted Message Error Protection

Error protection **shall** be provided by the ADS-B Transmitting Subsystem encoding all messages in accordance with the requirements provided in RTCA Document No. DO-181C, §2.2.16.2.1 (EUROCAE ED-73A, §3.20.2.1) and illustrated in Figure 2-10 of RTCA Document No. DO-181C (EUROCAE ED-73A, Figure 3-9).

Note: *The requirements of RTCA Document No. DO-181C, §2.2.16.2.1 and Figure 2-10 (EUROCAE ED-73A, §3.20.2.1 and Figure 3-9) are consistent with the requirements of ICAO Annex 10, Volume IV, second edition, July 1998, §3.1.2.3.3.*

2.2.4 ADS-B Receiver Characteristics

2.2.4.1 Minimum Triggering Level (MTL) Definition

a. The sensitivity of the ADS-B Receiver **shall** be sufficient to reliably detect and decode ADS-B Messages provided the received power is at or above a certain level. The receiver sensitivity requirements are stated in terms of the Minimum Triggering Level (MTL) defined in the following paragraphs.

b. Given a valid ADS-B Message signal that complies with the frequency, pulse spacing and pulse width requirements, and in the absence of interference or overloads, the MTL of an ADS-B receiver is defined as the received power level that results in a successful message reception ratio of 90%.

Note: *The term "MTL" originates from its use in transponders where it is associated with the triggering of a reply from the transponder. In order to maintain continuity with the 1090 MHz environment, the term is retained herein although there is no response triggered as in the transponder.*

2.2.4.2 Receivers Shared with a TCAS Unit

a. ADS-B receivers implemented as part of a TCAS unit **shall** comply with all receiver requirements specified in RTCA Document No. DO-185A, TCAS MOPS, §2.2.4.4.

b. ADS-B receivers operating with TCAS units that are more sensitive than the MTL requirements specified in RTCA Document No. DO-185A, **shall** implement the capabilities specified in §2.2.4.2.1 through §2.2.4.3.5.

Note: *RTCA Document No. DO-185A, TCAS MOPS, uses the term "Extended Squitter" to refer to messages having the same formats and transmission requirements as those messages referred to as ADS-B Messages in this document. These terms should be accepted as being equivalent when referring to the TCAS system.*

2.2.4.2.1 Dual Minimum Triggering Levels

2.2.4.2.1.1 TCAS Compatibility

No more than 10% of all ADS-B Messages received at an input signal level of -78 dBm or less **shall** be delivered to the TCAS functions specified in DO-185A.

Note: *Use of the standard TCAS MTL (-74 + 2dB as specified in DO-185A §2.2.4.4.1.1.a) for the TCAS surveillance functions preserves the current operation of TCAS surveillance when operating with a receiver with an improved MTL, such as those inferred in §2.2.4.3.1.*

2.2.4.2.1.2 ADS-B Compatibility

All ADS-B Messages **shall** be processed in accordance with §2.2.4.3.1.1.

2.2.4.2.2 Re-Triggerable Reply Processor

The TCAS Mode S reply processing function **shall** use a Mode S reply processor that will re-trigger if it detects a Mode S preamble that is at least 3 dB stronger than the reply that is currently being processed in order to ensure that the stronger signal is processed.

Note: *Care must be taken to ensure that low-level squitters (i.e., those below the nominal TCAS MTL) do not interfere with the processing of acquisition squitters for TCAS. This may happen if the low-level squitter is allowed to capture the reply processor. This may be prevented by using a separate reply processor for* *each function, or by requiring the reply processor to be re-triggered by a higher level squitter message.*

2.2.4.3 Receivers Not Shared With TCAS

2.2.4.3.1 In-Band Acceptance and Re-Triggerable Capability

2.2.4.3.1.1 In-Band Acceptance

The MTL requirements provided in the following subparagraphs are specified at the Antenna end of an Antenna to Receiver transmission line having loss equal to the maximum for which the receiving installation is designed.

a. The MTL of an ADS-B receiver processing signals over the frequency range of 1089 to 1091 MHz **shall** comply with the MTL limits provided in Table 2-62 for the applicable receiver Equipment Class.

Table 2-62: ADS-B Class "A" Equipment Receiver Sensitivity

EQUIPMENT CLASS	A0	A1	A2	A3
MTL	**-72** dBm	**-74** dBm	**-79** dBm	**-84** dBm

Note: *The MTL limits of Table 2-62 must be complied with over the entire environmental operating range specified by the manufacturer of the receiver (e.g., receiver performance variations over temperature and other conditions must be taken into account).*

b. In the absence of interference or overloads, each ADS-B receiver **shall** properly detect and decode at least 99% of all ADS-B Messages received at an input signal level between the MTL + 3 dB and -21 dBm.

c. In the absence of interference or overloads, each ADS-B receiver of equipment class A3 **shall** properly detect and decode at least 15% of all ADS-B Messages received at an input signal level of -87 dBm.

Notes:

1. This requirement need only be tested under ambient conditions.

2. The intent of this requirement is to emphasize the desirability of taking advantage of signals received below the required MTL.

2.2.4.3.1.2 Re-Triggerable Capability

ADS-B receivers having Equipment Class A1, A2 or A3 capability **shall** re-trigger if such receivers detect an ADS-B Message having a preamble that is at least 3 dB stronger than that of the message that is currently being processed, and that begins 6 microseconds or later than does the preamble of the message currently being processed.

Notes:

1. *This requirement is required in order to ensure that the ADS-B processor will properly detect and process the stronger signal.*

2. *Although re-triggering for the case of overlapping preambles is not required, such a capability is desirable. One way to accomplish this is described in Appendix I.*

2.2.4.3.2 Out-of-Band Rejection

For out-of-band signals the ADS-B Message signal level required to provide 90 percent ratio of decoded and accepted messages to the number of actual messages transmitted **shall** increase relative to the equipment MTL at 1090 MHz as provided in Table 2-63.

Table 2-63: ADS-B Receiver Out -of- Band Rejection

Message Frequency Difference (MHz from 1090 MHz)	Triggering Level (dB above MTL)
± 5.5	Greater Than -or- Equal to **3**
± 10	Greater Than -or - Equal to **20**
± 15	Greater Than -or - Equal to **40**
± 25	Greater Than -or - Equal to **60**

2.2.4.3.3 Dynamic Minimum Trigger Level (DMTL)

ADS-B Single Receiver Systems **shall** implement Dynamic Minimum Trigger Level (DMTL) control as a means of rejecting low level multipath signals.

The DMTL characteristics **shall** be compatible with the requirements provided in §2.2.4.3.4.1 through §2.2.4.3.4.3.

2.2.4.3.4 1090 MHz ADS-B Message Reception Techniques

2.2.4.3.4.1 ADS-B Message Reception

a. When listening for ADS-B Messages and upon receipt of a single pulse of greater than 300 nanoseconds duration and having amplitude **A**, where **A** exceeds MTL + 8 dB, the receiver threshold **shall** increase to **A** -6 dB ± 1 dB for a period of not less than five microseconds following the leading edge of the first pulse and **shall** be recovered in not more than eight microseconds, unless a valid or qualifying preamble is received (§2.2.3.1.1), in which case the threshold **shall** be held at **A** -6 dB +1 dB for a period of not less than 115 microseconds and **shall** be recovered in not more than 120 microseconds.

   The receiver threshold **shall** at no time exceed **A** -5 dB except for possible overshoot during the first microsecond following the leading edge of the first pulse.

b. If **A** is less than MTL + 8 dB, there is no requirement to raise the threshold.

Notes:

1. *The length of an ADS-B Message cannot be determined with certainty by the DMTL system. Therefore, the ADS-B Message DMTL desensitizes for the duration of the ADS-B Message.*

2. *These requirements are consistent with the requirements of RTCA Document No. DO-185, §2.2.2.3.2. Note that there is no direct correlation to these requirements provided in RTCA Document No. DO-185A. In fact, RTCA Document No. DO-185A has deleted the DMTL requirements previously provided and now relies completely on Whisper Shout level control techniques to provide multipath rejection (see §2.2.4.5.1 or RTCA Document No. DO-185A).*

2.2.4.3.4.2 Narrow Pulse Discrimination

The DMTL control **shall** not be responsive to pulses that have a width of less than 0.3 microseconds.

Note: *These requirements are consistent with the requirements of RTCA Document No. DO-185A, §2.2.4.5.1.2.1.*

2.2.4.3.4.3 TACAN and DME Discrimination

The DMTL control **shall** not be responsive to TACAN or DME pulses.

Note: *These requirements are consistent with the requirements of RTCA Document No. DO-185A, §2.2.4.5.3.*

2.2.4.3.4.4 Pulse Characteristics of Received ADS-B Messages

All pulse characteristics of the ADS-B Messages were previously defined in §2.2.2.2.1 and §2.2.3.1 and associated subparagraphs of this document.

2.2.4.3.4.5 Message Formats

The 1090 MHz receiver **shall** correctly decode all valid ADS-B Messages received in accordance with the requirements specified in §2.2.4.3.1.1 through §2.2.4.3.4.4. A valid extended squitter message follows the format defined in RTCA Document No. DO-181C (EUROCAE ED-73A) with the “PI” field defined with “II”=0 and “SI”=0.

General formats of the extended squitter (i.e., ADS-B) messages was provided is §2.2.3.1 through §2.2.3.2.1.1.6 of this document.

2.2.4.3.4.6 Description of 1090 MHz ADS-B Message Received Signals

Formats of ADS-B transmitted messages were previously defined in §2.2.3.2.3 through §2.2.3.2.7 of this document.

2.2.4.3.4.7 ADS-B Signal Reception

2.2.4.3.4.7.1 Criteria for ADS-B Message Transmission Pulse Detection

a. ADS-B Message transmission pulse decoding **shall** be based on pulse leading edges.

Note: *The occurrence of a leading edge may be determined directly from a positive slope or inferred from pulse widths and trailing edge positions. An actual leading edge is defined as an event for which: the signal rises at a rate exceeding 48 dB per microsecond to a level above the receiver threshold **AND** 0.125 microseconds later the rate of rise is less than 48 dB per microsecond. An inferred leading edge is defined as an event in which a leading edge is assumed to exist in order to account for a pulse whose width implies the existence of overlapping pulses.*

b. All performance requirements **shall** be met for pulses having the following characteristics:

(1). Pulse Amplitude Variation: up to +2 dB, relative to the amplitude of the first preamble pulse

(2). Pulse rise time: 0.1 microsecond or less

(3). Pulse decay time: 0.2 microseconds or less

2.2.4.3.4.7.2 Criteria for Preamble Acceptance

The first qualifying criterion for reception of an ADS-B 1090 MHz message signal **shall** be the reception of the Preamble (§2.2.3.1.1). A preamble **shall** be accepted if each of the four pulse positions of the preamble waveform contains a pulse that is above the receiver threshold for at least 75 percent of its nominal duration, ***AND*** the last three pulses are within ±0.125 microseconds of their nominal position relative to the first pulse, ***AND*** at least two of the four preamble pulses have actual leading edges (as defined in §2.2.4.3.4.7.1.a) that occur within ±0.125 microseconds of their nominal edge positions. All inferred leading edges **shall** occur within ±0.125 microseconds of the expected nominal position.

Note: *Appendix "I" provides description of an improved implementation.*

2.2.4.3.4.7.3 Criteria for Data Block Acceptance in ADS-B Message Signals

ADS-B Messages always contain 112 data bits. Each bit of the 1090 MHz ADS-B Message Data Block **shall** be decoded by comparing the received signal with a 0.5 microsecond delayed replica of itself to determine the difference between the signal amplitudes at the centers of the two possible pulse positions for that bit.

The ADS-B transmission **shall** be accepted as a valid ADS-B Message if:

a. The first five bits of the data block contain either the code 1 0001 or 1 0010 (i.e., either DF=17 or DF=18);

b. ***AND*** no error is detected, ***OR*** error correction performed in accordance with §2.2.4.4.2.2.d and Appendix A, Section 3 of RTCA Document No. DO-185A can be successfully applied, ***AND*** no more than seven consecutive data bits fail the following confidence test:

Sample the received signal at least eight times during the one microsecond bit interval to determine if the amplitude of the received signal is above or below the dynamic minimum triggering level of the receiver. The data bit **shall** be declared a high-confidence bit if, between the first and second of the two possible pulse positions for that bit, the difference in the number of samples for which the signal is above DMTL is at least three ***AND*** the sign of this difference agrees with the decoded value of the bit.

Notes:

1. *Alternative equivalent methods are acceptable, provided that the manufacturer provides evidence that performance is not degraded.*

2. *Acceptance of ADS-B transmissions with the first five bits identified as 1 0011 (i.e., DF=19) is optional.*

2.2.4.3.5 ADS-B Receiver Duty Factor

Available ADS-B receiver duty factor (i.e., the percentage of time that the ADS-B Message Reception function is able to receive and process ADS-B Messages at the required ADS-B MTL), when the receiver is shared with another receiving function using the 960-1215 MHz band, is an important consideration in meeting the intended ranges of operation for ADS-B equipment (see the note to Table E-1 in Appendix E, which assumes ADS-B receiver availability of 90 percent). The available ADS-B receiver duty factor **shall** be 90% or greater, averaged over a 10 second period. If the available ADS-B receiver duty factor is less than 90 percent, techniques for guaranteeing required equipage class range performance, such as improved MTL and/or improved message reception techniques, may be proposed, and equivalent performance to that calculated in the note within Appendix E substantiated using analysis of both the internationally-agreed LA99 traffic and power-limited range scenarios.

2.2.4.4 Enhanced Squitter Reception Techniques

2.2.4.4.1 Need for Enhanced Techniques

The 1090 MHz ADS-B Message Reception Techniques specified in §2.2.4.3.4 provide a high probability of correct reception when the desired squitter is overlapped with one ATCRBS interfering reply of equal or greater power. In some high interference environments (e.g., Los Angeles or Frankfurt, Germany), there is a relatively high probability that the desired squitter signal will be overlapped with two or more ATCRBS replies. In these environments, the air-to-air range may be reduced because of the effects of this interference.

2.2.4.4.2 Enhanced Squitter Reception Technique Overview

Enhanced squitter reception techniques have been developed (see Appendix I) that provide the ability to receive squitters with multiple overlapping Mode A/C fruit. Such enhanced reception techniques are composed of the following elements:

a. Improved preamble detection to reduce the probability of a false alarm caused by detection of an apparent Mode S preamble synthesized by overlapped Mode A/C fruit replies.

b. Improved code and confidence bit declaration typically based on the use of amplitude to aid in the interpretation of the squitter data block.

c. More capable error correction techniques that are optimized to the characteristics of the code and confidence process.

Class A1, A2 and A3 equipment **shall** demonstrate compliance with test procedures specified in §2.4.4.4.

Note: *The full set of enhanced techniques are applicable to Class A2 and A3 receiving equipment. Class A1 receiving equipment requires only a subset of the enhanced reception capabilities, and this is reflected in the test procedures of §2.4.4.4.*

2.2.4.4.3 Error Correction Restriction

The enhanced reception techniques are intended to operate in very high Mode A/C fruit environments. For this reason, the sliding window error correction technique **shall** not be used in conjunction with the enhanced techniques since it produces an unacceptably high undetected error rate in these high fruit environments.

Note: *See Appendix I, §I.3.3 and §I.4.3 for more details on error correcting techniques.*

2.2.4.5 ADS-B Received Message Error Protection

a. Error protection **shall** be provided by the ADS-B receiving device decoding all messages that have been encoded in accordance with the requirements provided in RTCA Document No. DO-181C, §2.2.16.2.1.c and illustrated in Figure 2-10 of RTCA Document No. DO-181C (EUROCAE ED-73A, §3.20.2.1.c and Figure 3.9).

b. Error correction techniques **shall** be applied by the receiving device in accordance with RTCA Document No. DO-185A, Appendix A, §A.3.

Note: *Additional algorithms are currently being developed to enable the ADS-B receiver function to use the parity coding of ADS-B Messages to correct messages that may be received in error and improve message decode capability.*

2.2.5 ADS-B Transmission Device Message Processor Characteristics

The primary functions of the Transmission Device Message Processor are described in the following subparagraphs:

2.2.5.1 ADS-B Transmission Device Data Processing and Message Formatting

2.2.5.1.1 ICAO 24-Bit Discrete Address

The ADS-B Transmitting Subsystem **shall** accept the ICAO 24-bit Discrete Address via an appropriate data input interface and format such data into the “AA” field (§2.2.3.2.1.1.1), Message bits 9 through 32, of ALL ADS-B Message Transmissions as identified in Figure 2-2.

2.2.5.1.2 ADS-B Emitter Category Data

The ADS-B Transmitting Subsystem **shall** accept the ADS-B Emitter Category (see §2.2.3.2.5.2) via an appropriate data input interface and use such data to establish the “ADS-B Emitter Category” Subfield in Aircraft Identification and Type Messages (see §2.2.3.2.5.1) as specified in §2.2.3.2.5.2.

If the ADS-B Emitter Category is not available to the ADS-B transmission device, then the device **shall** enter ALL ZEROS into the "ADS-B Emitter Category" Subfield in the Aircraft Identification and Type Message.

2.2.5.1.3 Air/Ground Status Data

The ADS-B Transmitting Subsystem **shall** accept Air/Ground status information via an appropriate data input interface and use such data to establish the “CA” Capability Field as specified in §2.2.3.2.1.1.2.

If the ADS-B Transmitting Subsystem does not accept Air/Ground status information via automatic means, the “CA” Capability field **shall** be set to 6 or 7 as specified in Table 2-8 in §2.2.3.2.1.1.2.

2.2.5.1.4 Surveillance Status Data

The ADS-B Transmitting Subsystem **shall** accept Surveillance status information via an appropriate data input interface and use such data to establish the “Surveillance Status” subfield in the ADS-B Airborne Position Message (see §2.2.3.2.3) as specified in §2.2.3.2.3.2.

Note: *The Surveillance Status information interface is an internal interface in transponder implementations.*

2.2.5.1.5 Altitude Data

a. **Pressure Altitude --** The ADS-B Transmitting Subsystem **shall** accept Barometric Altitude (see §2.2.3.2.3.4.1) information via an appropriate variable data input interface and use such data to establish the “Altitude” subfield in the ADS-B

Airborne Position Message (see §2.2.3.2.3) as provided in §2.2.3.2.3.4 through §2.2.3.2.3.4.3 with the following additional constraints:

(1). When operated in conjunction with a pressure-altitude encoder (digitizer) or an air data system, the ADS-B transmission device **shall** have the capability for pressure-altitude transmission up to its designed maximum altitude.

(2). If pressure-altitude Data is not available to the ADS-B transmission device, then the device **shall** enter ALL ZEROs into the Altitude subfield specified in §2.2.3.2.3.4.

b. **GNSS Height Above the Ellipsoid (HAE)** -- The ADS-B Transmitting Subsystem **shall** accept GNSS Height Above the Ellipsoid (HAE) (see §2.2.3.2.3.4.2) information via an appropriate variable data input interface and use such data to establish subfields in ADS-B transmitted messages as follows:

(1). The "Altitude" subfield in the ADS-B Airborne Position Message (see §2.2.3.2.3) as provided in §2.2.3.2.3.4.2 through §2.2.3.2.3.4.3,

(2). The "DIFFERENCE FROM BAROMETRIC ALTITUDE SIGN BIT" subfield (see §2.2.3.2.6.1.14) in the Airborne Velocity Information Subtype "1 & 2" (see §2.2.3.2.6.1 and §2.2.3.2.6.2) as specified in §2.2.3.2.6.1.14 and §2.2.3.2.6.2.14, respectively,

(3). The "DIFFERENCE FROM BAROMETRIC ALTITUDE SIGN BIT" subfield (see §2.2.3.2.6.1.14) in the Airborne Velocity Information Subtype "3 & 4" (see §2.2.3.2.6.3 and §2.2.3.2.6.4) as specified in §2.2.3.2.6.3.15 and §2.2.3.2.6.4.15, respectively,

(4). The "DIFFERENCE FROM BAROMETRIC ALTITUDE" subfield (see §2.2.3.2.6.1.15) in the Airborne Velocity Information Subtype "1 & 2" (see §2.2.3.2.6.1 and §2.2.3.2.6.2) as specified in §2.2.3.2.6.1.15 and §2.2.3.2.6.2.15, respectively, and

(5). The "DIFFERENCE FROM BAROMETRIC ALTITUDE" subfield (see §2.2.3.2.6.1.15) in the Airborne Velocity Information Subtype "3 & 4" (see §2.2.3.2.6.3 and §2.2.3.2.6.4) as specified in §2.2.3.2.6.3.15 and §2.2.3.2.6.4.15, respectively,

If appropriate "GNSS Height Above the Ellipsoid (HAE)" data is not available to the ADS-B transmission device, then the device **shall** set all subfields identified above in subparagraphs (1). through (5). to ZERO.

c. **GNSS Altitude (MSL)** -- If GNSS Height Above the Ellipsoid (HAE) data is not available to the ADS-B transmission device, then the device may accept GNSS Altitude (MSL) data and use such data to establish the subfields identified above in subparagraphs b.(1). through b.(5).

d. **NO GNSS Height/Altitude Data** -- If neither GNSS Height Above the Ellipsoid (HAE) nor GNSS Altitude (MSL) data are available to the ADS-B transmission device, then the device **shall** set all subfields identified above in subparagraphs b.(1). through b.(5). to ZERO.

2.2.5.1.6 Time Data and Time Mark Pulse

The ADS-B Transmitting Subsystem **shall** accept GPS/GNSS Time Mark information as provided in the following subparagraphs:

2.2.5.1.6.1 Case, where TIME ("T") = 0

a. If the ADS-B Transmitting Subsystem is not capable of setting the "TIME" ("T") subfield (see §2.2.3.2.3.5) in the Airborne Position Message (see §2.2.3.2.3) or in the Surface Position Message (see §2.2.3.2.4), then the ADS-B Transmitting Subsystem **shall** set the "TIME" subfield to ZERO.

b. Whenever the ADS-B Transmitting Subsystem is setting the "TIME" ("T") subfield to ZERO as provided in subparagraph a., then the ADS-B Transmitting Subsystem **shall** not be required to accept and process GPS/GNSS Time Mark information.

2.2.5.1.6.2 Case, where TIME ("T") = 1

a. If the ADS-B Transmitting Subsystem is capable of setting the TIME ("T") subfield (see §2.2.3.2.3.5) to ONE in the Airborne Position Message (see §2.2.3.2.3) or in the Surface Position Message (see §2.2.3.2.4), then the ADS-B Transmitting Subsystem **shall** accept and process a GPS/GNSS Time Mark pulse or an equivalent time synchronization indication from the source of navigation data.

b. The leading edge of the GPS/GNSS Time Mark pulse, or equivalent, **shall** indicate the exact moment (epoch of the UTC time scale) +/- 5 milliseconds that represents the time of applicability of Position, Velocity, and Time (PVT) information that is received from the navigation source. The PVT data **shall** be provided by the navigation data source no later than 200 milliseconds after the leading edge of the GPS/GNSS Time Mark pulse, or equivalent.

Note: *A possible implementation of the GPS/GNSS Time Mark pulse is illustrated in Figure 2-11.*

c. When the ADS-B Transmitting Subsystem sets the TIME ("T") subfield to ONE in the Airborne Position Message (see §2.2.3.2.3), then the ADS-B Transmitting Subsystem **shall** use the GPS/GNSS Time Mark pulse to accomplish the following:

(1). Synchronize the loading of the Airborne Position Message such that the register is properly loaded 100 milliseconds +/- 50 milliseconds prior to the time of applicability of the data being loaded into the register.

(2). Establish the "Time" subfield in ADS-B Airborne Position Messages (see §2.2.3.2.3) as specified in §2.2.3.2.3.5,

(3). Establish the "CPR Format" subfield in ADS-B Airborne Position Messages (see §2.2.3.2.3) as specified in §2.2.3.2.3.6, (4). Extrapolate Airborne Latitude Position in ADS-B Airborne Position Messages (see §2.2.3.2.3) as specified in §2.2.3.2.3.7.2.

(5). Extrapolate Airborne Longitude Position in ADS-B Airborne Position Messages (see §2.2.3.2.3) as specified in §2.2.3.2.3.8.2,

d. When the ADS-B Transmitting Subsystem sets the TIME ("T") subfield to ONE in the Surface Position Message (see §2.2.3.2.4), then the ADS-B Transmitting Subsystem **shall** use the GPS/GNSS Time Mark pulse to accomplish the following:

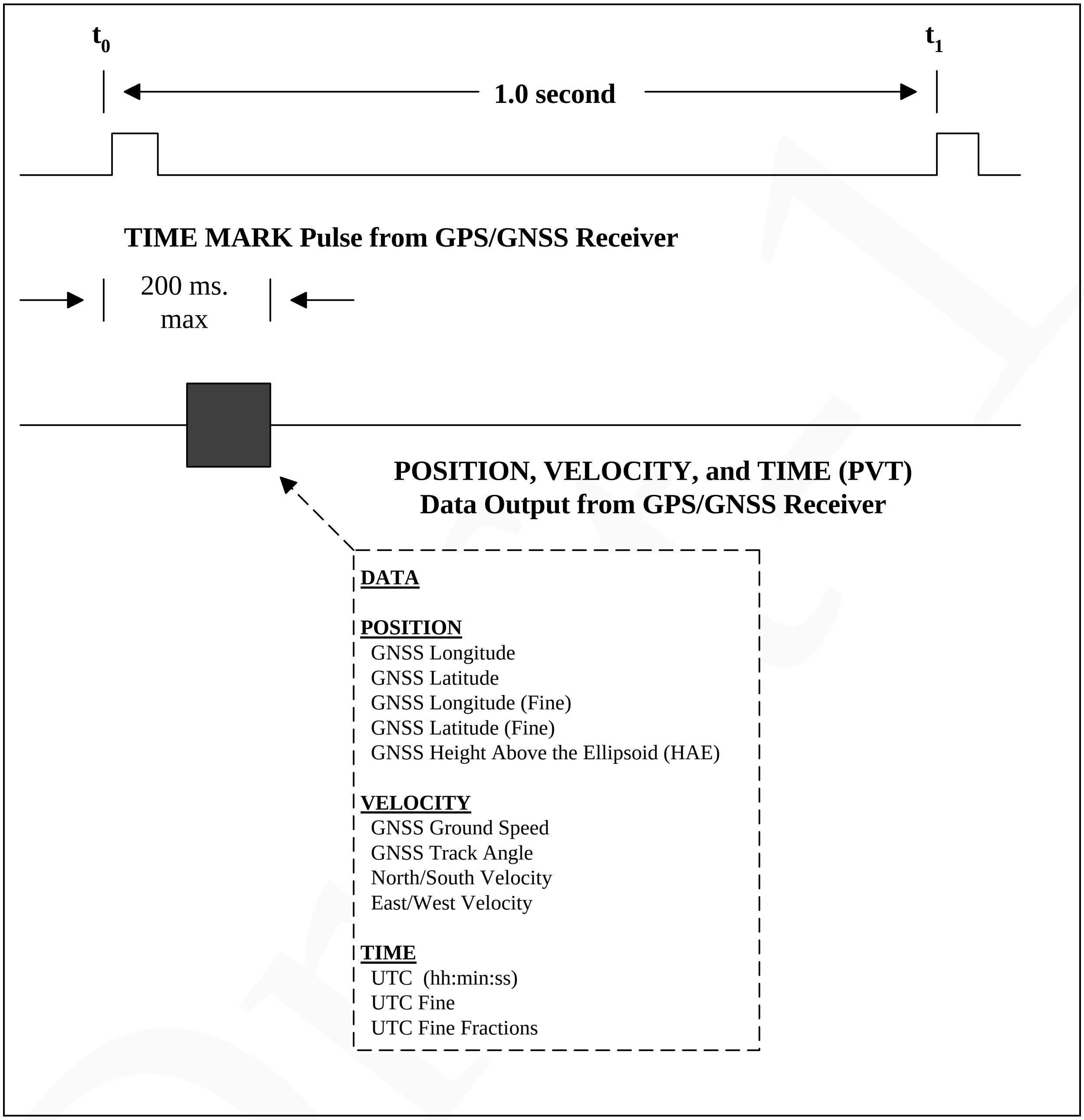
(1). Synchronize the loading of the Surface Position Message such that the register is properly loaded 100 milliseconds +/- 50 milliseconds prior to the time of applicability of the data being loaded into the register.

(2). Establish the "Time" subfield in ADS-B Surface Position Messages (see §2.2.3.2.4) as specified in §2.2.3.2.4.5,

(3). Establish the "CPR Format" subfield in ADS-B Surface Position Messages (see §2.2.3.2.4) as specified in §2.2.3.2.4.6,

(4). Extrapolate Surface Latitude Position in ADS-B Surface Position Messages (see §2.2.3.2.4) as specified in §2.2.3.2.4.7.2, and

(5). Extrapolate Surface Longitude Position in ADS-B Surface Position Messages (see §2.2.3.2.4) as specified in §2.2.3.2.4.8.2.



<u>Figure 2-11:</u> GPS/GNSS Time Mark Pulse

Note: *Navigation and UTC time information should be available within 200 milliseconds following the leading edge of the Time Mark at time t_0. The information is considered to be valid at time t_0. Specifically, the information is NOT projected to be valid at time t_1, which represents the beginning of the next GPS/GNSS Epoch.*

2.2.5.1.7 Own Position Latitude Data

The ADS-B Transmitting Subsystem **shall** accept own position Latitude information via an appropriate variable data input interface and use such data to establish subfields in ADS-B transmitted messages as follows:

a. The encoded Latitude subfield in the Airborne Position Message (see §2.2.3.2.3) as specified in §2.2.3.2.3.7 through §2.2.3.2.3.7.4,

b. The encoded Latitude subfield in the Surface Position Message (see §2.2.3.2.4) as specified in §2.2.3.2.4.7 through §2.2.3.2.4.7.4,

   Note: *Encoded Latitude for the Airborne and the Surface Position Messages will normally not be the same. However, the procedures used to obtain the Encoded Latitude for either case are essentially the same in the CPR algorithm. (See Appendix A).*

c. If Latitude data is not available to the ADS-B transmission device, then the device **shall** enter ALL ZEROs into the Encoded Latitude subfield of the Airborne Position Message (§2.2.3.2.3) when airborne or into the Encoded Latitude subfield of the Surface Position message (§2.2.3.2.4) when on the surface.

Note: *Any airport surface application(s) that will use ADS-B surface position information will need to account for the potential navigation error associated with the reported position relative to the navigation center of the aircraft.*

2.2.5.1.8 Own Position Longitude Data

The ADS-B Transmitting Subsystem **shall** accept own position Longitude information via an appropriate variable data input interface and use such data to establish subfields in ADS-B transmitted messages as follows:

a. The encoded Longitude subfield in the Airborne Position Message (see §2.2.3.2.3) as specified in §2.2.3.2.3.8 through §2.2.3.2.3.8.4,

b. The encoded Longitude subfield in the Surface Position Message (see §2.2.3.2.4) as specified in §2.2.3.2.4.8 through §2.2.3.2.4.8.4,

   Note: *Encoded Longitude for the Airborne and the Surface Position Messages will normally not be the same. However, the procedures used to obtain the Encoded Longitude for either case are essentially the same in the CPR algorithm. (See Appendix A).*

c. If Longitude data is not available to the ADS-B transmission device, then the device **shall** enter ALL ZEROs into the Encoded Longitude subfield of the Airborne Position Message (§2.2.3.2.3) when airborne or into the Encoded Longitude subfield of the Surface Position message (§2.2.3.2.4) when on the surface.

Note: *Any airport surface application(s) that will use ADS-B surface position information will need to account for the potential navigation error associated with the reported position relative to the navigation center of the aircraft.*

2.2.5.1.9 Ground Speed Data

a. The ADS-B Transmitting Subsystem **shall** accept own vehicle Ground Speed information via an appropriate variable data input interface and use such data to establish the “Movement” subfield (see §2.2.3.2.4.2) in the Surface Position Message as specified in §2.2.3.2.4.2.

b. If Ground Speed data is not available to the ADS-B transmission device, then the device **shall** enter ALL ZEROs into the Movement subfield specified in §2.2.3.2.4.2.

c. Ground Speed may be used in conjunction with Ground Track data to arithmetically establish East/West Velocity Data (see §2.2.5.1.2) and North/South Velocity Data (see §2.2.5.1.3) if East/West and/or North/South Velocity Data is not available.

   (1). When Ground Speed data is used as provided in subparagraph “c,” the NAC_V (see §2.2.5.1.22) data reported by the ADS-B Transmitting Subsystem **shall** be consistent with the accuracy, range, and resolution that can be obtained by using Ground Speed data as the input data to the arithmetic computations necessary.

   (2). When Ground Speed data is used as provided in subparagraph “c,” but Ground Speed Data is not available to the ADS-B transmission device, then the device **shall** enter ALL ZEROs into all transmitted subfields that are computed based on Ground Speed data.

2.2.5.1.10 Heading Data

The ADS-B transmitting subsystem **shall** accept own vehicle Heading information via an appropriate variable data input interface and use such data to establish subfields in transmitted ADS-B Messages as follows:

a. The “Status Bit for Heading” subfield in the Surface Position Message (See §2.2.3.2.4) as specified in §2.2.3.2.4.3,

b. The “Heading” subfield in the Surface Position Message (see §2.2.3.2.4.2) as specified in §2.2.3.2.4.4,

c. When Turn Rate data is not directly available, the ADS-B transmission device may use Heading data to establish the Turn Indicator Subfield as follows:

   (1). In the Airborne Velocity Information - Subtype “1 & 2” Messages (see §2.2.3.2.6.1 and §2.2.3.2.6.2) as specified in §2.2.3.2.6.1.13 and §2.2.3.2.6.2.13 respectively,

   (2). In the Airborne Velocity Information - Subtype “3 & 4” Messages (see §2.2.3.2.6.3 and §2.2.3.2.6.4) as specified in §2.2.3.2.6.3.13 and §2.2.3.2.6.4.13.

d. If Heading data is not available to the ADS-B transmission device, then the device **shall** enter ALL ZEROs into the “Status Bit for Heading” and “Heading” subfields specified in §2.2.3.2.4.3 and §2.2.3.2.4.4 respectively,

e. If Heading data and Turn Rate data are not available to the ADS-B transmission device, then the device **shall** ZERO the Turn Indicator Subfield:

(1). In the Airborne Velocity Information - Subtype “1 & 2” Messages (see §2.2.3.2.6.1 and §2.2.3.2.6.2) as specified in §2.2.3.2.6.1.13 and §2.2.3.2.6.2.13 respectively,

(2). in the Airborne Velocity Information - Subtype “3 & 4” Messages (see §2.2.3.2.6.3 and §2.2.3.2.6.4) as specified in §2.2.3.2.6.3.13 and §2.2.3.2.6.4.13 respectively.

f. Heading may be used in conjunction with Ground Speed data to arithmetically establish East/West Velocity Data (see §2.2.5.1.2) and North/South Velocity Data (see §2.2.5.1.3) if East/West and/or North/South Velocity Data is not available.

(1). When Heading data is used, the NAC_V (see §2.2.5.1.22) data reported by the ADS-B Transmitting Subsystem **shall** be consistent with the accuracy, range, and resolution that can be obtained by using Heading data as the input data to the arithmetic computations necessary.

(2). When Heading data is used, but Heading Data is not available to the ADS-B transmission device, then the device **shall** enter ALL ZEROs into all transmitted subfields that are computed based on Heading data.

Notes:

1. *True Heading data may be unreliable at low ground speeds.*

2. *At very low ground speeds, the best estimate of an aircraft’s or ground vehicle’s ground track angle may be from a heading source rather than from the “track angle” output of a GNSS receiver.*

2.2.5.1.11 Aircraft Identification (*or* Registration) Data

a. The ADS-B transmission device **shall** accept own vehicle Aircraft Identification Data via an appropriate data input interface and use such data to establish the Aircraft Identification or Flight Number Data in Aircraft Identification and Type Messages (see §2.2.3.2.5) as specified in §2.2.3.2.5.3.

b. When Aircraft Identification or Flight Number data specified in subparagraph a is not available or is not valid, the ADS-B transmission device **shall** accept own vehicle Aircraft Registration Character Data (N250DL, etc.) via an appropriate data input interface and use such data to establish the Aircraft Identification or Flight Number Data in Aircraft Identification and Type Messages (see §2.2.3.2.5) as specified in §2.2.3.2.5.3.

c. Only if Aircraft Identification or Flight Number Data, and Aircraft Registration Data is not available to the ADS-B transmission device, **shall** the device enter ALL ZEROs into the character fields specified in §2.2.3.2.5.3.

2.2.5.1.12 East / West Velocity Data

The ADS-B Transmitting Subsystem **shall** accept own vehicle East / West Velocity information via an appropriate variable data input interface and use such data to establish subfields in transmitted ADS-B Messages as follows:

a. The "Encoded Longitude" subfield in Airborne Position Messages (see §2.2.3.2.3) as specified in §2.2.3.2.3.8 through §2.2.3.2.3.8.4,

b. The "Encoded Longitude" subfield in Surface Position Messages (see §2.2.3.2.4) as specified in §2.2.3.2.4.8 through §2.2.3.2.4.8.4,

c. The "East/West Direction Bit" subfield in Airborne Velocity Information Messages - Subtypes "1 & 2" (see §2.2.3.2.6.1 and §2.2.3.2.6.2) as specified in §2.2.3.2.6.1.6 and §2.2.3.2.6.2.6 respectively,

d. The "East/West Velocity" subfield in Airborne Velocity Information Messages - Subtypes "1 & 2" (see §2.2.3.2.6.1 and §2.2.3.2.6.2 respectively) as specified in §2.2.3.2.6.1.7 and §2.2.3.2.6.2.7 respectively,

e. If East / West Velocity data is not available to the ADS-B transmission device, then the device **shall** enter ALL ZEROs in the E/W Direction Bit and E/W Velocity subfields specified in:

   (1). §2.2.3.2.6.1.6 and §2.2.3.2.6.1.7, and

   (2). §2.2.3.2.6.2.6 and §2.2.3.2.6.2.7, respectively.

2.2.5.1.13 North / South Velocity Data

The ADS-B Transmitting Subsystem **shall** accept own vehicle North / South Velocity information via an appropriate variable data input interface and use such data to establish subfields in transmitted ADS-B Messages as follows:

a. The "Encoded Latitude" subfield in Airborne Position Messages (see §2.2.3.2.3) as specified in §2.2.3.2.3.7 through §2.2.3.2.3.7.4,

b. The "Encoded Latitude" subfield in Surface Position Messages (see §2.2.3.2.4) as specified in §2.2.3.2.4.7 through §2.2.3.2.4.7.4,

c. The "North/South Direction Bit" subfield in Airborne Velocity Information Messages - Subtypes "1 & 2" (see §2.2.3.2.6.1 and §2.2.3.2.6.2) as specified in §2.2.3.2.6.1.8 and §2.2.3.2.6.2.8, respectively,

d. The "North/South Velocity" subfield in Airborne Velocity Information Messages - Subtypes "1 & 2" (see §2.2.3.2.6.1 and §2.2.3.2.6.2 respectively) as specified in §2.2.3.2.6.1.9 and §2.2.3.2.6.2.9, respectively,

e. If North / South Velocity data is not available to the ADS-B transmission device, then the device **shall** enter ALL ZEROs in the N/S Direction Bit and N/S Velocity subfields specified in:

(1). §2.2.3.2.6.1.8 and §2.2.3.2.6.1.9, and

(2). §2.2.3.2.6.2.8 and §2.2.3.2.6.2.9, respectively.

2.2.5.1.14 Vertical Rate Data

The ADS-B Transmitting Subsystem **shall** accept own vehicle Vertical Rate (Geometric ***AND/OR*** Barometric referenced) information via an appropriate variable data input interface and use such data to establish subfields in transmitted ADS-B Messages as follows:

a. The "Source Bit for Vertical Rate" subfield in the Airborne Velocity Information - Subtype "1,2,3, & 4" Messages (§2.2.3.2.6.1, §2.2.3.2.6.2, §2.2.3.2.6.3 and §2.2.3.2.6.4 respectively) as specified in §2.2.3.2.6.1.10, §2.2.3.2.6.2.10, §2.2.3.2.6.3.10 and §2.2.3.2.6.4.10, respectively,

b. The "Sign Bit for Vertical Rate" subfield in the Airborne Velocity Information - Subtype "1,2,3, & 4" Messages (§2.2.3.2.6.1, §2.2.3.2.6.2, §2.2.3.2.6.3 and §2.2.3.2.6.4 respectively) as specified in §2.2.3.2.6.1.11, §2.2.3.2.6.2.11, §2.2.3.2.6.3.11 and §2.2.3.2.6.4.11, respectively,

c. The "Vertical Rate" subfield in the Airborne Velocity Information - Subtype "1,2,3, & 4" Messages (§2.2.3.2.6.1, §2.2.3.2.6.2, §2.2.3.2.6.3 and §2.2.3.2.6.4 respectively) as specified in §2.2.3.2.6.1.12, §2.2.3.2.6.2.12, §2.2.3.2.6.3.12 and §2.2.3.2.6.4.12, respectively,

d. If Vertical Rate data is not available to the ADS-B transmission device, then the device **shall** enter ALL ZEROs in the "Source Bit for Vertical Rate," "Sign Bit for Vertical Rate," and "Vertical Rate" Subfields specified in subparagraphs a, b and c given directly above.

2.2.5.1.15 Turn Rate Data

The ADS-B Transmitting Subsystem **shall** accept own vehicle Turn Rate information via an appropriate variable data input interface and use such data to establish subfields in transmitted ADS-B Messages as follows:

a. The "Turn Indicator" subfield in the Airborne Velocity Information - Subtype "1,2,3, & 4" Messages (§2.2.3.2.6.1, §2.2.3.2.6.2, §2.2.3.2.6.3 and §2.2.3.2.6.4 respectively) as specified in §2.2.3.2.6.1.13, §2.2.3.2.6.2.13, §2.2.3.2.6.3.13 and §2.2.3.2.6.4.13, respectively,

b. If Turn Rate data is not available directly, then the ADS-B transmission device may use Ground Track data previously specified in §2.2.5.1.10 to establish the required Turn Indicator information specified in subparagraph a. directly above,

c. If both Ground Track data and Turn Rate data are not available to the ADS-B transmission device, then the device **shall** enter ALL ZEROs into the "Turn Indicator" subfield specified in subparagraph a. directly above.

2.2.5.1.16 Magnetic Heading Data

The ADS-B Transmitting Subsystem **shall** accept own vehicle Magnetic Heading information via an appropriate variable data input interface and use such data to establish subfields in transmitted ADS-B Messages as follows:

a. The “Magnetic Heading Status” subfield in Airborne Velocity Information - Subtype “3 & 4” (§2.2.3.2.6.3 and §2.2.3.2.6.4) as specified in §2.2.3.2.6.3.6 and §2.2.3.2.6.4.6, respectively,

b. The “Magnetic Heading” subfield in Airborne Velocity Information - Subtype “3 & 4” (§2.2.3.2.6.3 and §2.2.3.2.6.4) as specified in §2.2.3.2.6.3.7 and §2.2.3.2.6.4.7, respectively,

c. If Magnetic Heading data is not available to the ADS-B transmission device, then the device **shall** enter ALL ZEROs into the “Magnetic Heading Status Bit” and “Magnetic Heading” subfields specified in subparagraphs a. and b. directly above respectively.

Note: *If Magnetic Heading data is not available, then it may be calculated from True Heading and Magnetic Variation data provided that such information is available to the ADS-B Transmitting Subsystem and that such data is valid.*

2.2.5.1.17 True Airspeed Data

The ADS-B Transmitting Subsystem **shall** accept own vehicle True Airspeed information via an appropriate variable data input interface and use such data to establish subfields in transmitted ADS-B Messages as follows:

a. The “Airspeed Type” subfield in Airborne Velocity Information - Subtype “3 & 4” (§2.2.3.2.6.3 and §2.2.3.2.6.4) as specified in §2.2.3.2.6.3.8 and §2.2.3.2.6.4.8, respectively,

b. The “Airspeed” subfield in Airborne Velocity Information - Subtype “3 & 4” (§2.2.3.2.6.3 and §2.2.3.2.6.4) as specified in §2.2.3.2.6.3.9 and §2.2.3.2.6.4.9, respectively,

c. If appropriate “True Airspeed” or “Indicated Airspeed” (§2.2.5.1.18) data is not available to the ADS-B transmission device, then the device **shall** set the “Airspeed Type,” and “Airspeed” subfields to ALL ZEROs in the subfields specified in:

(1). §2.2.3.2.6.3.8, and §2.2.3.2.6.3.9, and

(2). §2.2.3.2.6.4.8, and §2.2.3.2.6.4.9.

2.2.5.1.18 Indicated Airspeed Data

The ADS-B Transmitting Subsystem **shall** accept own vehicle Indicated Airspeed information via an appropriate variable data input interface and use such data to establish subfields in transmitted ADS-B Messages as follows:

a. The “Airspeed Type” subfield in Airborne Velocity Information - Subtype “3 & 4” (§2.2.3.2.6.3 and §2.2.3.2.6.4) as specified in §2.2.3.2.6.3.8 and §2.2.3.2.6.4.8, respectively,

b. The “Airspeed” subfield in Airborne Velocity Information - Subtype “3 & 4” (§2.2.3.2.6.3 and §2.2.3.2.6.4) as specified in §2.2.3.2.6.3.9 and §2.2.3.2.6.4.9 respectively,

c. If appropriate “True Airspeed” (§2.2.5.1.17) or “Indicated Airspeed” data is not available to the ADS-B transmission device, then the device **shall** set the “Airspeed Type,” and “Airspeed” subfields to ALL ZEROs in the subfields specified in:

   (1). §2.2.3.2.6.3.8 and §2.2.3.2.6.3.9, and

   (2). §2.2.3.2.6.4.8 and §2.2.3.2.6.4.9.

2.2.5.1.19 Unused Section

2.2.5.1.20 Intent Change Data

a. Intent Change data necessary to establish the setting of the “Intent Change Flag” in Airborne Velocity Information - Subtype “1,2,3, & 4” Messages (§2.2.3.2.6.1, §2.2.3.2.6.2, §2.2.3.2.6.3 and §2.2.3.2.6.4, respectively) is a Mode-S Transponder function only. Therefore, appropriate requirements **shall** be established for such devices in RTCA Document No. DO-181C (EUROCAE ED-73A).

b. Non-transponder based ADS-B transmission devices need no additional data to establish the “Intent Change Flag” in Airborne Velocity Information - Subtype “1, 2, 3, & 4” Messages (§2.2.3.2.6.1, §2.2.3.2.6.2, §2.2.3.2.6.3 and §2.2.3.2.6.4, respectively) in accordance with §2.2.3.2.6.1.3, §2.2.3.2.6.2.3, §2.2.3.2.6.3.3 and §2.2.3.2.6.4.3, respectively.

2.2.5.1.21 IFR Capability Data

The ADS-B Transmitting Subsystem **shall** accept own vehicle IFR Capability information via an appropriate variable or fixed data input interface and use such data to establish subfields in transmitted ADS-B Messages as follows:

a. The “IFR Capability Flag” subfield in the Airborne Velocity Information - Subtype “1, 2, 3, & 4” Messages (§2.2.3.2.6.1, §2.2.3.2.6.2, §2.2.3.2.6.3 and §2.2.3.2.6.4, respectively) as specified in §2.2.3.2.6.1.4, §2.2.3.2.6.2.4, §2.2.3.2.6.3.4 and §2.2.3.2.6.4.4, respectively,

b. If IFR Capability data is not available to the ADS-B transmission device, then the device **shall** enter ALL ZEROs in the "IFR Capability Flag" subfields specified in §2.2.3.2.6.1.4, §2.2.3.2.6.2.4, §2.2.3.2.6.3.4 and §2.2.3.2.6.4.4.

2.2.5.1.22 NAC_V Data

The ADS-B Transmitting Subsystem **shall** accept own vehicle Navigation Uncertainty Category - Velocity (NAC_V) information via an appropriate variable data input interface and use such data to establish subfields in transmitted ADS-B Messages as follows:

a. The "NAC_V" subfield in the Airborne Velocity Information - Subtype "1, 2, 3, & 4" Messages (§2.2.3.2.6.1, §2.2.3.2.6.2, §2.2.3.2.6.3 and §2.2.3.2.6.4 respectively) as specified in §2.2.3.2.6.1.5, §2.2.3.2.6.2.5, §2.2.3.2.6.3.5 and §2.2.3.2.6.4.5, respectively,

b. If "NAC_V" data is not available to the ADS-B transmission device, then the device **shall** enter ALL ZEROs in the "NAC_V" subfields specified in §2.2.3.2.6.1.5, §2.2.3.2.6.2.5, §2.2.3.2.6.3.5 and §2.2.3.2.6.4.5.

2.2.5.1.23 Subtype (Aircraft Status) Data

The ADS-B Transmitting Subsystem **shall** accept own vehicle Subtype information via an appropriate variable data input interface and use such data to establish the "Subtype" subfield in the Aircraft Operational Status Messages (see §2.2.3.2.7.2) as specified in §2.2.3.2.7.2.2.

If appropriate Subtype data is not available to the ADS-B transmitting subsystem, then the device **shall** set the "Subtype" subfield specified in §2.2.3.2.7.2.2 to ZERO.

2.2.5.1.24 Capability Class (Reserved for Service Level) Data

The ADS-B Transmitting Subsystem **shall** accept ***TBD***

2.2.5.1.25 Capability Class (~TCAS) Data

The ADS-B Transmitting Subsystem **shall** accept ***TBD***

2.2.5.1.26 Capability Class (CDTI Traffic Display Capability) Data

The ADS-B Transmitting Subsystem **shall** accept ***TBD***

2.2.5.1.27 Capability Class (ARV Report Capability) Data

The ADS-B Transmitting Subsystem **shall** accept ***TBD***

2.2.5.1.28 Capability Class (TS Report Capability) Data

The ADS-B Transmitting Subsystem **shall** accept ***TBD***

2.2.5.1.29 Capability Class (TC Report Capability) Data

The ADS-B Transmitting Subsystem **shall** accept ***TBD***

2.2.5.1.30 Capability Class (Position Offset Applied) Data

The ADS-B Transmitting Subsystem **shall** accept ***TBD***

2.2.5.1.31 Operational Mode (OM Format) Data

The ADS-B Transmitting Subsystem **shall** accept ***TBD***

2.2.5.1.32 Operational Mode (TCAS/ACAS Resolution Advisory Active) Data

The ADS-B Transmitting Subsystem **shall** accept ***TBD***

2.2.5.1.33 Operational Mode (IDENT Switch Active) Data

The ADS-B Transmitting Subsystem **shall** accept ***TBD***

2.2.5.1.34 Operational Mode (Receiving ATC Services) Data

The ADS-B Transmitting Subsystem **shall** accept ***TBD***

2.2.5.1.35 Operational Mode (TBD) Data

The ADS-B Transmitting Subsystem **shall** accept ***TBD***

2.2.5.1.36 Radio Altitude Data

The ADS-B Transmitting Subsystem **shall** accept Radio Altitude via an appropriate variable data input interface and use such data to establish the "Air/Ground" state and thereby the "CA" field as provided in §2.2.3.2.1.1.2.

2.2.5.1.37 Version Number Data

ADS-B Transmitting Subsystems **shall** set the Version Number as indicated in Table A-21.

2.2.5.2 Unused Section

2.2.5.3 ADS-B Transmission Device Message Latency

2.2.5.3.1 Airborne Position Message Latency

The ADS-B Transmission Device Message Processor function **shall** update the Airborne Position Message data fields defined in §2.2.3.2.3 as follows:

a. Type information may change due to changes in the precision, quality, or integrity of received navigation information. As such, any change in the TYPE information identified in §2.2.3.2.3.1 **shall** be reflected in the Type subfield of the next scheduled Airborne Position message transmission provided that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Airborne Position message transmission.

b. Any change in the Surveillance Status identified in §2.2.3.2.3.2 **shall** be reflected in the Surveillance Status subfield of the next scheduled Airborne Position message transmission provided that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Airborne Position message transmission.

c. Any change in the Altitude identified in §2.2.3.2.3.4 **shall** be reflected in the Altitude subfield of the next scheduled Airborne Position message transmission provided that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Airborne Position message transmission.

d. CPR Format changes at 0.2 second intervals or more often as defined in §2.2.3.2.3.6. A change in the CPR Format **shall** be reflected in the CPR Format subfield of the next scheduled Airborne Position message transmission provided that the change occurs at least ***"X"*** milliseconds prior to the next scheduled Airborne Position message transmission. The time ***"X,"*** **shall** be dependent upon the NUC_P (see Table 2-11, §2.2.8.1.16 and §2.2.8.2.12) provided to the transmission device as follows:

(1). ***"X"*** is equal to 200 milliseconds if NIC $\leq$ 8 or $NAC_P \leq 8$

(2). ***"X"*** is equal to 50 milliseconds if NIC > 8 and $NAC_P > 8$

Note: *All efforts must be made to allocate the time necessary to update the actual transmission buffer within the 200 millisecond time frame allocated to the CPR Format changes. That is that no additional time can be added to the 200 milliseconds already allocated.*

e. Encoded Latitude (defined in §2.2.3.2.3.7) must be extrapolated in accordance with §2.2.3.2.3.7.2 for precision systems. Likewise, Encoded Latitude must be updated in accordance with §2.2.3.2.3.7.3 for non-precision systems. Any change in the Encoded Latitude **shall** be reflected in the Encoded Latitude subfield of the next scheduled Airborne Position message transmission provided that the change occurs at least ***"X"*** milliseconds prior to the next scheduled Airborne Position message transmission. The time ***"X,"*** **shall** be dependent upon the NUC_P (see Table 2-11, §2.2.8.1.16 and §2.2.8.2.12) provided to the transmission device as follows:

(1). ***"X"*** is equal to 200 milliseconds if NIC $\leq$ 8 or $NAC_P \leq 8$

(2). ***"X"*** is equal to 50 milliseconds if NIC > 8 and $NAC_P > 8$

Note: *All efforts must be made to allocate the time necessary to update the actual transmission buffer within the 200 millisecond time frame allocated updating the Encoded Latitude. That is, that no additional time can be added to the 200 milliseconds already allocated*

f. Encoded Longitude (defined in §2.2.3.2.3.8) must be extrapolated in accordance with §2.2.3.2.3.8.2 for precision systems. Likewise, Encoded Longitude must be updated in accordance with §2.2.3.2.3.8.3 for non-precision systems. Any change in the Encoded Longitude **shall** be reflected in the Encoded Longitude subfield of the next scheduled Airborne Position message transmission provided that the change occurs at least ***"X"*** milliseconds prior to the next scheduled Airborne Position message transmission. The time ***"X,"*** **shall** be dependent upon the NUC_P (see Table 2-11, §2.2.8.1.16 and §2.2.8.2.12) provided to the transmission device as follows:

(1). ***"X"*** is equal to 200 milliseconds if NIC $\leq$ 8 or $NAC_P \leq 8$

(2). ***"X"*** is equal to 50 milliseconds if NIC > 8 and $NAC_P > 8$

Note: *All efforts must be made to allocate the time necessary to update the actual transmission buffer within the 200 millisecond time frame allocated updating the Encoded Latitude. That is, that no additional time can be added to the 200 milliseconds already allocated*

2.2.5.3.2 Surface Position Message Latency

The ADS-B Transmission Device Message Processor function **shall** update the Surface Position Message data fields defined in §2.2.3.2.4 as follows:

a. Type information may change due to changes in the precision, quality, or integrity of received navigation information. As such, any change in the TYPE information identified in §2.2.3.2.4.1 **shall** be reflected in the Type subfield of the next scheduled Surface Position message transmission provided that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Surface Position message transmission.

b. Any change in Movement (i.e., Ground Speed) identified in §2.2.3.2.4.2 **shall** be reflected in the Movement subfield of the next scheduled Surface Position message transmission provided that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Surface Position message transmission.

c. Any change in Ground Track identified in §2.2.3.2.4.3 and 0 **shall** be reflected in the appropriate Ground Track subfields of the next scheduled Surface Position message transmission provided that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Surface Position message transmission.

d. CPR Format changes at 0.2 second intervals as defined in §2.2.3.2.4.6. A change in the CPR Format **shall** be reflected in the CPR Format subfield of the next scheduled Surface Position message transmission provided that the change occurs at least ***"X"*** milliseconds prior to the next scheduled Surface Position message transmission. The time ***"X,"*** **shall** be dependent upon the NUC_P (see Table 2-11, §2.2.8.1.16 and §2.2.8.2.12) provided to the transmission device as follows:

(1). ***"X"*** is equal to 200 milliseconds if NIC $\leq$ 8 or $NAC_P \leq 8$

(2). ***"X"*** is equal to 50 milliseconds if NIC > 8 and $NAC_P > 8$

Note: *All efforts must be made to allocate the time necessary to update the actual transmission buffer within the 200 millisecond time frame allocated to the CPR Format changes. That is that no additional time can be added to the 200 milliseconds already allocated.*

e. Encoded Latitude (defined in §2.2.3.2.4.7) must be extrapolated in accordance with §2.2.3.2.4.7.2 for precision systems. Likewise, Encoded Latitude must be updated in accordance with §2.2.3.2.4.7.3 for non-precision systems. Any change in the Encoded Latitude **shall** be reflected in the Encoded Latitude subfield of the next scheduled Surface Position message transmission provided that the change occurs at least ***"X"*** milliseconds prior to the next scheduled Surface Position message transmission. The time ***"X,"*** **shall** be dependent upon the NUC_P (see Table 2-11, §2.2.8.1.16 and §2.2.8.2.12) provided to the transmission device as follows:

(1). ***"X"*** is equal to 200 milliseconds if NIC $\leq$ 8 or $NAC_P \leq 8$

(2). ***"X"*** is equal to 50 milliseconds if NIC > 8 and $NAC_P > 8$

Note: *All efforts must be made to allocate the time necessary to update the actual transmission buffer within the 200 millisecond time frame allocated updating the Encoded Latitude. That is, that no additional time can be added to the 200 milliseconds already allocated*

f. Encoded Longitude (defined in §2.2.3.2.4.8) must be extrapolated in accordance with §2.2.3.2.4.8.2 for precision systems. Likewise, Encoded Latitude must be updated in accordance with §2.2.3.2.4.8.3 for non-precision systems. Any change in the Encoded Longitude **shall** be reflected in the Encoded Longitude subfield of the next scheduled Surface Position message transmission provided that the change occurs at least ***"X"*** milliseconds prior to the next scheduled Surface Position message transmission. The time ***"X,"*** **shall** be dependent upon the NUC_P (see Table 2-11, §2.2.8.1.16 and §2.2.8.2.12) provided to the transmission device as follows:

(1). ***"X"*** is equal to 200 milliseconds if NIC $\leq$ 8 or $NAC_P \leq 8$

(2). ***"X"*** is equal to 50 milliseconds if NIC > 8 and $NAC_P > 8$

Note: *All efforts must be made to allocate the time necessary to update the actual transmission buffer within the 200 millisecond time frame allocated updating the Encoded Latitude. That is, that no additional time can be added to the 200 milliseconds already allocated*

2.2.5.3.3 Aircraft Identification Message Latency

The ADS-B Transmission Device Message Processor function **shall** update the Aircraft Identification Message data fields defined in §2.2.3.2.5 as follows:

a. Type information for the Aircraft Identification Message should be fixed and therefore not change. However, if changes are imposed, any such change in the TYPE information identified in §2.2.3.2.5.1 **shall** be reflected in the Type subfield of the Aircraft Identification message once the data has been stable (i.e., no changes) for a period of 4 seconds.

b. ADS-B Emitter Category information for the Aircraft Identification Message should be fixed and therefore not change. However, if changes are imposed, any such change in the ADS-B Emitter Category information identified in §2.2.3.2.5.2 **shall** be reflected in the ADS-B Emitter Category subfield of the Aircraft Identification message once the data has been stable (i.e., no changes) for a period of 4 seconds.

c. Any change in Character information identified in §2.2.3.2.5.3 **shall** be reflected in the appropriate Character subfields of the Aircraft Identification message once the data has been stable (i.e., no changes) for a period of 4 seconds.

2.2.5.3.4 Airborne Velocity - Subtype "1" Message Latency

The ADS-B Transmission Device Message Processor function **shall** update the Aircraft Velocity - Subtype "1" Message data fields defined in §2.2.3.2.6.1 as follows:

Any change in the data used to structure the following subfields of the Airborne Velocity - Subtype "1" message **shall** be reflected in the affected subfield of the next scheduled Airborne Velocity - Subtype "1" message provided that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Airborne Velocity - Subtype "1" message transmission:

(1). TYPE – (see §2.2.3.2.6.1.1)

(2). SUBTYPE – (see §2.2.3.2.6.1.2)

(3). INTENT CHANGE FLAG – (see §2.2.3.2.6.1.3)

(4). IFR CAPABILITY FLAG – (see §2.2.3.2.6.1.4)

(5). NAC_V -- (see §2.2.3.2.6.1.5)

(6). EAST / WEST DIRECTION and EAST / WEST VELOCITY -- (see §2.2.3.2.6.1.6 and §2.2.3.2.6.1.7)

(7). NORTH / SOUTH DIRECTION and NORTH / SOUTH VELOCITY -- (see §2.2.3.2.6.1.8 and §2.2.3.2.6.1.9)

(8). VERTICAL RATE – (see §2.2.3.2.6.1.10 through §2.2.3.2.6.1.12)

(9). TURN INDICATOR – (see §2.2.3.2.6.1.13)

(10). DIFFERENCE FROM BAROMETRIC ALTITUDE – (see §2.2.3.2.6.1.14 and §2.2.3.2.6.1.15)

2.2.5.3.5 Airborne Velocity - Subtype “2” Message Latency

The ADS-B Transmission Device Message Processor function **shall** update the Aircraft Velocity - Subtype “2” Message data fields defined in §2.2.3.2.6.2 as follows:

Any change in the data used to structure the following subfields of the Airborne Velocity - Subtype “2” message **shall** be reflected in the affected subfield of the next scheduled Airborne Velocity - Subtype “2” message provided that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Airborne Velocity - Subtype “2” message transmission:

(1). TYPE – (see §2.2.3.2.6.2.1)

(2). SUBTYPE – (see §2.2.3.2.6.2.2)

(3). INTENT CHANGE FLAG – (see §2.2.3.2.6.2.3)

(4). IFR CAPABILITY FLAG – (see §2.2.3.2.6.2.4)

(5). NAC_V -- (see §2.2.3.2.6.2.5)

(6). EAST / WEST DIRECTION and EAST / WEST VELOCITY -- (see §2.2.3.2.6.2.6 and §2.2.3.2.6.2.7)

(7). NORTH / SOUTH DIRECTION and NORTH / SOUTH VELOCITY -- (see §2.2.3.2.6.2.8 and §2.2.3.2.6.2.9)

(8). VERTICAL RATE – (see §2.2.3.2.6.2.10 through §2.2.3.2.6.2.12)

(9). TURN INDICATOR – (see §2.2.3.2.6.2.13)

(10). DIFFERENCE FROM BAROMETRIC ALTITUDE – (see §2.2.3.2.6.2.14 and §2.2.3.2.6.2.15)

2.2.5.3.6 Airborne Velocity - Subtype "3" Message Latency

The ADS-B Transmission Device Message Processor function **shall** update the Aircraft Velocity - Subtype "3" Message data fields defined in §2.2.3.2.6.3 as follows:

Any change in the data used to structure the following subfields of the Airborne Velocity - Subtype "3" message **shall** be reflected in the affected subfield of the next scheduled Airborne Velocity - Subtype "3" message provided that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Airborne Velocity - Subtype "3" message transmission:

(1). TYPE – (see §2.2.3.2.6.3.1)

(2). SUBTYPE – (see §2.2.3.2.6.3.2)

(3). INTENT CHANGE FLAG – (see §2.2.3.2.6.3.3)

(4). IFR CAPABILITY FLAG – (see §2.2.3.2.6.3.4)

(5). NAC_V -- (see §2.2.3.2.6.3.5)

(6). MAGNETIC HEADING -- (see §2.2.3.2.6.3.6 through §2.2.3.2.6.3.7)

(7). AIRSPEED -- (see §2.2.3.2.6.3.8 and §2.2.3.2.6.3.9)

(8). VERTICAL RATE – (see §2.2.3.2.6.3.10 through §2.2.3.2.6.3.12)

(9). TURN INDICATOR – (see §2.2.3.2.6.3.13)

(10). DIFFERENCE FROM BAROMETRIC ALTITUDE – (see §2.2.3.2.6.3.14 and §2.2.3.2.6.3.15)

2.2.5.3.7 Airborne Velocity - Subtype "4" Message Latency

The ADS-B Transmission Device Message Processor function **shall** update the Aircraft Velocity - Subtype "4" Message data fields defined in §2.2.3.2.6.4 as follows:

Any change in the data used to structure the following subfields of the Airborne Velocity - Subtype "4" message **shall** be reflected in the affected subfield of the next scheduled Airborne Velocity - Subtype "4" message provided that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Airborne Velocity - Subtype "4" message transmission:

(1). TYPE – (see §2.2.3.2.6.4.1)

(2). SUBTYPE – (see §2.2.3.2.6.4.2)

(3). INTENT CHANGE FLAG – (see §2.2.3.2.6.4.3)

(4). IFR CAPABILITY FLAG – (see §2.2.3.2.6.4.4)

(5). NAC_V -- (see §2.2.3.2.6.4.5)

(6). MAGNETIC HEADING -- (see §2.2.3.2.6.4.6 through §2.2.3.2.6.4.7)

(7). AIRSPEED -- (see §2.2.3.2.6.4.8 and §2.2.3.2.6.4.9)

(8). VERTICAL RATE – (see §2.2.3.2.6.4.10 through §2.2.3.2.6.4.12)

(9). TURN INDICATOR – (see §2.2.3.2.6.4.13)

(10). DIFFERENCE FROM BAROMETRIC ALTITUDE - (see §2.2.3.2.6.4.14 and §2.2.3.2.6.4.15)

2.2.5.3.8 Airborne Velocity - Subtype "5" Message Latency

RESERVED FOR FUTURE APPLICATION.

2.2.5.3.9 Airborne Velocity - Subtype "6" Message Latency

RESERVED FOR FUTURE APPLICATION

2.2.5.3.10 Airborne Velocity - Subtype "7" Message Latency

RESERVED FOR FUTURE APPLICATION

2.2.5.3.11 Aircraft Trajectory Intent and System Status Message Latency

The ADS-B Transmission Device Message Processor function **shall** update the Aircraft Trajectory Intent and System Status (ATISS) Message data fields defined in §2.2.3.2.7.1 as follows:

Any change in the data used to structure the following subfields of the Aircraft Trajectory Intent and System Status Message **shall** be reflected in the affected subfield of the next scheduled Aircraft Trajectory Intent and System Status Message provided that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Aircraft Trajectory Intent Message transmission.

(1). TYPE – (see §2.2.3.2.7.1.1)

(2). ***TBD***

(3). ***TBD***

Note: *The ADS-B system must be capable of processing Trajectory Intent and System Status Messages that are independent of each other. That is, that one message is used to transfer of Current Target State information while the other message is used to transfer Trajectory Change information. Likewise, the latency requirements for each message **shall** be satisfied in an independent manner.*

2.2.5.3.12 Aircraft Operational Status Message Latency

The ADS-B Transmission Device Message Processor function **shall** update the Aircraft Operational Status Message data fields defined in §2.2.3.2.7.2 as follows:

Any change in the data used to structure the following subfields of the Aircraft Operational Status message **shall** be reflected in the affected subfield of the next scheduled Aircraft Operational Status message provided that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Aircraft Operational Status message transmission:

(1). TYPE – (see §2.2.3.2.7.2.1)

(2). SUBTYPE – (see §2.2.3.2.7.2.2)

(3). CAPABILITY CLASS – (see §2.2.3.2.7.2.3 through §2.2.3.2.7.2.3.4)

(4). OPERATIONAL MODE – (see §2.2.3.2.7.2.4 through §2.2.3.2.7.2.4.4)

2.2.5.3.13 TEST EVENT- Driven Message Latency

The ADS-B Transmission Device Message Processor **shall** process Vendor Specified data for ADS-B Test messages defined in §2.2.3.2.7.3 with any change in data being reflected in the next scheduled Test - Event Driven message provided that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Test - Event Driven message transmission.

2.2.5.3.14 TYPE 24 Event - Driven Message Latency

RESERVED for future use of Surface System Status.

2.2.5.3.15 TYPE 25 Event - Driven Message Latency

RESERVED FOR FUTURE APPLICATION.

2.2.5.3.16 TYPE 26 Event - Driven Message Latency

RESERVED FOR FUTURE APPLICATION.

2.2.5.3.17 TYPE 27 Event - Driven Message Latency

RESERVED FOR FUTURE APPLICATION.

2.2.6 ADS-B Receiving Device Message Processor Characteristics

To provide maximum flexibility in user application implementation of ADS-B information, ADS-B Receiving Devices are categorized into two major functional types, which are illustrated in Figure 2-12 and defined in the following subparagraphs.

Note: *Figure 2-15 provides additional detail in regards to ADS-B Message and Report general data flow.*

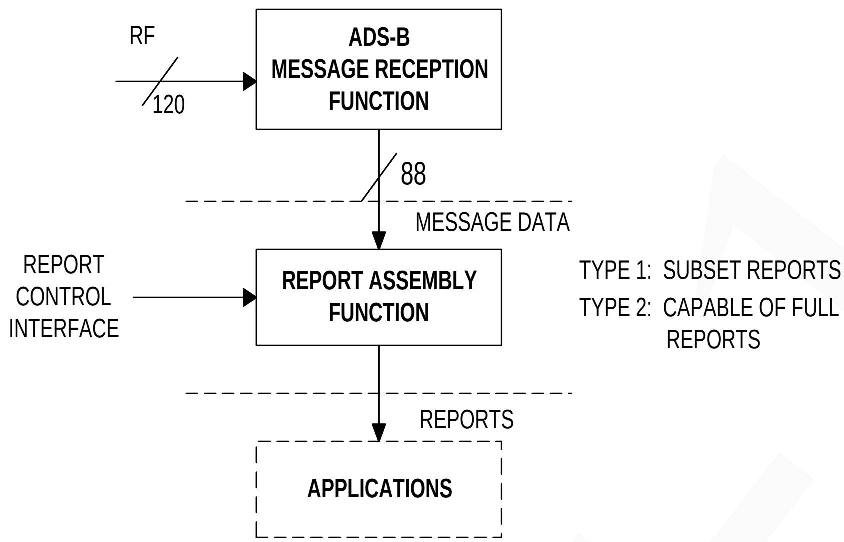


Figure 2-12: ADS-B Receiver / Report Assembly Functional Types

a. The ADS-B Message processing function begins with the ADS-B Message Reception Function receiving the transmitted message and then performing the necessary processing to deliver "Message Data" to the Report Assembly Function.

b. **TYPE 1** – TYPE 1 ADS-B Report Assembly subsystems are those that receive ADS-B Messages and produce application-specific subsets of ADS-B reports. As such, the Type 1 ADS-B Report Assembly subsystems may be customized to the particular applications using ADS-B reports. In addition, Type 1 ADS-B Report Assembly subsystems may be controlled by an external entity to produce installation-defined subsets of the reports that those subsystems are capable of producing.

c. **TYPE 2** – TYPE 2 ADS-B Report Assembly subsystems are those that receive ADS-B Messages and are capable of producing complete ADS-B reports in accordance with the applicable ADS-B equipment class requirements. Type 2 Report Assembly subsystems may be controlled by an external entity to produce installation-defined subsets of the reports that those subsystems are capable of producing.

2.2.6.1 ADS-B Message Reception Function Requirements

a. The ADS-B Message Reception Function **shall** properly decode valid ADS-B transmitted messages while ignoring other similar Mode-S transmissions.

b. The ADS-B Message Reception Function **shall** decode ADS-B transmitted messages in accordance with the requirements provided in §2.2.4.3.4.7 of this document.

2.2.6.1.1 ADS-B Message Reception Function Output Message Structure Requirements

All ADS-B Messages are received in the general format provided in Figure 2-2 and defined in §2.2.3.2.1.

Each ADS-B Message received **shall** be structured into the baseline ***OUTPUT MESSAGE*** shown in Figure 2-13 for delivery to the user interface or the Report Assembly function:

ADS-B OUTPUT MESSAGE FORMAT STRUCTURE			
Transmitted Message BIT #	**1 --- 5**	**9 ---------------32**	**33 ---88**
Output Message BIT #	**1 --- 5**	**6 --------------- 29**	**30 ---85**
FIELD NAME	**DF [5]**	**AA [24]**	**ME [56]**
	MSB LSB	MSB ------------ LSB	MSB --- LSB

Note: *"[#]" provided in the Field indicates the number of bits in the field.*

Figure 2-13: ADS-B Output Message Format Structure

2.2.6.1.2 ADS-B Message Reception Function Output Message Delivery Requirements

Figure 2-14 illustrates the transmitted message receipt capabilities and the ***OUTPUT MESSAGE*** delivery requirements, which are specified in the following subparagraphs:

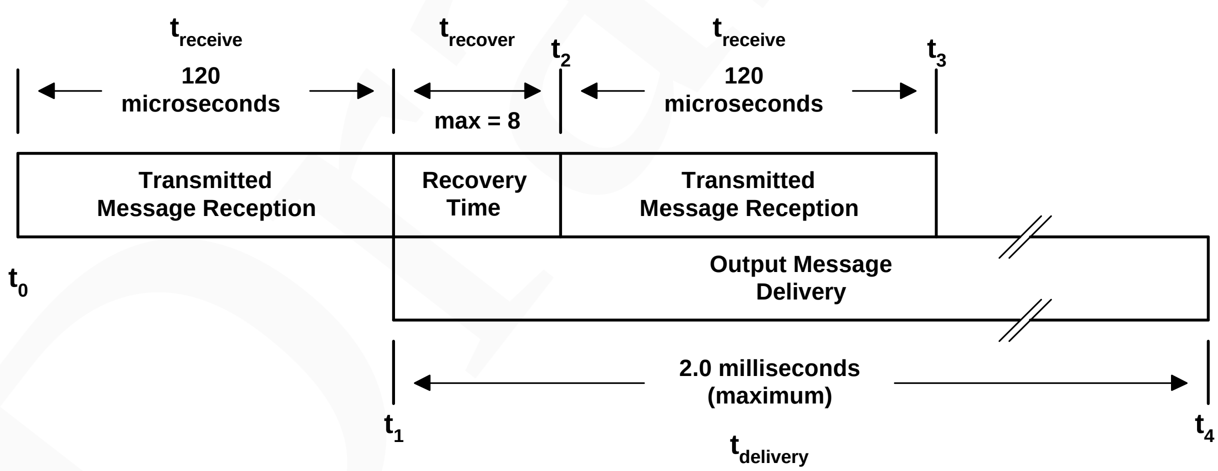


Figure 2-14: ADS-B Message Reception Function Output Message Delivery

The ADS-B Message Reception Function **shall** deliver All *OUTPUT MESSAGES* to the user interface or the Report Assembly function within 2.0 milliseconds of the receipt of the last message bit of the transmitted message.

2.2.7 ADS-B Message Processor Characteristics

2.2.7.1 ADS-B Receiving Device Message Reception

The ADS-B Receiver **shall** decode all valid ADS-B transmitted messages and structure the information from such messages into the appropriate ADS-B Reports identified in subsequent sections of this document. The structured reports **shall** then be made available to the appropriate user application as needed.

2.2.7.1.1 Receipt of Type Code Equal to ZERO

An ADS-B Message containing a Type Code of ZERO (binary 0 0000) can only be used to update the altitude data of an aircraft that is already being tracked by the entity receiving the altitude data in a Type ZERO ADS-B Message.

If an ADS-B Message with Type Code equal to ZERO is received, it should be checked to see if altitude data is present and then process the altitude data as follows:

a. If altitude data is not present, the message **shall** be discarded.

b. If altitude data is present, it may be used to update altitude as needed.

Note: *For TCAS systems, this could be an aircraft that was being maintained via hybrid surveillance when the position data input failed. In this case, altitude only could be used for a short period of time. Interrogation would have to begin at the update rate for that track to ensure update of range and bearing information on the TCAS display.*

2.2.8 ADS-B Report Characteristics

The intent of the following subparagraphs is to provide an example coding of each type of ADS-B report. Implementations may use alternative report structures and coding of the ADS-B reports. However, the contents of each report type **shall** include, as a minimum, the data parameters as defined in the following subparagaphs.

2.2.8.1 ADS-B State Vector Report Characteristics

Table 2.2.8.1 and the subsequent subparagraphs identify the data structure for all ADS-B State Vector Reports generated **for each ADS-B vehicle being reported**.

The intent of Table 2.2.8.1 is to illustrate the structure of all Items (i.e., parameters) required to be reported in an ADS-B State Vector Report. The exact structure of the data indicated in columns 10 and 11 is provided as a guide line or one possible method of satisfying the report structure. Implementers may choose to organize the data in another format; **however**, delivery to a user interface or application of all Items in Table 2.2.8.1 **shall** be consistent with the range, resolution, and units indicated in column 7, 8 and 9 of Table 2.2.8.1 respectively. Those requirements in §2.2.8.1.1 to §2.2.8.1.22 below that relate to specific data structure details (byte numbers, and bit numbers within the bytes) **shall** only apply to equipment that uses the sample report data structure shown in columns 10-11 of Table 2.2.8.1.

Note: *Table 2.2.8.1 is structured such that column 1, 2, and 6 through 11, pertain to the State Vector Report elements and how such elements should be structured into the report. Columns 3 through 5 provide information on where the appropriate data can be located in the ADS-B Messages for each of the Report elements.*

Table 2.2.8.1: ADS-B State Vector Data Elements - Source Data Mapping To Report Structure

Table 2.2.8.1: ADS-B State Vector Data Elements – Source Data Mapping To Report Structure											
Column #	REPORT STRUCTURE		MESSAGE STRUCTURE RELEVANT			REPORT STRUCTURE RELEVANT					
	1	2	3	4	5	6	7	8	9	10	11
Item #	**Parameter / Contents**	**Notes**	**Received Message Structure**	**"ME" Field Bits**	**Message Field Bits**	**# of Bits**	**Range**	**Resolution**	**Units**	**Data Structure**	**Data Byte #**
0a, 0b	Report Type and Structure Identification	4	Airborne Position - "DF"	N/A	1 – 5	24	N/A	N/A	discrete	MddL Mddd dddddddd ddddddL	0 -2
0c	Validity Flags		N/A	N/A	N/A	16	N/A	N/A	discrete	dddddddd dddddddd	3 - 4
1	Participant Address	4	Airborne Position - "AA" Surface Position - "AA" Airborne Velocity – "AA"	N/A N/A N/A	9 - 32 9 – 32 9 - 32	24	N/A	N/A	discrete	Mddddddd dddddddd dddddddL	5 - 7
2	Address Qualifier		N/A	N/A	N/A	8	N/A	N/A	discrete	00000MdL	8
3	Report Time of Applicability (Position and Velocity)	4	Airborne Position – "Time" Surface Position – "Time" Airborne Velocity	21 21 N/A	53 53 N/A	48	511.9921875	0.0078125 (1/128)	seconds	Mddddddd dddddddL Mddddddd dddddddL Mddddddd dddddddL	9 - 14
4	Encoded Latitude (WGS-84)	4	Airborne Position Surface Position –	23 - 39 23 - 39	55 - 71 55 – 71	24	+/- 180	0.0000215	degrees	SMdddddd dddddddd dddddddL	15 - 17
5	Encoded Longitude (WGS-84)	4	Airborne Position Surface Position	40 - 56 40 - 56	72 - 88 72 – 88	24	+/- 180	0.0000215	degrees	SMdddddd dddddddd dddddddL	18 - 20
6	Altitude, Geometric (WGS-84)	4, 5	Airborne Position – "TYPE", & "Altitude" Airborne Velocity - "Diff. from Baro Alt sign" & "Diff. from Baro. Alt."	1 - 5, & 9 - 20 49 50 - 56	33 - 37 41 – 52 81 82 - 88	24	+/- 131,072	0.015625	feet	SMdddddd dddddddd dddddddL	21 – 23
7	North / South Velocity	4, 5	Airborne Velocity – "N/S Direction" & "N/S Velocity"	25 26 - 35	57 58 – 67	16	+/- 4,096	0.125	knots	SMdddddd dddddddL	24 – 25
8	East / West Velocity	4, 5	Airborne Velocity - "E/W direction" & "E/W Velocity"	14 15 - 24	46 47 – 56	16	+/- 4,096	0.125	knots	SMdddddd dddddddL	26 – 27
9	Ground Speed while on the Surface	4, 6	Surface Position – "Movement"	6 - 12	38 – 44	8	N/A	N/A	discrete	MddddddL	28
10	Heading while on the Surface	4, 6	Surface Position – "Ground Track"	14 - 20	46 – 52	8	+/- 180	1.40625	degrees	SMdddddL	29
11	Altitude, Barometric (Pressure Altitude)	4, 5	Airborne Position – "TYPE", & "Altitude"	1 - 5 9 - 20	33 – 37 41 – 52	24	+/- 131,072	0.015625	feet	SMdddddd dddddddd dddddddL	30 – 32
12	Vertical Rate, Geometric/Barometric (WGS-84)	4, 5	Airborne Velocity – "Vert. Rate Source", "Vert. Rate Sign" & "Vert. Rate"	 36 37 38 - 46	 68 69 70 – 78	16	+/- 32,768	1.0	ft./min.	SMdddddd dddddddL	33 – 34
13	Navigation Integrity Category (NIC)	4	Airborne Position "Type Code" Surface Position "Type Code"	1 – 5 1 - 5	33 – 37 33 - 37	8	N/A	N/A	discrete	0000MddL	35

Table 2.2.8.1: ADS-B State Vector Data Elements – Source Data Mapping To Report Structure

Column #	REPORT STRUCTURE		MESSAGE STRUCTURE RELEVANT			REPORT STRUCTURE RELEVANT					
	1	2	3	4	5	6	7	8	9	10	11
Item #	**Parameter / Contents**	**Notes**	**Received Message Structure**	**"ME" Field Bits**	**Message Field Bits**	**# of Bits**	**Range**	**Resolution**	**Units**	**Data Structure**	**Data Byte #**
14	Estimated Latitude (WGS-84)	7	Airborne Position – "Encoded Latitude" Surface Position – "Encoded Latitude"	23 – 39 23 - 39	55 – 71 55 – 71	24	24	+/- 180	0.00002 15	degrees	36 – 38
15	Estimated Longitude (WGS-84)	7	Airborne Position – "Encoded Longitude" Surface Position – "Encoded Longitude"	40 - 56 40 - 56	72 - 88 72 – 88	24	24	+/- 180	0.00002 15	degrees	39 – 41
16	Estimated North/South Velocity	7	Airborne Velocity – "N/S Direction" & "N/S Velocity"	25 26 - 35	57 58 – 67	16	+/- 4,096	0.125	knots	SMdddddd dddddddL	42 – 43
17	Estimated East/West Velocity	7	Airborne Velocity - "E/W direction" & "E/W Velocity"	14 15 - 24	46 47 – 56	16	+/- 4,096	0.125	knots	SMdddddd dddddddL	44 – 45
18	Surveillance Status/Discretes		***Airborne Position – "*** ***Airborne Velocity – "***			4 4	N/A	N/A	discrete	dddd dddd	46
19	Report Mode		***(N/A***	N/A	N/A	8	N/A	N/A	discrete	000000ML	47
										TOTAL BYTES	48

Notes:

1. In the "Data Structure" column (i.e., column 10), "S" indicates the "sign-bit," "M" indicates the Most Significant Bit of the data field, "d" indicates data bits in the field, "L" indicates the Least Significant Bit of the data field, "0" indicates the bit is to always be set to a value of zero (0) and "x" indicates "Don't Care" bits in the data field.

*2. If data is not available to support theses fields, then the entire data field **shall** be set to ALL ZEROs if the field is delivered to the application.*

3. The Report Type Identifier is used to identify the type of ADS-B Report being generated as defined in section 2.2.8.1.1.1.

4. Items annotated with Note 4 represent "Critical" State Vector items, however certain items are only applicable while airborne and others only applicable while on the surface (see Notes 5 and 6 below).

5. Parameters annotated with Note 5 are only present in the State Vector Report when the aircraft is airborne

6. Parameters annotated with Note 6 are only present in the State Vector Report with the aircraft is on the airport surface

7. Estimated values may be either an actual value from a received message, if available, or a calculated value such as produced by a surveillance tracker algorithm. For example it is possible for a surveillance tracker to produce an updated estimate of the target's horizontal position based on just the receipt of a new velocity message.

8. The Time of Applicability is actually a grouping of 3 individual parameters as defined in 2.2.8.1.4.

2.2.8.1.1 State Vector Report Type and Structure Identification and Validity Flags

2.2.8.1.1.1 State Vector Report Type and Structure Identification

The Report Type is used to identify the type of ADS-B Report being generated by the report generation function and being provided to the User Application. The Report Type is a 4-bit field and **shall** be provided in the most significant nibble (i.e., bits 7 - 4) of the first byte (i.e., byte "0") of the Report. The Report Type formats and maximum number of bytes to be contained in each report are identified in Table 2.2.8.1.1.1a.

Table 2.2.8.1.1.1a: ADS-B Report Type Coding

Report Type Coding	Report Type	Maximum Number of Bytes in Report
0000	Undefined Report Type or no Report Available	1
0001	State Vector Report for ALL Class "A" Equipment	48
0010	Mode-Status Report for Class "A1" Equipment	35
0011	ADS-B Target State Report for Class "A2" and "A3" Equipment (Optional for Class "A1" equipment)	22
0100	Air Reference Velocity Report for Class "A1", "A2" and "A3" equipment)	14
0101	Reserved for Trajectory Change Report for Class "A2" and "A3" equipment	
0110 through 1111	Not Assigned (Reserved for Future Assignment)	

The Report Structure field is used to indicate the exact data parameters identified in Table 2.2.8.1 that are being provided in the State Vector report and is intended to provide a methodology for the report processor to structure shorter reports when data for some parameters or groups of related parameters are not available. In order to provide the capability to provide shorter State Vector reports the following basic conventions **shall** be adhered to:

a. Any given data parameter to be used in the report **shall** use the designated number of bytes and format as designated in Table 2.2.8.1.

b. Whenever a data parameter identified in Table 2.2.8.1, or a required grouping of data parameters as identified in Table 2.2.8.1.1.1b, is not provided in the report, then it is permissible to concatenate the next parameter to be included into the report immediately following the inclusion of the previous reported parameter. This feature **shall** be used accommodate the reporting of the different sets of required parameters, such as for when the aircraft is in the airborne condition versus on the airport surface as indicated in Table 2.2.8.1.

c. Each parameter of the State Vector report identified in Table 2.2.8.1 **shall** be properly declared in the Report Structure field as detailed in the following paragraphs and Table 2.2.8.1.1.1b.

Note: *Implementation of the methodology just provided is realizable and controllable due to the fact that the exact length of each report parameter is defined in Table 2.2.8.1 and the Report Structure field identifies exactly which parameters are included in the report. Therefore, the report user can easily re-construct the length and general format of the report.*

The Report Structure is a 20-bit field and **shall** be provided in the least significant nibble (i.e., bits 3 - 0) of the first byte (i.e., byte "0") and continuing into bytes 1 and 2 of the Report. The Report Structure format is defined in Table 2.2.8.1.1.1b where each bit is associated with a particular data parameter, or group of data parameters, of the State Vector Report. If the bit is set to "1," then the data parameter, or group of identified data parameters, is considered to be available and **shall** be transmitted in the report. Otherwise, the data parameter, or group of identified data parameters, is considered to not be available and **shall** not be transmitted in the report. Note that Table 2.2.8.1.1.1b does not address the Report Type and Structure Identification parameter, the Validity Flags parameter, nor the Participant Address parameter and the Address Qualifier, **since it is mandatory that these four parameters shall be included in the State Vector Report. Also, certain of the other State Vector data parameters are required to be reported, as defined in §2.2.9, even though bits have been allocated in the report structure field as shown in Table 2.2.8.1.1.1b.**

Table 2.2.8.1.1.1b: ADS-B State Vector Report Structure Coding

Byte #	Bit #	State Vector Data Parameter(s) to be Reported	Number of Bytes
0	3	Time of Applicability for Estimated Position/Velocity	2
	2	Position Time of Applicability	2
	1	Velocity Time of Applicability	2
	0	Latitude (WGS-84) & Longitude (WGS-84)	7
1	7	Altitude, Geometric (WGS-84)	4
	6	North / South Velocity & East / West Velocity	5
	5	Ground Speed while on the Surface	2
	4	Heading while on the Surface	2
	3	Altimeter, Barometric	4
	2	Vertical Rate Geometric/Baro.	3
	1	Navigation Integrity Category	1
	0	Estimated Latitude	3
2	7	Estimated Longitude	3
	6	Estimated North/South Velocity	2
	5	Estimated East/West Velocity	2
	4	Surveillance Status/Discretes	1
	3	Report Mode	1
	2	Reserved for Future Expansion	
	1	Reserved for Future Expansion	
	0	Reserved for Future Expansion	

2.2.8.1.1.2 State Vector Report Validity Flags

Validity Flags for data provided in the State Vector Report **shall** be indicated in bytes #3 and #4 of the State Vector Report as shown for item "0c" in Table 2.2.8.1. The State Vector Report elements that require validity flags are identified in Table 2.2.8.1.1.2. Table 2.2.8.1.1.2 identifies the byte and bit that **shall** be used as a flag for each element that requires a validity flag. Each validity flag bit **shall** be set to "1" to indicate that the corresponding State Vector Report Element data is valid. If such data is not valid, then the corresponding validity flag bit **shall** be set to "0."

Table 2.2.8.1.1.2: ADS-B State Vector Report Validity Flag Requirements

SV Report Item #	State Vector Report Element	Validity Flag Bit Required?	Validity Flag Bit Assignment	
			Byte #	**Bit #**
0a	Report Type	No		
0b	Structure Identification	No		
0c	Validity Flags	No		
1	Participant Address	No		
2	Address Qualifier	No		
3	Report Time of Applicability	No		
4	Latitude (WGS-84)	**Yes** (This validity flag bit is for Horizontal Position Valid)	3	7
5	Longitude (WGS-84)	**Yes** (This validity flag bit is for Horizontal Position Valid)	3	7 (MSB)
6	Altitude, Geometric (WGS-84)	**Yes** (This bit is validity flag bit for Geometric Altitude Valid)	3	6 (MSB)
7	North / South Velocity	**Yes** (This bit is validity flag bit for Airborne Horizontal Velocity Valid)	3	5
8	East / West Velocity	**Yes** (This bit is validity flag bit for Airborne Horizontal Velocity Valid)	3	5
9	Ground Speed while on the Surface	**Yes** (This bit is validity flag bit for Surface Ground Speed Valid)	3	4
10	Heading while on the Surface	**Yes** (This bit is validity flag bit for Surface HeadingValid)	3	3
11	Altitude, Barometric (Pressure Altitude)	**Yes** (This bit is validity flag bit for Barometric Altitude Valid)	3	2
12	Vertical Rate, Geometric/Barometric (WGS-84)	**Yes** (This bit is validity flag bit for Vertical Rate Valid)	3	1
13	Navigation Integrity Category (NIC)	No		
14	Estimated Latitude (WGS-84)	**Yes** (This validity flag bit is for Estimated Horizontal Position Valid -- If for some reason an estimation cannot be made of the horizontal position at the TOA of the report, then this could be indicated by zeroing the validity flag for the estimated horizontal position.)	3	0
15	Estimated Longitude (WGS-84)	**Yes** (This validity flag bit is for Estimated Horizontal Position Valid -- If for some reason an estimation cannot be made of the horizontal position at the TOA of the report, then this could be indicated by zeroing the validity flag for the estimated horizontal position.)	3	0

SV Report Item #	State Vector Report Element	Validity Flag Bit Required?	Validity Flag Bit Assignment	
0a	Report Type	No	**Byte #**	**Bit #**
16	Estimated North/South Velocity	**Yes** (This validity flag bit is for Estimated Horizontal Velocity Valid -- It may be possible to estimate velocity at some time after the TOA of the velocity message.)	4	7
17	Estimated East/West Velocity	**Yes** (This validity flag bit is for Estimated Horizontal Velocity Valid -- It may be possible to estimate velocity at some time after the TOA of the velocity message.)	4	7 (MSB)
18	Surveillance Status/Discretes	No		
19	Report Mode	No		

2.2.8.1.2 Participant Address

The Participant Address **shall** be encoded as defined in §2.2.3.2.1.1.1.

2.2.8.1.3 Address Qualifier

The Address Qualifier is used to indicate the type of participant address (2.2.8.1.2) being reported. The 3 least significant bits of the one byte field are used to convey the Address Qualifier information. The Address Qualifier subfield **shall** be coded as shown in Table 2.2.8.1.3.

Table 2.2.8.1.3: Address Qualifier Coding

Address Qualifier Coding (MbL)	**Meaning**	**ADS-B Emitter Cateogry Set** (see Note 3)
xx0	ICAO address being reported as Participant Address (see Note 2)	N/A
xx1	Non-ICAO address being reported as Participant Address (see Note 1)	N/A
00x	Participant Address is for an unknown emitter category	See Note 4
01x	Participant Address is for an Aircraft	“A” or “B”
10x	Participant Address is for a Surface Vehicle, a Fixed Ground or Tethered Obstruction	“C”
11x	Reserved for future use	N/A

Notes:

1. *In the Address Qualifier Coding column a value of “x” indicates “Don’t Care” bits in the data field for the indicated “Meaning” to be applicable.*
2. *All transponder-based based 1090 MHz ADS-B systems are required to use an ICAO 24-bit address. In the future, certain types of non-transponder-based 1090 MHz*

ADS-B systems may under certain conditions be permitted to broadcast an address other than an ICAO 24-bit address.

3. *The emitter category associated with the Participant Address is to be obtained from the "ADS-B Emitter Category" subfield (subparagraph 2.2.3.2.5.2) of the ADS-B Aircraft Identification and Type Message.*
4. *An Address Qualifier Code of 00x is to be reported if the value from the "ADS-B Emitter Category" subfield indicates "No ADS-B Emitter Category Information," or if an ADS-B Aircraft Identification and Type Message has not been received.*

2.2.8.1.4 Report Time of Applicability

Since separate messages are used for position and velocity, the Time of Applicability is reported individually for the position related report parameters and the velocity related report parameters. Also the State Vector Report may include estimated position and/or velocity values (i.e., not based on the receipt of a message with updated position or velocity information). In this latter case the State Vector report **shall** include a Time of Applicability for the estimated position/velocity parameters. The six-byte Report Time of Applicability Parameter field, as defined in Table 2.2.8.1, is sub-divided into three subfields as shown in Table 2.2.8.1.4. The coding of the subfields is defined in the following subparagraphs.

__Table 2.2.8.1.4:__ Report Time of Applicability Parameter Coding

Subfield	Coding
a Time of Applicability for Estimated Position/Velocity	Mddddddd dddddddL
b Position Time of Applicablity	Mddddddd dddddddL
c Velocity Time of Applicabilty	Mddddddd dddddddL

__Note:__ *In the "Data Structure" column (i.e., column 10), "M" indicates the Most Significant Bit of the data field and "L" indicates the Least Significant Bit of the data field.*

2.2.8.1.4.1 Time of Applicability for Estimated Position/Velocity

The Time of Applicability for the estimated position and velocity **shall** be generated under the conditions defined below:

a. Each time that an individual State Vector Report is updated as specified in §2.2.8.1.17, §2.2.8.1.18, §2.2.8.1.19, ***OR*** §2.2.8.1.20, the Report Assembly Function **shall** update the Time of Applicability for the Estimate Position/Velocity data in the State Vector Report with either the GPS/GNSS UTC Measure Time data (§2.2.8.4.1) or the Established Receiver Unit Time (§2.2.8.4.2), whichever is applicable to the Receiving device Report Assembly Function installation requirements.

b. Time of Applicability data **shall** be provided in the State Vector report in binary format as defined in Table 2.2.8.1.4**.**

2.2.8.1.4.2 Position Time of Applicability

Each time that an Airborne or Surface Position message is received with valid Latitude ***AND*** Longitude data, the Report Assembly Function **shall** update the Position Time of Applicability data in the State Vector Report with either the GPS/GNSS UTC Measure Time data (see §2.2.8.4.1) or the Established Receiver Unit Time (see §2.2.8.4.2), whichever is applicable to the Receiving device Report Assembly Function installation requirements.

2.2.8.1.4.3 Velocity Time of Applicability

a. Each time that an Airborne Velocity Subtype “1” or “2” message is received with valid East / West AND North / South Velocity data, the Report Assembly Function **shall** update the Velocity Time of Applicability data in the State Vector Report with either the GPS/GNSS UTC Measure Time data (see §2.2.8.4.1) or the Established Receiver Unit Time (see §2.2.8.4.2), whichever is applicable to the Receiving device Report Assembly Function installation requirements.

b. Each time that a Surface Position Message is received with valid Movement AND Ground Track data, the Report Assembly Function **shall** update the Velocity Time of Applicability data in the State Vector Report with either the GPS/GNSS UTC Measure Time data (see §2.2.8.4.1) or the Established Receiver Unit Time (see §2.2.8.4.2), whichever is applicable to the Receiving device Report Assembly Function installation requirements.

2.2.8.1.5 Latitude (WGS-84)

a. The ADS-B Report Assembly Function **shall** decode the Encoded Latitude data (§2.2.3.2.3.7 and /or §2.2.3.2.4.7) provided in the ADS-B broadcast. Decoding of the encoded latitude data **shall** be performed in accordance with §A.1.7.4 through §A.1.7.8.2 of Appendix A. Latitude data **shall** be provided to the user application in the State Vector report in angular weighted binary format (M bit = 90 degrees, S bit = negative, or 180 degrees) as defined in Table 2.2.8.1.

b. When valid encoded latitude data is not available, the latitude data provided to the user application **shall** be set to ALL ZEROs, and the Horizontal Position Validity Flag bit, i.e., bit #7 (MSB) of byte #3 of the State Vector Report (§2.2.8.1.1.2), **shall** be set to “0” to indicate that the reported Horizontal Position data is not valid.

   Otherwise, the Horizontal Position Validity Flag bit, i.e., bit #7 (MSB) of byte #3 of the State Vector Report, **shall** be set to “1,” unless modified by other conditions.

2.2.8.1.6 Longitude (WGS-84)

a. The ADS-B Report Assembly Function **shall** decode the Encoded Longitude data (§2.2.3.2.3.8 and / or 2.2.3.2.4.8) provided in the ADS-B broadcast. Decoding of the encoded longitude data **shall** be performed in accordance with §A.1.7.4 through A.1.7.8.2 of Appendix A. Latitude data **shall** be provided to the user application in the State Vector report in angular weighted binary format (M bit = 90 degrees, S bit = negative, or 180 degrees) as defined in Table 2.2.8.1.

b. When valid encoded longitude data is not available, the longitude data provided to the user application **shall** be set to ALL ZEROs, and the Horizontal Position Validity Flag bit, i.e., bit #7 (MSB) of byte #3 of the State Vector Report, **shall** be set to "0" to indicate that the reported Horizontal Position data is not valid

Otherwise, the Horizontal Position Validity Flag bit, i.e., bit #7 (MSB) of byte #3 of the State Vector Report, **shall** be set to "1," unless modified by other conditions.

2.2.8.1.7 Altitude, Geometric (WGS-84)

a. When Geometric Altitude Data is indicated by the "TYPE" subfield (§2.2.3.2.3.1) the ADS-B Report Assembly Function **shall** decode Altitude Data (§2.2.3.2.3.4) that has been encoded by the ADS-B transmission device as specified in §2.2.3.2.3.4.2.

b. Alternatively, Barometric Altitude Data (§2.2.3.2.3.4.1), Difference from Barometric Altitude Sign Bit (§2.2.3.2.6.1.14, §2.2.3.2.6.2.14, §2.2.3.2.6.3.14 or §2.2.3.2.6.4.14), and Difference from Barometric Altitude (§2.2.3.2.6.1.15, §2.2.3.2.6.2.15, §2.2.3.2.6.3.15 or §2.2.3.2.6.4.15), **shall** be decoded and the Geometric Altitude computed by the receiver Report Assembly Function.

c. Geometric Binary Altitude data **shall** be provided to the user application in the State Vector report in binary format as defined in Table 2.2.8.1. This format represents a true two's complement format where the MSB has a weight of 65,536 and the LSB has a weight of 0.015625. The maximum range of the data is then given by +/- [2*MSB - LSB] or +/- 131,071.984375.

d. When valid Geometric Altitude data is not available, the ADS-B receiver **shall** set the Geometric Altitude data provided to the user interface to ALL ZEROs, and the Geometric Altitude Validity Flag bit, i.e., bit #6 of byte #3 of the State Vector Report (§2.2.8.1.1.2), **shall** be set to "0" to indicate that the reported Geometric Altitude is not valid.

Otherwise, the Geometric Altitude Validity Flag bit, i.e., bit #6 of byte #3 of the State Vector Report, **shall** be set to "1," unless modified by other conditions.

Note: *Geometric Altitude is not required to be estimated when a State Vector Report is prepared as a result of receiving an airborne position and velocity messages. (i.e. The State Vector Report can include the most recently received value for this field.)*

2.2.8.1.8 North / South Velocity

a. The ADS-B Report Assembly Function **shall** extract the North / South Direction Bit (§2.2.3.2.6.1.8 or §2.2.3.2.6.2.8) and the North / South Velocity subfield (§2.2.3.2.6.1.9 or §2.2.3.2.6.2.9) from the ADS-B Message and provide North / South Velocity information to the user Application in the State Vector report in binary format as defined in Table 2.2.8.1. This format represents a true two's complement format where the MSB has a weight of 2,048 and the LSB has a weight of 0.125. The maximum range of the data is then given by +/- [2*MSB - LSB] or +/- 4,095.875.

b. When valid North / South Velocity data is not available, the North / South Velocity data provided to the user application **shall** be set to ALL ZEROs, and the Airborne Horizontal Velocity Validity Flag bit, i.e., bit #5 of byte #3 of the State Vector Report (§2.2.8.1.1.2), **shall** be set to “0” to indicate that the reported Airborne Horizontal Velocity is not valid.

   Otherwise, the Airborne Horizontal Velocity Validity Flag bit, i.e., bit #5 of byte #3 of the State Vector Report, **shall** be set to “1,” unless modified by other conditions.

2.2.8.1.9 East / West Velocity

a. The ADS-B Report Assembly Function **shall** extract the East / West Direction Bit (§2.2.3.2.6.1.6 or §2.2.3.2.6.2.6) and the East / West Velocity subfield (§2.2.3.2.6.1.7 or §2.2.3.2.6.2.7) from the ADS-B Message and provide East / West Velocity information to the user application in the State Vector report in binary format as defined in Table 2.2.8.1. This format represents a true two’s complement format where the MSB has a weight of 2,048 and the LSB has a weight of 0.125. The maximum range of the data is then given by +/- [2*MSB - LSB] or +/- 4,095.875.

b. When valid East / West Velocity data is not available, the East / West Velocity data provided to the user application **shall** be set to ALL ZEROs, and the Airborne Horizontal Velocity Validity Flag bit, i.e., bit # 5 of byte #3 of the State Vector Report (§2.2.8.1.1.2), **shall** be set to “0”to indocate that the reported Airborne Horizontal Velocity is not valid.

   Otherwise, the Airborne Horizontal Velocity Validity Flag bit, i.e., bit #5 of byte #3 of the State Vector Report, **shall** be set to “1,” unless modified by other conditions.

2.2.8.1.10 Ground Speed While on the Surface

a. The ADS-B Report Assembly Function **shall** extract the Movement Data (§2.2.3.2.4.2) from the ADS-B Surface Position Message and provide Ground Speed information to the user application in the State Vector report as defined in Table 2.2.8.1. Coding of the Movement information **shall** be the same as that identified for the Movement Data in §2.2.3.2.4.2.

b. When valid Movement data is not available, the ADS-B Report Assembly Function **shall** set the Ground Speed data provided to the user application to ALL ZEROs, and the Surface Ground Speed Validity Flag bit, i.e., bit #4 (LSB) of byte #3 of the State Vector Report, **shall** be set to “0” to indicate that the reported Surface Ground Speed is not valid.

   Otherwise, the Surface Ground Speed Validity Flag bit, i.e., bit #4 (LSB) of byte #3 of the State Vector Report, **shall** be set to “1,” unless modified by other conditions.

2.2.8.1.11 Heading While on the Surface

a. The ADS-B Report Assembly Function **shall** extract the Status Bit for Ground Track (§2.2.3.2.4.3) and Ground Track Data (§0) from the ADS-B Surface Position

Message and provide Heading while on the surface information to the user application in the State Vector Report in binary format as defined in Table 2.2.8.1. This format represents a true two's complement format where the MSB has a weight of 90 degrees and the LSB has a weight of 1.40625 degrees. The maximum range of the data is then given by +/- [2*MSB - LSB] or +/- 178.59375 degrees. Alternately, the format may be referred to as angular weighted binary.

b. When valid Heading while on the surface data is not available, the ADS-B Report Assembly Function **shall** set the Heading while on the surface data provided to the user application to ALL ZEROs, and the Surface Heading Validity Flag bit, i.e., bit #3 (MSB) of byte #3 of the State Vector Report, **shall** be set to "0" to indicate that the reported Surface Heading is not valid.

   Otherwise, the Surface Heading Validity Flag bit, i.e., bit #3 (MSB) of byte #3 of the State Vector Report, **shall** be set to "1," unless modified by other conditions.

2.2.8.1.12 Altitude, Barometric (Pressure Altitude)

a. When Barometric Altitude Data is indicated by the "TYPE" subfield (§2.2.3.2.3.1) of the ADS-B Airborne Position Message, the ADS-B Report Assembly Function **shall** decode Altitude Data (§2.2.3.2.3.4) that has been encoded by the ADS-B transmission device as specified in §2.2.3.2.3.4.1. Binary Altitude data **shall** be provided to the user application in the State Vector report as defined in Table 2.2.8.1. This format represents a true two's complement format where the MSB has a weight of 65,536 and the LSB has a weight of 0.015625. The maximum range of the data is then given by +/- [2*MSB - LSB] or +/- 131,071.984375.

b. When valid Barometric Altitude data is not available, the ADS-B Report Assembly Function **shall** set the Barometric Altitude data provided to the user application to ALL ZEROs, and the Barometric Altitude Validity Flag bit, i.e., bit #2 of byte #3 of the State Vector Report, **shall** be set to "0" to indicate that the reported Barometric Altitude is not valid.

   Otherwise, the Barometric Altitude Validity Flag bit, i.e., bit #2 of byte #3 of the State Vector Report, **shall** be set to "1," unless modified by other conditions.

<u>Note:</u> *Barometric Altitude is not required to be estimated when a State Vector Report is prepared as a result of receiving an airborne position and velocity messages. (i.e. The State Vector Report can include the most recently received value for this field.)*

2.2.8.1.13 Vertical Rate, Geometric/Barometric

The "Vertical Rate" field in the State Vector Report contains the altitude rate of an airborne ADS-B Participant. This **shall** be either the rate of change of pressure altitude, or of geometric altitude, as specified by the "Vertical Rate Type" element in the Mode Status Report (§2.2.8.2).

2.2.8.1.14 Vertical Rate, Geometric (WGS-84)

a. When Geometric Altitude Rate Data is indicated by the "Source Bit for Vertical Rate" subfield (§2.2.3.2.6.1.10, §2.2.3.2.6.2.10, §2.2.3.2.6.3.10 or §2.2.3.2.6.4.10) the ADS-B Report Assembly Function **shall** extract the Vertical Rate Sign Bit (§2.2.3.2.6.1.11, §2.2.3.2.6.2.11, §2.2.3.2.6.3.11 or §2.2.3.2.6.4.11) and the Vertical Rate subfield (§2.2.3.2.6.1.12, §2.2.3.2.6.2.12, §2.2.3.2.6.3.12 or §2.2.3.2.6.4.12) from the ADS-B Message and provide Vertical Rate, Geometric information to the user application in the State Vector report in binary format as defined in Table 2.2.8.1. This format represents a true two's complement format where the MSB has a weight of 16,384 and the LSB has a weight of 1. The maximum range of the data is then given by +/- [2*MSB - LSB] or +/- 32,767.

b. When valid Geometric Altitude Rate data is not available, the ADS-B Report Assembly Function **shall** set the Vertical Rate, Geometric data provided to the user application to ALL ZEROs, and the Vertical Rate Validity Flag bit, i.e., bit #4 of byte #4 of the State Vector Report (§2.2.8.1.1.2), **shall** be set to "0" to indicate that the reported Vertical Rate is not valid.

   Otherwise, the Vertical Rate Validity Flag bit, i.e., bit #1 of byte #3 of the State Vector Report, **shall** be set to "1," unless modified by other conditions.

Note: *Geometric Altitude Rate is not required to be estimated when a State Vector Report is prepared as a result of receiving an airborne position and velocity messages. (i.e. The State Vector Report can include the most recently received value for this field.)*

2.2.8.1.15 Barometric Altitude Rate

a. When Barometric Altitude Rate Data is indicated by the "Source Bit for Vertical Rate" subfield (§2.2.3.2.6.1.10, §2.2.3.2.6.2.10, §2.2.3.2.6.3.10 or §2.2.3.2.6.4.10) the ADS-B Report Assembly Function **shall** extract the Vertical Rate Sign Bit (§2.2.3.2.6.1.11, §2.2.3.2.6.2.11, §2.2.3.2.6.3.11 or §2.2.3.2.6.4.11) and the Vertical Rate subfield (§2.2.3.2.6.1.12, §2.2.3.2.6.2.12, §2.2.3.2.6.3.12 or §2.2.3.2.6.4.12) from the ADS-B Message and provide Vertical Rate, Barometric information to the user application in the State Vector report in binary format as defined in Table 2.2.8.1. This format represents a true two's complement format where the MSB has a weight of 16,384 and the LSB has a weight of 1. The maximum range of the data is then given by +/- [2*MSB - LSB] or +/- 32,767.

b. When valid Barometric Altitude Rate data is not available, the ADS-B Report Assembly Function **shall** set the Vertical Rate, Barometric data provided to the user application to ALL ZEROs, and the Vertical Rate Validity Flag bit, i.e., bit #1 of byte #3 of the State Vector Report, **shall** be set to "0."

   Otherwise, the Vertical Rate Validity Flag bit, i.e., bit #1 of byte #3 of the State Vector Report, **shall** be set to "1," unless modified by other conditions.

Note: *Barometric Altitude Rate is not required to be estimated when a State Vector Report is prepared as a result of receiving an airborne position and velocity* *messages. (i.e. The State Vector Report can include the most recently received value for this field.)*

2.2.8.1.16 Navigation Integrity Category (NIC)

a. The ADS-B Report Assembly Function **shall** extract "TYPE" data from the ADS-B Airborne Position Message (§2.2.3.2.3.1), or from the Surface Position Message (§2.2.3.2.4.1), and provide Navigation Integrity Category (NIC) information to the user application in the State Vector Report as defined in Table 2.2.8.1. Definition of the NIC coding is provided in Table 2.2.8.1.16.

b. When valid NIC data is not available, the NIC data sent to the user application **shall** be set to ALL ZEROs.

Table 2.2.8.1.16: Navigation Integrity Category (NIC) Encoding.

Reported NIC Value	**Containment Radius (R_C) and Vertical Protection Limit (VPL)**
0	R_C unknown
1	R_C < 20 NM (37.04 km)
2	R_C < 8 NM (14.816 km)
3	R_C < 4 NM (7.408 km)
4	R_C < 2 NM (3.704 km)
5	R_C < 1 NM (1852 m)
6	R_C < 0.6 NM (1111.2 m)
7	R_C < 0.2 NM (370.4 m)
8	R_C < 0.1 NM (185.2 m)
9	R_C < 75m *and* VPL < 112 m
10	R_C < 25m *and* VPL < 37.5 m
11	R_C < 7.5m *and* VPL < 11 m
12 - 15	Reserved

2.2.8.1.17 Estimated Latitude (WGS-84)

a. New Latitude Data Received

(1). Airborne or Surface Message Received: - Each time that the Report Assembly Function establishes a new decoded Latitude in accordance with §2.2.8.1.2, the Report Assembly Function **shall** update the Estimated Latitude (WGS-84) data in the State Vector Report with the new Latitude data received.

(2). Airborne or Surface Message Received: - The Estimated Latitude update **shall** be completed by the Report Assembly Function also updating the Report Time of Applicability in the State Vector Report with either the GPS/GNSS UTC Measure Time data (see §2.2.8.4.1) or the Established Receiver Unit Time (see §2.2.8.4.2) whichever is applicable to the Receiving device Report Assembly Function installation requirements.

b. New North / South Velocity Data Received: (Airborne Velocity Message Received)

(1). Each time that an Airborne Velocity Subtype "1" or "2" message is received with valid North / South Velocity data, the Report Assembly Function **shall** compute a new Estimated Latitude (WGS-84) position based on the last known

Estimated Latitude (WGS-84), the last known North / South velocity (***Note:*** Not the North / South Velocity data just received), and the time that has elapsed since the last update of the Estimated Latitude (WGS-84).

Accuracy of the Estimated Latitude (WGS-84) computation **shall** be within +/- 20 meters of the theoretical noise free position that could be established based on the previous position, the last known velocity, and the time of travel.

Note: *The accuracy requirement is stated in the manner given in order to specifically allow the implementation to use estimation techniques such as Kalman filters, alpha-beta trackers, or linear estimation as deemed necessary by the implementer to satisfy the accuracy requirement.*

(2). The new Estimated Latitude (WGS-84) computed in b.(1) **shall** be used by the Report Assembly Function to update the Estimated Latitude (WGS-84) data in the State Vector Report.

(3). The Estimated Latitude update **shall** be completed by the Report Assembly Function also updating the Report Time of Applicability in the State Vector Report with either the GPS/GNSS UTC Measure Time data (see §2.2.8.4.1) or the Established Receiver Unit Time (see §2.2.8.4.2) whichever is applicable to the Receiving device Report Assembly Function installation requirements.

c. Estimated Horizontal Position Validity Flag Requirements

When valid estimated Latitude or Longitude position data is not available, the estimated latitude and longitude data provided to the user application **shall** be set to ALL ZEROs and the Estimated Horizontal Position Validity Flag bit, i.e., bit #0 of byte #3 of the State Vector Report (§2.2.8.1.1.2), **shall** be set to "0"to indicate that the reported Estimated Horizontal Position is not valid.

Otherwise, the Estimated Horizontal Position Validity Flag bit, i.e., bit #0 of byte #3 of the State Vector Report, **shall** be set to "1," unless modified by other conditions.

2.2.8.1.18 Estimated Longitude (WGS-84)

a. New Longitude Data Received

(1). Airborne or Surface Message Received: - Each time that the Report Assembly Function establishes a new decoded Longitude in accordance with §2.2.8.1.6, the Report Assembly Function **shall** update the Estimated Longitude (WGS-84) data in the State Vector Report with the new Longitude data received.

(2). Airborne or Surface Message Received: - The Estimated Longitude update **shall** be completed by the Report Assembly Function also updating the Report Time of Applicability in the State Vector Report with either the GPS/GNSS UTC Measure Time data (see §2.2.8.4.1) or the Established Receiver Unit Time (see §2.2.8.4.2) whichever is applicable to the Receiving device Report Assembly Function installation requirements.

b. New East / West Velocity Data Received: (Airborne Velocity Message Received)

(1). Each time that an Airborne Velocity Subtype "1" or "2" message is received with valid East / West Velocity data, the Report Assembly Function **shall** compute a new Estimated Longitude (WGS-84) position based on the last known Estimated Longitude (WGS-84), the last known East / West velocity (***Note:*** Not the East / West Velocity data just received), and the time that has elapsed since the last update of the Estimated Longitude (WGS-84).

Accuracy of the Estimated Longitude (WGS-84) computation **shall** be within +/- 20 meters of the theoretical noise free position that could be established based on the previous position, the last known velocity, and the time of travel.

Note: *The accuracy requirement is stated in the manner given in order to specifically allow the implementation to use estimation techniques such as Kalman filters, alpha-beta trackers, or linear estimation as deemed necessary by the implementer to satisfy the accuracy requirement.*

(2). The new Estimated Longitude (WGS-84) computed in b.(1) **shall** be used by the Report Assembly Function to update the Estimated Longitude (WGS-84) data in the State Vector Report.

(3). The Estimated Longitude update **shall** be completed by the Report Assembly Function also updating the Report Time of Applicability in the State Vector Report with either the GPS/GNSS UTC Measure Time data (see §2.2.8.4.1) or the Established Receiver Unit Time (see §2.2.8.4.2) whichever is applicable to the Receiving device Report Assembly Function installation requirements.

c. Estimated Horizontal Position Validity Flag Requirements

When valid estimated Latitude or Longitude position data is not available, the estimated latitude and longitude data provided to the user application **shall** be set to ALL ZEROs and the Estimated Horizontal Position Validity Flag bit, i.e., bit #0 of byte #3 of the State Vector Report (§2.2.8.1.1.2), **shall** be set to "0" to indicate that the reported Estimated Horizontal Position is not valid.

Otherwise, the Estimated Horizontal Position Validity Flag bit, i.e., bit #0 of byte #3 of the State Vector Report, **shall** be set to "1," unless modified by other conditions.

2.2.8.1.19 Estimated North / South Velocity

<u>Note:</u> *The estimation of North / South Velocity is considered to be an optional function to be implemented in the ADS-B Report Assembly Function at the discretion of the implementer. If estimation of North / South Velocity is implemented then the requirements provided in the following subparagraphs a. through b.(3)* ***shall*** *be used as the minimum acceptable performance for such estimation.*

a. <u>New North / South Velocity Received:</u> (Airborne Velocity or Surface Position Message Received)

(1). Each time that the Report Assembly Function establishes a new North / South Velocity in accordance with §2.2.8.1.8, the Report Assembly Function **shall** update the Estimated North / South Velocity data in the State Vector Report with the new North / South Velocity data received.

(2). The Estimated North / South Velocity update **shall** be completed by the Report Assembly Function also updating the Report Time of Applicability in the State Vector Report with either the GPS/GNSS UTC Measure Time data (see §2.2.8.4.1) or the Established Receiver Unit Time (see §2.2.8.4.2) whichever is applicable to the Receiving device Report Assembly Function installation requirements.

b. <u>New Latitude Position Data Received:</u> (Airborne Position or Surface Position Message Received)

(1). Each time that the Report Assembly Function establishes a new decoded Latitude in accordance with §2.2.8.1.2, the Report Assembly Function **shall** compute a new Estimated North / South Velocity based on the last known Estimated Latitude (WGS-84), the new Latitude position data just received, and the time that has elapsed since the last update of the Estimated North / South Velocity.

Accuracy of the Estimated North / South Velocity computation **shall** be within +/- 0.3 meters/second of the theoretical noise free Estimated North / South Velocity that could be established based on the previous position, the new position, and the elapsed time of travel between the two positions.

<u>Note:</u> *The accuracy requirement is stated in the manner given in order to specifically allow the implementation to use estimation techniques such as Kalman filters, alpha-beta trackers, or linear estimation as deemed necessary by the implementer to satisfy the accuracy requirement.*

(2). The new Estimated North / South Velocity computed in b.(1) **shall** be used by the Report Assembly Function to update the Estimated North / South Velocity data in the State Vector Report.

(3). The Estimated North / South Velocity update **shall** be completed by the Report Assembly Function also updating the Report Time of Applicability in the State Vector Report with either the GPS/GNSS UTC Measure Time data (see §2.2.8.4.1) or the Established Receiver Unit Time (see §2.2.8.4.2) whichever is applicable to the Receiving device Report Assembly Function installation requirements.

c. Estimated Velocity Validity Flag Requirements

When valid estimated North / South or East / West Velocity data is not available, the estimated North / South or East / West Velocity data provided to the user application **shall** be set to ALL ZEROs and the Estimated Horizontal Velocity Validity Flag bit, i.e., bit #7 of byte #4 of the State Vector Report (§2.2.8.1.1.2), **shall** be set to "0" to indicate that the reported Estimated Horzontal Velocity is not valid.

Otherwise, the Estimated Horizontal Velocity Validity Flag bit, i.e., bit #7 of byte #4 of the State Vector Report, **shall** be set to "1," unless modified by other conditions.

2.2.8.1.20 Estimated East / West Velocity

Note: *The estimation of East / West Velocity is considered to be an optional function to be implemented in the ADS-B Report Assembly Function at the discretion of the implementer. If estimation of East / West Velocity is implemented then the requirements provided in the following subparagraphs a. through b.(3)* ***shall*** *be used as the minimum acceptable performance for such estimation.*

a. New East / West Velocity Data Received: (Airborne Velocity or Surface Position Message Received)

(1). Each time that the Report Assembly Function establishes a new East / West Velocity in accordance with §2.2.8.1.9, the Report Assembly Function **shall** update the Estimated East / West Velocity data in the State Vector Report with the new East / West Velocity data received.

(2). The Estimated East / West Velocity update **shall** be completed by the Report Assembly Function also updating the Report Time of Applicability in the State Vector Report with either the GPS/GNSS UTC Measure Time data (see §2.2.8.4.1) or the Established Receiver Unit Time (see §2.2.8.4.2) whichever is applicable to the Receiving device Report Assembly Function installation requirements.

b. New Longitude Position Data Received: (Airborne or Surface Position Message Received)

(1). Each time that the Report Assembly Function establishes a new decoded Longitude in accordance with §2.2.8.1.6, the Report Assembly Function **shall** compute a new Estimated East / West Velocity based on the last known Estimated Longitude (WGS-84), the new Longitude position data just received, and the time that has elapsed since the last update of the Estimated East / West Velocity.

Accuracy of the Estimated East / West Velocity computation **shall** be within +/- 0.3 meters/second of the theoretical noise free Estimated East / West Velocity that could be established based on the previous position, the new position, and the elapsed time of travel between the two positions.

Note: *The accuracy requirement is stated in the manner given in order to specifically allow the implementation to use estimation techniques such as Kalman filters, alpha-beta trackers, or linear estimation as deemed necessary by the implementer to satisfy the accuracy requirement.*

(2). The new Estimated East / West Velocity computed in b.(1) **Shall** be used by the Report Assembly Function to update the Estimated East / West Velocity data in the State Vector Report.

(3). The Estimated East / West Velocity update **shall** be completed by the Report Assembly Function also updating the Report Time of Applicability in the State Vector Report with either the GPS/GNSS UTC Measure Time data (see §2.2.8.4.1) or the Established Receiver Unit Time (see §2.2.8.4.2) whichever is applicable to the Receiving device Report Assembly Function installation requirements.

c. Estimated Horizontal Velocity Validity Flag Requirements

When valid estimated North / South or East / West Velocity data is not available, the estimated North / South or East / West Velocity data provided to the user application **shall** be set to ALL ZEROs and the Estimated Horizontal Velocity Validity Flag bit, i.e., bit #7 of byte #4 of the State Vector Report (§2.2.8.1.1.2), **shall** be set to “0” to indicate that the reported Estimated Horzontal Velocity is not valid.

Otherwise, the Estimated Horizontal Velocity Validity Flag bit, i.e., bit #7 of byte #4 of the State Vector Report, **shall** be set to “1,” unless modified by other conditions.

2.2.8.1.21 Surveillance Status / Discretes

a. The ADS-B Report Assembly Function **shall** extract the Surveillance Status (§2.2.3.2.3.2) from the ADS-B Airborne Position Message (§2.2.3.2.3) and map the surveillance status data into the most significant nibble of the State Vector Report byte on a bit for bit basis as shown in Table 2.2.8.1

b. When valid Surveillance Status data is not available, the ADS-B Report Assembly Function **shall** set the Surveillance Status data provided to the user application to ALL ZEROs.

c. The ADS-B Report Assembly Function **shall** extract the Intent Change Flag (§2.2.3.2.6.1.3 and Figure 2-7a,b) from the ADS-B Airborne Velocity Message (§2.2.3.2.6) and map the Intent Change Flag into the bit "b1" of the least significant nibble of the State Vector Report byte on a bit for bit basis as shown in Table 2.2.8.1.

d. The ADS-B Report Assembly Function **shall** extract the IFR Capability Flag (§2.2.3.2.6.1.4, Figure 2-7a, Figure 2-7b) from the ADS-B Airborne Velocity Message (§2.2.3.2.6) and map the IFR Capability Flag into the bit "b0" of the least significant nibble of the State Vector Report byte on a bit for bit basis as shown in Table 2.2.8.1.

2.2.8.1.22 Report Mode

The Report Mode is used to indicate the current state of the Report for each ADS-B vehicle being reported. Each time that the State Vector Report is updated, the Report Mode **shall** be updated with the encoding being as shown in Table 2-69.

Table 2-69: REPORT MODE Encoding

Coding	Report Mode
XXXX 0000	No Report Generation Capability
XXXX 0001	Acquisition Mode (see §2.2.10.2)
XXXX 0010	Track Mode (see §2.2.10.3)
XXXX 0011 through XXXX 1111	Reserved for Future Expansion

Note: *"X" in the table above, denotes "DON'T CARE."*

2.2.8.2 ADS-B Mode Status Report Characteristics

Table 2.2.8.2 and the subsequent subparagraphs identify the data structure for all ADS-B Mode Status Reports.

The intent of Table 2.2.8.2 is to illustrate the structure of all Items required to be reported in an ADS-B Mode Status Report. The exact structure of the data indicated in columns 10 and 11 is provided as a guideline or one possible method of satisfying the report structure. Implementers may choose to organize the data in another format; however, delivery to a user interface or application of all Items in Table 2.2.8.2 **shall** be consistent with the range, resolution, and units indicated in column 7, 8 and 9 of Table 2.2.8.2 respectively. Those requirements in §2.2.8.2.1 to §2.2.8.2.4 below that relate to specific data structure details (byte numbers, and bit numbers within the bytes) **shall** only apply to equipment that uses the sample data structure shown in columns 10-11 of Table 2.2.8.2.

Note: *Table 2.2.8.2 is structured such that column 1, 2, and 6 through 11, pertain to the Mode Status Report elements and how such elements should be structured into the report. Columns 3 through 5 provide information on where the appropriate data can be located in the ADS-B Messages for each of the Report elements.*

<u>Table 2.2.8.2</u>: ADS-B Mode Status Data Elements - Source Data Mapping To Report Structure

Column #	REPORT STRUCTURE		MESSAGE STRUCTURE RELEVANT			REPORT STRUCTURE RELEVANT					
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Item #	**Parameter / Contents**	**Notes**	**Received Message Sources**	**"ME" Field Bits**	**Message Field Bits**	**# of Bits**	**Range**	**Resolution**	**Units**	**Data Structure**	**Data Byte #**
0a,0b	Report Type and Structure		Airborne Position - "DF" Operational Status – "DF"	N/A N/A	1 – 5 1 - 5	24	N/A	N/A	discrete	MddL Mddd dddddddd ddddddddL	0 - 2
0c	Validity Flags		N/A	N/A	N/A	8	N/A	N/A	discrete	dddddddd	3
1	Participant Address		Airborne Velocity - "AA" - OR - Operational Status – "AA" - OR - Trajectory Intent & System Status - "AAs" - OR - Aircraft Identification – "AA"	N/A N/A N/A **N/A**	9 – 32 9 – 32 9 – 32 9 - 32	24 24 24 24	N/A	N/A	discrete	Mddddddd dddddddd ddddddddL	4 – 6
2	Address Qualifier		N/A reserved for future use			8	N/A	N/A	discrete	00000MdL	7
3	Time of Applicability		Operational Status Airborne Position Trajectory Intent & System Status	N/A	N/A	16	511.9921875	0.0078125 (1/128)	seconds	Mddddddd ddddddddL	8 - 9
4	ADS-B Version		Operational Status – "Version Number"	41 - 43	73 - 75	8	0 - 7	1	discrete	00000MdL	10
5a	Call Sign		Aircraft Identification – "Ident Char."	14 – 56	41 – 88	64	N/A	N/A	Alphanumeric characters	0MddddddL 0MddddddL 0MddddddL 0MddddddL 0MddddddL 0MddddddL 0MddddddL 0MddddddL	11 – 18
5b	Emitter Category		Aircraft Identification – "Emitter Category"	6 – 8	38 - 40	8	N/A	N/A	discrete	000MdddL	19
5c	A/V Length and Width Codes	4	Operational Status – "L/W Codes"	21 – 24	53 – 56	8	N/A	N/A	discrete	0000MddL	20
6	Emergency/Priority Status		Aircraft Status Message – Subtype 1 – "Emergency/Priority Status"	9 - 11	36 - 38	8	N/A	N/A	discrete	00000MbL	21
7	Capability Codes		Operational Status – "CC" Trajectory Intent & System Status "Capability/Mode Codes"	9 - 24 52 - 53	41 - 56 84 - 85	16 16	See Section 2.2.8.2.10			dddddddd dddddddd dddddddd	22 - 24

Column #	REPORT STRUCTURE		MESSAGE STRUCTURE RELEVANT			REPORT STRUCTURE RELEVANT					
	1	2	3	4	5	6	7	8	9	10	11
Item #	**Parameter / Contents**	**Notes**	**Received Message Sources**	**"ME" Field Bits**	**Message Field Bits**	**# of Bits**	**Range**	**Resolution**	**Units**	**Data Structure**	**Data Byte #**
8	Operational Mode		Operational Status – "OM" Trajectory Intent & System Status "Capability/Mode Codes"	25 40 52 - 53	57 - 72 84 - 85	16 16	See Section 2.2.8.2.11			dddddddd dddddddd	25 - 26
9a	SV Quality - NACp		Operational Status – "NACp" Trajectory Intent & System Status - "NACp"	45 - 48 40 - 43	77 - 80 72 - 75	8	N/A	N/A	discrete	0000MddL	27
9b	SV Quality - NAC_V		Airborne Velocity – "NAC_V"	11 - 13	43 - 45	8	N/A	N/A	discrete	00000MdL	28
9c	SV Quality – SIL		Operational Status – "SIL" Trajectory Intent & System Status - "SIL"	51 – 52 45 – 46	83 84 77 – 78	8	N/A	N/A	discrete	000000ML	29
9d	SV Quality – BAQ (reserved)					8	N/A	N/A	discrete	000000ML	30
9e	SV Quality – NIC_{BARO}		Operational Status – "NIC_{BARO}" Trajectory Intent & System Status - "NIC_{BARO}"	53 44	85 76	8	N/A	N/A	discrete	0000000L	31
10a	True/Magnetic Heading (HDR)		Operational Status – "Heading Reference Direction"	54	86	8	N/A	N/A	discrete	0000000L	32
10b	Vertical Rate Type		Airborne Velocity – "Vert. Rate Source"	36	68	8	N/A	N/A	discrete	0000000L	33
11	Other (Reserved)		Reserved			8	Reserved			dddddddd	34
										TOTAL BYTES:	35

Notes:

1. *In the "Data Structure" column (i.e., column 10), "S" indicates the "sign-bit," "M" indicates the Most Significant Bit of the data field, "d" indicates data bits in the field, "L" indicates the Least Significant Bit of the data field, and "x" indicates "Don't Care" bits in the data field.*

2. *If data is not available to support these fields, then the entire data field **shall** be set to ALL ZEROs if the field is delivered to the application.*

3. *The Report Type and Structure Identifier is used to identify the type of ADS-B Report being generated and the data parameters provided in the report as defined in §2.2.8.1.1.*

4. The A/V Length and Width Codes parameter is only applicable to Mode Status Reports for aircrafts or vehicles that are on the airport surface.

2.2.8.2.1 Mode Status Report Type and Structure Identification and Validity Flags

2.2.8.2.1.1 Mode Status Report Type and Structure Identification

The Report Type requirements were previously provided in §2.2.8.1.1. Report Type formats and the maximum number of bytes to be contained in each report are identified in Table 2.2.8.2.

The Report Structure field is used to indicate the exact data parameters identified in Table 2.2.8.2 that are being provided in the Mode Status report and is intended to provide a methodology for the Report Assembly Function to structure shorter reports when data for some parameters is not available. In order to provide the capability to provide shorter Mode Status reports the following basic conventions **shall** be adhered to:

a. Any given data parameter to be used in the report **shall** use the designated number of bytes and format as designated in Table 2.2.8.2.

b. Parameters that are designated in Table 2.2.8.2 are restricted to byte boundaries.

c. Whenever a data parameter identified in Table 2.2.8.2 is not provided in the report, then it is permissible to concatenate the next parameter to be included into the report immediately following the inclusion of the previous reported parameter.

d. Each parameter of the Mode Status report identified in Table 2.2.8.2 must be properly declared in the Report Structure field as detailed in the following paragraphs and Table 2.2.8.2.1.1.

Note: *Implementation of the methodology just provided is realizable and controllable due to the fact that the exact length of each report parameter is defined in Table 2.2.8.2 and the Report Structure field identifies exactly which parameters are included in the report. Therefore, the report user can easily re-construct the length and general format of the report.*

The Report Structure is a 20-bit field and **shall** be provided in the least significant nibble (i.e., bits 3 - 0) of the first byte (i.e., byte "0") and continuing into bytes 1 and 2 of the Report. The Report Structure format is defined in Table 2.2.8.2.1.1 where each bit is associated with a particular data parameter of the Mode Status Report. If the bit is set to "1," then the data parameter is considered to be available and **shall** be transmitted in the report. Otherwise, the data parameter is considered to not be available and **shall** not be transmitted in the report. Note that Table 2.2.8.2.1.1 does not address the Report Type and Structure Identification parameter, the Validity Flags parameter, nor the Participant Address parameter **since it is mandatory that these four parameters shall be included in the Mode Status Report. Also, certain of the other Mode Status data parameters are required to be reported, as defined in §2.2.9, even though bits have been allocated in the report structure field as shown in Table 2.2.8.2.1.1.**

Table 2.2.8.2.1.1: ADS-B Mode Status Report Structure Coding

Byte #	Bit #	Mode Status Data Parameter to be Reported	Number of Bytes
0	3	Time of Applicability	2
	2	ADS-B Version	1
	1	Call Sign	8
	0	Emitter Category	1
1	7	A/V Length and Width Code	1
	6	Emergency / Priority Status	1
	5	Capability Codes	2
	4	Operational Mode	2
	3	SV Quality - NACp	1
	2	SV Quality - NAC_V	1
	1	SV Quality - SIL	1
	0	SV Quality – BAQ (Reserved)	1
2	7	SV Quality - NICbaro	1
	6	True/Magnetic Heading	1
	5	Vertical Rate Type	1
	4	Other (Reserved)	1
	3	Reserved	
	2	Reserved	
	1	Reserved	
	0	Reserved	

2.2.8.2.1.2 Mode Status Report Validity Flags

Validity Flags for data provided in the Mode Status Report **shall** be indicated in byte #3 of the Mode Status Report as shown for item "0c" in Table 2.2.8.2. The Mode Status Report elements that require validity flags are identified in Table 2.2.8.2.1.2. Table 2.2.8.2.1.2 identifies the byte and bit that **shall** be used as a flag for each element that requires a validity flag. Each validity flag bit **shall** be set to "1" to indicate that the corresponding Mode Status Report Element data is valid. If such data is not valid, then the corresponding validity flag bit **shall** be set to "0." Only the five most significant bits of the subfield are currently assigned. The remaining 3 bits are reserved for future use.

Table 2.2.8.2.1.2: ADS-B Mode Status Report Validity Flag Requirements

MS Report Item #	Mode Status Report Element	Validity Flag Bit Required?	Validity Flag Bit Assignment Bit #
0a	Report Type	No	
0b	Report Data Structure Definition	No	
0c	Validity Flags	No	
1	Participant Address	No	
2	Address Qualifier	No	
3	Time of Applicability	No .	
4	ADS-B Version	No	
5a	Call Sign	No	
5b	Emitter Category	No	
5c	A/V Length and Width Codes	No	
6	Emergency/Priority Status	No	
7	Capability Codes	**Yes** If an update has not been received within 24 seconds, via a Operational Status and/or a Trajectory Intent and System Status message, then this report element is not considered valid	7 (MSB)
8	Operational Mode	**Yes** If an update has not been received within 24 seconds, via a Operational Status and/or a Trajectory Intent and System Status message, then this report element is not considered valid	6
9a	SV Quality - NACp	**Yes** If an update has not been received within 24 seconds, via a Operational Status and/or a Trajectory Intent and System Status message, then this report element is not considered valid	5
9b	SV Quality - NAC_V	**Yes** If an update has not been received within 24 seconds via Airborne Velocity message, then this report element is not considered valid	4
9c	SV Quality – SIL	**Yes** If an update has not been received within 24 seconds, via a Operational Status and/or a Trajectory Intent and System Status message then this report element is not considered valid	3
9d	SV Quality – BAQ (reserved)	No	
9e	SV Quality – NICbaro	No	
10a	True/Magnetic Heading	No	
10b	Vertical Rate Type	No	
11	Other (Reserved)	No	

2.2.8.2.2 Paritcipant Address

The Participant Address **shall** be encoded as defined in §2.2.3.2.1.1.1.

2.2.8.2.3 Address Qualifier

The Address Qualifier is used to indicate the type of participant address (2.2.8.1.2) being reported. The 3 least significant bits of the one byte field are used to convey the Address Qualifier information. The Address Qualifier subfield **shall** be coded as shown in Table 2.2.8.1.3.

2.2.8.2.4 Report Time of Applicability

a. Each time that an individual Mode Status Report is updated, the Report Assembly Function **shall** update the Report Time of Applicability data in the Mode Status Report with either the GPS/GNSS UTC Measure Time data (see §2.2.8.4.1) or the Established Receiver Unit Time (see §2.2.8.4.2), whichever is applicable to the Receiving device Report Assembly Function installation requirements.

b. Report Time of Applicability data **shall** be provided in the Mode Status report in binary format as defined in Table 2.2.8.2.

2.2.8.2.5 Version Number

a. The ADS-B Report Assembly Function **shall** extract the Version Number data from the ADS-B Aircraft Operational Status Message (§2.2.3.2.7.2.5) and provide the Version Number to the user application in the Mode Status Report in the binary format defined in Table 2.2.8.2.

b. When a valid Version Number is not available, the Version Number sent to the user application **shall** be set to ALL ZEROs.

2.2.8.2.6 Call Sign

a. The ADS-B Report Assembly Function **shall** first extract the Aircraft Identification Character subfields (§2.2.3.2.5.3) from the ADS-B Flight Identification and Type Message (§2.2.3.2.5.3) for further processing.

b. Each of the eight characters extracted is encoded in a subset of International Alphabet No. 5 (IA-5) in accordance with §2.2.3.2.5.3. The encoding of each character is 6 bits long with bit_6 being the most significant and bit_1 being the least significant. IA-5 is a seven bit encoding with bit_7 being the most significant and bit_1 being the least significant. In order to provide an IA-5 encoding in an eight bit format as indicated in Table 2.2.8.2, the Report Assembly Function **shall**:

(1). Retain bit_6 through bit_1 of the character encoding.

(2). If bit_6 is “ZERO,” set bit_7 to “ONE”

(3). If bit_6 is “ONE,” set bit_7 to “ZERO”

(4). Set bit_8 to “ZERO”

(5). Format bit_8 through bit_6 into “0MdddddL” for entry into the report as shown in Table 2.2.8.2.

c. When valid Flight Identity data is not available, the Call Sign data sent to the user application **shall** be set to ALL ZEROs.

2.2.8.2.7 Emitter Category

a. The ADS-B Report Assembly Function **shall** extract “TYPE” (§2.2.3.2.5.1) and “ADS-B Emitter Category” (§2.2.3.2.5.2) from the Aircraft Identification and Type Message (§2.2.3.2.5) and encode the “Emitter Category” field of the Mode Status Report as shown in Table 2-72.

Table 2-72: EMITTER CATEGORY Encoding

Encoding	Meaning
0	No Emitter Category Information Available
1	Light (<15,500 lbs.)
2	Reserved for Future Growth
3	Small (15,500 to 75,000 lbs.)
4	Reserved for Future Growth
5	Large (75,000 to 300,000 lbs.)
6	High-Vortex Large (aircraft such as B-757)
7	Heavy (>300,000 lbs.)
8	High Performance (>5 g acceleration ***and*** >400 knots)
9	Reserved for Future Growth
10	Rotorcraft
11	Glider / Sailplane
12	Lighter - than - Air
13	Unmanned Aerial Vehicle
14	Space / Trans-atmospheric Vehicle
15	Ultralight / hang-glider / paraglider
16	Parachutist / Skydiver
17	Reserved for Future Growth
18	Reserved for Future Growth
19	Reserved for Future Growth
20	Surface Vehicle - Emergency Vehicle
21	Surface Vehicle - Service Vehicle
22	Point Obstacle (includes Tethered Ballons)
23	Cluster Obstacle
24	Line Obstacle
25 through 255	Reserved for Future Growth

c. When valid ADS-B Emitter Category data is not available, the Emitter Category data sent to the user application **shall** be set to ALL ZEROs.

2.2.8.2.8 Aircraft/Vehilce (A/V) Length and Width Codes

The ADS-B Report Assemble Function **shall** extract the Aircraft/Vehicle (A/V) Length and Width Codes from the ADS-B Operation Status Message (§2.2.3.2.7.3) when the A/V is on the airport surface. The A/V length and Width Codes **shall** be coded as in Table 2.2.3.2.7.2.11.

2.2.8.2.9 Emergency / Priority Status

a. The ADS-B Report Assembly Function **shall** extract the “Emergency / Priority Status” data (§2.2.3.2.7.2.2 and Appendix A, Figure A-9) from the Aircraft Status Message (§2.2.3.2.7.2) and provide Emergency / Priority Status information to the user application in the Mode Status Report in the binary format defined in Table 2.2.8.2.

“Emergency / Priority Status,” bits 9 - 11 (see Appendix A, Figure A-9), of the Aircraft Status Message **shall** be mapped bit for bit into the three least significant bits of the report byte as indicated in Table 2.2.8.2.

b. When valid “Emergency / Priority Status” data is not available, the Emergency / Priority Status data sent to the user application **shall** be set to ALL ZEROs.

2.2.8.2.10 Capability Codes

a. The ADS-B Report Assemble Function **shall** extract the “Capabiilty Class Codes” data (§2.2.3.2.7.2.3) and the target State and Status Information Message from the ADS-B Operational Status Message (§2.2.3.2.7.2) and provide the Capability Class Codes to the user application in the Mode Status Report in the binary format defined in Table 2.2.8.2.

Capability Class Codes from the ADS-B Operational Status and the Target State and Status Information Messages, **shall** be mapped bit for bit into the 3-byte long Capability Class Codes field of the ADS-B Mode Status Report as defined in Table 2.2.8.2.10.

b. When valid “Capability Class” data is not available for a given parameter, then the Capability Class data sent to the user application for that parameter **shall** be set to ALL ZEROs.

c. When a Mode Status Report is generated and when the only received update to the “Capability Class” data has come from a Target State and Status Information Message, the reported value of all Capability Class parameters **shall** be based on the most recently received Operational Status Message, except updated with the data (i.e., TCAS parameter) received in the subsequent Target State and Status Information Message.

Table 2.2.8.2.10: Capability Code Mapping

MS Report			Operational Status Message Subtype 0 (Airborne)		Operational Status Message Subtype 1 (Surface)		Target State and Status Information Message	
MS Report CC Field Byte #	Bit #	Parameter	Msg. Bit # (ME field)	Mapping to MS Report	Msg. Bit # (ME field)	Mapping to MS Report	Msg. Bit # (ME field)	Mapping to MS Report
0	7	Service Level	9	Direct Mapping	9	Direct Mapping		
	6		10	Direct Mapping	10	Direct Mapping		
	5		13	Direct Mapping	13	Direct Mapping		
	4		14	Direct Mapping	14	Direct Mapping		
	3	Reserved						
	2	Reserved						
	1	Reserved						
	0	Reserved						
1	7	TCAS	11	Inverse Mapping			52	Inverse Mapping
	6	CDTI	12	Direct Mapping	***TBD***	Direct Mapping		
	5	ARV	15	Direct Mapping				
	4	TS Report	16	Direct Mapping				
	3	TC Report	17	Direct Mapping				
	2		18	Direct Mapping				
	1	POA			***TBD***	Direct Mapping		
	0	Reserved						
2	7	Reserved						
	6	Reserved						
	5	Reserved						
	4	Reserved						
	3	Reserved						
	2	Reserved						
	1	Reserved						
	0	Reserved						

Note: *Direct Mapping means the message bit state (i.e., 0 or 1) remains the same when mapped into the Mode Status Report. Inverse Mapping means the message bit state is reversed when mapped into the Mode Status Report.*

2.2.8.2.11 Operational Mode

a. The ADS-B Report Assembly Function **shall** extract the "Operational Mode" data (§2.2.3.2.7.2.4) from the Aircraft Status Message (§2.2.3.2.7.2) and provide Flight Mode Specific information to the user application in the Mode Status Report in the binary format defined in Table 2.2.8.2.

The Operational Mode subfield, ME bits 25 through 40 (see Figure 2.2.3.2.7.2.4 and §2.2.3.2.7.2.4), of the ADS-B Operational Status Message, **shall** be mapped bit for bit into the 2-byte long Operational Mode field of the ADS-B Mode Status Report.

c. When valid "Operational Mode" data is not available, the Flight Mode Specific data sent to the user application **shall** be set to ALL ZEROs.

2.2.8.2.12 SV Quality – NAC_P

The ADS-B Report Assembly Function **shall** extract the NAC_P data from the ADS-B Operational Status Message (§2.2.3.2.7.2) and from the Target State and Status Information Message (§2.2.3.2.7.1.3.11) and map the NAC_P value bit for bit from the received ADS-B Message to the Mode Status Report in the binary format defined in Table 2.2.8.2. WHAT IF THE TWO NAC_P VALUES ARE DIFFERENT???

2.2.8.2.13 SV Quality – NAC_V

The ADS-B Report Assembly Function **shall** extract the NAC_V data from the ADS-B Airborne Velocity Message (§2.2.3.2.6) and map the NAC_V value bit for bit from the received ADS-B Message to the Mode Status Report in the binary format defined in Table 2.2.8.2.

2.2.8.2.14 SV Quality – SIL

The ADS-B Report Assembly Function **shall** extract the SIL data from the ADS-B Operational Status Message (§2.2.3.2.7.2.8) and from the Target State and Status Information Message (§2.2.3.2.7.1.3.13), and map the SIL Value bit for bit from the received ADS-B Message to the Mode Status Report in the binary format defined in Table 2.2.8.2. WHAT IF THE TWO SIL VALUES ARE DIFFERENT???

2.2.8.2.15 SV Quality – BAQ Reserved

A 1-byte field is reserved for the future reporting of Barometric Altitude Quality.

2.2.8.2.16 SV Quality – NIC_{BARO}

The ADS-B Reprt Assembly Function **shall** extract the NIC_{BARO} data from the ADS-B Operational Status Message (§2.2.3.2.7.2.***TBD***) and from the Target State and Status Information Message (§2.2.3.2.7.1.3.12), and map the value of the NIC_{BARO} bit from the received ADS-B Message to the Mode Status Report in the binary format defined in Table 2.2.8.2. The NIC_{BARO} field in the Mode Status Report uses the least significant bit of a one-byte field as a one-bit flag that indicates whether or not the barometric pressure altitude that is provided in the State Vector Report has been cross-checked against another source of altitude. WHAT IF THE TWO NIC_{BARO} VALUES ARE DIFFERENT???

2.2.8.2.17 True/Magnetic Heading

The ADS-B Report Assembly Function **shall** extract the Track/Heading and the Horizontal Reference Direction (§2.2.3.2.7.3.12) flag bits from the Operational Status Message (§2.2.3.2.7.3) and set the True/Magnetic Heading field in the Mode Status Report in the binary format defined in Table 2.2.8.2. This item within the Mode Status Report is used to indicate the nature of the Horizontal Direction information being reported in the State Vector Reports and Target State Reports. This applies to both the aircraft reported Horizontal Direction (in the State Vector Report) as well as the target and/or selected Horizontal Direction (in the Target State Report). The encoding of bits 6 and 7 of the report True/Magnetic Heading field **shall** be as defined in Table 2.2.8.2.17. Bit 6 of the True/Magnetic Heading field indicates when Ground Track is being reported (i.e. set to zero) or when Heading is being reported (i.e., set to one). Bit 7 of the True/Magnetic Heading field indicates when Heading based on True North (i.e. set to zero) or when heading based on Magnetic North (i.e. set to one) is being reported.

Table 2.2.8.2.17: True/Magnetic Heading Coding

Encoding		**Meaning**
bit 6	**bit 7**	
0	0	Ground track being reported
0	1	Not Valid
1	0	Heading relative to true north being reported
1	1	Heading relative to magnetic north being reported

Note: *Bits 0 through 5 of the True/Magnetic Heading field are always set to ZERO (0).*

2.2.8.2.18 Vertical Rate Type

The ADS-B Report Assembly Function **shall** extract the Vertical Rate Source (§2.2.3.2.6.1.10) data from the ADS-B Airborne Velocity Message (§2.2.3.2.6) and set the Vertical Rate Type in the Mode Status Report in the binary format defined in Table 2.2.8.2. The Vertical Rate Type field uses the least significant bit of a one-byte field in the Mode Status Report. This one-bit flag **shall** be set to ZERO (0) to indicate that the Vertical Rate field in the State Vector Report holds the rate of change of barometric pressure altitude. Or, this one-bit flag **shall** be set to ONE (1) to indicate that the Vertical Rate field holds the rate of change of geometric altitude.

2.2.8.3 ADS-B On-Condition Report Characteristics

ADS-B On-Condition Reports include, but will not necessarily be limited to:

a. The Target State Report

b. The Air Referenced Velocity Report

Note: *It is anticipated that the Trajectory Change Reports will be defined by a future revision of these MOPS as an additional type of "On-Condition" Report.*

2.2.8.3.1 ADS-B Target State Report

Table 2.2.8.3.1 and the subsequent subparagraphs identify the data structure for all ADS-B Target State Reports.

The intent of Table 2.2.8.3.1 is to illustrate the structure of all Items that are required to be reported in an ADS-B Target State Report. The exact structure of the data indicated in columns 10 and 11 is provided as a guideline or one possible method of satisfying the report structure. Implementers may choose to organize the data in another format; however, delivery to a user interface or application of all Items in Table 2.2.8.3.1 **shall** be consistent with the range, resolution, and units indicated in column 7, 8 and 9 of Table 2.2.8.3.1 respectively. Those requirements in the subparagraphs below that relate to specific data structure details (byte numbers, and bit numbers within the bytes) **shall** only apply to equipment that uses the sample data structure shown in columns 10 and 11 of Table 2.2.8.3.1.

Note: *Table 2.2.8.3.1 is structured such that column 1, 2, and 6 through 11, pertain to the Target State Report elements and how such elements should be structured into the report. Columns 3 through 5 provide information on where the appropriate data can be located in the ADS-B Messages for each of the Report elements.*

Table 2.2.8.3.1: ADS-B Target State Data Elements - Source Data Mapping To Report Structure

Table 2.2.8.3.1: ADS-B Target State Data Elements – Source Data Mapping To Report Structure											
Column #	**REPORT STRUCTURE**		**MESSAGE STRUCTURE RELEVANT**			**REPORT STRUCTURE RELEVANT**					
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Item #	**Parameter / Contents**	**Notes**	**Received Message Sources**	**"ME" Field Bits**	**Message Field Bits**	**# of Bits**	**Range**	**Resolution**	**Units**	**Data Structure**	**Data Byte #**
0a,0b	Report Type and Structure Identification	3	Trajectory Intent & System Status - "DF"	N/A	1 - 5	16	N/A	N/A	discrete	MddL Mddd dddddddL	0 - 1
1	Participant Address		Trajectory Intent & System Status - "AA"	N/A	9 - 32	24	N/A	N/A	discrete	Mddddddd ddddddd dddddddL	2 - 4
2	Address Qualifier		N/A			8	N/A	N/A	discrete	00000MdL	5
3	Report Time of Applicability		Trajectory Intent & System Status	N/A	N/A	16	511.992187 5	0.0078125 (1/128)	seconds	Mddddddd dddddddL	6 - 7
4a	Horizontal Intent: Horizontal Data Available & Horizontal Target Source Indicator		Trajectory Intent & System Status – "Horizontal Data Available/Source Indicator"	26 - 27	58 - 59	8	N/A	N/A	discrete	000000ML	8
4b	Horizontal Intent: Target Heading or Track Angle		Trajectory Intent & System Status – "Target Heading/Track Angle"	28 - 36	60 - 68	16	0 - 359	1	degree	0000000M dddddddL	9- 10
4c	Horizontal Intent: Target Heading/Track Indicator		Trajectory Intent & System Status – "Target Heading/Track Indicator"	37	69	8	N/A	N/A	discrete	0000000L	11
4d	Horizontal Intent: Reserved for Heading/Track Capability		N/A			8	N/A	N/A	discrete	0000000L	12
4e	Horizontal Intent: Horizontal Mode Indicator		Trajectory Intent & System Status – "Horizontal Mode Indicator"	38 - 39	70 - 71	8	N/A	N/A	discrete	000000ML	13
4f	Horizontal Intent: Reserved for Horizontal Conformance		N/A			8	N/A	N/A	discrete	0000000L	14

Table 2.2.8.3.1: ADS-B Target State Data Elements – Source Data Mapping To Report Structure											
Column #	REPORT STRUCTURE		MESSAGE STRUCTURE RELEVANT			REPORT STRUCTURE RELEVANT					
	1	2	3	4	5	6	7	8	9	10	11
Item #	Parameter / Contents	Notes	Received Message Sources	"ME" Field Bits	Message Field Bits	# of Bits	Range	Resolution	Units	Data Structure	Data Byte #
5a	Vertical Intent: Vertical Data Available & Vertical Target Source Indicator		Trajectory Intent & System Status – "Vertical Data Available/Source Indicator	8 - 9	40 - 41	8	N/A	N/A	discrete	000000ML	15
5b	Vertical Intent: Target Altitude		Trajectory Intent & System Status – "Target Altitude"	16 - 25	48 - 57	16	-1000 to +100,000	100	feet	00000SMd dddddddL	16 - 17
5c	Vertical Intent: Target Altitude Type		Trajectory Intent & System Status – "Target Altitude Type"	10	42	8	N/A	N/A	discrete	0000000L	18
5d	Vertical Intent: Target Altitude Capability		Trajectory Intent & System Status – "Target Altitude Capability"	12 - 13	44 - 45	8	N/A	N/A	discrete	000000ML	19
5e	Vertical Intent: Vertical Mode Indicator		Trajectory Intent & System Status – "Vertical Mode Indicator"	14 - 15	46 - 47	8	N/A	N/A	discrete	000000ML	20
5f	Vertical Intent: Reserved for Vertical Conformance		N/A			8	N/A	N/A	discrete	0000000L	21
										TOTAL BYTES:	**22**

Notes:

1. *In the "Data Structure" column (i.e., column 10), "S" indicates the "sign-bit," "M" indicates the Most Significant Bit of the data field, "d" indicates data bits in the field, "L" indicates the Least Significant Bit of the data field, and "x" indicates "Don't Care" bits in the data field.*

2. *If data is not available to support these fields, then the entire data field* ***shall*** *be set to ALL ZEROs.*

3. *The Report Type Identifier is used to identify the type of ADS-B Report being generated as defined in §2.2.8.1.1.1*

2.2.8.3.1.1 Report Type and Structure Identification

The Report Type requirements were previously provided in §2.2.8.1.1. Report Type formats and the maximum number of bytes to be contained in each report are identified in Table 2.2.8.3.1.

The Report Structure field is used to indicate the exact data parameters identified in Table 2.2.8.3.1 that are being provided in the Target State Report and is intended to provide a methodology for the Report Assembly Function to structure shorter reports when data for some parameters is not available. In order to provide the capability to provide shorter Target State Reports the following basic conventions **shall** be adhered to:

a. Any given data parameter to be used in the report **shall** use the designated number of bytes and format as designated in Table 2.2.8.3.1.

b. Parameters that are designated in Table 2.2.8.3.1 are restricted to byte boundaries.

c. Whenever a data parameter identified in Table 2.2.8.3.1 is not provided in the report, then it is permissible to concatenate the next parameter to be included into the report immediately following the inclusion of the previous reported parameter.

d. Each parameter of the Target State Report identified in Table 2.2.8.3.1 must be properly declared in the Report Structure field as detailed in the following paragraphs and Table 2.2.8.3.1.1.

Note: *Implementation of the methodology just provided is realizable and controllable due to the fact that the exact length of each report parameter is defined in Table 2.2.8.3.1 and the Report Structure field identifies exactly which parameters are included in the report. Therefore, the report user can easily re-construct the length and general format of the report.*

The Report Structure is a 12-bit field and **shall** be provided in the least significant nibble (i.e., bits 3 - 0) of the first byte (i.e., byte "0") and continuing into byte 1 of the Report. The Report Structure format is defined in Table 2.2.8.3.1.1 where each bit is associated with a particular data parameter of the Target State Report. If the bit is set to "1," then the data parameter is considered to be available and **shall** be transmitted in the report. Otherwise, the data parameter is considered to not be available and **shall** not be transmitted in the report. Note that Table 2.2.8.3.1.1 does not address the Report Type and Structure Identification parameter, the Participant Address parameter, the Address Qualifier parameter, nor the Report Time of Applicability parameter, **since it is mandatory that these four parameters shall be included in the Target State Report**. **Also, certain of the other Target State data parameters are required to be reported, as defined in §2.2.9, even though**

bits have been allocated in the report structure field as shown in Table 2.2.8.3.1.1.

<u>Table 2.2.8.3.1.1:</u> ADS-B Target State Report – Structure Parameter Coding

Byte #	Bit #	Target State Data Parameter to be Reported	Number of Bytes
0	3	Horizontal Intent/Horizontal Data Available & Horizontal Target Source Indicator	1
	2	Horizontal Intent/Target Heading or Track Angle	2
	1	Horizontal Intent/Target Heading/Track Indicator	1
	0	Horizontal Intent/Reserved for Heading/Track Capability	1
1	7	Horizontal Intent/Horizontal Mode Indicator	1
	6	Horizontal Intent/Reserved for Horizontal Conformance	1
	5	Vertical Intent/Vertical Data Available & Vertical Target Source Indicator	1
	4	Vertical Intent/Target Altitude	2
	3	Vertical Intent/Target Altitude Type	1
	2	Vertical Intent/Target Altitude Capability	1
	1	Vertical Intent/Vertical Mode Indicator	1
	0	Vertical Intent/Reserved for Vertical Conformance	1

2.2.8.3.1.2 Participant Address

The Participant Address **shall** be encoded as defined in §2.2.3.2.1.1.1.

2.2.8.3.1.3 Address Qualifier

The Address Qualifier is used to indicate the type of Participant Address (§2.2.8.3.1.2) being reported. The three (3) least significant bits of the one-byte field are used to convey the Address Qualifier information. The Address Qualifier subfield **shall** be coded as shown in Table 2.2.8.1.3.

2.2.8.3.1.4 Report Time of Applicability

a. Each time that an individual Target State Report is updated, the Report Assembly Function **shall** update the Time of Applicability data in the On - Condition Report with either the GPS/GNSS UTC Measure Time data (see §2.2.8.4.1) or the Established Receiver Unit Time (see §2.2.8.4.2), whichever is applicable to the Receiving device Report Assembly Function installation requirements.

b. Report Time of Applicability data **shall** be provided in the Target State Report in binary format as defined in Table 2.2.8.3.1.

2.2.8.3.1.5 Horizontal Intent: Horizontal Data Available and Horizontal Target Source Indicator

The Data Available and Source Indicator parameter **shall** use the two (2) least significant bits within the byte to encode the parameter values defined in §2.2.3.2.7.1.3.7.

2.2.8.3.1.6 Horizontal Intent: Target Heading or Track Angle

The target Heading and Track Angle parameter **shall** use the least significant bit within the first byte and the 8 bits of the second byte to encode the parameter values defined in §2.2.3.2.7.1.3.8.

2.2.8.3.1.7 Horizontal Intent: Target Heading/Track Indicator

The Target Heading or Track Indicator parameter **shall**use the least significant bit within the byte to encode the patameter values defined in §2.2.3.2.7.1.3.9.

2.2.8.3.1.8 Horizontal Intent: Horizontal Mode Indicator

The Horizontal Mode Indicator parameter **shall** use the two (2) least significant bits within the byte to encode the parameter values defined in §2.2.3.2.7.1.3.10.

2.2.8.3.1.9 Horizontal Intent: Reserved for Horizontal Conformance Parameter

A one (1) byte long parameter is reserved for possible future use. The least significant bit within the byte would be used to convey the Horizontal Conformance information.

2.2.8.3.1.10 Vertical Intent: Vertical Data Available and Vertical Target Source Indicator

The Vertical Data Available and Vertical Target Source Indicator parameter **shall** use the two least significant bits within the byte to encode the parameter values defined in §2.2.3.2.7.1.3.1.

2.2.8.3.1.11 Vertical Intent: Target Altitude

The Target Altitude parameter **shall** use the three (3) least significant bits within the first byte and the 8 bits of the second byte to encode the parameter values defined in §2.2.3.2.7.1.3.6.

2.2.8.3.1.12 Vertical Intent: Target Altitude Type

The Target Altitude Type parameter **shall** use the least significant bit within the byte to encode the parameter values defined in §2.2.3.2.7.1.3.2.

2.2.8.3.1.13 Vertical Intent: Target Altitude Capability

The Target Altitude Capability parameter **shall** use the two least significant bits within the byte to encode the parameter values defined in §2.2.3.2.7.1.3.4.

2.2.8.3.1.14 Vertical Intent: Vertical Mode Indicator

The Vertical Mode Indicator parameter **shall** use the two (2) least significant bits within the byte to encode the parameter values defined in §2.2.3.2.7.1.3.5.

2.2.8.3.1.15 Vertical Intent: Reserved for Vertical Conformance

A one-byte parameter is reserved for possible future use. The least significant bit within the byte would be used to convey the Vertical Conformance information.

2.2.8.3.2 Air Referenced Velocity Report

The Air Referenced Velocity (ARV) Report is an On-Condition Report type that **shall** be provided when air-referenced velocity information is received from a target aircraft. Table 2.2.8.3.2 and the subsequent subparagraphs describe the data structure for all ARV Reports.

<u>Table 2.2.8.3.2</u>: ADS-B Air Referenced Velocity Data Elements - Source Data Mapping To Report Structure

Column #	REPORT STRUCTURE		MESSAGE STRUCTURE RELEVANT			REPORT STRUCTURE RELEVANT					
	1	2	3	4	5	6	7	8	9	10	11
Item #	**Parameter / Contents**	**Notes**	**Received Message Sources**	**"ME" Field Bits**	**Message Field Bits**	**# of Bits**	**Range**	**Resolution**	**Units**	**Data Structure**	**Data Byte #**
0a,0b	Report Type and Structure Identification		Airborne Velocity Subtype 3 or 4 – "DF"	N/A	1 - 5	16	N/A	N/A	discrete	MddL 0000 0000MddL	0 - 1
0c	Validity Flags		N/A	N/A	N/A	8	N/A	N/A	discrete	ddddddddd	2
1	Participant Address		Airborne Velocity Subtype 3 or 4 – "AA"	N/A	9 - 32	24	N/A	N/A	discrete	Mddddddd dddddddd ddddddddL	3 - 5
2	Address Qualifier		N/A Reserved for future use			8	N/A	N/A	discrete	00000MdL	6
3	Report Time of Applicability		Airborne Velocity Subtype 3 or 4–	N/A	N/A	16	511.9921875	0.0078125 (1/128)	seconds	Mddddddd dddddddL	7 - 8
4a	Airspeed	4	Airborne Velocity - Subtype 3 – "Airspeed" - OR - Subtype 4 - "Airspeed"	26 – 35 26 - 35	58 – 67 58 - 67	16 16	0 – 1000 1001 - 4000	1 4	knots knots	0000Mddd ddddddddL 0000Mddd dddddL00	9 - 10
4b	Airspeed Type		Airborne Velocity Subtype 3 – "Airspeed Type"	25	57	8	N/A	N/A	discrete	000000ML	11
5	Heading While Airborne		Airborne Velocity Subtype 3 – "Magnetic Heading"	15 - 24	47 - 56	16	0 – 359.6484375	0.3515625 (360/1024)	degrees	000000Md dddddddL	12 - 13
										TOTAL BYTES	**14**

<u>Notes:</u>

1. *In the "Data Structure" column (i.e., column 10), "S" indicates the "sign-bit," "M" indicates the Most Significant Bit of the data field, "d" indicates data bits in the field, "L" indicates the Least Significant Bit of the data field, "0" indicates the bit is to always be set to a value of zero (0), and "x" indicates "Don't Care" bits in the data field.*

2. *If data is not available to support these fields, then the entire data field **shall** be set to ALL ZEROs.*

3. *The Report Type Identifier is used to identify the type of ADS-B Report being generated as defined in §2.2.5.2.2.4.2.1.*

4. *Airspeed is coded with a fixed data structure using the 12 least significant bits of the 2-byte field. For the case where the source message for the air-referenced velocity information is of the type Aircraft Velocity – Subtype 3 (§2.2.3.2.6.3), a reported resolution of 1 knot is used for airspeed. This generally applies for aircraft airspeeds of 0 to 1000 knots, although under certain conditions, as described in §2.2.3.2.6.3, an airspeed of up to 1022 knots may be reported with 1 knot resolution. For airspeeds greater than 1000 knots and where the source message for the air-referenced velocity information is of the type Aircraft Velocity – Subtype 4 (§ 2.2.3.2.6.4), the two least significant bits are set to a value of ZERO (0) thus providing an actual reported resolution of 4 knots.*

2.2.8.3.2.1 Report Type and Structure Identification and Validity Flags

2.2.8.3.2.1.1 Report Type and Structure Identification

The Report Type requirements were previously provided in §2.2.8.1.1.1. The Report Type is provided in the most significant nibble of the first byte of the report. The Report Type format, coding and the maximum number of bytes (i.e., 13 bytes) to be contained in each Air Referenced Velocity report are identified in Table 2.2.8.3.2.

The Report Structure field is used to indicate the exact data parameters identified in Table 2.2.8.3.2 that are being provided in the Air Referenced Velocity report and is intended to provide a methodology for the Report Assembly Function to structure shorter reports when data for some parameters is not available. In order to provide the capability to provide shorter Air Referenced Velocity reports the following basic conventions **shall** be adhered to:

a. Any given data parameter to be used in the report **shall** use the designated number of bytes and format as designated in Table 2.2.8.3.2.

b. Parameters that are designated in Table 2.2.8.3.2 are restricted to byte boundaries.

c. Whenever a data parameter identified in Table 2.2.8.3.2 is not provided in the report, then it is permissible to concatenate the next parameter to be included into the report immediately following the inclusion of the previous reported parameter.

d. Each parameter of the Air Referenced Velocity report identified in Table 2.2.8.3.2 must be properly declared in the Report Structure field as detailed in the following paragraphs and Table 2.2.8.3.2.1.

Note: *Implementation of the methodology just provided is realizable and controllable due to the fact that the exact length of each report parameter is defined in Table 2.2.8.3.2 and the Report Structure field identifies exactly which parameters are included in the report. Therefore, the report user can easily re-construct the length and general format of the report.*

The Report Structure Identification parameter is a 12-bit field and **shall** be encoded in the least significant nibble (i.e., bits 3 through 0) of the first byte (i.e., byte "0") and continuing into byte 1 of the Report. The Report Structure Identification parameter format is defined in Table 2.2.8.3.1.1 where each bit is associated with a particular subsequent data parameter of the Air Referenced Velocity Report. If the bit is set to "1," then the data parameter is considered to be available and **shall** be transmitted in the report. Otherwise, the data parameter is considered to not be unavailable and **shall** not be transmitted in the report. Note that Table 2.2.8.3.2.1.1 does not address the Report Type and Structure Identification parameter, the Participant Address parameter, the Address Qualifier parameter, and the Report Time of Applicability parameter **since it is mandatory that these four parameters shall be included in each Target State Report**. **Also certain of the other Air Referenced Velocity data parameters are required to be reported, as defined in §2.2.9, even though bits have been allocated in the report structure field as shown in Table 2.2.8.3.2.1.1.**

Table 2.2.8.3.2.1.1: ADS-B Air Referenced Velocity Report – Structure Parameter Coding

Byte #	Bit #	Target State Data Parameter to be Reported	Number of Bytes
0	3 - 7	Reserved for future use	N/A
	2	Airspeed	2
	1	Airspeed Type and Validity	1
	0	Heading While Airborne	2

2.2.8.3.2.1.2 Validity Flags

The only Validity Flag defined by these MOPS for the Air Referenced Velocity Report uses the two (2) least significant bits of the one-byte field as shown in Table 2.2.8.3.2.1.2.

Table 2.2.8.3.2.1.2: ADS-B Air Referenced Velocity Report – Validity Parameter Coding

Byte #	Bit #	Target State Data Parameter to be Reported
2	2 – 7	Reserved for future use
	1	Airspeed Valid
	0	Heading Valid

The "Heading Valid" flag bit in the ARV report **shall** be set to ONE if the "Heading While Airborne" field contains valid heading information, or set to ZERO if that field is known to not contain valid heading information. The reported heading **shall** be indicated as not valid if the received ADS-B Aircraft Velocity Message (§2.2.3.2.6.3.8 or §2.2.3.2.6.4.8) includes a "Magnetic Heading Status Bit" (§2.2.3.2.6.3.6) indicating that "Magnetic Heading Data is NOT Available."

The "Airspeed Valid" flag bit **shall** be set to ONE if the "Airspeed" field (§2.2.8.3.2.6) contains valid heading information, or ZERO if that field is known to not contain valid airspeed information. The reported airspeed **shall** be indicated as "Not Valid" if the received ADS-B Aircraft Velocity Message (§2.2.3.2.6.3.8 or §2.2.3.2.6.4.8) includes either a value for the "Airspeed" subfield indicating "No Airspeed Information Available," or includes a value for the "NAC_V" subfield that is invalid.

2.2.8.3.2.2 Participant Address

The participant address **shall** be encoded as defined in §2.2.3.2.1.1.1.

2.2.8.3.2.3 Address Qualifier

The Address Qualifier is used to indicate the type of Participant Address (§2.2.8.3.2.3) being reported. The 3 least significant bits of the one-byte field are used to convey the Address Qualifier information. The Address Qualifier subfield **shall** be coded as shown in Table 2.2.8.1.3.

2.2.8.3.2.4 Report Time of Applicability

a. Each time that an individual Air Referenced Velocity Report is updated, the Report Assembly Function **shall** update the Time of Applicability data in the Air Referenced Velocity Report with either the GPS/GNSS UTC Measure Time data (see §2.2.8.4.1) or the Established Receiver Unit Time (see §2.2.8.4.2), whichever is applicable to the Receiving device Report Assembly Function installation requirements.

b. Report Time of Applicability data **shall** be provided in the Air Referenced Velocity report in binary format as defined in Table 2.2.8.3.2.

2.2.8.3.2.5 Airspeed

Airspeed **shall** be reported over the range of 0 to 4000 knots. The Airspeed parameter is coded with a fixed data structure using the 4 least significant bits of the first byte and the 8 bits of the second byte of the Airspeed field as identified in Table 2.2.8.3.2. For the case where the source message for the Air-Referenced Velocity information is of the type Aircraft Velocity – Subtype 3 (§2.2.3.2.6.3), a reported resolution of 1 knot is used for Airspeed. This generally applies for Aircraft Airspeeds of 0 to 1000 knots, although under certain conditions, as described in §2.2.3.2.6.3, an Airspeed of up to 1022 knots may be reported with 1 knot resolution. For Airspeeds greater than 1000 knots and where the source message for the Air-Referenced Velocity information is of the type Aircraft Velocity – Subtype 4 (§2.2.3.2.6.4), the two (2) least significant bits are set to a value of ZERO (0) thus providing an actual reported resolution of 4 knots.

2.2.8.3.2.6 Airspeed Type

The Airspeed Type and Validity field in the Air Referenced Velocity report is a 2-bit field that **shall** be encoded as specified in Table 2.2.8.3.2.7. The type of Airspeed being reported **shall** be obtained from the "Airspeed Type" subfield of the ADS-B Aircraft Velocity Message, Subtype 3 (§2.2.3.2.6.3.8) or Subtype 4 (§2.2.3.2.6.4.8). The reported Airspeed **shall** be indicated as "Not Valid" if the received ADS-B Aircraft Velocity Message (§2.2.3.2.6.3.8 or §2.2.3.2.6.4.8) includes either a value for the "Airspeed" subfield indicating "No Airspeed Information Available," or includes a value for the "NAC_V" subfield that is invalid. When set to indicate the "Airspeed Field is Not Valid," the corresponding Validity Flag parameter (§2.2.8.2.2.1.2) **shall** also be set to indicate that the reported Airspeed is not valid.

Table 2.2.8.3.2.7: Airspeed Type Encoding

Airspeed Type Value	Meaning
00	Airspeed Field Not Valid
01	True Airspeed (TAS)
10	Indicated Airspeed (IAS)
11	Reserved for Mach

2.2.8.3.2.7 Heading While Airborne

An Aircraft's Heading is reported as the angle measured clockwise from the reference direction (magnetic north) to the direction in which the Aircraft's nose is pointing. The heading field in Air Reference Velocity reports **shall** be encoded using the 2 least significant bits of the first byte and the 8 bits of the second byte of the "Heading While Airborne" field as defined in Table 2.2.8.3.2. The encoding **shall** be the same as that used in the "Magnetic Heading" subfield of the ADS-B Airborne Velocity Message – Subtype 3 as defined in §2.2.3.2.6.3.7.

2.2.8.4 Receiving Installation Time Processing

2.2.8.4.1 Precision Installations

Receiving devices intended to generate ADS-B reports based on Surface Position Messages received from type 5 or 6 (see §2.2.3.2.3.1) equipment or Airborne Position Messages received from type 9 or 10 (see §2.2.3.2.3.1) equipment **shall** accept GPS/GNSS UTC Measure Time data via an appropriate interface. Such data **shall** be used to establish Time of Applicability data required in §**Error! Reference source not found.** through §2.2.8.1.20, §**Error! Reference source not found.**, §2.2.8.2.4 and §**Error! Reference source not found.**.

UTC Measure Time data **shall** have a minimum range of 300 seconds and a resolution of 0.0078125 (1/128) seconds.

Note: *Time of Applicability information is required in Item #'s 18 through 23, and 25 of Table 2.2.8.1, Item #16 of Table 2.2.8.2, and Item #7 of Table 2.2.8.3.1. Each of these table entries specify the data to be entered in 9 bits of whole number and 7 bits of fractional data. Therefore, the full range can be up to 511.9921875 seconds having the required resolution of 0.0078125 seconds.*

2.2.8.4.2 Non-Precision Installations

Receiving devices that are not intended to generate ADS-B reports based on Surface Position Messages received from type 5 or 6 (see §2.2.3.2.3.1) equipment or Airborne Position Messages received from type 9, 10, 20 or 21 (see §2.2.3.2.3.1) equipment may choose not to use GPS/GNSS UTC Measure Time data if there is no requirement to do so by the end user of the ADS-B reports. In such cases, where there is no appropriate time reference, the Receiving device **shall** establish an appropriate internal clock or counter having a maximum clock cycle or count time of 20 milliseconds. The established cycle or clock count **shall** have a range of 300 seconds and a resolution of 0.0078125 (1/128) seconds in order to maintain commonality with the requirements of §2.2.8.4.1.

Note: *Time of Applicability information is required in Item #'s 18 through 23, and 25 of Table 2.2.8.1, Item #16 of Table 2.2.8.2, and Item #7 of Table 2.2.8.3.1. Each of these table entries specify the data to be entered in 9 bits of whole number and 7 bits of fractional data. Therefore, the full range can be up to 511.9921875 seconds having the required resolution of 0.0078125 seconds.*

2.2.9 ADS-B Report Type Requirements

Equipage classes are defined to accommodate tiered capabilities according to increasingly complex operational objectives while preserving basic inter-operability between classes of equipage. Each equipage class is required to receive messages and process the recovered information into specific ADS-B reports according to the applicable capability. The required ADS-B report capabilities for each class of equipage are defined in the following paragraphs.

2.2.9.1 ADS-B Receiver Reporting Requirements for Class A Equipage

ADS-B Report Requirements for Class A Equipage are defined in Table 2.2.9.1a. For each required report type all data elements, as defined in §2.2.8.1 through §2.2.8.3 (inclusive of subparagraphs), **shall** be included for which valid information is available (i.e., current information that has been received via one or multiple ADS-B Messages or is available from an onboard data source). Although the Report Assembly Function is required to support all data elements defined for the report types applicable to that Equipage Class, as per Table 2.2.9.1a, reports may be generated that convey only a subset of the report elements. This is a consequence of certain data elements only being applicable while airborne and others that are only applicable while on the surface. Also the ADS-B Messages may not have been received that included the information necessary to report a valid value for a given report data element. For each of the four types of reports there is a set of mandatory data elements that **shall** be included. The required mandatory set of data elements is defined in Table 2.2.9.1b through Table 2.2.9.1e inclusive) for the four report types.

Table 2.2.9.1a: ADS-B Class A Equipment Reporting Requirements

Equipage Class	INTERACTIVE AIRCRAFT/VEHICLES OPERATIONAL CAPABILITIES						
	Aid to Visual Acquisition	Conflict Detection	Conflict Avoidance	Separation Assurance and Sequencing	Flight Path Deconfliction Planning	Simultaneous Approaches	Airport Surface
	ADS-B OUTPUT REPORTS REQUIRED (Note 1)						
AO **Basic VFR** Aircraft/ Ground Vehicles	SV	SV MS	Not Applicable	Not Applicable	Not Applicable	Not Applicable	SV MS
A1 **Basic IFR** Aircraft and Ground Vehicles	SV	SV MS	SV MS ARV	Not Applicable	Not Applicable	SV MS ARV	SV MS
A2 **Enhanced IFR** Aircraft Only (Note 2)	SV	SV MS	SV MS TS ARV	SV MS TS ARV	Not Applicable	SV MS ARV	SV MS
A3 **Extended Capability** Aircraft Only (Note 2)	SV	SV MS	SV MS TS ARV	SV MS TS ARV	SV MS TS ARV	SV MS ARV	SV MS

Notes:

1. *The report structure and contents are defined in §2.2.8.1 through §2.2.8.3, inclusive of the subparagraphs.*

2. *It is anticipated that future revisions of these MOPS will require tat Equipage Class A2 and A3 systems will also be capable of generating Trajectory Change Reports.*

<u>Table 2.2.9.1b:</u> ADS-B State Vector Mandatory Report Elements

Report Element #	Report Element Description	Mandatory
0a, 0b	Report Type and Structure Identification	**Yes**
0c	Validity Flags	**Yes**
1	Participant Address	**Yes**
2	Address Qualifier	**Yes**
3	Time of Applicability (Position and Velocity)	**Yes**
4	*Latitude* (WGS-84)	Note 3
5	*Longitude* (WGS-84)	Note 3
6	*Altitude, Geometric* (WGS-84)	**No**
7	North / South Velocity	Note 3
8	East / West Velocity	Note 3
9	Ground Speed while on the Surface	Note 1
10	Heading while on the Surface	Note 1
11	Altitude, Barometric (Pressure Altitude)	Note 2
12	Vertical Rate, Geometric/Barometric (WGS-84)	**No**
13	Navigation Integrity Category (NIC)	**Yes**
14	Estimated Latitude (WGS-84)	**Yes**
15	Estimated Longitude (WGS-84)	**Yes**
16	Estimated North/South Velocity	Note 2
17	Estimated East/West Velocity	Note 2
18	Surveillance Status/Discretes	**No**
19	Report Mode	**No**

<u>Notes:</u>

1. *Mandatory when the report is for a target aircraft/vehicle that is on the airport surface.*
2. *Mandatory when the report is for a target aircraft that is airborne.*
3. *It is mandatory that each new state vector report for an airborne target include report elements 4 and 5 and/or report elements 7 and 8 since a new state vector report should only be generated based on the reception of an airborne position and/or an airborne velocity message.*

<u>Table 2.2.9.1c:</u> ADS-B Mode Status Mandatory Report Elements

Report Element Number	Report Element Description	Mandatory when A/V is on Surface	Mandatory when Aircraft is Airborne
0a, 0b	Report Type and Structure	**Yes**	**Yes**
0c	Validity Flags	**Yes**	**Yes**
1	Participant Address	**Yes**	**Yes**
2	Address Qualifier	**Yes**	**Yes**
3	Time of Applicability	**Yes**	**Yes**
4	ADS-B Version	**Yes**	**Yes**
5a	Call Sign	Note 1	Note 1
5b	Emitter Category	Note 1	Note 1
5c	A/V Length and Width Codes	Note 2	**No**
6	Emergency/Priority Status	Note 2	Note 2
7	Capability Codes	Note 3	Note 3
8	Operational Mode	Note 3	Note 3
9a	SV Quality - NACp	Note 3	Note 3
9b	SV Quality - NAC_V	Note 4	Note 4
9c	SV Quality – SIL	Note 3	Note 3
9d	SV Quality – BAQ (reserved)	**No**	**No**
9e	SV Quality – NIC_{BARO}	**No**	Note 3
10a	True/Magnetic Heading	Note 2	Note 2
10b	Vertical Rate Type	Note 4	Note 4
11	Other (Reserved)	**No**	**No**

<u>Notes:</u>

1. *Mandatory if an Aircraft Identification message has been received within the past 200 seconds.*

2. *Mandatory if an Operational Status message has been received within the past 100 seconds.*

3. *Mandatory if an Operational Status and/or a Trajectory Intent and System Status message has been received within the past 100 seconds.*

4. *Mandatory if an Airborne Velocity message has been received within the past 100 seconds.*

<u>Table 2.2.9.1d:</u> ADS-B Target State Mandatory Report Elements

Report Element Number	Report Element Description	Mandatory
0a,0b	Report Type and Structure Identification	**Yes**
1	Participant Address	**Yes**
2	Address Qualifier	**Yes**
3	Report Time of Applicability	**Yes**
4a	Horizontal Intent: Horizontal Data Available & Horizontal Target Source Indicator	**Yes**
4b	Horizontal Intent: Target Heading or Track Angle	Note 1
4c	Horizontal Intent: Target Heading/Track Indicator	Note 1
4d	Horizontal Intent: Reserved for Heading/Track Capability	Note 1
4e	Horizontal Intent: Horizontal Mode Indicator	Note 1
4f	Horizontal Intent: Reserved for Horizontal Conformance	**No**
5a	Vertical Intent: Vertical Data Available & Vertical Target Source Indicator	**Yes**
5b	Vertical Intent: Target Altitude	Note 2
5c	Vertical Intent: Target Altitude Type	Note 2
5d	Vertical Intent: Target Altitude Capability	Note 2
5e	Vertical Intent: Vertical Mode Indicator	Note 2
5f	Vertical Intent: Reserved for Vertical Conformance	**No**

<u>Notes:</u>

1. *Mandatory if Report Element 4a indicates that data is available.*

2. *Mandatory if Report Element 5a indicates that data is available.*

<u>Table 2.2.9.1e:</u> ADS-B Air Referenced Velocity Mandatory Report Elements

Report Element Number	Report Element Description	Mandatory
0a,0b	Report Type and Structure Identification	**Yes**
0c	Validity Flags	**Yes**
1	Participant Address	**Yes**
2	Address Qualifier	**Yes**
3	Report Time of Applicability	**Yes**
4a	Airspeed	**Yes**
4b	Airspeed Type and Validity	**Yes**
5	Heading While Airborne	**Yes**

2.2.9.1.1 ADS-B State Vector Reports for Class A Equipage

Equipage Class A0, A1, A2 and A3 equipment **shall** provide State Vector Reports as indicated in §2.2.9.1. An example report format is showin in Table 2.2.8.1.

2.2.9.1.2 ADS-B Mode Status Reports for Class A Equipage

Equipage Class A0, A1, A2 and A3 equipment **shall** provide Mode Status Reports as indicated in §2.2.9.1. An example report format is shown in Table 2.2.8.2.

2.2.9.1.3 ADS-B Target State Reports for Class A Equipage

a. Equipage Class A0 and A1 equipment are not required to provide Target State Reports.

b. Equipage Class A2 and A3 equipment **shall** provide Target State Reports as indicated in §2.2.9.1. An example report format is shown in Table 2.2.8.3.1.

2.2.9.1.4 ADS-B Air Referenced Velocity Reports for Class A Equipage

a. Equipage Class A0 equipment is not required to provide Air Referenced Reports.

b. Equipage Class A1, A2 and A3 equipment **shall** generate an Air Referenced Velocity Report as indicated in §2.2.9.1. An example report format is shown in Table 2.2.8.3.2.

2.2.9.2 ADS-B Receiver Report Content Requirements for Class B Equipage

There are no report requirements for Class B, i.e., Broadcast Only, Equipage.

2.2.10 ADS-B Receiver Report Assembly and Delivery

2.2.10.1 Fundamental Principals of Report Assembly and Delivery

2.2.10.1.1 General Data Flow

Figure 2-15 illustrates the general data flow of ADS-B Messages and Reports for the purposes of establishing the baseline requirements for Report Assembly and Delivery.

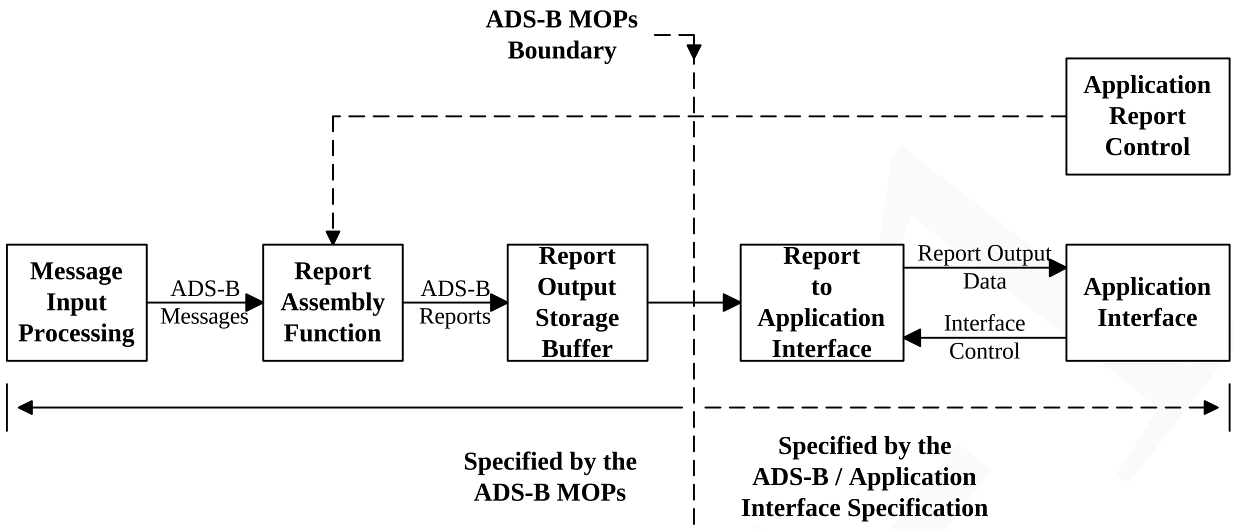


Figure 2-15: ADS-B Message And Report General Data Flow

a. **Message Input Processing** -- The Message Input Processing is performed by the ADS-B Message Reception Function previously depicted in Figure 2-12 and described in §2.2.6.1. The primary function of the Message Input Processing function is to deliver all received ADS-B Messages to the Report Assembly Function.

b. **Report Assembly Function** -- The Report Assembly Function receives all ADS-B Messages from the Message Input Processing Function and structures ADS-B Reports for delivery to the Report Output Storage Buffer.

It is important to note that the specification of requirements within this document is considered complete once the ADS-B Reports have been structured and delivered to the Report Output Storage Buffer. Specifically, the specification of data delivery via the Application Interface is not addressed in this document. Figure 2-15 illustrates the boundary of the ADS-B MOPS specification.

c. **Report Output Storage Buffer** -- The primary purpose of the Report Output Storage Buffer is to store and maintain all ADS-B reports such that the Reports are available for extraction by the Application Interface upon demand or as needed.

d. **Application Report Control** -- The Application Report Control depicted in Figure 2-15 represents an ***optional*** function that may be implemented for the application to provide commands or control to the Report Assembly Function in order to control the size of various ADS-B reports and/or the conditions under which such reports are issued.

e. **Application Interface** -- The Application Interface is responsible for the extraction of ADS-B reports from the Report Output Storage Buffer via the Report to Application Interface. Requirements for the Application Interface and Report to Application Interface are to be specified in various Application Interface specifications and therefore are not addressed in this document.

Note: *Figure 2-16a, Figure 2-16b and Figure 2-16c are provided below as a guideline to assist in understanding the Report Assembly and Delivery Process. As such, these figures should not be construed as presenting the actual requirements. Rather, the requirements for Report Assembly and Delivery are provided in the remaining sub-sections of §2.2.10.*

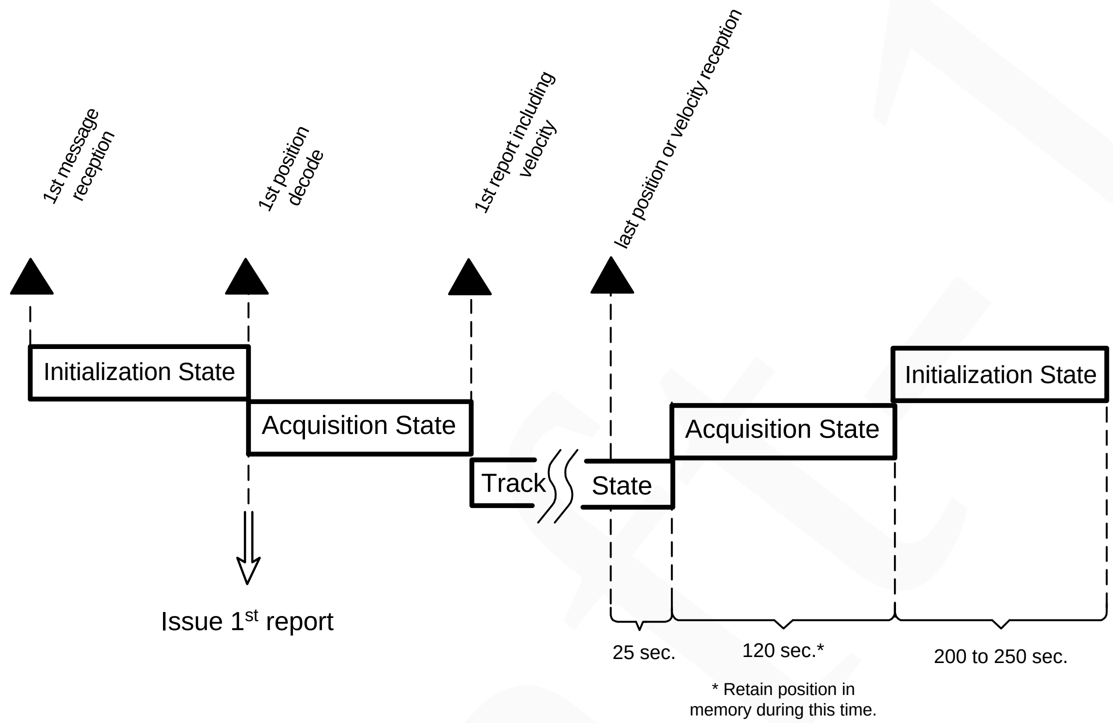
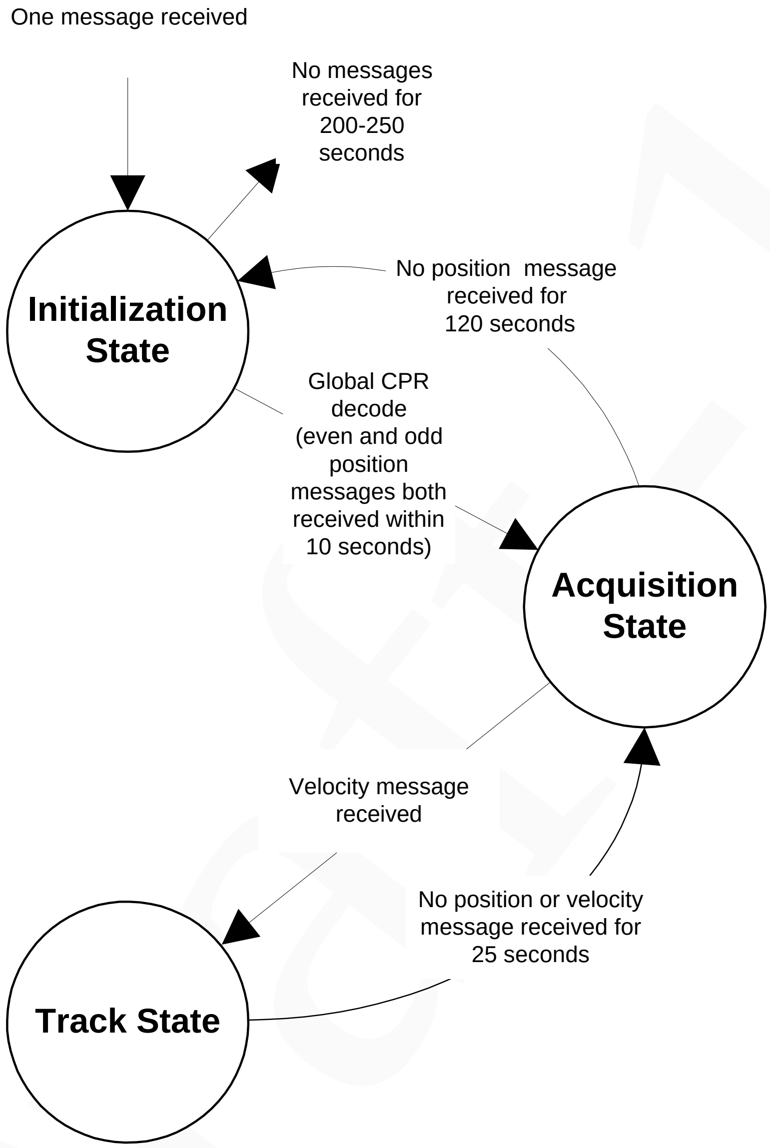


Figure 2-16a: Illustration Of Report State Changes In A Typical Case



<u>Figure 2-16b</u>: Report Assembly State Transition Diagram.

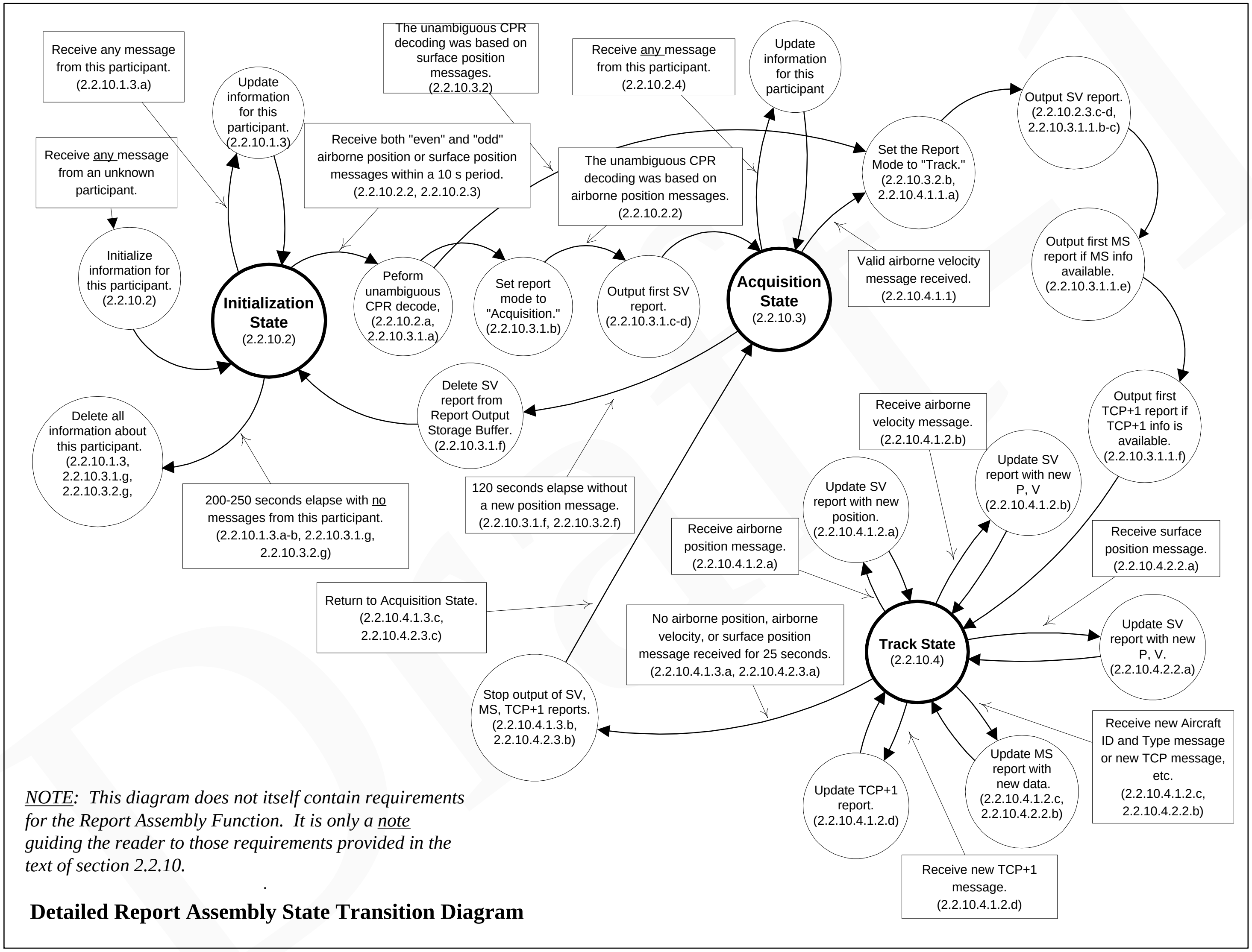


Figure 2-16c: Detailed Report Assembly State Transition Diagram

2.2.10.1.2 ADS-B Report Organization

a. All ADS-B Message receptions and Reports **shall** be organized (i.e., indexed) in accordance with the Participant Address that is transmitted in the "AA" Address Field of all ADS-B transmitted messages (see §2.2.3.2.1.1.1).

b. The Participant Address **shall** be a mandatory element in all ADS-B Reports (see Table 2.2.8.1 Item 1, Table 2.2.8.2 Item 1, Table 2.2.8.3.1 Item 1, and Table 2.2.8.3.2 Item 1).

2.2.10.1.3 ADS-B Message Temporary Retention

a. Unless otherwise specified, all ADS-B Messages and decoded latitude and longitude values received for a given Participant Address **shall** be appropriately time tagged and temporarily stored for at least 200 seconds unless replaced by a received message of equivalent type.

Note: *This requirement is intended to aid in the start-up of Report Assembly for a given Participant such that as much data as possible can be provided as soon as a Track is initialized on the given participant.*

b. If no new messages have been received from a given Participant for 250 seconds, then all records (including temporary storage) relevant to the Participant Address **shall** be deleted from temporary storage and from the Report Output Storage Buffer.

2.2.10.1.4 Participant ADS-B Track Files

A Track File is defined as the accumulation of reports maintained on a given participant. In the ADS-B case, the Track File refers to the State Vector, Mode Status, Target State and Air Referenced Velocity Reports, which comprise a set of reports maintained on a given participant.

The ADS-B Report Assembly function **shall** maintain one, and only one, Track File, i.e., set of reports on any given participant.

2.2.10.2 Report Assembly Initialization State

The Initialization State is entered for any given Participant for which there is no information upon receipt of any of the following ADS-B Messages received from the given Participant:

a. Airborne Position Message (i.e., a State Vector Position Message --- Airborne) (see §2.2.3.2.3)

b. Surface Position Message (i.e., a State Vector Position Message --- Surface) (see §2.2.3.2.4)

c. ADS-B Aircraft Identification and Type Message (see §2.2.3.2.5)

d. ADS-B Airborne Velocity Information Message (see §2.2.3.2.6)

e. "Aircraft" Trajectory Intent and System Status Message (see §2.2.3.2.7.1)

f. "Aircraft" Operational Status Message (see §2.2.3.2.7.2)

2.2.10.3 Report Assembly Acquisition State

2.2.10.3.1 Report Assembly Acquisition State --- Airborne Participant

Upon receipt of an ***"even"*** and an ***"odd"*** encoded Airborne Position Message from a given Participant within a ten second period, the Report Assembly Function **shall**:

a. Perform a successful Globally Unambiguous CPR decode of the Participant Position in accordance with §A.1.7.7 of Appendix A,

b. Set the Report Mode to "Acquisition" for the given Airborne Participant in the State Vector Report (see §2.2.8.1) in accordance with §2.2.8.1.22,

c. Structure all possible fields of the State Vector Report for the given Airborne Participant in accordance with §2.2.8.1 (all subsections inclusive),

d. Deliver the first structured State Vector Report for the given Airborne Participant to the Report Output Storage Buffer for subsequent access by the Application Interface on demand,

e. Continue to maintain the integrity of the State Vector Report for the given Airborne Participant in the Report Output Storage Buffer for at least 200 seconds unless replaced by an updated State Vector Report or otherwise specified in the following sections, the conditions of the following subparagraphs **shall** apply:

f. If a new Position Message is not received within a 120 second period, then the Globally Unambiguous CPR decode performed in step a. **shall** be considered to be invalid, and the Report Assembly Function **shall** return to the Initialization State. (In order to proceed to the Track State for the airborne participant, the Globally Unambiguous CPR decode will need to be repeated.)

   <u>Note:</u> *This action effectively represents a return to the Initialization State with the exception that the return is to step a. above, and the report is retained as per step e. The purpose of this action is to minimize the need to perform the Globally Unambiguous CPR decode since it is not necessary when position messages have been received within the reasonable time limit of 120 seconds. This action is illustrated in Figure 2-16b.*

g. If no new messages have been received from a given Airborne Participant for at least 200 seconds, then all reports relevant to the Participant Address **shall** be deleted from the Report Output Storage Buffer.

2.2.10.3.1.1 Latency, Report Assembly Acquisition State --- Airborne Participant

Step 2.2.10.3.1.d **shall** be completed within 500 milliseconds of receipt of the second Airborne Position Message of the "***even***" and "***odd***" pair.

2.2.10.3.2 Report Assembly Acquisition State --- Surface Participant

Upon receipt of an ***"even"*** and an ***"odd"*** encoded Surface Position Message from a given Participant within a ten second period, the Report Assembly Function **shall**:

a. Perform a successful Local Unambiguous CPR decode of the Participant Position in accordance with §A.1.7.6 of Appendix A,

b. Set the Report Mode to "Track" for the given Surface Participant in the State Vector Report (see §2.2.8.1) in accordance with §2.2.8.1.22,

c. Structure all possible fields of the State Vector Report for the given Surface Participant in accordance with §2.2.8.1 (all subsections inclusive),

d. Deliver the first structured State Vector Report for the given Surface Participant to the Report Output Storage Buffer for subsequent access by the Application Interface on demand,

e. Continue to maintain the integrity of the State Vector Report for the given Surface Participant in the Report Output Storage Buffer for at least 200 seconds unless replaced by an updated State Vector Report or otherwise specified in the following sections, and the conditions of the following subparagraphs **shall** apply:

f. If a new Position Message is not received within a 120 second period, then the Local Unambiguous CPR decode performed in step a. **shall** be considered to be invalid, and the Report Assembly Function **shall** return to the Initialization State. In order to proceed from the Acquisition State to the Track State, the Local Unambiguous CPR decode must be repeated.

   Note: *This action effectively represents a return to the Initialization State with the exception that the return is to step a. above, and the report is retained as per step e. The purpose of this action is to minimize the need to perform the Local Unambiguous CPR decode since it is not necessary when position messages have been received within the reasonable time limit of 120 seconds. This action is illustrated in Figure 2-16b.*

g. If no new messages have been received from a given Surface Participant for at least 200 seconds, then all reports relevant to the Participant Address **shall** be deleted from the Report Output Storage Buffer.

2.2.10.3.2.1 Latency, Report Assembly Acquisition State --- Surface Participant

Step 2.2.10.3.2.d **shall** be completed within 500 milliseconds of receipt of the second Surface Position Message of the "***even***" and "***odd***" pair.

2.2.10.3.3 Acquisition State Data Retention

Upon receipt of any of the messages identified in §2.2.10.2 for any given participant, the received message **shall** either:

a. Use the message as required in §2.2.10.3.1 for Airborne Participants or §2.2.10.3.2 for Surface Participants, or

b. Retain the message for future use as specified in §2.2.10.1.3.

2.2.10.4 Report Assembly Track State

2.2.10.4.1 Report Assembly Track State --- Airborne Participant

2.2.10.4.1.1 Report Assembly Track State Initialization --- Airborne Participant

Initialization of the Track State for a given Airborne Participant assumes that the Acquisition State has been established for the given Participant in accordance with §2.2.10.3.1.

Upon receipt of a valid Airborne Velocity Information Message (see §2.2.3.2.6) for a given Airborne Participant, the Report Assembly Function **shall**:

a. Set the Report Mode to “Track” for the given Airborne Participant in the State Vector Report (see §2.2.8.1) in accordance with §2.2.8.1.22,

b. Structure all possible fields of the State Vector Report for the given Airborne Participant in accordance with §2.2.8.1 (all subsections inclusive),

c. Deliver the new State Vector Report for the given Airborne Participant to the Report Output Storage Buffer within 500 milliseconds of receipt of the Airborne Velocity Information Message,

d. Maintain the integrity of the State Vector Report for the given Airborne Participant in the Report Output Storage Buffer for 100 +/- 5 seconds unless replaced by an updated State Vector Report or otherwise specified in the following sections,

e. Initiate Assembly of Mode Status Reports:

(1). The Report Assembly Function **shall** review all messages received from the given Airborne Participant that may have been placed in temporary storage in accordance with §2.2.10.1.3.

(2). Upon completion of the message review, the Report Assembly Function **shall** structure all possible fields of the Mode Status Report for the given Airborne Participant in accordance with §2.2.8.2 (all subsections inclusive).

(3). The Report Assembly Function **shall** deliver the new Mode Status Report for the given Airborne Participant to the Report Output Storage Buffer within 500 milliseconds of receipt of the Airborne Velocity Information Message which initialized the Track State.

(4). The Report Assembly Function **shall** maintain the integrity of the Mode Status Report for the given Airborne Participant in the Report Output Storage Buffer 100

+/- 5 seconds unless replaced by an updated Mode Status Report or otherwise specified in the following sections.

f. Initiate Assembly of ADS-B Target State Reports:

(1). The Report Assembly Function **shall** review all messages received from the given Airborne Participant that may have been placed in temporary storage in accordance with §2.2.10.1.3.

(2). Upon completion of the message review, the Report Assembly Function **shall** structure all possible fields of the ADS-B Target State Report for the given Airborne Participant in accordance with §2.2.8.3 (all subsections inclusive).

(3). The Report Assembly Function **shall** deliver the new ADS-B Target State Report for the given Airborne Participant to the Report Output Storage Buffer within 500 milliseconds of receipt of the Airborne Velocity Information Message which initialized the Track State.

(4). The Report Assembly Function **shall** maintain the integrity of the ADS-B Target State Report for the given Airborne Participant in the Report Output Storage Buffer for 100 +/- 5 seconds unless replaced by an updated ADS-B Target State Report or otherwise specified in the following sections.

2.2.10.4.1.2 Report Assembly Track State Maintenance --- Airborne Participant

The Track State **shall** be maintained for a given Airborne Participant for as long as Airborne Position Messages (see §2.2.3.2.3) and Airborne Velocity Information Messages (see §2.2.3.2.6) are being received from the Participant.

a. Each time that a new Airborne Position Message is received from the given Airborne Participant, the Report Assembly Function **shall**:

(1). Perform a CPR decode of the Participant Position in accordance with §A.1.7.4 and A.1.7.5 of Appendix A,

(2). Update all possible fields of the State Vector Report for the given Airborne Participant in accordance with §2.2.8.1 (all subsections inclusive),

(3). Deliver the updated State Vector Report to the Report Output Storage Buffer within 500 milliseconds of receipt of the new Airborne Position Message, and

(4). Maintain the integrity of the State Vector Report for the given Airborne Participant in the Report Output Storage Buffer for 100 +/- 5 seconds unless replaced by an updated State Vector Report or otherwise specified in the following sections.

b. Each time that a new Airborne Velocity Information Message is received from the Airborne Participant that contains Ground Referenced Velocity information, the Report Assembly Function **shall**:

(1). Update all possible fields of the State Vector Report for the given Airborne Participant in accordance with §2.2.8.1 (all subsections inclusive),

(2). Deliver the updated State Vector Report to the Report Output Storage Buffer within 500 milliseconds of receipt of the new Airborne Position Message, and

(3). Maintain the integrity of the State Vector Report for the given Airborne Participant in the Report Output Storage Buffer for 100 +/- 5 seconds unless replaced by an updated State Vector Report or otherwise specified in the following sections.

c. Each time an ADS-B Airborne Velocity Information Message (§2.2.3.2.6) with Subtype = 3 or 4 (i.e., providing Air Referenced Velocity information) is received from the ADS-B Airborne Participant, then the Report Assembly Function **shall**:

(1). Update all possible fields of the Air Referenced Velocity Report for the given ADS-B Airborne Participant in accordance with §2.2.8.3.2 (all subsections inclusive),

(2). Deliver the updated ARV Report to the Report Output Storage Buffer within 500 milliseconds of receipt of the new ADS-B Airborne Velocity Message, and

(3). Maintain the integrity of the ARV Report for the given ADS-B Airborne Participant in the Report Output Storage Buffer for 100 +/- 5 seconds unless replaced by an updated ARV Report or otherwise specified in the following sections.

d. Each time that a new Aircraft Identification and Type Message (see §2.2.3.2.5), Aircraft Trajectory Intent and System Status Message (see §2.2.3.2.7.1) having System Status information, Aircraft Operational Status Message (see §2.2.3.2.7.2), Airborne Velocity Message (§2.2.3.2.6), or Aircraft Status Message (see §2.2.3.2.7.8) is received from the Airborne Participant, the Report Assembly Function **shall**:

(1). Update all possible fields of the Mode Status Report for the given Airborne Participant in accordance with §2.2.8.2 (all subsections inclusive),

(2). Deliver the updated Mode Status Report to the Report Output Storage Buffer within 500 milliseconds of receipt of the new Message, and

(3). Maintain the integrity of the Mode Status Report for the given Airborne Participant in the Report Output Storage Buffer for 100 +/- 5 seconds unless replaced by an updated Mode Status Report or otherwise specified in the following sections.

e. Each time that a new Aircraft Trajectory Intent and System Status Message (see §2.2.3.2.7.1) having Target State information is received from the given Airborne Participant, the Report Assembly Function **shall**:

(1). Update all possible fields of the ADS-B Target State Report for the given Airborne Participant in accordance with §2.2.8.3 (all subsections inclusive), (2). Deliver the updated ADS-B Target State Report to the Report Output Storage Buffer within 500 milliseconds of receipt of the new Message, and

(3). Maintain the integrity of the ADS-B Target State Report for the given Airborne Participant in the Report Output Storage Buffer for 100 +/- 5 seconds unless replaced by an updated ADS-B Target State Report or otherwise specified in the following sections.

2.2.10.4.1.3 Report Assembly Track State Termination --- Airborne Participant

a. The Track State **shall** be terminated for a given Airborne Participant if no Airborne Position (see §2.2.3.2.3) or Airborne Velocity Information (see §2.2.3.2.6) Messages have been received from the Participant in 25 +/- 5 seconds.

b. Upon termination of the Track State for a given Airborne Participant, the Report Assembly Function **shall** immediately delete all State Vector, Mode Status, ADS-B Target State, and Air Referenced Velocity Reports that were placed in the Report Output Storage Buffer for the given Participant.

Note: *The track state termination requires deletion of all reports structured for a given participant into the Report Output Storage Buffer. Track state termination does not intend that temporary storage (see §2.2.10.1.3) established for the given Participant be deleted. The temporary storage is only deleted if NO ADS-B Messages have been received from the given Participant for 225 +/- 25 seconds.*

c. Upon completion of the preceding step b., the Report Assembly Function **shall** return to the Report Assembly Acquisition State for the given Airborne Participant as specified in §2.2.10.3.1.

2.2.10.4.2 Report Assembly Track State --- Surface Participant

2.2.10.4.2.1 Report Assembly Track State Initialization --- Surface Participant

Initialization of the Track State for a given Surface Participant is established in accordance with §2.2.10.3.2.

In addition to the requirements specified in §2.2.10.3.2, the Report Assembly Function **shall** initiate assembly of Mode Status Reports as follows:

a. The Report Assembly Function **shall** review all messages received from the given Surface Participant that may have been placed in temporary storage in accordance with §2.2.10.1.3.

b. Upon completion of the message review, the Report Assembly Function **shall** structure all possible fields of the Mode Status Report for the given Surface Participant in accordance with §2.2.8.2 (all subsections inclusive).

c. The Report Assembly Function **shall** deliver the new Mode Status Report for the given Surface Participant to the Report Output Storage Buffer within 500 milliseconds of receipt of the last received Surface Position Message which initialized the Track State.

d. The Report Assembly Function **shall** maintain the integrity of the Mode Status Report for the given Surface Participant in the Report Output Storage Buffer 100 +/- 5 seconds unless replaced by an updated Mode Status Report or otherwise specified in the following sections.

2.2.10.4.2.2 Report Assembly Track State Maintenance --- Surface Participant

The Track State **shall** be maintained for a given Surface Participant for as long as Surface Position Messages (see §2.2.3.2.4) are being received from the Surface Participant.

a. Each time that a new Surface Position Message is received from the given Surface Participant, the Report Assembly Function **shall**:

(1). Perform a CPR decode of the Participant Position in accordance with §A.1.7.4 and A.1.7.6 of Appendix A,

(2). Update all possible fields of the State Vector Report for the given Surface Participant in accordance with §2.2.8.1 (all subsections inclusive),

(3). Deliver the updated State Vector Report to the Report Output Storage Buffer within 500 milliseconds of receipt of the new Surface Position Message, and

(4). Maintain the integrity of the State Vector Report for the given Surface Participant in the Report Output Storage Buffer for 100 +/- 5 seconds unless replaced by an updated State Vector Report or otherwise specified in the following sections.

b. Each time that a new Aircraft Identification and Type Message (see §2.2.3.2.5), Aircraft Operational Status Message (see §2.2.3.2.7.2), or Aircraft Status Message (see §2.2.3.2.7.8) is received from the Surface Participant, the Report Assembly Function **shall**:

(1). Update all possible fields of the Mode Status Report for the given Surface Participant in accordance with §2.2.8.2 (all subsections inclusive),

(2). Deliver the updated Mode Status Report to the Report Output Storage Buffer within 500 milliseconds of receipt of the new Message, and

(3). Maintain the integrity of the Mode Status Report for the given Surface Participant in the Report Output Storage Buffer for 100 +/- 5 seconds unless replaced by an updated Mode Status Report or otherwise specified in the following sections.

2.2.10.4.2.3 Report Assembly Track State Termination --- Surface Participant

a. The Track State **shall** be terminated for a given Surface Participant if no Surface Position Message (see §2.2.3.2.4) has been received from the Participant in 25 +/- 5 seconds.

b. Upon termination of the Track State for a given Surface Participant, the Report Assembly Function **shall** immediately delete all State Vector and Mode Status Reports that were placed in the Report Output Storage Buffer for the given Participant.

Notes:

1. *The track state termination requires deletion of all reports structured into the Report Output Storage Buffer. Track state termination does not intend that temporary storage (see §2.2.10.1.3) established for the given Participant be deleted. The temporary storage is only deleted if NO ADS-B Messages have been received from the given Participant for 225 +/- 25 seconds.*

2. *ADS-B Surface Participants do not generate Trajectory Intent information; therefore, ADS-B Target State Report assembly is not required for Surface Participants.*

c. Upon completion of the preceding step b., the Report Assembly Function **shall** return to the Report Assembly Acquisition State for the given Surface Participant as specified in §2.2.10.3.2.

2.2.10.5 Minimum Number of Participant Track Files

In the absence of an applied interference environment and other interference, the ADS-B Report Assembly Function **shall** be capable of:

a. Maintaining the minimum number of track files (see 2.2.10.1.4) of ADS-B participants as specified in Table 2-76 for a given equipage class, and

Table 2-76: Minimum Participant Track File Capacity

Equipage Class of ADS-B Receiving Subsystem	Minimum Number of Participant Track Files
A0	100
A1	200
A2	400 ***TBD***
A3	400 ***TBD***

b. If the track file capacity of the ADS-B Receiving Subsystem is being exceeded by the number of participants whose messages are being received by the subsystem, then the subsystem may choose to discard track files of those participants that are at farther ranges relative to the receiving subsystem.

2.2.10.6 Participant Track File Maintenance in the Interference Environment

<<<The following original DO-260 requirement now applies to only Equipage Class A0 equipment (without the enhanced decoder). We need to expand the following requirements to define the required performance for equipage Class A1 (i.e, at least center sample) and for Class A2 and A3 (i.e., enhanced multi-sample) decoders. >>>

2.2.10.6.1 Track File Maintenance for Class A0 Receiving Devices

The Equipage Class A0 ADS-B Receiving Device Message Processor and Report Assembly functions **shall** properly decode at least 90% of valid ADS-B Messages that have been received in the following ATCRBS interference environment:

a. Each of the ADS-B Messages **shall** be valid, and **shall** be overlaid with an ATCRBS MODE-C Reply (see RTCA Document No. DO-181C §2.2.4.1 through §2.2.4.1.6) (EUROCAE ED-73A, §3.5.1 through §3.5.5) having the appropriate altitude encoding for an altitude of 50,000 feet,

b. The ATCRBS MODE-C message **shall** overlay the ADS-B Message at any point after the "DF" subfield,

c. The ADS-B Message signal level **shall** be a minimum of MTL + 6 dB and a maximum of -21 dBm, and

d. The ATCRBS MODE-C reply signal level **shall** be 3 dB greater than the ADS-B Message signal level.

2.2.10.6.2 Track File Maintenance for Class A1 Receiving Devices

TBD

2.2.10.6.3 Track File Maintenance for Class A2 and A3 Receiving Devices

TBD

2.2.11 Self Test and Monitors

2.2.11.1 Self Test

If a self-test feature or monitor is provided as part of the equipment:

a. The device which radiates test ADS-B Messages or prevents messages from being broadcast during the test period **shall** be limited to no longer than that required to determine the status of the system.

b. The self-test message signal level at the antenna end of the transmission line **shall** not exceed -40 dBm.

c. If provision is made for automatic periodic self-test procedure, such self-testing **shall** not radiate ADS-B Messages at an average rate exceeding one broadcast every ten seconds.

2.2.11.2 Broadcast Monitoring

2.2.11.2.1 Transponder Based Equipment

If the ADS-B transmission device is implemented as a non-broadcast only equipment installation, then a squitter monitor **shall** be provided to verify that DF=17 transmissions are generated at the rates defined in §2.2.3.3 through §2.2.3.3.2.10. If any of the DF=17 message types for which the equipment is certified is not transmitted at the specified rates, then the equipment **shall** be considered as failed and the appropriate "Fail/Warn" indicators **shall** be set to the "Fail/Warn" state.

2.2.11.2.2 Non-Transponder Based Equipment

If the ADS-B transmission device is a broadcast only device, then a monitor **shall** be provided to verify that DF=18 transmissions are generated at the applicable rates defined in §2.2.3.3 through §2.2.3.3.2.10. If any of the DF=18 message types for which the device is certified is not transmitted at the specified rates, then the broadcast only device **shall** be considered as failed and the appropriate "Fail/Warn" indicators **shall** be set to the "Fail/Warn" state.

2.2.11.3 Address Verification

2.2.11.3.1 Transponder Based Equipment

Transponder implemented ADS-B transmission devices **shall** declare a device failure in the event that it's own ICAO 24-bit Address (i.e., the Mode-S Address) is set to all "ZEROs" or all "ONEs."

2.2.11.3.2 Non-Transponder Based Equipment

Non-transponder implemented ADS-B transmission devices **shall** declare a device failure in the event that it's own ICAO 24-bit Address is set to all "ZEROs" or all "ONEs."

2.2.11.4 Receiver Self Test Capability

ADS-B Receiving Devices **shall** be designed to provide sufficient self-test capability to detect a loss of capability to receive ADS-B Messages, structure appropriate ADS-B reports, and make such reports available to the intended user interface. Should the receiving device detect that these basic functions cannot be performed properly, then the receiving device **shall** be considered as failed and the appropriate "Fail/Warn" indicators **shall** be set to the "Fail/Warn" state.

2.2.11.5 Failure Annunciation

2.2.11.5.1 ADS-B Transmission Device Failure Annunciation

An output **shall** be provided to indicate the validity/non-validity of the ADS-B transmission device. Failure to generate ADS-B Messages at a nominal rate, a failure detected by self-test or the monitoring function, or failure of the address verification **shall** cause the output to assume the invalid state. Momentary power interrupts **shall** not cause the output to assume the invalid state. The status of the ADS-B transmission device **shall** be enunciated to the flight crew where applicable.

2.2.11.5.2 ADS-B Receiving Device Failure Annunciation

An output **shall** be provided to indicate the validity/non-validity of the ADS-B receiving device. Failure to accept ADS-B Messages, structure appropriate ADS-B reports, make such reports available to the intended user interface, or failure detected by self-test or monitoring functions **shall** cause the output to assume the invalid state. Momentary power interrupts **shall** not cause the output to assume the invalid state. The status of the ADS-B receiving device **shall** be enunciated to the flight crew where applicable.

2.2.11.5.3 Co-Located ADS-B Transmission and Receiving Device Failure Annunciation

In installations where the ADS-B transmission and receiving functions are implemented in a common unit, it **shall** be permissible to use a singe Fail/Warn output that is used in common to satisfy the requirements of §2.2.11.5.1 and §2.2.11.5.2. Otherwise, the Fail/Warn mechanisms for the ADS-B transmission function and the ADS-B receiving function **shall** be independent.

2.2.12 Response to Mutual Suppression Pulses

Mutual suppression systems may be needed if the aircraft has other pulse L-band (also known as D-band) equipment on board or if the ADS-B equipment is used in conjunction with certain Collision Avoidance System equipment.

2.2.12.1 ADS-B Transmitting Subsystem Response to Mutual Suppression Pulses

If the ADS-B transmitting equipment is designed to accept and respond to mutual suppression pulses from other electronic equipment in the aircraft (to disable the equipment while the other equipment is transmitting), the equipment **shall** regain normal transmission capability not later than 15 microseconds after the end of the applied mutual suppression pulse.

2.2.12.2 ADS-B Receiving Device Response to Mutual Suppression Pulses

If the ADS-B receiving equipment is designed to accept and respond to mutual suppression pulses from other electronic equipment in the aircraft (to disable the equipment while the other equipment is transmitting), the equipment **shall** regain normal sensitivity, within 3 dB, not later than 15 microseconds after the end of the applied mutual suppression pulse.

Note: *This document does not establish the design parameters of the mutual suppression system. However, it is recommended that all sources of mutual suppression pulses be dc coupled while sinks are ac coupled. This standardization will prevent source or sink failures from disabling all users of the mutual suppression pulses.*

2.2.13 Antenna System

ADS B systems require omni-directional antenna(s) for transmitting and receiving. Separate antenna for receiving and transmitting are not required.

2.2.13.1 Transmit Pattern Gain

The gain of an omni-directional transmit antenna **shall** not be less than the gain of a matched quarter-wave stub minus 3 dB over 90 percent of a coverage volume from 0 to 360 degrees in azimuth and from 5 to 30 degrees above the ground plane when installed at center of 1.2 meter (4 feet) diameter (or larger) flat circular ground plane.

2.2.13.2 Receiver Pattern Gain

The gain of an omni-directional antenna should not be less than the gain of a matched quarter-wave stub minus one dB over 90% of a coverage volume from 0 to 360 degrees in azimuth and -15 to +20 degrees in elevation when installed at the center of a 1.2 m (4 ft.) diameter (or larger) circular ground plane that can be either flat or cylindrical.

Note: *These requirements are consistent with those provided in RTCA Document No. DO-185A, §2.2.4.7.1.*

2.2.13.3 Frequency Requirements for Transmit and Receive Antenna(s)

Antenna **shall** be designed to transmit and receive signals at 1090 plus or minus 1 MHz.

2.2.13.4 Impedance and VSWR

The VSWR produced by each antenna when terminated in a 50 ohm transmission line **shall** not exceed 1.5:1 at 1090 MHz.

2.2.13.5 Polarization

Antenna(s) **shall** be vertically polarized.

2.2.13.6 Diversity Operation

Diversity transmission and/or reception may be implemented. Such implementations **shall** employ two antennas, one mounted on the top and the other on the bottom of the aircraft. Separate requirements apply to transmitting diversity and receiving diversity as provide in the following sub-sections.

2.2.13.6.1 Transmitting Diversity

“Transmitting diversity” refers to the alternation between the top and bottom-mounted antennas for the transmission of ADS-B Messages. If an ADS-B Transmitting Subsystem implements transmitting diversity, it **shall** transmit each required type of ADS-B Message alternately from the top and bottom antennas.

Note: *For example, successive Airborne Position Messages would be transmitted on different antennas. Again, successive messages loaded into a transponder's event-driven register would be transmitted alternately from the top and bottom antennas.*

If transmission diversity is used, the bit described in §2.2.3.2.3.3 **shall** be set valid.

2.2.13.6.1.1 Transmitting Diversity Channel Isolation

The peak RF power transmitted from the selected antenna **shall** exceed the power transmitted from the non-selected antenna by at least 20 dB.

2.2.13.6.2 Receiving Diversity

"Receiving diversity" refers to an ADS-B receiving subsystem's use of signals received from either the top antenna, or the bottom antenna, or both antennas. For the purpose of these requirements, several alternate ADS-B receiving subsystem architectures that employ receiving antenna "diversity" are illustrated in Figure 2–17.

a. Full receiver and message processing function diversity:

   (see Figure 2-17, part b1.)

   There are two receiver input channels, each with its own receiver front end, preamble detection, bit demodulation, error detection, and error correction functions. Channel selection is based on declaration of a correct message by the parity error detection function. In the event that both channels produce an identical correct message with no parity errors, the message from either channel can be selected as the received message, which is then delivered to the report assembly function. In the event each channel produces valid, but different messages, both **shall** be delivered to the report assembly function.

b. Receiver Switching Front-end Diversity:

   (see Figure 2-17, part b2.)

   There are two receiver input channels, each with its own receiver front end and preamble detection; followed by single channel bit, demodulation, error detection, and error correction functions. Channel selection is based on the detection of valid preamble pulse patterns and connection of the single string elements to the receiver input having the strongest preamble pulse pattern. In the event that the preamble pulse patterns for both channels are within 1 dB of each other, either receiver input may be selected.

c. Receiving antenna switching:

   (see Figure 2-17, part b3.)

   A single receiver input channel, consisting of receiver RF front end, preamble detection, bit demodulation, and error detection, and error correction functions, is internally connected alternately and periodically to the top and bottom antennas. If this method is implemented, switching **shall** cause the channel to dwell for 2.0 seconds on each antenna and continue an alternating transition every 2 +/- 0.1 seconds. The switching function **shall** result in loss of no more than 1 input message for each transition when the RF message signals are present at the required maximum incoming message rate of 8000 ADS-B Messages per second.

Notes:

1. *The maximum rate is derived from §2.2.4.3.4.1.a which infers that the receiver sensitivity threshold **shall** be recovered in not more than 120 microseconds after the detection of the preamble. Therefore, the minimum separation between the leading edge of the first preamble pulse of two successive ADS-B Messages is established at 125 microseconds, thereby establishing the maximum possible short term rate of 8,000 ADS-B Messages per second.*

2. *The maximum rate identified above is not typical of the future ADS-B environment and should not be applied to the ADS-B Receiving subsystem as a steady state rate. This high rate should be applied to the ADS-B Receiving subsystem for short durations that are adequate to demonstrate compliance of the ADS-B Receiving subsystem.*

ADS-B Receiving Subsystems which implement antenna switching to a single receiver as discussed in §"c," **shall** provide a method of delivering all ADS-B Messages to an appropriate output interface for the purpose of monitoring the message throughput capability of the receiving subsystem. (see Figure 2-17, part a., "MOPS test point").

d. Other switching diversity techniques. Other diversity implementations may be used. Any implementation must meet the requirements of (a) or (b) above.

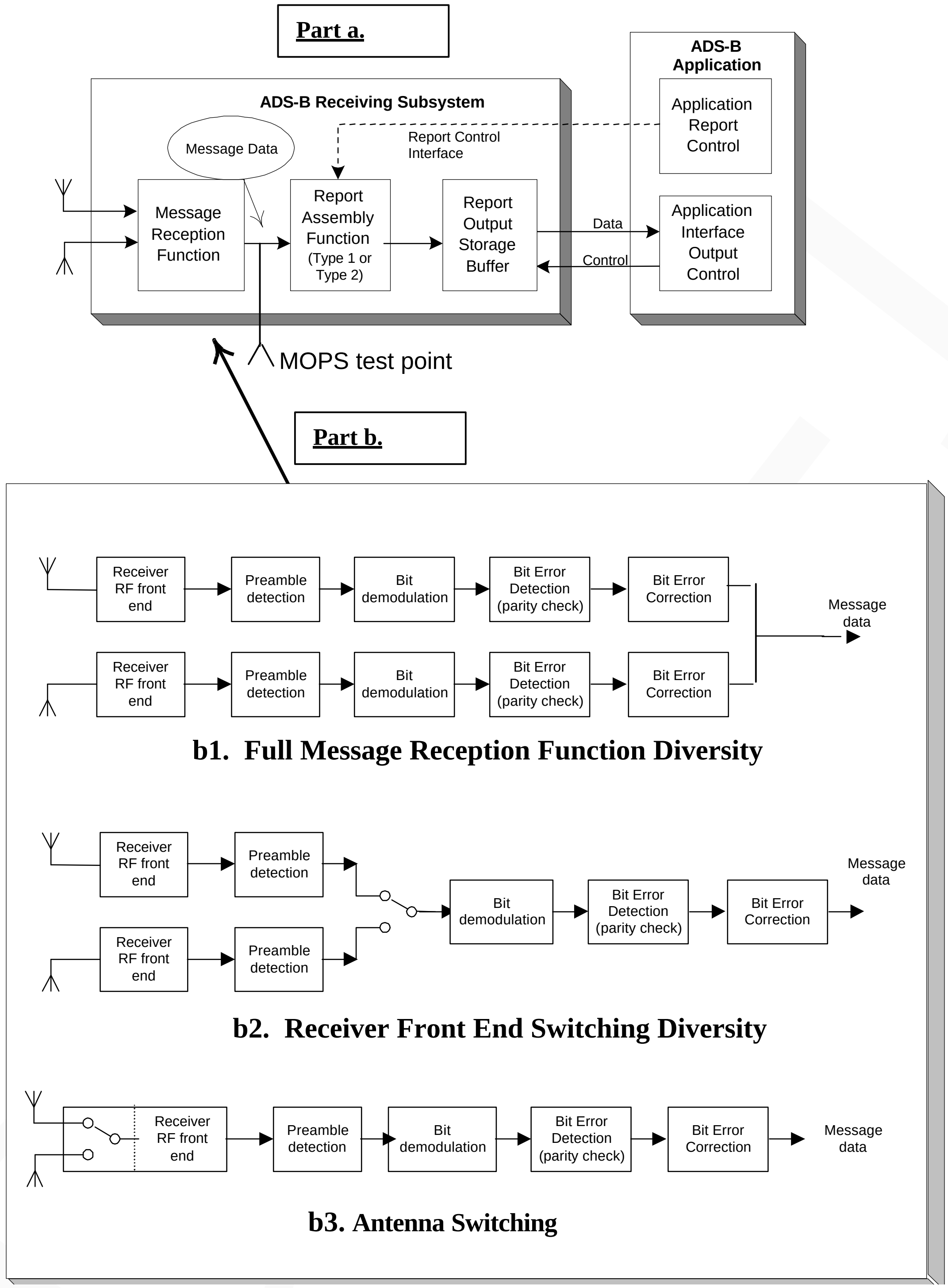


Figure 2-17: Various ADS-B Receiving Architectures.

2.2.14 Interfaces

2.2.14.1 ADS-B Transmitting Subsystem Interfaces

2.2.14.1.1 ADS-B Transmitting Subsystem Input Interfaces

Data delivery mechanisms **shall** ensure that each data parameter is provided to the input function of the ADS-B Transmitting Subsystem at sufficient update rates to support the ADS-B Message Update Rates provided in §2.2.3.3 through §2.2.3.3.2.11.

2.2.14.1.1.1 Discrete Input Interfaces

Appropriate discrete inputs may be used to provide the ADS-B Transmitting Subsystem with configuration and control information. When implemented, all discrete inputs **shall** provide appropriate diode isolation to prevent sneak current paths.

2.2.14.1.1.2 Digital Communication Input Interfaces

Approved Avionics Digital Communication interfaces **shall** be used to provide all digital data parameters (including control information) to the ADS-B Transmitting Subsystem. Such input interfaces **shall** implement appropriate error control techniques (i.e., parity as a minimum) to ensure that data is properly delivered to the ADS-B Transmitting Subsystem control and message generation functions.

2.2.14.1.1.3 Processing Efficiency

The ADS-B Transmitting Subsystem input processing function **shall** be capable of efficiently processing all data input interfaces in a manner that ensures that the most recent update received for all required data parameters is made available to the message generation function to support the rates identified in §2.2.3.3 through §2.2.3.3.2.11.

2.2.14.1.2 ADS-B Transmitting Subsystem Output Interfaces

2.2.14.1.2.1 Discrete Output Interfaces

Appropriate discrete outputs may be used by the ADS-B Transmitting Subsystem to provide Mode Status and Failure Monitoring information to other users or monitoring equipment. When implemented, all discrete outputs **shall** provide appropriate diode isolation to prevent sneak current paths.

2.2.14.1.2.2 Digital Communication Output Interfaces

Appropriate Avionics Digital Communication output interfaces **shall** be implemented by the ADS-B Transmitting Subsystem to provide status and data communication to other user or monitoring equipment. Such output interfaces **shall** implement appropriate error control techniques (i.e., parity as a minimum) to ensure that data is properly delivered to other user or monitoring equipment.

2.2.14.2 ADS-B Receiving Device Interfaces

2.2.14.2.1 ADS-B Receiving Device Input Interfaces

2.2.14.2.1.1 Discrete Input Interfaces

Appropriate discrete inputs may be used to provide the ADS-B Receiving device with configuration and control information. When implemented, all discrete inputs **shall** provide appropriate diode isolation to prevent sneak current paths.

2.2.14.2.1.2 Digital Communication Input Interfaces

Approved Avionics Digital Communication interfaces **shall** be used to provide all digital data parameters (including control information) to the ADS-B Receiving Device. Such input interfaces **shall** implement appropriate error control techniques (i.e., parity as a minimum) to ensure that data is properly delivered to the ADS-B Receiving device control and Report Assembly functions.

2.2.14.2.1.3 Processing Efficiency

The ADS-B Receiving Device input processing function **shall** be capable of efficiently processing all data input interfaces in a manner that ensures that the most recent update received for all required data parameters is made available to the Report Assembly function.

2.2.14.2.2 ADS-B Receiving Device Output Interfaces

2.2.14.2.2.1 Discrete Output Interfaces

Appropriate discrete outputs may be used by the ADS-B Receiving device to provide Mode Status and Failure Monitoring information to other users or monitoring equipment. When implemented, all discrete outputs **shall** provide appropriate diode isolation to prevent sneak current paths.

2.2.14.2.2.2 Digital Communication Output Interfaces

Appropriate Avionics Digital Communication output interfaces **shall** be implemented by the ADS-B Receiving device to provide status and data communication to other user or monitoring equipment. Such output interfaces **shall** implement appropriate error control techniques (i.e., parity as a minimum) to ensure that data is properly delivered to other user or monitoring equipment.

2.2.15 Power Interruption

The ADS-B transmitting and/or receiving equipment **shall** regain operational capability to within its operational limits within two seconds after the restoration of power following a momentary power interruption.

Note: *The ADS-B transmitting and/or receiving equipment is not required to continue operation during momentary power interruptions.*

2.2.16 Compatibility with Other Systems

2.2.16.1 EMI Compatibility

The ADS-B transmitting and/or receiving equipment **shall** not compromise the operation of any co-located communication or navigation equipment, or ATCRBS and/or Mode-S transponders. Likewise, the ADS-B antenna **shall** be mounted such that it does not compromise the operation of any other proximate antenna.

2.2.16.2 Compatibility with GPS Receivers

The ADS-B transmitting and/or receiving equipment **shall** not compromise the operation of a co-located proximate GPS receiver.

2.2.16.3 Compatibility with Other Navigation Receivers and ATC Transponders

The ADS-B transmitting and/or receiving equipment **shall** not compromise the operation of VOR, DME, ADF, LORAN, ATCRBS or Mode-S equipment installed in a proximate location.

In addition, the ADS-B receiver must be fully operational when located in close proximity of an ATCRBS or Mode-S transponder.

2.2.17 Traffic Information Services – Broadcast (TIS-B)

2.2.17.1 Introduction

TBD

2.2.17.2 TIS-B Format Structure

TIS-B information is broadcast using the 112-bit Mode S DF=18 format as shown below in Figure 2.2.17.2.

TIS-B Format Definition					
Bit #	1 ----- 5	6 --- 8	9 -------- 32	33 --------------------------------- 88	89 ------ 112
	DF [5]	CF [3]	AA [24]	ME [56]	PI [24]
	10010				
	MSB LSB	MSB LSB	MSB LSB	MSB LSB	MSB LSB

<u>Figure 2.2.17.2:</u> TIS-B Format Definition

The content of the DF=18 transmission is defined by the value of the control field, as specified in Table 2.2.17.2.

Table 2.2.17.2: "CF" Field Code Definitions in DF=18 ADS-B and TIS-B Messages

CF Value	ICAO/Mode A Flag (IMF)	Meaning
0	N/A	ADS-B Message from a non-transponder device, AA field holds 24-bit ICAO aircraft address
1	N/A	Reserved for ADS-B Message in which the AA field holds anonymous address or ground vehicle address or fixed obstruction address
2	0	Fine TIS-B message, AA field contains the 24-bit ICAO aircraft address
	1	Fine TIS-B message, AA field contains the 12-bit Mode A code followed by a 12-bit track file number
3	0	Coarse TIS-B airborne position and velocity message, AA field contains the 24-bit ICAO aircraft address
	1	Coarse TIS-B airborne position and velocity message, AA field contains the 12-bit Mode A code followed by a 12-bit track file number.
4	N/A	Reserved for TIS-B management message AA field holds TIS-B service volume ID + other information (e.g., MSB of reference position for the service volume)
5	0	Reserved for TIS-B messages that relay ADS-B Messages using anonymous 24-bit addresses
	1	Reserved
6 – 7	N/A	Reserved

2.2.17.2.1 "DF" Downlink Format

This field **shall** be set to DF=18 to indicate that this transmission is not from a Mode S transponder. See §2.2.3.2.1.1.4.

2.2.17.2.2 "CF" Control Field

This field **shall** be set to 2, 3 or 4 depending upon the TIS-B Message as specified in Table 2.2.17.2.

2.2.17.2.3 "AA" Address Announced Field

As specified in Table 2.2.17.2, the AA field **shall** contain either:

(1) the ICAO 24-bit aircraft address as specified in subparagraph 2.2.3.2.1.1.1, or

(2) the 12-bit Mode A code followed by a 12-bit track number.

2.2.17.2.4 "ME" Message Extended Squitter Field

This field **shall** be set as specified in §2.2.3.2.1.1.5.

2.2.17.2.5 "PI" Parity/Identity Field

This field **shall** be set as specified in §2.2.3.2.1.1.6.

2.2.17.3 TIS-B Messages

2.2.17.3.1 TIS-B Fine Airborne Position Message

TIS-B Fine Airborne Position Message Format								
MSG BIT #	33 --- 37	38 --------- 39	40	41 ----- 52	53	54	55 -------- 71	72 -------- 88
"ME" BIT #	1 ----- 5	6 ------------ 7	8	9 ----- 20	21	22	23 -------- 39	40 -------- 56
Field Name	TYPE [5]	Surveillance Status [2]	IMF [1]	Pressure Altitude [12]	Reserved [1]	CPR Format (F) [1]	CPR Encoded Latitude [17]	CPR Encoded Longitude [17]
	MSB LSB	MSB LSB		MSB LSB			MSB LSB	MSB LSB

Note: *"[#]" provided in the Field Name column indicates the number of bits in the specific field.*

Figure 2.2.17.3.1: TIS-B Fine Airborne Position Message Format

2.2.17.3.1.1 Relationship to ADS-B Format

The following fields **shall** be coded as specified for the ADS-B Airborne Position Message defined in §2.2.3.2.3:

Type Code	Surveillance Status
Altitude	CPR Format
Encoded Latitude	Encoded Longitude

2.2.17.3.1.2 ICAO/Mode A Flag (IMF)

This one-bit (ME bit 8) field **shall** indicate the type of identity associated with the aircraft data reported in the TIS-B message. IMF equal to ZERO (0) **shall** indicate that the TIS-B data is identified by an ICAO 24-bit address. IMF equal to ONE (1) **shall** indicate that the TIS-B data is identified by a "Mode A" code. A "Mode A" code of all ZEROes **shall** indicate a primary radar target.

***Note**: The AA field is coded differently for 24-bit addresses and Mode A codes as specified in Table 2.2.17.2.*

2.2.17.3.2 TIS-B Fine Surface Position Message

TIS-B Fine Surface Position Message Format								
MSG BIT #	33 -- 37	38 ------- 44	45	46 ----- 52	53	54	55 ------- 71	72 -------- 88
"ME" BIT #	1 ----- 5	6 --------- 12	13	14 ----- 20	21	22	23 ------- 39	40 -------- 56
Field Name	TYPE [5]	Movement [7]	Ground Track Status [1]	Ground Track [7]	IMF [1]	CPR Format (F) [1]	CPR Encoded Latitude [17]	CPR Encoded Longitude [17]
	MSB LSB	MSB LSB		MSB LSB			MSB LSB	MSB LSB

***Note:** "[#]" provided in the Field Name column indicates the number of bits in the specific field.*

Figure 2.2.17.3.2: TIS-B Fine Surface Position Message Format

2.2.17.3.2.1 Relationship to ADS-B Format

The following fields **shall** be coded as specified for the ADS-B Surface Position Message defined in §2.2.3.2.4:

Type Code	Movement
Ground Track Status	CPR Format
Encoded Latitude	Encoded Longitude

2.2.17.3.2.2 ICAO/Mode A Flag (IMF)

This one-bit (bit 21) field **shall** be set as specified in §2.2.17.3.1.2.

2.2.17.3.3 TIS-B Identification and Category Message

TIS-B Identification and Category Message Format										
MSG BIT #	33--37	38 --------- 40	41 -46	47-52	53 -58	59 -64	65 -70	71 -76	77 -82	83 -88
"ME" BIT #	1 --- 5	6 ------------- 8	9 -- 14	15 -20	21--26	27- 32	33 -38	39 -44	45 -50	51 -56
FIELD NAME	TYPE [5]	ADS-B EMITTER CATEGORY [3]	Ident Char. #1 [6]	Ident Char. #2 [6]	Ident Char. #3 [6]	Ident Char. #4 [6]	Ident Char. #5 [6]	Ident Char. #6 [6]	Ident Char. #7 [6]	Ident Char. #8 [6]
	MSB LSB	MSB LSB	MSB LSB	MSB LSB	MSB LSB	MSB LSB	MSB LSB	MSB LSB	MSB LSB	MSB LSB

Note: *"[#]" provided in the Field Name column indicates the number of bits in the specific field.*

Figure 2.2.17.3.3: TIS-B Identification and Category Message Format

2.2.17.3.3.1 Relationship to ADS-B Format

All of the message fields **shall** be coded as specified for the ADS-B Identification and Type Message defined in §2.2.3.2.5.

2.2.17.3.3.2 Application

This message **shall** only be used for aircraft identified with an ICAO 24-bit address.

2.2.17.3.4 TIS-B Airborne Velocity Message

TIS-B VELOCITY INFORMATION MESSAGE - SUBTYPES "1" and "2"															
MSG BIT #	33-37	38 ------ 40	41	42 ------- 45	46	47 --- 56	57	58 --- 67	68	69	70 -- 78	79	80 -- 83	84 -- 85	86 ---- 88
"ME" BIT #	1 --- 5	6 --------- 8	9	10 ------- 13	14	15 --- 24	25	26 --- 35	36	37	38 -- 46	47	48 -- 51	52 -- 53	54 ----- 56
FIELD NAME	TYPE [5]	SUBTYPE [3]	IMF [1]	Reserved [4]	E/W Direction Bit [1]	E/W Velocity [10]	N/S Direction Bit [1]	N/S Velocity [10]	**Reserved [1]**	Vert. Rate Sign [1]	Vert. Rate [9]	NIC [1]	NAC [4]	SIL [2]	**Reserved [3]**
	MSB LSB	MSB LSB		MSB LSB		MSB LSB		MSB LSB			MSB LSB		MSB LSB	MSB LSB	MSB LSB

Note: *"[#]" provided in the Field Name column indicates the number of bits in the specific field.*

Figure 2.2.17.3.4: TIS-B Airborne Velocity Information Message

2.2.17.3.4.1 Relationship to ADS-B Format

The following fields **shall** be coded as specified for the ADS-B Airborne Velocity Message with Subtype equal to ONE (1), as specified in §2.2.3.2.6.1, or Subtype equal 2, as specified in §2.2.3.2.6.2:

Type Code	Subtype Code
E/W Direction Bit	E/W Velocity
N/S Direction Bit	N/S Velocity
Vertical Rate Sign	Vertical Rate

2.2.17.3.4.2 ICAO/Mode A Flag (IMF)

This one-bit (bit 9) field **shall** be set as specified in §2.2.17.3.1.2.

2.2.17.3.4.3 Navigation Integrity Code (NIC) Supplement

This one-bit (ME bit 47) field **shall** be used together with the Message Type Code to define the NIC value for the Airborne and Surface Position Messages.

Coding of the NIC Supplement field **shall** be as specified for the Operational Status Message in Table ***TBD***.

2.2.17.3.4.4 Navigation Accuracy Coding (NAC)

This four-bit (ME bits 48 through 51) field **shall** define the NAC value for the Airborne and Surface Position Messages.

Coding of the NAC field **shall** be as specified for the Operational Status Message in Table ***TBD***.

2.2.17.3.4.5 Surveillance Integrity Level (SIL)

This two-bit (ME bits 52 through 53) field **shall** define the SIL value for the Airborne and Surface Position Messages.

Coding of the SIL field **shall** be as specified for the Operational Status Message in Table ***TBD***.

2.2.17.3.5 TIS-B Coarse Position Message

TIS-B Coarse Position Message Format										
MSG BIT #	33	34 ------- 35	36 -----39	40 -- 51	52	53 --- 57	58 -- 63	64	65 ------ 76	77 ------ 88
"ME" BIT #	1	2 --------- 3	4 ------- 7	8 ---19	20	21 --- 25	26 -- 31	32	33 ------ 44	45 ------ 56
Field Name	IMF [1]	Surveillance Status [2]	Service Volume ID (SVID) [4]	Pressur e Altitude [12]	Ground Track Status [1]	Ground Track Angle [5]	Ground Speed [6]	CPR Format (F) [1]	CPR Encoded Latitude [12]	CPR Encoded Longitude [12]
		MSB LSB	MSB LSB	MSB LSB		MSB LSB	MSB LSB		MSB LSB	MSB LSB

Note: *"[#]" provided in the Field Name column indicates the number of bits in the specific field.*

Figure 2.2.17.3.5: TIS-B Coarse Position Message Format

2.2.17.3.5.1 ICAO/Mode A Flag (IMF)

This one-bit (bit 1) field **shall** be set as specified in §2.2.17.3.1.2.

2.2.17.3.5.2 Service Volume ID (SVID)

The 4-bit SVID field **shall** identify the TIS-B site that delivered the surveillance data.

Note: *In the case where TIS-B messages are being received from more than one TIS-B ground stations, the SVID can be used to select coarse messages from a single source. This will prevent the TIS-B track from wandering due to the different error biases associated with different sources.*

2.2.17.3.5.3 Pressure Altitude

This field **shall** be coded as specified in §2.2.3.2.3.4.1.

2.2.17.3.5.4 Ground Track Status

This one bit (ME bit 20) field **shall** define the validity of the Ground Track value. Coding for this field **shall** be as follows: 0=not valid and 1= valid.

2.2.17.3.5.5 Ground Track Angle

This 5-bit (ME bits 21 through 25) field **shall** define the direction (in degrees clockwise from true north) of aircraft motion. The Ground Track **shall** be encoded as an unsigned angular weighted binary numeral, with an MSB of 180 degrees and an LSB of 360/32 degrees, with ZERO (0) indicating true north. The data in the field **shall** be rounded to the nearest multiple of 360/32 degrees.

2.2.17.3.5.6 Ground Speed

This 6-bit (ME bits 26 through 31) field **shall** define the aircraft speed over the ground. Coding of this field **shall** be as shown in Table 2.2.17.3.5.6.

Table 2.2.17.3.5.6: Ground Speed Encoding

Coding (binary)	**Coding** (decimal)	**Meaning** (Ground Speed in knots)
00 0000	0	No Ground Speed information available
00 0001	1	Ground Speed < 16 knots
00 0010	2	16 knots ≤ GS < 48 knots
00 0011	3	48 knots ≤ GS < 80 knots
***	***	***
11 1110	62	1936 knots ≤ GS < 1968 knots
11 1111	63	GS ≥ 1968 knots

Notes:

1. *The encoding shown in the table represents Positive Magnitude data only.*

2. *Raw data used to establish the Ground Speed Subfield will normally have more resolution (i.e., more bits) than that required by the Ground Speed Subfield. When converting such data to the Ground Speed Subfield, the accuracy of the data **shall** be maintained such that it is not worse than +/- ½ LSB where the LSB is that of the Ground Speed subfield.*

2.2.17.3.5.7 Encoded Latitude

This field **shall** be encoded as specified in §2.2.3.2.3.7, except that the 12-bit CPR coding specified in ***TBD*** **shall** be used.

2.2.17.3.5.8 Encoded Longitude

This field **shall** be encoded as specified in s§2.2.3.2.3.8, except that the 12-bit CPR coding specified in ***TBD*** **shall** be used.

2.2.17.3.6 Reserved for TIS-B Management Messages

TBD

2.2.17.4 TIS-B Message Processing and Report Generation

The information received in TIS-B Messages is reported directly to applications, with one exception. The exception is latitude-longitude position information, which is CPR-encoded when it is received, and must be decoded before reporting. In order to accomplish CPR decoding, it is necessary to track received messages, so that even-format and odd-format messages can be combined to determine the latitude and longitude of the target.

In the most common case, a particular target will result in TIS-B Message receptions or ADS-B Message receptions, but not both. It is possible, however, for both types of messages to be received for a single target. Therefore TIS-B Messages are compared with tracks of previous TIS-B receptions and tracks of ADS-B receptions. The tracking structure within ADS-B can either use separate tracking of TIS-B receptions and ADS-B receptions or combined tracking of the two types of receptions.

2.2.17.4.1 TIS-B Message-to-Track Correlation

Tracking makes it possible to associate a received message with information previously received about that same target, in the presence of many other intervening messages about other targets. As TIS-B Position Messages are received, they are compared with existing tracks. If a received TIS-B Message correlates with an existing track, the message is decoded (§2.2.17.4.2), the track is updated (§2.2.17.4.3), and a report is generated (§2.2.17.6). If the new message does not correlate, it is used in new-track initiation (§2.2.17.4.4).

2.2.17.4.1.1 TIS-B Messages Having a 24-Bit Address

For a target that has a 24-bit address, that address is used for correlating new receptions with information in the track file. Correlation is successful if the address matches exactly. If the 24-bit address in a received message is either all ZEROs or all ONEs, it is considered to be illegal, and the message **shall** be discarded. Otherwise, when a TIS-B Position Message having a 24-bit address is received, and an existing TIS-B track has the same address, the message **shall** be correlated with the track. When a TIS-B Message having a 24-bit address is received, and an existing ADS-B track has the same address, the message **shall** be correlated with the track.

2.2.17.4.1.2 TIS-B Messages Having Mode A Code and Track Number

For a target not identified by a 24-bit address, but instead having a Mode A code and a TIS-B track number, then these are used to correlate with information in the track file.

Correlation is successful if the Mode A code and the track number both match exactly. When a TIS-B Message having a Mode A code and TIS-B track number is received, and an existing TIS-B track has the same Mode A code and ADS-B track number, the message **shall** be correlated with the track.

2.2.17.4.2 TIS-B Position Message Decoding

When a received TIS-B Position Message correlates to an existing track, the message and the track are used together to decode the latitude and longitude of the target. If the track is "Complete," meaning that a global decode has been accomplished, then the new latitude-longitude information **shall** be decoded using local decoding, as specified in §A.1.7.4 in Appendix A, taking the previous position of the target as the reference.

If the track is Incomplete, meaning that a global decode has not yet been accomplished prior to this reception, then a global decode may be computed depending on the contents of the track. If the information in the track together with the new position message consist of at least one even format message and at least one odd format message received within 10 seconds, then a global decode **shall** be computed as specified in §A.1.7.7 of Appendix A. Otherwise the received encoded position, the even/odd format, and the time of applicability, **shall** be saved in the track file for later use.

For ADS-B tracks, as illustrated in Figure 2-16b, a track is Complete if it is in the Track State or is in the Acquisition State. Otherwise the track is Incomplete.

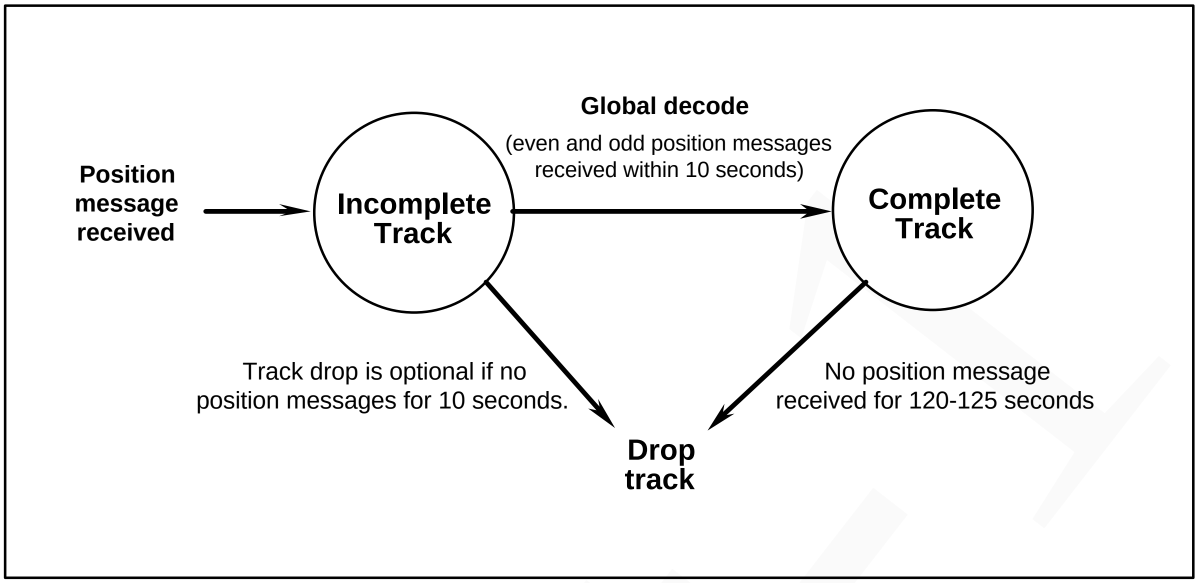
Note: *When decoding positions, a reasonableness test may be applied.*

2.2.17.4.3 TIS-B Track Update

When a position message is correlated to a TIS-B track that is Complete, then a new position is computed as specified in §2.2.17.4.2 and the tracked position **shall** be updated with the new position and time of applicability. The previous position and time need not be saved. Figure 2.2.17.4.3 illustrates the transition from Incomplete track to Complete track and later track drop.

When a position message is correlated with a TIS-B track that is Incomplete, the new information may make it possible for a global decode, as specified in §2.2.17.4.2. If a global decode is accomplished, the track **shall** be promoted to Complete, and the latitude, longitude, and time of applicability **shall** be saved in the track. The previous position and time information need not be saved. If a global decode is not accomplished, the even and odd encoded positions **shall** be saved for future decodes.

Note: *It is not necessary to save any encoded positions longer than 10 seconds.*



<u>Figure 2.2.17.4.3:</u> TIS-B Tracks

2.2.17.4.4 TIS-B Track Initiation

A TIS-B track begins with the reception of one position message. A new Incomplete track **shall** be created, and the encoded position, even/odd format bit, and time of applicability **shall** be saved.

2.2.17.4.5 TIS-B Track Drop

A TIS-B track that is Complete **shall** not be dropped within 120 seconds after any TIS-B Position Message reception. If 125 seconds elapses without any TIS-B Message reception, the track **shall** be dropped.

<u>Note:</u> *As specified in §2.2.17.4.3, for an Incomplete TIS-B track, it is not necessary to save any information more than 10 second after reception. Therefore the track can be dropped after 10 seconds.*

2.2.17.4.6 TIS-B Report Generation

As TIS-B Messages are received, the information is reported to applications. All received information elements, other than position, **shall** be reported directly. The reporting format is not specified in detail, except that the information content reported **shall** be the same as the information content received. The report **shall** be issued within 0.5 seconds of the message reception.

When a TIS-B Position Message is received, it is compared with tracks to determine whether it can be decoded into target position, as specified in §2.2.17.4.2. If the message is decoded into target position, a state vector report **shall** be generated, within 0.5 seconds of the message reception. The report **shall** contain the latitude, longitude, altitude, estimated velocity, address, time of applicability, and all other information in the received message. The estimated velocity **shall** include north-south velocity, east-west velocity, and altitude rate. These rates **shall** be estimated based on the received position information and the track history of this target.

When a TIS-B Velocity Message is received, if it is correlated to a complete track, then a state vector report **shall** be generated, within 0.5 seconds of the message reception. The report **shall** contain the received velocity information, estimated position, address, time of applicability, and all other information in the received message. The estimated position **shall** include latitude, longitude, and altitude. These values **shall** be estimated based on the received velocity information and the track history of this target.

Note: *In the absence of TIS-B Message receptions, it is possible for reports to be generated, but this is not required. Such additional reports might be useful as a means of counteracting possible flaws in an on-board data bus between ADS-B and an application.*

2.3 Equipment Performance - Environmental Conditions

The environmental tests and performance requirements described in this subsection provide a laboratory means of determining the overall performance characteristics of the equipment under conditions representative of those that may be encountered in actual aeronautical operations.

Some of the environmental tests contained in this subsection need not be performed unless the manufacturer wishes to qualify the equipment for that particular environmental condition. These tests are identified by the phrase "When Required." If the manufacturer wishes to qualify the equipment to these additional environmental conditions, then these "when required" tests **shall** be performed.

The test procedures applicable to a determination of equipment performance under environmental test conditions are contained in RTCA Document No. DO-160D (EUROCAE ED-14D), Environmental Conditions and Test Procedures for Airborne Equipment, July 1997.

Some of the performance requirements in Subsections 2.1 and 2.2 are not tested by test procedures herein. Moreover, not all tests are required to be done at each of the environmental conditions in RTCA/DO-160D (EUROCAE ED-14D). Judgment and experience have indicated that these particular performance parameters are not susceptible to certain environmental conditions and that the level of performance specified in Subsections 2.1 and 2.2 will not be measurably degraded by exposure to these environmental conditions.

The specified performance tests cover all classes of ADS-B Transmitting and Receiving subsystems. Only those tests that are applicable to the class of equipment being qualified need be performed. Additional tests may have to be performed in order to determine performance of particular design requirements that are not specified in this document. It is the responsibility of the manufacturer to determine appropriate tests for these functions.

Specific ADS-B Transmitting and Receiving subsystem performance tests have been included in this section for use in conjunction with the environmental procedures of DO-160D (EUROCAE ED-14D). These tests have been chosen as a subset of the ADS-B Transmitting and Receiving subsystem performance tests provided in subsection 2.4. Normally, a MOPS document does not provide specific equipment performance tests to be used in conjunction with the environmental procedures of RTCA/DO-160D (EUROCAE ED-14D). However, there is a sufficiently large number of ADS-B Transmitting and Receiving subsystem performance tests in subsection 2.4 that it would be impractical to repeat all of those tests in conjunction with all of the appropriate environmental procedures.

2.3.1 Environmental Test Conditions

Table 2-77 lists all of the environmental conditions and test procedures (hereafter referred to as environmental procedures) that are documented in RTCA/DO-160D (EUROCAE ED-14D). Table 2-78 lists the sets of ADS-B Transmitting and Receiving subsystem performance tests that are specified in detail in this section and which are intended to be run subject to the various environmental procedures of RTCA/DO-160D (EUROCAE ED-

14D). In order to simplify the process of relating the environmental procedures to the ADS-B equipment performance tests, Table 2-77 divides the environmental procedures into groups. All of the procedures in a given group are carried out in conjunction with the same set of ADS-B Transmitting and Receiving subsystem performance tests. Using this approach, the environmental procedures fall into five groups. The environmental procedures that apply to all of the sets of ADS-B Transmitting and Receiving subsystem tests fall into group 1. Group 2 procedures apply to 9 of the sets of ADS-B Transmitting and Receiving Subsystem performance tests. Group 3 procedures apply to 6 of the sets of ADS-B Transmitting and Receiving Subsystem performance tests. Group 4 procedures apply to one set of the performance tests. Group 5, which applies to none of the ADS-B Transmitting and Receiving Subsystem performance tests, includes only environmental procedures that are intended to determine the effect of the ADS-B Transmitting and/or Receiving subsystem on rack mounting hardware, compass needles, explosive gases, and other RF hardware.

Table 2-78 indicates which of the groups of environmental procedures is related to each set of ADS-B Transmitting and/or Receiving subsystem performance tests. Each ADS-B Transmitting and/or Receiving subsystem performance test **shall** be validated under all of the environmental procedures in the groups required for that test as indicated in Table 2-78.

Table 2-77: Environmental Test Groups

TEST #	ENVIRONMENTAL CONDITION	RTCA DO-160D Paragraph	EUROCAE ED-14D Paragraph	GROUPS	REMARKS
4a	Temperature	4.5	4.4 – 4.5	1	
4b	Altitude	4.6.1	4.6.1	3	
4c	Decompression & Overpressure	4.6.2 - 4.6.3	4.6.2 - 4.6.3	3	
5	Temperature Variation	5.0	5.0	3	
6	Humidity	6.0	6.0	2	
7a	Operational Shock	7.2	7.1	2	
7b	Crash Safety	7.3	7.2	5	NO TESTS
8	Vibration	8.0	8.0	3 & 1	3 during: 1 after
9	Explosion	9.0	9.0	5	NO TESTS
10	Waterproofness	10.0	10.0	2	
11	Fluids Susceptibility	11.0	11.0	2	
12	Sand and Dust	12.0	12.0	2	
13	Fungus Resistance	13.0	13.0	2	
14	Salt Spray	14.0	14.0	2	
15	Magnetic Effect	15.0	15.0	5	NO TESTS
16	Power Input Momentary Interruptions All Others	16.0	16.0	4 3 & 2	3 during: 2 after
17	Voltage Spike	17.0	17.0	2	
18	Audio Frequency Conducted Susceptibility	18.0	18.0	1	
19	Induced Signal Susceptibility	19.0	19.0	1	
20	RF Susceptibility	20.0	20.0	1	
21	Emission of RF Energy	21.1	21.1	5	NO TESTS
22	Lightning Induced Transient Susceptibility	22.0	22.0	3	
23	Lightning Direct Effects	23.0	23.0	3	
24	Icing	24.0	24.0	2	
25	Electrostatic Discharge	25.0	25.0		NO TESTS

Note: *Tests in Group 5 determine the effects of the ADS-B equipment on other equipment (mounts, compass needles, explosive gases, and other RF equipment) and therefore do not involve the ADS-B equipment performance requirements of this document.*

Table 2-78: Performance Test Requirements During Environmental Tests

Test Procedure Paragraph	DESCRIPTION	Required Environmental Test Groups (See Table 2-77)				
		1	2	3	4	5
§2.3.2.1	Transponder Based Transponders	X	X	X		
§2.3.2.2	Stand Alone (non-Transponder)based Transmitters	NT	NT	NT	NT	NT
§2.3.2.2.1	Frequency	X	X	X		
§2.3.2.2.2	Pulse Shapes	X				
§2.3.2.2.3	Pulse Interval	X				
§2.3.2.2.4	Preamble	X				
§2.3.2.2.5	Data Pulses	X		X		
§2.3.2.2.6	RF Peak Output Power	NT	NT	NT	NT	NT
§2.3.2.2.6.1	Class A0 Equipment RF Peak Output Power	X	X			
§2.3.2.2.6.2	Class B Equipment RF Peak Output Power	X	X			
§2.3.2.2.7	Transmission Rates for Transponder - Based Transmitters	NT	NT	NT	NT	NT
§2.3.2.2.7.1	Transmission Rates Compliant with RTCA/DO-181C	X	X			
§2.3.2.2.7.2	Transmission Rates not specified in RTCA/DO-181C	X	X			
§2.3.2.2.7.3	Maximum Transmission Rates for Transponder - Based Transmitters	X	X			
§2.3.2.2.8	Transmission Rates for Stand-Alone Transmitters	X	X			
§2.3.2.2.8.1	Power-On Initialization	X	X			
§2.3.2.2.8.2	ADS-B Airborne Position Message Broadcast Rate	X				
§2.3.2.2.8.3	ADS-B Surface Position Message Broadcast Rate	X				
§2.3.2.2.8.4	ADS-B Aircraft Identification and Type Message Broadcast Rate	X				
§2.3.2.2.8.5	ADS-B Velocity Information Message Broadcast Rate	X				
§2.3.2.2.8.6	ADS-B Aircraft Trajectory Intent Message Broadcast Rates	X				
§2.3.2.2.8.7	ADS-B Aircraft Operational Coordination Message Broadcast Rates	X				
§2.3.2.2.8.8	ADS-B Aircraft Operational Status Message Broadcast Rates	X				
§2.3.2.2.8.9	"Extended Squitter Aircraft Status" ADS-B Event-Driven Message Broadcast Rate	X				
§2.3.2.2.8.10	"Type 23 (TEST)" ADS-B Event-Driven Message Broadcast Rate	X				
§2.3.2.2.8.11	Maximum ADS-B Message Transmission Rates	X				
§2.3.2.3	Receivers Shared with a TCAS Unit	X	X	X		
§2.3.2.3.1	TCAS Compatibility	X				
§2.3.2.3.2	Re-Triggerable Reply Processor	X	X			
§2.3.2.4	Stand Alone Receivers	NT	NT	NT	NT	NT
§2.3.2.4.1	In-Band Acceptance	X	X	X		
§2.3.2.4.2	Dynamic Range	X	X	X		
§2.3.2.4.3	Re-Triggerable Capability	X	X			
§2.3.2.4.4	Out-of-Band Rejection	X	X			
§2.3.2.4.5	Dynamic Minimum Trigger Level	X	X			
§2.3.2.4.6	Criteria for ADS-B Message Transmission Pulse Detection	X				
§2.3.2.4.7	Criteria for Data Block Acceptance in ADS-B Message Signals	X				
§2.3.2.4.8	Track File Maintenance	X	X	X		
§2.3.2.5	Self Test and Monitors	NT	NT	NT	NT	NT
§2.3.2.5.1	Transponder Based Equipment Address	X	X	X	X	
§2.3.2.5.2	Non-Transponder Based Equipment	X	X	X	X	
§2.3.2.6	Response to Mutual Suppression	NT	NT	NT	NT	NT
§2.3.2.6.1	Transmitting Device Response to Mutual Suppression Pulses	X				
§2.3.2.6.2	Receiving Device Response to Mutual Suppression Pulses	X				
§2.3.2.7.2	Receiving Diversity	NT	NT	NT	NT	NT

Table 2-78: Performance Test Requirements During Environmental Tests (continued)

Test Procedure Paragraph	DESCRIPTION	Required Environmental Test Groups (See Table 2-77)				
		1	**2**	**3**	**4**	**5**
§2.3.2.7.2.1	Full Receiver and Message Processing or Receiver Switching Front-End Diversity	X	X			
§2.3.2.7.2.2	Receiving Antenna Switching Diversity	X	X			
§2.3.2.8	Power Interruption	NT	NT	NT	NT	NT
§2.3.2.8.1	Power Interruption to ADS-B Transmitting Functions	X			X	
§2.3.2.8.2	Power Interruption to ADS-B Receiving Functions	X			X	

Note: *"NT" in the above table means "NO TEST."*

2.3.2 Detailed Environmental Test Procedures

The test procedures set forth below are considered satisfactory for use in determining equipment performance under environmental conditions. Although specific test procedures are cited, it is recognized that other methods may be preferred. These alternative procedures may be used if the manufacturer can show that they provide at least equivalent information. In such cases, the procedures cited herein should be used as one criterion in evaluating the acceptability of the alternative procedures. The ADS-B Transmitting and Receiving subsystem performance tests do not include specific pass/fail criteria. It is intended that those criteria be obtained from the ADS-B Transmitting and Receiving performance requirements provided in subsection 2.2.

2.3.2.1 Transponder Based Transmitters (§2.2.2.1)

Transponder based transmitters **shall** be tested to comply with the requirements of RTCA Document No. DO-181C, §2.3.2.2 inclusive (EUROCAE ED-73A, chapter 4).

2.3.2.2 Stand Alone (non-Transponder) based Transmitters (§2.2.2.2)

No specific test procedure is required to validate §2.2.2.2.

2.3.2.2.1 Frequency (§2.2.2.2.1)

Equipment Required:

Provide equipment capable of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test through the operational interface.

Stub Tuner (Microlab/FXR Sl-05N, or equivalent).

Variable Air Line (Line Stretcher) (Microlab/FKR SR-05N, or equivalent).

Slotted Line (HP 805C, or equivalent).

Measurement Procedure:

Determine the transmission frequency

Load valid data into the ADS-B Airborne Position format and ensure that the expected ADS-B transmissions occur. Adjust the stub to establish a l.5:l VSWR at the antenna end of the coax line specified by the manufacturer. If the ADS-B transmitter requires a minimum length of a specified cable type, an attenuator equal to the loss of the minimum amount of cable may be placed between the 1.5:1 VSWR point and the equipment antenna jack. Alternately, a length of cable equal to the specified minimum length and cable type may be used in lieu of the attenuator. Adjust the line stretcher for maximum transmitter frequency shift above and below 1090 MHz. Determine that the frequency shift does not exceed the requirements of §2.2.2.2.1.

2.3.2.2.2 Pulse Shapes (§2.2.2.2.4)

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test. Provide a method of detecting the RF pulses of the ADS-B broadcast message for display on an oscilloscope.

Wide Band Dual Channel Oscilloscope (HP 1710B, or equivalent).

Measurement Procedure:

Step 1: ADS-B Message Pulse Amplitude Variation (§2.2.3.1.3.a)

Load valid data into the ADS-B Airborne Position Message and verify that the messages are being transmitted by the equipment under test. Measure the maximum power differential between pulses in ADS-B broadcast messages. Verify that it is within the tolerance specified in §2.2.3.1.3.a.

Step 2: ADS-B Message Pulse Shape (§2.2.3.1.3.b and c)

Load valid data into the ADS-B Airborne Position Message and verify that the messages are being transmitted by the equipment under test. Measure the rise and decay time of the ADS-B broadcast message pulses. Verify that they are within the tolerances specified in §2.2.3.1.3.b and c.

Note: *Pulse Rise Time is measured as the time interval between 10 percent and 90 percent of peak amplitude on the leading edge of the pulse. Pulse Decay Time is measured as the time interval between 90 percent and 10 percent of peak amplitude on the tailing edge of the pulse. See "Caution" statement below.*

CAUTION*: If the detector is not known to be linear, checks should be made to determine what amplitude points on the detected pulse correspond to the 10 percent and 90 percent amplitude points of the RF pulses. In addition, checks should be made to determine the rise and decay time of the detector.*

2.3.2.2.3 Pulse Interval (§2.2.2.2.6)

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test. Provide a method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope. Wide Band Dual Channel Oscilloscope (HP 1710B, or equivalent).

Measurement Procedure:

ADS-B Message Pulse Spacing Tolerance (§2.2.3.1.4)

Load valid data into the ADS-B Airborne Position Message and verify that the messages are being output. Determine that the leading edge of any reply pulse is within 50 nanoseconds of its assigned position.

Note: *Interval measurements are measured between half voltage points of the respective pulses as detected by a linear detector. If the detector is not known to be linear, a check should be made to determine the half voltage points.*

2.3.2.2.4 Preamble (§2.2.2.2.7)

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test. Provide a method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope.

Wide Band Dual Channel Oscilloscope (HP 1710B, or equivalent).

Measurement Procedure:

Determine Preamble Pulse Spacing

Load valid data into the ADS-B Airborne Position Message and verify that the messages are being transmitted by the equipment under test. Display the ADS-B Messages on the oscilloscope. Measure the pulse duration of the first four message pulses. Measure the pulse spacing between the leading edge of the first and each of the second, third, and fourth pulses. Determine that the spacing of the pulses is within the tolerances specified in §2.2.3.1.1.

Note: *Interval measurements are measured between half voltage points of the respective pulses as detected by a linear detector. If the detector is not known to be linear, a check should be made to determine the half voltage points.*

2.3.2.2.5 Data Pulses (§2.2.2.2.8)

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test. Provide a method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope.

Wide Band Dual Channel Oscilloscope (HP 1710B, or equivalent).

Measurement Procedure:

Determine Message Data Pulse Width and Duration

Note 1: *For tests in this section, unless otherwise specified, examine pulses at the beginning, middle and end of the ADS-B broadcast messages.*

Load valid data into the ADS-B Airborne Position Message and verify that the messages are being transmitted by the equipment under test. Measure the pulse duration of the pulses transmitted in the ADS-B Message throughout the message transmission. Determine that the duration of the pulses is within the tolerance specified in §2.2.3.1.2.

Measure the pulse spacing of the fifth reply pulse with reference to the first reply pulse. Determine that the pulse spacing is within the tolerance specified in §2.2.3.1.2.

Note 2: *Interval measurements are measured between half voltage points of the respective pulses as detected by a linear detector. If the detector is not known to be linear, a check should be made to determine the half voltage points.*

2.3.2.2.6 RF Peak Output Power (§2.2.2.2.10)

No specific test procedure is required to validate §2.2.2.2.10.

2.3.2.2.6.1 Class A0 Equipment RF Peak Output Power (§2.2.2.2.10.1)

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.

Wide Band Dual Channel Oscilloscope (HP l7l0B, or equivalent).

Measurement Procedure:

Load valid data into the ADS-B Airborne Position format and ensure that the expected ADS-B transmissions occur. Measure the single pulse having the maximum RF power output. Determine that the maximum power output meets the requirements of §2.2.2.2.10.1.

2.3.2.2.6.2 Class B Equipment RF Peak Output Power (§2.2.2.2.10.2)

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.

Wide Band Dual Channel Oscilloscope (HP l7l0B, or equivalent).

Measurement Procedure:

Load valid data into the ADS-B Airborne Position format and ensure that the expected ADS-B transmissions occur. Measure the single pulse having the maximum RF power output. Determine that the maximum power output meets the requirements of §2.2.2.2.10.2.

2.3.2.2.7 Transmission Rates for Transponder - Based Transmitters (§2.2.3.3.1)

No specific test procedure is required to validate §2.2.3.3.1.

2.3.2.2.7.1 Transmission Rates Compliant with RTCA Document No. DO-181C (§2.2.3.3.1.1)

Performance of ADS-B transmitters based on Mode S transponders **shall** validate Message Update Rates in accordance with RTCA Document No. DO-181C §2.5.4.6.2, for each class of transponder defined in FAA TSO-C112.

2.3.2.2.7.2 Transmission Rates that are not specified in RTCA Document No. DO-181C (§2.2.3.3.1.2) (EUROCAE ED-73A, §3.21.2.6.3)

When the transmission rate of a particular message type is not specified or is not tested in RTCA Document No. DO-181C (EUROCAE ED-73A), then the Mode S transponder based ADS-B transmitters **shall** verify the message delivery performance for those messages in accordance with §2.3.2.2.8 through §2.3.2.2.8.11 of this document for Stand - Alone Transmitters. If there is conflict between the requirements of RTCA/DO-181C and this document, then the requirements of RTCA/DO-181C (EUROCAE ED-73A) **shall** be adhered to.

2.3.2.2.7.3 Maximum Transmission Rates for Transponder - Based Transmitters (§2.2.3.3.1.3)

Performance of ADS-B transmitters based on Mode S transponders **shall** validate maximum transmission rates in accordance with RTCA Document No. DO-181C (EUROCAE ED-73A), for each class of transponder defined in FAA TSO-C112.

When the maximum transmission rate of a particular message type is not specified or is not tested in RTCA Document No. DO-181C (EUROCAE ED-73A), then the Mode S transponder based ADS-B transmitters **shall** verify the maximum message delivery rate in accordance with §2.3.2.2.8.11 of this document for Stand-Alone transmitters. If there is conflict between the requirements of RTCA/DO-181C (EUROCAE ED-73A) and this document, then the requirements of RTCA/DO-181C (EUROCAE ED-73A) **shall** be adhered to.

2.3.2.2.8 Transmission Rates for Stand - Alone Transmitters (§2.2.3.3.1.4)

<u>Purpose/Introduction:</u>

a. Transmitters for Class A0 and Class B equipment may be implemented independent of a Mode S transponder. Such transmitters **shall** meet the transmission rate requirements of §2.2.3.3.1.3 and the message update rate requirements specified in the following subparagraphs.

b. Add a quantization interval for the transmitted message jitter of 15 milliseconds or less.

Equipment Required:

Provide a method of loading valid data for the generation of ADS-B Airborne Position, Surface Position, Aircraft Identification and Type, Airborne Velocity, Intent, Operational Coordination, and Operational Status broadcast messages into the ADS-B Transmitting function under test.

Provide a method of recording and time stamping all ADS-B Broadcast messages transmitted by the ADS-B Transmitting function under test with the time stamping quantization being 15 milliseconds or less.

Measurement Procedure:

Step 1: ADS-B Message Broadcast Setup

Provide the ADS-B Transmitting function under test with all valid necessary data for the generation of ADS-B Airborne Position, Aircraft Identification and Type, Airborne Velocity, Intent, Operational Coordination, and Operational Status broadcast messages.

Verify that the ADS-B Transmitting function is broadcasting ADS-B Messages.

Step 2: ADS-B Message Recording and Time Stamping

Record and time stamp all ADS-B Messages that are broadcast by the ADS-B Transmitting function for a period of not less than 5 minutes.

Step 3: Distribution Checks

For each of the ADS-B Airborne Position, Aircraft Identification and Type, Airborne Velocity, Intent, Operational Coordination, and Operational Status message types transmitted, verify that the messages are distributed over the specified range of transmission intervals for each particular message type.

Step 4: Interval Quantization Checks

For each of the ADS-B Airborne Position, Aircraft Identification and Type, Airborne Velocity, Intent, Operational Coordination, and Operational Status message types transmitted, verify that the messages were distributed with the jitter spacing being 15 milliseconds or less between messages of equivalent type.

2.3.2.2.8.1 Power-On Initialization (§2.2.3.3.2.1.1)

Equipment Required

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.

Provide a method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope.

Provide a Wide Band Dual Channel Oscilloscope (HP 1710B, or equivalent).

Measurement Procedure

Step 1: No Data Available (§2.2.3.3.2.1.1.a)

Ensure that no appropriate valid message data are available for any of the possible ADS-B broadcast messages. Power up the equipment. Verify that no transmissions occur.

Step 2: Valid Data available (§2.2.3.3.2.1.1.b)

For each ADS-B Position and Velocity message type in turn, ensure that appropriate valid ADS-B Message data are available for that message type only. Power up the equipment. Verify that the correct ADS-B broadcast message is transmitted starting no later than 2.0 seconds after Power-On.

2.3.2.2.8.2 ADS-B Airborne Position Message Broadcast Rate (§2.2.3.3.2.2)

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.

Provide a method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope, or equivalent method of observing the message content.

Measurement Procedure:

Ensure that the equipment is set to the “Airborne” condition and that the appropriate valid ADS-B Airborne Position data is available. Verify that the ADS-B Airborne Position message is broadcast at intervals that are distributed over the range of 0.4 to 0.6 seconds as specified in §2.2.3.3.2.2.

2.3.2.2.8.3 ADS-B Surface Position Message Broadcast Rate (§2.2.3.3.2.3)

Equipment Required:

Provide a method of loading valid data for broadcasting ADS-B Messages into the ADS-B equipment under test.

Provide a method of monitoring the transmitted ADS-B Messages and measuring the rate at which they are output.

Measurement Procedure:

Step 1: Switching from High Rate to Low Rate (§2.2.3.3.2.3.a(1) and c)

Ensure that the equipment is set to the “On the Ground” condition and that the appropriate valid ADS-B Surface Position data is provided such that the position is changing at a rate of 10.1 meters in a 30 second sampling interval. At least 61 seconds after the start of the data input, verify that the ADS-B

Surface Position message is broadcast at intervals that are distributed over the range of 0.4 to 0.6 seconds as specified in §2.2.3.3.2.3.b.

Input new ADS-B Surface Position data with the position data changing at a rate of 9.9 meters in a 30 second sampling interval. At least 61 seconds after the inputting of the new data, verify that the ADS-B Surface Position Message is broadcast at intervals that are distributed over the range of 4.8 to 5.2 seconds as specified in §2.2.3.3.2.3.c.

Step 2: Switching from Low Rate to High Rate (§2.2.3.3.2.3.a(2) and c)

Ensure that the equipment is set to the "On the Ground" condition and that the appropriate valid ADS-B Surface Position data is provided such that the position is stationary. At least 61 seconds after establishing the data, verify that the ADS-B Surface Position Messages are broadcast at intervals that are distributed over the range of 4.8 to 5.2 seconds as specified in 2.2.3.3.2.3.c.

Input new ADS-B Surface Position data such that the position is stationary and 10.1 meters away from the position above. One (1) second after inputting the new data, verify that the ADS-B Surface Position Messages are broadcast at intervals that are distributed over the range of 0.4 to 0.6 seconds as specified in §2.2.3.3.2.3.b. Also verify that at least 61 seconds after establishing the new data that the ADS-B Surface Position Message is broadcast at intervals that are distributed over the range 4.8 to 5.2 seconds as specified in §2.2.3.3.2.3.c.

2.3.2.2.8.4 ADS-B Aircraft Identification and Type Message Broadcast Rate (§2.2.3.3.2.4)

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.

Provide a method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope.

Measurement Procedure:

Step 1: Airborne (§2.2.3.3.2.4.a)

Ensure that the equipment is set to the "Airborne" condition and that the appropriate valid ADS-B Aircraft Identification and Type data is available. Verify that the ADS-B Aircraft Identification and Type message is broadcast at intervals that are distributed over the range of 4.8 to 5.2 seconds as specified in §2.2.3.3.2.4.a.

Step 2: On the Ground (§2.2.3.3.2.4.b)

Ensure that the equipment is set to the "On the Ground" condition and that the appropriate valid ADS-B Aircraft Identification and Type data is available. Verify that the ADS-B Aircraft Identification and Type message is broadcast at intervals that are distributed over the range of 9.8 to 10.2 seconds as specified in §2.2.3.3.2.4.b.

2.3.2.2.8.5 ADS-B Velocity Information Message Broadcast Rate (§2.2.3.3.2.5)

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.

Provide a method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope.

Measurement Procedure:

Ensure that the appropriate valid ADS-B Velocity Information data is available. Verify that the ADS-B Velocity Information message is broadcast at intervals that are distributed over the range of 0.4 to 0.6 seconds as specified in §2.2.3.3.2.5.a.

2.3.2.2.8.6 ADS-B Aircraft Trajectory Intent Message Broadcast Rates (§2.2.3.3.2.6.1)

Equipment Required:

Provide a Method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.

Provide a method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope.

Measurement Procedure:

Ensure that no Trajectory Intent data is available. Verify that no Trajectory intent message is output for a period of 20 seconds. Inject the appropriate valid ADS-B Trajectory Intent data and verify that the ADS-B Trajectory Intent message is broadcast at intervals that are distributed over the range of 1.6 to 1.8 seconds as specified in §2.2.3.3.2.6.1.b for as long and data is available.

Repeat the procedure for each Trajectory Intent message independently as necessary.

2.3.2.2.8.7 ADS-B Aircraft Operational Coordination Message Broadcast Rates (§Error! Reference source not found.**)**

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.

Provide a method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope.

Measurement Procedure:

Step 1: Initialization (§**Error! Reference source not found.**.a and b)

Ensure that no Aircraft Operational Coordination data is available. Verify that no Operational Coordination message is output for a period of 20 seconds.

Inject the appropriate valid ADS-B Operational Coordination data. Verify that the ADS-B Aircraft Operational Coordination message is broadcast at intervals that are distributed over the range of 1.9 to 2.1 seconds as specified in §**Error! Reference source not found.**.b for a period of 30 +/- 1 seconds.

Step 2: Steady State (§**Error! Reference source not found.**.c)

Initialize the equipment as in Step 1 above and when a time of 19 seconds has elapsed, verify that the ADS-B Aircraft Operational Coordination message is broadcast at intervals that are distributed over the range of 4.8 to 5.2 seconds as specified in §2.2.3.3.2.6.1.c.

2.3.2.2.8.8 ADS-B Aircraft Operational Status Message Broadcast Rates (§2.2.3.3.2.6.2)

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.

Provide a method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope.

Measurement Procedure:

Ensure that no Aircraft Operational Status data is available. Verify that no Aircraft Operational Status message is output for a period of 20 seconds. Inject the appropriate valid ADS-B Aircraft Operational Status data. Verify that the ADS-B Aircraft Operational Status message is broadcast at intervals that are distributed over the range of 1.6 to 1.8 seconds as specified in §2.2.3.3.2.6.2.b for a period of 30 +/- 1 seconds.

2.3.2.2.8.9 "Extended Squitter Aircraft Status" ADS-B Event - Driven Message Broadcast Rate (§2.2.3.3.2.6.3)

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.

Provide a method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope.

Measurement Procedure:

Establish the emergency condition in accordance with Appendix A., Figure A.8-9, Note 2. Verify that the Emergency/Status Event Driven Message (Type-28, Subtype=1) is broadcast at intervals that are distributed over the range of 0.8 to 1.2 seconds. Clear the established emergency condition and verify that NO Emergency/Status Event Driven Messages are broadcast.

2.3.2.2.8.10 "TYPE 23 (TEST)" ADS-B Event - Driven Message Broadcast Rate (§2.2.3.3.2.7)

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.

Provide a method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope.

Measurement Procedure:

Update the TEST ADS-B Event Driven message and verify that it is broadcast only once. Repeat 10 times.

2.3.2.2.8.11 Maximum ADS-B Message Transmission Rates (§2.2.3.3.2.10)

Equipment Required:

Provide equipment capable of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test through the operational interface.

Provide a method of monitoring ADS-B broadcast messages output by the equipment under test.

Provide a Wide Band Dual Channel Oscilloscope (HP l7l0B, or equivalent).

Measurement Procedure:

Step 1: Maximum Combined ADS-B Message Output rate (§2.2.3.3.2.10--Airborne

Set the Airborne condition and load valid data into all the ADS-B Broadcast messages that can be supported by the equipment under test at a rate ensuring maximum transmission rate. Also ensure that the data for all event driven messages changes at a rate requiring more than the permitted maximum output rate of two messages per second. Verify that each of the ADS-B Broadcast messages types are output at rates within the specified tolerance, that the Airborne Position Messages are being transmitted, and that only two event driven messages per second are transmitted. Also verify that the total combined rate is less than or equal to 6.2 messages per second.

During this test, also verify that the transmitted output power remains within the specified limits.

2.3.2.3 Receivers Shared with a TCAS Unit (§2.2.4.2)

ADS-B receivers implemented as part of a TCAS unit **shall** demonstrate compliance with Test Procedures specified in RTCA document No. DO-185A, TCAS MOPS, §2.4.2.1.2.

In addition to tests specified in RTCA document No. DO-185A, TCAS MOPS, §2.4.2.1.2, TCAS units operating with receivers that are more sensitive than the MTL requirements specified in RTCA document No. DO-185A, TCAS MOPS **shall** be submitted to the following test procedures provided through §2.3.2.4.7.

2.3.2.3.1 TCAS Compatibility (§2.2.4.2.1.1)

Purpose/Introduction:

This test verifies that no more than 10% of ADS-B Messages received at a level of −78 dBm or below **shall** be passed to the TCAS surveillance function.

Input:

Equipment:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz
Frequency	=	1090 MHz
Power	=	-78 dBm

Measurement Procedure:

The ADS-B receiver power levels specified in this procedure are relative to the loss at the RF message source end of the transmission line used to interface the RF message source to the UUT receiver input port. For each ADS-B equipage class, the specified power level **shall** be adjusted to compensate for the maximum line loss for which the UUT receiver has been designed. For example, if the line loss is 3 dB, then each of the RF message power levels specified in the test procedures **shall** be lowered by 3 dB.

Step 1: Apply ADS-B **Input** Message

Apply **Input** at the receiver input port.

Step 2: Verify ADS-B **Input** Message Reception

Verify that no more than 10% of all ADS-B Messages are passed on to the TCAS surveillance function.

Step 3: Repeat on all Applicable Receiver Input Ports

Repeat Steps 1 and 2 on all other applicable receiver RF input ports of the UUT.

2.3.2.3.2 Re-Triggerable Reply Processor (§2.2.4.2.2)

Purpose/Introduction:

The following procedures verify the capability of the TCAS shared ADS-B receiver to detect overlapping Mode-S replies or ADS-B Messages in the TCAS level range.

Inputs:

All Intruder Aircraft:

Frequency = 1090 MHz.
Altitude Rate = 0 FPM

Intruder Aircraft 1:

Equipage	=	Mode-S ADS-B
Squitter Power	=	-50 dBm
Altitude	=	8000 ft.
Range	=	2 nmi at T=0 sec.

Intruder Aircraft 2:

Equipage	=	Mode-S ADS-B
Squitter Power	=	-44 dBm
Altitude	=	8000 ft.
Range	=	Maintained such that the leading edge of the first preamble pulse from Intruder 2 occurs 12 +/- 1.0 µs later than the leading edge of the first preamble pulse from Intruder 1 throughout the scenario.

TCAS Aircraft:

Altitude	=	8000 ft.
Altitude Rate	=	0 FPM
Range	=	0 nmi
Sensitivity Level Selection	=	Automatic

ADS-B Message Format (Intruder 1):

All ADS-B Message transmissions **shall** have the following standard data field values:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address

Mode-S Squitter Format (Intruder 2):

All Mode-S squitter transmissions **shall** have the following standard data field values:

"DF"	=	11
"CA"	=	0
"AA"	=	Any discrete address

Conditions:

TCAS initialized and operating at T = 0 seconds. Intruders 1 and 2 **shall** each transmit squitters during the squitter listening period following each whisper-shout sequence and **shall** reply with a short special surveillance format (DF = 0) to each TCAS discrete interrogation.

Scenario Description:

Both Intruders are co-altitude with TCAS and each transmits squitters when TCAS is in squitter listening mode and replies to discrete interrogations from TCAS. Intruder 2 is overlapping the Intruder 1 reply window.

Measurement Procedure:

The receiver power levels specified in this procedure are relative to the loss at the RF message source end of the transmission line used to interface the RF message source to the UUT receiver input port. For each ADS-B equipage class, the specified power level **shall** be adjusted to compensate for the maximum line loss for which the UUT receiver has been designed. For example, if the line loss is 3 dB, then each of the RF message power levels specified in the test procedures **shall** be lowered by 3 dB.

Step 1: Apply ADS-B and Mode-S Input Messages

Apply the message inputs defined above to the receiver input port.

Verify that the TCAS receiver detects intruder #2.

Step 2: Repeat on all Applicable Receiver Input Ports

Repeat Steps 1 on all other applicable receiver RF input ports of the UUT.

Step 3: Vary Signal Power Levels

Repeat Steps 1 and 2 with the following additional squitter power levels:

a. Intruder Aircraft 1 – Squitter Power = -30 dBm

Intruder Aircraft 2 – Squitter Power = -24 dBm

b. Intruder Aircraft 1 – Squitter Power = MTL + 3 dB

Intruder Aircraft 2 – Squitter Power = MTL + 9 dB

Verify that the TCAS receiver detects Intruder Aircraft #2 for each case.

2.3.2.4 Receivers Not Shared With TCAS (§2.2.4.3)

No specific test procedure is required to validate §2.2.4.3.

2.3.2.4.1 In-Band Acceptance (§2.2.4.3.1.1.a)

Purpose/Introduction:

This test verifies the compliance of the ADS-B receiver with the sensitivity requirements specified for the particular ADS-B equipage class.

Input:

Equipment:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

“DF” = 17
“CA” = 0

"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-68 dBm

Measurement Procedure:

The ADS-B receiver power levels specified in this procedure are relative to the loss at the RF message source end of the transmission line used to interface the RF message source to the UUT receiver input port. For each ADS-B equipage class, the specified power level **shall** be adjusted to compensate for the maximum line loss for which the UUT receiver has been designed. For example, if the line loss is 3 dB, then each of the RF message power levels specified in the test procedures **shall** be lowered by 3 dB.

Step 1: Apply ADS-B Input Messages

Apply **Input** at the receiver input port.

Step 2: Establish UUT Receiver MTL

Decrease the input power level and determine the minimum RF signal level required to produce a 90 percent ADS-B Message reception rate by the UUT receiver.

This value plus the loss line value represents the measured MTL of the UUT ADS-B receiver.

Verify that the measured MTL is in compliance with the limits specified in §2.2.4.3.1.1.a for the UUT equipment class.

Step 3: Verify UUT Receiver MTL over the Operational Frequency Range

Vary the RF signal frequency over the range of 1089 to 1091 MHz and determine the variation in RF signal level required to produce 90 percent ADS-B Message reception rate by the UUT receiver.

Verify that the measured MTL continues to comply with the limits specified in §2.2.4.3.1.1.a for the UUT equipment class.

Step 4: Repeat on all Applicable Receiver Input Ports

Repeat Steps 1 through 3 on all other applicable receiver RF input ports of the UUT.

2.3.2.4.2 Dynamic Range (§2.2.4.3.1.1.b)

Purpose/Introduction:

This test verifies that the ADS-B receiver can detect and decode valid ADS-B Messages over the equipment's specified dynamic range.

Input:

Equipment:

Provide a method of providing the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-68 dBm

Measurement Procedure:

The ADS-B receiver power levels specified in this procedure are relative to the loss at the RF message source end of the transmission line used to interface the RF message source to the UUT receiver input port. For each ADS-B equipage class, the specified power level **shall** be adjusted to compensate for the maximum line loss for which the UUT receiver has been designed. For example, if the line loss is 3 dB, then each of the RF message power levels specified in the test procedures **shall** be lowered by 3 dB.

Step 1: Apply ADS-B Input Messages

Apply **Input** at the receiver input port.

Step 2: Establish UUT Receiver MTL

Decrease the input power level and determine the minimum RF signal level required to produce 90 percent ADS-B Message reception rate by the UUT receiver.

This value plus the loss line value represents the measured MTL of the UUT ADS-B receiver.

Step 3: Verify UUT Receiver Dynamic Range

Increase the input signal power level to MTL + 3 dB.

Verify that the receiver properly detects and decodes at least 99% of all ADS-B Messages received.

Increase the input signal power level in 10 dB steps up to a signal level of -21 dBm.

At each step, verify that the receiver properly detects and decodes at least 99% of all ADS-B Messages received.

Step 4: Repeat on all Applicable Receiver Input Ports

Repeat Steps 1 through 3 on all other applicable receiver RF input ports of the UUT.

2.3.2.4.3 Re-Triggerable Capability (§2.2.4.3.1.2)

Purpose/Introduction:

The following procedures verify the capability of the Stand alone ADS-B receiver to detect overlapping ADS-B broadcast messages.

Input:

Equipment:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-50 dBm

Followed by a second Valid Mode S Extended Squitter:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address different from the first one
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-44 dBm

Starting 12.0 +/- 1.0 μsec later than the leading edge of the first ADS-B Message.

Measurement Procedure:

The ADS-B receiver power levels specified in this procedure are relative to the loss at the RF message source end of the transmission line used to interface the RF message source to the UUT receiver input port. For each ADS-B equipage class, the specified power level **shall** be adjusted to compensate for the maximum line loss for which the UUT receiver has been designed. For example, if the line loss is 3 dB, then each of the RF message power levels specified in the test procedures **shall** be lowered by 3 dB.

Step 1: Re-Trigger Capability - Part 1

Apply **Input** at the receiver input and verify that at least 90 percent of the second valid ADS-B Messages are correctly decoded.

Step 2: Re-Trigger Capability - Part 2

Repeat Step 1 with the **Input** signal power level at MTL + 6 dB for the first ADS-B Message and MTL + 12 dB for the second ADS-B Message.

Step 3: Re-Trigger Capability - Part 3

Repeat Step 1 with **Input** level at -30 dBm for the first ADS-B Message and

-24 dBm for the second ADS-B Message.

Step 4: Repeat on all Applicable Receiver Input Ports

Repeat Steps 1 through 3 on all other applicable receiver RF input ports of the UUT.

2.3.2.4.4 Out-of-Band Rejection (§2.2.4.3.2)

Purpose/Introduction:

This test verifies that the ADS-B out-of-band rejection is in accordance with the specified values.

Input A:

Equipment:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	MTL + 3 dB Where MTL is the measured value of MTL made at 1090 MHz.

Input B:

Same as Input A with:

Frequency	=	1084.5 MHz
Power	=	MTL + 6 dB

Input C:

Same as Input A with:

Frequency	=	1080.0 MHz
Power	=	MTL + 23 dB

Input D:

Same as Input A with:

Frequency	=	1075.0 MHz
Power	=	MTL + 43 dB

Input E:

Same as Input A with:

Frequency	=	1065.0 MHz
Power	=	MTL + 63 dB

Input F:

Same as Input A with:

Frequency	=	1095.5 MHz
Power	=	MTL + 6 dB

Input G:

Same as Input A with:

Frequency	=	1100.0 MHz
Power	=	MTL + 23 dB

Input H:

Same as Input A with:

Frequency	=	1105.0 MHz
Power	=	MTL + 43 dB

Input I:

Same as Input A with:

Frequency	=	1115.0 MHz
Power	=	MTL + 63 dB

Measurement Procedure:

The ADS-B receiver power levels specified in this procedure are relative to the loss at the RF message source end of the transmission line used to interface the RF message source to the UUT receiver input port. For each ADS-B equipage class, the specified power level **shall** be adjusted to compensate for the maximum line loss for which the UUT receiver has been designed. For example, if the line loss is 3 dB, then each of the RF message power levels specified in the test procedures **shall** be lowered by 3 dB.

Step 1: Apply Initial ADS-B Input Messages

Apply Input B at the receiver input port and decrease the power level until the percentage of decoded ADS-B Messages is less than or equal to 90 percent.

Verify that the measured signal power level required to produce a message decoding percentage of greater than or equal to 90 percent is greater than the limit specified in Table 2-63 in §2.2.4.3.2.

Step 2: Vary the Input Signal Power and Frequency

Repeat Step 1 using inputs C, D, E, F, G, H, and I.

Step 3: Repeat on all Applicable Receiver Input Ports

Repeat Steps 1 and 2 on all other applicable receiver RF input ports of the UUT.

2.3.2.4.5 Dynamic Minimum Trigger Level (DMTL) (§2.2.4.3.3)

Purpose/Introduction:

This test verifies that, when DMTL control is implemented (see §2.2.4.3.3), then the ADS-B receiver DMTL is capable of rejecting low level signals during a valid squitter reception and that DMTL is capable of recovering in not more than 128 microseconds after the leading edge of the first preamble pulse of a valid ADS-B Message.

Input A:

Equipment:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-61 dBm

Overlapped by a pulse having the following characteristics:

Pulse Width	=	120 +/- 1 µsec
Pulse Rise Time	=	0.05 to 0.1 µsec
Pulse Fall Time	=	0.05 to 0.2 µsec
Frequency	=	1090 MHz
Power	=	-69 dBm

Starting 0.7 +/- 0.2 µsec after the leading edge of the first preamble pulse of the ADS-B Message.

Input B:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-40 dBm

Overlapped by a pulse having the following characteristics:

Pulse Width	=	120 +/- 1 µsec
Pulse Rise Time	=	0.05 to 0.1 µsec
Pulse Fall Time	=	0.05 to 0.2 µsec
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-49 dBm

Starting 0.7 +/- 0.2 µsec after the leading edge of the first preamble pulse of the ADS-B Message.

Input C:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-21 dBm

Overlapped by a pulse having the following characteristics:

Pulse Width	=	120 +/- 1 µsec
Pulse Rise Time	=	0.05 to 0.1 µsec
Pulse Fall Time	=	0.05 to 0.2 µsec
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-30 dBm

Starting 0.7 +/- 0.2 µsec after the leading edge of the first preamble pulse of the ADS-B Message.

Input D:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-21 dBm

Followed by a second Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-60 dBm

Starting 129 +/- 1 µsec after the leading edge of the first preamble pulse of the first ADS-B Message.

Input E:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-70 dBm

Preceded by a pulse having the following characteristics:

Pulse Width	=	0.50 μsec
Pulse Rise Time	=	0.05 to 0.1 μsec
Pulse Fall Time	=	0.05 to 0.2 μsec
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-60 dBm

Starting 4.0 μsec before the leading edge of the first preamble pulse of the ADS-B Message.

<u>Input F:</u>

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-70 dBm

Preceded by a pulse having the following characteristics:

Pulse Width	=	0.50 μsec
Pulse Rise Time	=	0.05 to 0.1 μsec
Pulse Fall Time	=	0.05 to 0.2 μsec
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-60 dBm

Starting 9.0 μsec before the leading edge of the first preamble pulse of the ADS-B Message.

<u>Measurement Procedure:</u>

The ADS-B receiver power levels specified in this procedure are relative to the loss at the RF message source end of the transmission line used to interface the RF message source to the UUT receiver input port. For each ADS-B equipage class, the specified power level **shall** be adjusted to compensate for the maximum line loss for which the UUT receiver has been designed. For example, if the line loss is 3 dB, then each of the RF message power levels specified in the test procedures **shall** be lowered by 3 dB.

<u>Step 1:</u> <u>DMTL Desensitization - Part 1</u>

Apply **Input A** at the receiver input and verify that at least 90 percent of the valid ADS-B Messages are correctly decoded.

<u>Step 2:</u> <u>DMTL Desensitization - Part 2</u>

Repeat Step 1 using **Input B**.

<u>Step 3:</u> <u>DMTL Desensitization - Part 3</u>

Repeat Step 1 using **Input C**.

Step 4: DMTL Recovery - Part 4

Apply **Input D** at the receiver input and verify that at least 90 percent of the second valid ADS-B Messages are correctly decoded.

Step 5: DMTL Desensitization after a Single Pulse

Apply **Input E** at the receiver input and verify that no more than 10 percent of the valid ADS-B Messages are correctly decoded.

Step 6: DMTL Recovery after a Single Pulse

Apply **Input F** at the receiver input and verify that at least 90 percent of the valid ADS-B Messages are correctly decoded.

2.3.2.4.6 Criteria for ADS-B Message Transmission Pulse Detection (§2.2.4.3.4.7.1and §2.2.4.3.4.7.2)

Purpose/Introduction:

These tests verify that the ADS-B reply processor correctly detects the presence of a valid ADS-B preamble whose pulse characteristics are within the allowable limits and rejects preambles having pulse spacing and position characteristics that are outside the allowable limits.

Reference Input:

Equipment:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-23 dBm (for the first preamble pulse level

Input A:

Same as the **Reference Input**, but having the following preamble pulse characteristics:

Table 2-79: Input A: Preamble Pulse Characteristics

Pulse	**Rise time** (μsec)	**Fall time** (μsec)	D **Width** (μsec)	D **Position** (μsec)	D **Amplitude** (dB)
1	0.05 - 0.1	0.05 - 0.2	+0.05	—	—
2	0.05 - 0.1	0.05 - 0.2	-0.05	-0.125	+2
3	0.05 - 0.1	0.05 - 0.2	+0.05	+0.125	+2
4	0.05 - 0.1	0.05 - 0.2	-0.05	-0.125	0

Input B:

Same as the **Reference Input**, but having the following preamble pulse characteristics:

Table 2-80: Input B: Preamble Pulse Characteristics

Pulse	**Rise time** (μsec)	**Fall time** (μsec)	D **Width** (μsec)	D **Position** (μsec)	D **Amplitude** (dB)
1	0.05 - 0.1	0.05 - 0.2	-0.3	—	—
2	0.05 - 0.1	0.05 - 0.2	-0.3	0	0
3	0.05 - 0.1	0.05 - 0.2	-0.3	0	0
4	0.05 - 0.1	0.05 - 0.2	-0.3	0	0

Input C:

Same as the **Reference Input**, but having the following preamble pulse characteristics:

Table 2-81: Input C: Preamble Pulse Characteristics

Pulse	**Rise time** (μsec)	**Fall time** (μsec)	D **Width** (μsec)	D **Position** (μsec)	D **Amplitude** (dB)
1	0.05 - 0.1	0.05 - 0.2	0	—	—
2	0.05 - 0.1	0.05 - 0.2	0	+0.2	0
3	0.05 - 0.1	0.05 - 0.2	0	+0.2	0
4	0.05 - 0.1	0.05 - 0.2	0	+0.2	0

Input D:

Same as the **Reference Input**, but having the following preamble pulse characteristics:

Table 2-82: Input D: Preamble Pulse Characteristics

Pulse	**Rise time** (μsec)	**Fall time** (μsec)	D **Width** (μsec)	D **Position** (μsec)	D **Amplitude** (dB)
1	0.05 - 0.1	0.05 - 0.2	+4.5	—	—
2					
3	Pulse Not Present				
4					

Measurement Procedure:

The ADS-B receiver power levels specified in this procedure are relative to the loss at the RF message source end of the transmission line used to interface the RF message source to the UUT receiver input port. For each ADS-B equipage class, the specified power level **shall** be adjusted to compensate for the maximum line loss for which the UUT receiver has been designed. For example, if the line loss is 3 dB, then each of the RF message power levels specified in the test procedures **shall** be lowered by 3 dB.

Step 1: Preamble Pulse Characteristics set to the Extreme Limits of their Tolerance Range - Part 1

Apply **Input A** at the receiver input and verify that at least 90 percent of the ADS-B messages are correctly decoded.

Step 2: Preamble Pulse Characteristics set to the Extreme Limits of their Tolerance Range - Part 2

Repeat Step 1 with the signal power level at -65 dBm.

Step 3: Preamble Pulse Widths set to Out-of-Tolerance Values - Part 1

Apply **Input B** at the receiver input and verify that no more than 10 percent of the ADS-B Messages are correctly decoded.

Step 4: Preamble Pulse Widths set to Out-of-Tolerance Values - Part 2

Repeat Step 3 with the signal power level at -65 dBm.

Step 5: Preamble Pulse Positions set to Out-of-Tolerance Values - Part 1

Apply **Input C** at the receiver input and verify that no more than 10 percent of the ADS-B Messages are correctly decoded.

Step 6: Preamble Pulse Positions set to Out-of-Tolerance Values - Part 2

Repeat Step 5 with the signal power level at -65 dBm.

Step 7: Preamble Single Pulse - Part 1

Apply **Input D** at the receiver input and verify that no more than 10 percent of the ADS-B Messages are correctly decoded.

Step 8: Preamble Single Pulse - Part 2

Repeat Step 7 with the signal power level at -65 dBm.

2.3.2.4.7 Criteria for Data Block Acceptance in ADS-B Message Signals (§2.2.4.3.4.7.3)

Purpose/Introduction:

This test verifies that ADS-B Messages are accepted when DF field is 17 or 18 and when no more than seven consecutive bits fail the confidence test, as specified by §2.2.4.3.4.7.3.

Input A:

Equipment:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-50 dBm

The normal data block content **shall** be modified to contain energy throughout both halves (i.e., chips) of bit positions 33 to 39. The amplitude of the pulse in the half that would ordinarily contain no energy **shall** be 3 dB below the amplitude of the normal pulse in the other half of the bit position.

Input B:

Equipment:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	18
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-50 dBm

The normal data block content **shall** be modified to contain energy throughout both halves (i.e., chips) of bit positions 33 to 39. The amplitude of the pulse in the half that would ordinarily contain no energy **shall** be 3 dB below the amplitude of the normal pulse in the other half of the bit position.

Input C:

Equipment:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz.
Frequency	=	1090 MHz
Power	=	-50 dBm

The normal data block content **shall** be modified to contain energy throughout both halves (i.e., chips) of bit positions 33 to 40. The amplitude of the pulse in the half that would ordinarily contain no energy **shall** be 3 dB below the amplitude of the normal pulse in the other half of the bit position.

Measurement Procedure:

The ADS-B receiver power levels specified in this procedure are relative to the loss at the RF message source end of the transmission line used to interface the RF message source to the UUT receiver input port. For each ADS-B equipage class, the specified power level **shall** be adjusted to compensate for the maximum line loss for which the UUT receiver has been designed. For example, if the line loss is 3 dB, then each of the RF message power levels specified in the test procedures **shall** be lowered by 3 dB.

Step 1: Valid DF=17 ADS-B Message

Apply **Input A** at the receiver input and verify that all ADS-B Messages are correctly decoded.

Step 2: Valid DF=18 ADS-B Message

Apply **Input B** at the receiver input and verify that all ADS-B Messages are correctly decoded.

Step 3: Corrupted DF=17 ADS-B Messages - Part 1

Apply **Input C** at the receiver input and verify that ADS-B Messages are not decoded.

Step 4: Repeat on all Applicable Receiver Input Ports

Repeat Steps 1 through 3 on all other applicable receiver RF input ports of the UUT.

2.3.2.4.8 Track File Maintenance (§2.2.8 through §2.2.10)

Purpose/Introduction:

This procedure is used to verify the general performance characteristics of the ADS-B Receiving function under environmental conditions. The scenarios described herein should be repeated as needed to test the various aspects of the environmental requirements of the ADS-B Receiving function.

Equipment:

Provide a method of loading valid ADS-B Broadcast messages of all types into the ADS-B Receiving function under test.

Provide a method of loading valid position information into the ADS-B Receiving function under test.

Measurement Procedure:

Step 1: Establish ADS-B Receiving Function Position

Provide the ADS-B Receiving function with valid position data as listed in Table 2-83.

Step 2: Surface Participant Stimulus and Track File Maintenance

At a reference time of time zero, begin generation of a series of “even” and “odd” Surface Position from Participants 1 through 4 shown in Table 2-83. Each Message should be structured using subfield data shown in Table 2-83. Each message should be provided at the appropriate rate in accordance with §2.2.3.3.2.2.

a. For Receiving Functions that provide only Output Messages in accordance with §2.2.6, verify that the Receiving function delivers appropriate Output Messages to the user interface or to the Report Assembly function for all Surface Participants.

b. For Receiving Functions that provide a Report Assembly function, verify that the Receiving function delivers appropriate State Vector Reports for all Surface Participants in accordance with §2.2.8.1.

Step 3: Airborne Participant Stimulus and Track File Maintenance

While continuing to transmit the Surface Position Messages described in Step 1, begin generation of a series of “even” and “odd” Airborne Position Messages from Participants 5 through 28 shown in Table 2-83. Each message should be structured using subfield data shown in Table 2-83. Each message should be provided at the appropriate rate in accordance with §2.2.3.3.2.2.

While continuing to transmit the messages required by Step 1 and the previous paragraph, begin generation of Airborne Velocity Messages for participants 5 through 28. Each message should be structured using subfield data shown in Table 2-83. Each message should be provided at the appropriate rate in accordance with §2.2.3.3.2.5.

a. For Receiving Functions that provide only Output Messages in accordance with §2.2.6, verify that the Receiving function delivers appropriate Output Messages to the user interface or to the Report Assembly function for all Airborne Participants.

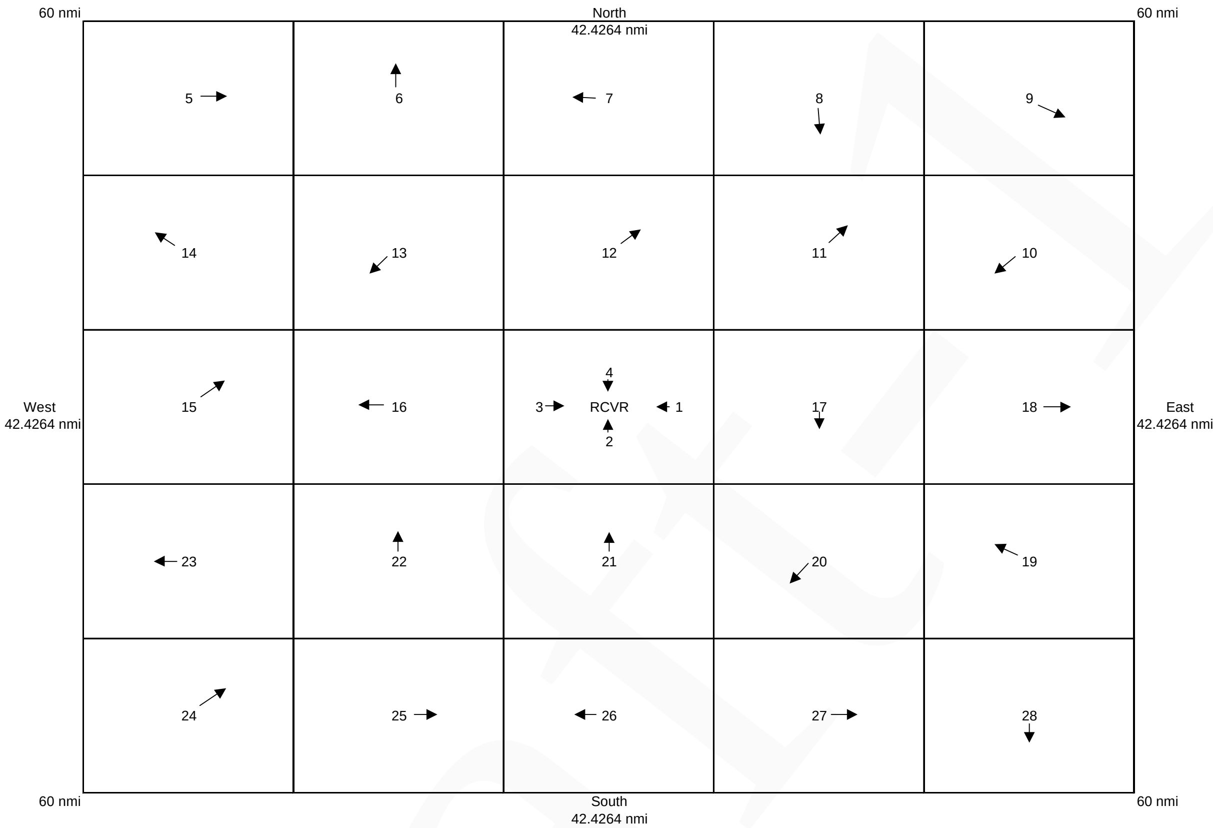
b. For Receiving Functions that provide a Report Assembly function, verify that the Receiving function delivers appropriate State Vector Reports for all Airborne Participants in accordance with §2.2.8.1.

Step 4: Broadcast Message Termination

Terminate the delivery of broadcast messages for all participants. Wait for at least 200 seconds.

a. For Receiving Functions that provide only Output Messages in accordance with §2.2.6, verify that the Receiving function ceases to deliver Output Messages to the user interface or to the Report Assembly function for All Participants.

b. For Receiving Functions that provide a Report Assembly function, verify that the Receiving function ceases to deliver State Vector Reports for all Airborne Participants.



<u>FIGURE 2-18</u>: ADS-B Receiving Function Environmental Test Scenario Pattern

<u>Note:</u> *Figure 2-18 provides a visual indication of the placement of the participants listed in Table 2-83*

Table 2-83: ADS-B Receiving Function Environmental Test Scenario

Target Number	DF (binary)	CA (binary)	AA (HEX)	Latitude	Longitude	Altitude (feet)	E/W Direction Bit (binary)	E/W Velocity (knots)	N/S Direction Bit (binary)	N/S Velocity (knots)	Ground Speed (knots)	Ground Track (degrees)
UUT Receiver Location				33.9425361	-118.4080744	126						
1	1 0001	100	AA AA AA	33.9425361	-118.3833333	126					10	270
2	1 0001	100	AA BB BB	33.9166666	-118.4080744	126					25	357
3	1 0001	100	AA CC CC	33.9425361	-118.4250000	126					35	90
4	1 0001	100	AA DD DD	33.9583333	-118.4080744	126					60	180
5	1 0001	101	BB AA AA	34.6496427	-119.1151811	35000	0	600	0	0		
6	1 0001	101	BB BB BB	34.6496427	-118.7616277	20000	0	0	0	700		
7	1 0001	101	BB CC CC	34.6496427	-118.4080744	10000	1	500	0	0		
8	1 0001	101	BB DD DD	34.6496427	-118.0545211	15000	0	0	1	550		
9	1 0001	101	BB EE EE	34.6496427	-117.7009677	9000	0	500	1	500		
10	1 0001	101	CC AA AA	34.2960894	-117.7009667	25000	1	400	1	400		
11	1 0001	101	CC BB BB	34.2960894	-118.0545211	15000	0	300	0	300		
12	1 0001	101	CC CC CC	34.2960894	-118.4080744	12000	0	250	0	250		
13	1 0001	101	CC DD DD	34.2960894	-118.7616277	30000	1	400	1	400		
14	1 0001	101	CC EE EE	34.2960894	-119.1151811	37000	1	600	0	600		
15	1 0001	101	DD AA AA	33.9425361	-119.1151811	8000	0	300	0	300		
16	1 0001	101	DD BB BB	33.9425361	-118.7616277	29000	1	600	0	0		
17	1 0001	101	DD CC CC	33.9425361	-118.0545211	26000	0	0	1	650		
18	1 0001	101	DD DD DD	33.9425361	-117.7009667	28000	0	600	0	0		
19	1 0001	101	DD EE EE	33.5889827	-117.7009667	31000	1	600	0	600		
20	1 0001	101	EE AA AA	33.5889827	-118.0545211	25000	1	400	1	400		
21	1 0001	101	EE BB BB	33.5889827	-118.4080744	14000	0	0	0	300		
22	1 0001	101	EE CC CC	33.5889827	-118.7616277	15000	0	0	0	300		
23	1 0001	101	EE DD DD	33.5889827	-119.1151811	16000	1	900	0	0		
24	1 0001	101	EE EE EE	33.2354294	-119.1151811	15000	0	400	0	500		
25	1 0001	101	FF AA AA	33.2354294	-118.7616277	36000	0	700	0	0		
26	1 0001	101	FF BB BB	33.2354294	-118.4080744	19000	1	600	0	0		
27	1 0001	101	FF CC CC	33.2354294	-118.0545211	25000	0	955	0	0		
28	1 0001	101	FF DD DD	33.2354294	-117.7009667	35000	0	0	1	850		

2.3.2.5 Self Test and Monitors (§2.2.11)

No specific test procedure is required to validate §2.2.11.

2.3.2.5.1 Transponder Based Equipment Address (§2.2.11.3.1)

Transponder Based Equipment **shall** be tested in accordance with the procedures provided in §2.3.2.5.2.

Note: *The requirement to test transponder based equipment is provided herein due to the fact that the test requirements provided in RTCA DO-181C do not test the function adequately.*

2.3.2.5.2 Non-Transponder Based Equipment (§2.2.11.3.2)

Purpose/Introduction:

The following Test Procedures **shall** be used to verify that the ADS-B Transmitting monitor function properly enunciates the “Fail Warn” condition in the event that the ICAO 24-Bit Address (§2.2.5.1.1) provided to the ADS-B Transmission function is set to ALL ZEROs or ALL ONEs.

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test. Provide a method of detecting and monitoring ADS-B broadcast messages. Provide a method of modifying the ICAO 24-Bit Address provided to the Unit Under Test.

Measurement Procedure:

Step 1: Initial Conditions

Establish any state where the ADS-B Transmission Function is operational and indicating no Fail Warn conditions.

Step 2: Address set to ALL ZEROs

Remove power from the Unit Under Test (UUT)

Set the ICAO 24-Bit Address provided to the UUT to ALL ZEROs.

Apply power to the UUT.

Verify that the ADS-B transmission function properly enunciates the “Fail Warn” state within no more than 2.0 seconds.

Step 3: New Initial Conditions

Repeat Step 1.

Step 4: Address set to ALL ONEs

Remove power from the Unit Under Test (UUT)

Set the ICAO 24-Bit Address provided to the UUT to ALL ONEs.

Apply power to the UUT.

Verify that the ADS-B transmission function properly enunciates the "Fail Warn" state within no more than 2.0 seconds.

Step 5: Restore Normal Operations

Establish any state where the ADS-B Transmission Function is operational and indicating no Fail Warn conditions prior to continuing with further testing.

2.3.2.6 Response to Mutual Suppression Pulses (§2.2.12)

No specific test procedure is required to validate §2.2.12.

2.3.2.6.1 Transmitting Device Response to Mutual Suppression Pulses (§2.2.12.1)

Purpose/Introduction:

The following Test Procedures **shall** be used to verify that the ADS-B Transmitting Subsystem functions properly in the Mutual Suppression environment.

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.

Provide a method of supplying the ADS-B Transmitting function with Mutual Suppression Pulses.

Provide a method of monitoring and recording ADS-B transmissions and the time at which such transmissions are generated with respect to the end of a mutual suppression pulse.

Measurement Procedure:

Step 1: Initialize ADS-B Airborne Participant Transmissions

Provide the ADS-B transmitting function with all necessary information to enable the transmitting function to generate the following DF=17 transmitted messages:

(1). Airborne Position Messages (§2.2.3.2.3),

(2). Aircraft Identification and Type Messages (§2.2.3.2.5), and

(3). Airborne Velocity Messages (§2.2.3.2.6)

Verify that the ADS-B transmitting function properly transmits Airborne Position, Aircraft Identification and Type, and Airborne Velocity Messages at the rates required in §2.2.3.3.2.2, §2.2.3.3.2.4 and §2.2.3.3.2.5.

Step 2: Apply Mutual Suppression

Apply Mutual Suppression pulses of the maximum length that the suppression interface is designed to accept.

Verify that no ADS-B transmissions occur during the suppression period.

Record the transmissions that are generated and verify that transmissions can be output no later than 15 microseconds after the end of the mutual suppression pulse.

2.3.2.6.2 Receiving Device Response to Mutual Suppression Pulses (§2.2.12.2)

Purpose/Introduction:

The following Test Procedures **shall** be used to verify that the ADS-B Receiving device functions properly in the Mutual Suppression environment.

Equipment Required:

Provide a method of supplying ADS-B Transmitted messages to the ADS-B Receiving function.

Provide a method of supplying the ADS-B receiving function with Mutual Suppression Pulses that can be synchronized to the ADS-B Transmitted messages provided to the ADS-B Receiving function.

Provide a method of monitoring and recording the Receiving function decoded ADS-B Messages or structured ADS-B Reports.

Measurement Procedure:

Step 1: Initialize ADS-B Message Reception

Provide the ADS-B Receiving function with appropriate ADS-B Messages at a minimum rate of two per second and having a signal level of the Receiver MTL + 3 dB.

Verify that the Receiving function decodes at least 99 % of the messages provided to the receiver.

Step 2: Apply Mutual Suppression

a. Apply Mutual Suppression pulses synchronized to start before each ADS-B Message provided to the Receiving function.

Ensure that the duration of each Mutual Suppression pulse exceeds that of the ADS-B Messages being provided to the Receiving function.

Verify that no ADS-B Messages are successfully decoded by the Receiving function.

b. Apply Mutual Suppression pulses that do not over lap any of the ADS-B Messages provided to the Receiving function and are synchronized to finish 15 microseconds prior to the start of each ADS-B Message provided to the Receiving function.

Verify that at least 90 percent of the ADS-B Messages provided to the Receiving function are properly decoded by the Receiving function.

2.3.2.7 Diversity Operation (§2.2.13.6)

No specific test procedure is required to validate §2.2.13.6.

2.3.2.7.1 Transmitting Diversity (§2.2.13.6.1)

Purpose/Introduction:

This test procedure verifies that an ADS-B Transmitting Subsystem implements transmitting diversity properly by transmitting each required type of ADS-B Message alternately from the top and bottom antennas.

Equipment Required:

Provide a method of supplying the ADS-B Transmission function with all data necessary to structure ADS-B Airborne Position, Airborne Velocity, and Aircraft Identification and Type messages. All data **shall** be provided via the operational interfaces.

Provide a method of monitoring the ADS-B Broadcast Messages transmitted by the ADS-B Transmission function.

Measurement Procedure:

Step 1: Broadcast Message Initialization

Provide the ADS-B Transmission function with all data necessary to structure Airborne Position, Airborne Velocity, and Aircraft Identification and Type ADS-B Broadcast Messages.

Step 2: Broadcast Message Verification

Verify that the ADS-B Transmission function properly transmits the appropriate Airborne Position Messages alternately on the Top and Bottom RF ports.

Verify that the ADS-B Transmission function properly transmits the appropriate Airborne Velocity Messages alternately on the Top and Bottom RF ports.

Verify that the ADS-B Transmission function properly transmits the appropriate Aircraft Identification and Type Messages alternately on the Top and Bottom RF ports.

2.3.2.7.2 Receiving Diversity (§2.2.13.6.2)

Appropriate test procedures to required to verify the performance of §2.2.13.6.2 are provided in §2.3.2.7.2.1 through §2.3.2.7.2.2.

2.3.2.7.2.1 Full Receiver and Message Processing or Receiver Switching Front-End Diversity (§2.2.13.6.2)

Purpose/Introduction:

This procedure verifies that the ADS-B Receiving function properly implements diversity by demonstrating proper reception of ADS-B Broadcast Messages from either the top antenna, or the bottom antenna, or both antennas. This procedure applies to those configurations that implement Full receiver and message processing function diversity as discussed in §2.2.13.6.2.a. This procedure also apples to those configurations that implement Receiver Switching Front-End diversity as discussed in §2.2.13.6.2.b.

Equipment Required:

Provide a method of supplying the equipment under test with appropriate Airborne Position ADS-B Broadcast Messages.

Provide a method of monitoring the Output Messages and/or ADS-B Reports generated by the ADS-B Receiving function.

RF Splitter/Combiner (2 port, or 3 dB type)

RF Attenuators (Fixed, various attenuation values, as needed)

Measurement Procedure:

Step 1: Test Equipment Configuration

Connect the ADS-B Broadcast Message generator to the RF Splitter input. Connect each output from the RF Splitter to the input of an RF Attenuator. Connect the output of one RF Attenuator to the Top Channel RF input port of the equipment under test. Connect the output of the other RF Attenuator to the Bottom Channel RF input port of the equipment under test.

Step 2: Top Channel is Primary Receiver

Adjust the Top Channel attenuator such that the signal level provided to the Top Channel RF input port is at least 3 dB above the MTL of the equipment under test.

Adjust the Bottom Channel attenuator such that the signal level provided to the Bottom Channel RF input port is 20 dB less than the MTL of the equipment under test.

Configure the ADS-B Broadcast Message generator to provide only Airborne Position messages for a single participant with the position continuously changing in the message.

Verify that the ADS-B Receiving function generates appropriate Output Messages or State Vector Reports for at least 90% of the Airborne Position Messages provided to the Top Channel RF input port.

Step 3: Bottom Channel is Primary Receiver

Adjust the Bottom Channel attenuator such that the signal level provided to the Bottom Channel RF input port is at least 3 dB above the MTL of the equipment under test.

Adjust the Top Channel attenuator such that the signal level provided to the Top Channel RF input port is 20 dB less than the MTL of the equipment under test.

Configure the ADS-B Broadcast Message generator to provide only Airborne Position messages for a single participant with the position continuously changing in the message.

Verify that the ADS-B Receiving function generates appropriate Output Messages or State Vector Reports for at least 90% of the Airborne Position Messages provided to the Bottom Channel RF input port.

Step 4: Top / Bottom Channel Equivalent

Adjust the Bottom Channel attenuator such that the signal level provided to the Bottom Channel RF input port is at least 3 dB above the MTL of the equipment under test.

Adjust the Top Channel attenuator such that the signal level provided to the Top Channel RF input port is at least 3 dB above the MTL of the equipment under test.

Configure the ADS-B Broadcast Message generator to provide only Airborne Position messages for a single participant with the position continuously changing in the message.

Verify that the ADS-B Receiving function generates appropriate Output Messages or State Vector Reports for between 90% and 100% of the Airborne Position Messages provided to the Bottom Channel RF input port.

2.3.2.7.2.2 Receiving Antenna Switching Diversity (§2.2.13.6.2)

Purpose/Introduction:

This procedure verifies that the ADS-B Receiving function properly implements diversity by demonstrating proper reception of ADS-B Broadcast Messages from either the top antenna or the bottom antenna. This procedure applies to those configurations that implement Receiving Antenna switching as discussed in §2.2.13.6.2.c.

Equipment Required:

Provide a method of supplying the equipment under test with appropriate Airborne Position ADS-B Broadcast Messages.

Provide a method of monitoring the Output Messages and/or ADS-B Reports generated by the ADS-B Receiving function.

RF Attenuators (Fixed, various attenuation values, as needed).

Measurement Procedure:

Step 1: Top Channel is Primary Receiver

Connect the ADS-B Broadcast Message generator to the RF Attenuator input. Connect the output of the RF Attenuator to the Top Channel RF input port of the equipment under test.

Adjust the attenuator such that the signal level provided to the Top Channel RF input port is at least 3 dB above the MTL of the equipment under test.

Configure the ADS-B Broadcast Message generator to provide only Airborne Position messages for a single participant with the position continuously changing in the message.

Verify that the ADS-B Receiving function generates appropriate Output Messages or State Vector Reports for at least 45% of the Airborne Position Messages provided to the Top Channel RF input port.

Step 2: Bottom Channel is Primary Receiver

Connect the ADS-B Broadcast Message generator to the RF Attenuator input. Connect the output of the RF Attenuator to the Bottom Channel RF input port of the equipment under test.

Adjust the attenuator such that the signal level provided to the Bottom Channel RF input port is at least 3 dB above the MTL of the equipment under test.

Configure the ADS-B Broadcast Message generator to provide only Airborne Position messages for a single participant with the position continuously changing in the message.

Verify that the ADS-B Receiving function generates appropriate Output Messages or State Vector Reports for at least 45% of the Airborne Position Messages provided to the Bottom Channel RF input port.

2.3.2.8 Power Interruption (§2.2.15)

Appropriate test procedures are found in 2.3.2.8.1 and 2.3.2.8.2.

2.3.2.8.1 Power Interruption to ADS-B Transmitting Functions (§2.2.15)

<u>Purpose/Introduction:</u>

The purpose of this procedure is to verify that the ADS-B Transmitting equipment regains operational capability to within its operational limits within two seconds after the restoration of power following a momentary power interruption.

<u>Equipment Required:</u>

Provide equipment capable of loading valid data for ADS-B broadcast messages into the ADS-B Transmitting equipment under test through the operational interface.

<u>Measurement Procedure:</u>

<u>Step 1:</u> <u>Enable Transmission of Airborne Position Messages</u>

Supply the ADS-B Transmission function with the appropriate data necessary to establish Airborne Position Messages.

Verify that the ADS-B Transmission function generates appropriate Airborne Position Messages at the rate specified in §2.2.3.3.1.1 or §2.2.3.3.2.2.

<u>Note:</u> *If the Transmission function uses diversity and the test is being performed on one RF output interface at a time, then the specified rate necessary to satisfy this test is half of that given in §2.2.3.3.1.1 or §2.2.3.3.2.2.*

<u>Step 2:</u> <u>Apply momentary power interrupts</u>

Apply momentary power interrupts to the ADS-B Transmission function under test in accordance with RTCA Document No. DO-160D section 16 and (EUROCAE ED-14D, section 16). Then restore the power to normal operating conditions.

Verify that the ADS-B Transmission function resumes generation of appropriate Airborne Position Messages no later than 2.0 seconds after the restoration of normal power.

<u>Step 3:</u> <u>Repeat for additional RF Output Interfaces</u>

If the ADS-B Transmission function implements diversity, then repeat steps 1 and 2 on the additional RF Output Interface.

2.3.2.8.2 Power Interruption to ADS-B Receiving Functions (§2.2.15)

Purpose/Introduction:

The purpose of this procedure is to verify that the ADS-B Receiving equipment regains operational capability to within its operational limits within two seconds after the restoration of power following a momentary power interruption.

Equipment Required:

Provide equipment capable of supplying valid ADS-B broadcast messages to the ADS-B Receiving equipment under test via the appropriate RF interface.

Measurement Procedure:

Step 1: Enable Reception of Airborne Position Messages

Via the receiver RF interface and in the absence of interference, apply valid 1090 MHz. Airborne Position Messages at a uniform rate of 2 per second and at a signal level that is at least 15 dB above the MTL of the ADS-B Receiving function.

Verify that the ADS-B Receiving function delivers appropriate Output Messages to the user interface or to the Report Assembly function for all messages received and that the Output Message formats are consistent with the requirements of §2.2.6.1.1.

Step 2: Apply momentary power interrupts

Apply momentary power interrupts to the ADS-B Receiving function under test in accordance with RTCA Document No. DO-160D section 16 (EUROCAE ED-14D, section 16). Then restore the power to normal operating conditions.

Verify that the ADS-B Receiving function resumes generation of appropriate Output Messages to the user interface or to the Report Assembly function no later than 2.0 seconds after the restoration of power.

Then verify that the ADS-B Receiving function continues to deliver appropriate Output Messages to the user interface or to the Report Assembly function for all messages received and that the Output Message formats are consistent with the requirements of §2.2.6.1.1.

Step 3: Repeat for additional RF Output Interfaces

If the ADS-B Receiving function implements diversity, then repeat steps 1 and 2 on the additional RF Input Interface.

2.4 Equipment Test Procedures

The test procedures set forth in the following subparagraphs are considered satisfactory for use in determining required performance under standard and stressed conditions. Although specific test procedures are cited, it is recognized that other methods may be preferred by the testing facility. These alternate procedures may be used if the equipment manufacturer can show that they provide at least equivalent information. In such cases, the procedures cited herein should be used as one criterion in evaluating the acceptability of the alternate procedures.

2.4.1 Definition of Terms and Conditions of Test

The following definitions of terms and conditions of tests are applicable to the equipment tests specified herein commencing at §2.4.2:

a. Power Input Voltage - Unless otherwise specified, all tests **shall** be conducted with the power input voltage adjusted to design voltage +/- 2 percent. The input voltage **shall** be measured at the input terminals of the equipment under test.

b. Power Input Frequency

(1). In the case of equipment designed for operation from an AC source of essentially constant frequency (e.g., 400 Hz), the input frequency **shall** be adjusted to design frequency +/- 2 percent.

(2). If the equipment is designed for operation from an AC source of variable frequency (e.g., 300 to 1000 Hz), tests **shall** be conducted with the input frequency adjusted to within five percent of a selected frequency and, unless otherwise specified, within the range for which the equipment is designed.

c. Accuracy of Test Equipment - Throughout this section, the accuracy of the test equipment is not addressed in detail, but rather is left to the calibration process prescribed by the agency which certifies the testing facility.

d. Adjustment of Equipment - The circuits of the equipment under test **shall** be properly aligned and otherwise adjusted in accordance with the manufacturer's recommended practices prior to application of the specified tests. Unless otherwise specified, adjustments may not be made once the test procedures have started.

e. Test Instrument Precautions - During the tests, precautions **shall** be taken to prevent the introduction of errors resulting from the connection of voltmeters, oscilloscopes and other test instruments, across the input and output terminals of the equipment under test.

f. Ambient Conditions - Unless otherwise specified, all tests **shall** be conducted under conditions of ambient room temperature, pressure and humidity. However, the room temperature **shall** not be lower than 10 degrees C.

g. Connected Loads - Unless otherwise specified, all tests **shall** be performed with the equipment connected to loads having the impedance values for which it is designed.

h. Standard ADS-B Broadcast Message Test Signals

The ADS-B Broadcast Message general signal conventions **shall** be as specified in §2.2.2 and §2.2.3 through §2.2.3.2.1.1.6.

General Characteristics

(a). Radio Frequency: The carrier frequency of the signal generator for ADS-B Broadcast Messages **shall** be 1090 +/- 1.0 MHz.

(b). CW Output: The CW output between pulses **shall** be at least 50 dB below the peak level of the pulse.

(c). Pulse Rise and Fall Time: Rise and fall times **shall** be as specified in §2.2.3.1.3.

(d). Pulse Top Ripple: The instantaneous amplitude of the pulses **shall** not fall more than 1 dB below the maximum value between the 90 percent voltage amplitude point on the leading and trailing edge of the pulse.

(e). Signal Level: Unless otherwise noted in the measurement procedure, the signal level **shall** be -60 +/- 3 dBm.

(f). Broadcast Message Rate: Unless otherwise noted in the measurement procedure, ADS-B Broadcast Message Rates **shall** be 60 +/- 5 Hz.

(g). ICAO 24-Bit Discrete Address: Unless otherwise noted in the measurement procedure, the ADS-B Transmitting System address used for all broadcast messages **shall** be: Hexadecimal – AA AAAA, (i.e., binary – 1010 1010 1010 1010 1010 1010).

2.4.2 Verification of ADS-B Transmitter Characteristics (§2.2.2)

No specific test procedure is required to validate §2.2.2.

2.4.2.1 Transponder Based Transmitters (§2.2.2.1)

Transponder based transmitters **shall** be tested to comply with the requirements of RTCA Document No. DO-181C, §2.4.2.2 (EUROCAE ED-73A, section 3.3) inclusive.

Note: *Class A0 and Class B equipment is limited to aircraft equipment only permitted to operate below 15,000 feet.*

2.4.2.1.1 Verification of RF Peak Output Power (minimum) (§2.2.2.1.1)

Transponder based transmitters **shall** be tested to comply with the requirements of RTCA Document No. DO-181C, §2.4.2.2.2 (EUROCAE ED-73A, §3.3.3).

2.4.2.1.1.1 Verification of Class A0 ADS-B Transponder Based Transmitter Power (§2.2.2.1.1.1)

Transponder based transmitters **shall** be tested to comply with the requirements of RTCA Document No. DO-181C, §2.4.2.2.2 (EUROCAE ED-73A, §3.3.3).

In addition, the equipment **shall** be tested in accordance with §2.4.2.2.10.1 of this document.

2.4.2.1.1.2 Verification of Class A1 ADS-B Transponder Based Transmitter Power (§2.2.2.1.1.2)

Transponder based transmitters **shall** be tested to comply with the requirements of RTCA Document No. DO-181C, §2.4.2.2.2 (EUROCAE ED-73A, §3.3.3).

2.4.2.1.1.3 Verification of Class A2 ADS-B Transponder Based Transmitter Power (§2.2.2.1.1.3)

Transponder based transmitters **shall** be tested to comply with the requirements of RTCA Document No. DO-181C, §2.4.2.2.2 (EUROCAE ED-73A, §3.3.3).

2.4.2.1.1.4 Verification of Class A3 ADS-B Transponder Based Transmitter Power (§2.2.2.1.1.4)

Transponder based transmitters **shall** be tested to comply with the requirements of RTCA Document No. DO-181C, §2.4.2.2.2 (EUROCAE ED-73A, §3.3.3).

2.4.2.1.1.5 Verification of Class B ADS-B Transponder Based Transmitter Power (§2.2.2.1.1.5)

Transponder based transmitters **shall** be tested to comply with the requirements of RTCA Document No. DO-181C, §2.4.2.2.2 (EUROCAE ED-73A, §3.3.3).

When the RF Peak Output Power (minimum) tests are not specified by RTCA Document No. DO-181C (EUROCAE ED-73A), then the equipment **shall** be tested in accordance with §2.4.2.2.10.2 of this document.

2.4.2.1.2 Verification of RF Peak Output Power (maximum) (§2.2.2.1.2)

Transponder based transmitters **shall** be tested to comply with the requirements of RTCA Document No. DO-181C, §2.4.2.2.2 (EUROCAE ED-73A, §3.3.3).

When the RF Peak Output Power (maximum) tests are not specified by RTCA Document No. DO-181C (EUROCAE ED-73A), then the equipment **shall** be tested in accordance with §2.4.2.2.10.3 of this document.

2.4.2.2 Verification of Stand Alone Transmitters (§2.2.2.2)

No specific test procedure is required to validate §2.2.2.2.

2.4.2.2.1 Verification of Transmission Frequency (§2.2.2.2.1)

Equipment Required:

Provide equipment capable of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test through the operational interface.
Stub Tuner (Microlab/FXR Sl-05N, or equivalent).
Variable Air Line (Line Stretcher) (Microlab/FKR SR-05N, or equivalent).
Slotted Line (HP 805C, or equivalent).

Measurement Procedure:

Determine the transmission frequency

Load valid data into the ADS-B Airborne Position format and ensure that the expected ADS-B transmissions occur. Adjust the stub to establish a l.5:l VSWR at the antenna end of the coax line specified by the manufacturer. If the ADS-B transmitter requires a minimum length of a specified cable type, an attenuator equal to the loss of the minimum amount of cable may be placed between the 1.5:1 VSWR point and the equipment antenna jack. Alternately, a length of cable equal to the specified minimum length and cable type may be used in lieu of the attenuator. Adjust the line stretcher for maximum transmitter frequency shift above and below 1090 MHz Determine that the frequency shift does not exceed the requirements of §2.2.2.2.1.

2.4.2.2.2 Verification of Transmission Spectrum (§2.2.2.2.2)

Test procedures to validate the spectrum requirements for the ADS-B transmitted message are provided in §2.4.3.1.3 of this document.

2.4.2.2.3 Verification of Modulation (§2.2.2.2.3)

Test procedures to validate the modulation requirements for the ADS-B transmitted message are provided in §2.4.3.1.1 and §2.4.3.1.2 of this document.

2.4.2.2.4 Verification of Pulse Shapes (§2.2.2.2.4)

Test procedures to validate the pulse shape requirements for the ADS-B transmitted message are provided in §2.4.3.1.3 of this document.

2.4.2.2.5 Verification of Message Structure (§2.2.2.2.5)

Test procedures to validate the message structure requirements for the ADS-B transmitted message are provided in §2.4.3.1.1 through §2.4.3.1.4 of this document.

2.4.2.2.6 Verification of Pulse Intervals (§2.2.2.2.6)

Test procedures to validate the pulse interval requirements for the ADS-B transmitted message are provided in §2.4.3.1.4 of this document.

2.4.2.2.7 Verification of Preamble (§2.2.2.2.7)

Appropriate test procedures to validate the ADS-B Message Preamble are provided in §2.4.3.1.1 of this document.

2.4.2.2.8 Verification of Data Pulses (§2.2.2.2.8)

Appropriate test procedures to validate the ADS-B Message Data pulses are provided in §2.4.3.1.2 of this document.

2.4.2.2.9 Verification of Pulse Amplitude (§2.2.2.2.9)

Appropriate test procedures to validate the ADS-B Message Data Pulse amplitudes are provided in §2.4.3.1.3 of this document.

2.4.2.2.10 Verification of RF Peak Output Power (§2.2.2.2.10)

No specific test procedure is required to validate §2.2.2.2.10, which provides only general information.

2.4.2.2.10.1 Verification of Class A0 Equipment RF Peak Output Power (§2.2.2.2.10.1)

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.

Wide Band Dual Channel Oscilloscope (HP l7l0B, or equivalent).

Measurement Procedure:

Load valid data into the ADS-B Airborne Position format and ensure that the expected ADS-B transmissions occur. Measure the single pulse having the maximum RF power output. Determine that the maximum power output meets the requirements of §2.2.2.2.10.1

2.4.2.2.10.2 Verification of Class B Equipment RF Peak Output Power (§2.2.2.2.10.2)

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.

Wide Band Dual Channel Oscilloscope (HP l7l0B, or equivalent).

Measurement Procedure:

Load valid data into the ADS-B Airborne Position format and ensure that the expected ADS-B transmissions occur. Measure the single pulse having the maximum RF power output. Determine that the maximum power output meets the requirements of §2.2.2.2.10.2.

2.4.2.2.10.3 Verification of RF Peak Output Power (maximum) (§2.2.2.2.10.3)

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.

Wide Band Dual Channel Oscilloscope (HP l7l0B, or equivalent).

Measurement Procedure:

Load valid data into the ADS-B Airborne Position format and ensure that the expected ADS-B transmissions occur. Measure the single pulse having the maximum RF power output. Determine that the maximum power output meets the requirements of §2.2.2.2.10.3.

2.4.2.2.11 Verification of Unwanted Output Power (§2.2.2.2.11)

Equipment Required:

Spectrum Analyzer (HP 8535A, or equivalent).
Directional Coupler (HP 796D, or equivalent).

Notes:

1. *For test equipment protection, the ADS-B transmitter modulation may be disabled by external means.*

2. *This unwanted power requirement should be interpreted as an RF leakage test from the ADS-B transmitter antenna. As such, the ideal implementation would provide a means to disable ADS-B transmissions while maintaining appropriate standby power to the transmitter function. That is, the transmitter is powered but NOT modulated.*

Measurement Procedure:

Ensure that no ADS-B Message data is available to the equipment under test and that there are NO ADS-B Broadcast messages being output.

Record the maximum power output in the range of 1090 MHz plus or minus 3 MHz and determine that the maximum power output meets the requirements of §2.2.2.2.11.

2.4.2.2.12 Verification of Broadcast Rate Capability (§2.2.2.2.12)

Test procedures to validate the broadcast rate capability requirements for the ADS-B transmitted message are provided in §2.4.3.3 through §2.4.3.3.2.12 of this document.

2.4.3 Verification of Broadcast Message Characteristics (§2.2.3)

No specific test procedure is required to validate §2.2.3.

2.4.3.1 Verification of ADS-B Message Characteristics (§2.2.3.1)

No specific test procedure is required to validate §2.2.3.1, which provides only general information. The ADS-B Message characteristics are tested in the following modulation tests as well as in all tests involving ADS-B Message decoding.

2.4.3.1.1 Verification of ADS-B Message Preamble (§2.2.3.1.1)

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test A method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope.

Wide Band Dual Channel Oscilloscope (HP 1710B, or equivalent).

Measurement Procedure:

Determine Preamble Pulse Spacing

Load valid data into the ADS-B Airborne Position Message and verify that the messages are being transmitted by the equipment under test. Display the ADS-B Messages on the oscilloscope. Measure the pulse duration of the first four message pulses. Measure the pulse spacing between the leading edge of the first and each of the second, third and fourth pulses. Determine that the spacing of the pulses is within the tolerances specified in §2.2.3.1.1.

Note: *Interval measurements are measured between half voltage points of the respective pulses as detected by a linear detector. If the detector is not known to be linear, a check should be made to determine the half voltage points.*

2.4.3.1.2 Verification of ADS-B Message Data Pulses (§2.2.3.1.2)

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test. Provide a method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope.

Wide Band Dual Channel Oscilloscope (HP 1710B, or equivalent).

Measurement Procedure:

Determine Message Data Pulse Width and Duration

Note: *For tests in this section, unless otherwise specified, examine pulses at the beginning, middle and end of the ADS-B broadcast messages.*

Load valid data into the ADS-B Airborne Position Message and verify that the messages are being transmitted by the equipment under test. Measure the pulse duration of the pulses transmitted in the ADS-B Message throughout the message transmission. Determine that the duration of the pulses is within the tolerance specified in §2.2.3.1.2.

Measure the pulse spacing of the fifth reply pulse with reference to the first reply pulse. Determine that the pulse spacing is within the tolerance specified in §2.2.3.1.2.

Note: *Interval measurements are measured between half voltage points of the respective pulses as detected by a linear detector. If the detector is not known to be linear, a check should be made to determine the half voltage points.*

2.4.3.1.3 Verification of ADS-B Message Pulse Shape (§2.2.3.1.3)

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test. Provide a method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope.

Wide Band Dual Channel Oscilloscope (HP 1710B, or equivalent).

Measurement Procedure:

Step 1: ADS-B Message Pulse Amplitude Variation (§2.2.3.1.3.a)

Load valid data into the ADS-B Airborne Position Message and verify that the messages are being transmitted by the equipment under test. Measure the maximum power differential between pulses in ADS-B Broadcast Message. Verify that it is within the tolerance specified in §2.2.3.1.3.a.

Step 2: ADS-B Message Pulse Shape (§2.2.3.1.3.b and c)

Load valid data into the ADS-B Airborne Position Message and verify that the messages are being transmitted by the equipment under test. Measure the rise and decay time of the ADS-B Broadcast Message pulses. Verify that they are within the tolerances specified in §2.2.3.1.3.b and c.

Note: *Pulse Rise Time is measured as the time interval between 10 percent and 90 percent of peak amplitude on the leading edge of the pulse. Pulse Decay Time is measured as the time interval between 90 percent and 10 percent of peak amplitude on the tailing edge of the pulse. See "Caution" statement below.*

CAUTION: *If the detector is not known to be linear, checks should be made to determine what amplitude points on the detected pulse correspond to the 10 percent and 90 percent amplitude points of the RF pulses. In addition, checks should be made to determine the rise and decay time of the detector.*

Step 3: Frequency Spectrum of ADS-B Message Transmission (§2.2.3.1.3.d)

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.

Spectrum Analyzer (HP 8535A, or equivalent).

Directional Coupler (HP 796D, or equivalent).

Measurement Procedure:

Load valid data into the ADS-B Airborne Position Message and verify that the messages are being transmitted by the equipment under test. Observe the spectral response of the ADS-B Broadcast Message. Verify that it is within the tolerances specified in Table 2-7.

2.4.3.1.4 Verification of ADS-B Message Pulse Spacing (§2.2.3.1.4)

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test. Provide a method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope. Wide Band Dual Channel Oscilloscope (HP 1710B, or equivalent).

Measurement Procedure:

ADS-B Message Pulse Spacing Tolerance (§2.2.3.1.4)

Load valid data into the ADS-B Airborne Position Message and verify that the messages are being output. Determine that the leading edge of any reply pulse is within 50 nanoseconds of its assigned position.

Note: *Interval measurements are measured between half voltage points of the respective pulses as detected by a linear detector. If the detector is not known to be linear, a check should be made to determine the half voltage points.*

2.4.3.2 Verification of ADS-B Message Format Structure (§2.2.3.2)

No specific test procedure is required to validate §2.2.3.2.

2.4.3.2.1 Verification of ADS-B Message Baseline Format Structure (§2.2.3.2.1)

No specific test procedure is required to validate §2.2.3.2.1.

2.4.3.2.1.1 Verification of ADS-B Message Baseline Field Descriptions (§2.2.3.2.1.1)

No specific test procedure is required to validate §2.2.3.2.1.1.

2.4.3.2.1.1.1 Verification of "AA" Address Field, Announced (§2.2.3.2.1.1.1, §2.2.5.1.1)

Appropriate test procedures to verify the "AA" field (§2.2.3.2.1.1.1) are included in the verification of the "PI" field in §2.4.3.2.1.1.6.

2.4.3.2.1.1.2 Verification of "CA" Capability Field (used in DF=17) (§2.2.3.2.1.1.2, §2.2.5.1.3)

Purpose/Introduction:

The "CA" field is a 3-bit field (baseline message bits 6 through 8) used to report the capability of the transponder based transmitting installation. The "CA" field is used to report the capability of the ADS-B transmitting system and is used in DF=11 and DF=17 transmissions. DF=11 is transmitted in response to an ATCRBS/Mode-S All-Call, Mode-S Only All-Call, and transmitted as an Acquisition Squitter. DF=17 is transmitted as an extended squitter. The codes used in the "CA" field are defined in Table 2-8.

The following test procedure **shall** be conducted for all transponder based ADS-B transmitter systems. The "CA" field is set according to the requirements in RTCA Document No. DO-181C (EUROCAE ED-73A) and §2.2.3.2.1.1.2. ADS-B transmitting systems **shall** determine on the ground/airborne status as specified in §2.2.3.2.1.1.2 to report the "CA" field reported in transponder replies.

2.4.3.2.1.1.2.1 Verification of On the Ground Determination (§2.2.3.2.1.1.2, §2.2.5.1.2, §2.2.5.1.3)

Purpose/Introduction:

This test verifies the correct encoding of the "CA" Capability field in ADS-B transmissions. If an ADS-B transmitting system supports both installations with and without automatic means of determining on the ground/airborne status, the following procedures **shall** be conducted for both configurations.

Notes:

1. *Various interface specifications require that Mode S transponder installations provide a means in which the transponder is rendered incapable of generating replies to ATCRBS, ATCRBS/Mode S All Call, and Mode S Only All Call interrogations, but continue to generate Mode S squitter transmissions and continue to reply to discretely addressed Mode S interrogations when the aircraft is on the ground. If this condition is enabled automatically when the aircraft is on the ground, a flight crew switch is not necessary. If performed manually, this condition **shall** have no effect on the transmission of extended squitters or on the reporting of on-the-ground state (DO-181C 2.1.7 b.) (EUROCAE ED-73A, section 2.5). Manual on the ground determination may be achieved through a flight crew switch. Automatic On the Ground determination can be achieved through weight on wheels, strut switch, etc..*

2. *Mode-S Transponders should also ensure that all previous TCS commands have been timed out or have been canceled prior to execution of the following*

procedures. (refer to RTCA Document No. DO-181C, §2.2.16.2.6 for additional information)

Measurement Procedure:

Step 1: "CA" Field Verification - No Input Data

The following procedure **shall** be utilized to verify that the "CA" field is properly transmitted in DF=17 messages. For ADS-B transmitting systems with automatic means of determining on the ground status, provide input external to the ADS-B transmitting system to indicate on the ground status. For Mode-S transponder based transmitting systems, force the "DR" field equal to zero (0) indicating no downlink requests. Setup the ADS-B transmitting system to broadcast extended squitters by providing data from the navigation source. After the initiation of extended squitters, remove radio altitude, ground speed and airspeed.

For ADS-B systems that have automatic means of determining on the ground status, verify that the "CA" Capability field contains a value of FOUR (binary 100) for each extended squitter type.

For ADS-B Transmitting Systems that do not have automatic means of determining on the ground status, verify that the "CA" field equals Six (binary 110) for each extended squitter type.

Step 2: "CA" Field Verification – With Input Data

Repeat the above procedure for ADS-B transmitting systems that have automatic means of determining on the ground status. Setup the ADS-B transmitting system as in step 1 except provide external input to set the ADS-B transmitting system to airborne status. Verify that the "CA" Capability field reports a value of FIVE (binary 101) for all extended squitter types.

Step 3: "FS and VS" field verification - Mode-S Transponders - Only

Refer to RTCA document DO-181C.

Step 4: "CA" Field Verification - Input Data Variation

For transponder based ADS-B transmitting systems that have automatic detection of on the ground status and have ground speed, airspeed or radio altitude available, the following procedure applies. For ADS-B Transmitting Systems for installations without automatic means of determining on the ground status, the following procedure **shall** verify that the "CA" field remains set to 6 throughout the procedure.

Set up the ADS-B transmitting system as in step 1 with on the ground status externally provided to the ADS-B transmitting system and additionally provide radio altitude input. Use a value greater than 50 feet. Vary the "Emitter Category" data input through the range of Emitter Category Sets that the system is capable. Verify that the ADS-B transmitting system correctly broadcasts each extended squitter message type with the “CA” field equal to 5 for all Emitter Category Set “A” codes 2 through 6 as specified in Table 2-9B. For all other values of Emitter Category Set “A” and for all code values of Emitter Category Sets “B,” “C” and “D” that the system supports, verify that the “CA” field equals 4.

Repeat the procedure given in the previous paragraph, except change the radio altitude data to a value less than 50 feet. Verify for each extended squitter type that the reported “CA” field equals 4 for all Emitter categories and codes that the system supports.

Maintain the radio altitude data at a value less than 50 feet and if the system is capable of accepting ground speed data input, provide ground speed data greater than 100 knots to the ADS-B transmitting system. Verify for each extended squitter type that the reported “CA” field equals 5 for Emitter category Set “A,” codes 2 through 6. For all other values of Emitter Category Set “A” and for all code values of Emitter Category Sets “B,” “C” and “D” that the system supports, verify that the “CA” field equals 4.

Maintain the radio altitude data at a value less than 50 feet and set the ground speed to a value less than or equal to 100 knots. Verify for each extended squitter type that the reported “CA” field equals 4 for all Emitter categories and codes that the system supports.

Maintain the radio altitude data at a value less than 50 feet and the ground speed at 100 knots or less. If the system is capable of accepting airspeed data input, provide airspeed data greater than 100 knots to the ADS-B transmitting system. Verify for each extended squitter type that the reported “CA” field equals 5 for Emitter category Set “A,” codes 2 through 6. For all other values of Emitter Category Set “A” and for all code values of Emitter Category Sets “B,” “C” and “D” that the system supports, verify that the “CA” field equals 4.

Maintain the radio altitude data at a value less than 50 feet and the ground speed at a value less than or equal to 100 knots. Set the airspeed to a value less than or equal to 100 knots. Verify for each extended squitter type that the reported “CA” field equals 4 for all Emitter categories and codes that the system supports.

Step 5: “CA” Field Verification - Input Data Variation

The following procedure verifies that ADS-B Transmitting Systems without automatic detection of “On-The-Ground” status and capable of inputting radio altitude, ground speed, or airspeed, correctly reports “CA” Field equal to SIX (6), even when Surface Position Message broadcast is determined according to Table 2-9A. Set up the ADS-B Transmitting System as in Step 1 above. For ADS-B Transmitting Systems with automatic means of determining “On-The-Ground” status, and capable of inputting radio altitude, ground speed or airspeed, provide external input to set the system to “Airborne” status and verify that the “CA” Field remains equal to FIVE (5) throughout this procedure.

For ADS-B Transmitting Systems capable of accepting radio altitude input, provide a value less than 50 feet. Do not input airspeed or ground speed data. Verify that the system broadcasts extended squitters with the "CA" Field equal to SIX (6).

For ADS-B Transmitting Systems capable of accepting ground speed input, provide a value less than 100 knots. Do not input airspeed or radio altitude data. Verify that the system broadcasts extended squitters with the "CA" Field equal to SIX (6).

For ADS-B Transmitting Systems capable of accepting airspeed input, provide a value less than 100 knots. Do not input ground speed or radio altitude data. Verify that the system broadcasts extended squitters with the "CA" Field equal to SIX (6).

2.4.3.2.1.1.2.2 Verification of Air/Ground Format Selection (§2.2.3.2.1.1.2, §2.2.5.1.3)

Purpose/Introduction:

The following test **shall** verify that the ADS-B Transmission Device properly selects the Airborne or Surface Message formats for broadcast. The determination is based upon the Air/Ground Status data input for aircraft with automatic means of determining on the ground status. Otherwise, the ADS-B Transmitting system broadcasts Airborne Messages unless the requirements of Table 2-9A are met to emit Surface Position Messages.

Measurement Procedure:

Step 1: Ground Status Verification - No Input Data

For ADS-B transmitting systems with automatic means of determining on the ground status, provide input external to the ADS-B transmitting system to indicate on the ground status. Setup the ADS-B transmitting system to broadcast extended squitters by providing data from the navigation source. Provide no radio altitude data, ground speed or airspeed data to the ADS-B transmitting system. For ADS-B systems that have automatic means of determining on the ground status, verify that the Surface Position Message is broadcast at the proper rate for each extended squitter type. For ADS-B Transmitting Systems that do not have automatic means of determining on the ground status, verify that the system broadcasts Airborne Position and Velocity Messages at the proper rate.

Step 2: Airborne Status Verification – No Input Data

For ADS-B transmitting systems with automatic means of determining on the ground status, provide input external to the ADS-B transmitting system to indicate airborne status. Setup the ADS-B transmitting system to broadcast extended squitters by providing data from the navigation source. Provide no radio altitude, ground speed or airspeed data to the ADS-B transmitting system. Verify that Airborne Position and Velocity Messages are broadcast at the proper rate.

Step 3: Air/Ground Status Verification - Input Data Variation

For ADS-B transmitting systems with automatic means of determining on the ground status, provide input external to the ADS-B transmitting system to indicate airborne status. Setup the ADS-B transmitting system to broadcast extended squitters by providing data from the navigation source. Provide Radio Altitude data, ground speed and airspeed data to the ADS-B transmitting system according to the values defined in Table 2-84 or in the case of no data, stop providing the data as indicated. For ADS-B transmitting systems with automatic means of determining on the ground status, verify that the ADS-B Transmitting System broadcasts Airborne Position and Velocity Messages for each run. For ADS-B transmitting systems without automatic means of determining on the ground status, verify that Airborne Position and Velocity messages or Surface Position Messages as indicated in Table 2-84 are broadcast at the proper rate for each run.

Table 2-84: Air/Ground Format Selection

Emitter Category / Coding	Ground Speed (knots)	Airspeed (knots)	Radio Altitude (feet)	Broadcast Format
A/2 – 6 B/7	50	100	50	Surface
A/2 – 6 B/7	100	75	50	Surface
A/2 – 6 B/7	No Data	75	50	Surface
A/2 – 6 B/7	No Data	50	No Data	Surface
A/2 – 6 B/7	100	100	25	Surface
All	100	No Data	No Data	Airborne
All	100	100	50	Airborne
A/2 – 6 B/7	75	No Data	No Data	Surface
A/2 – 6 B/7	No Data	100	50	Surface
A/2 – 6 B/7	100	No Data	25	Surface
A/2 - 6 B/7	No Data	No Data	25	Surface
All	100	100	No Data	Airborne

Step 4: Air/Ground Status Verification - input data variation

For ADS-B transmitting systems with automatic means of determining on the ground status, provide input external to the ADS-B transmitting system to indicate ground status. Setup the ADS-B transmitting system to broadcast extended squitters by providing data from the navigation source. Provide radio altitude data, ground speed and airspeed data to the ADS-B transmitting system according to the values defined in Table 2-85 or in the case of no data, stop providing the data as indicated. Verify that Airborne Position and Velocity messages or Surface Position Messages as indicated in Table 2-84 are broadcast at the proper rate for each run.

Table 2-85: Air/Ground Format Selection

Emitter Category / Coding	Ground Speed (knots)	Airspeed (knots)	Radio Altitude (feet)	Broadcast Format
A/2 - 6	150	100	50	Airborne
A/2 - 6	100	100	75	Airborne
A/2 - 6	100	150	50	Airborne
A/2 - 6	No Data	150	50	Airborne
A/2 - 6	No Data	150	No Data	Airborne
A/2 - 6	100	No Data	51	Airborne
All	100	No Data	No Data	Surface
All	50	75	No Data	Surface
All	100	100	50	Surface
All	50	No Data	25	Surface
A/2 - 6	150	No Data	No Data	Airborne
A/2 - 6	No Data	No Data	150	Airborne
All	No Data	50	No Data	Surface
All	No Data	No Data	100	Surface
A/2 – 6	200	50	No Data	Airborne
All	No Data	100	50	Surface

2.4.3.2.1.1.3 Verification of “CF” and “AF” (used in DF=18 and DF=19) (§2.2.3.2.1.1.3)

Appropriate test procedures to verify the “CF” or “AF” field (§2.2.3.2.1.1.3) are included in the verification of the “PI” field in §2.4.3.2.1.1.6.

2.4.3.2.1.1.4 Verification of “DF” Downlink Format Field (§2.2.3.2.1.1.4)

Appropriate test procedures to verify the “DF” field (§2.2.3.2.1.1.4) are included in the verification of the “PI” field in §2.4.3.2.1.1.6.

2.4.3.2.1.1.5 Verification of “ME” Message, Extended Squitter (§2.2.3.2.1.1.5)

No specific test procedure is required to validate §2.2.3.2.1.1.5.

2.4.3.2.1.1.6 Verification of “PI” Parity / Identity (§2.2.3.2.1.1.6, §2.2.5.1.1)

Purpose/Introduction:

The following test **shall** verify that the ADS-B transmitting system correctly outputs the Address (AA) field of ADS-B Messages, calculates the proper parity of ADS-B Messages and correctly outputs the PI field in the transmitted ADS-B Messages.

Measurement Procedure:

Configure the ADS-B Transmitting Subsystem to emit ADS-B Messages having Type Code equal to “0” and no Altitude data. Effectively, establish the messages with the “ME” field set to all ZEROs as indicated in Table 2-86. Refer to Table 2-86 and select the appropriate Set of stimulus to run for the type of equipment being tested as follows:

a. For equipment that can transmit “DF” = 17 and “CA” = 0, use Set 1.

b. For equipment that can transmit “DF” = 17 and “CA” = 4, use Set 2.

c. For equipment that can transmit “DF” = 17 and “CA” = 5, use Set 3.

d. For equipment that can transmit “DF” = 17 and “CA” = 6, use Set 4.

e. For equipment that can transmit “DF” = 17 and “CA” = 7, use Set 5.

f. For equipment that can transmit “DF” = 18 with “CF” = 0, use Set 6. Note that this is the case where the equipment is non-Transponder.

g. For equipment that can transmit “DF” = 19 with “AF” = 0, use Set 7. Note that this case is where the equipment is for Military Applications.

h. Where an equipment is capable of transmitting several of the cases described in paragraphs “a.” through “f.,” above, it should suffice that the equipment be testing to only one of the cases since the parity encoding should work the same for all.

For the Set of stimulus given in Table 2-86 that is selected for the equipment under test, establish each of the eight cases by establishing the message having “DF,” “CA” or “CF,” “AA,” and “ME” fields as indicated in Table 2-86.

Note: *Since the ADS-B Transmission function should not accept changes in the ICAO 24-Bit Address after initial power on, it will be necessary to re-cycle power to the unit under test each time that the ICAO 24-Bit Address is changed in this procedure.*

For each case of stimulus provided, verify that the ADS-B transmitting function properly generates the associated “PI” code as given in column 6 of Table 2-86.

Verify that the “AA” field (i.e., the ICAO 24-Bit Address) cannot be changed once the unit under test has been powered to the operational state.

Table 2-86: "PI" Field Encoding

Column #		1	2	3	4	5	6
		Bit #	1 --- 5	6 -- 8	9 -------------- 32	33 -------------- 88	89 ------ 112
SET #	CASE #	Field Name	"DF"	"CA" ("CF")	"AA" [HEX]	"ME" [HEX]	"PI" [HEX]
#1	1		1 0001	000	AA AA AA	ALL ZEROs	46E012
	2		1 0001	000	55 55 55	ALL ZEROs	5B7924
	3		1 0001	000	77 77 77	ALL ZEROs	7DC67B
	4		1 0001	000	BB BB BB	ALL ZEROs	AA45B9
	5		1 0001	000	DD DD DD	ALL ZEROs	C18458
	6		1 0001	000	EE EE EE	ALL ZEROs	B9EAC
	7		1 0001	000	FE DC BA	ALL ZEROs	7790F4
	8		1 0001	000	AB CD EF	ALL ZEROs	7EE5D2
#2	1		1 0001	100	AA AA AA	ALL ZEROs	D8D1FB
	2		1 0001	100	55 55 55	ALL ZEROs	C548CD
	3		1 0001	100	77 77 77	ALL ZEROs	E3F792
	4		1 0001	100	BB BB BB	ALL ZEROs	347450
	5		1 0001	100	DD DD DD	ALL ZEROs	5FB5B1
	6		1 0001	100	EE EE EE	ALL ZEROs	95AF45
	7		1 0001	100	FE DC BA	ALL ZEROs	E9A11D
	8		1 0001	100	AB CD EF	ALL ZEROs	E0D43B
#3	1		1 0001	101	AA AA AA	ALL ZEROs	80A083
	2		1 0001	101	55 55 55	ALL ZEROs	9D39B5
	3		1 0001	101	77 77 77	ALL ZEROs	BB86EA
	4		1 0001	101	BB BB BB	ALL ZEROs	6C0528
	5		1 0001	101	DD DD DD	ALL ZEROs	07C4C9
	6		1 0001	101	EE EE EE	ALL ZEROs	CDDE3D
	7		1 0001	101	FE DC BA	ALL ZEROs	B1DD65
	8		1 0001	101	AB CD EF	ALL ZEROs	B8A543
#4	1		1 0001	110	AA AA AA	ALL ZEROs	68330B
	2		1 0001	110	55 55 55	ALL ZEROs	75AA3D
	3		1 0001	110	77 77 77	ALL ZEROs	531562
	4		1 0001	110	BB BB BB	ALL ZEROs	8496A0
	5		1 0001	110	DD DD DD	ALL ZEROs	EF5741
	6		1 0001	110	EE EE EE	ALL ZEROs	254DB5
	7		1 0001	110	FE DC BA	ALL ZEROs	5943ED
	8		1 0001	110	AB CD EF	ALL ZEROs	5036CB
#5	1		1 0001	111	AA AA AA	ALL ZEROs	304273
	2		1 0001	111	55 55 55	ALL ZEROs	2DDB45
	3		1 0001	111	77 77 77	ALL ZEROs	0B641A
	4		1 0001	111	BB BB BB	ALL ZEROs	DCE7D8
	5		1 0001	111	DD DD DD	ALL ZEROs	B72639
	6		1 0001	111	EE EE EE	ALL ZEROs	7D3CCD
	7		1 0001	111	FE DC BA	ALL ZEROs	013295
	8		1 0001	111	AB CD EF	ALL ZEROs	0847B3
#6	1		1 0010	000	AA AA AA	ALL ZEROs	FDAC76
	2		1 0010	000	55 55 55	ALL ZEROs	E03540
	3		1 0010	000	77 77 77	ALL ZEROs	C68A1F
	4		1 0010	000	BB BB BB	ALL ZEROs	1109DD
	5		1 0010	000	DD DD DD	ALL ZEROs	7AC83C
	6		1 0010	000	EE EE EE	ALL ZEROs	B0D2C8
	7		1 0010	000	FE DC BA	ALL ZEROs	CCDC90
	8		1 0010	000	AB CD EF	ALL ZEROs	C5A9B6
#7	1		1 0011	000	AA AA AA	ALL ZEROs	3E3BAD
	2		1 0011	000	55 55 55	ALL ZEROs	23A29B
	3		1 0011	000	77 77 77	ALL ZEROs	051DC4
	4		1 0011	000	BB BB BB	ALL ZEROs	D29E06
	5		1 0011	000	DD DD DD	ALL ZEROs	B95FE7
	6		1 0011	000	EE EE EE	ALL ZEROs	734513
	7		1 0011	000	FE DC BA	ALL ZEROs	0F4B4B

	8		1 0011	000	AB CD EF	ALL ZEROs	063E6D

2.4.3.2.2 Verification of DF=17 and 18 Format Structures (§2.2.3.2.2)

No specific test procedure is required to validate §2.2.3.2.2.

2.4.3.2.3 Verification of ADS-B Airborne Position Messages (§2.2.3.2.3)

No specific test procedure is required to validate §2.2.3.2.3.

2.4.3.2.3.1 Verification of "TYPE" Subfield in ADS-B Airborne Position Messages (§2.2.3.2.3.1)

Purpose/Introduction:

This test procedure verifies that the ADS-B Transmitting System correctly outputs Airborne Position Messages with the correct TYPE subfield data content in Message Bits 33 through 37 in DF 17 Messages for Transponder Based Systems and DF 18 Messages for Non Transponder Based Systems. The ME field of the Airborne Position Message contains the TYPE subfield in bits 1 through 5 which is utilized to categorize the navigational accuracy of the position information. The ADS-B Transmitting System determines and outputs the TYPE subfield based upon the input it receives from the possible Navigational sources that may interface to the system. The ADS-B Transmitting System may receive the TYPE subfield directly through an external interface instead of dynamically determining the TYPE subfield. Whatever the implementation, the test cases must exercise all of the resulting TYPE code possibilities. If an ADS-B Transmitting System can only generate a subset of the possible Airborne Position Message Types, then only those test cases required to produce the possible Type codes **shall** be tested. The test configuration is based on the type(s) of Navigational System(s) that may interface to the ADS-B Transmitting System and the data it provides.

Measurement Procedure:

Step 1: Verification of Type Codes 9 through 18 and 20 through 22 with GNSS/Baro Altitude

Configure the ADS-B Transmitting System to transmit Airborne Position Messages by providing position information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set the ADS-B Transmitting System to Airborne status. Provide valid non zero barometric pressure altitude data to the ADS-B System. For each positional accuracy category supported, verify that the TYPE subfield in the ADS-B Message correctly matches the TYPE subfield value from the navigational accuracy depicted in Table 2-11. The TYPE code may be derived by either the Horizontal Protection Limits (HPL), or the Horizontal Position Error contained in the table. To test all of the possible resulting TYPE codes that could be produced from the Navigational source, degradation of the position data from the Navigation source may require an alarm or alert condition that must be sensed by the ADS-B Transmitting System. The TYPE subfield **shall** contain values in the range from 9 through 18.

Verify that TYPE codes 9 and 10 cannot be set if the unit under test is not provided with either a GNSS Time Mark (see §2.2.5.1.6) or UTC data unless the Non-Coupled Case of position estimation (see §2.2.3.2.3.7.2.2 for Latitude, and §2.2.3.2.3.8.2.2 for Longitude) is implemented.

Note: *UTC data is not acceptable to be used in place of GNSS Time Mark (see §2.2.5.1.6) due to the fact that UTC data may not be available for any possible time up to 200 milliseconds after the leading edge of the GNSS Time Mark. Therefore, UTC data may not be used to establish TYPE codes 9 and 10.*

Stop providing input of barometric altitude to the ADS-B Transmitting System. If the GNSS source provides GNSS Altitude data, verify that the TYPE subfield in the ADS-B Message correctly matches the TYPE subfield value from the navigational accuracy depicted in Table 2-11 for TYPE codes 20 through 22.

Verify that TYPE codes 20 and 21 cannot be set if the unit under test is not provided with either a GNSS Time Mark (see §2.2.5.1.6) or UTC data, unless the Non-Coupled Case of position estimation (see §2.2.3.2.3.7.2.2 for Latitude, and §2.2.3.2.3.8.2.2 for Longitude) is implemented.

Note: *UTC data is not acceptable to be used in place of GNSS Time Mark (see §2.2.5.1.6) due to the fact that UTC data may not be available for any possible time up to 200 milliseconds after the leading edge of the GNSS Time Mark. Therefore, UTC data may not be used to establish TYPE codes 20 and 21.*

Step 2: Verification of Type Codes 20 through 22 with GNSS Altitude

This step **shall** be performed for all ADS-B Transmitting Systems capable of broadcasting GNSS Altitude data. Configure the ADS-B Transmitting System to transmit Airborne Position Messages. Disconnect the barometric altitude source to the ADS-B Transmitting System so that only GNSS altitude data is available. For each positional accuracy category supported, verify that the TYPE subfield in the ADS-B Message correctly matches the TYPE subfield value from the navigational accuracy depicted in Table 2-11 for TYPE codes 20 through 22. The TYPE code may be derived by either the Horizontal Protection Limits (HPL), or the Horizontal Position Error contained in the table. To test all of the possible resulting TYPE codes that could be produced from the Navigational source, degradation of the position data from the Navigation source may require an alarm or alert condition that must be sensed by the ADS-B Transmitting System. If the GNSS Height accuracy and Horizontal Position Error vary independently, test all possible resultant TYPE codes from input data accuracy variations and verify that the least accurate data determines the TYPE code.

2.4.3.2.3.1.1 Verification of Airborne Position Message Type Code if Containment Radius is Available (§2.2.3.2.3.1.1)

Appropriate test procedures are provided in §2.4.3.2.3.1.

2.4.3.2.3.1.2 Verification of Airborne Position Message Type Code if Containment Radius is Not Available (§2.2.3.2.3.1.2)

Appropriate test procedures are provided in §2.4.3.2.3.1.

2.4.3.2.3.1.3 Verification of Special Processing for Type Code ZERO (§2.2.3.2.3.1.3)

No specific test procedure is required to validate §2.2.3.2.3.1.3.

2.4.3.2.3.1.3.1 Verification of Significance of Type Code Equal to ZERO (§2.2.3.2.3.1.3.1)

Purpose/Introduction:

Airborne Position Messages may be transmitted with a TYPE code of ZERO (0) under the following conditions:

An Airborne Position Message with a TYPE code of ZERO (0) **shall** set all 56 bits of the "ME" field bits to ZERO if NO barometric pressure Altitude data is available. If valid pressure altitude data IS available, then the "Altitude" Subfield, "ME" bits 9 through 20, Message Bits 41 through 52, **shall** report the altitude in accordance with §2.2.3.2.3.4.3.

Measurement Procedure:

Step 1: Type ZERO Verification - Part 1

Configure the ADS-B Transmitting System to Airborne status. Provide valid altitude code data to the ADS-B Transmitting System. Connect the GNSS data input and verify that Airborne Position, Velocity and Aircraft Identification Messages are transmitted at the proper rate. Stop update of the Navigational source of Airborne Latitude and Longitude position information. If the ADS-B Transmitting System is capable of receiving Airborne position data from more than one Navigation source, verify the following by disconnecting each Navigation source separately. Verify that after 2 seconds, the TYPE code of ZERO is transmitted twice per second. Verify that the remaining ME Bits of the message are ZERO, except for the Altitude subfield. After 60 seconds, verify that the Airborne Position Message is no longer transmitted. Connect the GNSS data input and verify that Surface Position and Airborne Position Messages are no longer transmitted.

Repeat above if the Latitude and Longitude sources can be received separately. Stop update of Latitude data while maintaining update of Longitude data and verify that TYPE code of ZERO is transmitted twice per second after 2 seconds from data input disconnection.

Repeat above except stop update of Longitude data while maintaining update of Latitude data and verify that TYPE code of ZERO is transmitted twice per second after 2 seconds from data input disconnection.

Step 2: Type ZERO Verification - Part 2

Setup the ADS-B Transmitting System as in Step 1. Provide valid altitude code data to the ADS-B Transmitting System. Connect the GNSS data input and verify that Airborne Position, Velocity and Aircraft Identification Messages are transmitted at the proper rate. Stop update of the Navigational source of Airborne Latitude and Longitude position information. If the ADS-B Transmitting System is capable of receiving Airborne position data from more than one Navigation source, verify the following by disconnecting each Navigation source separately. Verify that after 2 seconds, the TYPE code is ZERO and the remaining ME Bits are ZERO, except for the altitude data. After 60 seconds, verify that the Airborne Position Message is no longer transmitted.

2.4.3.2.3.1.3.2 Verification of Broadcast of Type Code Equal to ZERO (§2.2.3.2.3.1.3.2)

Appropriate test procedures are provided in §2.4.3.2.3.1.3.1.

2.4.3.2.3.1.4 Verification of Type Code based on Horizontal Position and Altitude Data (§2.2.3.2.3.1.4)

Appropriate test procedures are provided in §2.4.3.2.3.1.

2.4.3.2.3.2 Verification of "SURVEILLANCE STATUS" Subfield in ADS-B Airborne Position Messages (§2.2.3.2.3.2, 2.2.5.1.4)

Purpose/Introduction:

The Surveillance Status Subfield (SSS) is contained in ADS-B Airborne Position Messages Types 0, 9 through 18, and 20 through 22. The subfield is a 2-bit subfield used to indicate Alert Conditions and SPI Condition utilized in ATCRBS for ATC operations. The alert conditions, as defined, are generated external to the ADS-B Transmitting System. When an alert condition is generated and appears at the input to the ADS-B Transmitting System, the SSS **shall** indicate the proper code in the Airborne Position Message, using ME Bits 6 and 7. SSS **shall** be verified for all possible Airborne Position Messages. If the ADS-B Transmitting System is a Stand Alone Transmitter, and does not have the ability to set SSS, simply verify that SSS is ZERO in all generated Airborne Position Messages.

Measurement Procedure:

Step 1: Verification of "SSS" = "0"

Configure the ADS-B Transmitting System to transmit Airborne Position Messages. Disconnect the source for Permanent Alert Condition, Temporary Alert Condition and SPI Condition to the ADS-B Transmitting System. Verify that SSS is ZERO in Airborne Position Messages.

Step 2: Verification of "SSS" = Non "0"

Connect the source(s) for Permanent Alert Condition, Temporary Alert Condition and SPI Condition to the ADS-B Transmitting System. Input the following conditions:

a. Set the Permanent Alert Condition and verify that "SSS" equals "1" in Airborne Position Messages.

b. Set the Temporary Alert Condition and verify that "SSS" equals "2" in Airborne Position Messages.

c. Ensure Temporary Alert Condition is cleared. Set the SPI Condition and verify that "SSS" equals "3" in Airborne Position Messages.

d. Set the Permanent Alert Condition and the SPI Condition and verify that "SSS" equals "1" in Airborne Position Messages.

e. Set the Temporary Alert Condition and the SPI Condition and verify that "SSS" equals "2" in Airborne Position Messages.

2.4.3.2.3.3 Verification of "SINGLE ANTENNA" Subfield in ADS-B Airborne Position Messages (§2.2.3.2.3.3)

Purpose/Introduction:

The "SINGLE ANTENNA" subfield is a 1-bit field (ME Bit 8, Message Bit 40) used to indicate that the ADS-B transmitting function is operating with a single antenna. The following conventions apply to both Transponder Based and Stand Alone ADS-B Transmitting functions:

Measurement Procedure:

Step 1: Non-Diversity Configuration

For ADS-B Transmitting Systems that operate with a single antenna, configure the system to broadcast Airborne Position Messages. Verify that the Single Antenna subfield is set to "ONE" (1) at all times in the Airborne Position Message.

Step 2: Diversity Configuration

For ADS-B Transmitting Systems that operate in the diversity mode, configure the system to broadcast Airborne Position Messages. Verify that the Single Antenna subfield is set to "ZERO" (0) at all times in the Airborne Position Message.

Disable one antenna channel by whatever means that the ADS-B Transmitting System utilizes to detect a non-functioning antenna channel. Verify that the

Single Antenna subfield is set to "ONE" (1) in the Airborne Position Message. Repeat, except disable the alternate channel and verify that the Single Antenna subfield is set to ONE (1) in the Airborne Position Message.

2.4.3.2.3.4 Verification of "ALTITUDE" Subfield in ADS-B Airborne Position Messages (§2.2.3.2.3.4)

No specific test procedure is required to validate §2.2.3.2.1.

2.4.3.2.3.4.1 Verification of "BAROMETRIC ALTITUDE" in ADS-B Airborne Position Messages (§2.2.3.2.3.4.1, §2.2.5.1.5)

Purpose/Introduction:

This procedure verifies that the barometric altitude is reported correctly in ADS-B Messages and that the altitude field reported matches the altitude data at the input interface to the ADS-B transmitting system. The barometric altitude is reported in the "Altitude" subfield of ADS-B Message Type Code 0 and Airborne Position Type Codes 9 through 18.

Measurement Procedure:

Configure the ADS-B Transmitting System to transmit Airborne Position Messages. If the ADS-B transmitter is based on a Mode S transponder, set the ATS input to the transponder to ZERO.

Step 1: No Barometric Altitude Data

Disconnect the altitude source from the ADS-B Transmitting System. Verify that all altitude bits (Message Bits 41 through 52, and "ME" Bits 9 through 20) in Airborne Position Messages are set to ZERO.

Step 2: Barometric Altitude Data Available

Connect the barometric altitude source to the ADS-B Transmitting System.

Provide the ADS-B Transmitting System with the barometric Altitude Input_A values provided for each case in the following table.

For each case, verify that the altitude code is properly encoded into the Airborne Position Message Altitude Subfield.

Provide the ADS-B Transmitting System with the barometric Altitude Input_B values provided for each case in the following table.

For each case, verify that the altitude code is properly encoded into the Airborne Position Message Altitude Subfield.

Table 2-87: Barometric Altitude Data Inputs

Case #	Altitude Input_A (100 foot increments)	Altitude Input_B (≤ 25 foot increments)
1	- 1,000	- 1,012
2	- 900	- 500
3	- 200	- 12.5
4	0	0
5	800	18,025
6	2,800	32,050
7	6,800	50,175
8	14,800	50,200
9	30,800	51,600
10	62,800	79,800

2.4.3.2.3.4.2 Verification of "GNSS Height Above the Ellipsoid (HAE)" in ADS-B Airborne Position Messages (§2.2.3.2.3.4.2)

Purpose/Introduction:

This procedure verifies that GNSS Height (HAE) is reported correctly in ADS-B Messages and that the altitude field reported is consistent with the GNSS Height (HAE) data at the input interface to the ADS-B transmitting system. The GNSS Height (HAE) is reported in the "Altitude" subfield of Airborne Position Messages having Type Codes 20 through 22.

Measurement Procedure:

Configure the ADS-B Transmitting System to transmit Airborne Position Messages having any Type Code between 20 -and- 22. If the ADS-B transmitter is based on a Mode S transponder, set the ATS input to ONE (1).

Step 1: No GNSS Height (HAE) Data

Disconnect the GNSS Height (HAE) source from the ADS-B Transmitting System. Verify that all altitude bits (Message Bits 41 through 52, and "ME" Bits 9 through 20) in Airborne Position Messages are set to ZERO.

Step 2: GNSS Height (HAE) Data Available

Connect the GNSS Height (HAE) source to the ADS-B Transmitting System.

Provide the ADS-B Transmitting System with the GNSS Height (HAE) input values provided for each case in the following table.

For each case, verify that the altitude code is properly encoded into the Airborne Position Message Altitude Subfield.

Table 2-88: GNSS Height (HAE) Data Inputs

Case #	GNSS Height (HAE) (≤ 25 foot increments)
1	- 1,012
2	- 500
3	- 12.5
4	0
5	18,025
6	32,050
7	50,175
8	50,200
9	51,600
10	79,800

2.4.3.2.3.4.3 Verification of "ALTITUDE ENCODING" in ADS-B Airborne Position Messages (§2.2.3.2.3.4.3)

Appropriate test procedures to verify §2.2.3.2.3.4.3 were previously provided in §2.4.3.2.3.4.1 and §2.4.3.2.3.4.2.

2.4.3.2.3.5 Verification of "TIME" (T) Subfield in ADS-B Airborne Position Messages (§2.2.3.2.3.5, §2.2.5.1.6, §2.2.5.1.6.1, §2.2.5.1.6.2)

Purpose/Introduction:

The "TIME" (T) subfield is a 1-bit field (ME Bit 21, Message Bit 53) that indicates whether or not the epoch of validity for the horizontal position data in an Airborne Position Message is an exact 0.2 second UTC epoch. If the time of applicability of the position data is synchronized to an exact 0.2 second UTC epoch, the "TIME" (T) subfield **shall** be set to ONE (1); otherwise, the "TIME" (T) subfield **shall** be set to ZERO (0).

Measurement Procedure:

Configure the ADS-B Transmitting System to transmit Airborne Position Messages by providing position information at the nominal rate. Ensure that the time of applicability of the position data is synchronized to an exact 0.2 second UTC epoch. Verify that the ADS-B Transmitting System accepts a GNSS TIME MARK, or equivalent input from the navigation data source, which is required in order to be able to update the position data from the navigation data source to an exact 0.2 second UTC epoch. Verify that the "TIME" (T) subfield is set to ONE (1).

If the ADS-B Transmitting System is not capable of receiving a GNSS Time Mark, or if the input is not available, verify that the "TIME" (T) subfield is set to ZERO (0).

Note: *The ADS-B Transmitting Subsystem must be capable of monitoring the GNSS Time Mark unless the non-coupled case (see §2.2.3.2.4.7.2.2) is implemented.*

2.4.3.2.3.6 Verification of "CPR FORMAT" (F) Subfield in ADS-B Airborne Position Messages (§2.2.3.2.3.6)

Appropriate test procedures required to validate §2.2.3.2.3.6 are provided in §2.4.3.2.3.7.1 and §2.4.3.2.3.8.1.

2.4.3.2.3.7 Verification of "ENCODED LATITUDE" Subfield in ADS-B Airborne Position Messages (§2.2.3.2.3.6, §2.2.3.2.3.7, §2.2.5.1.7, §2.2.5.1.13, Appendix A.1.7)

Appropriate test procedures required to validate §2.2.3.2.3.7 are provided in §2.4.3.2.3.7.1 through §2.4.3.2.3.7.4.

2.4.3.2.3.7.1 Verification of Airborne Latitude and Longitude Data Encoding (§2.2.3.2.3.6, §2.2.3.2.3.7, §2.2.3.2.3.7.1, §2.2.3.2.3.8, §2.2.3.2.3.8.1, §2.2.5.1.7, §2.2.5.1.8, §2.2.5.1.12, §2.2.5.1.13, Appendix A.1.7)

Purpose/Introduction:

The "ENCODED LATITUDE" subfield is a 17-bit field (ME Bits 23 through 39, Message Bits 55 through 71) containing the encoded latitude of the airborne position. The following test procedure verifies that the ADS-B Transmitting System correctly receives Latitude position data from the Navigation source and outputs encoded Latitude data in the Airborne Position Message. The Latitude data is encoded according to the Compact Position Reporting (CPR) Format described in Appendix A. The Latitude data is dependent upon the positional accuracy supported by the ADS-B Transmitting System.

The following procedure verifies the ***static*** latitude encoding where the velocity input is 0.0 knots and is intended to verify the actual CPR Latitude encoding precision.

Note: *The following procedures are specifically intended to indicate any gross errors in implementation of the CPR encoding algorithm provided in Appendix A.*

Measurement Procedure:

Step 1: Establish Initial Conditions

a. Configure the ADS-B Transmitting System to create an Airborne Position Message, i.e., Type Codes 9 through 18, or 20 through 21.

b. Ensure that the Velocity input provided to the ADS-B Transmitting System is set to **ZERO**.

Step 2: Verify Encoded Latitude Data

a. Via the appropriate Navigation Data Source interface, provide the ADS-B Transmitting system with the exact latitude and longitude data pair provided in the Angular Weighted Binary Values Latitude and Longitude Columns for each line item given in Table 2-89.

Provide the latitude and longitude data via the interface at the nominal rate of the navigation data source.

Allow the system to stabilize for at least 2 seconds after the data change prior to continuing with the following steps.

Table 2-89: Airborne Position Encoding Values

Angular Weighted Binary Values (degrees)				Even Airborne Encoding		Odd Airborne Encoding	
Latitude Decimal	**Latitude HEX**	**Longitude Decimal**	**Longitude HEX**	**Latitude HEX**	**Longitude HEX**	**Latitude HEX**	**Longitude HEX**
-90.000000	C0000000	-180.000000	80000000	00000	10000	08000	10000
-89.950000	C0091A2B	179.500000	7FA4FA50	00444	0FF4A	08432	0FF4A
-89.500000	C05B05B0	178.500000	7EEEEEEF	02AAB	0FDDE	0A9F5	0FDDE
-89.000000	C0B60B61	175.500000	7CCCCCCD	05555	0F99A	0D3E9	0F99A
-87.500000	C1C71C72	-165.000000	8AAAAAAB	0D555	11555	151C7	11555
-86.750000	C24FA4FA	-171.500000	860B60B6	11555	0182E	190B6	10C17
-86.500000	C27D27D2	-172.500000	85555555	12AAB	12000	1A5B0	01555
-85.850000	C2F37C05	65.750000	2EC16C17	16222	11889	1DC3B	0BB06
-85.000000	C38E38E4	-142.750000	9A7D27D2	1AAAB	0D3E9	0238E	19EEF
-84.250000	C416C16C	60.000000	2AAAAAAB	1EAAB	1AAAB	0627D	15555
-83.550000	C4962FC9	-60.000000	D5555555	02666	00000	09D3A	05555
-82.680000	C53490BA	120.000000	55555555	070A4	0AAAB	0E63B	00000
-81.750000	C5DDDDDE	-120.000000	AAAAAAAB	0C000	0AAAB	13444	15555
-80.250000	C6EEEEEF	144.000000	66666666	14000	13333	1B222	06666
-79.750000	C749F49F	-144.000000	9999999A	16AAB	00000	1DC17	0CCCD
-78.400000	C83FB72F	-121.000000	A9F49F4A	1DDDE	09B06	04D5E	1471C
-77.400000	C8F5C28F	121.000000	560B60B6	03333	01111	0A148	164FA
-76.550000	C9907F6E	-154.280000	924A2EE0	07BBC	0DB89	0E89B	1B6F4
-75.600000	CA3D70A4	154.280000	6DB5D120	0CCCD	1FFE3	13852	12477
-74.750000	CAD82D83	157.500000	70000000	11555	12000	17FA5	04000
-73.650000	CBA06D3A	-157.500000	90000000	17333	00000	1DBF2	0E000
-72.750000	CC444444	-120.000000	AAAAAAAB	1C000	0AAAB	02777	15555
-71.550000	CD1EB852	120.000000	55555555	02666	00000	08C29	15555
-70.650000	CDC28F5C	-144.000000	9999999A	07333	0CCCD	0D7AE	1999A
-69.550000	CE8ACF13	144.000000	66666666	0D111	00000	133FB	13333
-68.750000	CF1C71C7	-114.550000	AE8ACF13	11555	0A2C6	1771C	145B0
-67.750000	CFD27D28	114.550000	517530ED	16AAB	00024	1CB06	15D3A
-66.550000	D0ACF135	-67.500000	D0000000	1D111	16000	02FB7	1C000
-65.550000	D162FC96	67.500000	30000000	02666	10000	083A0	0A000
-64.450000	D22B3C4D	-83.080000	C4EBBF60	08444	0760B	0DFEE	0EC34
-63.250000	D305B05B	83.080000	3B1440A0	0EAAB	0001D	1449F	189F5
-62.250000	D3BBBBBC	-64.290000	D2485CD8	14000	05B44	19889	0B6B3
-61.250000	D471C71C	64.290000	2DB7A328	19555	0002C	1EC72	1A4BC
-60.250000	D527D27D	-72.000000	CCCCCCCD	1EAAB	06666	0405B	0CCCD
-59.960000	D55C9D78	-120.500000	AA4FA4FA	0036A	0960B	058B1	1416C

<u>Table 2-89</u>: Airborne Position Encoding Values (con't)

Angular Weighted Binary Values (degrees)				Even Airborne Encoding		Odd Airborne Encoding	
Latitude	**Latitude**	**Longitude**	**Longitude**	**Latitude**	**Longitude**	**Latitude**	**Longitude**
Decimal	**HEX**	**Decimal**	**HEX**	**HEX**	**HEX**	**HEX**	**HEX**
-59.955000	D55D867C	120.000000	55555555	003D7	15555	0591C	0AAAB
-59.930000	D5621392	-119.500000	AB05B05B	005F9	01555	05B35	0BF4A
-58.000000	D6C16C17	-78.750000	C8000000	0AAAB	07000	0FD28	0E000
-58.500000	D6666666	78.750000	38000000	08000	19000	0D333	12000
-57.950000	D6CA8642	-22.500000	F0000000	0AEEF	02000	1015A	04000
-56.850000	D792C5F9	22.500000	10000000	10CCD	00000	15DA7	1E000
-55.500000	D8888889	-52.940000	DA5A912E	18000	04B59	1CEEF	096A4
-54.620000	D928BB81	52.940000	25A56ED2	1CB18	1FFF1	018C6	1B4A7
-53.250000	DA222222	-30.000000	EAAAAAAB	04000	02AAB	08BBC	05555
-51.950000	DB0ECA86	30.000000	15555555	0AEEF	00000	0F8D1	1D555
-50.750000	DBE93E94	-75.790000	CA1ADA00	11555	06BC3	15D83	0D78D
-49.650000	DCB17E4B	75.790000	35E52600	17333	00007	1B9D0	1943D
-48.250000	DDB05B06	-27.000000	ECCCCCCD	1EAAB	02666	02F4A	04CCD
-47.000000	DE93E93F	27.000000	13333333	05555	00000	0982E	1D99A
-45.600000	DF92C5F9	-68.570000	CF3D3663	0CCCD	0619B	10DA7	0C321
-44.250000	E0888889	-180.000000	80000000	14000	00000	17EEF	10000
-42.850000	E1876543	179.500000	7FA4FA50	1B777	0E16C	1F469	1E222
-41.400000	E28F5C29	178.500000	7EEEEEEF	03333	1A222	06E14	0A444
-40.000000	E38E38E4	175.500000	7CCCCCCD	0AAAB	1E000	0E38E	0E666
-38.500000	E49F49F5	-160.900000	8D950C84	12AAB	0E190	1616C	1C666
-36.900000	E5C28F5C	-171.500000	860B60B6	1B333	1382E	1E7AE	02C17
-35.250000	E6EEEEEF	-172.500000	85555555	04000	00000	07222	0F555
-33.600000	E81B4E82	65.750000	2EC16C17	0CCCD	1E60B	0FC96	18889
-31.800000	E962FC96	-142.750000	9A7D27D2	16666	058E4	193A0	123E9
-30.000000	EAAAAAAB	59.500000	2A4FA4FA	00000	0DBBC	02AAB	0871C
-28.000000	EC16C16C	-60.000000	D5555555	0AAAB	0AAAB	0D27D	10000
-25.900000	ED950C84	-66.700000	D091A2B4	15DDE	05C4D	182B4	0BB2A
-23.600000	EF37C049	-120.000000	AAAAAAAB	02222	00000	043B3	0AAAB
-21.100000	F0FEDCBB	41.500000	1D82D82E	0F777	0AE39	1157A	07333
-18.200000	F30ECA86	-144.000000	9999999A	1EEEF	13333	008D1	00000
-14.900000	F56789AC	-121.000000	A9F49F4A	10889	1AEEF	11DB9	05B06
-10.500000	F8888889	121.000000	560B60B6	08000	0FD28	08EEF	05111
-5.100000	FC5F92C6	6.250000	0471C71C	04CCD	00C72	0540E	0038E
-2.500000	FE38E38E	154.280000	6DB5D120	12AAB	091CE	12E39	1B663
0.000000	00000000	60.000000	2AAAAAAB	00000	1AAAB	00000	15555
0.000000	00000000	-157.500000	90000000	00000	06000	00000	14000
90.000000	40000000	-180.000000	80000000	00000	10000	18000	10000
89.950000	3FF6E5D5	179.500000	7FA4FA50	1FBBC	0FF4A	17BCE	0FF4A
89.500000	3FA4FA50	178.500000	7EEEEEEF	1D555	0FDDE	1560B	0FDDE
89.000000	3F49F49F	175.500000	7CCCCCCD	1AAAB	0F99A	12C17	0F99A
87.500000	3E38E38E	-165.000000	8AAAAAAB	12AAB	11555	0AE39	11555

Table 2-89: Airborne Position Encoding Values (con't)

Angular Weighted Binary Values (degrees)				Even Airborne Encoding		Odd Airborne Encoding	
Latitude	**Latitude**	**Longitude**	**Longitude**	**Latitude**	**Longitude**	**Latitude**	**Longitude**
Decimal	**HEX**	**Decimal**	**HEX**	**HEX**	**HEX**	**HEX**	**HEX**
86.750000	3DB05B06	-171.500000	860B60B6	0EAAB	0182E	06F4A	10C17
86.500000	3D82D82E	-172.500000	85555555	0D555	12000	05A50	01555
85.850000	3D0C83FB	65.750000	2EC16C17	09DDE	11889	023C5	0BB06
85.000000	3C71C71C	-142.750000	9A7D27D2	05555	0D3E9	1DC72	19EEF
84.250000	3BE93E94	60.000000	2AAAAAAB	01555	1AAAB	19D83	15555
83.550000	3B69D037	-60.000000	D5555555	1D99A	00000	162C6	05555
82.680000	3ACB6F46	120.000000	55555555	18F5C	0AAAB	119C5	00000
81.750000	3A222222	-120.000000	AAAAAAAB	14000	0AAAB	0CBBC	15555
80.250000	39111111	144.000000	66666666	0C000	13333	04DDE	06666
79.750000	38B60B61	-144.000000	9999999A	09555	00000	023E9	0CCCD
78.400000	37C048D1	-121.000000	A9F49F4A	02222	09B06	1B2A2	1471C
77.400000	370A3D71	121.000000	560B60B6	1CCCD	01111	15EB8	164FA
76.550000	366F8092	-154.280000	924A2EE0	18444	0DB89	11765	1B6F4
75.600000	35C28F5C	154.280000	6DB5D120	13333	1FFE3	0C7AE	12477
74.750000	3527D27D	157.500000	70000000	0EAAB	12000	0805B	04000
73.650000	345F92C6	-157.500000	90000000	08CCD	00000	0240E	0E000
72.750000	33BBBBBC	-120.000000	AAAAAAAB	04000	0AAAB	1D889	15555
71.550000	32E147AE	120.000000	55555555	1D99A	00000	173D7	15555
70.650000	323D70A4	-144.000000	9999999A	18CCD	0CCCD	12852	1999A
69.550000	317530ED	144.000000	66666666	12EEF	00000	0CC05	13333
68.750000	30E38E39	-114.550000	AE8ACF13	0EAAB	0A2C6	088E4	145B0
67.750000	302D82D8	114.550000	517530ED	09555	00024	034FA	15D3A
66.550000	2F530ECB	-67.500000	D0000000	02EEF	16000	1D049	1C000
65.550000	2E9D036A	67.500000	30000000	1D99A	10000	17C60	0A000
64.450000	2DD4C3B3	-83.080000	C4EBBF60	17BBC	0760B	12012	0EC34
63.250000	2CFA4FA5	83.080000	3B1440A0	11555	0001D	0BB61	189F5
62.250000	2C444444	-64.290000	D2485CD8	0C000	05B44	06777	0B6B3
61.250000	2B8E38E4	64.290000	2DB7A328	06AAB	0002C	0138E	1A4BC
60.250000	2AD82D83	-72.000000	CCCCCCCD	01555	06666	1BFA5	0CCCD
59.960000	2AA36288	-120.500000	AA4FA4FA	1FC96	0960B	1A74F	1416C
59.955000	2AA27984	120.000000	55555555	1FC29	15555	1A6E4	0AAAB
59.930000	2A9DEC6E	-119.500000	AB05B05B	1FA07	01555	1A4CB	0BF4A
58.000000	293E93E9	-78.750000	C8000000	15555	07000	102D8	0E000
58.500000	2999999A	78.750000	38000000	18000	19000	12CCD	12000
57.950000	293579BE	-22.500000	F0000000	15111	02000	0FEA6	04000
56.850000	286D3A07	22.500000	10000000	0F333	00000	0A259	1E000
55.500000	27777777	-52.940000	DA5A912E	08000	04B59	03111	096A4
54.620000	26D7447F	52.940000	25A56ED2	034E8	1FFF1	1E73A	1B4A7
53.250000	25DDDDDE	-30.000000	EAAAAAAB	1C000	02AAB	17444	05555
51.950000	24F1357A	30.000000	15555555	15111	00000	1072F	1D555
50.750000	2416C16C	-75.790000	CA1ADA00	0EAAB	06BC3	0A27D	0D78D

<u>Table 2-89</u>: Airborne Position Encoding Values (con't)

Angular Weighted Binary Values (degrees)				Even Airborne Encoding		Odd Airborne Encoding	
Latitude Decimal	**Latitude HEX**	**Longitude Decimal**	**Longitude HEX**	**Latitude HEX**	**Longitude HEX**	**Latitude HEX**	**Longitude HEX**
49.650000	234E81B5	75.790000	35E52600	08CCD	00007	04630	1943D
48.250000	224FA4FA	-27.000000	ECCCCCCD	01555	02666	1D0B6	04CCD
47.000000	216C16C1	27.000000	13333333	1AAAB	00000	167D2	1D99A
45.600000	206D3A07	-68.570000	CF3D3663	13333	0619B	0F259	0C321
44.250000	1F777777	-180.000000	80000000	0C000	00000	08111	10000
42.850000	1E789ABD	179.500000	7FA4FA50	04889	0E16C	00B97	1E222
41.400000	1D70A3D7	178.500000	7EEEEEEF	1CCCD	1A222	191EC	0A444
40.000000	1C71C71C	175.500000	7CCCCCCD	15555	1E000	11C72	0E666
38.500000	1B60B60B	-160.900000	8D950C84	0D555	0E190	09E94	1C666
36.900000	1A3D70A4	-171.500000	860B60B6	04CCD	1382E	01852	02C17
35.250000	19111111	-172.500000	85555555	1C000	00000	18DDE	0F555
33.600000	17E4B17E	65.750000	2EC16C17	13333	1E60B	1036A	18889
31.800000	169D036A	-142.750000	9A7D27D2	0999A	058E4	06C60	123E9
30.000000	15555555	59.500000	2A4FA4FA	00000	0DBBC	1D555	0871C
28.000000	13E93E94	-60.000000	D5555555	15555	0AAAB	12D83	10000
25.900000	126AF37C	-66.700000	D091A2B4	0A222	05C4D	07D4C	0BB2A
23.600000	10C83FB7	-120.000000	AAAAAAAB	1DDDE	00000	1BC4D	0AAAB
21.100000	0F012345	41.500000	1D82D82E	10889	0AE39	0EA86	07333
18.200000	0CF1357A	-144.000000	9999999A	01111	13333	1F72F	00000
14.900000	0A987654	-121.000000	A9F49F4A	0F777	1AEEF	0E247	05B06
10.500000	07777777	121.000000	560B60B6	18000	0FD28	17111	05111
5.100000	03A06D3A	6.250000	0471C71C	1B333	00C72	1ABF2	0038E
2.500000	01C71C72	154.280000	6DB5D120	0D555	091CE	0D1C7	1B663
0.000000	00000000	60.000000	2AAAAAAB	00000	1AAAB	00000	15555
0.000000	00000000	-157.500000	90000000	00000	06000	00000	14000

b. For each Even interval Airborne Position Message that is broadcast by the ADS-B Transmitting System:

(1). Verify that the "CPR Format" (F) subfield is set to "0," and

(2). Verify that the Encoded Even Interval Latitude subfield is encoded exactly as shown in the Even Airborne Encoding Latitude column of Table 2-89.

If the encoding is not exact, verify that the encoding does not differ from the table value by more that "1" Least Significant Bit (LSB).

If the encoded value differs from the table value by more than "1" LSB, then the test **shall** be considered to have Failed. Otherwise, the test **shall** be considered to have passed.

(3). Verify that the Encoded Even Interval Longitude subfield is encoded exactly as shown in the Even Airborne Encoding Longitude column of Table 2-89.

If the encoding is not exact, verify that the encoding does not differ from the table value by more that "1" Least Significant Bit (LSB).

If the encoded value differs from the table value by more than "1" LSB, then the test **shall** be considered to have Failed. Otherwise, the test **shall** be considered to have passed.

c. For each Odd interval Airborne Position Message that is broadcast by the ADS-B Transmitting System:

(1). Verify that the "CPR Format" (F) subfield is set to "1," and

(2). Verify that the Encoded Odd Interval Latitude subfield is encoded exactly as shown in the Odd Airborne Encoding Latitude column of Table 2-89.

If the encoding is not exact, verify that the encoding does not differ from the table value by more that "1" Least Significant Bit (LSB).

If the encoded value differs from the table value by more than "1" LSB, then the test **shall** be considered to have Failed. Otherwise, the test **shall** be considered to have passed.

(3). Verify that the Encoded Odd Interval Longitude subfield is encoded exactly as shown in the Odd Airborne Encoding Longitude column of Table 2-89.

If the encoding is not exact, verify that the encoding does not differ from the table value by more that "1" Least Significant Bit (LSB).

If the encoded value differs from the table value by more than "1" LSB, then the test **shall** be considered to have Failed. Otherwise, the test **shall** be considered to have passed.

2.4.3.2.3.7.2 Verification of Airborne Latitude Position Extrapolation/Estimation (Precision Case, Type Codes 9, 10, 20 and 21) (§2.2.3.2.3.7.2)

Appropriate test procedures are provided in §2.4.3.2.3.7.2.1 and §2.4.3.2.3.7.2.2.

2.4.3.2.3.7.2.1 Verification of GPS/GNSS Time Mark Coupled Case (Extrapolation, "TIME" (T) = "1") (§2.2.3.2.3.7.2.1)

Purpose/Introduction:

This test procedure will be used to verify that the ADS-B Transmitting System correctly extrapolates and encodes Airborne Position data when working with GNSS synchronized time.

Equipment Required:

Equipment capable of performing the following:

a. Load all valid data required for the ADS-B Airborne Position Message into the ADS-B Transmitting system via the operational interfaces.

   The equipment should be capable of updating Latitude position and North/South Velocity given time, initial Latitude position, initial North/South velocity, and North/South acceleration. The Latitude Position provided to the ADS-B Transmission system **shall** be referred to as the Computed Latitude. Likewise, the North/South velocity provided to the ADS-B Transmission system **shall** be referred to as the Computed N/S Velocity.

   The equipment should be capable of updating Longitude position and East/West Velocity given time, initial Longitude position, initial East/West velocity, and East/West acceleration. The Longitude Position provided to the ADS-B Transmission system **shall** be referred to as the Computed Longitude. Likewise, the East/West velocity provided to the ADS-B Transmission system **shall** be referred to as the Computed E/W Velocity.

   The equipment should be capable of providing position information and velocity information to the ADS-B Transmitting system at a rate of not less than 5 times per second for each navigation parameter provided.

b. Provide the ADS-B Transmitting system with an appropriate GNSS Time Mark as described in §2.2.5.1.6.

   The equipment **shall** also be capable of time-tagging the GNSS Time Mark leading edge event to a minimum accuracy of 1.0 milliseconds.

c. When providing the GNSS Time Mark described in subparagraph b, above, the equipment **shall** have re-computed position and velocity information required by subparagraph a, above, available at one second intervals that are synchronized with the leading edge of the GNSS Time Mark. Initial delivery of the all new computed position and velocity data to the ADS-B Transmission system **shall** be completed no later than 200 milliseconds after the leading edge of the GNSS Time Mark.

d. The monitoring of transmitted ADS-B Airborne Position Messages and the Airborne Velocity Messages and the extraction of all subfields as may be required. The equipment **shall** also be capable of time-tagging the receipt of any ADS-B Broadcast message to a minimum accuracy of 1.0 milliseconds.

e. Performing local unambiguous CPR decoding of the encoded latitude and longitude subfields in accordance with Appendix A, §A.1.7.4, §A.1.7.5 and §A.1.7.9.

f. After performing the encoded latitude and longitude local unambiguous CPR decoding, the equipment **shall** be capable of computing the difference between the Decoded Latitude Position and the Computed Latitude. Likewise, the equipment

shall be capable of computing the difference between the Decoded Longitude Position and the Computed Longitude.

g. After extraction of the Velocity subfields from the Airborne Velocity Message, the equipment **shall** compute the difference between the extracted North/South Velocity and the Computed N/S Velocity. Likewise, the equipment **shall** compute the difference between the extracted East/West Velocity and the Computed E/W Velocity.

Measurement Procedure:

Step 1: Equipment Initialization (North-South)

Initialize the equipment to provide the following to the ADS-B Transmitting system.

DO NOT START DELIVERY OF THE DATA AT THIS TIME

a.	Initialize Time Reference at:	$\mathbf{t_0}$		
	Set initial Computed Longitude to:	45.0	degrees	**WEST**
	Set initial Computed Latitude to:	0.0625	degrees	**NORTH**
	Set initial Computed N/S Velocity to:	1,020	knots	**SOUTH**

Note: *The velocity requirements above are specified in terms of North/South velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to verify that such information is properly resolved into the North/South velocity required in the transmitted messages.*

b. GNSS Time Mark as described above under Equipment subparagraphs b and c.

c. All other data required to generate the Airborne Position Message and the Airborne Velocity Message.

Step 2: Equipment Data Delivery Start Up

Allow the equipment to start delivery of the data specified in Step 1 and designate this time as $\mathbf{t_0}$.

Continue to let the equipment to provide the data for at least 35 seconds.

Step 3: Latitude Position Performance

Notes:

1. *Since there has been no position or velocity data provided to the ADS-B Transmitting system up to this time (at least for the purposes of this test procedure), a minimal amount of time will need to be allowed for the transmitted message data to stabilize. This fact has been factored in to the following required response criteria.*

2. *Be advised that this test scenario is forcing movement across the Equator at 1,020 knots from North to South.*

a. At 4.0 +/- 0.005 seconds after executing Step 2 where data has started being provided to the ADS-B Transmitting system under test:

   Verify that the Decoded Latitude Position differs from the Computed Latitude Position by no more than **22.1** meters (i.e., approximately 0.0002 degrees of Latitude).

b. At all successive points during the time of test that occur at least 6 seconds after the execution of Step 2:

   Verify that the Decoded Latitude Position differs from the Computed Latitude Position by no more than **6.375** meters (i.e., approximately 0.000058 degrees of Latitude).

c. Select an Airborne Position Message that was received at least 6 seconds after the execution of Step 2 and within 50 +/- 25 milliseconds of a GNSS Time Mark generated by the Test Equipment and provided to the ADS-B Transmitting System. Designate the leading edge of the GNSS Time Mark as $\mathbf{t_1}$.

   Verify that the Decoded Latitude Position differs from the Computed Latitude Position at time $\mathbf{t_1}$ **+ 200 milliseconds** by no more than **6.375** meters (i.e., approximately 0.000058 degrees of Latitude).

d. Verify that the received message was encoded in the proper format, i.e., odd or even encoding, by correlating the received message to the stimulus data provided by the test equipment.

   Note: *This test is intended to demonstrate that UUT is encoding data correctly in regards to 0.2 UTC Epochs and in regards to alternating odd and even encodings. Since the test set knows what the data is at given 1.0 second intervals, and it also time tags the received data, it is reasonable to expect that the capability is adequate to establish the proper 0.2 UTC Epochs and the appropriate format encoding.*

<u>Step 4:</u> <u>Velocity Performance</u> (Optional. Apply only if the UUT is estimating or extrapolating velocity)

a. At 4.0 +/- 0.005 seconds after executing Step 2 where data has started being provided to the ADS-B Transmitting system under test:

Verify that the Extracted North/South velocity differs no more than **5%** from the Computed North/South velocity that was provided to the ADS-B transmitting system during the GNSS Epoch defined by the leading edge of the GNSS Time Mark delivered to the ADS-B Transmitting system at least **325** milliseconds prior to the transmission of the Airborne Velocity Message for which the accuracy is being checked.

b. At all successive points during the time of test that occur at least 6 seconds after the execution of Step 2:

Verify that the Extracted North/South velocity differs no more than **1%** from the Computed North/South velocity that was provided to the ADS-B transmitting system during the GNSS Epoch defined by the leading edge of the GNSS Time Mark delivered to the ADS-B Transmitting system at least **325** milliseconds prior to the transmission of the Airborne Velocity Message for which the accuracy is being checked.

<u>Step 5:</u> <u>Equipment Re-Initialization (South-North)</u>

<u>Note:</u> *Be advised that this test scenario is forcing movement across the Equator at 1,020 knots from South to North.*

Repeat Step 1 with the following equipment settings:

Initialize Time Reference at:	$\mathbf{t_0}$		
Set initial Computed Longitude to:	45.0	degrees	**EAST**
Set initial Computed Latitude to:	0.0625	degrees	**SOUTH**
Set initial Computed N/S Velocity to:	1,020	knots	**NORTH**

<u>Note:</u> *The velocity requirements above are specified in terms of North/South velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to verify that such information is properly resolved into the North/South velocity required in the transmitted messages.*

<u>Step 6:</u> <u>Performance Check (South-North)</u>

Repeat Steps 2 through 4.

Step 7: Equipment Re-Initialization (North Pole)

Note: *Be advised that this test scenario is forcing movement across the North Pole at 1,020 knots from South to North. It is up to the equipment designers to insure that equipment under test and the test equipment properly move across the pole by moving up to 90.0 degrees North and then down from the pole for the duration of the test.*

Repeat Step 1 with the following equipment settings:

Initialize Time Reference at:	$\mathbf{t_0}$		
Set initial Computed Longitude to:	45.0	degrees	**EAST**
Set initial Computed Latitude to:	89.9375	degrees	**NORTH**
Set initial Computed N/S Velocity to:	1,020	knots	**NORTH**

Note: *The velocity requirements above are specified in terms of North/South velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to verify that such information is properly resolved into the North/South velocity required in the transmitted messages.*

Step 8: Performance Check (North Pole)

Repeat Steps 2 through 4.

Step 9: Equipment Re-Initialization (South Pole)

Note: *Be advised that this test scenario is forcing movement across the South Pole at 1,020 knots from North to South. It is up to the equipment designers to insure that equipment under test and the test equipment properly move across the pole by moving up to 90.0 degrees South and then down from the pole for the duration of the test.*

Repeat Step 1 with the following equipment settings:

Initialize Time Reference at:	$\mathbf{t_0}$		
Set initial Computed Longitude to:	45.0	degrees	**WEST**
Set initial Computed Latitude to:	89.9375	degrees	**SOUTH**
Set initial Computed N/S Velocity to:	1,020	knots	**SOUTH**

Note: *The velocity requirements above are specified in terms of North/South velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the* *implementer to verify that such information is properly resolved into the North/South velocity required in the transmitted messages.*

Step 10: Performance Check (South Pole)

Repeat Steps 2 through 4.

Step 11: Maximum Velocity Performance Checks

Note: *This procedure step must be performed only for those ADS-B Transmitting Subsystems that are expected to be installed in vehicles capable of attaining North/South or East/West velocities in excess of 1022 knots.*

Repeat Steps 1 through 10 with the exception that for each case where the velocity magnitude is specified, set the magnitude to 4,084 knots and the time of test duration should be retained at 35 seconds.

2.4.3.2.3.7.2.2 Verification of Non-Coupled Case (Estimation, "TIME" (T) = "0") (§2.2.3.2.3.7.2.2)

Purpose/Introduction:

This test procedure will be used to verify that the ADS-B Transmitting System correctly extrapolates and encodes Airborne Position data when NOT working with GNSS synchronized time.

Equipment Required:

Equipment capable of performing the following:

a. Load all valid data required for the ADS-B Airborne Position Message into the ADS-B Transmitting system via the operational interfaces.

   The equipment should be capable of updating Latitude position and North/South Velocity given time, initial Latitude position, initial North/South velocity, and North/South acceleration. The Latitude Position provided to the ADS-B Transmission system **shall** be referred to as the Computed Latitude. Likewise, the North/South velocity provided to the ADS-B Transmission system **shall** be referred to as the Computed N/S Velocity.

   The equipment should be capable of updating Longitude position and East/West Velocity given time, initial Longitude position, initial East/West velocity, and East/West acceleration. The Longitude Position provided to the ADS-B Transmission system **shall** be referred to as the Computed Longitude. Likewise, the East/West velocity provided to the ADS-B Transmission system **shall** be referred to as the Computed E/W Velocity.

The equipment should be capable of providing position information and velocity information to the ADS-B Transmitting system at a rate of not less than 5 times per second for each navigation parameter provided.

b. Generate an appropriate GNSS Time Mark as described in §2.2.5.1.6, but **DO NOT** apply the GNSS Time Mark to the ADS-B Transmitting System.

   The equipment **shall** also be capable of time-tagging the GNSS Time Mark leading edge event to a minimum accuracy of 1.0 milliseconds.

c. Referenced to the GNSS Time Mark described in subparagraph b, above, the equipment **shall** have re-computed position and velocity information required by subparagraph a, above, available at one second intervals that are synchronized with the leading edge of the GNSS Time Mark. Initial delivery of the all new computed position and velocity data to the ADS-B Transmission system **shall** be completed no later than 200 milliseconds after the leading edge of the GNSS Time Mark.

d. The monitoring of transmitted ADS-B Airborne Position Messages and the Airborne Velocity Messages and the extraction of all subfields as may be required. The equipment **shall** also be capable of time-tagging the receipt of any ADS-B Broadcast message to a minimum accuracy of 1.0 milliseconds.

e. Performing local unambiguous CPR decoding of the encoded latitude and longitude subfields in accordance with Appendix A, §A.1.7.4, §A.1.7.5 and §A.1.7.9.

f. After performing the encoded latitude and longitude local unambiguous CPR decoding, the equipment **shall** be capable of computing the difference between the Decoded Latitude Position and the Computed Latitude. Likewise, the equipment **shall** be capable of computing the difference between the Decoded Longitude Position and the Computed Longitude.

g. After extraction of the Velocity subfields from the Airborne Velocity Message, the equipment **shall** compute the difference between the extracted North/South Velocity and the Computed N/S Velocity. Likewise, the equipment **shall** compute the difference between the extracted East/West Velocity and the Computed E/W Velocity.

<u>Measurement Procedure:</u>

<u>Step 1:</u> <u>Equipment Initialization (North-South)</u>

Initialize the equipment to provide the following to the ADS-B Transmitting system.

DO NOT START DELIVERY OF THE DATA AT THIS TIME

a. Initialize Time Reference at: $\mathbf{t_0}$

Set initial Computed Longitude to	45.0	degrees	**WEST**
Set initial Computed Latitude to:	0.0625	degrees	**NORTH**
Set initial Computed N/S Velocity to:	1,020	knots	**SOUTH**

Note: *The velocity requirements above are specified in terms of North/South velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to verify that such information is properly resolved into the North/South velocity required in the transmitted messages.*

b. GNSS Time Mark as described above under Equipment subparagraphs b and c.

c. All other data required to generate the Airborne Position Message and the Airborne Velocity Message.

Step 2: Equipment Data Delivery Start Up

Allow the equipment to start delivery of the data specified in Step 1 and designate this time as $\mathbf{t_0}$.

Continue to let the equipment to provide the data for at least 35 seconds.

Step 3: Latitude Position Performance

Notes:

1. *Since there has been no position or velocity data provided to the ADS-B Transmitting system up to this time (at least for the purposes of this test procedure), a minimal amount of time will need to be allowed for the transmitted message data to stabilize. This fact has been factored in to the following required response criteria.*

2. *Be advised that this test scenario is forcing movement across the Equator at 1,020 knots from North to South.*

a. At 4.0 +/- 0.005 seconds after executing Step 2 where data has started being provided to the ADS-B Transmitting system under test:

Verify that the Decoded Latitude Position differs from the Computed Latitude Position by no more than **22.1** meters (i.e., approximately 0.0002 degrees of Latitude).

b. At all successive points during the time of test that occur at least 6 seconds after the execution of Step 2:

Verify that the Decoded Latitude Position differs from the Computed Latitude Position by no more than **6.375** meters (i.e., approximately 0.000058 degrees of Latitude).

c. Select an Airborne Position Message that was received at least 6 seconds after the execution of Step 2 and within 150 +/- 25 milliseconds of a GNSS Time Mark generated by the Test Equipment and provided to the ADS-B Transmitting System. Designate the leading edge of the GNSS Time Mark as $\mathbf{t_1}$.

Verify that the Decoded Latitude Position differs from the Computed Latitude Position at time $\mathbf{t_1}$ **+ 200 milliseconds** by no more than **6.375** meters (i.e., approximately 0.000058 degrees of Latitude).

d. Verify that the received message was encoded in the proper format, i.e., odd or even encoding, by correlating the received message to the stimulus data provided by the test equipment.

Note: *This test is intended to demonstrate that UUT is encoding data correctly in regards to 0.2 UTC Epochs and in regards to alternating odd and even encodings. Since the test set knows what the data is at given 1.0 second intervals, and it also time tags the received data, it is reasonable to expect that the capability is adequate to establish the proper 0.2 UTC Epochs and the appropriate format encoding.*

Step 4: Velocity Performance (Optional. Apply only if the UUT is estimating or extrapolating velocity)

a. At 4.0 +/- 0.005 seconds after executing Step 2 where data has started being provided to the ADS-B Transmitting system under test:

Verify that the Extracted North/South velocity differs no more than **5%** from the Computed North/South velocity that was provided to the ADS-B transmitting system during the GNSS Epoch defined by the leading edge of the GNSS Time Mark delivered to the ADS-B Transmitting system at least **325** milliseconds prior to the transmission of the Airborne Velocity Message for which the accuracy is being checked.

b. At all successive points during the time of test that occur at least 6 seconds after the execution of Step 2:

Verify that the Extracted North/South velocity differs no more than **1%** from the Computed North/South velocity that was provided to the ADS-B transmitting system during the GNSS Epoch defined by the leading edge of the GNSS Time Mark delivered to the ADS-B Transmitting system at least

325 milliseconds prior to the transmission of the Airborne Velocity Message for which the accuracy is being checked.

Step 5: Equipment Re-Initialization (South-North)

Note: *Be advised that this test scenario is forcing movement across the Equator at 1,020 knots from South to North.*

Repeat Step 1 with the following equipment settings:

Initialize Time Reference at:	$\mathbf{t_0}$		
Set initial Computed Longitude to:	45.0	degrees	**EAST**
Set initial Computed Latitude to:	0.0625	degrees	**SOUTH**
Set initial Computed N/S Velocity to:	1,020	knots	**NORTH**

Note: *The velocity requirements above are specified in terms of North/South velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to verify that such information is properly resolved into the North/South velocity required in the transmitted messages.*

Step 6: Performance Check (South-North)

Repeat Steps 2 through 4.

Step 7: Equipment Re-Initialization (North Pole)

Note: *Be advised that this test scenario is forcing movement across the North Pole at 1,020 knots from South to North. It is up to the equipment designers to insure that equipment under test and the test equipment properly move across the pole by moving up to 90.0 degrees North and then down from the pole for the duration of the test.*

Repeat Step 1 with the following equipment settings:

Initialize Time Reference at:	$\mathbf{t_0}$		
Set initial Computed Longitude to:	45.0	degrees	**EAST**
Set initial Computed Latitude to:	89.9375	degrees	**NORTH**
Set initial Computed N/S Velocity to:	1,020	knots	**NORTH**

Note: *The velocity requirements above are specified in terms of North/South velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the* *implementer to verify that such information is properly resolved into the North/South velocity required in the transmitted messages.*

Step 8: Performance Check (North Pole)

Repeat Steps 2 through 4.

Step 9: Equipment Re-Initialization (South Pole)

Note: *Be advised that this test scenario is forcing movement across the South Pole at 1,020 knots from North to South. It is up to the equipment designers to insure that equipment under test and the test equipment properly move across the pole by moving up to 90.0 degrees South and then down from the pole for the duration of the test.*

Repeat Step 1 with the following equipment settings:

Initialize Time Reference at:	$\mathbf{t_0}$		
Set initial Computed Longitude to:	45.0	degrees	**WEST**
Set initial Computed Latitude to:	89.9375	degrees	**SOUTH**
Set initial Computed N/S Velocity to:	1,020	knots	**SOUTH**

Note: *The velocity requirements above are specified in terms of North/South velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to verify that such information is properly resolved into the North/South velocity required in the transmitted messages.*

Step 10: Performance Check (South Pole)

Repeat Steps 2 through 4.

Step 11: Maximum Velocity Performance Checks

Note: *This procedure step must be performed only for those ADS-B Transmitting Subsystems that are expected to be installed in vehicles capable of attaining North/South or East/West velocities in excess of 1022 knots.*

Repeat Steps 1 through 10 with the exception that for each case where the velocity magnitude is specified, set the magnitude to 4,084 knots and the time of test duration should be retained at 35 seconds.

2.4.3.2.3.7.3 Verification of Airborne Latitude Position Extrapolation/Estimation (non - precision) (§2.2.3.2.3.7.3)

Appropriate test procedures are provided in §2.4.3.2.3.7.3.1 and §2.4.3.2.3.7.3.2.

2.4.3.2.3.7.3.1 Verification of Airborne Latitude Position Extrapolation Case (non - precision) (§2.2.3.2.3.7.3.1)

The procedures provided in §2.4.3.2.3.7.2.1 **shall** be used to validate performance of §2.4.3.2.3.7.3.1.

2.4.3.2.3.7.3.2 Verification of Airborne Latitude Position Estimation Case (non - precision) (§2.2.3.2.3.7.3.2)

The procedures provided in §2.4.3.2.3.7.2.2 **shall** be used to validate performance of §2.4.3.2.3.7.3.2.

2.4.3.2.3.7.4 Verification of Airborne Latitude Position Data Retention (§2.2.3.2.3.7.4)

Purpose/Introduction:

The extrapolation or estimation, and update of latitude data fields defined in §2.2.3.2.3.7.2 through §2.2.3.2.3.7.3.2 and **shall** be limited to no more than two seconds, in the event that the latitude position data is no longer available.

At the end of two seconds, the latitude data registers and the encoded latitude field **shall** be set to ALL ZEROs.

Measurement Procedures:

Step 1: Termination of Latitude Data Input - Part 1

Provide normal Airborne Position data to the ADS-B Transmitting System at the nominal rate. First, filter the data so that the ADS-B Transmitting System does not receive any latitude data for at least 2 seconds. After 2 seconds, verify that the latitude data registers are set to ALL ZEROs.

Note: *In order to terminate latitude data, it may also be necessary to terminate longitude information since a position fix normally includes both latitude and longitude.*

Step 2: Termination of Latitude Data Input - Part 2

Return to providing normal Airborne Position data at the nominal rate. Next, filter the data so that the device does not receive any latitude data. After 1 second, stop providing data. Verify that after 1 second more, the latitude registers are set to ALL ZEROs.

2.4.3.2.3.8 Verification of "ENCODED LONGITUDE" Subfield in ADS-B Airborne Position Messages (§2.2.3.2.3.6, §2.2.3.2.3.8, §2.2.5.1.8, §2.2.5.1.12)

Appropriate test procedures are provided in §2.4.3.2.3.8.1 through §2.4.3.2.3.8.4.

2.4.3.2.3.8.1 Verification of Airborne Longitude Data Encoding (§2.2.3.2.3.8.1, §2.2.5.1.8, §2.2.5.1.12)

Appropriate test procedures to verify the airborne longitude data encoding were previously provided in §2.4.3.2.3.7.1.

2.4.3.2.3.8.2 Airborne Longitude Position Extrapolation/Estimation (Precision Case, Type Codes 9, 10, 20 and 21)

Appropriate test procedures are provided in §2.4.3.2.3.8.2.1 and §2.4.3.2.3.8.2.2.

2.4.3.2.3.8.2.1 Verification of GPS/GNSS Time Mark Coupled Case (Extrapolation, "TIME" (T) = "1") (§2.2.3.2.3.8.2.1)

Purpose/Introduction:

This test procedure will be used to verify that the ADS-B Transmitting System correctly extrapolates and encodes Airborne Position data when working with GNSS synchronized time.

Equipment Required:

Equipment requirements remain the same as provided in §2.4.3.2.3.7.2.1.

Measurement Procedure:

Step 1: Equipment Initialization (GM-E-W)

Initialize the equipment to provide the following to the ADS-B Transmitting system.

DO NOT START DELIVERY OF THE DATA AT THIS TIME

a. Initialize Time Reference at: $\mathbf{t_0}$

Set initial Computed Longitude to:	-0.0625	degrees	**EAST**
Set initial Computed Latitude to:	45.0	degrees	**NORTH**
Set initial Computed E/W Velocity to:	1,020	knots	**WEST**

Note: *The velocity requirements above are specified in terms of East/West velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the* *implementer to verify that such information is properly resolved into the East/West velocity required in the transmitted messages.*

b. GNSS Time Mark as described above under Equipment subparagraphs b and c.

c. All other data required to generate the Airborne Position Message and the Airborne Velocity Message.

Step 2: Equipment Data Delivery Start Up

Allow the equipment to start delivery of the data specified in Step 1 and designate this time as $\mathbf{t_0}$.

Continue to let the equipment to provide the data for at least 35 seconds.

Step 3: Longitude Position Performance

Notes:

1. *Since there has been no position or velocity data provided to the ADS-B Transmitting system up to this time (at least for the purposes of this test procedure), a minimal amount of time will need to be allowed for the transmitted message data to stabilize. This fact has been factored in to the following required response criteria.*

2. *Be advised that this test scenario is forcing movement across the Greenwich Meridian at 1,020 knots from East to West. It is up to the equipment designers to insure that equipment under test and the test equipment properly move across the Greenwich Meridian by moving across 0 degrees.*

a. At 4.0 +/- 0.005 seconds after executing Step 2 where data has started being provided to the ADS-B Transmitting system under test:

Verify that the Decoded Longitude Position differs from the Computed Longitude Position by no more than **22.1** meters (i.e., approximately 0.0002 degrees of Longitude).

b. At all successive points during the time of test that occur at least 6 seconds after the execution of Step 2:

Verify that the Decoded Longitude Position differs from the Computed Longitude Position by no more than **6.375** meters (i.e., approximately 0.000058 degrees of Longitude).

c. Select an Airborne Position Message that was received at least 6 seconds after the execution of Step 2 and within 50 +/- 25 milliseconds of a GNSS Time Mark generated by the Test Equipment and provided to the ADS-B

Transmitting System. Designate the leading edge of the GNSS Time Mark as $\mathbf{t_1}$.

Verify that the Decoded Longitude Position differs from the Computed Longitude Position at time **$\mathbf{t_1}$ + 200 milliseconds** by no more than **6.375** meters (i.e., approximately 0.000058 degrees of Longitude).

d. Verify that the received message was encoded in the proper format, i.e., odd or even encoding, by correlating the received message to the stimulus data provided by the test equipment.

Note: *This test is intended to demonstrate that UUT is encoding data correctly in regards to 0.2 UTC Epochs and in regards to alternating odd and even encodings. Since the test set knows what the data is at given 1.0 second intervals, and it also time tags the received data, it is reasonable to expect that the capability is adequate to establish the proper 0.2 UTC Epochs and the appropriate format encoding.*

Step 4: Velocity Performance (Optional. Apply only if the UUT is estimating or extrapolating velocity)

a. At 4.0 +/- 0.005 seconds after executing Step 2 where data has started being provided to the ADS-B Transmitting system under test:

Verify that the Extracted East/West velocity differs no more than **5%** from the Computed East/West velocity that was provided to the ADS-B transmitting system during the GNSS Epoch defined by the leading edge of the GNSS Time Mark delivered to the ADS-B Transmitting system at least **325** milliseconds prior to the transmission of the Airborne Velocity Message for which the accuracy is being checked.

b. At all successive points during the time of test that occur at least 6 seconds after the execution of Step 2:

Verify that the Extracted East/West velocity differs no more than **1%** from the Computed East/West velocity that was provided to the ADS-B transmitting system during the GNSS Epoch defined by the leading edge of the GNSS Time Mark delivered to the ADS-B Transmitting system at least **325** milliseconds prior to the transmission of the Airborne Velocity Message for which the accuracy is being checked.

Step 5: Equipment Re-Initialization (GM-W-E)

Note: *Be advised that this test scenario is forcing movement across the Greenwich Meridian at 1,020 knots from West to East.*

Repeat Step 1 with the following equipment settings:

Initialize Time Reference at:	$\mathbf{t_0}$		
Set initial Computed Longitude to:	0.0625	degrees	**EAST**
Set initial Computed Latitude to:	45.0	degrees	**SOUTH**
Set initial Computed E/W Velocity to:	1,020	knots	**EAST**

Note: *The velocity requirements above are specified in terms of East/West velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to verify that such information is properly resolved into the East/West velocity required in the transmitted messages.*

Step 6: Performance Check (West - East)

Repeat Steps 2 through 4.

Step 7: Equipment Re-Initialization (IDL-E-W)

Note 1: *Be advised that this test scenario is forcing movement across the International Dateline at 1,020 knots from East to West.*

Repeat Step 1 with the following equipment settings:

Initialize Time Reference at:	$\mathbf{t_0}$		
Set initial Computed Longitude to:	179.9375	degrees	**EAST**
Set initial Computed Latitude to:	45.0	degrees	**NORTH**
Set initial Computed E/W Velocity to:	1,020	knots	**WEST**

Note 2: *The velocity requirements above are specified in terms of East/West velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to verify that such information is properly resolved into the East/West velocity required in the transmitted messages.*

Step 8: Performance Check (IDL-E-W)

Repeat Steps 2 through 4.

Step 9: Equipment Re-Initialization (IDL-W-E)

Note: *Be advised that this test scenario is forcing movement across the International Dateline at 1,020 knots from West to East. It is up to the equipment designers to insure that equipment under test and the test* *equipment properly move across the International Dateline by moving up to 180 degrees and then down for the duration of the test.*

Repeat Step 1 with the following equipment settings:

Initialize Time Reference at:	$\mathbf{t_0}$		
Set initial Computed Longitude to:	179.9375	degrees	**WEST**
Set initial Computed Latitude to:	45.0	degrees	**SOUTH**
Set initial Computed E/W Velocity to:	1,020	knots	**EAST**

Note: *The velocity requirements above are specified in terms of East/West velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to verify that such information is properly resolved into the East/West velocity required in the transmitted messages.*

Step 10: Performance Check (IDL-W-E)

Repeat Steps 2 through 4.

Step 11: Maximum Velocity Performance Checks

Note: *This procedure step must be performed only for those ADS-B Transmitting Subsystems that are expected to be installed in vehicles capable of attaining North/South or East/West velocities in excess of 1022 knots.*

Repeat Steps 1 through 10 with the exception that for each case where the velocity magnitude is specified, set the magnitude to 4,084 knots and the time of test duration should be retained at 35 seconds.

Step 12: Repeat for additional Navigation Data Sources

Repeat Steps 1 through 11 for each Navigation Data Source input interface that the equipment is designed to accommodate.

2.4.3.2.3.8.2.2 Verification of Non-Coupled Case (Estimation, "TIME" (T) = "0") (§2.2.3.2.3.8.2.2)

Purpose/Introduction:

This test procedure will be used to verify that the ADS-B Transmitting System correctly extrapolates and encodes Airborne Position data when NOT working with GNSS synchronized time.

Equipment Required:

Equipment requirements remain the same as provided in §2.4.3.2.3.7.2.2.

Measurement Procedure:

Step 1: Equipment Initialization (GM-E-W)

Initialize the equipment to provide the following to the ADS-B Transmitting system.

DO NOT START DELIVERY OF THE DATA AT THIS TIME

a. Initialize Time Reference at: $\mathbf{t_0}$

Set initial Computed Longitude to:	-0.0625	degrees	**EAST**
Set initial Computed Latitude to:	45.0	degrees	**NORTH**
Set initial Computed E/W Velocity to:	1,020	knots	**WEST**

Note: *The velocity requirements above are specified in terms of East/West velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to verify that such information is properly resolved into the East/West velocity required in the transmitted messages.*

b. GNSS Time Mark as described above under Equipment subparagraphs b and c.

c. All other data required to generate the Airborne Position Message and the Airborne Velocity Message.

Step 2: Equipment Data Delivery Start Up

Allow the equipment to start delivery of the data specified in Step 1 and designate this time as $\mathbf{t_0}$.

Continue to let the equipment to provide the data for at least 35 seconds.

Step 3: Longitude Position Performance

Notes:

1. *Since there has been no position or velocity data provided to the ADS-B Transmitting system up to this time (at least for the purposes of this test procedure), a minimal amount of time will need to be allowed for the transmitted message data to stabilize. This fact has been factored in to the following required response criteria.*

2. Be advised that this test scenario is forcing movement across the Greenwich Meridian at 1,020 knots from East to West. It is up to the equipment designers to insure that equipment under test and the test equipment properly move across the Greenwich Meridian by moving across 0 degrees.

a. At 4.0 +/- 0.005 seconds after executing Step 2 where data has started being provided to the ADS-B Transmitting system under test:

Verify that the Decoded Longitude Position differs from the Computed Longitude Position by no more than **22.1** meters (i.e., approximately 0.0002 degrees of Longitude).

b. At all successive points during the time of test that occur at least 6 seconds after the execution of Step 2:

Verify that the Decoded Longitude Position differs from the Computed Longitude Position by no more than **6.375** meters (i.e., approximately 0.000058 degrees of Longitude).

c. Select an Airborne Position Message that was received at least 6 seconds after the execution of Step 2 and within 50 +/- 25 milliseconds of a GNSS Time Mark generated by the Test Equipment and provided to the ADS-B Transmitting System. Designate the leading edge of the GNSS Time Mark as $\mathbf{t_1}$.

Verify that the Decoded Longitude Position differs from the Computed Longitude Position at time $\mathbf{t_1}$ **+ 200 milliseconds** by no more than **6.375** meters (i.e., approximately 0.000058 degrees of Longitude).

d. Verify that the received message was encoded in the proper format, i.e., odd or even encoding, by correlating the received message to the stimulus data provided by the test equipment.

Note: *This test is intended to demonstrate that UUT is encoding data correctly in regards to 0.2 UTC Epochs and in regards to alternating odd and even encodings. Since the test set knows what the data is at given 1.0 second intervals, and it also time tags the received data, it is reasonable to expect that the capability is adequate to establish the proper 0.2 UTC Epochs and the appropriate format encoding.*

Step 4: Velocity Performance (Optional. Apply only if the UUT is estimating or extrapolating velocity)

a. At 4.0 +/- 0.005 seconds after executing Step 2 where data has started being provided to the ADS-B Transmitting system under test:

Verify that the Extracted East/West velocity differs no more than **5%** from the Computed East/West velocity that was provided to the ADS-B transmitting system during the GNSS Epoch defined by the leading edge of the GNSS Time Mark delivered to the ADS-B Transmitting system at least **325** milliseconds prior to the transmission of the Airborne Velocity Message for which the accuracy is being checked.

b. At all successive points during the time of test that occur at least 6 seconds after the execution of Step 2:

Verify that the Extracted East/West velocity differs no more than **1%** from the Computed East/West velocity that was provided to the ADS-B transmitting system during the GNSS Epoch defined by the leading edge of the GNSS Time Mark delivered to the ADS-B Transmitting system at least **325** milliseconds prior to the transmission of the Airborne Velocity Message for which the accuracy is being checked.

Step 5: Equipment Re-Initialization (GM-W-E)

Note: *Be advised that this test scenario is forcing movement across the Greenwich Meridian at 1,020 knots from West to East.*

Repeat Step 1 with the following equipment settings:

Initialize Time Reference at:	$\mathbf{t_0}$		
Set initial Computed Longitude to:	0.0625	degrees	**EAST**
Set initial Computed Latitude to:	45.0	degrees	**SOUTH**
Set initial Computed E/W Velocity to:	1,020	knots	**EAST**

Note: *The velocity requirements above are specified in terms of East/West velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to verify that such information is properly resolved into the East/West velocity required in the transmitted messages.*

Step 6: Performance Check (West - East)

Repeat Steps 2 through 4.

Step 7: Equipment Re-Initialization (IDL-E-W)

Note: *Be advised that this test scenario is forcing movement across the International Dateline at 1,020 knots from East to West.*

Repeat Step 1 with the following equipment settings:

Initialize Time Reference at:	$\mathbf{t_0}$		
Set initial Computed Longitude to:	179.9375	degrees	**EAST**
Set initial Computed Latitude to:	45.0	degrees	**NORTH**
Set initial Computed E/W Velocity to:	1,020	knots	**WEST**

Note: *The velocity requirements above are specified in terms of East/West velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to verify that such information is properly resolved into the East/West velocity required in the transmitted messages.*

Step 8: Performance Check (IDL-E-W)

Repeat Steps 2 through 4.

Step 9: Equipment Re-Initialization (IDL-E-W)

Note: *Be advised that this test scenario is forcing movement across the International Dateline at 1,020 knots from East to West. It is up to the equipment designers to insure that equipment under test and the test equipment properly move across the International Dateline by moving up to 180 degrees and then down for the duration of the test.*

Repeat Step 1 with the following equipment settings:

Initialize Time Reference at:	$\mathbf{t_0}$		
Set initial Computed Longitude to:	179.9375	degrees	**WEST**
Set initial Computed Latitude to:	45.0	degrees	**SOUTH**
Set initial Computed E/W Velocity to:	1,020	knots	**EAST**

Note: *The velocity requirements above are specified in terms of East/West velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to verify that such information is properly resolved into the East/West velocity required in the transmitted messages.*

Step 10: Performance Check (IDL-E-W)

Repeat Steps 2 through 4.

Step 11: Maximum Velocity Performance Checks

Note: *This procedure step must be performed only for those ADS-B Transmitting Subsystems that are expected to be installed in vehicles capable of attaining North/South or East/West velocities in excess of 1022 knots.*

Repeat Steps 1 through 10 with the exception that for each case where the velocity magnitude is specified, set the magnitude to 4,084 knots and the time of test duration should be retained at 35 seconds.

Step 12: Repeat for additional Navigation Data Sources

Repeat Steps 1 through 11 for each Navigation Data Source input interface that the equipment is designed to accommodate.

2.4.3.2.3.8.3 Verification of Airborne Longitude Position Extrapolation/Estimation (non - precision) (§2.2.3.2.3.8.3)

Appropriate test procedures are provided in §2.4.3.2.3.8.3.1 and §2.4.3.2.3.8.3.2.

2.4.3.2.3.8.3.1 Verification of Airborne Longitude Position Extrapolation Case (non - precision) (§2.2.3.2.3.8.3.1)

The procedures provided in §2.4.3.2.3.8.2.1 **shall** be used to validate performance of §2.4.3.2.3.8.3.1.

2.4.3.2.3.8.3.2 Verification of Airborne Longitude Position Estimation Case (non - precision) (§2.2.3.2.3.8.3.2)

The procedures provided in §2.4.3.2.3.8.2.2 **shall** be used to validate performance of §2.4.3.2.3.8.3.2.

2.4.3.2.3.8.4 Verification of Airborne Longitude Position Data Retention (§2.2.3.2.3.8.4)

Purpose/Introduction:

The extrapolation or estimation, and update of longitude data fields defined in §2.2.3.2.3.8.2 through §2.2.3.2.3.8.3.2 and **shall** be limited to no more than two seconds, in the event that the longitude position data is no longer available.

At the end of two seconds, the longitude data registers and the encoded longitude field **shall** be set to ALL ZEROs.

Measurement Procedure:

Step 1: Longitude Data Termination - Part 1

Provide normal Airborne Position data to the ADS-B Transmitting System at the nominal rate. First, filter the data so that the ADS-B Transmitting System does not receive any longitude data for at least 2 seconds. After 2 seconds, verify that the longitude data registers are set to ALL ZEROs.

Note: *In order to terminate longitude data, it may also be necessary to terminate latitude information since a position fix normally includes both latitude and longitude.*

Step 2: Longitude Data Termination - Part 2

Return to providing normal Airborne Position data at the nominal rate. Next, filter the data so that the device does not receive any longitude data. After 1 second, stop providing data. Verify that after 1 second more, the longitude registers are set to ALL ZEROs.

2.4.3.2.4 Verification of ADS-B Surface Position Messages (§2.2.3.2.4)

No specific test procedure is required to validate §2.2.3.2.4.

2.4.3.2.4.1 Verification of "TYPE" Subfield in ADS-B Surface Position Messages (§2.2.3.2.4.1)

Purpose/Introduction:

This test procedure verifies that the ADS-B Transmitting System correctly outputs Surface Position Messages with the correct TYPE subfield data content in Message Bits 33 through 37 in DF 17 Messages for Transponder Based Systems and DF 18 Messages for Non Transponder Based Systems. The ME field of the Surface Position Message contains the TYPE subfield in bits 1 through 5 which is utilized to categorize the navigational accuracy of the position information. The ADS-B Transmitting System determines and outputs the TYPE subfield based upon the input it receives from the possible Navigational sources that may interface to the system. The ADS-B Transmitting System may receive the TYPE subfield directly through an external interface instead of dynamically determining the TYPE subfield. Whatever the implementation, the test cases must exercise all of the resulting TYPE code possibilities. If an ADS-B Transmitting System can only generate a subset of the possible Surface Position Message Types, then only those test cases required to produce the possible Type codes **shall** be tested. The test configuration is based on the type(s) of Navigational System(s) that may interface to the ADS-B Transmitting System and the data it provides.

Measurement Procedure:

Step 1: Verification of Type Codes 5 through 8

Configure the ADS-B Transmitting System to transmit Surface Position Messages by providing position information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set the ADS-B Transmitting System to On-Ground status. Provide appropriate Ground Speed information to the ADS-B system in order to establish the high rate of transmission for the Surface Position Message. For each positional accuracy category supported, verify that the TYPE subfield in the ADS-B Surface Position Message correctly matches the TYPE subfield value from the navigational accuracy depicted in Table 2-11. The TYPE code may be derived by either the Horizontal Protection Limits (HPL), or the Horizontal Position Error contained in the table. To test all of the possible resulting TYPE codes that could be produced from the Navigational source, degradation of the position data from the Navigation source may require an alarm or alert condition that must be sensed by the ADS-B Transmitting System. The TYPE subfield **shall** contain values in the range from 5 through 8.

2.4.3.2.4.1.1 Verification of Surface Position Message Type Code if Containment Radius is Available (§2.2.3.2.4.1.1)

Purpose/Introduction:

This test procedure verifies that the ADS-B Transmitting System correctly outputs Surface Position Messages with the correct TYPE subfield data content in Message Bits 33 through 37 in DF 17 Messages for Transponder Based Systems and DF 18 Messages for Non Transponder Based Systems. The ME field of the Surface Position Message contains the TYPE subfield which is utilized to categorize the navigational accuracy of the position information. If an ADS-B Transmitting System can only generate a subset of the possible Surface Position Message Types, then only those test cases required to produce the possible TYPE codes **shall** be tested. The test configuration is based on the type of Navigational System that interfaces to the ADS-B Transmitting System and the data it provides.

Measurement Procedure:

Configure the ADS-B Transmitting System to transmit Surface Position Messages by providing position information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Setup the system to enable broadcast of Surface Position Messages at the nominal rate. Set the ADS-B Transmitting System to “On Ground” status. For each positional accuracy category supported, verify that the TYPE subfield in the ADS-B Message correctly matches the TYPE subfield value from the navigational accuracy depicted in Table 2-11. The TYPE code may be derived by either the Containment radius (R_C), or the Navigation Integrity Code (NIC) contained in the table. To test all of the possible resulting TYPE codes that could be produced from the Navigational source, degradation of the position data from the Navigation source may require an alarm or alert condition that must be sensed by the ADS-B Transmitting System. The TYPE subfield **shall** contain values in the range from 5 through 8.

2.4.3.2.4.1.2 Verification of Surface Position Message Type Code if Containment Radius is Not Available (§2.2.3.2.4.1.2)

Appropriate test procedures are provided in §2.4.3.2.4.1.1.

2.4.3.2.4.1.3 Verification of Special Processing for Type Code ZERO (§2.2.3.2.3.1.3, §2.2.3.2.4.1.3)

No specific test procedure is required to validate §2.2.3.2.4.1.3.

2.4.3.2.4.1.3.1 Verification of Significance of Type Code Equal to ZERO (§2.2.3.2.4.1.3.1)

Purpose/Introduction:

TYPE code equal to ZERO is broadcast as a result of loss of ADS-B data updates. The following test verifies that the ADS-B Transmitting System correctly outputs TYPE code equal to ZERO for each ADS-B Position Message type.

Measurement Procedure:

Setup the ADS-B Transmitting System to on the ground status. Connect the GNSS data input and verify that Surface Position and Aircraft Identification Messages are transmitted at the proper rate. Stop update of the Navigational source of Latitude and Longitude position information. If the ADS-B Transmitting System is capable of receiving position data from more than one Navigation source, verify the following by disconnecting each Navigation source separately. Verify that after 2 seconds, the TYPE code is ZERO and the remaining ME Bits are ZERO. After 60 seconds, verify that the Surface Position Message is no longer transmitted.

2.4.3.2.4.1.3.2 Verification of Broadcast of Type Code Equal to ZERO (§2.2.3.2.4.1.3.2)

Appropriate test procedures are provided in §2.4.3.2.4.1.3.1.

2.4.3.2.4.1.4 Verification of Type Code based on Horizontal Protection Level or Estimated Horizontal Position Accuracy (§2.2.3.2.4.1.4)

Appropriate test procedures are provided in §2.4.3.2.4.1.3.1.

2.4.3.2.4.2 Verification of "MOVEMENT" Subfield in ADS-B Surface Position Messages (§2.2.3.2.4.2)

Purpose/Introduction:

The "MOVEMENT" subfield is a 7-bit field (ME Bits 6 through 12, Message Bits 38 through 44) that is used to encode information regarding the status of "Movement" of the ADS-B Transmitting Subsystem in accordance with the coding provided in Table 2-13.

This test procedure will verify that the ADS-B Transmitting System correctly outputs Surface Position Messages with the correct "MOVEMENT" subfield data encoding in DF=17 Messages for Transponder Based Systems and DF=18 Messages for Non Transponder Based Systems.

Measurement Procedure:

Step 1: Movement Verification - Part 1

Configure the ADS-B Transmitting System to transmit Surface Position Messages by providing position information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set up the system to enable broadcast of Surface Position Messages at the nominal rate. Set the ADS-B Transmitting System to "On Ground" status. Provide valid, non-zero MOVEMENT data to the ADS-B System. Discontinue the MOVEMENT data and verify that when MOVEMENT data is not provided to the ADS-B Transmitting System, the MOVEMENT subfield is set to ZERO (binary 000 0000).

Step 2: Movement Verification - Part 2

Set up the ADS-B Transmitting System as above and set the MOVEMENT input to represent a MOVEMENT of greater than or equal to Zero knots, but less than 0.125 knots. Verify that the MOVEMENT subfield is set to ONE (binary 000 0001). Increase the MOVEMENT input to exactly 0.125 knots and verify that the MOVEMENT subfield is set to TWO (binary 000 0010). Continue to increase the MOVEMENT input data at increments of 0.125 knots and verify that for each increment for Ground Speed greater than or equal to 0.125 knots and less than 1 knot, the encoding of the MOVEMENT subfield corresponds to the encoding identified in Table 2-13 representing values between 2 and 8.

Step 3: Movement Verification - Part 3

Continue to increase the MOVEMENT input in increments equal to those identified in Table 2-13 for values greater than or equal to ONE knot and less than 175 knots. Verify that for each such increment, the encoding of the MOVEMENT subfield is equal to that defined in Table 2-13. Increase the Ground Speed input data to exactly 175 knots and verify that the MOVEMENT subfield is set to 124. Continue increasing the Ground Speed data input for values greater than 175 knots and verify that the MOVEMENT subfield continues to be set at 124.

Note: *The last three encodings (125, 126, 127) of the MOVEMENT subfield in Table 2-13 are reserved to indicate high levels of ground speed change, etc. The precedence of the codes is not defined yet, as inputs that would be required are not currently available.*

2.4.3.2.4.3 Verification of "STATUS BIT FOR HEADING" Subfield in ADS-B Surface Position Messages (§2.2.3.2.4.3, §2.2.5.1.10)

Purpose/Introduction:

The "Status Bit for Heading" subfield is a 1-bit field (ME Bit 13, Message Bit 45) that **shall** be used to indicate the validity of the Heading as defined in Table 2-14.

This test procedure will verify that the ADS-B Transmitting System correctly outputs Surface Position Messages with the correct "STATUS BIT FOR HEADING" subfield data encoding in DF=17 Messages for Transponder Based Systems and DF=18 Messages for Non Transponder Based Systems.

Measurement Procedure:

Configure the ADS-B Transmitting System to transmit Surface Position Messages by providing position information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set up the system to enable broadcast of Surface Position Messages at the nominal rate. Set the ADS-B Transmitting System to "On Ground" status. Provide valid, non-zero HEADING data to the ADS-B System. Verify that the STATUS BIT FOR HEADING is set to ONE (1). Discontinue the valid HEADING data and verify that when non-valid HEADING data is provided to the ADS-B Transmitting System, the STATUS BIT FOR HEADING subfield is set to ZERO (0).

2.4.3.2.4.4 Verification of "HEADING" Subfield in ADS-B Surface Position Messages (§0, 2.2.5.1.10)

Purpose/Introduction:

The "GROUND TRACK" subfield is a 7-bit field (ME Bit 14 through 20, Message Bit 46 through 52) used to report the Ground Track (True), or motion of the ADS-B transmission device, Clockwise from North (i.e., Ground Track Sign Bit = 0). Coding of the Ground Track Subfield is defined in Table 2-15.

This test procedure will verify that the ADS-B Transmitting System correctly outputs Surface Position Messages with the correct "GROUND TRACK" subfield data encoding in DF=17 Messages for Transponder Based Systems and DF=18 Messages for Non Transponder Based Systems.

Measurement Procedure:

Step 1: Ground Track Verification - Part 1

Configure the ADS-B Transmitting System to transmit Surface Position Messages by providing position information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set up the system to enable broadcast of Surface Position Messages at the nominal rate. Set the ADS-B Transmitting System to "On Ground" status. Provide valid, non-zero GROUND TRACK data to the ADS-B System. Verify that the GROUND TRACK subfield is NOT set to ZERO (0). Set the Ground Track input to exactly ZERO degrees and verify that the encoding of the GROUND TRACK subfield is set to ZERO (binary 000 0000).

Step 2: Ground Track Verification - Part 2

Raw data used to establish the GROUND TRACK subfield will normally have more resolution (i.e., more bits) than that required by the GROUND TRACK subfield. When converting such data to the GROUND TRACK subfield, the accuracy of the data **shall** be maintained such that it is not worse than +/- ½ LSB where the LSB is that of the GROUND TRACK subfield.

Set up the ADS-B Transmitting System as above and set the Ground Track data input to 2.8125 degrees. Verify that the GROUND TRACK subfield is set to ONE (binary 000 0001). Continue increasing the Ground Track data input in increments of 2.8125 degrees and verify that for each such increment, the encoding of the GROUND TRACK subfield is set to the corresponding binary code shown in Table 2-15.

2.4.3.2.4.5 Verification of "TIME" (T) Subfield in ADS-B Surface Position Messages (§2.2.3.2.4.5, §2.2.5.1.6)

Measurement Procedure:

Configure the ADS-B Transmitting System to transmit Surface Position Messages by providing position information at the nominal rate. Ensure that the time of applicability of the position data is synchronized to an exact 0.2 second UTC epoch. Verify that the ADS-B Transmitting System accepts a GNSS TIME MARK, or equivalent, input from the navigation data source, which is required in order to be able to update the position data from the navigation data source to an exact 0.2 second UTC epoch. Verify that the "TIME" (T) subfield is set to ONE (1).

If the ADS-B Transmitting System is not capable of receiving a GNSS Time Mark, or if the input is not available, verify that the "TIME" (T) subfield is set to ZERO.

Note: *The ADS-B Transmitting Subsystem must be capable of monitoring the GNSS Time Mark unless the non-coupled case (see §2.2.3.2.3.7.2.2) is implemented.*

2.4.3.2.4.6 Verification of "CPR FORMAT" (F) Subfield in ADS-B Surface Position Messages (§2.2.3.2.4.6)

Appropriate procedures to validate §2.2.3.2.4.6 are provided in §2.4.3.2.4.7.1 and §2.4.3.2.4.8.1.

2.4.3.2.4.7 Verification of "ENCODED LATITUDE" Subfield in ADS-B Surface Position Messages (§2.2.3.2.4.6, §2.2.3.2.4.7, §2.2.5.1.7, §2.2.5.1.13, Appendix A.1.7)

Appropriate test procedures are provided in §2.4.3.2.4.7.1 through §2.4.3.2.4.7.4.

2.4.3.2.4.7.1 Verification of Latitude Transition Points and Encoding (§2.2.3.2.4.6, §2.2.3.2.4.7, §2.2.3.2.4.7.1, §2.2.5.1.7, §2.2.5.1.13, Appendix A.1.7)

2.4.3.2.4.7.1.1 Verification of Latitude Transition Points (§2.2.3.2.4.6, §2.2.3.2.4.7, §2.2.3.2.4.7.1, §2.2.5.1.7, §2.2.5.1.13, Appendix A.1.7)

Purpose/Introduction:

This procedure verifies that the latitude transition points used in CPR encoding are properly computed or established to satisfy the equations provided in Appendix A, §A.1.7.2.d.

Measurement Procedure:

Step 1: Encode Lower Values

a. Set the input longitude value to 45.00 degrees East and keep it at that value for the duration of this test procedure.

b. For each line item in Table 2-90, set the input latitude value to the value provided in the lat_{low} column provided in the table.

c. Verify that the Even Surface Position latitude encoding agrees with the value provided in the "lower latitude" column of the table.

   If the latitude encoding does not agree with the table value, proceed to subparagraph d.

   Otherwise, verify that the Even Surface Position longitude encoding agrees with the value provided in the "lower longitude" column of the table.

   If the Even Surface Position latitude and longitude encoding values agree with the values provided in the "lower latitude" and "lower longitude" columns of the table, then this portion of the test **shall** be considered as PASSED and testing **shall** proceed with Step 2 below.

d. Increase or decrease, as appropriate, the input latitude value until the Surface Position latitude encoding agrees with the value provided in the "lower latitude" column of the table.

Verify that the difference between the input latitude value and the lat_{low} value provided in the table does not exceed 2^{-19} * 10 degrees.

Verify that the Even Surface Position longitude encoding agrees with the value provided in the "lower longitude" column of the table.

If the Even Surface Position latitude and longitude encoding values agree with the values provided in the "lower latitude" and "lower longitude" columns of the table, then this portion of the test **shall** be considered as PASSED and testing **shall** proceed with Step 2 below.

Step 2: Encode Upper Values

a. Set the input longitude value to 45.00 degrees East and keep it at that value for the duration of this test procedure.

b. For each line item in Table 2-90, set the input latitude value to the value provided in the lat_{up} column provided in the table.

c. Verify that the Even Surface Position latitude encoding agrees with the value provided in the "upper latitude" column of the table.

If the latitude encoding does not agree with the table value, proceed to subparagraph d.

Otherwise, verify that the Even Surface Position longitude encoding agrees with the value provided in the "upper longitude" column of the table.

If the Even Surface Position latitude and longitude encoding values agree with the values provided in the "upper latitude" and "upper longitude" columns of the table, then this portion of the test **shall** be considered as PASSED.

d. Increase or decrease, as appropriate, the input latitude value until the Surface Position latitude encoding agrees with the value provided in the "upper latitude" column of the table.

Verify that the difference between the input latitude value and the lat_{up} value provided in the table does not exceed 2^{-19} * 10 degrees.

Verify that the Even Surface Position longitude encoding agrees with the value provided in the "upper longitude" column of the table.

If the Even Surface Position latitude and longitude encoding values agree with the values provided in the "upper latitude" and "upper longitude" columns of the table, then this portion of the test **shall** be considered as PASSED.

Table 2-90: Verification of Transition Table

Latitude in degrees (rounded to nearest AWB value)				Even Surface Position Encodings			
lat_{low}	lat_{low}	lat_{up}	lat_{up}	lower		upper	
Decimal	HEX	Decimal	HEX	latitude	longitude	latitude	longitude
10.470463	077216EF	10.470474	07721777	1F5EB	10000	1F5EC	00000
14.828167	0A8B62AB	14.828178	0A8B6333	1C559	00000	1C55A	10000
18.186253	0CEEB4CD	18.186264	0CEEB555	03F93	10000	03F94	00000
21.029388	0EF44889	21.029400	0EF44911	00A08	00000	00A09	10000
23.545040	10BE3E66	23.545052	10BE3EEF	164B5	10000	164B6	00000
25.829247	125E1222	25.829258	125E12AB	07062	00000	07063	10000
27.938976	13DE22AB	27.938988	13DE2333	14081	10000	14082	00000
29.911354	15453222	29.911366	154532AB	1E1BE	00000	1E1BF	10000
31.772095	1697EEEF	31.772106	1697EF77	05CE0	10000	05CE1	00000
33.539932	17D9C222	33.539944	17D9C2AB	0B84C	00000	0B84D	10000
35.228989	190D3DDE	35.229000	190D3E66	0F8D4	10000	0F8D5	00000
36.850250	1A346222	36.850262	1A3462AB	12238	00000	12239	10000
38.412415	1B50C444	38.412426	1B50C4CD	13770	10000	13771	00000
39.922565	1C63AE66	39.922577	1C63AEEF	13AE7	00000	13AE8	10000
41.386517	1D6E2F77	41.386528	1D6E3000	12E99	10000	12E9A	00000
42.809132	1E712A22	42.809143	1E712AAB	1142F	00000	11430	10000
44.194542	1F6D5EEF	44.194553	1F6D5F77	0ED12	10000	0ED13	00000
45.546261	2063719A	45.546272	20637222	0BA75	00000	0BA76	10000
46.867332	2153F000	46.867344	2153F089	07D62	10000	07D63	00000
48.160389	223F54CD	48.160400	223F5555	036BF	00000	036C0	10000
49.427753	23260C44	49.427765	23260CCD	1E757	10000	1E758	00000
50.671497	240876EF	50.671509	24087777	18FDF	00000	18FE0	10000
51.893417	24E6E889	51.893429	24E6E911	130F4	10000	130F5	00000
53.095161	25C1ADDE	53.095173	25C1AE66	0CB26	00000	0CB27	10000
54.278172	26990A22	54.278183	26990AAB	05EF3	10000	05EF4	00000
55.443775	276D3B33	55.443787	276D3BBC	1ECCF	00000	1ECD0	10000
56.593185	283E799A	56.593197	283E7A22	17524	10000	17525	00000
57.727467	290CF6EF	57.727478	290CF777	0F84F	00000	0F850	10000
58.847637	29D8E2AB	58.847649	29D8E333	076A9	10000	076AA	00000
59.954590	2AA26666	59.954601	2AA266EF	1F080	00000	1F081	10000
61.049171	2B69A99A	61.049183	2B69AA22	1661E	10000	1661F	00000
62.132160	2C2ED089	62.132172	2C2ED111	0D7C7	00000	0D7C8	10000
63.204266	2CF1FC44	63.204277	2CF1FCCD	045B9	10000	045BA	00000
64.266163	2DB34C44	64.266174	2DB34CCD	1B02F	00000	1B030	10000
65.318447	2E72DC44	65.318459	2E72DCCD	1175D	10000	1175E	00000
66.361702	2F30C777	66.361713	2F30C800	07B76	00000	07B77	10000
67.396465	2FED26EF	67.396477	2FED2777	1DCA9	10000	1DCAA	00000
68.423218	30A81111	68.423229	30A8119A	13B20	00000	13B21	10000
69.442417	31619B33	69.442429	31619BBC	09703	10000	09704	00000
70.454510	3219DA22	70.454521	3219DAAB	1F079	00000	1F07A	10000
71.459862	32D0DEEF	71.459873	32D0DF77	147A2	10000	147A3	00000
72.458839	3386BAAB	72.458851	3386BB33	09C9E	00000	09C9F	10000
73.451763	343B7C44	73.451775	343B7CCD	1EF89	10000	1EF8A	00000
74.438931	34EF319A	74.438942	34EF3222	1407D	00000	1407E	10000
75.420559	35A1E4CD	75.420570	35A1E555	08F8D	10000	08F8E	00000
76.396843	36539EEF	76.396854	36539F77	1DCCA	00000	1DCCB	10000
77.367886	370464CD	77.367897	37046555	1283D	10000	1283E	00000
78.333733	37B43889	78.333744	37B43911	071EA	00000	071EB	10000
79.294281	38631555	79.294292	386315DE	1B9C8	10000	1B9C9	00000
80.249222	3910ECCD	80.249233	3910ED55	0FFBC	00000	0FFBD	10000
81.198006	39BDA555	81.198017	39BDA5DE	04396	10000	04397	00000
82.139568	3A690D55	82.139580	3A690DDE	184F9	00000	184FA	10000
83.071987	3B12CB33	83.071999	3B12CBBC	0C33D	10000	0C33E	00000
83.991726	3BBA3A22	83.991737	3BBA3AAB	1FD2D	00000	1FD2E	10000
84.891655	3C5E0DDE	84.891666	3C5E0E66	1305A	10000	1305B	00000
85.755409	3CFB4BBC	85.755421	3CFB4C44	0572E	00000	0572F	10000
86.535370	3D894889	86.535381	3D894911	16168	10000	16169	00000
86.999999	3DDDDDDD	87.000011	3DDDDE66	00000	00000	00001	10000

Note: *An entry from Table 2-90 consists of a pair of latitudes which, in the process of encoding with maximum precision, will produce values which straddle the transition latitudes as closely as possible. In addition, each entry contains 2 pairs of even surface encodings for the positions at each latitude in the entry and 45 degrees longitude. Both the latitudes and the encodings are distinguished by "upper" and "lower" where the upper position is the one closer to the North Pole.*

2.4.3.2.4.7.1.2 Verification of Surface Latitude and Longitude Data Encoding (§2.2.3.2.4.6, §2.2.3.2.4.7, §2.2.3.2.4.7.1, §2.2.3.2.4.8, §2.2.3.2.4.8.1, §2.2.5.1.7, §2.2.5.1.8, §2.2.5.1.12, §2.2.5.1.13, Appendix A.1.7)

Purpose/Introduction:

The “ENCODED LATITUDE” subfield is a 17-bit field (ME Bits 23 through 39, Message Bits 55 through 71) containing the encoded latitude of the surface position. The following test procedure verifies that the ADS-B Transmitting System correctly receives Latitude position data from the Navigation source and outputs encoded Latitude data in the Surface Position Message. The Latitude data is encoded according to the Compact Position Reporting (CPR) Format described in Appendix A. The Latitude data is dependent upon the positional accuracy supported by the ADS-B Transmitting System.

The following procedure verifies the ***static*** latitude encoding where the velocity input is 0.0 knots and is intended to verify the actual CPR Latitude encoding precision.

Measurement Procedure:

Step 1: Establish Initial Conditions

a. Configure the ADS-B Transmitting System to create a Surface Position Message, i.e., Type Codes 5 through 8.

b. Ensure that the Velocity input provided to the ADS-B Transmitting System is set to **ZERO**.

Step 2: Verify Encoded Latitude Data

a. Via the appropriate Navigation Data Source interface, provide the ADS-B Transmitting system with the exact latitude and longitude data pair provided in the Angular Weighted Binary Values Latitude and Longitude Columns for each line item given in Table 2-91.

Provide the latitude and longitude data via the interface at the nominal rate of the navigation data source.

Allow the system to stabilize for at least 2 seconds after the data change prior to continuing with the following steps.

Table 2-91: Surface Position Encoding Values

Angular Weighted Binary Values (degrees)				Even Surface Encoding		Odd Surface Encoding	
Latitude	**Latitude**	**Longitude**	**Longitude**	**Latitude**	**Longitude**	**Latitude**	**Longitude**
Decimal	**HEX**	**Decimal**	**HEX**	**HEX**	**HEX**	**HEX**	**HEX**
-90.000000	C0000000	-180.000000	80000000	00000	00000	00000	00000
-89.950000	C0091A2B	179.500000	7FA4FA50	01111	1FD28	010C8	1FD28
-89.500000	C05B05B0	178.500000	7EEEEEEF	0AAAB	1F777	0A7D2	1F777
-89.000000	C0B60B61	175.500000	7CCCCCCD	15555	1E666	14FA5	1E666
-87.500000	C1C71C72	-165.000000	8AAAAAAB	15555	05555	1471C	05555
-86.750000	C24FA4FA	-171.500000	860B60B6	05555	060B6	042D8	0305B
-86.500000	C27D27D2	-172.500000	85555555	0AAAB	08000	096C1	05555
-85.850000	C2F37C05	65.750000	2EC16C17	18889	06222	170ED	0EC17
-85.000000	C38E38E4	-142.750000	9A7D27D2	0AAAB	14FA5	08E39	07BBC
-84.250000	C416C16C	60.000000	2AAAAAAB	1AAAB	0AAAB	189F5	15555
-83.550000	C4962FC9	-60.000000	D5555555	0999A	00000	074E8	15555
-82.680000	C53490BA	120.000000	55555555	1C28F	0AAAB	198EB	00000
-81.750000	C5DDDDDE	-120.000000	AAAAAAAB	10000	0AAAB	0D111	15555
-80.250000	C6EEEEEF	144.000000	66666666	10000	0CCCD	0C889	1999A
-79.750000	C749F49F	-144.000000	9999999A	1AAAB	00000	1705B	13333
-78.400000	C83FB72F	-121.000000	A9F49F4A	17777	06C17	1357A	11C72
-77.400000	C8F5C28F	121.000000	560B60B6	0CCCD	04444	0851F	193E9
-76.550000	C9907F6E	-154.280000	924A2EE0	1EEEF	16E23	1A26B	0DBD2
-75.600000	CA3D70A4	154.280000	6DB5D120	13333	1FF8B	0E148	091DD
-74.750000	CAD82D83	157.500000	70000000	05555	08000	1FE94	10000
-73.650000	CBA06D3A	-157.500000	90000000	1CCCD	00000	16FC9	18000
-72.750000	CC444444	-120.000000	AAAAAAAB	10000	0AAAB	09DDE	15555
-71.550000	CD1EB852	120.000000	55555555	0999A	00000	030A4	15555
-70.650000	CDC28F5C	-144.000000	9999999A	1CCCD	13333	15EB8	06666
-69.550000	CE8ACF13	144.000000	66666666	14444	00000	0CFEE	0CCCD
-68.750000	CF1C71C7	-114.550000	AE8ACF13	05555	08B18	1DC72	116C1
-67.750000	CFD27D28	114.550000	517530ED	1AAAB	00092	12C17	174E8
-66.550000	D0ACF135	-67.500000	D0000000	14444	18000	0BEDD	10000
-65.550000	D162FC96	67.500000	30000000	0999A	00000	00E82	08000
-64.450000	D22B3C4D	-83.080000	C4EBBF60	01111	1D82E	17FB7	1B0D0
-63.250000	D305B05B	83.080000	3B1440A0	1AAAB	00075	1127D	027D2
-62.250000	D3BBBBBC	-64.290000	D2485CD8	10000	16D0E	06222	0DACB
-61.250000	D471C71C	64.290000	2DB7A328	05555	000AF	1B1C7	092F2
-60.250000	D527D27D	-72.000000	CCCCCCCD	1AAAB	1999A	1016C	13333
-59.960000	D55C9D78	-120.500000	AA4FA4FA	00DA7	0582E	162C2	105B0
-59.955000	D55D867C	120.000000	55555555	00F5C	15555	16470	0AAAB
-59.930000	D5621392	-119.500000	AB05B05B	017E5	05555	16CD4	0FD28
-58.000000	D6C16C17	-78.750000	C8000000	0AAAB	1C000	1F49F	18000
-58.500000	D6666666	78.750000	38000000	00000	04000	14CCD	08000

<u>Table 2-91</u>: Surface Position Encoding Values (con't)

Angular Weighted Binary Values (degrees)				Even Surface Encoding		Odd Surface Encoding	
Latitude Decimal	Latitude HEX	Longitude Decimal	Longitude HEX	Latitude HEX	Longitude HEX	Latitude HEX	Longitude HEX
-57.950000	D6CA8642	-22.500000	F0000000	0BBBC	08000	00568	10000
-56.850000	D792C5F9	22.500000	10000000	03333	00000	1769D	18000
-55.500000	D8888889	-52.940000	DA5A912E	00000	12D66	13BBC	05A91
-54.620000	D928BB81	52.940000	25A56ED2	12C60	1FFC6	0631A	0D29A
-53.250000	DA222222	-30.000000	EAAAAAAB	10000	0AAAB	02EEF	15555
-51.950000	DB0ECA86	30.000000	15555555	0BBBC	00000	1E345	15555
-50.750000	DBE93E94	-75.790000	CA1ADA00	05555	1AF0C	1760B	15E35
-49.650000	DCB17E4B	75.790000	35E52600	1CCCD	0001D	0E741	050F4
-48.250000	DDB05B06	-27.000000	ECCCCCCD	1AAAB	0999A	0BD28	13333
-47.000000	DE93E93F	27.000000	13333333	15555	00000	060B6	16666
-45.600000	DF92C5F9	-68.570000	CF3D3663	13333	1866E	0369D	10C84
-44.250000	E0888889	-180.000000	80000000	10000	00000	1FBBC	00000
-42.850000	E1876543	179.500000	7FA4FA50	0DDDE	185B0	1D1A3	18889
-41.400000	E28F5C29	178.500000	7EEEEEEF	0CCCD	08889	1B852	09111
-40.000000	E38E38E4	175.500000	7CCCCCCD	0AAAB	18000	18E39	1999A
-38.500000	E49F49F5	-160.900000	8D950C84	0AAAB	18642	185B0	1199A
-36.900000	E5C28F5C	-171.500000	860B60B6	0CCCD	0E0B6	19EB8	0B05B
-35.250000	E6EEEEEF	-172.500000	85555555	10000	00000	1C889	1D555
-33.600000	E81B4E82	65.750000	2EC16C17	13333	1982E	1F259	02222
-31.800000	E962FC96	-142.750000	9A7D27D2	1999A	1638E	04E82	08FA5
-30.000000	EAAAAAAB	59.500000	2A4FA4FA	00000	16EEF	0AAAB	01C72
-28.000000	EC16C16C	-60.000000	D5555555	0AAAB	0AAAB	149F5	00000
-25.900000	ED950C84	-66.700000	D091A2B4	17777	17135	00ACF	0ECA8
-23.600000	EF37C049	-120.000000	AAAAAAAB	08889	00000	10ECB	0AAAB
-21.100000	F0FEDCBB	41.500000	1D82D82E	1DDDE	0B8E4	055E7	1CCCD
-18.200000	F30ECA86	-144.000000	9999999A	1BBBC	0CCCD	02345	00000
-14.900000	F56789AC	-121.000000	A9F49F4A	02222	0BBBC	076E6	16C17
-10.500000	F8888889	121.000000	560B60B6	00000	1F49F	03BBC	14444
-5.100000	FC5F92C6	6.250000	0471C71C	13333	031C7	15037	00E39
-2.500000	FE38E38E	154.280000	6DB5D120	0AAAB	0473A	0B8E4	0D98B
0.000000	00000000	60.000000	2AAAAAAB	00000	0AAAB	00000	15555
0.000000	00000000	-157.500000	90000000	00000	18000	00000	10000
90.000000	40000000	-180.000000	80000000	00000	00000	00000	00000
89.950000	3FF6E5D5	179.500000	7FA4FA50	1EEEF	1FD28	1EF38	1FD28
89.500000	3FA4FA50	178.500000	7EEEEEEF	15555	1F777	1582E	1F777
89.000000	3F49F49F	175.500000	7CCCCCCD	0AAAB	1E666	0B05B	1E666
87.500000	3E38E38E	-165.000000	8AAAAAAB	0AAAB	05555	0B8E4	05555
86.750000	3DB05B06	-171.500000	860B60B6	1AAAB	060B6	1BD28	0305B
86.500000	3D82D82E	-172.500000	85555555	15555	08000	1693F	05555

Table 2-91: Surface Position Encoding Values (con't)

Angular Weighted Binary Values (degrees)				Even Surface Encoding		Odd Surface Encoding	
Latitude Decimal	Latitude HEX	Longitude Decimal	Longitude HEX	Latitude HEX	Longitude HEX	Latitude HEX	Longitude HEX
85.850000	3D0C83FB	65.750000	2EC16C17	07777	06222	08F13	0EC17
85.000000	3C71C71C	-142.750000	9A7D27D2	15555	14FA5	171C7	07BBC
84.250000	3BE93E94	60.000000	2AAAAAAB	05555	0AAAB	0760B	15555
83.550000	3B69D037	-60.000000	D5555555	16666	00000	18B18	15555
82.680000	3ACB6F46	120.000000	55555555	03D71	0AAAB	06715	00000
81.750000	3A222222	-120.000000	AAAAAAAB	10000	0AAAB	12EEF	15555
80.250000	39111111	144.000000	66666666	10000	0CCCD	13777	1999A
79.750000	38B60B61	-144.000000	9999999A	05555	00000	08FA5	13333
78.400000	37C048D1	-121.000000	A9F49F4A	08889	06C17	0CA86	11C72
77.400000	370A3D71	121.000000	560B60B6	13333	04444	17AE1	193E9
76.550000	366F8092	-154.280000	924A2EE0	01111	16E23	05D95	0DBD2
75.600000	35C28F5C	154.280000	6DB5D120	0CCCD	1FF8B	11EB8	091DD
74.750000	3527D27D	157.500000	70000000	1AAAB	08000	0016C	10000
73.650000	345F92C6	-157.500000	90000000	03333	00000	09037	18000
72.750000	33BBBBBC	-120.000000	AAAAAAAB	10000	0AAAB	16222	15555
71.550000	32E147AE	120.000000	55555555	16666	00000	1CF5C	15555
70.650000	323D70A4	-144.000000	9999999A	03333	13333	0A148	06666
69.550000	317530ED	144.000000	66666666	0BBBC	00000	13012	0CCCD
68.750000	30E38E39	-114.550000	AE8ACF13	1AAAB	08B18	0238E	116C1
67.750000	302D82D8	114.550000	517530ED	05555	00092	0D3E9	174E8
66.550000	2F530ECB	-67.500000	D0000000	0BBBC	18000	14123	10000
65.550000	2E9D036A	67.500000	30000000	16666	00000	1F17E	08000
64.450000	2DD4C3B3	-83.080000	C4EBBF60	1EEEF	1D82E	08049	1B0D0
63.250000	2CFA4FA5	83.080000	3B1440A0	05555	00075	0ED83	027D2
62.250000	2C444444	-64.290000	D2485CD8	10000	16D0E	19DDE	0DACB
61.250000	2B8E38E4	64.290000	2DB7A328	1AAAB	000AF	04E39	092F2
60.250000	2AD82D83	-72.000000	CCCCCCCD	05555	1999A	0FE94	13333
59.960000	2AA36288	-120.500000	AA4FA4FA	1F259	0582E	09D3E	105B0
59.955000	2AA27984	120.000000	55555555	1F0A4	15555	09B90	0AAAB
59.930000	2A9DEC6E	-119.500000	AB05B05B	1E81B	05555	0932C	0FD28
58.000000	293E93E9	-78.750000	C8000000	15555	1C000	00B61	18000
58.500000	2999999A	78.750000	38000000	00000	04000	0B333	08000
57.950000	293579BE	-22.500000	F0000000	14444	08000	1FA98	10000
56.850000	286D3A07	22.500000	10000000	1CCCD	00000	08963	18000
55.500000	27777777	-52.940000	DA5A912E	00000	12D66	0C444	05A91
54.620000	26D7447F	52.940000	25A56ED2	0D3A0	1FFC6	19CE6	0D29A
53.250000	25DDDDDE	-30.000000	EAAAAAAB	10000	0AAAB	1D111	15555
51.950000	24F1357A	30.000000	15555555	14444	00000	01CBB	15555
50.750000	2416C16C	-75.790000	CA1ADA00	1AAAB	1AF0C	089F5	15E35

<u>Table 2-91</u>: Surface Position Encoding Values (con't)

Angular Weighted Binary Values (degrees)				Even Surface Encoding		Odd Surface Encoding	
Latitude	Latitude	Longitude	Longitude	Latitude	Longitude	Latitude	Longitude
Decimal	HEX	Decimal	HEX	HEX	HEX	HEX	HEX
49.650000	234E81B5	75.790000	35E52600	03333	0001D	118BF	050F4
48.250000	224FA4FA	-27.000000	ECCCCCCD	05555	0999A	142D8	13333
47.000000	216C16C1	27.000000	13333333	0AAAB	00000	19F4A	16666
45.600000	206D3A07	-68.570000	CF3D3663	0CCCD	1866E	1C963	10C84
44.250000	1F777777	-180.000000	80000000	10000	00000	00444	00000
42.850000	1E789ABD	179.500000	7FA4FA50	12222	185B0	02E5D	18889
41.400000	1D70A3D7	178.500000	7EEEEEEF	13333	08889	047AE	09111
40.000000	1C71C71C	175.500000	7CCCCCCD	15555	18000	071C7	1999A
38.500000	1B60B60B	-160.900000	8D950C84	15555	18642	07A50	1199A
36.900000	1A3D70A4	-171.500000	860B60B6	13333	0E0B6	06148	0B05B
35.250000	19111111	-172.500000	85555555	10000	00000	03777	1D555
33.600000	17E4B17E	65.750000	2EC16C17	0CCCD	1982E	00DA7	02222
31.800000	169D036A	-142.750000	9A7D27D2	06666	1638E	1B17E	08FA5
30.000000	15555555	59.500000	2A4FA4FA	00000	16EEF	15555	01C72
28.000000	13E93E94	-60.000000	D5555555	15555	0AAAB	0B60B	00000
25.900000	126AF37C	-66.700000	D091A2B4	08889	17135	1F531	0ECA8
23.600000	10C83FB7	-120.000000	AAAAAAAB	17777	00000	0F135	0AAAB
21.100000	0F012345	41.500000	1D82D82E	02222	0B8E4	1AA19	1CCCD
18.200000	0CF1357A	-144.000000	9999999A	04444	0CCCD	1DCBB	00000
14.900000	0A987654	-121.000000	A9F49F4A	1DDDE	0BBBC	1891A	16C17
10.500000	07777777	121.000000	560B60B6	00000	1F49F	1C444	14444
5.100000	03A06D3A	6.250000	0471C71C	0CCCD	031C7	0AFC9	00E39
2.500000	01C71C72	154.280000	6DB5D120	15555	0473A	1471C	0D98B
0.000000	00000000	60.000000	2AAAAAAB	00000	0AAAB	00000	15555
0.000000	00000000	-157.500000	90000000	00000	18000	00000	10000

b. For each Even interval Surface Position Message that is broadcast by the ADS-B Transmitting System:

(1). Verify that the "CPR Format" (F) subfield is set to "0", and

(2). Verify that the Encoded Even Interval Latitude subfield is encoded exactly as shown in the Even Surface Encoding Latitude column of Table 2-91.

If the encoding is not exact, verify that the encoding does not differ from the table value by more that "1" Least Significant Bit (LSB).

If the encoded value differs from the table value by more than "1" LSB, then the test **shall** be considered to have Failed. Otherwise, the test **shall** be considered to have passed.

(3). Verify that the Encoded Even Interval Longitude subfield is encoded exactly as shown in the Even Surface Encoding Longitude column of Table 2-91.

If the encoding is not exact, verify that the encoding does not differ from the table value by more that "1" Least Significant Bit (LSB).

If the encoded value differs from the table value by more than "1" LSB, then the test **shall** be considered to have Failed. Otherwise, the test **shall** be considered to have passed.

c. For each Odd interval Surface Position Message that is broadcast by the ADS-B Transmitting System:

(1). Verify that the "CPR Format" (F) subfield is set to "1", and

(2). Verify that the Encoded Odd Interval Latitude subfield is encoded exactly as shown in the Odd Surface Encoding Latitude column of Table 2-91.

If the encoding is not exact, verify that the encoding does not differ from the table value by more that "1" Least Significant Bit (LSB).

If the encoded value differs from the table value by more than "1" LSB, then the test **shall** be considered to have Failed. Otherwise, the test **shall** be considered to have passed.

(3). Verify that the Encoded Odd Interval Longitude subfield is encoded exactly as shown in the Odd Surface Encoding Longitude column of Table 2-91.

If the encoding is not exact, verify that the encoding does not differ from the table value by more that "1" Least Significant Bit (LSB).

If the encoded value differs from the table value by more than "1" LSB, then the test **shall** be considered to have Failed. Otherwise, the test **shall** be considered to have passed.

2.4.3.2.4.7.2 Verification of Surface Latitude Position Extrapolation/Estimation (Precision Case, Type Codes 5 and 6) (§2.2.3.2.4.7.2)

Appropriate test procedures are provided in §2.4.3.2.3.7.2.1 and §2.4.3.2.3.7.2.2.

2.4.3.2.4.7.2.1 Verification of GPS/GNSS Time Mark Coupled Case (Extrapolation, "TIME" (T) = "1") (§2.2.3.2.4.7.2.1, §2.2.5.1.6, §2.2.5.1.7, §2.2.5.1.13)

<u>Purpose/Introduction:</u>

This test procedure will be used to verify that the ADS-B Transmitting System correctly extrapolates and encodes Surface Position data when working with GNSS synchronized time.

Equipment Required:

Provide equipment capable of performing the following:

a. Load all valid data required for the ADS-B Surface Position Message into the ADS-B Transmitting system via the operational interfaces.

   The equipment should be capable of updating Latitude position and North/South Velocity given time, initial Latitude position, initial North/South velocity, and North/South acceleration. The Latitude Position provided to the ADS-B Transmission system **shall** be referred to as the Computed Latitude. Likewise, the North/South velocity provided to the ADS-B Transmission system **shall** be referred to as the Computed N/S Velocity.

   The equipment should be capable of updating Longitude position and East/West Velocity given time, initial Longitude position, initial East/West velocity, and East/West acceleration. The Longitude Position provided to the ADS-B Transmission system **shall** be referred to as the Computed Longitude. Likewise, the East/West velocity provided to the ADS-B Transmission system **shall** be referred to as the Computed E/W Velocity.

   The equipment should be capable of providing position information and velocity information to the ADS-B Transmitting system at a rate of not less than 5 times per second for each navigation parameter provided.

b. Provide the ADS-B Transmitting system with an appropriate GNSS Time Mark as described in §2.2.5.1.6.

   The equipment **shall** also be capable of time-tagging the GNSS Time Mark leading edge event to a minimum accuracy of 1.0 milliseconds.

c. When providing the GNSS Time Mark described in subparagraph b, above, the equipment **shall** have re-computed position and velocity information required by subparagraph a, above, available at one second intervals that are synchronized with the leading edge of the GNSS Time Mark. Initial delivery of the all new computed position and velocity data to the ADS-B Transmission system **shall** be completed no later than 200 milliseconds after the leading edge of the GNSS Time Mark.

d. Monitoring the transmitted ADS-B Surface Position Messages and the Airborne Velocity Messages and extracting all subfields as may be required. The equipment **shall** also be capable of time-tagging the receipt of any ADS-B Broadcast message to a minimum accuracy of 1.0 milliseconds.

e. Performing local unambiguous CPR decoding of the encoded latitude and longitude subfields in accordance with Appendix A, §A.1.7.4, §A.1.7.6 and §A.1.7.9.

f. After performing the encoded latitude and longitude local unambiguous CPR decoding, the equipment **shall** be capable of computing the difference between the Decoded Latitude Position and the Computed Latitude. Likewise, the equipment **shall** be capable of computing the difference between the Decoded Longitude Position and the Computed Longitude.

Measurement Procedure:

Step 1: Equipment Initialization (North-South)

Initialize the equipment to provide the following to the ADS-B Transmitting system.

DO NOT START DELIVERY OF THE DATA AT THIS TIME

a. Initialize Time Reference at: $\mathbf{t_0}$

Set initial Computed Longitude to:	45.0	degrees	**WEST**
Set initial Computed Latitude to:	0.0625	degrees	**NORTH**
Set initial Computed N/S Velocity to:	1,020	knots	**SOUTH**

Note: *The velocity requirements above are specified in terms of North/South velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to verify that such information is properly resolved into the North/South velocity required in the transmitted messages.*

b. GNSS Time Mark as described above under Equipment subparagraphs b and c.

c. All other data required to generate the Surface Position Message.

Step 2: Equipment Data Delivery Start Up

Allow the equipment to start delivery of the data specified in Step 1 and designate this time as $\mathbf{t_0}$.

Continue to let the equipment to provide the data for at least 35 seconds.

Step 3: Latitude Position Performance

Notes:

1. *Since there has been no position or velocity data provided to the ADS-B Transmitting system up to this time (at least for the purposes of this test procedure), a minimal amount of time will need to be allowed for the transmitted message data to stabilize. This fact has been factored in to the following required response criteria.*

2. *Be advised that this test scenario is forcing movement across the Equator at 1,020 knots from North to South.*

a. At 4.0 +/- 0.005 seconds after executing Step 2 where data has started being provided to the ADS-B Transmitting system under test:

Verify that the Decoded Latitude Position differs from the Computed Latitude Position by no more than **22.1** meters (i.e., approximately 0.0002 degrees Latitude).

b. At all successive points during the time of test that occur at least 6 seconds after the execution of Step 2:

Verify that the Decoded Latitude Position differs from the Computed Latitude Position by no more than **3.0** meters (i.e., approximately 0.000027 degrees Latitude).

c. Select a Surface Position Message that was received at least 6 seconds after the execution of Step 2 and within 50 +/- 25 milliseconds of a GNSS Time Mark generated by the Test Equipment and provided to the ADS-B Transmitting System. Designate the leading edge of the GNSS Time Mark as $\mathbf{t_1}$.

Verify that the Decoded Latitude Position differs from the Computed Latitude Position at time $\mathbf{t_1}$ **+ 200 milliseconds** by no more than **3.0** meters (i.e., 0.000027 degrees Latitude).

d. Verify that the received message was encoded in the proper format, i.e., odd or even encoding, by correlating the received message to the stimulus data provided by the test equipment.

Note: *This test is intended to demonstrate that UUT is encoding data correctly in regards to 0.2 UTC Epochs and in regards to alternating odd and even encodings. Since the test set knows what the data is at given 1.0 second intervals, and it also time tags the received data, it is reasonable to expect that the capability is adequate to establish the proper 0.2 UTC Epochs and the appropriate format encoding.*

Step 4: Equipment Re-Initialization (South-North)

Note: *Be advised that this test scenario is forcing movement across the Equator at 1,020 knots from South to North.*

Repeat Step 1 with the following equipment settings:

Initialize Time Reference at:	$\mathbf{t_0}$		
Set initial Computed Longitude to:	45.0	degrees	**EAST**
Set initial Computed Latitude to:	0.0625	degrees	**SOUTH**
Set initial Computed N/S Velocity to:	1,020	knots	**NORTH**

Note: *The velocity requirements above are specified in terms of North/South velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to verify that such information is properly resolved into the North/South velocity required in the transmitted messages.*

Step 5: Performance Check (South-North)

Repeat Steps 2 through 3.

Step 6: Equipment Re-Initialization (North Pole)

Note: *Be advised that this test scenario is forcing movement across the North Pole at 1,020 knots from South to North. It is up to the equipment designers to insure that equipment under test and the test equipment properly move across the pole by moving up to 90.0 degrees North and then down from the pole for the duration of the test.*

Repeat Step 1 with the following equipment settings:

Initialize Time Reference at:	$\mathbf{t_0}$		
Set initial Computed Longitude to:	45.0	degrees	**EAST**
Set initial Computed Latitude to:	89.9375	degrees	**NORTH**
Set initial Computed N/S Velocity to:	1,020	knots	**NORTH**

Note: *The velocity requirements above are specified in terms of North/South velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to verify that such information is properly resolved into the North/South velocity required in the transmitted messages.*

Step 7: Performance Check (North Pole)

Repeat Steps 2 through 3.

Step 8: Equipment Re-Initialization (South Pole)

Note: *Be advised that this test scenario is forcing movement across the South Pole at 1,020 knots from North to South. It is up to the equipment designers to insure that equipment under test and the test equipment properly move across the pole by moving up to 90.0 degrees South and then down from the pole for the duration of the test.*

Repeat Step 1 with the following equipment settings:

Initialize Time Reference at:	$\mathbf{t_0}$		
Set initial Computed Longitude to:	45.0	degrees	**WEST**
Set initial Computed Latitude to:	89.9375	degrees	**SOUTH**
Set initial Computed N/S Velocity to:	1,020	knots	**SOUTH**

Note: *The velocity requirements above are specified in terms of North/South velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to verify that such information is properly resolved into the North/South velocity required in the transmitted messages.*

Step 9: Performance Check (South Pole)

Repeat Steps 2 through 3.

Step 10: Repeat for additional Navigation Data Sources

Repeat Steps 1 through 9 for each Navigation Data Source input interface that the equipment is designed to accommodate.

2.4.3.2.4.7.2.2 Verification of Non-Coupled Case (Estimation, "TIME" (T) = "0") (§2.2.3.2.4.7.2.2, §2.2.5.1.7, §2.2.5.1.13)

Purpose/Introduction:

This test procedure will be used to verify that the ADS-B Transmitting System correctly extrapolates and encodes Surface Position data when NOT working with GNSS synchronized time.

Equipment Required:

Provide equipment capable of performing the following:

a. Load all valid data required for the ADS-B Surface Position Message into the ADS-B Transmitting system via the operational interfaces.

   The equipment should be capable of updating Latitude position and North/South Velocity given time, initial Latitude position, initial North/South velocity, and North/South acceleration. The Latitude Position provided to the ADS-B Transmission system **shall** be referred to as the Computed Latitude. Likewise, the North/South velocity provided to the ADS-B Transmission system **shall** be referred to as the Computed N/S Velocity.

   The equipment should be capable of updating Longitude position and East/West Velocity given time, initial Longitude position, initial East/West velocity, and

East/West acceleration. The Longitude Position provided to the ADS-B Transmission system **shall** be referred to as the Computed Longitude. Likewise, the East/West velocity provided to the ADS-B Transmission system **shall** be referred to as the Computed E/W Velocity.

The equipment should be capable of providing position information and velocity information to the ADS-B Transmitting system at a rate of not less than 5 times per second for each navigation parameter provided.

b. Generate an appropriate GNSS Time Mark as described in §2.2.5.1.6 but **DO NOT** apply the GNSS Time Mark to the ADS-B Transmitting System.

The equipment **shall** also be capable of time-tagging the GNSS Time Mark leading edge event to a minimum accuracy of 1.0 milliseconds.

c. Referenced to the GNSS Time Mark described in subparagraph b, above, the equipment **shall** have re-computed position and velocity information required by subparagraph a, above, available at one second intervals that are synchronized with the leading edge of the GNSS Time Mark. Initial delivery of the all new computed position and velocity data to the ADS-B Transmission system **shall** be completed no later than 200 milliseconds after the leading edge of the GNSS Time Mark.

d. Monitoring the transmitted ADS-B Surface Position Messages and the Airborne Velocity Messages and extracting all subfields as may be required. The equipment **shall** also be capable of time-tagging the receipt of any ADS-B Broadcast message to a minimum accuracy of 1.0 milliseconds.

e. Performing local unambiguous CPR decoding of the encoded latitude and longitude subfields in accordance with Appendix A, §A.1.7.4, §A.1.7.5 and §A.1.7.9.

f. After performing the encoded latitude and longitude local unambiguous CPR decoding, the equipment **shall** be capable of computing the difference between the Decoded Latitude Position and the Computed Latitude. Likewise, the equipment **shall** be capable of computing the difference between the Decoded Longitude Position and the Computed Longitude.

<u>Measurement Procedure:</u>

<u>Step 1:</u> <u>Equipment Initialization (North-South)</u>

Initialize the equipment to provide the following to the ADS-B Transmitting system.

DO NOT START DELIVERY OF THE DATA AT THIS TIME

a. Initialize Time Reference at:	$\mathbf{t_0}$		
Set initial Computed Longitude to:	45.0	degrees	**WEST**
Set initial Computed Latitude to:	0.0625	degrees	**NORTH**
Set initial Computed N/S Velocity to:	1,020	knots	**SOUTH**

Note: *The velocity requirements above are specified in terms of North/South velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to verify that such information is properly resolved into the North/South velocity required in the transmitted messages.*

b. GNSS Time Mark as described above under Equipment subparagraphs b and c.

c. All other data required to generate the Surface Position Message.

Step 2: Equipment Data Delivery Start Up

Allow the equipment to start delivery of the data specified in Step 1 and designate this time as $\mathbf{t_0}$.

Continue to let the equipment to provide the data for at least 35 seconds.

Step 3: Latitude Position Performance

Notes:

1. *Since there has been no position or velocity data provided to the ADS-B Transmitting system up to this time (at least for the purposes of this test procedure), a minimal amount of time will need to be allowed for the transmitted message data to stabilize. This fact has been factored in to the following required response criteria.*

2. *Be advised that this test scenario is forcing movement across the Equator at 1,020 knots from North to South.*

a. At 4.0 +/- 0.005 seconds after executing Step 2 where data has started being provided to the ADS-B Transmitting system under test:

Verify that the Decoded Latitude Position differs from the Computed Latitude Position by no more than **22.1** meters (i.e., approximately 0.0002 degrees Latitude).

b. At all successive points during the time of test that occur at least 6 seconds after the execution of Step 2:

Verify that the Decoded Latitude Position differs from the Computed Latitude Position by no more than **3.0** meters (i.e., approximately 0.000027 degrees Latitude).

c. Select a Surface Position Message that was received within 150 +/- 25 milliseconds of a GNSS Time Mark generated by the Test Equipment and provided to the ADS-B Transmitting System. Designate the leading edge of the GNSS Time Mark as $\mathbf{t_1}$.

Verify that the Decoded Latitude Position differs from the Computed Latitude Position at time $\mathbf{t_1}$ **+ 200 milliseconds** by no more than **3.0** meters (i.e., 0.000027 degrees Latitude).

d. Verify that the received message was encoded in the proper format, i.e., odd or even encoding, by correlating the received message to the stimulus data provided by the test equipment.

Note: *This test is intended to demonstrate that UUT is encoding data correctly in regards to 0.2 UTC Epochs and in regards to alternating odd and even encodings. Since the test set knows what the data is at given 1.0 second intervals, and it also time tags the received data, it is reasonable to expect that the capability is adequate to establish the proper 0.2 UTC Epochs and the appropriate format encoding.*

Step 4: Equipment Re-Initialization (South-North)

Note: *Be advised that this test scenario is forcing movement across the Equator at 1,020 knots from South to North.*

Repeat Step 1 with the following equipment settings:

Initialize Time Reference at:	$\mathbf{t_0}$		
Set initial Computed Longitude to:	45.0	degrees	**EAST**
Set initial Computed Latitude to:	0.0625	degrees	**SOUTH**
Set initial Computed N/S Velocity to:	1,020	knots	**NORTH**

Note: *The velocity requirements above are specified in terms of North/South velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to verify that such information is properly resolved into the North/South velocity required in the transmitted messages.*

Step 5: Performance Check (South-North)

Repeat Steps 2 through 4.

Step 6: Equipment Re-Initialization (North Pole)

Note: *Be advised that this test scenario is forcing movement across the North Pole at 1,020 knots from South to North. It is up to the equipment designers to insure that equipment under test and the test equipment properly move across the pole by moving up to 90.0 degrees North and then down from the pole for the duration of the test.*

Repeat Step 1 with the following equipment settings:

Initialize Time Reference at:	$\mathbf{t_0}$		
Set initial Computed Longitude to:	45.0	degrees	**EAST**
Set initial Computed Latitude to:	89.9375	degrees	**NORTH**
Set initial Computed N/S Velocity to:	1,020	knots	**NORTH**

Note: *The velocity requirements above are specified in terms of North/South velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to verify that such information is properly resolved into the North/South velocity required in the transmitted messages.*

Step 7: Performance Check (North Pole)

Repeat Steps 2 through 4.

Step 8: Equipment Re-Initialization (South Pole)

Note: *Be advised that this test scenario is forcing movement across the South Pole at 1,020 knots from North to South. It is up to the equipment designers to insure that equipment under test and the test equipment properly move across the pole by moving up to 90.0 degrees South and then down from the pole for the duration of the test.*

Repeat Step 1 with the following equipment settings:

Initialize Time Reference at:	$\mathbf{t_0}$		
Set initial Computed Longitude to:	45.0	degrees	**WEST**
Set initial Computed Latitude to:	89.9375	degrees	**SOUTH**
Set initial Computed N/S Velocity to:	1,020	knots	**SOUTH**

Note: *The velocity requirements above are specified in terms of North/South velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to verify that such information is properly resolved into the North/South velocity required in the transmitted messages.*

Step 9: Performance Check (South Pole)

Repeat Steps 2 through 4.

Step 10: Repeat for additional Navigation Data Sources

Repeat Steps 1 through 9 for each Navigation Data Source input interface that the equipment is designed to accommodate.

2.4.3.2.4.7.3 Verification of Surface Latitude Position Extrapolation/Estimation (non - precision) (§2.2.3.2.4.7.3)

Appropriate test procedures are provided in §2.4.3.2.4.7.3.1 and §2.4.3.2.4.7.3.2.

2.4.3.2.4.7.3.1 Verification of Surface Latitude Position Extrapolation Case (non - precision) (§2.2.3.2.4.7.3.1)

The procedures provided in §2.4.3.2.4.7.2.1 **shall** be used to validate performance of §2.4.3.2.4.7.3.1.

2.4.3.2.4.7.3.2 Verification of Surface Latitude Position Estimation Case (non - precision) (§2.2.3.2.4.7.3.2)

The procedures provided in §2.4.3.2.4.7.2.2 **shall** be used to validate performance of §2.4.3.2.4.7.3.2.

2.4.3.2.4.7.4 Verification of Surface Latitude Position Data Retention (§2.2.3.2.4.7.4, §2.2.5.1.7)

Purpose/Introduction:

The extrapolation or estimation, and update of latitude data and fields defined in §2.2.3.2.4.7.2 through §2.2.3.2.4.7.3.2 and **shall** be limited to no more than two seconds, in the event that the latitude position data is no longer available.

At the end of two seconds, the latitude data registers and the encoded latitude field **shall** be set to ALL ZEROs.

Measurement Procedures:

Step 1: Termination of Latitude Data Input - Part 1

Provide normal Surface Position data to the ADS-B Transmitting System at the nominal rate. First, filter the data so that the ADS-B Transmitting System does not receive any latitude data for at least 2 seconds. After 2 seconds, verify that the latitude data registers are set to ALL ZEROs.

Note: *In order to terminate latitude data, it may also be necessary to terminate longitude information since a position fix normally includes both latitude and longitude.*

Step 2: Termination of Latitude Data Input - Part 2

Return to providing normal Surface Position data at the nominal rate. Next, filter the data so that the device does not receive any latitude data. After 1 second, stop providing data. Verify that after 1 second more, the latitude registers are set to ALL ZEROs.

2.4.3.2.4.8 Verification of "ENCODED LONGITUDE" Subfield in ADS-B Surface Position Messages (§2.2.3.2.4.6, §2.2.3.2.4.8, §2.2.5.1.6, §2.2.5.1.8, §2.2.5.1.13)

Appropriate test procedures are provided in §2.4.3.2.4.8 through §2.4.3.2.4.8.4.

2.4.3.2.4.8.1 Verification of Surface Longitude Data Encoding (§2.2.3.2.4.8.1, §2.2.5.1.8, §2.2.5.1.13)

Appropriate test procedures to verify the surface longitude data encoding were previously provided in §2.4.3.2.4.7.1.2.

2.4.3.2.4.8.2 Verification of Surface Longitude Position Extrapolation/Estimation (Precision Case, Type Codes 5 and 6) (§2.2.3.2.4.8.2)

Appropriate test procedures are provided in §2.4.3.2.4.8.2.1 and §2.4.3.2.4.8.2.2.

2.4.3.2.4.8.2.1 Verification of GPS/GNSS Time Mark Coupled Case (Extrapolation, "TIME" (T) = "1") (§2.2.3.2.4.8.2.1, §2.2.5.1.6, §2.2.5.1.8, §2.2.5.1.13)

Purpose/Introduction:

This test procedure will be used to verify that the ADS-B Transmitting System correctly extrapolates and encodes Surface Position data when working with GNSS synchronized time.

Equipment Required:

Equipment requirements remain the same as provided in §2.4.3.2.4.7.2.1.

Measurement Procedure:

Step 1: Equipment Initialization (GM-E-W)

Initialize the equipment to provide the following to the ADS-B Transmitting system.

DO NOT START DELIVERY OF THE DATA AT THIS TIME

a. Initialize Time Reference at:	$\mathbf{t_0}$		
Set initial Computed Longitude to:	-0.0625	degrees	**EAST**
Set initial Computed Latitude to:	45.0	degrees	**NORTH**
Set initial Computed E/W Velocity to:	1,020	knots	**WEST**

Note: *The velocity requirements above are specified in terms of East/West velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to verify that such information is properly resolved into the East/West velocity required in the transmitted messages.*

b. GNSS Time Mark as described above under Equipment subparagraphs b and c.

c. All other data required to generate the Surface Position Message.

Step 2: Equipment Data Delivery Start Up

Allow the equipment to start delivery of the data specified in Step 1 and designate this time as $\mathbf{t_0}$.

Continue to let the equipment to provide the data for at least 35 seconds.

Step 3: Longitude Position Performance

Notes:

1. Since there has been no position or velocity data provided to the ADS-B Transmitting system up to this time (at least for the purposes of this test procedure), a minimal amount of time will need to be allowed for the transmitted message data to stabilize. This fact has been factored in to the following required response criteria.

2. Be advised that this test scenario is forcing movement across the Greenwich Meridian at 1,020 knots from East to West. It is up to the equipment designers to insure that equipment under test and the test equipment properly move across the International Dateline by moving up to 180 degrees and then down for the duration of the test.

a. At 4.0 +/- 0.005 seconds after executing Step 2 where data has started being provided to the ADS-B Transmitting system under test:

Verify that the Decoded Longitude Position differs from the Computed Longitude Position by no more than **22.1** meters (i.e., approximately 0.0002 degrees Longitude).

b. At all successive points during the time of test that occur at least 6 seconds after the execution of Step 2:

Verify that the Decoded Longitude Position differs from the Computed Longitude Position by no more than **3.0** meters (i.e., approximately 0.000027 degree Longitude).

c. Select a Surface Position Message that was received at least 6 seconds after the execution of Step 2 and within 50 +/- 25 milliseconds of a GNSS Time Mark generated by the Test Equipment and provided to the ADS-B Transmitting System. Designate the leading edge of the GNSS Time Mark as $\mathbf{t_1}$.

Verify that the Decoded Longitude Position differs from the Computed Longitude Position at time $\mathbf{t_1}$ **+ 200 milliseconds** by no more than **3.0** meters (i.e., approximately 0.000027 degrees Longitude).

d. Verify that the received message was encoded in the proper format, i.e., odd or even encoding, by correlating the received message to the stimulus data provided by the test equipment.

Note: *This test is intended to demonstrate that UUT is encoding data correctly in regards to 0.2 UTC Epochs and in regards to alternating odd and even encodings. Since the test set knows what the data is at given 1.0 second intervals, and it also time tags the received data, it is reasonable to expect that the capability is adequate to establish the proper 0.2 UTC Epochs and the appropriate format encoding.*

Step 4: Equipment Re-Initialization (GM-W-E)

Note: *Be advised that this test scenario is forcing movement across the Greenwich Meridian at 1,020 knots from West to East.*

Repeat Step 1 with the following equipment settings:

Initialize Time Reference at:	$\mathbf{t_0}$		
Set initial Computed Longitude to:	0.0625	degrees	**EAST**
Set initial Computed Latitude to:	45.0	degrees	**SOUTH**
Set initial Computed E/W Velocity to:	1,020	knots	**EAST**

Note: *The velocity requirements above are specified in terms of East/West velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to verify that such information is properly resolved into the East/West velocity required in the transmitted messages.*

Step 5: Performance Check (West - East)

Repeat Steps 2 through 3.

Step 6: Equipment Re-Initialization (IDL-E-W)

Note: *Be advised that this test scenario is forcing movement across the International Dateline at 1,020 knots from East to West.*

Repeat Step 1 with the following equipment settings:

Initialize Time Reference at:	$\mathbf{t_0}$		
Set initial Computed Longitude to:	179.9375	degrees	**EAST**
Set initial Computed Latitude to:	45.0	degrees	**NORTH**
Set initial Computed E/W Velocity to:	1,020	knots	**WEST**

Note: *The velocity requirements above are specified in terms of East/West velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to verify that such information is properly resolved into the East/West velocity required in the transmitted messages.*

Step 7: Performance Check (IDL-E-W)

Repeat Steps 2 through 3.

Step 8: Equipment Re-Initialization (IDL-E-W)

Note: *Be advised that this test scenario is forcing movement across the International Dateline at 1,020 knots from East to West. It is up to the equipment designers to insure that equipment under test and the test equipment properly move across the International Dateline by moving up to 180 degrees and then down for the duration of the test.*

Repeat Step 1 with the following equipment settings:

Initialize Time Reference at:	$\mathbf{t_0}$		
Set initial Computed Longitude to:	179.9375	degrees	**WEST**
Set initial Computed Latitude to:	45.0	degrees	**SOUTH**
Set initial Computed E/W Velocity to:	1,020	knots	**EAST**

Note: *The velocity requirements above are specified in terms of East/West velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to* *verify that such information is properly resolved into the East/West velocity required in the transmitted messages.*

Step 9: Performance Check (IDL-E-W)

Repeat Steps 2 through 3.

Step 10: Repeat for additional Navigation Data Sources

Repeat Steps 1 through 9 for each Navigation Data Source input interface that the equipment is designed to accommodate.

2.4.3.2.4.8.2.2 Verification of Non-Coupled Case (Estimation, "TIME" (T) = "0") (§2.2.3.2.4.8.2.2, §2.2.5.1.8, §2.2.5.1.13)

Purpose/Introduction:

This test procedure will be used to verify that the ADS-B Transmitting System correctly extrapolates and encodes Surface Position data when NOT working with GNSS synchronized time.

Equipment Required:

Equipment requirements remain the same as provided in §2.4.3.2.4.7.2.2.

Measurement Procedure:

Step 1: Equipment Initialization (GM-E-W)

Initialize the equipment to provide the following to the ADS-B Transmitting system.

DO NOT START DELIVERY OF THE DATA AT THIS TIME

a.	Initialize Time Reference at:	$\mathbf{t_0}$		
	Set initial Computed Longitude to:	-0.0625	degrees	**EAST**
	Set initial Computed Latitude to:	45.0	degrees	**NORTH**
	Set initial Computed E/W Velocity to:	1,020	knots	**WEST**

Note: *The velocity requirements above are specified in terms of East/West velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to verify that such information is properly resolved into the East/West velocity required in the transmitted messages.*

b. GNSS Time Mark as described above under Equipment subparagraphs b and c.

c. All other data required to generate the Airborne Position Message and the Airborne Velocity Message.

Step 2: Equipment Data Delivery Start Up

Allow the equipment to start delivery of the data specified in Step 1 and designate this time as $\mathbf{t_0}$.

Continue to let the equipment to provide the data for at least 35 seconds.

Step 3: Longitude Position Performance

Notes:

1. *Since there has been no position or velocity data provided to the ADS-B Transmitting system up to this time (at least for the purposes of this test procedure), a minimal amount of time will need to be allowed for the transmitted message data to stabilize. This fact has been factored in to the following required response criteria.*

2. *Be advised that this test scenario is forcing movement across the Greenwich Meridian at 1,020 knots from East to West. It is up to the equipment designers to insure that equipment under test and the test equipment properly move across the International Dateline by moving up to 180 degrees and then down for the duration of the test.*

a. At 4.0 +/- 0.005 seconds after executing Step 2 where data has started being provided to the ADS-B Transmitting system under test:

   Verify that the Decoded Longitude Position differs from the Computed Longitude Position by no more than **22.1** meters (i.e., approximately 0.0002 degrees Longitude).

b. At all successive points during the time of test that occur at least 6 seconds after the execution of Step 2:

   Verify that the Decoded Longitude Position differs from the Computed Longitude Position by no more than **3.0** meters (i.e., approximately 0.000027 degrees Longitude).

c. Select an Airborne Position Message that was received at least 6 seconds after the execution of Step 2 and within 50 +/- 25 milliseconds of a GNSS Time Mark generated by the Test Equipment and provided to the ADS-B Transmitting System. Designate the leading edge of the GNSS Time Mark as $\mathbf{t_1}$.

   Verify that the Decoded Longitude Position differs from the Computed Longitude Position at time $\mathbf{t_1}$ **+ 200 milliseconds** by no more than **3.0** meters (i.e., approximately 0.000027 degrees Longitude).

d. Verify that the received message was encoded in the proper format, i.e., odd or even encoding, by correlating the received message to the stimulus data provided by the test equipment.

Note: *This test is intended to demonstrate that UUT is encoding data correctly in regards to 0.2 UTC Epochs and in regards to alternating odd and even encodings. Since the test set knows what the data is at given 1.0 second intervals, and it also time tags the received data, it is reasonable to expect that the capability is adequate to establish the proper 0.2 UTC Epochs and the appropriate format encoding.*

Step 4: Equipment Re-Initialization (GM-W-E)

Note: *Be advised that this test scenario is forcing movement across the Greenwich Meridian at 1,020 knots from West to East.*

Repeat Step 1 with the following equipment settings:

Initialize Time Reference at:	$\mathbf{t_0}$		
Set initial Computed Longitude to:	0.0625	degrees	**EAST**
Set initial Computed Latitude to:	45.0	degrees	**SOUTH**
Set initial Computed E/W Velocity to:	1,020	knots	**EAST**

Note: *The velocity requirements above are specified in terms of East/West velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to verify that such information is properly resolved into the East/West velocity required in the transmitted messages.*

Step 5: Performance Check (West - East)

Repeat Steps 2 through 3.

Step 6: Equipment Re-Initialization (IDL-E-W)

Note: *Be advised that this test scenario is forcing movement across the International Dateline at 1,020 knots from East to West.*

Repeat Step 1 with the following equipment settings:

Initialize Time Reference at:	$\mathbf{t_0}$		
Set initial Computed Longitude to:	179.9375	degrees	**EAST**
Set initial Computed Latitude to:	45.0	degrees	**NORTH**
Set initial Computed E/W Velocity to:	1,020	knots	**WEST**

Note: *The velocity requirements above are specified in terms of East/West velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to verify that such information is properly resolved into the East/West velocity required in the transmitted messages.*

Step 7: Performance Check (IDL-E-W)

Repeat Steps 2 through 3.

Step 8: Equipment Re-Initialization (IDL-E-W)

Note: *Be advised that this test scenario is forcing movement across the International Dateline at 1,020 knots from East to West. It is up to the equipment designers to insure that equipment under test and the test equipment properly move across the International Dateline by moving up to 180 degrees and then down for the duration of the test.*

Repeat Step 1 with the following equipment settings:

Initialize Time Reference at:	$\mathbf{t_0}$		
Set initial Computed Longitude to:	179.9375	degrees	**WEST**
Set initial Computed Latitude to:	45.0	degrees	**SOUTH**
Set initial Computed E/W Velocity to:	1,020	knots	**EAST**

Note: *The velocity requirements above are specified in terms of East/West velocities. If alternate velocity and direction sources are used, i.e., ground speed and ground track, then it is up to the implementer to verify that such information is properly resolved into the East/West velocity required in the transmitted messages.*

Step 9: Performance Check (IDL-E-W)

Repeat Steps 2 through 3.

Step 10: Repeat for additional Navigation Data Sources

Repeat Steps 1 through 9 for each Navigation Data Source input interface that the equipment is designed to accommodate.

2.4.3.2.4.8.3 Verification of Surface Longitude Position Extrapolation/Estimation (non - precision) (§2.2.3.2.4.8.3)

Appropriate test procedures are provided in §2.4.3.2.4.8.3.1 and §2.4.3.2.4.8.3.2.

2.4.3.2.4.8.3.1 Verification of Surface Longitude Position Extrapolation Case (non - precision) (§2.2.3.2.4.8.3.1)

The procedures provided in §2.4.3.2.4.8.2.1 **shall** be used to validate performance of §2.4.3.2.4.8.3.1.

2.4.3.2.4.8.3.2 Verification of Surface Longitude Position Estimation Case (non - precision) (§2.2.3.2.4.8.3.2)

The procedures provided in §2.4.3.2.4.8.2.2 **shall** be used to validate performance of §2.4.3.2.4.8.3.2.

2.4.3.2.4.8.4 Verification of Surface Longitude Position Data Retention (§2.2.3.2.4.8.4, §2.2.5.1.8)

Purpose/Introduction:

The extrapolation or estimation, and update of longitude data and fields defined in §2.2.3.2.4.8.2 through §2.2.3.2.4.8.3.2 and **shall** be limited to no more than two seconds, in the event that the longitude position data is no longer available.

At the end of two seconds, the longitude data registers and the encoded longitude field **shall** be set to ALL ZEROs.

Measurement Procedure:

Step 1: Longitude Data Termination - Part 1

Provide normal Surface Position data to the ADS-B Transmitting System at the nominal rate. First, filter the data so that the ADS-B Transmitting System does not receive any longitude data for at least 2 seconds. After 2 seconds, verify that the longitude data registers are set to ALL ZEROs.

Note: *In order to terminate longitude data, it may also be necessary to terminate latitude information since a position fix normally includes both latitude and longitude.*

Step 2: Longitude Data Termination - Part 2

Return to providing normal Surface Position data at the nominal rate. Next, filter the data so that the device does not receive any longitude data. After 1 second, stop providing data. Verify that after 1 second more, the longitude registers are set to ALL ZEROs. Verify that after 1 second more, the longitude registers are set to ALL ZEROs.

2.4.3.2.5 Verification of ADS-B Aircraft Identification and Type Messages (§2.2.3.2.5)

The format for the Aircraft Identification and Type Message "ME" field contents is defined in Figure 2-6. Testing requirements for each of the subfields is defined in the following subparagraphs.

2.4.3.2.5.1 Verification of "TYPE" Subfield in ADS-B Aircraft Identification and Type Message (§2.2.3.2.5.1)

The procedures provided in §2.4.3.2.5.2 **shall** be used to validate performance of §2.4.3.2.5.1.

2.4.3.2.5.2 Verification of "ADS-B EMITTER CATEGORY" Subfield in ADS-B Aircraft Identification and Type Message (§2.2.3.2.5.2, §2.2.5.1.2)

Purpose/Introduction:

The "ADS-B EMITTER CATEGORY" subfield is a 3-bit field (ME Bits 6 through 8, Message Bits 38 through 40) used to identify particular aircraft or vehicle types within the ADS-B Emitter Type Sets A, B, C, or D identified by Message Format Type codes 4, 3, 2 and 1 respectively. Each of the ADS-B Emitter Type sets are defined in Table 2-16.

If the ADS-B Emitter Category is not available to the ADS-B transmission device, then the device **shall** enter ALL ZEROS into the "ADS-B Emitter Category" Subfield in the Aircraft Identification and Type Message.

Measurement Procedure:

Step 1: Emitter Category Data Input

Provide the ADS-B Transmitting System with appropriate ADS-B Emitter Category data via the appropriate interface. Vary the "Emitter Category" data input through the range of codes, values 0 through 7 for Emitter Category Sets "A," "B," "C" and "D," for all Emitter Categories and codes that the system supports.

For each ADS-B Emitter Category data input selected, verify that the Format Type Code is properly transmitted in the ADS-B Aircraft Identification and Type Message.

For each ADS-B Emitter Category data input selected, verify that the ADS-B Emitter Category subfield is properly transmitted in the ADS-B Aircraft Identification and Type Message in accordance with the encodings provided in Table 2-16.

Step 2: Emitter Category Data Not Available

Set up the ADS-B Transmitting System as in Step 1 above. Discontinue the input of valid ADS-B Emitter Category data and verify that the ADS-B Emitter Category Subfield is set to ALL ZEROs (binary 000) in the Aircraft Identification and Type Message.

2.4.3.2.5.3 Verification of "CHARACTER" Subfield in ADS-B Aircraft Identification and Type Message (§2.2.3.2.5.3, §2.2.5.1.11)

Purpose/Introduction:

Each of the 8 "CHARACTER" subfields is a 6-bit field as shown in Figure 2-6.

The 8 "Character" subfields **shall** encode the following information:

a. If the aircraft flight plan is available, then the aircraft identification employed in the flight plan **shall** be encoded.

b. If the aircraft flight plan is not available, then the Aircraft Registration Marking **shall** be encoded.

Measurement Procedure:

Step 1: Aircraft Identification Data Input - Part 1

Provide the ADS-B Transmitting System with appropriate ADS-B Emitter Category data via the appropriate interface. Set the input data for each of the eight characters to the character "5."

Verify that each of the characters in the ADS-B Aircraft Identification and Type Message is transmitted properly in accordance with the encoding provided in §A.1.4.4.1 of Appendix A. For an input character of "5," the encoding for each character should be 110101 Binary.

Step 2: Aircraft Identification Data Input - Part 2

Provide the ADS-B Transmitting System with appropriate ADS-B Emitter Category data via the appropriate interface. Set the input data for each of the eight characters to the character "J."

Verify that each of the characters in the ADS-B Aircraft Identification and Type Message is transmitted properly in accordance with the encoding provided in §A.1.4.4.1 of Appendix A. For an input character of "J," the encoding for each character should be 001010 Binary.

Step 3: Aircraft Registration Marking Data Input

Repeat Step 1 and 2 while providing the ADS-B Transmitting System with Aircraft Registration Marking data instead of Aircraft Identification via the appropriate interface.

Step 4: No Aircraft Identification or Aircraft Registration Data

Discontinue the input of Aircraft Identification or Aircraft Registration Marking Data.

Verify that each of the characters in the ADS-B Aircraft Identification and Type Message is transmitted properly with all bits of each character set to a binary "0." The encoding for each character should be 000000 Binary.

Note: *The message will continue to be transmitted as long as Category data continues to be updated.*

2.4.3.2.6 Verification of ADS-B Airborne Velocity Information Messages (§2.2.3.2.6)

Formats for the various Airborne Velocity Information Messages are further classified by subtype as identified in Figure 2-7a and Figure 2-7b. Test procedures to verify the various fields within the Airborne Velocity Information Message are described in the following paragraphs.

2.4.3.2.6.1 Verification of ADS-B Airborne Velocity Message - Subtype "1" (§2.2.3.2.6.1)

Appropriate test procedures are provided in §2.4.3.2.6.1.1 through §2.4.3.2.6.1.15.

2.4.3.2.6.1.1 Verification of "TYPE" Subfield in Aircraft Velocity - Subtype "1" Messages (§2.2.3.2.6.1.1)

Appropriate test procedures are provided in §2.4.3.2.6.1.2.

2.4.3.2.6.1.2 Verification of "SUBTYPE" Subfield in Aircraft Velocity - Subtype "1" Messages (§2.2.3.2.6.1.1, §2.2.3.2.6.1.2, §2.2.3.2.6.2.1, §2.2.3.2.6.2.2, §2.2.3.2.6.3.1, §2.2.3.2.6.3.2, §2.2.3.2.6.4.1, §2.2.3.2.6.4.2, §2.2.5.1.19)

Purpose/Introduction:

The "SUBTYPE" subfield is contained in Message Bits 38 through 40 (ME Bits 6 through 8), and is coded according to the chart presented in the above referenced subparagraph. This test procedure is intended to verify that the appropriate SUBTYPE subfield is used in all Airborne Velocity Messages.

Measurement Procedure:

Step 1: Type and Subtype Verification - Part 1

Configure the ADS-B Transmitting System to transmit Airborne Velocity Messages by providing velocity information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set up the system to enable broadcast of Airborne Velocity Messages (see additional information in §2.2.3.3.2.5, "ADS-B Velocity Message Broadcast Rate"). Set the ADS-B Transmitting System to Airborne status. Provide velocity information in the form of Velocity Over Ground (i.e., Ground Speed) with a valid value that is greater than zero but non-supersonic (i.e., both North/South AND East/West velocity inputs are less than 1000 knots).

Verify that ADS-B Messages are generated with TYPE value "19" and that all such messages contain SUBTYPE value "1."

Raise the East/West Velocity input to a value of 1021 knots, and verify that ADS-B Messages are generated with TYPE value "19" and that all such messages contain SUBTYPE value "1." Lower the East/West Velocity input to a value below 1000 knots, and raise the North/South Velocity input to a value of 1021 knots.

Verify that ADS-B Messages are generated with TYPE value "19" and that all such messages contain SUBTYPE value "1."

Lower the North/South Velocity input to a value below 1000 knots, then raise both the East/West and North/South Velocity inputs to values of 1021 knots.

Verify that ADS-B Messages are generated with TYPE value "19" and that all such messages contain SUBTYPE value "1."

Note: *During the execution of the previous step, care must be taken to ensure that neither the East/West nor the North/South Velocity inputs are raised to a value greater than 1021 knots.*

Step 2: Type and Subtype Verification - Part 2

This step verifies that the ADS-B Transmitting System correctly transitions between SUBTYPE equal "1" and SUBTYPE equal "2" in Airborne Velocity Messages.

Set up the system to enable broadcast of Airborne Velocity Messages as indicated in Step 1. Provide velocity information in the form of Velocity Over Ground (i.e., Ground Speed). Initially, both the East/West Velocity input and the North/South velocity input **shall** be greater than 0 knots but less than 1000 knots, as in Step 1. Raise the East/West velocity to a value of 1023 knots.

Verify that ADS-B Messages are generated with TYPE value "19" and that all such messages contain SUBTYPE value "2."

Decrease the East/West velocity input to a value of 999 knots. Verify that ADS-B Messages are generated with TYPE value "19" and that all such messages revert to SUBTYPE value "1." Raise the North/South velocity to a value of 1023 knots.

Verify that ADS-B Messages are generated with TYPE value "19" and that all such messages contain SUBTYPE value "2."

Decrease the North/South velocity input to a value of 999 knots.

Verify that ADS-B Messages are generated with TYPE value "19" and that all such messages revert to SUBTYPE value "1."

Raise both North/South and East/West input values to 1023 knots, and verify that ADS-B Messages are generated with TYPE value "19" and that all such messages contain SUBTYPE value "2."

Decrease both North/South and East/West input values to 999 knots, and verify that ADS-B Messages are generated with TYPE value “19” and that all such messages contain SUBTYPE value “1.”

Step 3: Type and Subtype Verification - Part 3

Provide velocity information in the form of Airspeed and Heading Information with a valid value that is greater than zero but non-supersonic (i.e., the Airspeed input is less than 1000 knots).

Verify that ADS-B Airborne Velocity Messages are generated with TYPE value “19” and that all such messages contain SUBTYPE value “3.”

Raise the Airspeed input to 1021 knots, without exceeding the value of 1022 knots in the process.

Verify that ADS-B Messages are generated with TYPE value “19” and that all such messages contain SUBTYPE value “3.”

Step 4: Type and Subtype Verification - Part 4

This step verifies that the ADS-B Transmitting System correctly transitions between SUBTYPE equal “3” and SUBTYPE equal “4” in Airborne Velocity Messages containing Airspeed and Heading Information.

Set up the system to enable broadcast of Airborne Velocity Messages as indicated in Step 1 but with velocity information provided in the form of Airspeed and Heading Information rather than Velocity Over Ground. Initially, the Airspeed input **shall** be greater than 0 knots but less than 1000 knots, as in Step 1. Raise the input Airspeed to a value of 1023 knots.

Verify that ADS-B Messages are generated with TYPE value “19” and that all such messages contain SUBTYPE value “4.”

Decrease the Airspeed input to a value of 999 knots.

Verify that ADS-B Messages are generated with TYPE value “19” and that all such messages revert to SUBTYPE value “3.”

2.4.3.2.6.1.3 Verification of “INTENT CHANGE FLAG” Subfield in Aircraft Velocity - Subtype “1” Messages (§2.2.3.2.6.1.3, §2.2.3.2.6.2.3, §2.2.3.2.6.3.3, §2.2.3.2.6.4.3, §2.2.5.1.20)

Purpose/Introduction:

This test procedure verifies that the ADS-B Transmitting System correctly outputs Airborne Velocity Messages with “INTENT CHANGE FLAG” subfield (Message Bit 41, ME Bit 9) set to the value “0” for Non-Transponder Based Implementations.

These test procedures are intended for use for Airborne Velocity Messages of all subtypes. The type and values of the input Velocity data should be set so as to generate Airborne Velocity Messages for all appropriate SUBTYPE fields.

Measurement Procedure:

Configure the ADS-B Transmitting System to transmit Airborne Velocity Messages by providing velocity information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set up the system to enable broadcast of Airborne Velocity Messages (see additional information in 2.2.3.3.2.5, "ADS-B Velocity Message Broadcast Rate"). Set the ADS-B Transmitting System to Airborne status. Provide valid non-zero velocity data to the ADS-B System.

Verify that ADS-B Airborne Velocity Messages are generated with TYPE value "19" and that all such messages correctly report Message Bit 41, ME Bit 9 (INTENT CHANGE FLAG subfield) set to "0."

2.4.3.2.6.1.4 Verification of "IFR Capability Flag" Subfield in Aircraft Velocity - Subtype "1" Messages (§2.2.3.2.6.1.4, §2.2.3.2.6.2.4, §2.2.3.2.6.3.4, §2.2.3.2.6.4.4, §2.2.5.1.21)

Purpose/Introduction:

The "IFR CAPABILITY FLAG" subfield is a one-bit field contained in Message Bit 42 (ME Bit 10). This test procedure verifies that the IFR CAPABILITY FLAG subfield in Airborne Velocity Messages is correctly encoded according to the above referenced subparagraph.

These test procedures are intended for use for Airborne Velocity Messages of all subtypes. The type and values of the input Velocity data should be set so as to generate Airborne Velocity Messages for all appropriate SUBTYPE fields.

Measurement Procedure:

Configure the ADS-B Transmitting System to transmit Airborne Velocity Messages by providing velocity information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set up the system to enable broadcast of Airborne Velocity Messages (see additional information in 2.2.3.3.2.5, "ADS-B Velocity Message Broadcast Rate"). Set the ADS-B Transmitting System to Airborne status. Provide valid non-zero velocity data to the ADS-B System.

Verify that ADS-B Airborne Velocity Messages are generated with TYPE value "19."

If the ADS-B Transmitting Subsystem has capability for applications requiring ADS-B equipage class "A1" or above, verify that Message Bit 42 (ME Bit 10) in these messages is set to "1."

If the ADS-B Transmitting Subsystem does NOT have capability for such applications, verify that these messages have Message Bit 42 (ME Bit 10) set to "0."

2.4.3.2.6.1.5 Verification of "NAC_V" Subfield in Aircraft Velocity - Subtype "1" Messages (§2.2.3.2.6.1.5, §2.2.3.2.6.2.5, §2.2.3.2.6.3.5, §2.2.3.2.6.4.5, §2.2.5.1.22)

Purpose/Introduction:

These test procedures are intended for use for Airborne Velocity Messages of all subtypes. The type and values of the input Velocity data should be set so as to generate Airborne Velocity Messages for all appropriate SUBTYPE fields.

Measurement Procedure:

Step 1: Verifying NAC_V When $HFOM_R$ and $VFOM_R$ Are Provided

Configure the ADS-B Transmitting System to transmit Airborne Velocity Messages by providing velocity information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set up the system to enable broadcast of Airborne Velocity. Set the ADS-B Transmitting System to Airborne status. Provide valid non-zero velocity data to the ADS-B System. Verify that your external data source provides 95% accuracy figures of merit for horizontal and vertical velocity [$HFOM_R$ (Horizontal Figure of Merit for Velocity) and $VFOM_R$ (Vertical Figure of Merit for Velocity)].

Verify that for each $HFOM_R$ and $VFOM_R$ value in Table 2-92 that the system generates Airborne Velocity Messages with the NAC_V subfield set equal to the corresponding binary coding value shown in the table.

Table 2-92: Values for NAC_V when $HFOM_R$ & $VFOM_R$ are provided

NAVIGATION UNCERTAINTY CATEGORY - VELOCITY			
CODING (binary)	**MEANING**		
NAC_V	**$HFOM_R$ value**		**$VFOM_R$ value**
000	$HFOM_R$ is unknown or ≥ 10 m/s (32.8 fps)	***OR***	$VFOM_R$ is unknown or ≥ 15.2 m/s (50 fps)
001	< 10 m/s (32.8 fps)	***AND***	< 15.2 m/s (50fps)
010	< 3 m/s (9.84fps)	***AND***	< 4.6 m/s (15.0 fps)
011	< 1 m/s (3.28 fps)	***AND***	< 1.5 m/s (5.0 fps)
100	< 0.3 m/s (0.984 fps)	***AND***	< 0.46 m/s (1.5 fps)

Step 2: Verifying NAC_V From a GNSS Receiver Operating in LAAS or WAAS Mode

Configure the ADS-B Transmitting System to transmit Airborne Velocity Messages by providing velocity information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set up the system to enable broadcast of Airborne Velocity. Set the ADS-B Transmitting System to Airborne status. Provide valid non-zero velocity data to the ADS-B System. If the external data source does not provide $HFOM_R$ and $VFOM_R$, the 95% accuracy figures of merit for horizontal and vertical velocity, then verify that the external data source does provide 95% accuracy figures of merit for the horizontal and vertical positions [HFOM (Horizontal Figure of Merit for position) and VFOM (Vertical Figure of Merit for position)].

If the external data source provides position and velocity from a GNSS/LAAS or GNSS/WAAS receiver, when that receiver is operating in LAAS or WAAS mode, then verify that for each HFOM and VFOM value in Table 2-93 that the system generates Airborne Velocity Messages with the NAC_V subfield set equal to the corresponding binary coding value shown in the table.

Table 2-93: Values for NAC_V From a GNSS Receiver in LAAS or WAAS Mode

NAVIGATION UNCERTAINTY CATEGORY - VELOCITY				
CODING (binary)	**CODING** (decimal)	**MEANING**		
NAC_V	NAC_V	HFOM value		VFOM value
000	0	49.5 m	**OR**	> 248 ft
001	1	> 14.5m **AND** ≤ 49.5 m	**OR**	> 73.3 ft **AND** ≤ 248 ft
010	2	> 4.5 m **AND** ≤ 14.5 m	**OR**	> 23.3 ft **AND** ≤ 73.3 ft
011	3	> 1 m **AND** ≤ 4.5 m	**OR**	> 5.85 ft **AND** ≤ 23.3 ft
100	4	≤ 1 m	**AND**	≤ 5.85 ft

Step 3: Verifying NAC_V When Differential GNSS Corrections Are Not Available

Configure the ADS-B Transmitting System to transmit Airborne Velocity Messages by providing velocity information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set up the system to enable broadcast of Airborne Velocity. Set the ADS-B Transmitting System to Airborne status. Provide valid non-zero velocity data to the ADS-B System. If the external data source does not provide $HFOM_R$ and $VFOM_R$, the 95% accuracy figures of merit for horizontal and vertical velocity, then verify that the external data source does provide 95% accuracy figures of merit for the horizontal and vertical positions [HFOM (Horizontal Figure of Merit for position) and VFOM (Vertical Figure of Merit for position)].

If the external data source provides position and velocity from a GNSS receiver, when that receiver is operating in autonomous mode, then verify that for each HFOM and VFOM value in Table 2-94 that the system generates Airborne Velocity Messages with the NAC_V subfield set equal to the corresponding binary coding value shown in the table.

Table 2-94: Values for NAC_V When Differential GNSS Corrections Are Not Available

NAVIGATION UNCERTAINTY CATEGORY - VELOCITY				
CODING (binary)	**CODING** (decimal)	**MEANING**		
NACV	NACV	HFOM value		VFOM value
000	0	> 475m	**OR**	> 2335ft
001	1	> 125 m **AND** ≤ 475m	**OR**	> 585 ft **AND** ≤ 2335ft
010	2	≤ 125m	**AND**	≤ 585ft

2.4.3.2.6.1.6 Verification of "EAST / WEST DIRECTION BIT" Subfield in Aircraft Velocity - Subtype "1" Messages (§2.2.3.2.6.1.6, §2.2.3.2.6.2.6, §2.2.5.1.12)

Purpose/Introduction:

The "EAST/WEST DIRECTION BIT" subfield is contained in Message Bit 46 (ME Bit 14) of Airborne Velocity Messages, subtypes 1 and 2. This test procedure verifies that the EAST/WEST DIRECTION BIT in Airborne Velocity Messages is correctly set to "0" for inputs indicating travel in an eastward direction, and "1" for travel in a westward direction.

These test procedures are intended for use for Airborne Velocity Messages of SUBTYPES 1 and 2. The values of the input Velocity data should be set so as to generate Airborne Velocity Messages for each SUBTYPE value.

Measurement Procedure:

Step 1: East / West Direction Bit Verification when Velocity is Not Available

Configure the ADS-B Transmitting System to transmit Airborne Velocity Messages with subtype "1" by providing velocity information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set up the system to enable broadcast of Airborne Velocity Messages (see additional information in §2.2.3.3.2.5, "ADS-B Velocity Message Broadcast Rate"). Set the ADS-B Transmitting System to Airborne status. Provide valid non-zero velocity data to the ADS-B System.

Verify that when East/West Velocity Data is not provided to the ADS-B transmission device, the EAST/WEST DIRECTION BIT is set to "0."

Step 2: East / West Direction Bit Verification – Directional Components

The method for testing this field depends largely upon the nature of the input for East/West Velocity Data.

CASE 1:

If the directional component of the input is a single bit or a "flag" type (i.e. a single discrete value is used to represent "EAST," and another discrete value is used to represent "WEST"), then the procedure for this step **shall** be as follows.

Set the input to the value that indicates travel in an eastward direction, and check that ADS-B Airborne Velocity Messages are generated with TYPE value "19," and that all such messages contain an EAST/WEST DIRECTION BIT subfield with a value of ZERO (0).

Next, set the input to the value that indicates travel in a westward direction. Verify that ADS-B Airborne Velocity Messages are generated with TYPE value "19," and that all such messages contain an EAST/WEST DIRECTION BIT subfield with a value of ONE (1).

CASE 2:

If the directional component of the input is variable (e.g. a heading expressed in degrees or other similar manner so that the input value must be evaluated by the ADS-B transmission device in order to determine the proper value for the EAST/WEST DIRECTION BIT), then the test procedure **shall** be as follows. In this case, the input variable must be made to assume values corresponding to movement in an eastward direction.

It must be verified for each such input value that Airborne Velocity Messages are generated with TYPE value "19" and that all such messages contain an EAST/WEST DIRECTION BIT subfield with a value of ZERO (0).

The input must then be varied to assume values corresponding to movement in a westward direction. It must be verified for each such value that the system generates Airborne Velocity Messages with TYPE value "19" and that all such messages contain an EAST/WEST DIRECTION BIT subfield with a value of ONE (1).

2.4.3.2.6.1.7 Verification of "EAST / WEST VELOCITY" Subfield in Aircraft Velocity - Subtype "1" Messages (§2.2.3.2.6.1.7, §2.2.5.1.12)

Purpose/Introduction:

The "EAST/WEST VELOCITY" subfield is contained in Message Bits 47 through 56 (ME Bits 15 through 24) of Airborne Velocity Messages, subtypes "1" and "2." The following test procedures verify that the EAST/WEST VELOCITY subfield in Airborne Velocity Messages is correctly set according to the coding specified.

Measurement Procedure:

Step 1: East / West Velocity Verification – Velocity Data Not Available

Configure the ADS-B Transmitting System to transmit Airborne Velocity Messages by providing velocity information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set up the system to enable broadcast of Airborne Velocity Messages with SUBTYPE "1" (see additional information in §2.2.3.3.2.5, "ADS-B Velocity Message Broadcast Rate"). Set the ADS-B Transmitting System to Airborne status. Provide valid non-zero velocity data to the ADS-B System. Discontinue East/West Velocity data.

Verify that when East/West Velocity Data is not provided to the ADS-B transmission device, the EAST/WEST VELOCITY subfield is set to ZERO (binary 00 0000 0000).

Step 2: East / West Velocity Verification – Velocity Equal ZERO

Setup the ADS-B Transmitting System as in Step 1 and set the East/West Velocity input to represent a velocity of ZERO knots. Verify that the East/West Velocity subfield is set to “1” (binary 00 0000 0001).

Step 3: East / West Velocity Verification – Discrete Values

Verify that for each integer East/West Velocity input value in knots in Table 2-95, that the system generates Airborne Velocity Messages with the TYPE Subfield equal to “19” and that the EAST/WEST VELOCITY subfield in each such message is set equal to the corresponding binary coding value in Table 2-95.

Table 2-95: Discrete Values for East/West Velocity

EAST / WEST VELOCITY (sub-sonic)		
Coding (binary)	**Coding** (decimal)	**Meaning** (E/W Velocity in knots)
00 0000 0010	2	E/W Velocity = 1 knot
00 0000 0101	5	E/W Velocity = 4 knots
00 0000 1010	10	E/W Velocity = 9 knots
00 0000 1111	15	E/W Velocity = 14 knots
00 0101 0000	80	E/W Velocity = 79 knots
00 0101 1010	90	E/W Velocity = 89 knots
00 1010 0101	165	E/W Velocity = 164 knots
00 1010 1010	170	E/W Velocity = 169 knots
01 0101 0101	341	E/W Velocity = 340 knots
10 0101 0101	597	E/W Velocity = 596 knots
10 1010 1010	682	E/W Velocity = 681 knots
11 0101 0101	853	E/W Velocity = 852 knots
11 1010 1010	938	E/W Velocity = 937 knots
11 1111 1110	1022	E/W Velocity = 1021 knots

Step 4: East / West Velocity Verification – Maximum Values

If the resolution of the input value is the same as the resolution of the EAST/WEST VELOCITY subfield in the output message (i.e., 1 knot), verify that for an input corresponding to an eastward velocity of 1022 (in knots), Airborne Velocity Messages are generated with TYPE “19” and all such messages contain an EAST/WEST VELOCITY subfield with a value of 1023 (binary 11 1111 1111).

If the resolution of the input value is greater than the resolution of the EAST/WEST VELOCITY subfield, verify that for the input value corresponding to the largest possible eastward velocity that is less than 1021.5 knots, Airborne Velocity – Subtype “1” Messages are generated and all such messages contain an EAST/WEST VELOCITY subfield with a value of 1022 (binary 11 1111 1110).

If the resolution of the input data makes it possible to enter an input value that corresponds to exactly 1021.5 knots, then this value **shall** be input and it **shall** be verified that the resultant EAST/WEST VELOCITY output field is equal to either

1022 (binary 11 1111 1110, represents 1021 knots) or 1023 (binary 11 1111 1111, represents > 1021.5 knots).

Step 5: East / West Velocity Verification - Part 5

If the input data used to establish the EAST/WEST VELOCITY subfield has more resolution than that required by the EAST/WEST VELOCITY subfield (i.e., more than 10 bits), then this step **shall** be used to ensure that the accuracy of the data is maintained such that it is not worse than +/- ½ LSB, where the LSB is the least significant bit of the EAST/WEST VELOCITY subfield.

If the input data field that is used to determine the output value of the EAST/WEST VELOCITY subfield consists of 10 bits or less, proceed to Step 6.

Enter an input value corresponding to an eastward velocity of 1.5 knots.

Verify that the value of the EAST/WEST VELOCITY subfield in the output message is either "2" (binary 00 0000 0010, represents 1 knot) or "3" (binary 00 0000 0011, represents 2 knots).

If the input field used to establish the EAST/WEST VELOCITY subfield has exactly 11 bits, skip to step 6. Otherwise (indicating that more than 11 bits are used to establish EAST/WEST VELOCITY subfield), let *Z* be equal to the smallest possible fraction that can be represented by the number of bits in the input field (i.e., *Z* is the value of the least significant bit of the input field). Set the value of the input field to correspond to an eastward velocity of (1.5 – *Z*).

Verify that the value of the EAST/WEST VELOCITY subfield in the output Airborne Velocity Message is "2" (binary 00 0000 0010, represents 1 knot).

Set the value of the input field to correspond to an eastward velocity of (1.5 + *Z*).

Verify that the value of the EAST/WEST VELOCITY subfield in the output Airborne Velocity Message is "3" (binary 00 0000 0011, represents 2 knots).

Note: *If the resolution of the East/West Velocity input is such that an eastward velocity of 1.5 knots cannot be represented (but is still greater than 1 knot, e.g., a resolution of 0.2 knot increments), then values corresponding to eastward velocity must be tested, and the output examined for each value to confirm that the output is within +/- 0.5 knots (inclusive) of the input value.*

Step 6: East / West Velocity Verification - Part 6

Note: *If the nature of the inputs is such that a separate bit or "flag" type field is input to the transmitter to indicate "East" or "West," the following step is not necessary. However, if the transmitter must perform some interpretation of its inputs in order to determine the correct output value of the EAST/WEST DIRECTION BIT, the following step must be performed.*

Repeat Steps 3, 4 and 5 so that each step is performed with East/West Velocity input data indicating travel in both EAST and WEST directions, i.e., replace the word "eastward" with "westward" in steps 3, 4 and 5.

2.4.3.2.6.1.8 Verification of "NORTH / SOUTH DIRECTION BIT" Subfield in Aircraft Velocity - Subtype "1" Messages (§2.2.3.2.6.1.8, §2.2.3.2.6.2.8, §2.2.5.1.13)

Purpose/Introduction:

The "NORTH/SOUTH DIRECTION BIT" subfield is contained in Message Bit 57 (ME Bit 25) of Airborne Velocity Messages, subtypes "1" and "2." This test procedure verifies that the NORTH/SOUTH DIRECTION BIT in Airborne Velocity Messages is correctly set to "0" for travel in a northward direction, and "1" for travel in a southward direction.

These test procedures are intended for use for Airborne Velocity Messages of subtypes "1" and "2." The values of the input Velocity data should be set so as to generate Airborne Velocity Messages for all appropriate SUBTYPE fields.

Measurement Procedure:

Step 1: North / South Direction Bit Verification – Velocity Data Not Available

Configure the ADS-B Transmitting System to transmit Airborne Velocity Messages by providing velocity data at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set up the system to enable broadcast of Airborne Velocity Messages (see additional information in 2.2.3.3.2.5, "ADS-B Velocity Message Broadcast Rate"). Set the ADS-B Transmitting System to Airborne status. Provide valid non-zero barometric pressure altitude data and valid non-zero velocity data to the ADS-B System.

Verify that when North/South Velocity Data is not provided to the ADS-B transmission device, the NORTH/SOUTH DIRECTION BIT is set to "0," as specified in 2.2.5.1.13, item (e).

Step 2: North / South Direction Bit Verification – Directional Components

The method for testing this field depends largely upon the nature of the input for North/South Velocity Data.

CASE 1:

If the directional component of the input is a single bit or a "flag" type (i.e. a single discrete value is used to represent "NORTH," and another discrete value is used to represent "SOUTH"), then the procedure for this step **shall** be as follows:

Set this input to the value that indicates travel in an northward direction, and check that ADS-B Airborne Velocity Messages are generated with TYPE value "19," and that all such messages contain a NORTH/SOUTH DIRECTION BIT subfield with a value of "0."

Next, set the input to the value that indicates travel in a southward direction, and verify that ADS-B Airborne Velocity Messages are generated with TYPE value "19," and that all such messages contain a NORTH/SOUTH DIRECTION BIT subfield with a value of "1."

CASE 2:

If the directional component of the input is variable (e.g., a heading expressed in degrees or other similar manner, so that the input value must be evaluated by the ADS-B transmission device in order to determine the proper value for the NORTH/SOUTH DIRECTION BIT), then the test procedure **shall** be as follows.

In this case, the input variable must be made to assume values corresponding to movement in a northward direction, and it must be verified, for each such value, that Airborne Velocity Messages are generated with TYPE value "19" and that all such messages contain a NORTH/SOUTH DIRECTION BIT subfield with a value of "0."

The input must then be made to assume values corresponding to movement in a southward direction, and it must be verified, for each such value, that the transmitter generates Airborne Velocity Messages with TYPE value "19," and that all such messages contain a NORTH/SOUTH DIRECTION BIT subfield with a value of "1."

2.4.3.2.6.1.9 Verification of "NORTH /SOUTH VELOCITY" Subfield in Aircraft Velocity - Subtype "1" Messages (§2.2.3.2.6.1.9, §2.2.5.1.13)

Purpose/Introduction:

The "NORTH/SOUTH VELOCITY" subfield is contained in Message Bits 55 through 65 (ME Bits 23 through 33) of Airborne Velocity Messages, subtypes "1" and "2." This test procedure verifies that the NORTH/SOUTH VELOCITY subfield in Airborne Velocity Messages is correctly set.

Measurement Procedure:

Step 1: North / South Velocity Verification – Velocity Data Not Available

Configure the ADS-B Transmitting System to transmit Airborne Velocity Messages by providing velocity information at the nominal update rate. Provide the data externally at the interface to the ADS-B system.

Set up the system to enable broadcast of Airborne Velocity Messages with SUBTYPE "1" (see additional information in 2.2.3.3.2.5, "ADS-B Velocity Message Broadcast Rate"). Set the ADS-B Transmitting System to Airborne status. Provide valid non-zero velocity data to the ADS-B System.

Discontinue North/South Velocity data and verify that when North/South Velocity Data is not provided to the ADS-B transmission device, the NORTH/SOUTH VELOCITY subfield is set to ZERO (binary 00 0000 0000).

Step 2: North / South Velocity Verification – Velocity Equal ZERO

Set up the ADS-B Transmitting System as above and set the North/South Velocity input to represent a velocity of ZERO knots.

Verify that the North/South Velocity subfield is set to "1."

Step 3: North / South Velocity Verification – Discrete Values

Verify that for each integer North/South Velocity input value in knots in Table 2-96 that the system generates Airborne Velocity Messages with the TYPE Subfield equal to "19" and that the NORTH/SOUTH VELOCITY subfield in each such message is set equal to the corresponding binary coding value in Table 2-96.

Table 2-96: Discrete Values for North/South Velocity

NORTH / SOUTH VELOCITY (sub-sonic)		
Coding (binary)	**Coding** (decimal)	**Meaning** (N/S Velocity in knots)
00 0000 0010	2	N/S Velocity = 1 knot
00 0000 0101	5	N/S Velocity = 4 knots
00 0000 1010	10	N/S Velocity = 9 knots
00 0000 1111	15	N/S Velocity = 14 knots
00 0101 0000	80	N/S Velocity = 79 knots
00 0101 1010	90	N/S Velocity = 89 knots
00 1010 0101	165	N/S Velocity = 164 knots
00 1010 1010	170	N/S Velocity = 169 knots
01 0101 0101	341	N/S Velocity = 340 knots
10 0101 0101	597	N/S Velocity = 596 knots
10 1010 1010	682	N/S Velocity = 681 knots
11 0101 0101	853	N/S Velocity = 852 knots
11 1010 1010	938	N/S Velocity = 937 knots
11 1111 1110	1022	N/S Velocity = 1021 knots

Step 4: North / South Velocity Verification – Maximum Values

If the resolution of the input value is the same as the output resolution (i.e., 1 knot), verify that for an input corresponding to a northward velocity of 1022 (in knots), Airborne Velocity Messages are generated with TYPE "19" and all such messages contain a NORTH/SOUTH VELOCITY subfield with a value of 1023 (binary 11 1111 1111).

If the resolution of the input value is greater than the output resolution, verify that for input value corresponding to the largest possible northward velocity that is less than 1021.5 knots, Airborne Velocity – Subtype “1” Messages are generated and all such messages contain a NORTH/SOUTH VELOCITY subfield with a value of 1022 (binary 11 1111 1110).

If the resolution of the input data makes it possible to enter an input value that corresponds to exactly 1021.5 knots, then this value **shall** be input and it **shall** be verified that the resultant NORTH/SOUTH VELOCITY output field is equal to either 1022 (binary 11 1111 1110, representing 1021 knots) or 1023 (binary 11 1111 1111, representing > 1021.5 knots).

Step 5: North / South Velocity Verification - Part 5

If the input data used to establish the NORTH/SOUTH VELOCITY subfield has more resolution than that required by the NORTH/SOUTH VELOCITY subfield (i.e., more than 10 bits), then this step **shall** be used to ensure that the accuracy of the data is maintained such that it is not worse than +/- ½ LSB, where the LSB is the least significant bit of the NORTH/SOUTH VELOCITY subfield. If the input data field that is used to determine the output value of the NORTH/SOUTH VELOCITY subfield consists of 10 bits or less, proceed to Step 6.

Enter an input value corresponding to a northward velocity of 1.5 knots.

Verify that the value of the NORTH/SOUTH VELOCITY subfield in the output message is either “2” (binary 00 0000 0010, representing 1 knot) or “3” (binary 00 0000 0011, representing 2 knots).

If the input field used to establish the NORTH/SOUTH VELOCITY subfield has exactly 11 bits, skip to step 6. Otherwise (indicating that more than 11 bits are used to establish NORTH/SOUTH VELOCITY subfield), let *Z* be equal to the smallest possible fraction that can be represented by the number of bits in the input field (i.e., *Z* is the value of the least significant bit of the input field). Set the value of the input field to correspond to a northward velocity of (1.5 – *Z*).

Verify that the value of the NORTH/SOUTH VELOCITY subfield in the output Airborne Velocity Message is “2” (binary 00 0000 0010, representing 1 knot).

Set the value of the input field to correspond to a northward velocity of (1.5 + *Z*).

Verify that the value of the NORTH/SOUTH VELOCITY subfield in the output Airborne Velocity Message is “3” (binary 00 0000 0011, representing 2 knots).

Note: *If the resolution of the North/South Velocity input is such that a northward velocity of 1.5 knots cannot be represented (but is still greater than 1 knot, e.g., a resolution of 0.2 knot increments), then values corresponding to northward velocity must be tested, and the* *output examined for each value to confirm that the output is within +/- 0.5 knots (inclusive) of the input value.*

Step 6: North / South Velocity Verification - Part 6

Note: *If the nature of the inputs is such that a separate bit or "flag" type field is input to the transmitter to indicate "North" or "South," the following step is not necessary. However, if the transmitter must perform some interpretation of its inputs in order to determine the correct output value of the NORTH/SOUTH DIRECTION BIT, the following step must be performed.*

Repeat Steps 3, 4 and 5 so that each step is performed with North/South Velocity input data indicating travel in both NORTH and SOUTH directions, i.e., replace the word "northward" with "southward" in steps 3, 4 and 5.

2.4.3.2.6.1.10 Verification of "SOURCE BIT FOR VERTICAL RATE" Subfield in Aircraft Velocity - Subtype "1" Messages (§2.2.3.2.6.1.10, §2.2.3.2.6.2.10, §2.2.3.2.6.3.10, §2.2.3.2.6.4.10, §2.2.5.1.14)

Purpose/Introduction:

The "SOURCE BIT FOR VERTICAL RATE" subfield is contained in Message Bit 68 (ME Bit 36) of Airborne Velocity Messages. The following test verifies that this bit is correctly set according to the table contained in the above referenced section.

These test procedures are intended for use for Airborne Velocity Messages of all subtypes. The type and values of the input Velocity data should be set so as to generate Airborne Velocity Messages for all appropriate SUBTYPE fields.

Measurement Procedure:

Step 1: Vertical Rate Source Bit Verification - Part 1

Configure the ADS-B Transmitting System to transmit Airborne Velocity Messages by providing velocity information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set up the system to enable broadcast of Airborne Velocity Messages (see additional information in §2.2.3.3.2.5, "ADS-B Velocity Information Message Broadcast Rate"). Set the ADS-B Transmitting System to Airborne status. Provide valid non-zero barometric pressure altitude data and valid non-zero velocity data to the ADS-B System.

Verify that if the input Vertical Rate data is from Geometric Source (GNSS or INS), then the SOURCE BIT FOR VERTICAL RATE subfield is set to ZERO (0).

Step 2: Vertical Rate Source Bit Verification - Part 2

Change the Vertical Rate input data so that it indicates to the ADS-B Transmitting System that it is from Barometric Source.

Verify that the SOURCE BIT FOR VERTICAL RATE subfield in subsequent output messages is set to ONE (1).

2.4.3.2.6.1.11 Verification of "SIGN BIT FOR VERTICAL RATE" Subfield in Aircraft Velocity - Subtype "1" Messages (§2.2.3.2.6.1.11, §2.2.3.2.6.2.11, §2.2.3.2.6.3.11, §2.2.3.2.6.4.11, §2.2.5.1.14)

Purpose/Introduction:

The "SIGN BIT FOR VERTICAL RATE" subfield is contained in Message Bit 69 (ME Bit 37) of Airborne Velocity Messages. The following test verifies that this bit is correctly set to "0" to indicate an upward vertical rate vector (climb), and "1" to indicate a downward vertical rate vector (descent).

These test procedures are intended for use for Airborne Velocity Messages of all subtypes. The type and values of the input Velocity data should be set so as to generate Airborne Velocity Messages for all appropriate SUBTYPE fields.

Measurement Procedure:

Step 1: Vertical Rate Sign Bit Verification – Data Not Available

Configure the ADS-B Transmitting System to transmit Airborne Velocity Messages by providing velocity information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set up the system to enable broadcast of Airborne Velocity Messages (see additional information in §2.2.3.3.2.5, "ADS-B Velocity Message Broadcast Rate"). Set the ADS-B Transmitting System to Airborne status. Provide valid non-zero barometric pressure altitude data and valid non-zero velocity data to the ADS-B System.

Verify that when Vertical Rate Data is not provided to the ADS-B transmission device, the VERTICAL RATE SIGN BIT is set to "0," as specified in 2.2.5.1.14, item (d).

Step 2: Vertical Rate Sign Bit Directional Component Verification

The method for testing this field depends largely upon the nature of the input for Vertical Rate Data.

CASE 1:

If the directional component of the input is a single bit or a "flag" type (i.e. a single discrete value is used to represent "UP," and another discrete value is used to represent "DOWN"), then the procedure for this step **shall** be as follows:

Set this input to the value that indicates an upward direction, and verify that ADS-B Airborne Velocity Messages are generated with TYPE value "19," and that all such messages contain a VERTICAL RATE SIGN BIT subfield with a value of "0."

Next, set the input to the value that indicates a downward direction, and verify that ADS-B Airborne Velocity Messages are generated with TYPE value "19," and that all such messages contain a VERTICAL RATE SIGN BIT subfield with a value of "1."

CASE 2:

If the directional component of the input is variable (e.g., a heading expressed in degrees or other similar manner, so that the input value must be evaluated by the ADS-B transmission device in order to determine the proper value for the VERTICAL RATE SIGN BIT), then the test procedure **shall** be as follows.

In this case, the input variable must be made to assume values corresponding to an upward climb, and it must be verified, for each such value, that Airborne Velocity Messages are generated with TYPE value "19" and that all such messages contain a VERTICAL RATE SIGN BIT subfield with a value of "0."

The input must then be made to assume values corresponding to a descent, and it must be verified, for each such value, that the transmitter generates Airborne Velocity Messages with TYPE value "19," and that all such messages contain a VERTICAL RATE SIGN BIT subfield with a value of "1."

2.4.3.2.6.1.12 Verification of "VERTICAL RATE" Subfield in Aircraft Velocity - Subtype "1" Messages (§2.2.3.2.6.1.12, §2.2.3.2.6.2.12, §2.2.3.2.6.3.12, §2.2.3.2.6.4.12, §2.2.5.1.14)

Purpose/Introduction:

The "VERTICAL RATE" subfield is contained in Message Bits 70 through 78 (ME Bits 38 through 46) of Airborne Velocity Messages. This test procedure verifies that the VERTICAL RATE subfield in Airborne Velocity Messages is correctly set.

These test procedures are intended for use for Airborne Velocity Messages of all subtypes. The type and values of the input Velocity data should be set so as to generate Airborne Velocity Messages for all appropriate SUBTYPE fields.

Measurement Procedure:

Step 1: Vertical Rate Not Available Verification

Configure the ADS-B Transmitting System to transmit Airborne Velocity Messages by providing velocity information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set up the system to enable broadcast of Airborne Velocity Messages (see additional information in 2.2.3.3.2.5, "ADS-B Velocity Message Broadcast Rate"). Set the ADS-B Transmitting System to Airborne status. Provide valid non-zero barometric pressure altitude data and valid non-zero velocity data to the ADS-B System.

Verify that when Vertical Rate Data is not provided to the ADS-B transmission device, the VERTICAL RATE subfield in Airborne Velocity output messages is set to "0" (binary 0 0000 0000).

Step 2: Vertical Rate Equal To ZERO Verification

The input for this field **shall** initially be set to represent a Vertical Rate of ZERO feet per minute.

Verify that the ADS-B transmission device generates Airborne Velocity Messages with TYPE "19" and that the VERTICAL RATE subfield in each such message contains the value "1" (binary 0 0000 0001).

Step 3: Vertical Rate Verification – Discrete Values

Increase the value of the Vertical Rate Data input so that it assumes each discrete decimal coding value from Table 2-97.

Verify that for each discrete decimal coding input value, the VERTICAL RATE subfield in subsequent Airborne Velocity Messages of TYPE "19" matches identically the corresponding Binary Coding value from Table 2-97.

Table 2-97: Vertical Rate Discrete Values

VERTICAL RATE		
Coding (binary)	**Coding** (decimal)	**Meaning** (VERTICAL RATE in feet / minute)
0 0000 0101	5	Vertical Rate = 256 feet / minute
0 0000 1010	10	Vertical Rate = 576 feet / minute
0 0000 1111	15	Vertical Rate = 896 feet / minute
0 0101 0000	80	Vertical Rate = 5,056 feet / minute
0 0101 1111	95	Vertical Rate = 6,016 feet / minute
0 1010 0000	160	Vertical Rate = 10,176 feet / minute
0 1010 1111	175	Vertical Rate = 11,136 feet / minute
0 1111 1111	255	Vertical Rate = 16,256 feet / minute
1 0000 0000	256	Vertical Rate = 16,320 feet / minute
1 0101 0101	341	Vertical Rate = 21,760 feet / minute
1 1010 1010	426	Vertical Rate = 27,200 feet / minute
1 1111 1110	510	Vertical Rate = 32,576 feet / minute

Verify that the VERTICAL RATE subfield in the output message is not incremented until the input value reaches a number corresponding to an integer multiple of 64 feet/minute with an accuracy of +/- 32 feet/minute.

Step 4: Vertical Rate Verification – Out of Bounds Test

Continue to increase the value of the Vertical Rate Data input.

Verify that for values greater than 32,576 feet per minute but less than or equal to 32,608 feet per minute, the VERTICAL RATE subfield continues to be set to "510" (binary 1 1111 1110).

Continue to increase the value of the vertical rate input.

Verify that for values representing a vertical rate greater than 32,608 feet per minute, up to the maximum possible input value, that the transmitter continues to generate Airborne Velocity Messages with a TYPE subfield equal to "19" and that the VERTICAL RATE subfield for all such messages is set to "511" (binary 1 1111 1111).

Step 5: Vertical Rate Verification - Part 5

Note: *If the nature of the inputs is such that a separate bit or "flag" type field is input to the transmitter to indicate "Up" or "Down," the following step is not necessary. However, if the transmitter must perform some interpretation of its inputs in order to determine the correct output value of the VERTICAL RATE SIGN BIT, the following step must be performed.*

Repeat steps 3 through 5, so that each step is performed with Vertical Rate input data indicating directional vectors of both UP (climb) and DOWN (descent) turns.

2.4.3.2.6.1.13 Verification of "TURN INDICATOR" Subfield in Aircraft Velocity - Subtype "1" Messages (§2.2.3.2.6.1.13, §2.2.3.2.6.2.13, §2.2.3.2.6.3.13, §2.2.3.2.6.4.13, §2.2.5.1.15)

Purpose/Introduction:

The "TURN INDICATOR" subfield is contained in Message Bits 79-80 (ME Bits 47-48) of Airborne Velocity Messages. This test procedure verifies that the TURN INDICATOR in Airborne Velocity Messages is correctly set.

These test procedures are intended for use for Airborne Velocity Messages of all subtypes. The type and values of the input Velocity data should be set so as to generate Airborne Velocity Messages with each appropriate SUBTYPE field.

Measurement Procedure:

Step 1: Turn Indicator Verification - Part 1

Configure the ADS-B Transmitting System to transmit Airborne Velocity Messages by providing velocity information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set up the system to enable broadcast of Airborne Velocity Messages (see additional information in §2.2.3.3.2.5, "ADS-B Velocity Information Message Broadcast Rate"). Set the ADS-B Transmitting System to Airborne status. Provide valid non-zero barometric pressure altitude data and valid non-zero velocity data to the ADS-B System.

Verify that when Turn Rate Data is not provided to the ADS-B transmission device, the TURN INDICATOR is set to "0" (binary 00), as indicated in §2.2.5.1.15, item c.

Step 2: Turn Indicator Verification - Part 2

Set the Turn Rate input to represent a turn rate of ZERO degrees per second (aircraft NOT turning).

Verify that the ADS-B transmission device generates Airborne Velocity Messages with TYPE "19" and that the TURN INDICATOR subfield in each such message contains the value "0" (binary 00).

Step 3: Turn Indicator Verification - Part 3

Increase the value of the Turn Rate Data input so that it assumes values for a right turn, from the smallest possible discrete value above "0" through the value corresponding to a right turn at a rate of 3 degrees per second.

Verify that for every input value below that which corresponds to 3 degrees per second, the TURN INDICATOR subfield in Airborne Velocity Messages of TYPE "19" remains set to "0" (binary 00).

Verify that once the input value represents a right turn with a turn rate of 3 degrees per second, the value of the TURN INDICATOR subfield is set to "0" (binary 00), and that it remains set to "0" for input values representing a right turn at a rate greater than 3 degrees per second.

Step 4: Turn Indicator Verification - Part 4

Repeat Step 3 for values of left turns, i.e., substitute "left turn" for each occurrence of "right turn" in Step 3.

2.4.3.2.6.1.14 Verification of "DIFFERENCE FROM BAROMETRIC ALTITUDE SIGN BIT" Subfield in Aircraft Velocity - Subtype "1" Messages (§2.2.3.2.6.1.14, §2.2.3.2.6.2.14, §2.2.3.2.6.3.14, §2.2.3.2.6.4.14)

Purpose/Introduction:

The "DIFFERENCE FROM BAROMETRIC ALTITUDE SIGN BIT" is contained in Message Bit 81 (ME Bit 49) of Airborne Velocity Messages, Subtypes "1," "2," "3" and "4."

These test procedures are intended for use for Airborne Velocity Messages of all subtypes. The type and values of the input Velocity data should be set so as to generate Airborne Velocity Messages for all appropriate SUBTYPE fields.

Measurement Procedure:

Step 1: Difference from Baro Altitude Sign Bit Verification - Part 1

Configure the ADS-B Transmitting System to transmit Airborne Velocity Messages by providing velocity information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set up the system to enable broadcast of Airborne Velocity Messages (see additional information in §2.2.3.3.2.5, "ADS-B Velocity Information Message Broadcast Rate"). Set the ADS-B Transmitting System to Airborne status. Provide valid non-zero barometric pressure altitude data, valid non-zero Geometric Source data and valid non-zero velocity data to the ADS-B System. Set the inputs so that the input Geometric Altitude Source data is greater than (above) the input Barometric Altitude.

Verify that the DIFFERENCE FROM BAROMETRIC ALTITUDE SIGN BIT subfield in subsequent Airborne Velocity output messages is set to "0."

Step 2: Difference from Baro Altitude Sign Bit Verification - Part 2

Lower the input Geometric Altitude Source data.

Verify that as long as the input Geometric Altitude Source data is greater than the input Barometric Altitude (in feet), all transmitted Airborne Velocity messages continue to contain a "0" in the SIGN BIT subfield.

Verify that as soon as the input Geometric Altitude Source data becomes lower than the input Barometric Altitude, the SIGN BIT subfield in Airborne Velocity Messages is changed to a "1."

2.4.3.2.6.1.15 Verification of "DIFFERENCE FROM BAROMETRIC ALTITUDE" Subfield in Aircraft Velocity - Subtype "1" Messages (§2.2.3.2.6.1.15, §2.2.3.2.6.2.15, §2.2.3.2.6.3.15, §2.2.3.2.6.4.15)

Purpose/Introduction:

The "DIFFERENCE FROM BAROMETRIC ALTITUDE" subfield is contained in Message Bits 82 through 88 (ME Bits 50 through 56) of the Airborne Velocity Messages, subtypes "1," "2," "3" and "4."

These test procedures are intended for use for Airborne Velocity messages of all subtypes. The type and values of the input Velocity data should be set so as to generate Airborne Velocity messages for all appropriate SUBTYPE fields.

Measurement Procedure:

Step 1: Difference from Barometric Altitude Verification – Not Available

Configure the ADS-B Transmitting System to transmit Airborne Velocity Messages by providing velocity information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set up the system to enable broadcast of Airborne Velocity Messages (see additional information in §2.2.3.3.2.5, "ADS-B Velocity Information Message Broadcast Rate"). Set the ADS-B Transmitting System to Airborne status. Provide valid non-zero barometric pressure altitude data, valid non-zero Geometric Altitude Source data and valid non-zero velocity data to the ADS-B System.

Discontinue the input of Geometric Altitude Source data and verify that subsequent Airborne Velocity messages contain a DIFFERENCE FROM BAROMETRIC ALTITUDE subfield with a value of "0" (binary 000 0000). Stop the input of Barometric Altitude data and verify that the value of this field remains "0" in subsequent Airborne Velocity Messages.

Begin the input of only Geometric Altitude Source data and verify that the value of this field remains "0" in subsequent messages of this type.

<u>Step 2:</u> <u>Difference from Barometric Altitude Verification – No Differences</u>

Re-start the input of Barometric Altitude data, and set the inputs so that the Geometric Altitude Source data input and the Barometric Altitude input both represent the exact same altitude (in feet); i.e., the difference between the two altitude values is ZERO.

Verify that the DIFFERENCE FROM BAROMETRIC ALTITUDE subfield in subsequent Airborne Velocity messages is set to "1" (binary 000 0001, representing a Difference of ZERO).

<u>Step 3:</u> <u>Difference from Barometric Altitude Verification – Discrete Values</u>

Adjust the value of the Barometric Altitude input data so that the set of possible inputs includes a value that represents an altitude at least 3,140 feet above the chosen value and a value that represents an altitude at least 3,140 feet below the chosen value. Adjust the Geometric Altitude Source data input to represent the same altitude as that chosen for the Barometric Altitude input.

Increase the value of the Geometric Altitude Source data input while keeping the Barometric Altitude constant so that the Geometric Altitude Source data difference input assumes each value from Table 2-98. Verify that for each Altitude Source Data Difference in Table 2-98 that the system generates Airborne Velocity Messages with the DIFFERENCE FROM BAROMETRIC ALTITUDE subfield in each message set equal to the corresponding binary coding value from the table.

Table 2-98: Difference from Barometric Altitude Discrete Values

DIFFERENCE FROM BAROMETRIC ALTITUDE		
Coding (binary)	**Coding** (decimal)	**Meaning** (Geometric (GNSS or INS) Altitude Source data Difference in feet)
000 0010	2	GNSS Altitude Source data Difference = 25 feet
000 0011	3	GNSS Altitude Source data Difference = 50 feet
000 0101	5	GNSS Altitude Source data Difference = 100 feet
000 1010	10	GNSS Altitude Source data Difference = 225 feet
001 0101	21	GNSS Altitude Source data Difference = 500 feet
010 1010	42	GNSS Altitude Source data Difference = 1,025 feet
101 0101	85	GNSS Altitude Source data Difference = 2,100 feet
101 1010	90	GNSS Altitude Source data Difference = 2,225 feet
111 1110	126	GNSS Altitude Source data Difference = 3,125 feet

Additionally verify that for every 25 feet increase in the difference between the two, the DIFFERENCE FROM BAROMETRIC ALTITUDE subfield in subsequent Airborne Velocity Messages of TYPE "19" is incremented by one from the previous value (i.e., that the value of the DIFFERENCE FROM BAROMETRIC ALTITUDE subfield corresponds to the decimal coding values given in the table in the above referenced section).

Verify that the DIFFERENCE FROM BAROMETRIC ALTITUDE subfield in the output message is not incremented until the difference in the input values reaches a number corresponding to an integer multiple of 25 feet with an accuracy of +/- 12.5 feet.

Step 4: Difference from Barometric Altitude Verification - Part 4

Continue to increase the value of the Geometric Altitude Source Data input.

Verify that, for values that are greater than 3,125 feet above the Barometric Altitude, but less than or equal to 3,137.5 feet above the Barometric Altitude, the DIFFERENCE FROM BAROMETRIC ALTITUDE subfield continues to be set to "126" (binary 111 1110).

Continue to increase the value of the Geometric Altitude Source data input.

Verify, for values representing an altitude greater than 3,137.5 feet above the barometric altitude, up to the maximum possible input value, that the transmitter continues to generate Airborne Velocity Messages and that the DIFFERENCE FROM BAROMETRIC ALTITUDE subfield for all such messages is set to "127" (binary 111 1111).

<u>Step 5:</u> <u>Difference from Barometric Altitude Verification - Part 5</u>

Note: *If the nature of the inputs is such that a separate bit or "flag" type field is input to the transmitter to indicate "Up" or "Down," the following step is not necessary. However, if the transmitter must perform some interpretation of its inputs in order to determine the correct output value of the DIFFERENCE FROM BAROMETRIC ALTITUDE SIGN BIT, the following step must be performed.*

Repeat steps 3 through 5, but this time decreasing the value of the Geometric Altitude Source data input, rather than increasing it.

2.4.3.2.6.2 Verification of ADS-B Airborne Velocity Message - Subtype "2" (§2.2.3.2.6.2)

Appropriate test procedures are provided in §2.4.3.2.6.2.1 through §2.4.3.2.6.2.15.

2.4.3.2.6.2.1 Verification of "TYPE" Subfield in Aircraft Velocity - Subtype "2" Messages (§2.2.3.2.6.2.1)

Appropriate test procedures are provided in §2.4.3.2.6.1.2.

2.4.3.2.6.2.2 Verification of "SUBTYPE" Subfield in Aircraft Velocity - Subtype "2" Messages (§2.2.3.2.6.2.2)

Appropriate test procedures are provided in §2.4.3.2.6.1.2.

2.4.3.2.6.2.3 Verification of "INTENT CHANGE FLAG" Subfield in Aircraft Velocity - Subtype "2" Messages (§2.2.3.2.6.2.3, §2.2.5.1.20)

Appropriate test procedures are provided in §2.4.3.2.6.1.3.

2.4.3.2.6.2.4 Verification of "IFR Capability Flag" Subfield in Aircraft Velocity - Subtype "2" Messages (§2.2.3.2.6.2.4, §2.2.5.1.21)

Appropriate test procedures are provided in §2.4.3.2.6.1.4.

2.4.3.2.6.2.5 Verification of "NAC_V" Subfield in Aircraft Velocity - Subtype "2" Messages (§2.2.3.2.6.2.5, §2.2.5.1.22)

Appropriate test procedures are provided in §2.4.3.2.6.1.5.

2.4.3.2.6.2.6 Verification of "EAST / WEST DIRECTION BIT" Subfield in Aircraft Velocity - Subtype "2" Messages (§2.2.3.2.6.2.6)

Appropriate test procedures are provided in §2.4.3.2.6.1.6.

2.4.3.2.6.2.7 Verification of “EAST / WEST VELOCITY” Subfield in Aircraft Velocity - Subtype “2” Messages (§2.2.3.2.6.2.7, §2.2.5.1.12)

Purpose/Introduction:

The “EAST/WEST VELOCITY” subfield is contained in Message Bits 47 through 56 (ME Bits 15 through 24) of Airborne Velocity Messages, subtypes “1” and “2.” The following test procedures verify that the EAST/WEST VELOCITY subfield in Airborne Velocity Messages is correctly set according to the coding specified.

Measurement Procedure:

Step 1: East / West Velocity Verification – Data Not Available

Configure the ADS-B Transmitting System to transmit Airborne Velocity Messages by providing velocity information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set up the system to enable broadcast of Airborne Velocity Messages with SUBTYPE 2 (see additional information in 2.2.3.3.2.5, “ADS-B Velocity Message Broadcast Rate”) by providing East/West Velocity input data with a value greater than 1022 knots. Set the ADS-B Transmitting System to Airborne status.

Discontinue East/West Velocity data and verify that when East/West Velocity Data is not provided to the ADS-B transmission device, the EAST/WEST VELOCITY subfield in output Airborne Velocity – Subtype “2” Messages is set to ZERO (binary 00 0000 0000).

Step 2: East / West Velocity Verification – Velocity Equal ZERO

Set up the ADS-B Transmitting System as above and set the East/West Velocity input to represent a velocity of ZERO knots.

Verify that the EAST/WEST VELOCITY subfield in subsequent Airborne Velocity – Subtype “2” output messages is set to “1” (binary 00 0000 0001).

Step 3: East / West Velocity Verification – Discrete Values

Verify that for each integer East/West Velocity input value in knots identified in Table 2-99 that the system generates Airborne Velocity Messages with the EAST/WEST VELOCTIY Subfield set equal to the corresponding binary coding value in the table.

Table 2-99: East/West Velocity Discrete Values

EAST / WEST VELOCITY (supersonic)		
Coding (binary)	**Coding** (decimal)	**Meaning** (E/W Velocity in knots)
00 0000 0010	2	E/W Velocity = 4 knots
00 0000 0101	5	E/W Velocity = 16 knots
00 0000 1010	10	E/W Velocity = 36 knots
00 0000 1111	15	E/W Velocity = 56 knots
00 0101 0000	80	E/W Velocity = 316 knots
00 0101 1010	90	E/W Velocity = 356 knots
00 1010 0101	165	E/W Velocity = 656 knots
00 1010 1010	170	E/W Velocity = 676 knots
01 0101 0101	341	E/W Velocity = 1,360 knots
10 0101 0101	597	E/W Velocity = 2,384 knots
10 1010 1010	682	E/W Velocity = 2,724 knots
11 0101 0101	853	E/W Velocity = 3,408 knots
11 1010 1010	938	E/W Velocity = 3,748 knots
11 1111 1110	1022	E/W Velocity = 4,084 knots

Verify that for 4 knot increases in the input value, the EAST/WEST VELOCITY subfield in subsequent Airborne Velocity Messages of TYPE “19” is incremented by one from the previous value (i.e., that the value of the EAST/WEST VELOCITY subfield binary values corresponds to the values given in the table in the above referenced section).

Verify that the EAST/WEST VELOCITY subfield in the output message is not incremented to the next higher integer value until the input velocity value reaches a number corresponding to an even multiple of 4 knots.

Step 4: East / West Velocity Verification – Maximum Velocity

Continue to increase the value of the East/West Velocity Data input.

Verify that, for values greater than or equal to 4084 knots but less than or equal to 4086 knots, the output EAST/WEST VELOCITY subfield continues to be set to “1022” (binary 11 1111 1110).

Continue to increase the value of the East/West Velocity input.

Verify, for every input value representing an East/West Velocity greater than 4086 knots, up to the maximum possible input value, that the transmitter continues to generate Airborne Velocity Messages with a TYPE subfield equal to "19," a SUBTYPE subfield equal to "2," and that the EAST/WEST VELOCITY subfield for all such messages is set to "1023" (binary 11 1111 1111).

Step 5: East / West Velocity Verification – Input Resolution

If the input data used to establish the EAST/WEST VELOCITY subfield has more resolution than that required by the EAST/WEST VELOCITY subfield, then this step **shall** be used to ensure that the accuracy of the data is maintained such that it is not worse than +/- ½ LSB, where the LSB is the least significant bit of the EAST/WEST VELOCITY subfield. If the input data field that is used to determine the output value of the EAST/WEST VELOCITY subfield does not have finer resolution than that required by the EAST/WEST VELOCITY subfield, proceed to Step 6.

Enter an input value corresponding to an eastward velocity of 6 knots.

Verify that the value of the EAST/WEST VELOCITY subfield in the output message is either "2" (binary 00 0000 0010, representing 4 knots) or "3" (binary 00 0000 0011, representing 8 knots).

If the input field used to establish the EAST/WEST VELOCITY subfield does not have resolution finer than 2 knots, skip to step 6. Otherwise (indicating that East/West Velocity input resolution is finer than 2 knots), let *Z* be equal to the smallest possible value that can be represented by the number of bits in the input field (i.e., *Z* is the value of the least significant bit of the input field).

Set the value of the input field to correspond to an eastward velocity of (6 – *Z*).

Verify that the value of the EAST/WEST VELOCITY subfield in the output Airborne Velocity Message is "2" (binary 00 0000 0010, representing 4 knots).

Set the value of the input field to correspond to an eastward velocity of (6 + *Z*).

Verify that the value of the EAST/WEST VELOCITY subfield in the output Airborne Velocity Message is "3" (binary 00 0000 0011, representing 8 knots).

Note: *If the resolution of the East/West Velocity input is such that an eastward velocity of 6 knots cannot be represented (but is still finer than 4 knots, e.g., a resolution of 1.75 knot increments), then values corresponding to eastward velocity must be tested, and the output examined for each value to confirm that the output is within +/- 2 knots (inclusive) of the input value.*

Step 6: East / West Velocity Verification - Part 6

Note: *If the nature of the inputs is such that a separate bit or "flag" type field is input to the transmitter to indicate "East" or "West," the following step is not necessary. However, if the transmitter must perform some* *interpretation of its inputs in order to determine the correct output value of the EAST/WEST DIRECTION BIT, the following step must be performed.*

Repeat Steps 3, 4 and 5 so that each step is performed with East/West Velocity input data indicating travel in both EAST and WEST directions, i.e., replace the word “eastward” with “westward” in steps 3, 4 and 5.

2.4.3.2.6.2.8 Verification of “NORTH / SOUTH DIRECTION BIT” Subfield in Aircraft Velocity - Subtype “2” Messages (§2.2.3.2.6.2.8)

Appropriate test procedures are provided in §2.4.3.2.6.1.8.

2.4.3.2.6.2.9 Verification of “NORTH / SOUTH VELOCITY” Subfield in Aircraft Velocity - Subtype “2” Messages (§2.2.3.2.6.2.9, §2.2.5.1.13)

Purpose/Introduction:

The “NORTH/SOUTH VELOCITY” subfield is contained in Message Bits 55 through 65 (ME Bits 23 through 33) of Airborne Velocity Messages, subtypes “1” and “2.” This test procedure verifies that the NORTH/SOUTH VELOCITY subfield in Airborne Velocity Messages is correctly set.

Measurement Procedure:

Step 1: North / South Velocity Verification – Data Not Available

Configure the ADS-B Transmitting System to transmit Airborne Velocity Messages by providing velocity information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set up the system to enable broadcast of Airborne Velocity Messages with SUBTYPE “2” (see additional information in §2.2.3.3.2.5, “ADS-B Velocity Message Broadcast Rate”) by providing North/South Velocity input data with a value greater than 1022 knots.

Set the ADS-B Transmitting System to Airborne status. Discontinue North/South Velocity data and verify that when North/South Velocity Data is not provided to the ADS-B transmission device, the NORTH/SOUTH VELOCITY subfield in output Airborne Velocity – Subtype “2” Messages is set to ZERO (binary 00 0000 0000).

Step 2: North / South Velocity Verification – Velocity Equal ZERO

Setup the ADS-B Transmitting System as above and set the North/South Velocity input to represent a velocity of ZERO knots.

Verify that the NORTH/SOUTH VELOCITY subfield in subsequent Airborne Velocity – Subtype “2” output messages is set to ONE “1” (binary 00 0000 0001).

Step 3: North / South Velocity Verification – Discrete Values

Verify that for each integer North/South Velocity input value in knots identified in Table 2-100 that the system generates Airborne Velocity Messages with the NORTH/SOUTH VELOCITY Subfield set equal to the corresponding binary coding value in the table.

Table 2-100: North/South Velocity Discrete Values

NORTH / SOUTH VELOCITY (supersonic)		
Coding (binary)	**Coding** (decimal)	**Meaning** (N/S Velocity in knots)
00 0000 0010	2	N/S Velocity = 4 knots
00 0000 0101	5	N/S Velocity = 16 knots
00 0000 1010	10	N/S Velocity = 36 knots
00 0000 1111	15	N/S Velocity = 56 knots
00 0101 0000	80	N/S Velocity = 316 knots
00 0101 1010	90	N/S Velocity = 356 knots
00 1010 0101	165	N/S Velocity = 656 knots
00 1010 1010	170	N/S Velocity = 676 knots
01 0101 0101	341	N/S Velocity = 1,360 knots
10 0101 0101	597	N/S Velocity = 2,384 knots
10 1010 1010	682	N/S Velocity = 2,724 knots
11 0101 0101	853	N/S Velocity = 3,408 knots
11 1010 1010	938	N/S Velocity = 3,748 knots
11 1111 1110	1022	N/S Velocity = 4,084 knots

Verify that for 4 knot increases in the input value, the NORTH/SOUTH VELOCITY subfield in subsequent Airborne Velocity Messages of TYPE "19" is incremented by one from the previous value (i.e., that the value of the NORTH/SOUTH VELOCITY subfield corresponds to the values given in the table in the above referenced section).

Verify that the NORTH/SOUTH VELOCITY subfield in the output message is not incremented until the input value reaches a number corresponding to an even multiple of 4 knots.

Step 4: North / South Velocity Verification – Maximum Velocity

Continue to increase the value of the North/South Velocity Data input.

Verify that, for discrete values greater than or equal to 4084 knots but less than or equal to 4086 knots, the NORTH/SOUTH VELOCITY subfield continues to be set to "1022" (binary 11 1111 1110).

Continue to increase the value of the North/South Velocity input.

Verify that for discrete input values representing a North/South Velocity greater than 4086 knots, up to the maximum possible input value, that the transmitter continues to generate Airborne Velocity Messages with a TYPE subfield equal to "19," a SUBTYPE subfield equal to "2," and that the NORTH/SOUTH VELOCITY subfield for all such messages is set to "1023" (binary 11 1111 1111).

Step 5: North / South Velocity Verification – Input Resolution

If the input data used to establish the NORTH/SOUTH VELOCITY subfield has finer resolution than that required by the NORTH/SOUTH VELOCITY subfield, then this step **shall** be used to ensure that the accuracy of the data is maintained such that it is not worse than +/- ½ LSB, where the LSB is the least significant bit of the NORTH/SOUTH VELOCITY subfield. If the input data field that is used to determine the output value of the NORTH/SOUTH VELOCITY subfield does not have finer resolution than that required by the NORTH/SOUTH VELOCITY subfield, proceed to Step 6.

Enter an input value corresponding to a northward velocity of 6 knots.

Verify that the value of the NORTH/SOUTH VELOCITY subfield in the output message is either "2" (binary 00 0000 0010, representing 4 knots) or "3" (binary 00 0000 0011, representing 8 knots).

If the input field used to establish the NORTH/SOUTH VELOCITY subfield does not have resolution finer than 2 knots, skip to step 6. Otherwise (North/South Velocity input resolution is finer than 2 knots), let Z be equal to the smallest possible value that can be represented by the number of bits in the input field (i.e., Z is the value of the least significant bit of the input field). Set the value of the input field to correspond to a northward velocity of $(6 – Z)$.

Verify that the value of the NORTH/SOUTH VELOCITY subfield in the output Airborne Velocity Message is "2" (binary 00 0000 0010, representing 4 knots). Set the value of the input field to correspond to a northward velocity of $(6 + Z)$.

Verify that the value of the NORTH/SOUTH VELOCITY subfield in the output Airborne Velocity Message is "3" (binary 00 0000 0011, representing 8 knots).

Note: *If the resolution of the North/South Velocity input is such that a northward velocity of 6 knots cannot be represented (but is still finer than 4 knots, e.g., a resolution of 1.75 knot increments), then values corresponding to northward velocity must be tested, and the output examined for each value to confirm that the output is within +/- 2 knots (inclusive) of the input value.*

Step 6: North / South Velocity Verification - Part 6

Note: *If the nature of the inputs is such that a separate bit or "flag" type field is input to the transmitter to indicate "North" or "South," the following* *step is not necessary. However, if the transmitter must perform some interpretation of its inputs in order to determine the correct output value of the NORTH/SOUTH DIRECTION BIT, the following step must be performed.*

Repeat Steps 3, 4 and 5 so that each step is performed with North/South Velocity input data indicating travel in both NORTH and SOUTH directions, i.e., replace the word "northward" with "southward" in steps 3, 4 and 5.

2.4.3.2.6.2.10 Verification of "SOURCE BIT FOR VERTICAL RATE" Subfield in Aircraft Velocity - Subtype "2" Messages (§2.2.3.2.6.2.10, §2.2.5.1.14)

Appropriate test procedures are provided in §2.4.3.2.6.1.10.

2.4.3.2.6.2.11 Verification of "SIGN BIT FOR VERTICAL RATE" Subfield in Aircraft Velocity - Subtype "2" Messages (§2.2.3.2.6.2.11, §2.2.5.1.14)

Appropriate test procedures are provided in §2.4.3.2.6.1.11.

2.4.3.2.6.2.12 Verification of "VERTICAL RATE" Subfield in Aircraft Velocity - Subtype "2" Messages (§2.2.3.2.6.2.12, §2.2.5.1.14)

Appropriate test procedures are provided in §2.4.3.2.6.1.12.

2.4.3.2.6.2.13 Verification of "TURN INDICATOR" Subfield in Aircraft Velocity - Subtype "2" Messages (§2.2.3.2.6.2.13, §2.2.5.1.15)

Appropriate test procedures are provided in §2.4.3.2.6.1.13.

2.4.3.2.6.2.14 Verification of "DIFFERENCE FROM BAROMETRIC ALTITUDE SIGN BIT" Subfield in Aircraft Velocity - Subtype "2" Messages (§2.2.3.2.6.2.14)

Appropriate test procedures are provided in §2.4.3.2.6.1.14.

2.4.3.2.6.2.15 Verification of "DIFFERENCE FROM BAROMETRIC ALTITUDE" Subfield in Aircraft Velocity - Subtype "2" Messages (§2.2.3.2.6.2.15)

Appropriate test procedures are provided in §2.4.3.2.6.1.15.

2.4.3.2.6.3 Verification of ADS-B Airborne Velocity Message - Subtype "3" (§2.2.3.2.6.3)

Appropriate test procedures are provided in §2.4.3.2.6.3.1 through §2.4.3.2.6.3.15.

2.4.3.2.6.3.1 Verification of "TYPE" Subfield in Aircraft Velocity - Subtype "3" Messages (§2.2.3.2.6.3.1)

Appropriate test procedures are provided in §2.4.3.2.6.1.2.

2.4.3.2.6.3.2 Verification of "SUBTYPE" Subfield in Aircraft Velocity - Subtype "3" Messages (§2.2.3.2.6.3.1, §2.2.3.2.6.3.2, §2.2.5.1.19)

Appropriate test procedures are provided in §2.4.3.2.6.1.2.

2.4.3.2.6.3.3 Verification of "INTENT CHANGE FLAG" Subfield in Aircraft Velocity - Subtype "3" Messages (§2.2.3.2.6.3.3, §2.2.5.1.20)

Appropriate test procedures are provided in §2.4.3.2.6.1.3.

2.4.3.2.6.3.4 Verification of "IFR Capability Flag" Subfield in Aircraft Velocity - Subtype "3" Messages (§2.2.3.2.6.3.4, §2.2.5.1.21)

Appropriate test procedures are provided in §2.4.3.2.6.1.4.

2.4.3.2.6.3.5 Verification of "NAC_V" Subfield in Aircraft Velocity - Subtype "3" Messages (§2.2.3.2.6.3.5, §2.2.5.1.22)

Appropriate test procedures are provided in §2.4.3.2.6.1.5.

2.4.3.2.6.3.6 Verification of "MAGNETIC HEADING STATUS BIT" Subfield in Aircraft Velocity - Subtype "3" Messages (§2.2.3.2.6.3.6, §2.2.3.2.6.4.6, §2.2.5.1.16)

Purpose/Introduction:

The MAGNETIC HEADING STATUS BIT is contained in Message Bit 46 (ME Bit 14) of Airborne Velocity – Subtypes "3" and "4" messages. This test procedure verifies that the ADS-B Transmitting System correctly outputs Airborne Velocity Messages – Subtypes "3" and "4" with the MAGNETIC HEADING STATUS BIT correctly set to ONE "1" if Magnetic Heading information is available, and ZERO "0" if it is not.

These test procedures are intended for use for Airborne Velocity messages of subtypes "3" and "4." The values of the input Velocity data should be set so as to generate Airborne Velocity messages for all appropriate SUBTYPE fields.

Measurement Procedure:

Step 1: Magnetic Heading Status Bit Verification – Data Available

Configure the ADS-B Transmitting System to transmit Airborne Velocity – Subtypes "3" and "4" Messages by providing airspeed and heading information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set up the system to enable broadcast of Airborne Velocity Messages (see additional information in 2.2.3.3.2.5, "ADS-B Velocity Message Broadcast Rate"). Set the ADS-B Transmitting System to Airborne status. Provide non-zero airspeed data to the ADS-B System. This data should indicate non-supersonic velocity (less than 1000 knots) for testing Subtype "3" messages, and supersonic (greater than 1022 knots) for testing Subtype "4" messages. Provide magnetic heading input data to the ADS-B Transmitting System, and verify that output

Airborne Velocity messages have Message Bit 46 (ME Bit 14) correctly set to ONE ("1").

Step 2: Magnetic Heading Status Bit Verification – Data Not Available

Discontinue the input of magnetic heading information to the ADS-B Transmitting Subsystem.

Verify that subsequent Airborne Velocity output messages have Message Bit 46 (ME Bit 14) correctly set to ZERO ("0").

2.4.3.2.6.3.7 Verification of "MAGNETIC HEADING" Subfield in Aircraft Velocity - Subtype "3" Messages (§2.2.3.2.6.3.7, §2.2.3.2.6.4.7, §2.2.5.1.16)

Purpose/Introduction:

The "MAGNETIC HEADING" subfield is contained in Message Bits 47 through 56 (ME Bits 15 through 24) of Airborne Velocity – Subtypes "3" and "4" messages. This test will verify that the MAGNETIC HEADING subfield in these messages is correctly set according to the chart in the above-referenced subparagraphs.

These test procedures are intended for use for Airborne Velocity messages of subtypes 3 and 4. The values of the input Velocity data should be set so as to generate Airborne Velocity messages for all appropriate SUBTYPE fields.

Measurement Procedure:

Step 1: Magnetic Heading Verification – Data Equal ZERO

Configure the ADS-B Transmitting System to transmit Airborne Velocity – Subtype "3" and "4" messages by providing airspeed information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set up the system to enable broadcast of Airborne Velocity Messages (see additional information in §2.2.3.3.2.5, "ADS-B Velocity Message Broadcast Rate"). Set the ADS-B Transmitting System to Airborne status. Provide valid, non-zero airspeed data to the ADS-B System. This data should indicate non-supersonic airspeed (less than 1022 knots) for testing Subtype "3" messages, and supersonic airspeed (greater than 1022 knots) for testing Subtype "4" messages.

Provide magnetic heading input data with a value of ZERO to the ADS-B Transmitting System, and verify that the output MAGNETIC HEADING subfield in subsequent Airborne Velocity Messages is set to ZERO (binary 00 0000 0000). Also verify that the MAGNETIC HEADING STATUS BIT is set to ONE.

Step 2: Magnetic Heading Verification – Discrete Values

This test will verify that the ADS-B Transmitting Subsystem properly encodes the Magnetic Heading data for positive direction values.

Begin increasing the input Magnetic Heading data so that it assumes all values identified in Table 2-101. Verify that the value transmitted in the MAGNETIC HEADING subfield of the ADS-B Airborne Velocity Messages corresponds to the binary coding of the input Magnetic Heading in Table 2-101.

Table 2-101: Magnetic Heading Discrete Values

MAGNETIC HEADING (MHDG)		
Coding (binary)	**Coding** (decimal)	**Meaning** (Magnetic Heading in degrees)
00 0000 0001	1	Magnetic Heading = 0.3515625 degrees
00 0000 0010	2	Magnetic Heading = 0.703125 degrees
00 0000 0011	3	Magnetic Heading = 1.0546875 degrees
00 0000 0101	5	Magnetic Heading = 1.7578125 degrees
00 0000 1010	10	Magnetic Heading = 3.515625 degrees
00 0000 1111	15	Magnetic Heading = 5.2734375 degrees
00 0101 0000	80	Magnetic Heading = 28.125 degrees
00 0101 1010	90	Magnetic Heading = 31.640625 degrees
00 1010 0101	165	Magnetic Heading = 58.0078125 degrees
00 1010 1010	170	Magnetic Heading = 59.765625 degrees
01 0101 0101	341	Magnetic Heading = 119.8828125 degrees
01 1111 1111	511	Magnetic Heading = 179.6484375 degrees
10 0000 0000	512	Magnetic Heading = 180.0 degrees
10 0000 0001	513	Magnetic Heading = 180.3515625 degrees
10 0000 0010	514	Magnetic Heading = 180.703125 degrees
10 0101 0101	597	Magnetic Heading = 209.8828125 degrees
10 1010 1010	682	Magnetic Heading = 239.765625 degrees
11 0101 0101	853	Magnetic Heading = 299.8828125 degrees
11 1010 1010	938	Magnetic Heading = 329.765625 degrees
11 1111 1110	1022	Magnetic Heading = 359.296875 degrees
11 1111 1111	1023	Magnetic Heading = 359.6484375 degrees

Note: *The resolution of the raw data used as input to establish the Ground Track subfield may not be capable of setting values to exact multiples of 0.3515625 degrees. Where this is the case, the input should be set to values as close to the required values as possible.*

Step 3: Magnetic Heading Verification – Incremental Checks

Note: *If the resolution of the Magnetic Heading input to the ADS-B Transmitting Subsystem is exactly equal to 0.3515625 degrees, then this step* ***shall*** *not apply. If the resolution of the Magnetic Heading input to the ADS-B Transmitting Subsystem is greater than 0.3515625 degrees, then the ½ LSB rule given in Note 2 of §2.2.3.2.6.3.7* ***shall*** *apply, and this step* ***shall*** *be used to ensure that the accuracy of the data is maintained such that it is not worse than +/- ½ LSB, where the LSB is the least significant bit of the MAGNETIC HEADING output subfield. In this case, this means that the output data must be accurate to within 1/2 of 0.3515625 degrees, i.e., within 0.17578125 degrees.*

Set up the ADS-B transmitting system as in Step 1. Set the input heading to 0.3515625 degrees, and verify that the output MAGNETIC HEADING subfields is set to ONE (00 0000 0001). Increase the input value by the smallest increment possible, so that it assumes values greater than 0.3515625 degrees but less than 0.52734375 degrees.

Verify that for any value less than 0.52734375 degrees, the output of the MAGNETIC HEADING subfield does not change.

Increase the input value to the smallest possible value that is greater than 0.52734375 degrees.

Verify that the output MAGNETIC HEADING subfield in subsequent output messages is set to TWO (00 0000 0010).

Decrease the input so that it is set to the largest possible value that is less than 0.52734375 degrees.

Verify that the MAGNETIC HEADING subfield reverts to ONE (00 0000 0001).

2.4.3.2.6.3.8 Verification of "AIRSPEED TYPE" Subfield in Aircraft Velocity - Subtype "3" Messages (§2.2.3.2.6.3.8, §2.2.3.2.6.4.8, §2.2.5.1.17, §2.2.5.1.18)

Purpose/Introduction:

The AIRSPEED TYPE subfield is contained in Message Bit 57 (ME Bit 25) of Airborne Velocity Messages, Subtypes "3" and "4." This test will verify that the AIRSPEED TYPE subfield is correctly set to ZERO (0) to if the airspeed type is Indicated Airspeed (IAS), and ONE (1) if the airspeed type is True Airspeed (TAS).

These test procedures are intended for use for Airborne Velocity messages of subtypes "3" and "4." The values of the input Velocity data should be set so as to generate Airborne Velocity messages with the appropriate SUBTYPE field.

Measurement Procedure:

Step 1: Airspeed Type Verification – Indicated Airspeed

Configure the ADS-B Transmitting System to transmit Airborne Velocity – Subtypes “3” and “4” messages by providing airspeed and heading information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set up the system to enable broadcast of Airborne Velocity Messages (see additional information in §2.2.3.3.2.5, “ADS-B Velocity Message Broadcast Rate”). Set the ADS-B Transmitting System to Airborne status. Provide non-zero airspeed and heading data to the ADS-B System. This data should indicate non-supersonic velocity (less than 1022 knots) for testing Subtype “3” messages, and supersonic (greater than 1022 knots) for testing Subtype “4” messages.

Provide input airspeed data to the ADS-B Transmitting System in the form of “Indicated Airspeed” (IAS) data. Verify that the output Airborne Velocity messages have an AIRSPEED TYPE subfield with a value of ZERO “0.”

Step 2: Airspeed Type Verification – True Airspeed

Discontinue the input of IAS data to the ADS-B Transmitting Subsystem and instead provide input airspeed data in the form of “True Airspeed” (TAS) data.

Verify that subsequent Airborne Velocity messages have an AIRSPEED TYPE subfield with a value of ONE “1.”

2.4.3.2.6.3.9 Verification of “AIRSPEED” Subfield in Aircraft Velocity - Subtype “3” Messages (§2.2.3.2.6.3.9, §2.2.5.1.17, §2.2.5.1.18)

Purpose/Introduction:

The AIRSPEED subfield is contained in Message Bits 58 through 67 (ME Bits 26-35) of Airborne Velocity – Subtypes “3” and “4” Messages. This test will verify that the AIRSPEED subfield in these messages is correctly encoded by the ADS-B Transmitting System.

Measurement Procedure:

Step 1: Airspeed Verification – Data Not Available

Configure the ADS-B Transmitting System to transmit Airborne Velocity Messages by providing airspeed and heading information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set up the system to enable broadcast of Airborne Velocity Messages with SUBTYPE 3 (see additional information in §2.2.3.3.2.5, “ADS-B Velocity Message Broadcast Rate”). Set the ADS-B Transmitting System to Airborne status. Provide valid non-zero, non-supersonic airspeed and heading data to the ADS-B System.

Discontinue Airspeed data and verify that when Airspeed data is not provided to the ADS-B transmission device, the AIRSPEED subfield in subsequent Airborne Velocity – Subtype “3” output messages is set to ZERO (binary 00 0000 0000).

Step 2: Airspeed Verification – Data Equal to ZERO

Setup the ADS-B Transmitting System as above and set the Airspeed input to represent a velocity of ZERO knots.

Verify that the AIRSPEED subfield in subsequent Airborne Velocity – Subtype “3” output messages is set to “1” (binary 00 0000 0001).

Step 3: Airspeed Verification – Discrete Values

Verify for each integer Airspeed (expressed in knots) in Table 2-102, that the system generates Airborne Velocity Messages with TYPE “19” and subtype “3” and that the AIRSPEED subfield coding in each such message is set equal to the corresponding binary coding value in the table.

Table 2-102: Discrete Values for Airspeed

AIRSPEED (IAS or TAS) (sub-sonic)		
Coding (binary)	**Coding** (decimal)	**Meaning** (Airspeed in knots)
00 0000 0010	2	Airspeed = 1 knot
00 0000 0101	5	Airspeed = 4 knots
00 0000 1010	10	Airspeed = 9 knots
00 0000 1111	15	Airspeed = 14 knots
00 0101 0000	80	Airspeed = 79 knots
00 0101 1010	90	Airspeed = 89 knots
00 1010 0101	165	Airspeed = 164 knots
00 1010 1010	170	Airspeed = 169 knots
01 0101 0101	341	Airspeed = 340 knots
10 0101 0101	597	Airspeed = 596 knots
10 1010 1010	682	Airspeed = 681 knots
11 0101 0101	853	Airspeed = 852 knots
11 1010 1010	938	Airspeed = 937 knots
11 1111 1110	1022	Airspeed = 1021 knots

Step 4: Airspeed Verification - Part 4

Note: *If the nature of the inputs is such that a separate bit or "flag" type field is input to the transmitter to indicate "Indicated Airspeed" or "True Airspeed," the following step is not necessary. However, if the transmitter must perform some interpretation of its inputs in order to determine the correct output value of the AIRSPEED TYPE, the following step must be performed.*

Repeat Steps 2 and 3 so that each step is performed with Airspeed Type input data indicating both Indicated Airspeed (IAS) and True Airspeed (TAS).

2.4.3.2.6.3.10 Verification of "SOURCE BIT FOR VERTICAL RATE" Subfield in Aircraft Velocity - Subtype "3" Messages (§2.2.3.2.6.3.10, §2.2.5.1.14)

Appropriate test procedures are provided in §2.4.3.2.6.1.10.

2.4.3.2.6.3.11 Verification of "SIGN BIT FOR VERTICAL RATE" Subfield in Aircraft Velocity - Subtype "3" Messages (§2.2.3.2.6.3.11, §2.2.5.1.14)

Appropriate test procedures are provided in §2.4.3.2.6.1.11.

2.4.3.2.6.3.12 Verification of "VERTICAL RATE" Subfield in Aircraft Velocity - Subtype "3" Messages (§2.2.3.2.6.3.12, §2.2.5.1.14)

Appropriate test procedures are provided in §2.4.3.2.6.1.12.

2.4.3.2.6.3.13 Verification of "TURN INDICATOR" Subfield in Aircraft Velocity - Subtype "3" Messages (§2.2.3.2.6.3.13, §2.2.5.1.15)

Appropriate test procedures are provided in §2.4.3.2.6.1.13.

2.4.3.2.6.3.14 Verification of "DIFFERENCE FROM BAROMETRIC ALTITUDE SIGN BIT" Subfield in Aircraft Velocity - Subtype "3" Messages (§2.2.3.2.6.3.14)

Appropriate test procedures are provided in §2.4.3.2.6.1.14.

2.4.3.2.6.3.15 Verification of "DIFFERENCE FROM BAROMETRIC ALTITUDE" Subfield in Aircraft Velocity - Subtype "3" Messages (§2.2.3.2.6.3.15)

Appropriate test procedures are provided in §2.4.3.2.6.1.15.

2.4.3.2.6.4 Verification of ADS-B Airborne Velocity Message - Subtype "4" (§2.2.3.2.6.4)

Appropriate test procedures are provided in §2.4.3.2.6.4.1 through §2.4.3.2.6.4.15.

2.4.3.2.6.4.1 Verification of "TYPE" Subfield in Aircraft Velocity - Subtype "4" Messages (§2.2.3.2.6.4.1)

Appropriate test procedures are provided in §2.4.3.2.6.1.2.

2.4.3.2.6.4.2 Verification of "SUBTYPE" Subfield in Aircraft Velocity - Subtype "4" Messages (§2.2.3.2.6.4.2, §2.2.5.1.19)

Appropriate test procedures are provided in §2.4.3.2.6.1.2.

2.4.3.2.6.4.3 Verification of "INTENT CHANGE FLAG" Subfield in Aircraft Velocity - Subtype "4" Messages (§2.2.3.2.6.4.3, §2.2.5.1.20)

Appropriate test procedures are provided in §2.4.3.2.6.1.3.

2.4.3.2.6.4.4 Verification of "IFR Capability Flag" Subfield in Aircraft Velocity - Subtype "4" Messages (§2.2.3.2.6.4.4, §2.2.5.1.21)

Appropriate test procedures are provided in §2.4.3.2.6.1.4.

2.4.3.2.6.4.5 Verification of "NAC_V" Subfield in Aircraft Velocity - Subtype "4" Messages (§2.2.3.2.6.4.5, §2.2.5.1.22)

Appropriate test procedures are provided in §2.4.3.2.6.1.5.

2.4.3.2.6.4.6 Verification of "MAGNETIC HEADING STATUS BIT" Subfield in Aircraft Velocity - Subtype "4" Messages (§2.2.3.2.6.4.6, §2.2.5.1.16)

Appropriate test procedures are provided in §2.4.3.2.6.3.6.

2.4.3.2.6.4.7 Verification of "MAGNETIC HEADING" Subfield in Aircraft Velocity - Subtype "4" Messages (§2.2.3.2.6.4.7, §2.2.5.1.16)

Appropriate test procedures are provided in §2.4.3.2.6.3.7.

2.4.3.2.6.4.8 Verification of "AIRSPEED TYPE" Subfield in Aircraft Velocity - Subtype "4" Messages (§2.2.3.2.6.4.8, §2.2.5.1.17, §2.2.5.1.18)

Appropriate test procedures are provided in §2.4.3.2.6.3.8.

2.4.3.2.6.4.9 Verification of "AIRSPEED" Subfield in Aircraft Velocity - Subtype "4" Messages (§2.2.3.2.6.4.9, §2.2.5.1.17, §2.2.5.1.18)

Purpose/Introduction:

The AIRSPEED subfield is contained in Message Bits 58 through 67 (ME Bits 26-35) of Airborne Velocity – Subtypes "3" and "4" Messages. This test will verify that the AIRSPEED subfield in these messages is correctly encoded by the ADS-B Transmitting System.

Measurement Procedure:

Step 1: Airspeed Verification – Data Not Available

Configure the ADS-B Transmitting System to transmit Airborne Velocity Messages by providing airspeed and heading information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set up the system to enable broadcast of Airborne Velocity Messages with SUBTYPE 4 (see additional information in §2.2.3.3.2.5, "ADS-B Velocity Message Broadcast Rate"). Set the ADS-B Transmitting System to Airborne status. Provide valid non-zero airspeed and heading data to the ADS-B System.

Discontinue the input of Airspeed data and verify that when Airspeed data is not provided to the ADS-B transmission device, the AIRSPEED subfield in subsequent Airborne Velocity – Subtype "4" output messages is set to ZERO (binary 00 0000 0000).

Step 2: Airspeed Verification – Data Equal to ZERO

Setup the ADS-B Transmitting System as above and set the Airspeed input to represent a velocity of ZERO knots.

Verify that the AIRSPEED subfield in subsequent Airborne Velocity – Subtype “4” output messages is set to 1.

Step 3: Airspeed Verification – Discrete Values

Verify for each integer Airspeed (expressed in knots) in Table 2-103, that the system generates Airborne Velocity Messages with TYPE “19” and subtype “4” and that the AIRSPEED subfield coding in each such message is set equal to the corresponding binary coding value in the table.

Table 2-103: Discrete Values for Airspeed

AIRSPEED (IAS or TAS) (supersonic)		
Coding (binary)	**Coding** (decimal)	**Meaning** (Airspeed in knots)
00 0000 0010	2	Airspeed = 4 knots
00 0000 0101	5	Airspeed = 16 knots
00 0000 1010	10	Airspeed = 36 knots
00 0000 1111	15	Airspeed = 56 knots
00 0101 0000	80	Airspeed = 316 knots
00 0101 1010	90	Airspeed = 356 knots
00 1010 0101	165	Airspeed = 656 knots
00 1010 1010	170	Airspeed = 676 knots
01 0101 0101	341	Airspeed = 1,360 knots
10 0101 0101	597	Airspeed = 2,384 knots
10 1010 1010	682	Airspeed = 2,724 knots
11 0101 0101	853	Airspeed = 3,408 knots
11 1010 1010	938	Airspeed = 3,748 knots
11 1111 1110	1022	Airspeed = 4,084 knots

Verify that for 4 knot increases in the input value, that the AIRSPEED subfield in subsequent Airborne Velocity Messages of TYPE “19” is incremented by one from the previous value (i.e., that the value of the AIRSPEED subfield corresponds to the values given in the table in the above referenced section).

Verify that the AIRSPEED subfield in the output message is not incremented until the input value reaches a number corresponding to an even multiple of 4 knots.

Step 4: Airspeed Verification - Part 4

Continue to increase the value of the Airspeed Data input.

Verify that for discrete values above or equal to 4084 knots but below or equal to 4086 knots, the AIRSPEED subfield continues to be set to “1022” (binary 11 1111 1110).

Continue to increase the value of the Airspeed input.

Verify that for discrete input values representing an Airspeed greater than 4086 knots, up to the maximum possible input value, that the transmitter continues to generate Airborne Velocity Messages with a TYPE subfield equal to “19” and that the AIRSPEED subfield for all such messages is set to “1023” (binary 11 1111 1111).

Step 5: Airspeed Verification - Part 5

Note: *If the nature of the inputs is such that a separate bit or “flag” type field is input to the transmitter to indicate “Indicated Airspeed” or “True Airspeed,” the following step is not necessary. However, if the transmitter must perform some interpretation of its inputs in order to determine the correct output value of the AIRSPEED TYPE, the following step must be performed.*

Repeat Steps 2, 3 and 4 so that each step is performed with Airspeed Type input data indicating both Indicated Airspeed (IAS) and True Airspeed (TAS).

2.4.3.2.6.4.10 Verification of “SOURCE BIT FOR VERTICAL RATE” Subfield in Aircraft Velocity - Subtype “4” Messages (§2.2.3.2.6.4.10, §2.2.5.1.14)

Appropriate test procedures are provided in §2.4.3.2.6.1.10.

2.4.3.2.6.4.11 Verification of “SIGN BIT FOR VERTICAL RATE” Subfield in Aircraft Velocity - Subtype “4” Messages (§2.2.3.2.6.4.11, §2.2.5.1.14)

Appropriate test procedures are provided in §2.4.3.2.6.1.11.

2.4.3.2.6.4.12 Verification of “VERTICAL RATE” Subfield in Aircraft Velocity - Subtype “4” Messages (§2.2.3.2.6.4.12, §2.2.5.1.14)

Appropriate test procedures are provided in §2.4.3.2.6.1.12.

2.4.3.2.6.4.13 Verification of “TURN INDICATOR” Subfield in Aircraft Velocity - Subtype “4” Messages (§2.2.3.2.6.4.13, §2.2.5.1.15)

Appropriate test procedures are provided in §2.4.3.2.6.1.13.

2.4.3.2.6.4.14 Verification of "DIFFERENCE FROM BAROMETRIC ALTITUDE SIGN BIT" Subfield in Aircraft Velocity - Subtype "4" Messages (§2.2.3.2.6.4.14)

Appropriate test procedures are provided in §2.4.3.2.6.1.14.

2.4.3.2.6.4.15 Verification of "DIFFERENCE FROM BAROMETRIC ALTITUDE" Subfield in Aircraft Velocity - Subtype "4" Messages (§2.2.3.2.6.4.15)

Appropriate test procedures are provided in §2.4.3.2.6.1.15.

2.4.3.2.6.5 Verification of ADS-B Aircraft Velocity Message - Subtype "5, 6, & 7" (§2.2.3.2.6.5)

ADS-B Airborne Velocity Information Messages are not defined for Subtypes 5, 6 and 7 and **shall** be considered to be reserved for future expansion of Velocity Information Type Messages.

Appropriate test procedures will be added to this document as these messages are defined.

2.4.3.2.7 Verification of ADS-B Intent and Operational Status Messages (§2.2.3.2.7)

Appropriate test procedures to validate the requirements of §2.2.3.2.7 are included in the following subparagraphs.

2.4.3.2.7.1 Verification of "Aircraft Trajectory Intent and System Status" Messages (§2.2.3.2.7.1)

No specific test procedure is required to validate §2.2.3.2.7.1.

2.4.3.2.7.1.1 Verification of "TYPE" Subfield in ATISS Messages (§2.2.3.2.7.1.1)

<u>Purpose/Introduction:</u>

These test procedures verify that the ADS-B Transmitting System correctly outputs Aircraft Trajectory Intent and System Status Messages with the correct TYPE subfield data content in Message Bits 33 through 37 in DF 17 Messages for Transponder based Systems and DF 18 Messages for Non Transponder Based Systems. The TYPE subfield for the Aircraft Trajectory Intent Messages should contain the value "29."

The ADS-B Transmitting System determines and outputs the "TYPE" subfield based upon the input it receives from the type of Navigational System source that may interface to the system. The ADS-B Transmitting System may receive the "TYPE" subfield directly through an external interface instead of dynamically determining the "TYPE" subfield.

<u>Measurement Procedure:</u>

Configure the ADS-B Transmitting System to transmit Airborne Trajectory Intent and System Status Messages by providing valid trajectory information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set the ADS-B Transmitting System to Airborne status.

Verify that the "TYPE" subfield in the ADS-B Message correctly matches the "TYPE" subfield value of 29. See Table 2-11.

2.4.3.2.7.1.2 Verification of the "SUBTYPE" Subfield in ATISS Message (§2.2.3.2.7.1.2)

Purpose/Introduction:

The "SUBTYPE" subfield is a 2-bit ("ME" bits 6 and 7, Message bits 38 and 39) field used to identify if the format of the remainder of the ATISS Message. The "SUBTYPE" subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.2.

Measurement Procedure:

TBD

2.4.3.2.7.1.3 Verification of the Target State and Status Information (SUBTYPE = 0) Format (§2.2.3.2.7.1.3)

Appropriate test procedures required to validate the requirements of §2.2.3.2.7.1.3 are included in §2.4.3.2.7.1.3.1 through §2.4.3.2.7.1.3.15.

2.4.3.2.7.1.3.1 Verification of the "Vertical Data Available/Source Indicator" Subfield in ATISS Message (§2.2.3.2.7.1.3.1)

Purpose/Introduction:

The "Vertical Data Available/Source Indicator" subfield is a 2-bit ("ME" bits 8 and 9, Message bits 40 and 41) field used to identify if aircraft vertical state information is available and present as well as the data source for the vertical data when present in the subsequent subfields ("ME" bits 10 through 25, Message bits 42 through 57) of the ATISS Message. The "Vertical Data Available/Source Indicator" subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.3.1. If the "Vertical Data Available/Source Indicator" subfield is encoded with a value of ZERO (0), the target altitude related data in the subsequent subfields **shall** be ignored.

Measurement Procedure:

TBD

2.4.3.2.7.1.3.2 Verification of the "Target Altitude Type" Subfield in ATISS Message (§2.2.3.2.7.1.3.2)

Purpose/Introduction:

The "Target Altitude Type" subfield is a 1-bit ("ME" bit 10, Message bit 42) field used to identify whether the altitude reported in the "Target Altitude" subfield is referenced to mean sea level (MSL) or to a flight level (FL). The "Target Altitude Type" subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.3.2.

Measurement Procedure:

TBD

2.4.3.2.7.1.3.3 Verification of the Backward Compatibility Flag” Subfield in ATISS Message (§2.2.3.2.7.1.3.3)

Purpose/Introduction:

For systems compliant with this MOPS (RTCA DO-260A), the “Backward Compatibility Flag **shall** be set to ZERO (0). A value of ONE (1) for the “Backward Compatibility Flag” is invalid and the entire Aircraft Trajectory Intent and System Status Message **shall** be discarded.

Measurement Procedure:

TBD

2.4.3.2.7.1.3.4 Verification of the “Target Altitude Capability” Subfield in ATISS Message (§2.2.3.2.7.1.3.4)

Purpose/Introduction:

The “Target Altitude Capability” subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.3.4.

Measurement Procedure:

TBD

2.4.3.2.7.1.3.5 Verification of the “Vertical Mode Indicator” Subfield in ATISS Message (§2.2.3.2.7.1.3.5)

Purpose/Introduction:

The “Vertical Mode Indicator” subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.3.5.

Measurement Procedure:

TBD

2.4.3.2.7.1.3.6 Verification of the “Target Altitude” Subfield in ATISS Message (§2.2.3.2.7.1.3.6)

Purpose/Introduction:

It is intended that the reported “Target Altitude” be the operational altitude recognized by the aircraft’s guidance system. The reported “Target Altitude” **shall** be consistent with the reported “Target Altitude Capability” as defined in 2.2.3.2.7.1.3.4. The “Target Altitude” subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.3.6.

Measurement Procedure:

TBD

2.4.3.2.7.1.3.7 Verification of the “Horizontal Data Available/Source Indicator” Subfield in ATISS Message (§2.2.3.2.7.1.3.7)

Purpose/Introduction:

The “Horizontal Data Available/Source Indicator” subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.3.7. If the “Horizontal Data Available/Source Indicator” subfield is encoded with a value of ZERO (0), the target heading related data in the subsequent subfields **shall** be ignored.

Measurement Procedure:

TBD

2.4.3.2.7.1.3.8 Verification of the “Target Heading/Track Angle” Subfield in ATISS Message (§2.2.3.2.7.1.3.8)

Purpose/Introduction:

The “Target Heading/Track Angle” subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.3.8.

Measurement Procedure:

TBD

2.4.3.2.7.1.3.9 Verification of the “Target Heading/Track Indicator” Subfield in ATISS Message (§2.2.3.2.7.1.3.9)

Purpose/Introduction:

The “Target Heading/Track Indicator” subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.3.9.

Measurement Procedure:

TBD

2.4.3.2.7.1.3.10 Verification of the "Horizontal Mode Indicator" Subfield in ATISS Message (§2.2.3.2.7.1.3.10)

Purpose/Introduction:

The "Horizontal Mode Indicator" subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.3.10.

Measurement Procedure:

TBD

2.4.3.2.7.1.3.11 Verification of the "NAC_P" Subfield in ATISS Message (§2.2.3.2.7.1.3.11)

Purpose/Introduction:

The "NAC_P " subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.3.11.

Measurement Procedure:

TBD

2.4.3.2.7.1.3.12 Verification of the "NIC_{BARO}" Subfield in ATISS Message (§2.2.3.2.7.1.3.12)

Purpose/Introduction:

The "NIC_{BARO} " subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.3.12.

Measurement Procedure:

TBD

2.4.3.2.7.1.3.13 Verification of the "SIL" Subfield in ATISS Message (§2.2.3.2.7.1.3.13)

Purpose/Introduction:

The "SIL" subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.3.13.

Measurement Procedure:

TBD

2.4.3.2.7.1.3.14 Verification of the "Capability/Mode Codes" Subfield in ATISS Message (§2.2.3.2.7.1.3.14)

Purpose/Introduction:

The "Capability/Mode Codes" subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.3.14 as two individual 1-bit length data elements that each indicates the status of a specific system or function on the transmitting aircraft.

Measurement Procedure:

TBD

2.4.3.2.7.1.3.15 Verification of the Emergency/Priority Status" Subfield in ATISS Message (§2.2.3.2.7.1.3.15)

Purpose/Introduction:

The "Emergency/Priority Status" subfield **shall** be encoded in accordance with Table 2.2.3.2.7.1.3.15.

Measurement Procedure:

TBD

2.4.3.2.7.1.4 Verification of the Trajectory Change Information (TYPE=29 and SUBTYPE>0) Format (§2.2.3.2.7.1.4)

No specific test procedures are required to validate the requirements of §2.2.3.2.7.1.4.

2.4.3.2.7.2 Verification of "AIRCRAFT OPERATIONAL STATUS" Messages (§2.2.3.2.7.2)

No specific test procedure is required to validate §2.2.3.2.7.2.

2.4.3.2.7.2.1 Verification of "TYPE" Subfield in Aircraft Operational Status Messages (§2.2.3.2.7.2.1)

Purpose/Introduction:

These test procedures verify that the ADS-B Transmitting System correctly outputs Aircraft Trajectory Intent Messages with the correct TYPE subfield data content in Message Bits 33 through 37 in DF 17 Messages for Transponder based Systems and DF 18 Messages for Non Transponder Based Systems.

Measurement Procedure:

Configure the ADS-B Transmitting System to transmit Aircraft Operational Status Messages. Verify that the output Aircraft Operational Status Messages have a TYPE subfield which contains the value "31."

2.4.3.2.7.2.2 Verification of "SUBTYPE" Subfield in Aircraft Operational Status Messages (§2.2.3.2.7.2.2, §2.2.5.1.23)

Purpose/Introduction:

The "SUBTYPE" subfield is a 3-bit field (Message Bits 38 through 40, ME Bits 6 through 8) used to indicate various types of Aircraft Operational Status messages.

Measurement Procedure:

Configure the ADS-B Transmitting System to transmit Aircraft Operational Status Messages. Verify that if Emergency/Priority Status information is provided in accordance with Appendix A, Figure A.8-9, BDS6,1 that the SUBTYPE subfield coding is correctly set to ONE (binary 001).

Verify that for normal Aircraft Operational Status information, the SUBTYPE subfield coding is correctly set to ZERO (binary 000).

2.4.3.2.7.2.3 Verification of "CAPABILITY CLASS (CC)" Subfield in Aircraft Operational Status Messages (§2.2.3.2.7.2.3)

No specific test procedure is required to validate §2.2.3.2.7.2.3.

2.4.3.2.7.2.3.1 Verification of the "Reserved for Service Level" CC Code Subfield in Aircraft Operational Status Message (§2.2.3.2.7.2.3.1, §2.2.5.1.24)

Purpose/Identification:

Within the CC Code subfield, a four-bit subfield ("ME" bits 41-42 and 45- 46, Message bits 9-10 and 13-14) is reserved for the "Service Level" of the ADS-B transmitting subsystem. ADS-B equipment conforming to Version 1 (DO-260A) of these MOPS **shall** set the Service Level code to ALL ZEROs.

Measurement Procedure:

TBD

2.4.3.2.7.2.3.2 Verification of the "~TCAS" CC Code Subfield in Aircraft Operational Status Messages (§2.2.3.2.7.2.3.2, §2.2.5.1.25)

Purpose/Identification:

The "~TCAS" CC Code in Aircraft Operational Status Messages **shall** be set to ZERO in Aircraft Operational Status Messages if the transmitting aircraft is fitted with a TCAS II or ACAS computer and that computer is turned on and operating in a mode that can generate Resolution Advisory (RA) alerts. Likewise, this CC Code Subfield in Aircraft Operational Status Messages **shall** be set to ZERO if the ADS-B transmitting subsystem cannot ascertain whether or not a TCAS II or ACAS computer is installed, or cannot ascertain whether that computer, if installed, is operating in a mode that can generate RA alerts. Otherwise, this CC Code Subfield in Aircraft Operational Status Messages **shall** be set to ONE.

Measurement Procedure:

TBD

2.4.3.2.7.2.3.3 Verification of "CDTI Traffic Display Capability" CC Code Subfield in Aircraft Operational Status Messages (§2.2.3.2.7.2.3.3, §2.2.5.1.26)

Purpose/Identification:

The CC Code for "CDTI Traffic Display Capability" in Aircraft Operational Status Messages (Type = 31, Subtype = 0 or 1) that **shall** be set to ONE if the transmitting aircraft has a Cockpit Display of Traffic Information (CDTI) installed and that display is currently operating in a mode capable of displaying nearby ADS-B traffic. Otherwise, this CC code **shall** be ZERO.

Measurement Procedure:

TBD

2.4.3.2.7.2.3.4 Verification of the "ARV Report Capability" CC Code Subfield in Aircraft Operational Status Messages (§2.2.3.2.7.2.3.4, §2.2.5.1.27)

Purpose/Identification:

The "ARV Report Capability" subfield of the CC Codes subfield is a one-bit Boolean flag that **shall** be encoded as defined in Table 2.2.3.2.7.2.3.4:

Measurement Procedure:

TBD

2.4.3.2.7.2.3.5 Verification of the "TS Report Capability" CC Code Subfield in Aircraft Operational Status Messages (§2.2.3.2.7.2.3.5)

Purpose/Identification:

The "Target State (TS) Report Capability" subfield of the CC Codes subfield is a one-bit Boolean flag in the "airborne" format of the Aircraft Operational Status Message (Type = 31, Subtype = 0) that **shall** be encoded as defined in Table 2.2.3.2.7.2.3.5:

Measurement Procedure:

TBD

2.4.3.2.7.2.3.6 Verification of the "TC Report Capability" CC Code Subfield in Aircraft Operational Status Messages (§2.2.3.2.7.2.3.6)

Purpose/Identification:

The "Trajectory Change (TC) Report Capability" subfield of the CC Code subfield is a two-bit subfield in the "airborne" format of the Aircraft Operational Status Message (Type = 31, Subtype = 0) that **shall** be encoded as defined in Table 2.2.3.2.7.2.3.6:

Measurement Procedure:

TBD

2.4.3.2.7.2.3.7 Verification of the "Position Offset Applied" CC Code Subfield in Aircraft Operational Status Messages (§2.2.3.2.7.2.3.7)

Purpose/Identification:

The "Position Offset Applied"(POA) subfield of the CC Code subfield of the "surface" format Aircraft Operational Status Message (Type = 31, Subtype = 1) is a one-bit Boolean flag that the ADS-B transmitting subsystem **shall** set to ONE if the position that it is transmitting (in Airborne Position Messages (§2.2.3.2.3) and Surface Position Messages (§2.2.3.2.4)) is known to be the position of the ADS-B participant's ADS-B position reference point (§***TBD***) rather than, for example, the position of the antenna of the navigation receiver. Otherwise, the ADS-B transmitting subsystem **shall** set this flag to ZERO.

Measurement Procedure:

TBD

2.4.3.2.7.2.4 Verification of "OPERATIONAL MODE (OM)" Subfield in Aircraft Operational Status Messages (§2.2.3.2.7.2.4)

Appropriate test procedures required to validate the requirements of §2.2.3.2.7.2.4 are included in §2.4.3.2.7.2.4.1 through §2.4.3.2.7.2.4.4..

2.4.3.2.7.2.4.1 Verification of the "OM" Subfield Format Code in Aircraft Operational Status Messages (§2.2.3.2.7.2.4.1, §2.2.5.1.32)

Purpose/Introduction:

The first two bits of the OM subfield ("ME" bits 25 and 26) are reserved for selecting one of up to four OM subfield formats. For this version of these MOPS (DO-260A), the OM subfield format code **shall** be set to ZERO.

Measurement Procedure:

TBD

2.4.3.2.7.2.4.2 Verification of the "TCAS/ACAS Resolution Advisory Active" OM Code Subfield in Aircraft Operational Status Message (§2.2.3.2.7.2.4.2, §2.2.5.1.33)

Purpose/Introduction:

The "TCAS/ACAS Resolution Advisory Active" (RA Active) Operational Mode Code is a one-bit subfield ("ME" bit 11, Message bit 43) of the OM subfield in Aircraft Operational Status Messages. The ADS-B transmitting subsystem **shall** set this code to ONE so long as a TCAS II or ACAS resolution advisory is known to be in effect; otherwise, it **shall** set this OM code to ZERO.

Measurement Procedure:

TBD

2.4.3.2.7.2.4.3 Verification of the "IDENT Switch Active" OM Code Subfield in Aircraft Operational Status Message (§2.2.3.2.7.2.4.3, §2.2.5.1.34)

Purpose/Introduction:

The "IDENT Switch Active" Operational Mode code is a one-bit subfield ("ME" bit 12, message bit 44) of the OM Code subfield in Aircraft Operational Status Messages. Initially, the "IDENT Switch Active" OM Code **shall** be set to ZERO. Upon activation of the IDENT switch, the ADS-B transmitting subsystem **shall** set this code to ONE for a period of 20 ± 3 seconds; thereafter, the ADS-B transmitting subsystem **shall** set this OM Code to ZERO.

Measurement Procedure:

TBD

2.4.3.2.7.2.4.4 Verification of the "Receiving ATC Services" OM Code Subfield in Aircraft Operational Status Message (§2.4.3.2.7.2.4.4, §2.2.5.1.35)

Purpose/Introduction:

The "Receiving ATC Services" Operational Mode Code is a one-bit subfield ("ME" bit 13, Message bit 45) of the OM Code subfield in Aircraft Operational Status Messages. The ADS-B transmitting subsystem **shall** set this OM Code to ONE when the ADS-B transmitting subsystem is receiving ATC services, as indicated by an appropriate interface on board the transmitting aircraft. Otherwise, this OM Code **shall** be set to ZERO.

Measurement Procedure:

TBD

2.4.3.2.7.2.5 Verification of "Version Number" Subfield in Aircraft Operational Status Message (§2.2.3.2.7.2.5)

Purpose/Introduction:

The "Version Number" subfield is a 3-bit field (Message Bits 73 through 75, ME Bits 41 through 43) used to indicate the Version Number of the formats and protocols in use on the aircraft installation.

Measurement Procedure:

Configure the ADS-B Transmitting System to transmit Aircraft Operational Status Messages at the nominal rate (see §2.2.3.3.2.6.2). Verify that the unit under test was built in conformance with RTCA DO-260A. Verify that the "Version Number" subfield in the Aircraft Operational Status Message is correctly set to binary 001 in Message Bits 73 through 75.

2.4.3.2.7.2.6 Verification of the "NIC Supplenment" Subfield in Aircraft Operational Status Messages (§2.2.3.2.7.2.6)

Purpose/Introduction:

Table 2.2.3.2.7.2.6 lists the possible NIC codes and the values of the Position Message Type codes, and of the NIC Supplement subfield that **shall** be used to encode those NIC Modes in messages on the 1090 MHz ADS-B data link.

Measurement Procedure:

TBD

2.4.3.2.7.2.7 Verification of the "Navigation Accuracy Category for Position (NAC_P)" Subfield in Aircraft Operational Status Messages (§2.2.3.2.7.2.7)

Purpose/Introduction:

Measurement Procedure:

TBD

2.4.3.2.7.2.8 Verification of the "Reserved for Barometric Altitude Quality (BAQ)" Subfield in Aircraft Operational Status Messages (§2.2.3.2.7.2.8)

Purpose/Introduction:

The "Reserved for Barometric Altitude Quality (BAQ)" subfield of "subtype 0" Aircraft Operational Status Message is a two-bit field ("ME" bits 51-52, Message bits 83-84) that **shall** be set to ZERO by ADS-B Transmitting Subsystems that conform to these MOPS (RTCA DO-260A).

Measurement Procedure:

TBD

2.4.3.2.7.2.9 Verification of the "Surveillance Integrity Level (SIL)" Subfield in Aircraft Operational Status Messages (§2.2.3.2.7.2.9)

Purpose/Introduction:

??TBD??

Measurement Procedure:

TBD

2.4.3.2.7.2.10 Verification of the "Barometric Altitude Integrity Code (NIC_{BARO})" Subfield in Aircraft Operational Status Messages (§2.2.3.2.7.2.10)

Appropriate test procedures required to validate the requirements of §2.2.3.2.7.2.10 are included in §***TBD***.

2.4.3.2.7.2.11 Verification of the "Aircraft Length and Width Codes" Subfield in Aircraft Operational Status Messages (§2.2.3.2.7.2.11)

Purpose/Introduction:

The Aircraft Length and Width Codes Subfield is a four-bit field ("ME" bits 21 to 24, Message bits 53 to 56) of "subtype 1" Aircraft Operational Status Messages. This field describes the amount of space that an aircraft or ground vehicle occupies. The length and width codes are based on the actual dimensions of the transmitting aircraft or surface vehicle as specified in Table 2.2.3.2.7.2.11. Each aircraft or vehicle **shall** be assigned the smallest length and width codes for which its overall length and width qualify it.

Each A/V for which the length code is 2 or more (that is, for which Length/Width Code is 4 or more) **shall** broadcast its length/width code while it is on the surface. For this purpose, the determination of when an aircraft is on the surface **shall** be as described in §***TBD***.

Measurement Procedure:

TBD

2.4.3.2.7.2.12 Verification of the "Track Angle/Heading" Subfield in Aircraft Operational Status Messages (§2.2.3.2.7.2.12)

Purpose/Introduction:

??TBD??

Measurement Procedure:

TBD

2.4.3.2.7.2.13 Verification of the "Horizontal Reference Direction (HRD)" Subfield in Aircraft Operational Status Messages (§2.2.3.2.7.2.13)

Purpose/Introduction:

The Horizontal Reference Direction subfield **shall** be encoded as specified in Table 2.2.3.2.7.2.13.

Measurement Procedure:

TBD

2.4.3.2.7.2.14 Verification of "NOT ASSIGNED" Subfield in Aircraft Operational Status Message (§2.2.3.2.7.2.6)

No specific test procedure is required to validate §2.2.3.2.7.2.6.

2.4.3.2.7.3 Verification of RESERVED TYPE "23" ADS-B Event - Driven Messages for "TEST" (§2.2.3.2.7.3)

No specific test procedure is required to validate §2.2.3.2.7.3.

2.4.3.2.7.4 Verification of RESERVED TYPE "24" ADS-B Event - Driven Messages (§2.2.3.2.7.4)

No specific test procedure is required to validate §2.2.3.2.7.4.

2.4.3.2.7.5 Verification of RESERVED TYPE "25" ADS-B Event - Driven Messages (§2.2.3.2.7.5)

No specific test procedure is required to validate §2.2.3.2.7.5.

2.4.3.2.7.6 Verification of RESERVED TYPE "26" ADS-B Event - Driven Messages (§2.2.3.2.7.6)

No specific test procedure is required to validate §2.2.3.2.7.6.

2.4.3.2.7.7 Verification of RESERVED TYPE "27" ADS-B Event - Driven Messages (§2.2.3.2.7.7)

No specific test procedure is required to validate §2.2.3.2.7.7.

2.4.3.2.7.8 Verification of Extended Squitter Aircraft Status Messages (TYPE "28") (§2.2.3.2.7.8)

Purpose/Introduction:

The Extended Squitter Aircraft Status Message (TYPE "28") is used to provide additional information regarding aircraft status. Subtype "1" is used specifically to provide Emergency / Priority status.

Specific formatting of the TYPE "28," Subtype "1" is provided in Appendix A, Figure A-9.

Measurement Procedure:

Configure the ADS-B Transmitting System to transmit Airborne Position Messages. Set the ADS-B Transmitting System to Airborne status. Produce valid Airborne Position Messages at the nominal rate with valid position and altitude data with the Surveillance Status Subfield set to ONE (binary 01) to signify an emergency condition.

Verify that the ADS-B Transmitting System begins to transmit Extended Squitter Aircraft Status Messages at the nominal rate with the TYPE Subfield set to 28 (binary 1 1100) and the SUBTYPE Subfield set to ONE (binary 001).

Verify that for each integer Emergency/Priority Status input value in Table 2-110 the system generates Extended Squitter Aircraft Status Messages with the TYPE subfield set to 28, the SUBTYPE subfield set to ONE and the Emergency/Priority Status subfield in each such message set equal to the corresponding binary coding in the table.

Table 2-110: Discrete Values for Emergency/Priority Status

EMERGENCY/PRIORITY STATUS		
Coding (binary)	**Coding** (decimal)	**Meaning** (Emergency/Priority Status)
000	0	No Emergency
001	1	General Emergency
010	2	Lifeguard/medical
011	3	Minimum fuel
100	4	No Communications
101	5	Unlawful Interference
110	6	Downed Aircraft
111	7	Reserved

2.4.3.3 Verification of ADS-B Message Update Rates (§2.2.3.3)

No specific test procedure is required to validate §2.2.3.3.

Note: *One way to test for random uniformity is to use the Chi-squared Goodness-of-Fit test. It is not important to have a tight confidence (85% would suffice), but it is important to test both that the wait times are uniformly distributed and that the difference between consecutive wait times (modulo 400 ms) is uniformly distributed.*

2.4.3.3.1 Verification of Transmission Rates for Transponder - Based Transmitters (§2.2.3.3.1)

No specific test procedure is required to validate §2.2.3.3.1.

2.4.3.3.1.1 Verification of Transmission Rates compliant with RTCA Document No. DO-181C (§2.2.3.3.1.1)

Performance of ADS-B transmitters based on Mode S transponders **shall** validate Message Update Rates in accordance with RTCA Document No. DO-181C §2.5.4.6.2 (no applicable section in EUROCAE ED-73A), for each class of transponder defined in FAA TSO-C112.

2.4.3.3.1.2 Verification of Transmission Rates that are not specified in with RTCA Document No. DO-181C (§2.2.3.3.1.2)

When the transmission rate of a particular message type is not specified or is not tested in RTCA Document No. DO-181C (EUROCAE ED-73A), then the Mode S transponder based ADS-B transmitters **shall** verify the message delivery performance for those messages in accordance with §2.4.3.3.2 through §2.4.3.3.2.12 of this document for Stand - Alone

Transmitters. If there is conflict between the requirements of RTCA/DO-181C (EUROCAE ED-73A) and this document, then the requirements of RTCA/DO-181C (EUROCAE ED-73A) **shall** be adhered to.

2.4.3.3.1.3 Verification of Maximum Transmission Rates for Transponder - Based Transmitters (§2.2.3.3.1.3)

Performance of ADS-B transmitters based on Mode S transponders **shall** validate maximum transmission rates in accordance with RTCA Document No. DO-181C (EUROCAE ED-73A), for each class of transponder defined in FAA TSO-C112.

When the maximum transmission rate of a particular message type is not specified or is not tested in RTCA Document No. DO-181C (EUROCAE ED-73A), then the Mode S transponder based ADS-B transmitters **shall** verify the maximum message delivery rate in accordance with §2.4.3.3.2.10 of this document for Stand-Alone transmitters. If there is conflict between the requirements of RTCA/DO-181C (EUROCAE ED-73A) and this document, then the requirements of RTCA/DO-181C (EUROCAE ED-73A) **shall** be adhered to.

2.4.3.3.1.4 Verification of the ADS-B Event-Driven Message Broadcast Rates (§2.2.3.3.1.4)

No specific test procedures are required to validate the requirements of §2.2.3.3.1.4).

2.4.3.3.1.4.1 Verification of the ADS-B ATISS Message Broadcast Rates (§2.2.3.3.1.4.1)

Purpose/Introduction:

a. The Aircraft Trajectory Intent and System Status (ATISS) Message(s) (message TYPE = 29, §2.2.3.2.7.1) **shall** be initiated only when the aircraft is airborne and when vertical and/or horizontal trajectory intent information is available and valid as a minimum.

b. The ATISS Message with a SUBTYPE value of ZERO (0) **shall**, for the nominal case, be broadcast at random intervals that are uniformly distributed over the range of 1.2 to 1.3 seconds relative to the previous Aircraft Trajectory Intent Message and System for as long as data is available to satisfy the requirements of subparagraph “a.” above.

c. The broadcast rates for ATISS Messages with a SUBTYPE subfield value of other than ZERO (0) are not defined by this version of these MOPS.

Measurement Procedure:

TBD

2.4.3.3.1.4.2 Verification of the ADS-B Aircraft Operational Status Message Broadcast Rates (§2.2.3.3.1.4.2)

Purpose/Introduction:

The rate at which the Aircraft Operational Status Messages (message TYPE = 31 and SUBTYPE = ZERO (0), §2.2.3.2.7.3) **shall** be broadcast varies depending on the following conditions:

Condition 1: Aircraft Trajectory Intent and System Status message (§2.2.3.2.7.1) for Target State and System Information (i.e., TYPE = 29 and SUBTYPE = 0) is not being broadcast versus being broadcast.

Condition 2: There has been a change within the past 24 seconds in the value of one or more of the following parameters included in the Operational Status Message

a. TCAS/ACAS Operational

b. ACAS/TCAS resolution advisory active

c. NAC_p

d. SIL

a. For the two cases where:

i. The Aircraft Trajectory Intent and System Status Message (§2.2.3.2.7.1) with SUBTYPE = ZERO (0) is not being broadcast and Condition 2 above is not applicable (nominal condition); or

ii. The Aircraft Trajectory Intent and System Status message with SUBTYPE = ZERO (0) is being broadcast regardless of the applicability of Condition 2 above;

The Aircraft Operational Status Message **shall** be broadcast at random intervals uniformly distributed over the range of 2.4 to 2.6 seconds.

b. For the case where the Aircraft Trajectory Intent and System Status Message (§2.2.3.2.7.1) with SUBTYPE = ZERO (0) is not being broadcast and Condition 2 above is applicable, the Aircraft Operational Status Message broadcast rate **shall** be increased for a period of 24 seconds (+/- 1 second) such that the broadcasts occur at random intervals that are uniformly distributed over the range of 0.75 to 0.85 seconds.

Measurement Procedure:

TBD

2.4.3.3.1.4.3 Verification of the "Extended Squitter Aircraft Status" ADS-B Event-Driven Message Broadcast Rate (§2.2.3.3.1.4.3)

Purpose/Introduction:

The rate at which the "Extended Squitter Aircraft Status" (TYPE = 28), "Emergency/Priority Status" ADS-B Event - Driven Message (SUBTYPE = 1) **shall** be broadcast, varies depending on whether the "Aircraft Trajectory Intent and System Status Message" (§2.2.3.2.7.1) with SUBTYPE = ZERO (0) is not being broadcast versus being broadcast.

a. In the case where the "Aircraft Trajectory Intent and System Status Message" with SUBTYPE = ZERO (0) is not being broadcast, the "Emergency/Priority Status" **shall** be broadcast at random intervals that are uniformly distributed over the range of 0.75 to 0.85 seconds relative to the previous Emergency/Priority Status Message for the duration of the emergency condition established in accordance with Appendix A, Figure A-9, Note 2.

b. In the case where the "Aircraft Trajectory Intent and System Status Message" with SUBTYPE = ZERO (0) is being broadcast, the "Emergency/Priority Status" **shall** be broadcast at random intervals that are uniformly distributed over the range of 2.4 to 2.6 seconds relative to the previous Emergency/Priority Status Message for the duration of the emergency condition established in accordance with Appendix A, Figure A-9, Note 2.

Measurement Procedure:

TBD

2.4.3.3.1.4.4 Verification of the "TYPE 23 (TEST)" ADS-B Event-Driven Message Broadcast Rate (§2.2.3.3.1.4.4)

Purpose/Introduction:

The "TEST" ADS-B Event - Driven Messages **shall** be broadcast NOT MORE THAN ONCE each time the Event Driven Test Information is updated to the transponder.

Measurement Procedure:

TBD

2.4.3.3.1.4.5 Verification of the "TYPE 24 – 27" ADS-B Event-Driven Message Broadcast Rate (§2.2.3.3.1.4.5)

Purpose/Introduction:

In general, TYPE 24 - 27 ADS-B Event-Driven Messages **shall** be broadcast ONCE each time the Event-Driven TYPE 24 - 27 information is updated to the transponder.

Measurement Procedure:

TBD

2.4.3.3.1.4.6 Verification of the ADS-B Message Transmission Scheduing (§2.2.3.3.1.4.6)

Purpose/Introduction:

An ADS-B Message scheduling function **shall** be used to determine the sequence of ADS-B Messages to be broadcast and to control the overall transmission rate of event-driven messages. ADS-B systems that are not capable of supporting the broadcast of Aircraft Trajectory Intent and System Status Messages (§2.2.3.2.7.1) **shall** be permitted to use a simplified scheduling function for Event-Driven messages (i.e., the subset of the defined Event-Driven Message Scheduling function that is applicable to the specific messages types that are supported) in lieu of the full scheduling function described in §2.2.3.3.1.4.6.1.

Measurement Procedure:

TBD

2.4.3.3.1.4.6.1 Verification of the Event-Driven Message Scheduling Functiohn (§2.2.3.1.1.4.6.1)

Purpose/Introduction:

The Event-Driven Message Scheduling Function **shall** ensure that the total Event-Driven message rate does not exceed 2 transmitted messages per second. This is consistent with the required overall maximum allowed transmission rate specified in §2.2.3.3.1.3.

The Event-Driven Message Scheduling Function **shall** apply the following rules as a means of prioritizing the Event-Driven Message transmissions and limited the transmission rates:

a. The Event-Driven Message scheduling function **shall** reorder, as necessary, pending Event-Driven Messages according to the following message priorities, listed below in descending order from highest to lowest priority:

    i. When an Extended Squitter Status Message (§2.2.3.2.7.9) is active for the broadcast of an Emergency/Priority Condition (message TYPE = 28 and SUBTYPE

= 1), that message **shall** continue to be transmitted at the rate specified in §2.2.3.3.1.4.3 for the duration of the emergency/priority condition.

ii. Reserved for future use.

Note: This priority level may be used in a future version of these MOPS for the case when an Aircraft Trajectory Intent and System Status Message (§2.2.3.2.7.1) is active for the broadcast of trajectory change information (message TYPE = 29 and SUBTYPE = 0) and there has been a change in one or more of the message parameters that results in a higher update rate reporting requirement.

iii. Reserved for future use.

Note: This priority may be used in a future version of these MOPS for the case when an Aircraft Trajectory Intent and System Status Message (§2.2.3.2.7.1) is active for the broadcast of trajectory change information (message TYPE = 29 and SUBTYPE > 0) and there has been a change in one or more of the message parameters that results in a higher update rate reporting requirement.

iv. When an Aircraft Operational Status Message (§2.2.3.2.7.3) is active (message TYPE = 31 and SUBTYPE = 0) and there has been a change in one or more of the message parameters within the past 24 seconds that results in a higher update rate reporting requirement, the Aircraft Operational Status Message **shall** be transmitted at the nominal rate specified in §2.2.3.3.1.4.2.

v. When an Aircraft Trajectory Intent and System Status Message (§2.2.3.2.7.1) is active for the broadcast of trajectory state information (message TYPE = 29 and SUBTYPE = 0) the Aircraft Trajectory Intent and System Status message **shall** be transmitted at the nominal rate specified in §2.2.3.3.1.4.1.

vi. Reserved for future use.

Note: This priority level may be used in a future version of these MOPS for the case when an Aircraft Trajectory Intent and System Status Message (§2.2.3.2.7.1) is active for the broadcast of trajectory change information (message TYPE = 29 and SUBTYPE > 0) at a nominal rate.

vii. When an Aircraft Operational Status Message (§2.2.3.2.7.3) is active (message TYPE = 31 and SUBTYPE = 0) and is being broadcast at a nominal rate, the Aircraft Operational Status Message s**hall** be transmitted at the rate specified in §2.2.3.3.1.4.2.

viii. This priority level applies as a default to any event-driven message TYPE and SUBTYPE combination not specifically identified at a higher priority level above. Event-Driven messages of this default priority level **shall** be delivered to the transponder on a first-in-first-out basis at equal priority.

b. The Event-Driven Message scheduling function **shall** limit the number of Event-Driven messages provided to the transponder to two (2) messages per second.

Note: *It is possible that future versions of these MOPS, and requiring a complementary change to the Mode S transponder MOPS, will allow for Event-Driver messages to be transmitted at a rate of greater than the current limit of two (2) messages per second. Therefore, a means should be provided to allow for a future adjustment to the value used for the message rate limit in the Event-Driven Message scheduling function.*

c. If (b) results in a queue of messages awaiting delivery to the transponder, the higher priority pending messages, according to (a) above **shall** be delivered to the transponder for transmission before lower priority messages.

d. If (b) results in a queue of messages awaiting delivery to the transponder, new Event-Driven messages **shall** directly replace older messages of the same exact Type and Subtype (where a Subtype is defined) that are already in the pending message queue. The updated message **shall** maintain the same position in the message queue as the pending message that is being replaced.

e. If (b) above results in a queue of messages awaiting delivery to the transponder, then pending message(s), **shall** be deleted from the message transmission queue if not delivered to the transponder for transmission, or not replaced with a newer message of the same message Type and Subtype, within the Message Lifetime value specified in the Table 2.2.3.3.1.4.6.1**.**

Measurement Procedure:

TBD

2.4.3.3.2 Verification of Transmission Rates for Stand - Alone Transmitters (§2.2.3.3.1.4)

Purpose/Introduction:

a. Transmitters for Class A0 and Class B equipment may be implemented independent of a Mode S transponder. Such transmitters **shall** meet the transmission rate requirements of §2.2.3.3.1.3 and the message update rate requirements specified in the following subparagraphs.

b. Extended squitter messages **shall** be transmitted at random intervals that are uniformly distributed over the specified time interval using a time quantization no greater than 15 milliseconds.

Equipment Required:

A Method of loading valid data for the generation of ADS-B Airborne Position, Surface Position, Aircraft Identification and Type, Airborne Velocity, Intent, Operational Coordination, and Operational Status broadcast messages into the ADS-B Transmitting function under test.

A Method of recording and time stamping all ADS-B Broadcast messages transmitted by the ADS-B Transmitting function under test with the time stamping quantization being 15 milliseconds or less.

Measurement Procedure:

Step 1: ADS-B Message Broadcast Setup

Provide the ADS-B Transmitting function under test with all valid necessary data for the generation of ADS-B Airborne Position, Aircraft Identification and Type, Airborne Velocity, Intent, Operational Coordination, and Operational Status broadcast messages.

Verify that the ADS-B Transmitting function is broadcasting ADS-B Messages.

Step 2: ADS-B Message Recording and Time Stamping

Record and time stamp all ADS-B Messages that are broadcast by the ADS-B Transmitting function for a period of not less than 10 minutes.

Note: *At a maximum rate of 6.2 ADS-B Broadcast messages per second, the recording period of 10 minutes should provide approximately 3,720 messages. That is, approximately 1,200 Airborne Position, 1,200 Airborne Velocity, 1,200 Intent-Operational Coordination-Operational Status, and 120 Aircraft Identification and Type Messages. This should provide a representative sample size to support the subsequent statistical evaluations.*

Step 3: Uniform Distribution Checks

For each of the ADS-B Airborne Position, Aircraft Identification and Type, Airborne Velocity, Intent, Operational Coordination, and Operational Status message types transmitted, verify that the messages were uniformly and randomly distributed over the specified range of transmission intervals for each particular message type.

Step 4: Interval Quantization Checks

For each of the ADS-B Airborne Position, Aircraft Identification and Type, Airborne Velocity, Intent, Operational Coordination, and Operational Status message types transmitted, verify that the messages were distributed with the jitter spacing being 15 milliseconds or less between messages of equivalent type.

Step 5: Surface Condition checks (High Rate)

Repeat steps 1 -through- 4 using only ADS-B Surface Position and Aircraft Identification and Type messages using the high transmission rate (see §2.2.3.3.2.3 and §2.2.3.3.2.4) for each message type.

Step 6: Surface Condition checks (Low Rate)

Repeat steps 1 -through- 4 using only ADS-B Surface Position and Aircraft Identification and Type messages using the low transmission rate (see §2.2.3.3.2.3 and §2.2.3.3.2.4) for each message type.

2.4.3.3.2.1 Verification of Power-On Initialization and Start Up (§2.2.3.3.2.1)

No specific test procedure is required to validate §2.2.3.3.2.1.

2.4.3.3.2.1.1 Verification of Power-On Initialization (§2.2.3.3.2.1.1)

Equipment Required

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.

Provide a method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope.

Provide a Wide Band Dual Channel Oscilloscope (HP 1710B, or equivalent).

Measurement Procedure

Step 1: No Data Available (§2.2.3.3.2.1.1.a)

Ensure that no appropriate valid message data are available for any of the possible ADS-B broadcast messages. Power up the equipment. Verify that no transmissions occur.

Step 2: Valid Data available (§2.2.3.3.2.1.1.b)

For each ADS-B Position and Velocity message type in turn, ensure that appropriate valid ADS-B Message data are available for that message type only. Power up the equipment. Verify that the correct ADS-B broadcast message is transmitted starting no later than 2.0 seconds after Power-On.

Step 3: Built-in-Test Completion (§2.2.3.3.2.1.1.c)

a. Repeat the procedure provided in Step 2

b. Verify that the Unit-Under-Test (UUT) has completed all Built-in-Test functions no later than 20 seconds after applying power to the UUT.

> ***Note:*** *In order to demonstrate compliance with this procedure, the manufacturer should design the equipment to provide an appropriate indication that the equipment is performing Built-in-Test functions during the Power Up sequence.*

2.4.3.3.2.1.2 Verification of Start Up (§2.2.3.3.2.1.2)

Note: *To save time and repeating of tests the tests in this section can be combined with those testing §2.2.3.3.2.2 to §2.2.3.3.2.9 inclusive.*

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.

Provide a method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope.

Measurement Procedure:

Step 1: Data Available for only One Variable Data Field (§2.2.3.3.2.1.2.a and b)

Ensure that no appropriate valid message data are available for any of the possible ADS-B broadcast messages. Power up the equipment. Verify that no transmissions occur. For ADS-B broadcast message specified in §2.2.3.3.2.2, for each data field in turn, make data available for only that data field. Verify that for each data field, the message is transmitted at the rate specified in §2.2.3.3.2.3 to §2.2.3.3.2.9 inclusive.

Repeat Step 1 for all of the ADS-B broadcast message types specified in §2.2.3.3.2.3 to §2.2.3.3.2.9 inclusive.

Step 2: Data Ceases to be Available After Transmission has been Initiated (§2.2.3.3.2.1.2.c)

Ensure that appropriate valid ADS-B Message data are available for each ADS-B Message type. For each ADS-B Message type in turn, make all data fields unavailable and verify that the broadcast of the relevant message is discontinued when the input data has not been available for a period of 60 seconds.

2.4.3.3.2.2 Verification of ADS-B Airborne Position Message Broadcast Rate (§2.2.3.3.2.2)

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.

Provide a method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope, or equivalent method of observing the message content.

Measurement Procedure:

Step 1: All Data Available (§2.2.3.3.2.2)

Ensure that the equipment is set to the on the "Airborne" condition and that the appropriate valid ADS-B Airborne Position data is available. Verify that the ADS-B Airborne Position message is broadcast at intervals that are distributed over the range of 0.4 to 0.6 seconds as specified in §2.2.3.3.2.2.

Step 2: Only Barometric Altitude Data Available (§2.2.3.2.3.1.3.1)

Repeat Step 1 with only barometric altitude data available this time and verifying that the Type Code = 0.

Step 3: Data Ceases to be Updated (§2.2.3.3.2.11)

Establish the broadcast of the ADS-B Airborne Position message as in Step 1 above. Then stop the input of data for the ADS-B Airborne Position message.

Verify that the ADS-B Airborne Position message is broadcast with all data bits being set to ZERO no more than 2.6 seconds after stopping the data input.

Verify that the ADS-B Airborne Position message is no longer broadcast 60 +/- 1 seconds after stopping the data input.

2.4.3.3.2.3 Verification of ADS-B Surface Position Message Broadcast Rate (§2.2.3.3.2.3)

Equipment Required:

Provide a method of loading valid data for broadcasting ADS-B Messages into the ADS-B equipment under test.

Provide a method of monitoring the transmitted ADS-B Messages and measuring the rate at which they are output.

Measurement Procedure:

Step 1: Switching from High Rate to Low Rate (§2.2.3.3.2.3.a(1) and c)

Ensure that the equipment is set to the "On the Ground" condition and that the appropriate valid ADS-B Surface Position data is provided such that the position is changing at a rate of 10.1 meters in a 30 second sampling interval. At least 61 seconds after the start of the data input, verify that the ADS-B Surface Position message is broadcast at intervals that are distributed over the range of 0.4 to 0.6 seconds as specified in §2.2.3.3.2.3.b.

Input new ADS-B Surface Position data with the position data changing at a rate of 9.9 meters in a 30 second sampling interval. At least 61 seconds after the inputting of the new data, verify that the ADS-B Surface Position Message is broadcast at intervals that are distributed over the range of 4.8 to 5.2 seconds as specified in §2.2.3.3.2.3.c.

Step 2: Switching from Low Rate to High Rate (§2.2.3.3.2.3.a(2) and c)

Ensure that the equipment is set to the “On the Ground” condition and that the appropriate valid ADS-B Surface Position data is provided such that the position is stationary. At least 61 seconds after establishing the data, verify that the ADS-B Surface Position Messages are broadcast at intervals that are distributed over the range of 4.8 to 5.2 seconds as specified in §2.2.3.3.2.3.c.

Input new ADS-B Surface Position data such that the position is stationary and 10.1 meters away from the position above. One (1) second after inputting the new data, verify that the ADS-B Surface Position Messages are broadcast at intervals that are distributed over the range of 0.4 to 0.6 seconds as specified in §2.2.3.3.2.3.b. Also verify that at least 61 seconds after establishing the new data that the ADS-B Surface Position Message is broadcast at intervals that are distributed over the range 4.8 to 5.2 seconds as specified in §2.2.3.3.2.3.c.

2.4.3.3.2.4 Verification of ADS-B Aircraft Identification and Type Message Broadcast Rate (§2.2.3.3.2.4)

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.

Provide a method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope.

Measurement Procedure:

Step 1: Airborne with No TCP, TCP+1, and Aircraft Operational Status (§2.2.3.3.2.4.a)

Ensure that the equipment is set to the “Airborne” condition and that the appropriate valid ADS-B Aircraft Identification and Type data is available. Verify that the ADS-B Aircraft Identification and Type message is broadcast at intervals that are distributed over the range of 4.8 to 5.2 seconds as specified in §2.2.3.3.2.4.a.

Step 2: Airborne with TCP, TCP+1, and Aircraft Operational Status (§2.2.3.3.2.4.b)

Ensure that the equipment is set to the “Airborne” condition and that the appropriate valid ADS-B Aircraft Identification and Type data is available.

Provide the equipment with valid Trajectory Intent Data necessary to establish TCP Trajectory Intent Broadcast Messages (see §2.2.3.2.7.1 and §2.2.3.3.2.6.1).

Provide the equipment with valid Trajectory Intent Data necessary to establish TCP+1 Trajectory Intent Broadcast Messages (see §2.2.3.2.7.1 and §2.2.3.3.2.6.1).

Provide the equipment with valid Operational Status Data necessary to establish Aircraft Operational Status Messages (see §2.2.3.2.7.2 and §2.2.3.3.2.6.2).

Verify that TCP, TCP+1, and Aircraft Operational Status Messages are being broadcast.

Note: *It is not necessary to verify the rate of broadcast for the Intent Messages at this time since direct verification of the broadcast rates for these messages is verified in procedures later in this document.*

Verify that the ADS-B Aircraft Identification and Type Message is broadcast at an average rate of one message per 2.5 seconds over a time period of 60 seconds.

Step 3: On the Ground (§2.2.3.3.2.4.c)

Ensure that the equipment is set to the "On the Ground" condition and that the appropriate valid ADS-B Aircraft Identification and Type data is available. Verify that the ADS-B Aircraft Identification and Type message is broadcast at intervals that are distributed over the range of 9.8 to 10.2 seconds as specified in §2.2.3.3.2.4.c.

Step 4: Data Ceases to be Updated (§2.2.3.3.2.11)

Establish the broadcast of the ADS-B Aircraft Identification and Type message as in Step 1 above. Then stop the input of data for the ADS-B Aircraft Identification and Type message.

Verify that the ADS-B Aircraft Identification and Type message continues to be broadcast with the same data that existed prior to stopping the data input for up to 60 +/- 1 second after stopping the data input.

Verify that the ADS-B Aircraft Identification and Type message is no longer broadcast 60 +/- 1 seconds after stopping the data input.

2.4.3.3.2.5 Verification of ADS-B Velocity Information Message Broadcast Rate (§2.2.3.3.2.5)

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.

Provide a method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope.

Measurement Procedure:

Step 1: Data Available (§2.2.3.3.2.5)

Ensure that the appropriate valid ADS-B Velocity Information data is available. Verify that the ADS-B Velocity Information message is broadcast at intervals that are distributed over the range of 0.4 to 0.6 seconds as specified in §2.2.3.3.2.5.a.

Step 2: Data Ceases to be Updated (§2.2.3.3.2.11)

Establish the broadcast of the ADS-B Airborne Velocity message as in Step 1 above. Then stop the input of data for the ADS-B Airborne Velocity message.

Verify that the ADS-B Airborne Velocity message is broadcast with all data bits being set to ZERO no more than 2.6 seconds after stopping the data input.

Verify that the ADS-B Airborne Velocity message is no longer broadcast 60 +/- 1 seconds after stopping the data input.

2.4.3.3.2.6 Verification of ADS-B Trajectory Intent and Status Message Broadcast Rates (§2.2.3.3.2.6)

No specific test procedure is required to validate §2.2.3.3.2.6.

2.4.3.3.2.6.1 Verification of ADS-B Aircraft Trajectory Intent Message Broadcast Rates (§2.2.3.3.2.6.1)

Purpose/Introduction:

a. The requirements of §2.2.3.3.1.4.1 are applicable.

b. The Aircraft Trajectory Intent and System Status Message (TYPE = 29, SUBTYPE = 0, §2.2.3.2.7.1) **shall** be broadcast at random intervals that are uniformly distributed over the range of 1.2 to 1.3 seconds relative to the previous Aircraft Trajectory Intent and System Status Message for as long as data is available to satisfy the requirements of subparagraph “a.” above.

c. Exceptions to these transmission rate requirements **shall** be as defined in §2.2.3.3.2.9.

Equipment Required:

Provide a Method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.

Provide a method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope.

Measurement Procedure:

Step 1: Initialization

TBD

2.4.3.3.2.6.2 Verification of ADS-B Aircraft Operational Status Message Broadcast Rates (§2.2.3.3.2.6.2)

Purpose/Introduction:

a. The Aircraft Operational Status Message (TYPE = 31 and SUBTYPE = 0) (§2.2.3.2.7.2) **shall** be broadcast at varying rates as defined in §2.2.3.3.1.4.2.

b. Exceptions to these transmission rate requirements **shall** be as defined in §2.2.3.3.2.9.

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.

Provide a method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope.

Measurement Procedure:

Step 1: Initialization

TBD

2.4.3.3.2.6.3 Verification of “Extended Squitter Aircraft Status” ADS-B Event - Driven Message Broadcast Rate (§2.2.3.3.2.6.3)

Purpose/Introduction:

a. The rate at which the “Extended Squitter Aircraft Status” (Type = 28), “Emergency/Priority Status” ADS-B Event-Driven Message (SUBTYPE = 1) **shall** be broadcast varies as defined in Section 2.2.3.3.1.4.3.

b. The exceptional conditions specified in §2.2.3.3.2.9 **shall** be observed.

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.

Provide a method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope.

Measurement Procedure:

Step 1: Initialization

Establish the emergency condition in accordance with Appendix A. ***TBD***

Step 2: Data Ceases to be Updated (§2.2.3.3.2.11)

Establish the broadcast of the ADS-B Emergency/Status Event Driven Message (Type-28, Subtype=1) message as in Step 1 above. Then stop the input of data for the ADS-B Emergency/Status Event Driven Message (Type-28, Subtype=1) message.

Verify that the ADS-B Emergency/Status Event Driven Message (Type-28, Subtype=1) message is no longer broadcast 60 +/- 1 seconds after stopping the data input.

2.4.3.3.2.7 Verification of "TYPE 23 (TEST)" ADS-B Event - Driven Message Broadcast Rate (§2.2.3.3.2.7)

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.

Provide a method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope.

Measurement Procedure:

Update the TEST ADS-B Event Driven message and verify that it is broadcast only once. Repeat 10 times.

2.4.3.3.2.8 Verification of "TYPE 24 - 27" ADS-B Event - Driven Message Broadcast Rate (§2.2.3.3.2.8)

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.

Provide a method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope.

Measurement Procedure:

These messages are reserved for future expansion. When implemented perform the following test:

Update each of the implemented Type 24 to 27 ADS-B Event Driven messages in turn and verify that it is broadcast only once. Repeat 10 times.

2.4.3.3.2.9 Verification of ADS-B Message Transmission Scheduling (§2.2.3.3.2.9)

Purpose/Introduction:

An ADS-B Message scheduling function **shall** be used to determine the sequence of ADS-B Messages to be broadcast and to control the overall transmission rate of event-driven messages.

As an exception to the general requirement for the transmission of ADS-B Messages, the scheduled message transmission **shall** be delayed if a Mutual Suppression interface is active.

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.

Provide a method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope.

Measurement Procedure:

Step 1:

TBD

Step 2: Mutual Suppression

If a Mutual Suppression Interface is provided activate this interface and update the TEST ADS-B Event Driven Message. Verify that the message is only broadcast when the Mutual Suppression interface is deactivated.

2.4.3.3.2.9.1 Verification of Position, Velocity and Identification Message Scheduling (§2.2.3.3.2.9.1)

Purpose/Introduction:

The priority for transmission (from highest to lowest) for the message types that are not event-driven **shall** be:

a. Position Message (either Airborne Position Message, as defined in §2.2.3.2.3, or Surface Position Message, as defined in §2.2.3.2.4)

b. Airborne Velocity Message (§2.2.3.2.6.3)

c. Aircraft Identification and Type Message (§2.2.3.2.5)

Measurement Procedure:

TBD

2.4.3.3.2.9.2 Verification of Event-Driven Message Scheduling (§2.2.3.3.2.9.2)

Purpose/Introduction:

An Event-Driven Message Scheduling function **shall**:

a. Ensure that the total Event-Driven Message rate does not exceed 2 transmitted messages per second. This is consistent with the required overall maximum allowed transmission rate specified in §2.2.3.3.2.10.

Note: *It is possible that future versions of these MOPS may allow for Event-Driven messages to be transmitted at a rate of greater than the current limit of two (2) messages per second. Therefore a means should be provided to allow for a future adjustment to the value used for the message rate limit in the Event-Driven Message scheduling function.*

b. The Event-Driven Message scheduling requirements of §2.2.3.3.1.4.6 **shall** be used as the means of ensuring the Event-Driven message broadcast limit of 2 messages per second is not exceeded.

Measurement Procedure:

TBD

2.4.3.3.2.10 Verification of Maximum ADS-B Message Transmission Rates (§2.2.3.3.2.10)

Purpose/Introduction:

The maximum ADS-B Message transmission rate of non-transponder ADS-B Transmitter implementations **shall** not exceed 6.2 transmitted messages per second.

Equipment Required:

Provide equipment capable of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test through the operational interface.

Provide a method of monitoring ADS-B broadcast messages output by the equipment under test.

Provide a Wide Band Dual Channel Oscilloscope (HP l7l0B, or equivalent).

Measurement Procedure:

Step 1: Airborne

TBD

Step 2: Surface

TBD

2.4.3.3.2.11 Verification of ADS-B Message Timeout (§2.2.3.3.2.11)

ADS-B Message Timeout performance is tested in §2.4.3.3.2.2 through §2.4.3.3.2.8.

2.4.3.3.2.12 Verification of ADS-B Message Termination (§2.2.3.3.2.12)

ADS-B Message Timeout performance is tested in §2.4.3.3.2.2 through §2.4.3.3.2.8.

2.4.3.4 Verification of ADS-B Transmitted Message Error Protection (§2.2.3.4)

ADS-B Transmitted Error Protection performance was previously tested in §2.4.3.2.1.1.6.

2.4.4 Verification of ADS-B Receiver Characteristics (§2.2.4)

No specific test procedure is required to validate §2.2.4.

2.4.4.1 Verification of Minimum Triggering Level (MTL) Definition (§2.2.4.1)

No specific test procedure is required to validate §2.2.4.1 since appropriate procedures are provided in subsequent subparagraphs of this document.

2.4.4.2 Verification of Receivers Shared with a TCAS Unit (§2.2.4.2)

ADS-B receivers implemented as part of a TCAS unit **shall** demonstrate compliance with Test Procedures specified in RTCA document No. DO-185A, TCAS MOPS, §2.4.2.1.2.

In addition to tests specified in RTCA document No. DO-185A, TCAS MOPS, §2.4.2.1.2, TCAS units operating with receivers that are more sensitive than the MTL requirements specified in RTCA document No. DO-185A, TCAS MOPS **shall** be submitted to the following test procedures provided through §2.4.4.4.

2.4.4.2.1 Verification of Dual Minimum Triggering Levels (§2.2.4.2.1)

No specific test procedure is required to validate §2.2.4.2.1.

2.4.4.2.1.1 Verification of TCAS Compatibility (§2.2.4.2.1.1)

Purpose/Introduction:

This test verifies that no more than 10% of ADS-B Messages received at a level of –78 dBm or below **shall** be passed to the TCAS surveillance function.

Input:

Equipment:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz
Frequency	=	1090 MHz
Power	=	-78 dBm

Measurement Procedure:

The ADS-B receiver power levels specified in this procedure are relative to the loss at the RF message source end of the transmission line used to interface the RF message source to the UUT receiver input port. For each ADS-B equipage class, the specified power level **shall** be adjusted to compensate for the maximum line loss for which the UUT receiver has been designed. For example, if the line loss is 3 dB, then each of the RF message power levels specified in the test procedures **shall** be lowered by 3 dB.

Step 1: Apply ADS-B **Input** Message

Apply **Input** at the receiver input port.

Step 2: Verify ADS-B **Input** Message Reception

Verify that no more than 10% of all ADS-B Messages are passed on to the TCAS surveillance function.

Step 3: Repeat on all Applicable Receiver Input Ports

Repeat Steps 1 and 2 on all other applicable receiver RF input ports of the UUT.

2.4.4.2.1.2 Verification of ADS-B Compatibility (§2.2.4.2.1.2)

Appropriate test procedures to verify the requirements of §2.2.4.2.1.2 are provided in §2.4.4.3.1.1.

2.4.4.2.2 Verification of Re-Triggerable Reply Processor (§2.2.4.2.2)

Purpose/Introduction:

The following procedures verify the capability of the TCAS shared ADS-B receiver to detect overlapping Mode-S replies or ADS-B Messages in the TCAS level range.

Inputs:

All Intruder Aircraft:

Frequency	=	1090 MHz
Altitude Rate	=	0 FPM

Intruder Aircraft 1:

Equipage	=	Mode-S ADS-B
Squitter Power	=	-50 dBm
Altitude	=	8000 ft.
Range	=	2 nmi at T = 0 sec

Intruder Aircraft 2:

Equipage	=	Mode-S
Squitter Power	=	-44 dBm
Altitude	=	8000 ft
Range	=	Maintained such that the leading edge of the first preamble pulse from Intruder 2 occurs 12 ± 1.0 μs later than the leading edge of the first preamble pulse from Intruder 1 throughout the scenario.

TCAS Aircraft:

Altitude	=	8000 ft.
Altitude Rate	=	0 FPM
Range	=	0 nmi

Sensitivity Level Selection = Automatic

ADS-B Message Format (Intruder 1):

All ADS-B Message transmissions **shall** have the following standard data field values:

"DF"	=	17
"CA"	=	0
"AA"	=	Any valid discrete address.

Mode-S Squitter Format (Intruder 2):

All Mode-S squitter transmissions **shall** have the following standard data field values:

"DF"	=	11
"CA"	=	0
"AA"	=	Any valid discrete address.

Conditions:

TCAS initialized and operating at T = 0 seconds. Intruders 1 and 2 **shall** each transmit squitters during the squitter listening period following each whisper-shout sequence and **shall** reply with a short special surveillance format (DF = 0) to each TCAS discrete interrogation.

Scenario Description:

Both Intruders are co-altitude with TCAS and each transmits squitters when TCAS is in squitter listening mode and replies to discrete interrogations from TCAS. Intruder 2 is overlapping the Intruder 1 reply window.

Measurement Procedure:

The receiver power levels specified in this procedure are relative to the loss at the RF message source end of the transmission line used to interface the RF message source to the UUT receiver input port. For each ADS-B equipage class, the specified power level **shall** be adjusted to compensate for the maximum line loss for which the UUT receiver has been designed. For example, if the line loss is 3 dB, then each of the RF message power levels specified in the test procedures **shall** be lowered by 3 dB.

Step 1: Apply ADS-B and Mode-S Input Messages

Apply the message inputs defined above to the receiver input port.

Verify that the TCAS receiver detects intruder #2.

Step 2: Repeat on all Applicable Receiver Input Ports

Repeat Steps 1 on all other applicable receiver RF input ports of the UUT.

Step 3: Vary Signal Power Levels

Repeat Steps 1 and 2 with the following additional squitter power levels:

a. Intruder Aircraft 1 – Squitter Power = -30 dBm

Intruder Aircraft 2 – Squitter Power = -24 dBm

b. Intruder Aircraft 1 – Squitter Power = MTL + 3 dB

Intruder Aircraft 2 – Squitter Power = MTL + 9 dB

Verify that the TCAS receiver detects Intruder Aircraft #2 for each case.

2.4.4.3 Verification of Receivers Not Shared With TCAS (§2.2.4.3)

No specific test procedure is required to validate §2.2.4.3.

2.4.4.3.1 Verification of In-Band Acceptance and Re-Triggerable Capability (§2.2.4.3.1)

No specific test procedure is required to validate §2.2.4.3.1.

2.4.4.3.1.1 Verification of In-Band Acceptance and Dynamic Range (§2.2.4.3.1.1)

Appropriate test procedures to verify the requirements of §2.2.4.3.1.1 are provided in §2.4.4.3.1.1.1 and §2.4.4.3.1.1.2.

2.4.4.3.1.1.1 Verification of In-Band Acceptance (§2.2.4.3.1.1.a)

Purpose/Introduction:

This test verifies the compliance of the ADS-B receiver with the sensitivity requirements specified for the particular ADS-B equipage class.

Input:

Equipment:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz
Frequency	=	1090 MHz
Power	=	-68 dBm

Measurement Procedure:

The ADS-B receiver power levels specified in this procedure are relative to the loss at the RF message source end of the transmission line used to interface the RF message source to the UUT receiver input port. For each ADS-B equipage class, the specified power level

shall be adjusted to compensate for the maximum line loss for which the UUT receiver has been designed. For example, if the line loss is 3 dB, then each of the RF message power levels specified in the test procedures **shall** be lowered by 3 dB.

Step 1: Apply ADS-B Input Messages

Apply **Input** at the receiver input port.

Step 2: Establish UUT Receiver MTL

Decrease the input power level and determine the minimum RF signal level required to produce a 90 percent ADS-B Message reception rate by the UUT receiver.

This value plus the loss line value represents the measured MTL of the UUT ADS-B receiver.

Verify that the measured MTL is in compliance with the limits specified in §2.2.4.3.1.1.a for the UUT equipment class.

Step 3: Verify UUT Receiver MTL over the Operational Frequency Range

Vary the RF signal frequency over the range of 1089 to 1091 MHz and determine the variation in RF signal level required to produce 90 percent ADS-B Message reception rate by the UUT receiver.

Verify that the measured MTL continues to comply with the limits specified in §2.2.4.3.1.1.a for the UUT equipment class.

Step 4: Repeat on all Applicable Receiver Input Ports

Repeat Steps 1 through 3 on all other applicable receiver RF input ports of the UUT.

2.4.4.3.1.1.2 Verification of Dynamic Range (§2.2.4.3.1.1.b, §2.2.4.3.1.1.c)

Purpose/Introduction:

This test verifies that the ADS-B receiver can detect and decode valid ADS-B Messages over the equipment's specified dynamic range.

Input:

Equipment:

Provide a method of providing the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address

Message Rate	=	50 Hz
Frequency	=	1090 MHz
Power	=	-68 dBm

Measurement Procedure:

The ADS-B receiver power levels specified in this procedure are relative to the loss at the RF message source end of the transmission line used to interface the RF message source to the UUT receiver input port. For each ADS-B equipage class, the specified power level **shall** be adjusted to compensate for the maximum line loss for which the UUT receiver has been designed. For example, if the line loss is 3 dB, then each of the RF message power levels specified in the test procedures **shall** be lowered by 3 dB.

Step 1: Apply ADS-B Input Messages

Apply **Input** at the receiver input port.

Step 2: Establish UUT Receiver MTL

Decrease the input power level and determine the minimum RF signal level required to produce 90 percent ADS-B Message reception rate by the UUT receiver.

This value plus the loss line value represents the measured MTL of the UUT ADS-B receiver.

Step 3: Verify UUT Receiver Dynamic Range

Increase the input signal power level to MTL + 3 dB.

Verify that the receiver properly detects and decodes at least 99% of all ADS-B Messages received.

Increase the input signal power level in 10 dB steps up to a signal level of -21 dBm.

At each step, verify that the receiver properly detects and decodes at least 99% of all ADS-B Messages received.

Step 4: Verify Class A3 UUT Receiver Performance

Decrease the input signal power level to –87 dBm. Verify that the receiver properly detects and decodes at least 15% of all ADS-B Messages input.

Step 5: Repeat on all Applicable Receiver Input Ports

Repeat Steps 1 through 4 on all other applicable receiver RF input ports of the UUT.

2.4.4.3.1.2 Verification of Re-Triggerable Capability (§2.2.4.3.1.2)

Purpose/Introduction:

The following procedures verify the capability of the Stand alone ADS-B receiver to detect overlapping ADS-B broadcast messages.

Input:

Equipment:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz
Frequency	=	1090 MHz
Power	=	-50 dBm

Followed by a second Valid Mode S Extended Squitter:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address different from the first one
Message Rate	=	50 Hz
Frequency	=	1090 MHz
Power	=	–44 dBm

Starting 12.0 +/- 1.0 μsec later than the leading edge of the first ADS-B Message.

Measurement Procedure:

The ADS-B receiver power levels specified in this procedure are relative to the loss at the RF message source end of the transmission line used to interface the RF message source to the UUT receiver input port. For each ADS-B equipage class, the specified power level **shall** be adjusted to compensate for the maximum line loss for which the UUT receiver has been designed. For example, if the line loss is 3 dB, then each of the RF message power levels specified in the test procedures **shall** be lowered by 3 dB.

Step 1: Re-Trigger Capability - Part 1

Apply **Input** at the receiver input and verify that at least 90 percent of the second valid ADS-B Messages are correctly decoded.

Step 2: Re-Trigger Capability - Part 2

Repeat Step 1 with the **Input** signal power level at MTL + 6 dB for the first ADS-B Message and MTL + 12 dB for the second ADS-B Message.

Step 3: Re-Trigger Capability - Part 3

Repeat Step 1 with **Input** level at -30 dBm for the first ADS-B Message and

-24 dBm for the second ADS-B Message.

Step 4: Repeat on all Applicable Receiver Input Ports

Repeat Steps 1 through 3 on all other applicable receiver RF input ports of the UUT.

2.4.4.3.2 Verification of Out-of-Band Rejection (§2.2.4.3.2)

Purpose/Introduction:

This test verifies that the ADS-B out-of-band rejection is in accordance with the specified values.

Input A:

Equipment:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz
Frequency	=	1090 MHz
Power	=	MTL + 3 dB
		Where MTL is the measured value of MTL made at 1090 MHz

Input B:

Same as Input A with:

Frequency	=	1084.5 MHz
Power	=	MTL + 6 dB

Input C:

Same as Input A with:

Frequency	=	1080.0 MHz
Power	=	MTL + 23 dB

Input D:

Same as Input A with:

Frequency	=	1075.0 MHz
Power	=	MTL + 43 dB

<u>Input E:</u>

Same as Input A with:		
Frequency	=	1065.0 MHz
Power	=	MTL + 63 dB

<u>Input F:</u>

Same as Input A with:		
Frequency	=	1095.5 MHz
Power	=	MTL + 6 dB

<u>Input G:</u>

Same as Input A with:		
Frequency	=	1100.0 MHz
Power	=	MTL + 23 dB

<u>Input H:</u>

Same as Input A with:		
Frequency	=	1105.0 MHz
Power	=	MTL + 43 dB

<u>Input I:</u>

Same as Input A with:		
Frequency	=	1115.0 Mhz
Power	=	MTL + 63 dB

<u>Measurement Procedure:</u>

The ADS-B receiver power levels specified in this procedure are relative to the loss at the RF message source end of the transmission line used to interface the RF message source to the UUT receiver input port. For each ADS-B equipage class, the specified power level **shall** be adjusted to compensate for the maximum line loss for which the UUT receiver has been designed. For example, if the line loss is 3 dB, then each of the RF message power levels specified in the test procedures **shall** be lowered by 3 dB.

<u>Step 1:</u> <u>Apply Initial ADS-B Input Messages</u>

Apply Input B at the receiver input port and decrease the power level until the percentage of decoded ADS-B Messages is less than or equal to 90 percent.

Verify that the measured signal power level required to produce a message decoding percentage of greater than or equal to 90 percent is greater than the limit specified in Table 2-63 of §2.2.4.3.2.

<u>Step 2:</u> <u>Vary the Input Signal Power and Frequency</u>

Repeat Step 1 using inputs C, D, E, F, G, H and I.

<u>Step 3:</u> <u>Repeat on all Applicable Receiver Input Ports</u>

Repeat Steps 1 and 2 on all other applicable receiver RF input ports of the UUT.

2.4.4.3.3 Verification of Dynamic Minimum Trigger Level (DMTL) (§2.2.4.3.3)

Purpose/Introduction:

This test verifies that, when DMTL control is implemented (see §2.2.4.3.3), then the ADS-B receiver DMTL is capable of rejecting low level signals during a valid squitter reception and that DMTL is capable of recovering in not more than 128 microseconds after the leading edge of the first preamble pulse of a valid ADS-B Message.

Input A:

Equipment:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:
"DF" = 17
"CA" = 0
"AA" = Any discrete address
Message Rate = 50 Hz
Frequency = 1090 MHz
Power = -61 dBm

Overlapped by a pulse having the following characteristics:

Pulse Width = 120 +/- 1 μsec
Pulse Rise Time = 0.05 to 0.1 μsec
Pulse Fall Time = 0.05 to 0.2 μsec
Message Rate = 50 Hz
Frequency = 1090 MHz
Power = -69 dBm
Starting 0.7 +/- 0.2 μsec after the leading edge of the first preamble pulse of the ADS-B Message.

Input B:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:
"DF" = 17
"CA" = 0
"AA" = Any discrete address
Message Rate = 50 Hz
Frequency = 1090 MHz
Power = -40 dBm

Overlapped by a pulse having the following characteristics:

Pulse Width = 120 +/- 1 μsec
Pulse Rise Time = 0.05 to 0.1 μsec
Pulse Fall Time = 0.05 to 0.2 μsec
Message Rate = 50 Hz
Frequency = 1090 MHz
Power = -49 dBm

Starting 0.7 +/- 0.2 μsec after the leading edge of the first preamble pulse of the ADS-B Message.

Input C:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz
Frequency	=	1090 MHz
Power	=	-21 dBm

Overlapped by a pulse having the following characteristics:

Pulse Width	=	120 +/- 1 μsec
Pulse Rise Time	=	0.05 to 0.1 μsec
Pulse Fall Time	=	0.05 to 0.2 μsec
Message Rate	=	50 Hz
Frequency	=	1090 MHz
Power	=	-30 dBm

Starting 0.7 +/- 0.2 μsec after the leading edge of the first preamble pulse of the ADS-B Message.

Input D:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz
Frequency	=	1090 MHz
Power	=	-21 dBm

Followed by a second Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz
Frequency	=	1090 MHz
Power	=	-60 dBm

Starting 129 +/- 1 μsec after the leading edge of the first preamble pulse of the first ADS-B Message.

Input E:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0

"AA"	=	Any discrete address
Message Rate	=	50 Hz
Frequency	=	1090 MHz
Power	=	-70 dBm

Preceded by a pulse having the following characteristics:

Pulse Width	=	0.50 μsec
Pulse Rise Time	=	0.05 to 0.1 μsec
Pulse Fall Time	=	0.05 to 0.2 μsec
Message Rate	=	50 Hz
Frequency	=	1090 MHz
Power	=	-60 dBm

Starting 4.0 μsec before the leading edge of the first preamble pulse of the ADS-B Message.

Input F:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz
Frequency	=	1090 MHz
Power	=	-70 dBm

Preceded by a pulse having the following characteristics:

Pulse Width	=	0.50 μsec
Pulse Rise Time	=	0.05 to 0.1 μsec
Pulse Fall Time	=	0.05 to 0.2 μsec
Message Rate	=	50 Hz
Frequency	=	1090 MHz
Power	=	-60 dBm

Starting 9.0 μsec before the leading edge of the first preamble pulse of the ADS-B Message.

Measurement Procedure:

The ADS-B receiver power levels specified in this procedure are relative to the loss at the RF message source end of the transmission line used to interface the RF message source to the UUT receiver input port. For each ADS-B equipage class, the specified power level **shall** be adjusted to compensate for the maximum line loss for which the UUT receiver has been designed. For example, if the line loss is 3 dB, then each of the RF message power levels specified in the test procedures **shall** be lowered by 3 dB.

Step 1: DMTL Desensitization - Part 1

Apply **Input A** at the receiver input and verify that at least 90 percent of the valid ADS-B Messages are correctly decoded.

Step 2: DMTL Desensitization - Part 2

Repeat Step 1 using **Input B**.

Step 3: DMTL Desensitization - Part 3

Repeat Step 1 using **Input C**.

Step 4: DMTL Recovery - Part 4

Apply **Input D** at the receiver input and verify that at least 90 percent of the second valid ADS-B Messages are correctly decoded.

Step 5: DMTL Desensitization after a Single Pulse

Apply **Input E** at the receiver input and verify that no more than 10 percent of the valid ADS-B Messages are correctly decoded.

Step 6: DMTL Recovery after a Single Pulse

Apply **Input F** at the receiver input and verify that at least 90 percent of the valid ADS-B Messages are correctly decoded.

2.4.4.3.4 Verification of 1090 MHz ADS-B Message Reception Techniques (§2.2.4.3.4)

No specific test procedure is required to validate §2.2.4.3.4.

2.4.4.3.4.1 Verification of ADS-B Message Reception (§2.2.4.3.4.1)

Appropriate test procedures required to validate §2.2.4.3.4.1 are provided in §2.4.4.3.3.

2.4.4.3.4.2 Verification of Narrow Pulse Discrimination (§2.2.4.3.4.2)

Purpose/Introduction:

This test verifies that the ADS-B receiver DMTL is responsive neither to short pulses nor to TACAN/DME pulses.

Input A:

Equipment:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz
Frequency	=	1090 MHz
Power	=	-61 dBm

Preceded by a pulse having the following characteristics:

Pulse Width	=	0.20 +/- 0.05 µsec
Pulse Rise Time	=	0.05 to 0.1 µsec
Pulse Fall Time	=	0.05 to 0.2 µsec
Message Rate	=	50 Hz
Frequency	=	1090 MHz
Power	=	-61 dBm

Starting 1.0 +/- 0.2 µsec earlier than the leading edge of the first preamble pulse of the ADS-B Message.

<u>Input B:</u>

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz
Frequency	=	1090 MHz
Power	=	-61 dBm

Preceded by a pulse having the following characteristics:

Pulse Width	=	3.00 +/- 0.20 µsec
Pulse Rise Time	=	0.60 +/- 0.1 µsec
Pulse Fall Time	=	0.60 +/- 0.1 µsec
Message Rate	=	50 Hz
Frequency	=	1090 MHz
Power	=	-61 dBm

Starting 4.0 +/- 0.2 µsec earlier than the leading edge of the first preamble pulse of the ADS-B Message.

<u>Measurement Procedure:</u>

The ADS-B receiver power levels specified in this procedure are relative to the loss at the RF message source end of the transmission line used to interface the RF message source to the UUT receiver input port. For each ADS-B equipage class, the specified power level **shall** be adjusted to compensate for the maximum line loss for which the UUT receiver has been designed. For example, if the line loss is 3 dB, then each of the RF message power levels specified in the test procedures **shall** be lowered by 3 dB.

<u>Step 1:</u> <u>Narrow Pulse Discrimination - Part 1</u>

Apply **Input A** at the receiver input and verify that at least 90 percent of the valid ADS-B Messages are correctly decoded.

<u>Step 2:</u> <u>Narrow Pulse Discrimination- Part 2</u>

Repeat the Step 1 procedure while increasing the narrow pulse amplitude in 5 dB steps up to a signal level of -21 dBm.

At each step, verify that the receiver properly detects and decodes at least 99% of all ADS-B Messages received.

Step 3: TACAN/DME Discrimination - Part 1

Repeat Step 1 using **Input B**.

Step 4: TACAN/DME Discrimination - Part 2

Repeat the Step 3 procedure while increasing the TACAN/DME pulse amplitude in 5 dB steps up to a signal level of -21 dBm.

At each step, verify that the receiver properly detects and decodes at least 99% of all ADS-B Messages received.

2.4.4.3.4.3 Verification of TACAN and DME Discrimination (§2.2.4.3.4.3)

Appropriate test procedures required to validate §2.4.4.3.4.3 are provided in §2.4.4.3.4.2.

2.4.4.3.4.4 Verification of Pulse Characteristics of Received ADS-B Messages (§2.2.4.3.4.4)

No specific test procedure is required to validate §2.2.4.3.4.4.

2.4.4.3.4.5 Message Formats (§2.2.4.3.4.5)

Appropriate test procedures to validate §2.2.4.3.4.5 have previously been provided in §2.4.4.3.1.1 through §2.4.4.3.4.4.

2.4.4.3.4.6 Description of 1090 MHz ADS-B Message Received Signals (§2.2.4.3.4.6)

No specific test procedure is required to validate §2.2.4.3.4.6.

2.4.4.3.4.7 Verification of ADS-B Signal Reception (§2.2.4.3.4.7)

No specific test procedure is required to validate §2.2.4.3.4.7.

2.4.4.3.4.7.1 Verification of Criteria for ADS-B Message Transmission Pulse Detection (§2.2.4.3.4.7.1 and §2.2.4.3.4.7.2)

Purpose/Introduction:

These tests verify that the ADS-B reply processor correctly detects the presence of a valid ADS-B preamble whose pulse characteristics are within the allowable limits and rejects preambles having pulse spacing and position characteristics that are outside the allowable limits.

Reference Input:

Equipment:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:
"DF" = 17
"CA" = 0
"AA" = Any discrete address
Message Rate = 50 Hz
Frequency = 1090 MHz
Power = -23 dBm (for the first preamble pulse level)

Input A:

Same as the **Reference Input**, but having the following preamble pulse characteristics:

Table 2-111: Input A: Preamble Pulse Characteristics

Input A: Preamble Pulse Characteristics					
Pulse	**Rise time** (µsec)	**Fall time** (µsec)	D **Width** (µsec)	D **Position** (µsec)	D **Amplitude** (dB)
1	0.05 - 0.1	0.05 - 0.2	+0.05	—	—
2	0.05 - 0.1	0.05 - 0.2	-0.05	-0.125	+2
3	0.05 - 0.1	0.05 - 0.2	+0.05	+0.125	+2
4	0.05 - 0.1	0.05 - 0.2	-0.05	-0.125	0

Input B:

Same as the **Reference Input**, but having the following preamble pulse characteristics:

Table 2-112: Input B: Preamble Pulse Characteristics

Input B: Preamble Pulse Characteristics					
Pulse	**Rise time** (µsec)	**Fall time** (µsec)	D **Width** (µsec)	D **Position** (µsec)	D **Amplitude** (dB)
1	0.05 - 0.1	0.05 - 0.2	-0.3	—	—
2	0.05 - 0.1	0.05 - 0.2	-0.3	0	0
3	0.05 - 0.1	0.05 - 0.2	-0.3	0	0
4	0.05 - 0.1	0.05 - 0.2	-0.3	0	0

Input C:

Same as the **Reference Input**, but having the following preamble pulse characteristics:

Table 2-113: Input C: Preamble Pulse Characteristics

Input C: Preamble Pulse Characteristics					
Pulse	**Rise time** (µsec)	**Fall time** (µsec)	D **Width** (µsec)	D **Position** (µsec)	D **Amplitude** (dB)
1	0.05 - 0.1	0.05 - 0.2	0	—	—
2	0.05 - 0.1	0.05 - 0.2	0	+0.2	0
3	0.05 - 0.1	0.05 - 0.2	0	+0.2	0
4	0.05 - 0.1	0.05 - 0.2	0	+0.2	0

Input D:

Same as the **Reference Input**, but having the following preamble pulse characteristics:

Table 2-114: Input D: Preamble Pulse Characteristics

Input D: Preamble Pulse Characteristics					
Pulse	**Rise time** (µsec)	**Fall time** (µsec)	D **Width** (µsec)	D **Position** (µsec)	D **Amplitude** (dB)
1	0.05 - 0.1	0.05 - 0.2	+4.5	—	—
2	Pulse Not Present				
3	Pulse Not Present				
4	Pulse Not Present				

Measurement Procedure:

The ADS-B receiver power levels specified in this procedure are relative to the loss at the RF message source end of the transmission line used to interface the RF message source to the UUT receiver input port. For each ADS-B equipage class, the specified power level **shall** be adjusted to compensate for the maximum line loss for which the UUT receiver has been designed. For example, if the line loss is 3 dB, then each of the RF message power levels specified in the test procedures **shall** be lowered by 3 dB.

Step 1: Preamble Pulse Characteristics set to the Extreme Limits of their Tolerance Range - Part 1

Apply **Input A** at the receiver input and verify that at least 90 percent of the ADS-B messages are correctly decoded.

Step 2: Preamble Pulse Characteristics set to the Extreme Limits of their Tolerance Range - Part 2

Repeat Step 1 with the signal power level at -65 dBm.

Step 3: Preamble Pulse Widths set to Out-of-Tolerance Values - Part 1

Apply **Input B** at the receiver input and verify that no more than 10 percent of the ADS-B Messages are correctly decoded.

Step 4: Preamble Pulse Widths set to Out-of-Tolerance Values - Part 2

Repeat Step 3 with the signal power level at -65 dBm.

Step 5: Preamble Pulse Positions set to Out-of-Tolerance Values - Part 1

Apply **Input C** at the receiver input and verify that no more than 10 percent of the ADS-B Messages are correctly decoded.

Step 6: Preamble Pulse Positions set to Out-of-Tolerance Values - Part 2

Repeat Step 5 with the signal power level at -65 dBm.

Step 7: Preamble Single Pulse - Part 1

Apply **Input D** at the receiver input and verify that no more than 10 percent of the ADS-B Messages are correctly decoded.

Step 8: Preamble Single Pulse - Part 2

Repeat Step 7 with the signal power level at -65 dBm.

2.4.4.3.4.7.2 Verification of Criteria for Preamble Acceptance (§2.2.4.3.4.7.2)

Appropriate test procedures required to validate §2.2.4.3.4.7.2 are provided in §2.4.4.3.4.7.1.

2.4.4.3.4.7.3 Verification of Criteria for Data Block Acceptance in ADS-B Message Signals (§2.2.4.3.4.7.3)

Purpose/Introduction:

This test verifies that ADS-B Messages are accepted when DF field is 17 or 18 and when no more than seven consecutive bits fail the confidence test, as specified by §2.2.4.3.4.7.3.

Input A:

Equipment:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz
Frequency	=	1090 MHz
Power	=	-50 dBm

The normal data block content **shall** be modified to contain energy throughout both halves (i.e., chips) of bit positions 33 to 39. The amplitude of the pulse in the half that would ordinarily contain no energy **shall** be 3 dB below the amplitude of the normal pulse in the other half of the bit position.

Input B:

Equipment:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:		
"DF"	=	18
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz
Frequency	=	1090 MHz
Power	=	-50 dBm

The normal data block content **shall** be modified to contain energy throughout both halves (i.e., chips) of bit positions 33 to 39. The amplitude of the pulse in the half that would ordinarily contain no energy **shall** be 3 dB below the amplitude of the normal pulse in the other half of the bit position.

Input C:

Equipment:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:		
"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz
Frequency	=	1090 MHz
Power	=	-50 dBm

The normal data block content **shall** be modified to contain energy throughout both halves (i.e., chips) of bit positions 33 to 40. The amplitude of the pulse in the half that would ordinarily contain no energy **shall** be 3 dB below the amplitude of the normal pulse in the other half of the bit position.

Measurement Procedure:

The ADS-B receiver power levels specified in this procedure are relative to the loss at the RF message source end of the transmission line used to interface the RF message source to the UUT receiver input port. For each ADS-B equipage class, the specified power level **shall** be adjusted to compensate for the maximum line loss for which the UUT receiver has been designed. For example, if the line loss is 3 dB, then each of the RF message power levels specified in the test procedures **shall** be lowered by 3 dB.

Step 1: Valid DF=17 ADS-B Message

Apply **Input A** at the receiver input and verify that all ADS-B Messages are correctly decoded.

Step 2: Valid DF=18 ADS-B Message

Apply **Input B** at the receiver input and verify that all ADS-B Messages are correctly decoded.

Step 3: Corrupted DF=17 ADS-B Messages - Part 1

Apply **Input C** at the receiver input and verify that ADS-B Messages are not decoded.

Step 4: Repeat on all Applicable Receiver Input Ports

Repeat Steps 1 through 3 on all other applicable receiver RF input ports of the UUT.

2.4.4.3.5 Verification of ADS-B Receiver Duty Factor (§2.2.4.3.5)

Purpose/Introduction:

Available ADS-B receiver duty factor (i.e., the percentage of time that the ADS-B Message Reception function is able to receive and process ADS-B Messages at the required ADS-B MTL), when the receiver is shared with another receiving function using the 960-1215 MHz band, is an important consideration in meeting the intended ranges of operation for ADS-B equipment (see the note to Table E-1 in Appendix E, which assumes ADS-B receiver availability of 90 percent). The available ADS-B receiver duty factor **shall** be 90% or greater, averaged over a 10 second period. If the available ADS-B receiver duty factor is less than 90%, techniques for guaranteeing required equipage class range performance, such as improved MTL and/or improved message reception techniques, may be proposed, and equivalent performance to that calculated in the note within Appendix E substantiated using analysis of both the internationally-agreed LA99 traffic and power-limited range scenarios.

Analysis Procedure:

Note that due to the many types of configurations and techniques that may be implemented in the ADS-B Receiver function, verification of the Receiver Duty Factor is to be done by analysis. As such, this procedure does not provide a direct test procedure.

This analysis **shall** take into consideration all effects presented to the ADS-B Receiver function for an interference environment equivalent to the internationally-agreed LA99 traffic scenario used in Appendix E.

Step 1: Identify Functions that Degrade Receiver Availability

The first step of the analysis is for the ADS-B Receiver manufacturer to specifically identify all functions that may preclude the use of the ADS-B Receiver to properly receive ADS-B Messages. Examples of such functions are provided (but not limited to) as follows:

a. Receiver Self-Test

b. Antenna Self-Test

c. Receiver being used for other than ADS-B receiving functions

d. Antenna being used for other than ADS-B receiving functions

e. Receiver being suppressed by other in-band systems, i.e., Mode-S Transponder, TCAS, DME, JTIDS, etc.

f. Antenna operating in other than omni-directional mode.

For each function that may preclude the use of the ADS-B Receiver to properly receive ADS-B Messages, the analysis **shall** establish the probability of the Receiver not being available to process ADS-B Messages.

Step 2: Establish the Improvements Environment for the Analysis

The Receiver manufacturer **shall** specifically identify all functions that may improve the capability of the ADS-B Receiver to receive ADS-B Messages at the MTL levels specified in §2.2.4.3.1.1, Table 2-62. Examples of such functions are provided (but not limited to) as follows:

a. Improved antenna gain

b. Improved Receiver gain (i.e., lower MTL capability)

c. Improved message or signal processing techniques

d. Improved Error Correction techniques

For each function that improves the capability of the ADS-B Receiver to receive ADS-B Messages, the analysis **shall** establish the message decode probability that improvement will realize in the effective Receiver availability at the MTL levels specified in §2.2.4.3.1.1, Table 2-62.

Step 3: Establish the Equivalent Receiver Performance

From the analysis performed in step 1 and 2 demonstrate that equivalent receiver performance is sufficient to meet the required equipage class range performance. Demonstrate that [Receiver Availability (step 1) plus (+) Reception Improvements (step 2)] is not less than 90% of the total time when averaged over a processing time of 10 seconds.

2.4.4.4 Verification of Enhanced Squitter Reception Techniques (§2.2.4.4)

No specific test procedures are required to validate the requirements of §2.2.4.4.

2.4.4.4.1 Verification of the Need for Enhanced Squitter Reception Techniques (§2.2.4.4.1)

No specific test procedures are required to validate the requirements of §2.2.4.4.1.

2.4.4.4.2 Verification for the Enhanced Squitter Reception Technique Overview (§2.2.4.4.2)

Purpose/Introduction:

Enhanced squitter reception techniques have been developed (see Appendix I) that provide the ability to receive squitters with multiple overlapping Mode A/C fruit. Such enhanced reception techniques are composed of the following elements:

a. Improved preamble detection to reduce the probability of a false alarm caused by detection of an apparent Mode S preamble synthesized by overlapped Mode A/C fruit replies.

b. Improved code and confidence bit declaration typically based on the use of amplitude to aid in the interpretation of the squitter data block.

c. More capable error correction techniques that are optimized to the characteristics of the code and confidence process.

Class A1, A2 and A3 equipment **shall** demonstrate compliance with test procedures specified in §2.4.4.4.

Note: *The full set of enhanced techniques are applicable to Class A2 and A3 receiving equipment. Class A1 receiving equipment requires only a subset of the enhanced reception capabilities, and this is reflected in the test procedures of §2.4.4.4.*

2.4.4.4.2.1 Test Equipment Requirements

Note: *This section defines the tests that are conducted to evaluate the performance of the improved preamble and enhanced squitter reception techniques of the equipment under test.*

The tests consist of injecting special waveforms to test the limits of preamble detection. The tests then proceed to inject a known Mode S extended squitter waveform at a nominal power level with a defined fruit overlap scenario to test the reception of the extended squitter data block. These tests are followed by a test scenario where Mode S fruit precedes a nominal Mode S extended squitter waveform to measure the re-triggering capability. Finally, a test is conducted to verify that the sliding window error correction technique is not used.

The success criteria for the tests require the monitoring of the Mode S extended squitter data content. This data must be available for test monitoring. Report level monitoring is not adequate.

In the following tests, the parameter **T** defines the number of trials that are to be executed. Unless otherwise indicated, **T** equals 1000.

2.4.4.4.2.1.1 Mode A/C Fruit Signal Source Requirements

Five RF sources **shall** be provided that are capable of generating Mode A/C 14-pulse replies. Each fruit source **shall** be capable of the following:

The waveform **shall** consist of framing pulses and an average of five data pulses. The data content of the fruit reply **shall** be pseudo randomly varied each time a fruit reply is generated. The data pulses **shall** be uniformly pseudo randomly distributed across the 12 data bit positions (the **X** pulse position **shall** not be used).

Each fruit source **shall** be able to generate Mode A/C replies at received power levels ranging from –80 to –58 dBm as required within plus or minus 1 dB.

The fruit sources should be able to sustain a repetition rate of at least 100 replies per second.

The signals for each of the fruit sources **shall** be non-coherent with any of the other fruit sources and the extended squitter signal source (§2.4.4.4.2.1.3).

The leading edge of the P1 pulse of the Extended Squitter waveform **shall** be defined as t=0. The timing of the generation of the beginning of the F1 pulse of each fruit reply **shall** be controllable to be uniformly pseudo randomly distributed over the interval -20 to +100 microseconds (Combined extended squitter preamble and data block with Mode A/C fruit test).

The pseudo random timing of the generation of fruit replies from each fruit source **shall** be independent of the timing of the other fruit sources.

2.4.4.4.2.1.2 Mode S Fruit Signal Source Requirements

One RF source **shall** be provided that is capable of generating a Mode S 112-bit transmission as follows:

The content of the 112-bit Mode S transmission **shall** consist of a valid DF code (16, 17, 18, 20, 21, or 24), an 83-bit field that is set pseudo randomly for each transmission, and a 24-bit PI field appropriate for the content of this transmission. If an extended squitter message type is used (DF = 17 or 18) the test equipment **shall** be capable of distinguishing the reception of the desired extended squitter from that of the Mode S fruit.

The Mode S fruit source should be able to sustain a squitter rate of at least 100 squitters per second.

The Mode S fruit source **shall** be capable of generating a signal power equal to 12 dB above the minimum MTL required for the equipment class being tested within plus or minus 1 dB with no more than 1 dB droop.

The signal for the Mode S fruit source **shall** be non-coherent with the extended squitter signal source (§2.4.4.4.2.1.3).

The leading edge of the P1 pulse of the Extended Squitter waveform **shall** be defined as t=0. The timing of the generation of the beginning of the P1 pulse of the Mode S fruit waveform **shall** be controllable to be uniformly pseudo randomly distributed over a defined interval or fixed as required by the test procedure. The following define the timing of the Mode S fruit source relative to the Extended Squitter waveform:

+8 to +90 microseconds (Data Block Tests with Mode S Fruit)

-112 to –6 microseconds (Re-triggering Tests with Varying Position Mode S Fruit)

-6 microseconds (Re-triggering Tests with Fixed Position Mode S Fruit)

2.4.4.4.2.1.3 Extended Squitter Signal Source Requirements

One RF source **shall** be provided that is capable of generating a 112-bit extended squitter transmissions with no more than 1 dB droop as follows:

The extended squitter power level **shall** be adjustable ranging from –21 dBm to –84 dBm within plus or minus 1 dB as required by the test procedures.

The extended squitter signal source should be able to sustain a squitter rate of at least 100 squitters per second.

Unless otherwise required, the contents of the extended squitter transmission **shall** consist of the five-bit DF field set to 17, an 83-bit field that is set pseudo randomly for each extended squitter transmission except for ME Field bits 1 to 5 (the Format Type Code) which may be set to a fixed value, and a 24-bit PI field appropriate for the content of this transmission.

Note: *The Four-Pulse Preamble Detection tests and the Preamble Validation Tests do not require pseudo-random message content, all other test procedures do.*

Provision **shall** be made to record the contents of each extended squitter transmission

Note: *This information is required to check for undetected errors.*

The extended squitter signal source **shall** have the capability to selectively control the width and/or position of individual preamble pulses with at least 25 nanosecond resolution. The extended squitter signal source **shall** also provide the capability of individually omitting preamble pulses or any of the first 5 data pulses from the transmission.

2.4.4.4.2.2 Four-Pulse Preamble Detection Tests

Purpose/Introduction:

These tests verify that the ADS-B reply processor correctly detects the presence of a valid ADS-B preamble whose pulse characteristics are within the allowable limits and rejects preambles having pulse spacing and position characteristics that are outside the allowable limits.

Reference Input:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

“DF”	=	17
“CA”	=	0
“AA”	=	Any discrete address
Message Rate	=	50 Hz
Frequency	=	1090 MHz
Power	=	-23 dBm (for the first preamble pulse level)

Input A:

Same as the **Reference Input**, but having the following preamble pulse characteristics:

Table 2.4.4.4.2.2.A: Input A: Preamble Pulse Characteristics

Input A: Preamble Pulse Characteristics					
Pulse	**Rise time** (μsec)	**Fall time** (μsec)	D **Width** (μsec)	D **Position** (μsec)	D **Amplitude** (dB)
1	0.05 - 0.1	0.05 - 0.2	+0.05	—	—
2	0.05 - 0.1	0.05 - 0.2	-0.05	+0.125	+2
3	0.05 - 0.1	0.05 - 0.2	+0.05	+0.125	+2
4	0.05 - 0.1	0.05 - 0.2	-0.05	+0.125	0

Input B:

Same as the **Reference Input**, but having the following preamble pulse characteristics:

Table 2.4.4.4.2.2.B: Input B: Preamble Pulse Characteristics

Input B: Preamble Pulse Characteristics					
Pulse	**Rise time** (μsec)	**Fall time** (μsec)	D **Width** (μsec)	D **Position** (μsec)	D **Amplitude** (dB)
1	0.05 - 0.1	0.05 - 0.2	+0.05	—	—
2	0.05 - 0.1	0.05 - 0.2	-0.05	-0.125	+2
3	0.05 - 0.1	0.05 - 0.2	+0.05	-0.125	+2
4	0.05 - 0.1	0.05 - 0.2	-0.05	-0.125	0

Input C:

Same as the **Reference Input**, but having the following preamble pulse characteristics:

Table 2.4.4.4.2.2.C: Input C: Preamble Pulse Characteristics

Input C: Preamble Pulse Characteristics					
Pulse	**Rise time** (μsec)	**Fall time** (μsec)	D **Width** (μsec)	D **Position** (μsec)	D **Amplitude** (dB)
1	0.05 - 0.1	0.05 - 0.2	-0.3	—	—
2	0.05 - 0.1	0.05 - 0.2	-0.3	0	0
3	0.05 - 0.1	0.05 - 0.2	-0.3	0	0
4	0.05 - 0.1	0.05 - 0.2	-0.3	0	0

Input D:

Same as the **Reference Input**, but having the following preamble pulse characteristics:

Table 2.4.4.4.2.2.D: Input D: Preamble Pulse Characteristics

Input D: Preamble Pulse Characteristics					
Pulse	**Rise time** (μsec)	**Fall time** (μsec)	D **Width** (μsec)	D **Position** (μsec)	D **Amplitude** (dB)
1	0.05 - 0.1	0.05 - 0.2	0	—	—
2	0.05 - 0.1	0.05 - 0.2	0	+0.2	0
3	0.05 - 0.1	0.05 - 0.2	0	+0.2	0
4	0.05 - 0.1	0.05 - 0.2	0	+0.2	0

Input E:

Same as the **Reference Input**, but having the following preamble pulse characteristics:

Table 2.4.4.4.2.2.E: Input E: Preamble Pulse Characteristics

Input E: Preamble Pulse Characteristics					
Pulse	**Rise time** (μsec)	**Fall time** (μsec)	D **Width** (μsec)	D **Position** (μsec)	D **Amplitude** (dB)
1	0.05 - 0.1	0.05 - 0.2	0	—	—
2	0.05 - 0.1	0.05 - 0.2	0	-0.125	0
3	0.05 - 0.1	0.05 - 0.2	0	0	0
4	0.05 - 0.1	0.05 - 0.2	0	+0.125	0

Input F:

Same as the **Reference Input**, but having the following preamble pulse characteristics:

Table 2.4.4.4.2.2.F: Input F: Preamble Pulse Characteristics

Input F: Preamble Pulse Characteristics					
Pulse	**Rise time** (μsec)	**Fall time** (μsec)	D **Width** (μsec)	D **Position** (μsec)	D **Amplitude** (dB)
1	0.05 - 0.1	0.05 - 0.2	0	—	—
2	0.05 - 0.1	0.05 - 0.2	0	0	0
3	0.05 - 0.1	0.05 - 0.2	0	+0.125	0
4	0.05 - 0.1	0.05 - 0.2	0	-0.125	0

Input G:

Same as the **Reference Input**, but having the following preamble pulse characteristics:

Table 2.4.4.4.2.2.G: Input G: Preamble Pulse Characteristics

Input G: Preamble Pulse Characteristics					
Pulse	**Rise time** (μsec)	**Fall time** (μsec)	D **Width** (μsec)	D **Position** (μsec)	D **Amplitude** (dB)
1	0.05 - 0.1	0.05 - 0.2	+4.5	—	—
2	Pulse Not Present				
3	Pulse Not Present				
4	Pulse Not Present				

Measurement Procedure:

The ADS-B receiver power levels specified in this procedure are relative to the loss at the RF message source end of the transmission line used to interface the RF message source to the UUT receiver input port. For each ADS-B equipage class, the specified power level is adjusted to compensate for the maximum line loss for which the UUT receiver has been designed. For example, if the line loss is 3 dB, then each of the RF message power levels specified in the test procedures is lowered by 3 dB.

Step 1: Preamble Pulse Characteristics set to the Extreme Limits of their Tolerance Range - Part 1

Apply **Input A** at the receiver input and verify that at least 90 percent of the ADS-B Messages are correctly decoded.

Step 2: Preamble Pulse Characteristics set to the Extreme Limits of their Tolerance Range - Part 2

Repeat Step 1 with the signal power level at -65 dBm.

Step 3: Preamble Pulse Characteristics set to the Extreme Limits of their Tolerance Range - Part 3

Apply **Input B** at the receiver input and verify that at least 90 percent of the ADS-B Messages are correctly decoded.

Step 4: Preamble Pulse Characteristics set to the Extreme Limits of their Tolerance Range - Part 4

Repeat Step 3 with the signal power level at -65 dBm.

Step 5: Preamble Pulse Widths set to Out-of-Tolerance Values - Part 1

Apply **Input C** at the receiver input and verify that no more than 10 percent of the ADS-B Messages are correctly decoded.

Step 6: Preamble Pulse Widths set to Out-of-Tolerance Values - Part 2

Repeat Step 5 with the signal power level at -65 dBm.

Step 7: Preamble Pulse Positions set to Out-of-Tolerance Values - Part 1

Apply **Input D** at the receiver input and verify that no more than 10 percent of the ADS-B Messages are correctly decoded.

Step 8: Preamble Pulse Positions set to Out-of-Tolerance Values - Part 2

Repeat Step 7 with the signal power level at -65 dBm.

Step 9: Preamble Pulse Positions set to Out-of-Tolerance Values - Part 3

Apply **Input E** at the receiver input and verify that no more than 10 percent of the ADS-B Messages are correctly decoded.

Step 10: Preamble Pulse Positions set to Out-of-Tolerance Values - Part 4

Repeat Step 9 with the signal power level at -65 dBm.

Step 11: Preamble Pulse Positions set to Out-of-Tolerance Values - Part 5

Apply **Input F** at the receiver input and verify that no more than 10 percent of the ADS-B Messages are correctly decoded.

Step 12: Preamble Pulse Positions set to Out-of-Tolerance Values - Part 6

Repeat Step 11 with the signal power level at -65 dBm.

Step 13: Preamble Single Pulse - Part 1

Apply **Input G** at the receiver input and verify that no more than 10 percent of the ADS-B Messages are correctly decoded.

Step 14: Preamble Single Pulse - Part 2

Repeat Step 13 with the signal power level at -65 dBm.

2.4.4.4.2.3 Preamble Validation Tests

Purpose/Introduction:

These tests verify that the ADS-B reply processor correctly validates the ADS-B preamble. It is verified that when energy is contained in at least one chip of the first five data bits the preamble is accepted and the preamble is rejected if one or more of the first five data bits has no energy in either chip.

Reference Input:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:

"DF"	=	17
"CA"	=	0
"AA"	=	Any discrete address
Message Rate	=	50 Hz
Frequency	=	1090 MHz
Power	=	-23 dBm

The transmitted power in the first six data bits is controlled in such a way that a data bit can occur with no power being transmitted in either chip.

Measurement Procedure:

The ADS-B receiver power levels specified in this procedure are relative to the loss at the RF message source end of the transmission line used to interface the RF message source to the UUT receiver input port. For each ADS-B equipage class, the specified power level is adjusted to compensate for the maximum line loss for which the UUT receiver has been designed. For example, if the line loss is 3 dB, then each of the RF message power levels specified in the test procedures is lowered by 3 dB.

For this test to be valid the receiver must perform error correction.

Step 1: Preamble Validation – Missing First Data Bit - Part 1

Input the DF=17 messages with no energy in either chip of the first data bit into the receiver and verify that less than 10 percent of the ADS-B Messages are correctly decoded.

<u>Step 2:</u> <u>Preamble Validation – Missing First Data Bit - Part 2</u>

Repeat Step 1 with the signal power level at -65 dBm.

<u>Step 3:</u> <u>Preamble Validation – Missing Second Data Bit - Part 1</u>

Input the DF=17 messages with no energy in either chip of the second data bit into the receiver and verify that less than 10 percent of the ADS-B Messages are correctly decoded.

<u>Step 4:</u> <u>Preamble Validation – Missing Second Data Bit - Part 2</u>

Repeat Step 3 with the signal power level at -65 dBm.

<u>Step 5:</u> <u>Preamble Validation – Missing Third Data Bit - Part 1</u>

Input the DF=17 messages with no energy in either chip of the third data bit into the receiver and verify that less than 10 percent of the ADS-B Messages are correctly decoded.

<u>Step 6:</u> <u>Preamble Validation – Missing Third Data Bit - Part 2</u>

Repeat Step 5 with the signal power level at -65 dBm.

<u>Step 7:</u> <u>Preamble Validation – Missing Fourth Data Bit - Part 1</u>

Input the DF=17 messages with no energy in either chip of the first data bit into the receiver and verify that less than 10 percent of the ADS-B Messages are correctly decoded.

<u>Step 8:</u> <u>Preamble Validation – Missing Fourth Data Bit - Part 2</u>

Repeat Step 7 with the signal power level at -65 dBm.

<u>Step 9:</u> <u>Preamble Validation – Missing Fifth Data Bit - Part 1</u>

Input the DF=17 messages with no energy in either chip of the fifth data bit into the receiver and verify that less than 10 percent of the ADS-B Messages are correctly decoded.

<u>Step 10:</u> <u>Preamble Validation – Missing Fifth Data Bit - Part 2</u>

Repeat Step 9 with the signal power level at -65 dBm.

<u>Step 11:</u> <u>Preamble Validation – Missing Sixth Data Bit - Part 1</u>

Input the DF=17 messages with no energy in either chip of the sixth data bit into the receiver and verify that greater than 90 percent of the ADS-B Messages are correctly decoded.

Step 12: Preamble Validation – Missing Sixth Data Bit - Part 2

Repeat Step 11 with the signal power level at -65 dBm.

2.4.4.4.2.4 Combined Preamble and Data Block Tests with Mode A/C Fruit

Purpose/Introduction:

The following tests measure the performance of the equipment under test in decoding the extended squitter preamble and data block overlapped with Mode A/C fruit. The test series begins with monitoring the reception performance in the absence of interference to establish that the equipment under test is operating correctly.

Next, a series of tests are conducted with the number of Mode A/C fruit overlaps set to one to five respectively for A2 and A3 equipment class. For A1 equipment class, the tests are limited to a maximum of three Mode A/C fruit overlaps. For each test, the timing of the overlapping fruit is uniformly pseudo randomly distributed across the preamble and data block for seven different relative power levels. The fruit power levels will be set according to the test step being conducted and will remain constant while each of the seven extended squitter power levels are tested. **T** samples are taken at each power level. Squitters that are declared to be correctly received (i.e., received without errors or successfully error corrected) are compared to the known content of the extended squitter transmission. Any difference between the content of the decoded extended squitter and the known content of the injected squitter is recorded as an undetected error and that squitter reception is removed from the count of successfully received squitters.

The observed probability of correct squitter reception for each relative power level is computed. An average value of the performance across all power levels is computed and compared to the required performance to determine success or failure for the test.

Step 1: Verification of Operation of Equipment Under Test

Connect the extended squitter signal source and set the power level at the receiver input equal to the MTL limit required for the UUT equipment class:

–74 dBm for A1 equipment class or,

–79 dBm for A2 equipment class or,

–84 dBm for A3 equipment class.

Inject the extended squitter signal **T** times and record the extended squitters that are declared to be output as error free. Compare the decoded content of each extended squitter with the known content of the injected extended squitter. Any differences that are detected are recorded as an undetected error and that squitter reception is deleted from the count of error free receptions.

Calculate the measured probability of correct receptions and the number of undetected errors. The test is passed if the probability of correct receptions is at least 90% and there is no more than one undetected error event.

If this test is successful, proceed to Step 2. Otherwise, the test setup and equipment under test should be checked and Step 1 is repeated.

Step 2: Test with One Mode A/C Fruit Overlap

Set the extended squitter signal source as specified in Step 1.

Set the power level of one Mode A/C fruit source at the receiver input to the value corresponding to the UUT equipment class:

–62 dBm for A1 equipment class or,

–67 dBm for A2 equipment class or,

–72 dBm for A3 equipment class.

Activate the Mode A/C fruit source so that the fruit is pseudo randomly distributed across the extended squitter preamble and data block as specified in 2.4.4.4.2.1.

Inject the extended squitter waveform **T** times and record the receptions that are declared to be error free. Check for undetected errors and adjust as necessary the number of correctly received replies as specified in Step 1. Calculate the measured probability of correct reception and the number of undetected errors.

Repeat the above step six times while increasing the extended squitter power level by 4 dB with each iteration.

Calculate the average probability of reception and the total number of undetected errors across the seven power levels.

Step 3: Test with Two Mode A/C Fruit Overlaps

Repeat Step 2 with two fruit overlaps set to the following power levels and record the results:

-65 and –60 dBm for A1 equipment class or,

-69 and –65 dBm for A2 equipment class or,

-74 and –70 dBm for A3 equipment class.

Step 4: Test with Three Mode A/C Fruit Overlaps

Repeat Step 2 with three fruit overlaps set to the following power levels and record the results:

-66, -62 and –58 dBm for A1 equipment class or,

-71, -67 and –63 dBm for A2 equipment class or,

-76, -72 and –68 dBm for A3 equipment class.

Step 5: Test with Four Mode A/C Fruit Overlaps

Repeat Step 2 with four fruit overlaps set to the following power levels and record the results:

-73, -69, -65 and –61 dBm for A2 equipment class or,

-78, -74, -70 and –66 dBm for A3 equipment class.

Step 6: Test with Five Mode A/C Fruit Overlaps

Repeat Step 2 with five fruit overlaps set to the following power levels and record the results:

-75, -71, -67, -63 and –59 dBm for A2 equipment class or,

-80, -76, -72, -68 and –64 dBm for A3 equipment class.

Step 7: Determination of Success or Failure

Compare the results recorded above with the requirements in Table 2.4.4.4.5.1 or 2.4.4.4.5.1a.

Table 2.4.4.4.2.4a: Success Criteria for Preamble and Data Block Tests with Mode A/C Fruit – A2 and A3 Equipment Class

Number of Fruit	**1**	**2**	**3**	**4**	**5**
Minimum Probability	.99	.97	.93	.88	.82
Max Undetected Errors	1	1	1	1	1

Table 2.4.4.4.2.4b: Success Criteria for Preamble and Data Block Tests with Mode A/C Fruit – A1 Equipment Class

Number of Fruit	**1**	**2**	**3**
Minimum Probability	.97	.73	.58
Max Undetected Errors	1	1	1

2.4.4.4.2.5 Data Block Tests with Mode S Fruit

Purpose/Introduction:

The following tests measure the performance of the equipment under test in decoding the extended squitter data content overlapped with Mode S fruit. The test series begins with monitoring the reception performance in the absence of interference to establish that the equipment under test is operating correctly.

Next, a test is conducted with a single Mode S fruit overlap. For this test, the timing of the overlapping fruit is uniformly pseudo randomly distributed across the data block for four different relative power levels. **T** samples are taken at each power level. Squitters that are declared to be correctly received (i.e., received without errors or successfully error corrected) are compared to the known content of the extended squitter transmission. Any difference between the content of the decoded extended squitter and the known content of the injected squitter is recorded as an undetected error and that squitter reception is removed from the count of successfully received squitters.

Finally, the observed probability of correct squitter reception for each relative power level is computed.

Step 1: Verification of Operation of Equipment Under Test

Connect the extended squitter signal source. Set and verify that the power level at the receiver input is equal to the MTL limit required for the UUT equipment class plus 12 dB:

–62 dBm for A1 equipment class or,

–67 dBm for A2 equipment class or,

–72 dBm for A3 equipment class.

Inject the signal **T** times and record the extended squitters that are declared to be output as error free. Compare the decoded content of each extended squitter with the known content of the injected extended squitter. Any differences that are detected are recorded as an undetected error and that squitter reception is deleted from the count of error free receptions.

Calculate the measured probability of correct receptions and the number of undetected errors. The test is passed if the probability of correct receptions is at least 95% and there is no more than one undetected error event.

If this test is successful, proceed to Step 2. Otherwise, the test setup and equipment under test should be checked and Step 1 is repeated.

<u>Step 2:</u> <u>Test with One Mode S Fruit Overlap</u>

Set the extended squitter signal source as specified in Step 1.

Activate the Mode S fruit source so that the Mode S fruit is pseudo randomly distributed across the data extended squitter data block as specified in §2.4.4.4.2.1.2.

Set the extended squitter power to 0 dB relative to the Mode S fruit signal level.

Inject the extended squitter waveform **T** times and record the receptions that are declared to be error free. Check for undetected errors and adjust as necessary the number of correctly received replies as specified in Step 1. Calculate the measured probability of correct reception and the number of undetected errors.

Repeat the above step for relative powers of signal to interference (S/I) of +4, +8, and + 12 dB.

Calculate the probability of correct reception and the number of undetected errors for each of the four power levels.

<u>Step 3:</u> <u>Determination of Success or Failure</u>

Compare the results recorded above with the requirements in Table 2.4.4.4.2.5.

<u>Table 2.4.4.4.2.5:</u> Success Criteria for Data Block Tests with Mode S Fruit

Relative Power (S/I) dB	**0**		**+4**		**+8**		**+12**	
Equipment Class	A1	A2, A3	A1	A2, A3	A1	A2, A3	A1	A2, A3
Minimum Probability	0	0.01	0.22	0.5	0.87	1	1	1
Max Undetected Errors	1		1		1		1	

2.4.4.4.2.6 Re-Triggering Performance

<u>Purpose/Introduction:</u>

The following tests measure the capability of the equipment under test to detect extended squitters that are preceded by lower level Mode S fruit. The test series begins with monitoring the reception performance in the absence of interference to establish that the equipment under test is operating correctly.

Next, a test is conducted with a single Mode S fruit overlap with a varying position. For this test, the timing of the overlapping fruit is uniformly pseudo randomly distributed across the time interval beginning at –112 microseconds and ending at –6 microseconds relative to the leading edge of the P1 preamble pulse of the extended squitter.

Finally, a test is conducted with a single Mode S fruit overlap with a fixed position. For this test, the timing of the overlapping fruit is fixed at –6 microseconds relative to the leading edge of the P1 preamble pulse of the extended squitter.

The re-triggering performance tests are conducted at three different relative power levels. **T** samples are taken at each power level. Squitters that are declared to be correctly received (i.e., received without errors or successfully error corrected) are compared to the known content of the extended squitter transmission. Any difference between the content of the decoded extended squitter and the known content of the injected squitter is recorded as an undetected error and that squitter reception is removed from the count of successfully received squitters. The observed probability of correct squitter reception for each relative power level is computed.

<u>Step 1:</u> <u>Verification of Operation of Equipment Under Test</u>

Connect the extended squitter signal source. Set and verify that the power level at the receiver input is equal to the MTL limit required for the UUT equipment class plus 12 dB:

–62 dBm for A1 equipment class or,

–67 dBm for A2 equipment class or,

–72 dBm for A3 equipment class.

Inject the signal **T** times and record the extended squitters that are declared to be output as error free. Compare the decoded content of each extended squitter with the known content of the injected extended squitter. Any differences that are detected are recorded as an undetected error and that squitter reception is deleted from the count of error free receptions.

Calculate the measured probability of correct receptions and the number of undetected errors. The test is passed if the probability of correct receptions is at least 95% and there is no more than one undetected error event.

If this test is successful, proceed to Step 2. Otherwise, the test setup and equipment under test should be checked and Step 1 is repeated.

<u>Step 2:</u> <u>Re-triggering Test with Varying Position Mode S Fruit</u>

Connect the Mode S Fruit signal source. Set and verify that the power level at the receiver input is equal to the MTL limit required for the UUT equipment class plus 12 dB:

–62 dBm for A1 equipment class or,

–67 dBm for A2 equipment class or,

–72 dBm for A3 equipment class.

Set the extended squitter power to +4 dB relative to the Mode S fruit signal level.

Activate the Mode S fruit source so that the 112-bit Mode S fruit signal is uniformly randomly distributed across the time interval beginning at –112 microseconds and ending at –6 microseconds relative to the leading edge of the P1 preamble pulse of the extended squitter. The timing indicated is the spacing from the leading edge of the P1 pulse of the Mode S fruit to the leading edge of the P1 pulse of the extended squitter.

Inject the extended squitter waveform **T** times and record the receptions that are declared to be error free. Check for undetected errors and adjust as necessary the number of correctly received replies as specified in Step 1. Calculate the measured probability of correct reception and the number of undetected errors.

Repeat the above step for relative powers of Signal to Interference (S/I) of +8, and + 12 dB.

Calculate the probability of correct reception and the number of undetected errors for each of the three power levels.

Compare the results recorded above with the requirements in Table 2.4.4.4.2.6a.

Table 2.4.4.4.2.6a: Success Criteria for Re-Triggering Test with Varying Position Mode S Fruit

Relative Power, (S/I) dB	**+4**		**+8**		**+12**	
Equipment Class	A1	A2, A3	A1	A2, A3	A1	A2, A3
Minimum Probability	0.11	0.13	0.72	0.93	0.95	0.99
Max Undetected Errors	1		1		1	

Step 3: Re-triggering Test with Fixed Position Mode S Fruit

Connect the Mode S Fruit signal source. Set and verify that the power level at the receiver input is equal to the MTL limit required for the UUT equipment class plus 12 dB:

–62 dBm for A1 equipment class or,

–67 dBm for A2 equipment class or,

–72 dBm for A3 equipment class.

Set the extended squitter power to +4 dB relative to the Mode S fruit signal level.

Activate the Mode S fruit source so that the 112-bit Mode S fruit signal has a fixed position at –6 microseconds relative to the leading edge of the P1 preamble pulse of the extended squitter. The 6-microsecond spacing is the time from the leading edge of the P1 pulse of the Mode S fruit to the leading edge of the P1 pulse of the extended squitter.

Inject the extended squitter waveform **T** times and record the receptions that are declared to be error free. Check for undetected errors and adjust as necessary the number of correctly received replies as specified in Step 1. Calculate the measured probability of correct reception and the number of undetected errors.

Repeat the above step for relative powers of Signal to Interference (S/I) of +8, and +12 dB.

Calculate the probability of correct reception and the number of undetected errors for each of the three power levels.

Compare the results recorded above with the requirements in Table 2.4.4.4.2.6b.

<u>Table 2.4.4.4.2.6b:</u> Success Criteria for Re-Triggering Test with Fixed Position Mode S Fruit

Relative Power, (S/I) dB	**+4**		**+8**		**+12**	
Equipment Class	A1	A2, A3	A1	A2, A3	A1	A2, A3
Minimum Probability	0	0.31	0.45	0.95	0.89	0.99
Max Undetected Errors	1		1		1	

2.4.4.4.3 Verification of Error Correction Restriction (§2.2.4.4.3)

<u>Purpose/Introduction:</u>

The enhanced reception techniques are intended to operate in very high Mode A/C fruit environments. For this reason, the sliding window error correction technique **shall** not be used in conjunction with the enhanced techniques since it produces an unacceptably high undetected error rate in these high fruit environments.

<u>Note:</u> *See Appendix I, §I.3.3 and §I.4.3 for more details on error correcting techniques.*

<u>Measurement Procedure:</u>

<u>TBD</u>

2.4.4.5 Verification of ADS-B Received Message Error Protection (§2.2.4.5)

Appropriate test procedures to verify the requirements of §2.2.4.5 are provided in §2.4.4.3.4.7.3.

2.4.5 Verification of ADS-B Transmission Device Message Processor Characteristics (§2.2.5)

No specific test procedures are required to validate the requirements of §2.2.5.

2.4.5.1 Verification of ADS-B Transmission Device Data Processing and Message Formatting (§2.2.5.1)

No specific test procedure is required to validate §2.2.5.1.

2.4.5.1.1 Verification of ICAO 24-Bit Discrete Address (§2.2.5.1.1)

Appropriate test procedures required to validate the requirements of §2.2.5.1.1 were previously provided in §2.4.3.2.1.1.6 during verification of the "PI" field.

2.4.5.1.2 Verification of ADS-B Emitter Category Data (§2.2.5.1.2)

Appropriate test procedures required to validate the requirements of §2.2.5.1.2 were previously provided in §2.4.3.2.5.2 during verification of the Emitter Category Data in the Aircraft Identification and Type Message.

2.4.5.1.3 Verification of Air/Ground Status Data (§2.2.5.1.3)

Appropriate test procedures required to validate the requirements of §2.2.5.1.3 were previously provided in §2.4.3.2.1.1.2 through §2.4.3.2.1.1.2.2 during verification of the "CA" field.

2.4.5.1.4 Verification of Surveillance Status Data (§2.2.5.1.4)

Appropriate test procedures required to validate the requirements of §2.2.5.1.4 were previously provided in §2.4.3.2.3.2 during verification of "Surveillance Status" in the Airborne Position Message.

2.4.5.1.5 Verification of Altitude Data (§2.2.5.1.5)

Appropriate test procedures required to validate the requirements of §2.2.5.1.5 were previously provided in §2.4.3.2.3.4 through §2.4.3.2.3.4.3 during verification of Altitude data provided in the Airborne Position Message.

2.4.5.1.6 Verification of Time Data and Time Mark Pulse (§2.2.5.1.6)

No specific test procedure is required to validate the requirements of §2.2.5.1.6.

2.4.5.1.6.1 Verification of Case, where TIME ("T") = 0 (§2.2.5.1.6.1)

Appropriate test procedures required to validate the requirements of §2.2.5.1.6.1 were previously provided in §2.4.3.2.3.5, §2.4.3.2.3.7.2.2 and §2.4.3.2.3.8.2.2 for the Airborne Position Message and §2.4.3.2.4.5, §2.4.3.2.4.7.2.2 and §2.4.3.2.4.8.2.2 for the Surface Position Message.

2.4.5.1.6.2 Verification of Case, where TIME ("T") = 1 (§2.2.5.1.6.2)

Appropriate test procedures required to validate the requirements of §2.2.5.1.6.2 were previously provided in §2.4.3.2.3.5, §2.4.3.2.3.7.2.1 and §2.4.3.2.3.8.2.1 for the Airborne

Position Message and §2.4.3.2.4.5, §2.4.3.2.4.7.2.1 and §2.4.3.2.4.8.2.1 for the Surface Position Message.

2.4.5.1.7 Verification of Own Position Latitude Data (§2.2.5.1.7)

Appropriate test procedures required to validate the requirements of §2.2.5.1.7 were previously provided in §2.4.3.2.3.7.1 through §2.4.3.2.3.7.4 for the Airborne Position Message and §2.4.3.2.4.7.1 through §2.4.3.2.4.7.4 for the Surface Position Message.

2.4.5.1.8 Verification of Own Position Longitude Data (§2.2.5.1.8)

Appropriate test procedures required to validate the requirements of §2.2.5.1.8 were previously provided in §2.4.3.2.3.8.1 through §2.4.3.2.3.8.4 for the Airborne Position Message and §2.4.3.2.4.8.1 through §2.4.3.2.4.8.4 for the Surface Position Message.

2.4.5.1.9 Verification of Ground Speed Data (§2.2.5.1.9)

Appropriate test procedures required to validate the requirements of §2.2.5.1.9 were previously provided in §2.4.3.2.4.2 during verification of the "Movement" subfield in the Surface Position Message.

2.4.5.1.10 Verification of Ground Track Data (§2.2.5.1.10)

Appropriate test procedures required to validate the requirements of §2.2.5.1.10 were previously provided in §2.4.3.2.4.3 and §2.4.3.2.4.4 during verification Ground Track information provided in the Surface Position Message.

2.4.5.1.11 Verification of Aircraft Identification (*or* Registration) Data (§2.2.5.1.11)

Appropriate test procedures required to validate the requirements of §2.2.5.1.11 were previously provided in §2.4.3.2.5.3 during verification of Character information provided in the Aircraft Identification and Type Message.

2.4.5.1.12 Verification of East / West Velocity Data (§2.2.5.1.12)

Appropriate test procedures required to validate the requirements of §2.2.5.1.12 were previously provided in §2.4.3.2.6.1.6 and §2.4.3.2.6.1.7 for Subtype "1" Velocity Messages and in §2.4.3.2.6.2.6 and §2.4.3.2.6.2.7 for Subtype "2" Velocity Messages.

2.4.5.1.13 Verification of North / South Velocity Data (§2.2.5.1.13)

Appropriate test procedures required to validate the requirements of §2.2.5.1.13 were previously provided in §2.4.3.2.6.1.8 and §2.4.3.2.6.1.9 for Subtype "1" Velocity Messages and in §2.4.3.2.6.2.8 and §2.4.3.2.6.2.9 for Subtype "2" Velocity Messages.

2.4.5.1.14 Verification of Vertical Rate Data (§2.2.5.1.14)

Appropriate test procedures required to validate the requirements of §2.2.5.1.14 were previously provided in §2.4.3.2.6.1.10 and §2.4.3.2.6.1.11 for Subtype “1” Velocity Messages and in §2.4.3.2.6.2.10 and §2.4.3.2.6.2.11 for Subtype “2” Velocity Messages.

2.4.5.1.15 Verification of Turn Rate Data (§2.2.5.1.15)

Appropriate test procedures required to validate the requirements of §2.2.5.1.15 were previously provided in §2.4.3.2.6.1.13 for Subtype “1” through “2”Velocity Messages.

2.4.5.1.16 Verification of Magnetic Heading Data (§2.2.5.1.16)

Appropriate test procedures required to validate the requirements of §2.2.5.1.16 were previously provided in §2.4.3.2.6.3.6 and §2.4.3.2.6.3.7 for Subtype “3” and “4” Velocity Messages.

2.4.5.1.17 Verification of True Airspeed Data (§2.2.5.1.17)

Appropriate test procedures required to validate the requirements of §2.2.5.1.17 were previously provided in §2.4.3.2.6.3.8 and §2.4.3.2.6.3.9 for Subtype “3” Velocity Messages and §2.4.3.2.6.4.8 and §2.4.3.2.6.4.9 for Subtype “4” Velocity Messages.

2.4.5.1.18 Verification of Indicated Airspeed Data (§2.2.5.1.18)

Appropriate test procedures required to validate the requirements of §2.2.5.1.18 were previously provided in §2.4.3.2.6.3.8 and §2.4.3.2.6.3.9 for Subtype “3” Velocity Messages and §2.4.3.2.6.4.8 and §2.4.3.2.6.4.9 for Subtype “4” Velocity Messages.

2.4.5.1.19 Unused Section

2.4.5.1.20 Verification of Intent Change Data (§2.2.5.1.20)

Appropriate test procedures required to validate the requirements of §2.2.5.1.20 were previously provided in §2.4.3.2.6.1.3 for Subtype “1” through “4” Velocity Messages.

2.4.5.1.21 Verification of IFR Capability Data (§2.2.5.1.21)

Appropriate test procedures required to validate the requirements of §2.2.5.1.21 were previously provided in §2.4.3.2.6.1.4 for Subtype “1” through “4” Velocity Messages.

2.4.5.1.22 Verification of NAC_V Data (§2.2.5.1.22)

Appropriate test procedures required to validate the requirements of §2.2.5.1.22 were previously provided in §2.4.3.2.6.1.5 for Subtype “1” through “4” Velocity Messages.

2.4.5.1.23 Verification of Subtype (Aircraft Status) Data (§2.2.5.1.23)

Appropriate test procedures required to validate the requirements of §2.2.5.1.23 were previously provided in §2.4.3.2.7.2.2.

2.4.5.1.24 Verification of Capability Class (Reserved for Service Level) Data (§2.2.5.1.24)

Appropriate test procedures required to validate the requirements of §2.2.5.1.24 were previously provided in §2.4.3.2.7.2.3.1.

2.4.5.1.25 Verification of Capability Class (~TCAS) Data (§2.2.5.1.25)

Appropriate test procedures required to validate the requirements of §2.2.5.1.25 were previously provided in §2.4.3.2.7.2.3.2.

2.4.5.1.26 Verification of Capability Class (CDTI Traffic Display Capability) Data (§2.2.5.1.26)

Appropriate test procedures required to validate the requirements of §2.2.5.1.26 were previously provided in §2.4.3.2.7.2.3.3.

2.4.5.1.27 Verification of Capability Class (ARV Report Capability) Data (§2.2.5.1.27)

Appropriate test procedures required to validate the requirements of §2.2.5.1.27 were previously provided in §2.4.3.2.7.2.3.4.

2.4.5.1.28 Verification of Capability Class (TS Report Capability) Data (§2.2.5.1.28)

Appropriate test procedures required to validate the requirements of §2.2.5.1.28 were previously provided in §2.4.3.2.7.2.3.5.

2.4.5.1.29 Verification of Capability Class (TC Report Capability) Data (§2.2.5.1.29)

Appropriate test procedures required to validate the requirements of §2.2.5.1.29 were previously provided in §2.4.3.2.7.2.3.6.

2.4.5.1.30 Verification of Capability Class (Position Offset Applied) Data (§2.2.5.1.30)

Appropriate test procedures required to validate the requirements of §2.2.5.1.30 were previously provided in §2.4.3.2.7.2.3.7.

2.4.5.1.31 Verification of Operational Mode (OM Format) Data (§2.2.5.1.31)

Appropriate test procedures required to validate the requirements of §2.2.5.1.31 were previously provided in §2.4.3.2.7.2.4.1.

2.4.5.1.32 Verification of Operational Mode (TCAS/ACAS Resolution Advisory Active) Data (§2.2.5.1.32)

Appropriate test procedures required to validate the requirements of §2.2.5.1.32 were previously provided in §2.4.3.2.7.2.4.2.

2.4.5.1.33 Verification of Operational Mode (IDENT Switch Active) Data (§2.2.5.1.33)

Appropriate test procedures required to validate the requirements of §2.2.5.1.33 were previously provided in §2.4.3.2.7.2.4.3.

2.4.5.1.34 Verification of Operational Mode (Receiving ATC Services) Data (§2.2.5.1.34)

Appropriate test procedures required to validate the requirements of §2.2.5.1.34 were previously provided in §2.4.3.2.7.2.4.4.

2.4.5.1.35 Verification of the Radio Altitude Data (§2.2.5.1.35)

Appropriate test procedures required to validate the requirements of §2.2.5.1.35 were previously provided in §2.4.3.2.1.1.2.

2.4.5.1.36 Verification of the Version Number Data (§2.2.5.1.36)

Appropriate test procedures required to validate the requirements of §2.2.5.1.36 were previously provided in §2.4.3.2.7.2.5.

2.4.5.2 Unused Section

2.4.5.3 ADS-B Transmission Device Message Latency (§2.2.5.3)

No specific test procedure is required to validate the requirements of §2.2.5.3.

2.4.5.3.1 Verification of Airborne Position Message Latency (§2.2.5.3.1)

Purpose/Introduction:

This test verifies the latency of the Airborne Position Message.

Step 1: Airborne Position Message - "Type" Subfield (§2.2.3.2.3.1 and §2.2.5.3.1.a)

Purpose/Introduction:

Any change in the TYPE information identified in §2.2.3.2.3.1 **shall** be reflected in the TYPE subfield of the next scheduled Airborne Position message transmission provided that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Airborne Position message transmission.

Measurement Procedure:

Configure the ADS-B Transmitting System to transmit Airborne Position Messages by providing position information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set the ADS-B Transmitting System to Airborne status. Provide valid non zero barometric pressure altitude data to the ADS-B System. Continue transmitting Airborne Position Messages at the nominal rate with all parameters unchanged. Verify that the TYPE subfield in the Airborne Position Message correctly matches the TYPE subfield value from the navigational accuracy depicted in Table 2-11.

Change input to the ADS-B System so as to affect the TYPE subfield value so that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Airborne Position Message transmission. Verify that the TYPE subfield value has changed in the next transmitted Airborne Position Message and that it is the correct value.

Step 2: Airborne Position Message – "Surveillance Status" Subfield (§2.2.3.2.3.2 and §2.2.5.3.1.b)

Purpose/Introduction:

Any change in the Surveillance Status identified in §2.2.3.2.3.2 **shall** be reflected in the Surveillance Status subfield of the next scheduled Airborne Position message transmission provided that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Airborne Position message transmission.

Measurement Procedure:

Configure the ADS-B Transmitting System to transmit Airborne Position Messages by providing position information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set the ADS-B Transmitting System to Airborne status. Provide valid non zero barometric pressure altitude data to the ADS-B System. Continue transmitting Airborne Position Messages at the nominal rate with all parameters unchanged. Verify that the "Surveillance Status" subfield in the Airborne Position Message correctly matches the "Surveillance Status" subfield value from the code definitions depicted in Table 2-12.

Change input to the ADS-B System so as to affect the "Surveillance Status" subfield value so that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Airborne Position Message transmission. Verify that the "Surveillance Status" subfield value has changed in the next transmitted Airborne Position Message and that it is the correct value.

Step 3: Airborne Position Message – "Altitude" Subfield (§2.2.3.2.3.4 and §2.2.5.3.1.c)

Purpose/Introduction:

Any change in the Altitude identified in §2.2.3.2.3.4 **shall** be reflected in the Altitude subfield of the next scheduled Airborne Position message transmission provided that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Airborne Position message transmission.

Measurement Procedure:

Configure the ADS-B Transmitting System to transmit Airborne Position Messages by providing position information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set the ADS-B Transmitting System to Airborne status. Provide valid non zero barometric pressure altitude data to the ADS-B System. Continue transmitting Airborne Position Messages at the nominal rate with all parameters unchanged. Verify that the "Altitude" subfield in the Airborne Position Message is correct.

Change input to the ADS-B System so as to affect the "Altitude" subfield value so that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Airborne Position Message transmission. Verify that the "Altitude" subfield value has changed in the next transmitted Airborne Position Message and that it is the correct value.

Step 4: Airborne Position Message – "CPR Format" Subfield (§2.2.3.2.3.6 and §2.2.5.3.1.d)

Appropriate test procedures to verify §2.2.5.3.1.d are provided in §2.4.3.2.3.7.2 and §2.4.3.2.3.8.2.

Step 5: Airborne Position Message – "Encoded Latitude" Subfield (§2.2.3.2.3.7 and §2.2.5.3.1.e)

Appropriate test procedures to verify §2.2.5.3.1.e are provided in §2.4.3.2.3.7.2 and §2.4.3.2.3.8.2.

Step 6: Airborne Position Message – "Encoded Longitude" Subfield (§2.2.3.2.3.8 and §2.2.5.3.1.f)

Appropriate test procedures to verify §2.2.5.3.1.f are provided in §2.4.3.2.3.7.2 and §2.4.3.2.3.8.2.

2.4.5.3.2 Verification of Surface Position Message Latency (§2.2.5.3.2)

Purpose/Introduction:

This test verifies the latency of the Surface Position Message.

Step 1: Surface Position Message – "Type" Subfield" (§2.2.3.2.4.1 and §2.2.5.3.2.a)

Purpose/Introduction:

Any change in the TYPE information identified in §2.2.3.2.4.1 **shall** be reflected in the Type subfield of the next scheduled Surface Position message transmission provided that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Surface Position message transmission.

Measurement Procedure:

Configure the ADS-B Transmitting System to transmit Surface Position Messages by providing position information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set the ADS-B Transmitting System to Surface status. Continue transmitting Surface Position Messages at the nominal rate with all parameters unchanged. Verify that the TYPE subfield in the Surface Position Message correctly matches the TYPE subfield value from the navigational accuracy depicted in Table 2-11. for TYPE codes 5, 6, 7 and 8 only.

Change input to the ADS-B System so as to affect the TYPE subfield value so that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Surface Position Message transmission. Verify that the TYPE subfield value has changed in the next transmitted Surface Position Message and that it is the correct value.

Step 2: Surface Position Message – "Movement" Subfield (§2.2.3.2.4.2 and §2.2.5.3.2.b)

Purpose/Introduction:

Any change in Movement (i.e., Ground Speed) identified in §2.2.3.2.4.2 **shall** be reflected in the Movement subfield of the next scheduled Surface Position message transmission provided that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Surface Position message transmission.

Measurement Procedure:

Configure the ADS-B Transmitting System to transmit Surface Position Messages by providing position information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set the ADS-B Transmitting System to Surface status. Continue transmitting Surface Position Messages at the nominal rate with all parameters unchanged. Verify that the Movement subfield in the Surface Position Message correctly matches the Movement subfield value from the Movement subfield Code Definitions in Table 2-13.

Change input to the ADS-B System so as to affect the Movement subfield value so that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Surface Position Message transmission. Verify that the Movement subfield value has changed in the next transmitted Surface Position Message and that it is the correct value.

Step 3: Surface Position Message – "Ground Track" Subfield (§2.2.3.2.4.3, §2.2.3.2.4.4 and §2.2.5.3.2.c)

Purpose/Introduction:

Any change in Ground Track identified in §2.2.3.2.4.3 and §2.2.3.2.4.4 **shall** be reflected in the appropriate Ground Track subfields of the next scheduled Surface Position message transmission provided that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Surface Position message transmission.

Measurement Procedure:

Configure the ADS-B Transmitting System to transmit Surface Position Messages by providing position information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set the ADS-B Transmitting System to Surface status. Continue transmitting Surface Position Messages at the nominal rate with all parameters unchanged. Verify that the Ground Track subfields in the Surface Position Message correctly matches the Ground Track subfield values from the Tables 2-14 and 2-15 (§2.2.3.2.4.3 and §2.2.3.2.4.4).

Change input to the ADS-B System so as to affect the Ground Track subfield values so that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Surface Position Message transmission. Verify that the Ground Track subfield values have changed in the next transmitted Surface Position Message and that they contain the correct values.

Step 4: Surface Position Message – "CPR Format" Subfield (§2.2.3.2.4.6 and 2.2.5.3.2.d)

Appropriate test procedures to verify §2.2.5.3.2.d are provided in §2.4.3.2.3.7.2 and §2.4.3.2.3.8.2.

Step 5: Surface Position Message – "Encoded Latitude" Subfield (§2.2.3.2.4.7 and §2.2.5.3.2.e)

Appropriate test procedures to verify §2.2.5.3.2.e are provided in §2.4.3.2.3.7.2 and §2.4.3.2.3.8.2.

Step 6: Surface Position Message – "Encoded Longitude" Subfield (§2.2.3.2.4.8 and §2.2.5.3.2.f)

Appropriate test procedures to verify §2.2.5.3.2.f are provided in §2.4.3.2.3.7.2 and §2.4.3.2.3.8.2.

2.4.5.3.3 Verification of Aircraft Identification and Type Message Latency (§2.2.5.3.3)

Purpose/Introduction:

This test verifies the latency of the Aircraft Identification and Type Message.

Step 1: Aircraft Identification and Type Message – "Type" Subfield (§2.2.3.2.5.1 and §2.2.5.3.3.a)

Purpose/Introduction:

The TYPE information for the Aircraft Identification Message should be fixed and therefore not change. However, if changes are imposed, any such change in the TYPE information identified in §2.2.3.2.5.1 **shall** be reflected in the TYPE subfield of the Aircraft Identification Message once the data has been stable (i.e., no changes) for a period of 4 seconds.

Measurement Procedure:

Configure the ADS-B Transmitting System to transmit Aircraft Identification Messages by providing position information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Continue transmitting Aircraft Identification Messages at the nominal rate with all parameters unchanged.

Change input to the ADS-B System so as to force a change in the TYPE subfield value. Continue transmitting Aircraft Identification Messages at the nominal rate with all parameters unchanged for a minimum of 4 seconds. Verify that the Aircraft Identification Message accurately reflects the change in the TYPE subfield once the data has been unchanged for a period of 4 seconds.

Step 2: Aircraft Identification and Type Message – "Emitter Category" Subfield (§2.2.3.2.5.2 and §2.2.5.3.3.b)

Purpose/Introduction:

ADS-B Emitter Category information for the Aircraft Identification Message should be fixed and therefore not change. However, if changes are imposed, any such change in the ADS-B Emitter Category information identified in §2.2.3.2.5.2 **shall** be reflected in the ADS-B Emitter Category subfield of the Aircraft Identification Message once the data has been stable (i.e., no changes) for a period of 4 seconds.

Measurement Procedure:

Configure the ADS-B Transmitting System to transmit Aircraft Identification Messages by providing position information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Continue transmitting Aircraft Identification Messages at the nominal rate with all parameters unchanged.

Change input to the ADS-B System so as to force a change in the ADS-B Emitter Category subfield value. Continue transmitting Aircraft Identification Messages at the nominal rate with all parameters unchanged for a minimum of 4 seconds. Verify that the Aircraft Identification Message accurately reflects the change in the ADS-B Emitter Category subfield once the data has been unchanged for a period of 4 seconds.

Step 3: Aircraft Identification and Type Message – "Character" Subfields (§2.2.3.2.5.3 and §2.2.5.3.3.c)

Purpose/Introduction:

Any change in Character information identified in §2.2.3.2.5.3 **shall** be reflected in the appropriate Character subfields of the Aircraft Identification message once the data has been stable (i.e., no changes) for a period of 4 seconds.

Measurement Procedure:

Configure the ADS-B Transmitting System to transmit Aircraft Identification Messages by providing position information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Continue transmitting Aircraft Identification Messages at the nominal rate with all parameters unchanged.

Change input to the ADS-B System so as to force a change in the Character subfield value. Continue transmitting Aircraft Identification Messages at the nominal rate with all parameters unchanged for a minimum of 4 seconds. Verify that the Aircraft Identification Message accurately reflects the change in the Character subfield once the data has been unchanged for a period of 4 seconds.

2.4.5.3.4 Verification of Airborne Velocity – Subtype "1" Message Latency (§2.2.5.3.4, §2.2.3.2.6.1)

Purpose/Introduction:

The following Test Procedures **shall** be used to test Airborne Velocity – Subtype "1" Messages transmitted by Airborne ADS-B Transmitting Subsystems when Velocity Over Ground information is available, and the transmitting device is installed in an environment having NON-supersonic airspeed capabilities.

Any change in the data used to structure the subfields of the Airborne Velocity – Subtype "1" Messages **shall** be reflected in the affected subfield of the next scheduled Airborne Velocity – Subtype "1" Message, provided that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Airborne Velocity – Subtype "1" Message transmission.

Step 1: Airborne Velocity - Subtype "1" Message – "Type" Subfield (§2.2.3.2.6.1.1 and §2.2.5.3.4)

Measurement Procedure:

Configure the ADS-B Transmitting System to transmit Airborne Velocity – Subtype "1" Messages by providing subsonic velocity information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set the ADS-B Transmitting System to Airborne status. Provide valid non zero subsonic velocity data to the ADS-B System. Continue transmitting Airborne Velocity - Subtype "1" Messages at the nominal rate with all parameters unchanged. Verify that the TYPE subfield in the Airborne Velocity – Subtype "1" Message equals 19, which is the only TYPE value assigned to Airborne Velocity Messages.

Step 2: Airborne Velocity - Subtype "1" Message – "Subtype" Subfield (§2.2.3.2.6.1.2 and §2.2.5.3.4)

Measurement Procedure:

Continue transmitting Airborne Velocity - Subtype "1" Messages at the nominal rate with all parameters unchanged. Increase the velocity data input to the ADS-B System to a supersonic value so that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Airborne Velocity Message transmission. Verify that the Subtype subfield value has changed to Two "2" in the next transmitted Airborne Velocity Message.

Step 3: Airborne Velocity - Subtype "1" Message – "Intent Change Flag" Subfield (§2.2.3.2.6.1.3 and §2.2.5.3.4)

Measurement Procedure:

Continue transmitting Airborne Velocity - Subtype "1" Messages at the nominal rate with all parameters unchanged. Insert changed data to the ADS-B System to cause a change to occur in the Intent Change Flag so that it is detected at least 100 milliseconds prior to the next scheduled Airborne Velocity Message transmission. Verify that the Intent Change Flag subfield value has changed to ONE (1) in the next transmitted Airborne Velocity Message.

Step 4: Airborne Velocity - Subtype "1" Message – "IFR Capability Flag" Subfield (§2.2.3.2.6.1.4 and §2.2.5.3.4)

Repeat Step 3 above replacing the words "Intent Change Flag" with "IFR Capability Flag."

Step 5: Airborne Velocity - Subtype "1" Message – "NAC_V" Subfield (§2.2.3.2.6.1.5 and §2.2.5.3.4)

Continue transmitting Airborne Velocity - Subtype "1" Messages at the nominal rate with all parameters unchanged. Verify that the NAC_V value equals Zero (0). Insert changed data to the ADS-B System to cause a change to occur in the NAC_V value and so that the change is detected at least 100 milliseconds prior to the next scheduled Airborne Velocity Message transmission. Verify that the NAC_V subfield value has changed to the correct value in the next transmitted Airborne Velocity Message.

Step 6: Airborne Velocity - Subtype "1" Message – "East / West Direction Bit" Subfield (§2.2.3.2.6.1.6 and §2.2.5.3.4)

Measurement Procedure:

Continue transmitting Airborne Velocity - Subtype "1" Messages at the nominal rate with all parameters unchanged. Verify that the East/West Direction Bit equals Zero (0). Insert changed data to the ADS-B System to cause a change to occur in the East/West Direction Bit so that the direction will become "West" and so that the change is detected at least 100 milliseconds prior to the next scheduled Airborne Velocity Message transmission. Verify that the East/West Direction Bit subfield value has changed to ONE (1) in the next transmitted Airborne Velocity Message.

Step 7: Airborne Velocity - Subtype "1" Message – "East / West Velocity" Subfield (§2.2.3.2.6.1.7 and §2.2.5.3.4)

Measurement Procedure:

Configure the ADS-B Transmitting System to transmit Airborne Velocity – Subtype "1" Messages by providing subsonic velocity information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set the ADS-B Transmitting System to Airborne status. Provide valid non zero subsonic East/West velocity data to the ADS-B System. Continue transmitting Airborne Velocity - Subtype "1" Messages at the nominal rate with all parameters unchanged.

Insert changed data to the ADS-B System to cause a change to occur in the East/West Velocity so that it is detected at least 100 milliseconds prior to the next scheduled Airborne Velocity Message transmission. Verify that the East/West Velocity subfield value has changed in the next transmitted Airborne Velocity Message and that the value in the subfield is correct.

Step 8: Airborne Velocity - Subtype "1" Message – "North / South Direction Bit" Subfield (§2.2.3.2.6.1.8 and §2.2.5.3.4)

Repeat the tests in Step 6 above changing the word "East" to "North" and the word "West" to "South."

Step 9: Airborne Velocity - Subtype "1" – "North / South Velocity" Subfield (§2.2.3.2.6.1.9 and §2.2.5.3.4)

Repeat the tests in Step 7 above changing the words "East/West" to "North/South."

Step 10: Airborne Velocity - Subtype "1" – "Vertical Rate Source Bit" Subfield (§2.2.3.2.6.1.10 and §2.2.5.3.4)

Measurement Procedure:

a. Continue transmitting Airborne Velocity - Subtype "1" Messages at the nominal rate with all parameters unchanged. Verify that the Source Bit for Vertical Rate equals Zero (0), indicating receipt of Vertical Rate information from a Geometric Source. Insert changed data to the ADS-B System to cause a change to occur in the Source Bit for Vertical Rate so that the Vertical Rate information will come from a Barometric Source, and so that the change is detected at least 100 milliseconds prior to the next scheduled Airborne Velocity Message transmission. Verify that the Source Bit for Vertical Rate subfield value has changed to ONE (1) in the next transmitted Airborne Velocity Message.

b. Continue transmitting Airborne Velocity – Subtype "1" Messages at the nominal rate with all parameters unchanged and verify that the Source Bit for Vertical Rate contains the value ONE (1). Continue transmitting Airborne Velocity - Subtype "1" Messages at the nominal rate with all parameters unchanged. Insert changed data to the ADS-B System to cause a change to occur in the Source Bit for Vertical Rate so that the Vertical rate information will come from a Geometric Source, and so that the change is detected at least 100 milliseconds prior to the next scheduled Airborne Velocity Message transmission. Verify that the Source Bit for Vertical Rate subfield value has changed to ZERO (0) in the next transmitted Airborne Velocity Message.

Step 11: Airborne Velocity - Subtype "1" Message – "Vertical Rate Sign Bit" Subfield (§2.2.3.2.6.1.11 and §2.2.5.3.4)

Measurement Procedure:

a. Continue transmitting Airborne Velocity - Subtype "1" Messages at the nominal rate with all parameters unchanged. Verify that the Vertical Rate Sign Bit equals Zero (0), indicating Vertical Rate information in the UP Direction. Insert changed data to the ADS-B System to cause a change to occur in the Vertical Rate Sign Bit so that the Vertical Direction information will be DOWN, and so that the change is detected at least 100 milliseconds prior to the next scheduled Airborne Velocity Message transmission. Verify that the Vertical Rate Sign Bit subfield value has changed to ONE (1) in the next transmitted Airborne Velocity Message.

b. Continue transmitting Airborne Velocity – Subtype "1" Messages at the nominal rate with all parameters unchanged and verify that the Vertical Rate Sign Bit contains the value ONE (1). Continue transmitting Airborne Velocity - Subtype "1" Messages at the nominal rate with all parameters unchanged. Insert changed data to the ADS-B System to cause a change to occur in the Vertical Rate Sign Bit so that the Vertical Direction information will be UP, and so that the change is detected at least 100 milliseconds prior to the next scheduled Airborne Velocity Message transmission. Verify that the Vertical Rate Sign Bit subfield value has changed to ZERO (0) in the next transmitted Airborne Velocity Message.

Step 12: Airborne Velocity - Subtype “1” Message – “Vertical Rate” Subfield (§2.2.3.2.6.1.12 and §2.2.5.3.4)

Measurement Procedure:

Configure the ADS-B Transmitting System to transmit Airborne Velocity – Subtype “1” Messages by providing subsonic velocity information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set the ADS-B Transmitting System to Airborne status. Provide valid non zero Vertical Rate data to the ADS-B System. Continue transmitting Airborne Velocity - Subtype “1” Messages at the nominal rate with all parameters unchanged.

Insert changed data to the ADS-B System to cause a change to occur in the Vertical Rate so that it is detected at least 100 milliseconds prior to the next scheduled Airborne Velocity Message transmission. Verify that the Vertical Rate subfield value has changed in the next transmitted Airborne Velocity Message and that the value in the subfield is correct.

Step 13: Airborne Velocity - Subtype “1” Message – “Turn Indicator” Subfield (§2.2.3.2.6.1.13 and §2.2.5.3.4)

With regard to the specifications currently outlined by the above referenced subparagraph, the TURN INDICATOR will be set to a coding of ZERO (0) until further modifications are made to the specification. Therefore, no testing of the latency of this subfield is required until further specifications are implemented.

Step 14: Airborne Velocity - Subtype “1” Message – “Difference From Barometric Altitude Sign Bit” Subfield (§2.2.3.2.6.1.14 and §2.2.5.3.4)

Measurement Procedure:

a. Continue transmitting Airborne Velocity - Subtype “1” Messages at the nominal rate with all parameters unchanged. Verify that the Geometric Altitude Source data is greater than (above) the Barometric. Verify that the Difference From Barometric Altitude Sign Bit equals Zero (0). Insert changed data to the ADS-B System to cause a change to occur in the Difference From Barometric Altitude Sign Bit so that the Geometric Altitude Source Data is less than (below) Barometric, and so that the change is detected at least 100 milliseconds prior to the next scheduled Airborne Velocity Message transmission. Verify that the Difference From Barometric Altitude Sign Bit subfield value has changed to ONE (1) in the next transmitted Airborne Velocity Message.

b. Continue transmitting Airborne Velocity – Subtype “1” Messages at the nominal rate with all parameters unchanged and verify that the Difference

From Barometric Altitude Sign Bit contains the value ONE (1). Continue transmitting Airborne Velocity - Subtype "1" Messages at the nominal rate with all parameters unchanged. Insert changed data to the ADS-B System to cause a change to occur in the Difference From Barometric Altitude Sign Bit so that the Geometric Altitude Source data is greater than (above) the Barometric, and so that the change is detected at least 100 milliseconds prior to the next scheduled Airborne Velocity Message transmission. Verify that the Difference From Barometric Altitude Sign Bit subfield value has changed to ZERO (0) in the next transmitted Airborne Velocity Message.

Step 15: Airborne Velocity - Subtype "1" Message – "Difference From Barometric Altitude" Subfield (§2.2.3.2.6.1.15 and §2.2.5.3.4)

Measurement Procedure:

Configure the ADS-B Transmitting System to transmit Airborne Velocity – Subtype "1" Messages by providing subsonic velocity information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set the ADS-B Transmitting System to Airborne status. Provide valid Geometric Altitude Source data and Barometric Altitude data. Continue transmitting Airborne Velocity - Subtype "1" Messages at the nominal rate with all parameters unchanged.

Insert changed data to the ADS-B System to cause a change to occur in the Difference From Barometric Altitude so that it is detected at least 100 milliseconds prior to the next scheduled Airborne Velocity Message transmission. Verify that the Difference From Barometric Altitude subfield value has changed in the next transmitted Airborne Velocity Message and that the value in the subfield is correct.

2.4.5.3.5 Verification of Airborne Velocity – Subtype "2" Message Latency (§2.2.3.2.6.2, §2.2.5.3.5)

Purpose/Introduction:

The following Test Procedures **shall** be used to test Airborne Velocity – Subtype "2" Messages transmitted by Airborne ADS-B Transmitting Subsystems when Velocity Over Ground information is available, and the transmitting device is installed in an environment having Supersonic airspeed capabilities.

Measurement Procedure:

Repeat all tests in §2.4.5.3.4 Steps 1 through 15 changing all occurrences of 'Subtype "1"' to 'Subtype "2"' and all occurrences of "subsonic" to "supersonic" and vice versa.

2.4.5.3.6 Verification of Airborne Velocity – Subtype "3" Message Latency (§2.2.3.2.6.3, §2.2.5.3.6)

Purpose/Introduction:

The following Test Procedures **shall** be used to test Airborne Velocity – Subtype "3" Messages transmitted by Airborne ADS-B Transmitting Subsystems when Velocity Over Ground information is NOT available, and the transmitting device is installed in an environment having NON-supersonic airspeed capabilities.

Measurement Procedure:

Step 1: Airborne Velocity - Subtype "3" Message – "Type" Subfield (§2.2.3.2.6.3.1 and §2.2.5.3.6)

Repeat the test outlined in §2.4.5.3.4, Step 1 for the TYPE subfield changing all occurrences of 'Subtype "1"' to 'Subtype "3"'.

Step 2: Airborne Velocity - Subtype "3" Message – "Subtype" Subfield (§2.2.3.2.6.3.2 and §2.2.5.3.6)

Repeat the test outlined in §2.4.5.3.4, Step 2 for the SUBTYPE subfield changing all occurrences of 'Subtype "1"' to 'Subtype "3"'.

Step 3: Airborne Velocity - Subtype "3" Message – "Intent Change Flag" Subfield (§2.2.3.2.6.3.3 and §2.2.5.3.6)

Repeat the test outlined in §2.4.5.3.4, Step 3 for the INTENT CHANGE FLAG subfield changing all occurrences of 'Subtype "1"' to 'Subtype "3"'.

Step 4: Airborne Velocity - Subtype "3" Message – "IFR Capability Flag" Subfield (§2.2.3.2.6.3.4 and §2.2.5.3.6)

Repeat the test outlined in §2.4.5.3.4, Step 4 for the IFR Capability Flag subfield changing all occurrences of 'Subtype "1"' to 'Subtype "3"'.

Step 5: Airborne Velocity - Subtype "3" Message – "NAC_V" Subfield (§2.2.3.2.6.3.5 and §2.2.5.3.6)

Repeat the test outlined in §2.4.5.3.4, Step 5 for the NAC_V subfield changing all occurrences of 'Subtype "1"' to 'Subtype "3"'.

Step 6: Airborne Velocity - Subtype "3" Message – "Magnetic Heading Status" Subfield (§2.2.3.2.6.3.6 and §2.2.5.3.6)

Measurement Procedure:

a. Continue transmitting Airborne Velocity - Subtype "3" Messages at the nominal rate with all parameters unchanged. Verify that the Magnetic Heading Status Bit equals Zero (0), indicating that Magnetic Heading Data is available. Insert changed data to the ADS-B System to indicate that Magnetic Heading Data is NOT available, and so that the change is detected at least 100 milliseconds prior to the next scheduled Airborne Velocity Message transmission. Verify that the Magnetic Heading Status Bit subfield value has changed to ONE (1) in the next transmitted Airborne Velocity Message.

b. Continue transmitting Airborne Velocity – Subtype "3" Messages at the nominal rate with all parameters unchanged and verify that the Magnetic Heading Status Bit contains the value ONE (1). Continue transmitting Airborne Velocity - Subtype "3" Messages at the nominal rate with all parameters unchanged. Insert changed data to the ADS-B System to indicate that Magnetic Heading Data IS available, and so that the change is detected at least 100 milliseconds prior to the next scheduled Airborne Velocity Message transmission. Verify that the Magnetic Heading Status Bit subfield value has changed to ZERO (0) in the next transmitted Airborne Velocity Message.

Step 7: Airborne Velocity - Subtype "3" Message – "Magnetic Heading" Subfield (§2.2.3.2.6.3.7 and §2.2.5.3.6)

Measurement Procedure:

Configure the ADS-B Transmitting System to transmit Airborne Velocity – Subtype "3" Messages by providing subsonic velocity information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set the ADS-B Transmitting System to Airborne status. Provide valid Magnetic Heading data. Continue transmitting Airborne Velocity - Subtype "3" Messages at the nominal rate with all parameters unchanged.

Insert changed data to the ADS-B System to cause a change to occur in the Magnetic Heading so that it is detected at least 100 milliseconds prior to the next scheduled Airborne Velocity Message transmission. Verify that the Magnetic Heading subfield value has changed in the next transmitted Airborne Velocity Message and that the value in the subfield is correct.

Step 8: Airborne Velocity - Subtype "3" – "Airspeed Type" Subfield (§2.2.3.2.6.3.8 and §2.2.5.3.6)

Measurement Procedure:

a. Continue transmitting Airborne Velocity - Subtype "3" Messages at the nominal rate with all parameters unchanged. Verify that the Airspeed Type equals Zero (0), indicating that the Airspeed Type is "Indicated Airspeed" (IAS). Insert changed data to the ADS-B System to indicate that Airspeed Type has changed to True Airspeed (TAS), and so that the change is detected at least 100 milliseconds prior to the next scheduled Airborne Velocity Message transmission. Verify that the Airspeed Type subfield value has changed to ONE (1) in the next transmitted Airborne Velocity Message.

b. Continue transmitting Airborne Velocity – Subtype "3" Messages at the nominal rate with all parameters unchanged and verify that the Airspeed Type contains the value ONE (1). Continue transmitting Airborne Velocity - Subtype "3" Messages at the nominal rate with all parameters unchanged.

Insert changed data to the ADS-B System to indicate that the Airspeed Type has changed to Indicated Airspeed, and so that the change is detected at least 100 milliseconds prior to the next scheduled Airborne Velocity Message transmission. Verify that the Airspeed Type subfield value has changed to ZERO (0) in the next transmitted Airborne Velocity Message.

Step 9: Airborne Velocity - Subtype "3" Message – "Airspeed" Subfield (§2.2.3.2.6.3.9 and §2.2.5.3.6)

Measurement Procedure:

Configure the ADS-B Transmitting System to transmit Airborne Velocity – Subtype "3" Messages by providing subsonic velocity information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set the ADS-B Transmitting System to Airborne status. Provide valid Airspeed data. Continue transmitting Airborne Velocity - Subtype "3" Messages at the nominal rate with all parameters unchanged.

Insert changed data to the ADS-B System to cause a change to occur in the Airspeed so that it is detected at least 100 milliseconds prior to the next scheduled Airborne Velocity Message transmission. Verify that the Airspeed subfield value has changed in the next transmitted Airborne Velocity Message and that the value in the subfield is correct.

Step 10: Airborne Velocity - Subtype "3" – "Vertical Rate Source" Subfield (§2.2.3.2.6.3.10 and §2.2.5.3.6)

Repeat the test outlined in §2.4.5.3.4, Step 10 for the Source Bit For Vertical Rate subfield changing all occurrences of 'Subtype "1"' to 'Subtype "3"'.

Step 11: Airborne Velocity - Subtype "3" – "Vertical Rate Sign Bit" Subfield (§2.2.3.2.6.3.11 and §2.2.5.3.6)

Repeat the test outlined in §2.4.5.3.4, Step 11 for the Sign Bit For Vertical Rate subfield changing all occurrences of 'Subtype "1"' to 'Subtype "3"'.

Step 12: Airborne Velocity - Subtype "3" – "Vertical Rate" Subfield (§2.2.3.2.6.3.12 and §2.2.5.3.6)

Repeat the test outlined in §2.4.5.3.4, Step 12 for the Vertical Rate subfield changing all occurrences of 'Subtype "1"' to 'Subtype "3"'.

Step 13: Airborne Velocity - Subtype "3" – "Turn Indicator" Subfield (§2.2.3.2.6.3.13 and §2.2.5.3.6)

Repeat the test outlined in §2.4.5.3.4, Step 13 for the Turn Indicator subfield changing all occurrences of 'Subtype "1"' to 'Subtype "3"'.

Step 14: Airborne Velocity - Subtype "3" – "Difference From Barometric Altitude Sign Bit" Subfield (§2.2.3.2.6.1.14 and §2.2.5.3.6)

Repeat the test outlined in §2.4.5.3.4, Step 14 for the Difference From Barometric Altitude Sign Bit subfield changing all occurrences of 'Subtype "1"' to 'Subtype "3"'.

Step 15: Airborne Velocity - Subtype "3" – "Difference From Barometric Altitude" Subfield (§2.2.3.2.6.3.15 and §2.2.5.3.6)

Repeat the test outlined in §2.4.5.3.4, Step 15 for the Difference From Barometric Altitude subfield changing all occurrences of 'Subtype "1"' to 'Subtype "3"'.

2.4.5.3.7 Verification of Airborne Velocity – Subtype "4" Message Latency (§2.2.3.2.6.4, §2.2.5.3.7)

Purpose/Introduction:

The following Test Procedures **shall** be used to test Airborne Velocity – Subtype "4" Messages transmitted by Airborne ADS-B Transmitting Subsystems when Velocity Over Ground information is NOT available, and the transmitting device is installed in an environment having supersonic airspeed capabilities.

Measurement Procedure:

Repeat all tests in §2.4.5.3.6 Steps 1 through 15 changing all occurrences of 'Subtype "3"' to 'Subtype "4"' and all occurrences of "subsonic" to "supersonic" and vice versa.

2.4.5.3.8 Verification of Airborne Velocity – Subtype "5" Message Latency (§2.2.5.3.8)

RESERVED FOR FUTURE APPLICATION

No specific test procedure is required to validate §2.2.5.3.8.

2.4.5.3.9 Verification of Airborne Velocity – Subtype "6" Message Latency (§2.2.5.3.9)

RESERVED FOR FUTURE APPLICATION

No specific test procedure is required to validate §2.2.5.3.9.

2.4.5.3.10 Verification of Airborne Velocity – Subtype "7" Message Latency (§2.2.5.3.10)

RESERVED FOR FUTURE APPLICATION

No specific test procedure is required to validate §2.2.5.3.10.

2.4.5.3.11 Verification of Aircraft Trajectory Intent and System Status Message Latency (§2.2.3.2.7.1, §2.2.5.3.11)

Purpose/Introduction:

Any change in the data used to structure the subfields of the Aircraft Trajectory Intent and System Status (ATISS) Message **shall** be reflected in the affected subfield of the next scheduled Aircraft Trajectory Intent Message provided that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Aircraft Trajectory Intent and System Status Message transmission.

Measurement Procedure:

Step 1: ATISS – "Type" Subfield (§2.2.3.2.7.1.1 and §2.2.5.3.11)

Configure the ADS-B Transmitting System to transmit ATISS Messages by providing valid trajectory information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set the ADS-B Transmitting System to Airborne status. Verify that the TYPE subfield in the ATISS Message equals 29, which is the only TYPE value assigned to ATISS Messages.

Step 2: TBD

2.4.5.3.12 Verification of Aircraft Operational Status Message Latency (§2.2.3.2.7.2, §2.2.5.3.12)

Purpose/Introduction:

Any change in the data used to structure the subfields of the Aircraft Operational Status message **shall** be reflected in the affected subfield of the next scheduled Aircraft Operational Status message provided that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Aircraft Operational Status message transmission:

Measurement Procedure:

Step 1: Aircraft Operational Status Message - "Type" Subfield (§2.2.3.2.7.2.1 and §2.2.5.3.12)

No specific test procedure is required to validate §2.2.5.3.12.a.1.

Step 2: Aircraft Operational Status Message - "Subtype" Subfield (§2.2.3.2.7.2.2 and §2.2.5.3.12)

No specific test procedure is required to validate s§2.2.5.3.12.a.2.

Step 3: Aircraft Operational Status Message - "Capability Class, CC" Subfield (§2.2.3.2.7.2.3 and §2.2.5.3.12)

a. Capability Class Code for "Reserved for Service Level" (§2.2.3.2.7.2.3.1)

TBD

b. Capability Class Code for "~TCAS" (§2.2.3.2.7.2.3.2)

TBD

c. Capability Class Code for "CDTI Traffic Display Capability" (§2.2.3.2.7.2.3.3)

TBD

d. Capability Class Code for "ARV Report Capability" (§2.2.3.2.7.2.3.4)

TBD

e. Capability Class Code for "TS Report Capability" (§2.2.3.2.7.2.3.5)

TBD

f. Capability Class Code for "TC Report Capability" (§2.2.3.2.7.2.3.6)

TBD

g. Capability Class Code for "Position Offset Applied (POA)" (§2.2.3.2.7.2.3.7)

TBD

Step 4: Aircraft Operational Status Message - "Operational Mode, OM" Subfield (§2.2.3.2.7.2.4 and §2.2.5.3.12)

a. Operational Mode Code for the OM Format (§2.2.3.2.7.2.4.1)

TBD

b. Operational Mode Code for "TCAS/ACAS Resolution Advisory Active" (§2.2.3.2.7.2.4.2)

TBD

c. Operational Mode Code for "IDENT Switch Active" (§2.2.3.2.7.2.4.3)

TBD

d. Operational Mode Code for "Receiving ATC Services" (§2.2.3.2.7.2.4.4)

TBD

2.4.5.3.13 Verification of Test Event-Driven Message Latency (§2.2.5.3.13)

Purpose/Introduction:

The ADS-B Transmission Device Message Processor **shall** process Vendor Specified data for ADS-B Test messages defined in §2.2.3.2.7.3 with any change in data being reflected in the next scheduled Test - Event Driven message provided that the change occurs and is detected at least 100 milliseconds prior to the next scheduled Test - Event Driven message transmission.

Measurement Procedure:

Step 1: Test Event Driven Message – “Type” Subfield (§2.2.3.2.7.3)

Configure the ADS-B Transmitting System to transmit Test Event Driven Messages by providing valid information at the nominal update rate. Provide the data externally at the interface to the ADS-B system. Set the ADS-B Transmitting System to Airborne status. Verify that the TYPE subfield in the Test Event Driven Message equals 23, which is the only TYPE value assigned to Test Event Driven Messages.

Step 2: Test Event Driven Message (§2.2.3.2.7.3)

Continue transmitting Test Event Driven Messages at the nominal rate with all parameters unchanged. Insert changed data to the ADS-B System to cause a change to occur in the Test Event Driven Message so that it is detected at least 100 milliseconds prior to the next scheduled Test Event Driven Message transmission. Verify that the Test Event Driven subfield value has changed as expected in the next transmitted Test Event Driven Message.

2.4.5.3.14 Verification of Type 24 Event-Driven Message Latency (§2.2.5.3.14)

RESERVED FOR FUTURE APPLICATION

No specific test procedure is required to validate §2.2.5.3.14.

2.4.5.3.15 Verification of Type 25 Event-Driven Message Latency (§2.2.5.3.15)

RESERVED FOR FUTURE APPLICATION

No specific test procedure is required to validate §2.2.5.3.15.

2.4.5.3.16 Verification of Type 26 Event-Driven Message Latency (§2.2.5.3.16)

RESERVED FOR FUTURE APPLICATION

No specific test procedure is required to validate §2.2.5.3.16.

2.4.5.3.17 Verification of Type 27 Event-Driven Message Latency (§2.2.5.3.17)

RESERVED FOR FUTURE APPLICATION

No specific test procedure is required to validate §2.2.5.3.17.

2.4.6 Verification of ADS-B Receiving Device Message Processor Characteristics (§2.2.6)

No specific test procedure is required to validate §2.2.6.

2.4.6.1 Verification of ADS-B Message Reception Function Requirements (§2.2.6.1)

The procedures provided in §2.4.6.1.2 **shall** be used to validate performance of §2.4.6.1.

2.4.6.1.1 Verification of ADS-B Message Reception Function Output Message Structure Requirements (§2.2.6.1.1)

The procedures provided in §2.4.6.1.2 **shall** be used to validate performance of §2.4.6.1.1.

2.4.6.1.2 Verification of ADS-B Message Reception Function Output Message Delivery Requirements (§2.2.6.1.2)

Purpose/Introduction:

The following Test Procedures **shall** be used to demonstrate that the ADS-B Receiver Function properly receives and decodes all valid ADS-B transmitted messages and delivers the messages to the user interface or to the Report Assembly function.

Measurement Procedure:

Step 1: ADS-B Message ONLY Reception (§2.2.6.1, §2.2.6.1.1)

Provide the ADS-B Receiver under test with MODE-S messages having random data but appropriate "AP" or "PI" fields for the downlink formats DF=0, DF=4, DF=5, DF=11, DF=16, DF=17, DF=18, DF=20, DF=21 and DF=24.

Verify that the ADS-B Receiver DOES NOT generate Output Messages for all of the downlink formats received with the exception of DF=17 and DF=18.

Verify that the ADS-B Receiver delivers appropriate Output Messages to the user interface or to the Report Assembly function for each DF=17 and DF=18 message received and that the Output Message formats are consistent with the requirements of §2.2.6.1.1.

Step 2: ADS-B Message Reception (§2.2.6.1, §2.2.6.1.1)

Provide the ADS-B Receiver under test with the ADS-B Messages listed in Table 2-115 in the following manner:

a. The messages **shall** be provided sequentially as listed in Table 2-115 in a burst of 17 messages where

b. The first preamble pulse of each message is separated from the first preamble pulse of the previous message by not more than 8.0 microseconds, and

c. The burst **shall** be repeated at least four times with the beginning of each burst being separated from the end of the last burst by not more than 2.0 milliseconds.

Table 2-115: ADS-B Message Reception

ADS-B MESSAGE RECEPTION					
BIT #	1 ---- 5	6 - 8	9 --------- 32	33 ----------------------------------- 88	89 ----------------------- 112
CASE No.	**DF [5]**	**CA (CF) [3]**	**AA [24] (HEX)**	**ME [56] (HEX)**	**PI [24] (HEX)**
1	1 0001	000	AA AA AA	AA AA AA AA AA AA AA	**See Note**
2	1 0001	001	55 55 55	55 55 55 55 55 55 55	
3	1 0001	010	77 77 77	77 77 77 77 77 77 77	
4	1 0001	011	BB BB BB	BB BB BB BB BB BB BB	
5	1 0001	100	DD DD DD	DD DD DD DD DD DD DD	
6	1 0001	101	EE EE EE	EE EE EE EE EE EE EE	
7	1 0001	110	AA AA AA	AA AA AA AA AA AA AA	
8	1 0001	111	55 55 55	55 55 55 55 55 55 55	
9	1 0010	000	AA AA AA	AA AA AA AA AA AA AA	
10	1 0010	000	55 55 55	55 55 55 55 55 55 55	
11	1 0010	001	77 77 77	77 77 77 77 77 77 77	
12	1 0010	010	BB BB BB	BB BB BB BB BB BB BB	
13	1 0010	011	DD DD DD	DD DD DD DD DD DD DD	
14	1 0010	100	EE EE EE	EE EE EE EE EE EE EE	
15	1 0010	101	AA AA AA	AA AA AA AA AA AA AA	
16	1 0010	110	55 55 55	55 55 55 55 55 55 55	
17	1 0010	111	AA AA AA	AA AA AA AA AA AA AA	

Note: *The "PI" subfield of the Message must be properly generated in accordance with §2.2.3.2.1.1.6.*

Verify that each message provided to the ADS-B Receiver results in an Output Message that is delivered to the user interface or Report Assembly function in not more than 2.0 milliseconds after receipt of the last message bit of each message. Verify that the Output Message format for each message is consistent with the requirements of §2.2.6.1.1 and represent the data provided in the message as defined in Table 2-115.

2.4.7 Verification of the ADS-B Message Processor Characteristics (§2.2.7)

No specific test procedure is required to validate §2.2.7.

2.4.7.1 Verification of the ADS-B Receiving Device Message Reception (§2.2.7.1)

Appropriate test procedures to validate the requirements of this section are provided in §2.4.8.1, §2.4.8.2, §2.4.8.3, all subsections inclusive.

2.4.7.1.1 Verification of the Receipt of Type Code Equal to ZERO (§2.2.7.1.1)

Purpose/Introduction:

An ADS-B Message containing Type Code ZERO can only be used to update the altitude data of an aircraft that is already being tracked by the entity receiving the altitude data in Type ZERO ADS-B Message.

If an ADS-B Message with Type Code equal to ZERO is received, it should be checked to see if altitude data is present and then process the altitude data as follows:

a. If altitude data is not present, the message **shall** be discarded.

b. If altitude data is present, it may be used to update altitude as needed.

Measurement Procedure:

Appropriate test procedures to validate the requirements of this section are provided in §2.4.10.4.1.3.

2.4.8 Verification of the ADS-B Report Characteristics (§2.2.8)

Appropriate test procedures required to validate the requirements of §2.2.8 are included in the following subparagraphs.

2.4.8.1 Verification of the ADS-B State Vector Report Characteristics (§2.2.8.1)

No specific test procedure is required to validate §2.2.8.1.

2.4.8.1.1 Verification of the State Vector Report Type and Structure Identification and Validity Flags (§2.2.8.1.1)

No specific test procedure is required to validate §2.2.8.1.1.

2.4.8.1.1.1 Verification of the State Vector Report Type and Structure Identification (§2.2.8.1.1.1)

Purpose/Introduction:

The Report Type is used to identify the type of ADS-B Report being generated by the report generation function and being provided to the User Application. The Report Type is a 4-bit field and **shall** be provided in the most significant nibble (i.e., bits 7 - 4) of the first byte (i.e., byte “0”) of the Report. The Report Type formats and maximum number of bytes to be contained in each report are identified in Table 2.2.8.1.1.1a.

The Report Structure field is used to indicate the exact data parameters identified in Table 2.2.8.1 that are being provided in the State Vector report and is intended to provide a methodology for the report processor to structure shorter reports when data for some parameters, or groups of parameters, are not available. In order to provide the capability to provide shorter State Vector reports the following basic conventions **shall** be adhered to:

a. Any given data parameter to be used in the report **shall** use the designated number of bytes and format as designated in Table 2.2.8.1.

b. Whenever a data parameter identified in Table 2.2.8.1, or a required grouping of data parameters as identified in Table 2.2.8.1.1.1b, is not provided in the report, then it is permissible to concatenate the next parameter to be included into the report immediately following the inclusion of the previous reported parameter. This feature **shall** be used to accommodate the reporting of the different sets of required parameters, such as for when the aircraft is in the airborne condition versus on the airport surface as indicated in Table 2.2.8.1.

c. Each parameter of the State Vector report identified in Table 2.2.8.1 **shall** be properly declared in the Report Structure field as detailed in the following paragraphs and Table 2.2.8.1.1.1b.

The Report Structure is a 20-bit field and **shall** be provided in the least significant nibble (i.e., bits 3 - 0) of the first byte (i.e., byte "0") and continuing into bytes 1 and 2 of the Report. The Report Structure format is defined in Table 2.2.8.1.1.1b where each bit is associated with a particular data parameter, or group of data parameters, of the State Vector Report. If the bit is set to "1," then the data parameter, or group of identified data parameters, is considered to be available and **shall** be transmitted in the report. Otherwise, the data parameter, or group of identified data parameters, is considered to not be available and **shall** not be transmitted in the report. Note that Table 2.2.8.1.1.1b does not address the Report Type and Structure Identification parameter, the Validity Flags parameter, nor the Participant Address parameter and the Address Qualifier, **since it is mandatory that these four parameters shall be included in the State Vector Report. Also, certain of the other State Vector data parameters are required to be reported, as defined in §2.2.9, even though bits have been allocated in the report structure field as shown in Table 2.2.8.1.1.1b.**

Measurement Procedure:

For each case in Table 2-116 below, execute Step 1 followed by Step 2.

Step 1: Verification of Report Structure Bit Function (§2.2.8.1.1.1.a-c)

Generate a Test Message Type (column 1), which includes the encoded data representing any valid case of the corresponding Parameter Datum (column 2), command the ADS-B Receiver/Report Assembly to output State Vector Reports of Type 0001, and set to "ONE" the corresponding Structure Coding Bit (column 3).

Verify that the Structure Coding Bit, and the Validity Flag Bit (if specified in column 4), for the corresponding Parameter Datum, are "ONEs."

Verify that the Binary Decoded Parameter Datum appears in it's proper position in the Report (column 5), and in the proper binary format as defined in Table 2.2.8.1 (§2.2.8.1).

Step 2: Verification of Report Structure Bit Function (§2.2.8.1.1.1.a-c)

Repeat Step 1 while implementing the following changes:

Set the Structure Coding Bit, and the Validity Flag, to "ZERO."

Verify that the Structure Coding Bit, and the Validity Flag Bit, are both "ZEROs."

Verify that the Binary Decoded Parameter Datum no longer appears in the Report.

Table 2-116: Report Structure Identification Bit Test Data

REPORT STRUCTURE IDENTIFICATION BIT CODING							
Column 1	**Column 2**	**Column 3**		**Column 4**		**Column 5**	
		State Vector Report Test Fields					
Test Message Type	**Parameter Data Type**	**Structure Coding**		**Validity Flag**		**Parameter Reported In**	
		Byte	**Bit**	**Byte**	**Bit**	**Bytes**	**#Bits**
Airborne Position	Latitude (WGS-84)	0	3	4	7	9-11	24
Airborne Position	Longitude (WGS-84)	0	2	4	7	12-14	24
Airborne Position	Altitude, Geometric (WGS-84)	0	1	4	6	15-17	24
Airborne Position	NUC_P	0	0	N/A	N/A	18	4
Airborne Velocity - Type 1	NAC_V	1	7	N/A	N/A	19	4
Airborne Position	Geometric Position Valid (Horizontal)	1	6	N/A	N/A	4	1
Airborne Position	Geometric Position Valid (Vertical)	1	5	N/A	N/A	4	1
Airborne Velocity - Type 1	North / South Velocity	1	4	4	5	20-21	16
Airborne Velocity - Type 1	East / West Velocity	1	3	4	5	22-23	16
Airborne Velocity - Type 1	Vertical Rate, Geometric (WGS-84)	1	2	4	4	24-25	16
Airborne Position	Altitude, Barometric (Pressure)	1	1	4	3	26-28	24
Airborne Velocity - Type 1	Barometric Altitude Rate	1	0	4	2	29-30	16
Airborne Velocity - Type 3	True Airspeed (TAS)	2	7	4	1	31-32	16
Airborne Velocity - Type 3	Indicated Airspeed (IAS)	2	6	4	1	33-34	16
Surface Position	Movement (i.e., Ground Speed)	2	5	4	0	35	8
Surface Position	Ground Track	2	4	5	7	36	8
Airborne Velocity - Type 3	Magnetic Heading	2	3	5	6	37-38	16
Airborne Velocity - Type 1	Turn Indication	2	2	N/A	N/A	39	8
Airborne Position	Position Time of Applicability	2	1	N/A	N/A	40-41	16
Airborne Velocity - Type 1	Velocity Time of Applicability	2	0	N/A	N/A	42-43	16
Airborne Position	Estimated Latitude (WGS-84)	3	7	5	5	44-46	24
Airborne Position	Estimated Longitude (WGS-84)	3	6	5	5	47-49	24
Airborne Velocity - Type 1	Estimated North / South Velocity	3	5	5	4	50-51	16
Airborne Velocity - Type 1	Estimated East / West Velocity	3	4	5	4	52-53	16
Airborne Position & Airborne Velocity	Surveillance Status / Discretes (for Report Formatting see §2.2.8.1.21)	3	3	N/A	N/A	54 54	4 4
Airborne Position	Report Time of Applicability	3	2	N/A	N/A	55-56	16
Any Message Type	Report Mode	3	1	N/A	N/A	57	4
Not Applicable	**Reserved For Future Expansion**	3	0	N/A	N/A	N/A	N/A

2.4.8.1.1.2 Verification of State Vector Report Validity Flags Reporting (§2.2.8.1.1.2)

Appropriate test procedures provided in §2.4.8.1.5 through §2.4.8.1.20 **shall** be used to validate the reporting of validity flags.

2.4.8.1.2 Verification of the Participant Address (§2.2.8.1.2)

Appropriate test procedures to validate the Participant Address (§2.2.3.2.1.1.1) are included in the verification of the "PI" field in §2.4.3.2.1.1.6.

2.4.8.1.3 Verification of the Address Qualifier (§2.2.8.1.3)

Purpose/Introduction:

The Address Qualifier subfield **shall** be coded as shown in Table 2.2.8.1.3.

Measurement Procedure:

TBD

2.4.8.1.4 Verification of the Report Time of Applicability

Appropriate test procedures required to validate the requirements of §2.2.8.1.4 are included in the following subparagraphs.

2.4.8.1.4.1 Verification of the Time of Applicability for Estimated Position/Velocity (§2.2.8.1.4.1)

Purpose/Introduction:

The Time of Applicability for the estimated position and velocity **shall** be generated under the conditions defined below:

a. Each time that an individual State Vector Report is updated as specified in §2.2.8.1.17, §2.2.8.1.18, §2.2.8.1.19, ***OR*** §2.2.8.1.20, the Report Assembly Function **shall** update the Time of Applicability for the Estimate Position/Velocity data in the State Vector Report with either the GPS/GNSS UTC Measure Time data (§2.2.8.4.1) or the Established Receiver Unit Time (§2.2.8.4.2), whichever is applicable to the Receiving device Report Assembly Function installation requirements.

b. Time of Applicability data **shall** be provided in the State Vector report in binary format as defined in Table 2.2.8.1.4**.**

Measurement Procedure:

TBD

2.4.8.1.4.2 Verification of the Position Time of Applicability (§2.2.8.1.4.2)

Purpose/Introduction:

Each time that an Airborne or Surface Position message is received with valid Latitude ***AND*** Longitude data, the Report Assembly Function **shall** update the Position Time of Applicability data in the State Vector Report with either the GPS/GNSS UTC Measure Time data (see §2.2.8.4.1) or the Established Receiver Unit Time (see §2.2.8.4.2), whichever is applicable to the Receiving device Report Assembly Function installation requirements.

Measurement Procedure:

Step 1: Position Time of Applicability Updating and Reporting (resulting from received Airborne Position Messages) Reporting

Within a ten (10) second period, generate a series of "**even**" and "**odd**" Airborne Position Messages having a stable TYPE code which include encoded data ("ME" Bits 23 - 39 for Latitude, and Bits 40 - 56 for Longitude) for both valid Latitude and valid Longitude based on any convenient starting position. Verify that the Report Assembly Function outputs a State Vector Report with the Report Mode set to ONE (binary xxxx 0001) within 500 milliseconds of receipt of the second Airborne Position Message of the "**even**" and "**odd**" pair for the given Airborne Participant.

Verify that the corresponding Position Time of Applicability presence bit (Report Byte #2, Bit 1), and the Latitude and Longitude validity flag (Report Byte #4, Bit 7), are "ONEs."

Verify that the reported Binary Decoded Position Time of Applicability datum (Report Bytes # 40 - 41) changes by less than 500 ms between reports. Table 2.4.8.1.4.2 below shows an example of a possible time progression from a series of reports.

Table 2.4.8.1.4.2: Position Time of Applicability Example Test Data

POSITION TIME OF APPLICABILITY	
Example Time (seconds)	**Binary Decoded Position Time of Applicability**
Reference Time	0101 0101 0101 0110
Reference Time + Approximately 0.5	0101 0101 1001 0010
Reference Time + Approximately 1.0	0101 0101 1101 0111
Reference Time + Approximately 1.5	0101 0110 0001 0110
Reference Time + Approximately 2.0	0101 0110 0101 0011

Step 2: Position Time of Applicability Updating and Reporting (resulting from received Surface Position Messages) Reporting

Within a ten (10) second period, generate a series of "**even**" and "**odd**" Surface Position Messages having a stable TYPE code which include encoded data ("ME" Bits 23 - 39 for Latitude, and Bits 40 - 56 for Longitude) for both valid Latitude and valid Longitude based on any convenient starting position, and which include encoded data ("ME" Bits 6 - 12) for a Ground Speed (Movement) of 2 knots (forces "High" rate of two Surface Position Messages per second). Verify that the Report Assembly Function outputs a State Vector Report with the Report Mode set to TWO (binary xxxx 0010) within 500 milliseconds of receipt of the second Surface Position Message of the "**even**" and "**odd**" pair for the given Surface Participant.

Verify that the corresponding Position Time of Applicability presence bit (Report Byte #2, Bit 1), and the Latitude and Longitude validity flag (Report Byte #4, Bit 7), are "ONEs."

Verify that the reported Binary Decoded Position Time of Applicability datum changes by less than 500 ms between reports. Table 2.4.8.1.4.2 above shows an example of a possible time progression from a series of reports.

2.4.8.1.4.3 Verification of the Velocity Time of Applicability (§2.2.8.1.4.3)

<u>Purpose/Introduction:</u>

a. Each time that an Airborne Velocity Subtype "1" or "2" message is received with valid East / West ***AND*** North / South Velocity data, the Report Assembly Function **shall** update the Velocity Time of Applicability data in the State Vector Report with either the GPS/GNSS UTC Measure Time data (see §2.2.8.4.1) or the Established Receiver Unit Time (see §2.2.8.4.2), whichever is applicable to the Receiving device Report Assembly Function installation requirements.

b. Each time that a Surface Position Message is received with valid Movement ***AND*** Ground Track data, the Report Assembly Function **shall** update the Velocity Time of Applicability data in the State Vector Report with either the GPS/GNSS UTC Measure Time data (see §2.2.8.4.1) or the Established Receiver Unit Time (see §2.2.8.4.2), whichever is applicable to the Receiving device Report Assembly Function installation requirements.

<u>Measurement Procedure:</u>

<u>Step 1:</u> <u>Velocity Time of Applicability Updating and Reporting (resulting from received Airborne Velocity Messages, Subtype 1) Reporting</u>

Repeat Step 1 of §2.4.8.1.4.2 and verify that the Report Assembly Function outputs a State Vector Report with the Report Mode set to ONE (binary xxxx 0001). Generate an Airborne Velocity Message ("Type" code of 19, Subtype 1), which includes encoded data ("ME" Bits 14 - 24 for E/W Velocity, and "ME" Bits 25 - 35 for N/S Velocity) based on any convenient valid velocity. Verify that the Report Assembly Function outputs a State Vector Report with the Report Mode set to TWO (binary xxxx 0010) within 500 milliseconds of the receipt of the Airborne Velocity Information Message.

Verify that the corresponding Velocity Time of Applicability presence bit (Report Byte #2, Bit 0), and the N/S & E/W Velocity validity flag (Report Byte #4, Bit 5), are set to "ONEs."

Verify that the reported Binary Decoded Velocity Time of Applicability datum (Report Bytes # 42 - 43) changes by less than 500 ms between reports. Table 2.4.8.1.4.3 below shows an example of a possible time progression from a series of reports.

Table 2.4.8.1.4.3: Velocity Time of Applicability Example Test Data

VELOCITY TIME OF APPLICABILITY	
Example Time (seconds)	**Binary Decoded Velocity Time of Applicability**
Reference Time	0101 0101 0101 0110
Reference Time + Approximately 0.5	0101 0101 1001 0010
Reference Time + Approximately 1.0	0101 0101 1101 0111
Reference Time + Approximately 1.5	0101 0110 0001 0110
Reference Time + Approximately 2.0	0101 0110 0101 0011

Step 2: Velocity Time of Applicability Updating and Reporting (resulting from received Surface Position Messages)

Repeat Step 2 of §2.4.8.1.4.2 and verify that the Report Assembly Function outputs a State Vector Report with the Report Mode set to TWO (binary xxxx 0010). Generate a series of "**even**" and "**odd**" Surface Position Messages having a stable TYPE code, which include encoded data ("ME" Bits 6 - 12) for a Ground Speed (Movement) of 2 knots (forces "High" rate of two Surface Position Messages per second), which include a Ground Track Status ("ME" Bit 13) of "ONE," and which include encoded data ("ME" Bits 14 - 20) for any convenient Ground Track heading.

Verify that the corresponding Velocity Time of Applicability presence bit (Report Byte #2, Bit 0), Ground Speed validity flag (Report Byte #4, Bit 0), and Ground Track validity flag (Report Byte #5, Bit 7), are set to "ONEs."

Verify that the reported Binary Decoded Velocity Time of Applicability datum changes by less than 500 ms between reports. Table 2.4.8.1.4.3 above shows an example of a possible time progression from a series of reports.

2.4.8.1.5 Verification of Latitude (WGS-84) Reporting (§2.2.8.1.5)

Purpose/Introduction:

a. The ADS-B Report Assembly Function **shall** decode the Encoded Latitude data (§2.2.3.2.3.7 and /or §2.2.3.2.4.7) provided in the ADS-B broadcast. Decoding of the encoded latitude data **shall** be performed in accordance with §A.1.7.4 through §A.1.7.8.4 of Appendix A. Latitude data **shall** be provided to the user application in the State Vector report in angular weighted binary format (M bit = 90 degrees, S bit = negative, or 180 degrees) as defined in Table 2.2.8.1.

b. When valid encoded latitude data is not available, the latitude data provided to the user application **shall** be set to ALL ZEROs, and the Horizontal Position Validity Flag bit, i.e., bit #7 (MSB) of byte #3 of the State Vector Report, **shall** be set to “0” to indicate that the reported Horizontal Position data is not valid.

Otherwise, the Horizontal Position Validity Flag bit, i.e., bit #7 (MSB) of byte #3 of the State Vector Report, **shall** be set to “1,” unless modified by other conditions.

Measurement Procedure:

Step 1: Latitude (WGS-84) Decoding

For each case in Table 2-118 below, generate valid Airborne Position Messages that include the encoded data (“ME” Bits 23 - 39) for the Decimal Latitude value listed, and verify that the ADS-B Receiver/Report Assembly outputs State Vector Report of Type 0001.

Verify that the corresponding Latitude presence bit (Report Byte #0, Bit 0), and the Horizontal Position Validity flag (Report Byte #3, Bit 7), are “ONEs.”

Verify that the reported Binary Decoded (WGS-84) Latitude datum match the corresponding value in the table.

Table 2-117: Longitude Test Data

LONGITUDE		
Decimal Longitude (degrees)	**Integer Longitude (degrees)**	**Binary Decoded (WGS-84) Longitude (angular weighted)**
0.000000	0	0000 0000 0000 0000 0000 0000
0.000021	1	0000 0000 0000 0000 0000 0001
0.000043	2	0000 0000 0000 0000 0000 0010
0.000107	5	0000 0000 0000 0000 0000 0101
0.000215	10	0000 0000 0000 0000 0000 1010
0.000429	20	0000 0000 0000 0000 0001 0100
0.000880	41	0000 0000 0000 0000 0010 1001
0.001760	82	0000 0000 0000 0000 0101 0010
0.003541	165	0000 0000 0000 0000 1010 0101
0.007081	330	0000 0000 0000 0001 0100 1010
0.014162	660	0000 0000 0000 0010 1001 0100
0.028324	1320	0000 0000 0000 0101 0010 1000
0.056648	2640	0000 0000 0000 1010 0101 0000
0.113297	5280	0000 0000 0001 0100 1010 0000
0.226593	10560	0000 0000 0010 1001 0100 0000
0.453186	21120	0000 0000 0101 0010 1000 0000
0.906372	42240	0000 0000 1010 0101 0000 0000
1.812744	84480	0000 0001 0100 1010 0000 0000
3.625488	168960	0000 0010 1001 0100 0000 0000
7.250977	337920	0000 0101 0010 1000 0000 0000
14.501953	675840	0000 1010 0101 0000 0000 0000
29.003906	1351680	0001 0100 1010 0000 0000 0000
58.007813	2703360	0010 1001 0100 0000 0000 0000
116.015625	5406720	0101 0010 1000 0000 0000 0000
-127.968750	10813440	1010 0101 0000 0000 0000 0000
104.062500	4849664	0100 1010 0000 0000 0000 0000
-151.875000	9699328	1001 0100 0000 0000 0000 0000
56.250000	2621440	0010 1000 0000 0000 0000 0000
112.500000	5242880	0101 0000 0000 0000 0000 0000
-135.000000	10485760	1010 0000 0000 0000 0000 0000
90.000000	4194304	0100 0000 0000 0000 0000 0000
180.000000	8388608	1000 0000 0000 0000 0000 0000

Step 2: Longitude (WGS-84) Decoding

For each case in Table 2-117 above, generate valid Airborne Position Messages that include the encoded data (“ME” Bits 40 - 56) for the Decimal Longitude value listed, and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding Longitude presence bit (Report Byte #0, Bit 0), and the Horizontal Position Validity flag (Report Byte #3, Bit 7), are “ONEs.”

Verify that the reported Binary Decoded (WGS-84) Longitude datum match the corresponding value in the table.

Table 2-118: Latitude Test Data

LATITUDE		
Decimal Latitude (degrees)	**Integer Latitude (degrees)**	**Binary Decoded (WGS-84) Latitude (angular weighted)**
0.000000	0	0000 0000 0000 0000 0000 0000
0.000037	1	0000 0000 0000 0000 0000 0001
0.000073	3	0000 0000 0000 0000 0000 0011
0.000147	6	0000 0000 0000 0000 0000 0110
0.000294	13	0000 0000 0000 0000 0000 1101
0.000587	27	0000 0000 0000 0000 0001 1011
0.001175	54	0000 0000 0000 0000 0011 0110
0.002350	109	0000 0000 0000 0000 0110 1101
0.004699	219	0000 0000 0000 0000 1101 1011
0.009398	438	0000 0000 0000 0001 1011 0110
0.018797	876	0000 0000 0000 0011 0110 1100
0.037594	1752	0000 0000 0000 0110 1101 1000
0.075188	3504	0000 0000 0000 1101 1011 0000
0.150375	7008	0000 0000 0001 1011 0110 0000
0.300751	14016	0000 0000 0011 0110 1100 0000
0.601501	28032	0000 0000 0110 1101 1000 0000
1.203003	56064	0000 0000 1101 1011 0000 0000
2.406006	112128	0000 0001 1011 0110 0000 0000
4.812012	224256	0000 0011 0110 1100 0000 0000
9.624023	448512	0000 0110 1101 1000 0000 0000
19.248047	897024	0000 1101 1011 0000 0000 0000
38.496094	1794048	0001 1011 0110 0000 0000 0000
76.992188	3588096	0011 0110 1100 0000 0000 0000
-52.031250	14352384	1101 1011 0000 0000 0000 0000
-56.250000	14155776	1101 1000 0000 0000 0000 0000
-90.000000	12582912	1100 0000 0000 0000 0000 0000

Step 3: Latitude and Longitude Data Not Available

Keep the Latitude and Longitude presence bits at "ONE," and set the Horizontal Position Validity flag to "ZERO."

Verify that the reported Binary Decoded Latitude and Longitude data are set to all "ZEROs."

2.4.8.1.6 Verification of Longitude (WGS-84) Reporting (§2.2.8.1.6)

Appropriate test procedures to validate the requirements of §2.2.8.1.6 are provided in §2.4.8.1.7.

2.4.8.1.7 Verification of Altitude, Geometric (WGS-84) Reporting (§2.2.8.1.7)

Purpose/Introduction:

a. When Geometric Altitude Data is indicated by the "TYPE" subfield (§2.2.3.2.3.1) the ADS-B Report Assembly Function **shall** decode Altitude Data (§2.2.3.2.3.4) that has been encoded by the ADS-B transmission device as specified in §2.2.3.2.3.4.2.

b. Alternatively, Barometric Altitude Data (§2.2.3.2.3.4.1), Difference from Barometric Altitude Sign Bit (§2.2.3.2.6.1.14, §2.2.3.2.6.2.14, §2.2.3.2.6.3.14 or §2.2.3.2.6.4.14), and Difference from Barometric Altitude (§2.2.3.2.6.1.15, §2.2.3.2.6.2.15, §2.2.3.2.6.3.15 or §2.2.3.2.6.4.15), **shall** be decoded and the Geometric Altitude computed by the receiver Report Assembly Function.

c. Geometric Binary Altitude data **shall** be provided to the user application in the State Vector report in binary format as defined in Table 2.2.8.1. This format represents a true two's complement format where the MSB has a weight of 65,536 and the LSB has a weight of 0.015625. The maximum range of the data is then given by +/- [2*MSB - LSB] or +/- 131,071.984375.

d. When valid Geometric Altitude data is not available, the ADS-B receiver **shall** set the Geometric Altitude data provided to the user interface to ALL ZEROs, and the Geometric Altitude Validity Flag bit, i.e., bit #6 of byte #3 of the State Vector Report (§2.2.8.1.1.2), **shall** be set to "0" to indicate that the reported Geometric Altitude is not valid.

   Otherwise, the Geometric Altitude Validity Flag bit, i.e., bit #6 of byte #3 of the State Vector Report, **shall** be set to "1," unless modified by other conditions.

Measurement Procedure:

Step 1: Geometric Altitude (WGS-84) Reporting for "Q" Bit ="ONE" (§2.2.8.1.7.a & .c)

For each case in Table 2-119 below, generate valid Airborne Position Messages, with "Type" codes of 20 through 22, which include the encoded datum ("ME" Bits 9 - 20) for the Decimal Altitude value listed, with an imbedded "**Q**" bit ("ME" Bit 16) of "ONE," and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding Geometric Altitude presence bit (Report Byte #1, Bit 7), and Geometric Altitude Validity Flag (Report Byte #3, Bit 6), are "ONEs."

Verify that the reported Binary Decoded (WGS-84) Geometric Altitude datum (Report Bytes # 15 - 17) matches the corresponding value in the table.

Table 2-119: Geometric Altitude Test Data (Q Bit = One)

GEOMETRIC (WGS-84) ALTITUDE ("Q" Bit = "ONE")		
Decimal Altitude (feet)	**Integer Altitude (binary)**	**Binary Decoded (WGS-84) Geometric Altitude**
-1000	-8000	1111 1111 1110 0000 1100 0000
-975	-7800	1111 1111 1110 0001 1000 1000
-925	-7400	1111 1111 1110 0011 0001 1000
-825	-6600	1111 1111 1110 0110 0011 1000
-625	-5000	1111 1111 1110 1100 0111 1000
-575	-4600	1111 1111 1110 1110 0000 1000
-500	-4000	1111 1111 1111 0000 0110 0000
-225	-1800	1111 1111 1111 1000 1111 1000
-200	-1600	1111 1111 1111 1001 1100 0000
-125	-1000	1111 1111 1111 1100 0001 1000
-25	-200	1111 1111 1111 1111 0011 1000
0	0	0000 0000 0000 0000 0000 0000
25	200	0000 0000 0000 0000 1100 1000
50	400	0000 0000 0000 0001 1001 0000
100	800	0000 0000 0000 0011 0010 0000
200	1600	0000 0000 0000 0110 0100 0000
400	3200	0000 0000 0000 1100 1000 0000
800	6400	0000 0000 0001 1001 0000 0000
1600	12800	0000 0000 0011 0010 0000 0000
3200	25600	0000 0000 0110 0100 0000 0000
6400	51200	0000 0000 1100 1000 0000 0000
12800	102400	0000 0001 1001 0000 0000 0000
25600	204800	0000 0011 0010 0000 0000 0000
49175	393400	0000 0110 0000 0000 1011 1000
49200	393600	0000 0110 0000 0001 1000 0000
50175	401400	0000 0110 0001 1111 1111 1000

Step 2: Geometric Altitude (WGS-84) Reporting for "**Q**" Bit ="ZERO" (§2.2.8.1.7.a &.c)

For each case in Table 2-120 below, generate valid Airborne Position Messages, with "Type" codes of 20 through 22, which include the encoded datum ("ME" Bits 9 - 20) for the Decimal Altitude value listed, with an imbedded "**Q**" bit ("ME" Bit 16) of "ZERO," and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding Geometric Altitude presence bit (Report Byte #1, Bit 7), and Geometric Altitude Validity Flag (Report Byte #3, Bit 6), are set to "ONEs."

Verify that the reported Binary Decoded (WGS-84) Geometric Altitude datum (Report Bytes # 15 - 17) matches the corresponding value in the table.

Table 2-120: Geometric Altitude Test Data (Q Bit = Zero)

GEOMETRIC (WGS-84) ALTITUDE (“Q” Bit = “ZERO”)		
Decimal Altitude (feet)	**Integer Altitude (binary)**	**Binary Decoded (WGS-84) Geometric Altitude**
-1000	-8000	1111 1111 1110 0000 1100 0000
-800	-6400	1111 1111 1110 0111 0000 0000
-100	-800	1111 1111 1111 1100 1110 0000
0	0	0000 0000 0000 0000 0000 0000
100	800	0000 0000 0000 0011 0010 0000
200	1600	0000 0000 0000 0110 0100 0000
400	3200	0000 0000 0000 1100 1000 0000
800	6400	0000 0000 0001 1001 0000 0000
1600	12800	0000 0000 0011 0010 0000 0000
3200	25600	0000 0000 0110 0100 0000 0000
6400	51200	0000 0000 1100 1000 0000 0000
12800	102400	0000 0001 1001 0000 0000 0000
25600	204800	0000 0011 0010 0000 0000 0000
51200	409600	0000 0110 0100 0000 0000 0000
102400	819200	0000 1100 1000 0000 0000 0000
126700	1013600	0000 1111 0111 0111 0110 0000

Step 3: Barometric Altitude (WGS-84) Reporting for “Q” Bit =“ONE” (§2.2.8.1.7.b &.c)

For each case in Table 2-119 above**,** generate valid Airborne Position Messages, with “Type” codes of 9 through 18, which include the encoded datum (“ME” Bits 9 - 20) for the Decimal Altitude value listed, with an imbedded “**Q**” bit (“ME” Bit 16) of “ONE,” and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding Barometric Altitude presence bit (Report Byte #1, Bit 7), and Geometric Altitude Validity Flag (Report Byte #3, Bit 6), are “ONEs.”

Verify that the reported Binary Decoded (WGS-84) Barometric Altitude datum (Report Bytes # 15 - 17) matches the corresponding value in the table.

Step 4: Barometric Altitude (WGS-84) Reporting for “**Q**” Bit = “ZERO” (§2.2.8.1.7.b&c)

For each case in Table 2-120 above**,** generate valid Airborne Position Messages, with “Type” codes of 9 through 18, which include the encoded datum (“ME” Bits 9 - 20) for the Decimal Altitude value listed, with an imbedded “**Q**” bit (“ME” Bit 16) of “ZERO,” and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding Barometric Altitude presence bit (Report Byte #1, Bit 7), and Geometric Altitude Validity Flag (Report Byte #3, Bit 6), are “ONEs.”

Verify that the reported Binary Decoded (WGS-84) Barometric Altitude datum (Report Bytes # 15 - 17) matches the corresponding value in the table.

Step 5: Difference from Barometric Altitude Reporting (§2.2.8.1.7.b)

For each case in Table 2-121 below, generate valid Airborne Velocity Messages, with "Type" code of 19, and with Subtype 1, which includes the encoded data (Difference from Barometric Altitude Sign, "ME" bit 49, and Difference from Barometric Altitude, "ME" Bits 50 - 56) resulting from using the Decimal GNSS Altitude and Decimal Barometric Altitude values listed, and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding Difference From Barometric Altitude presence bit (Report Byte #1, Bit 7), and Geometric Altitude Validity Flag (Report Byte #3, Bit 6), are "ONEs."

Verify that the reported Binary Decoded (WGS-84) Difference from Barometric Altitude datum matches the corresponding value in the table.

Repeat this procedure for Velocity Message Subtypes 2, 3 and 4.

Table 2-121: Difference From Barometric Altitude (w/ Sign) Test Data

DIFFERENCE FROM BAROMETRIC ALTITUDE			
Decimal GNSS Altitude (feet)	**Decimal Barometric Altitude (feet)**	**Decimal Difference (feet)**	**Binary Decoded (WGS-84) Difference from Barometric**
100	3250	-3150	1111 1111 1001 1101 1001 0000
100	1700	-1600	1111 1111 1100 1110 0000 0000
100	900	-800	1111 1111 1110 0111 0000 0000
100	500	-400	1111 1111 1111 0011 1000 0000
100	300	-200	1111 1111 1111 1001 1100 0000
100	200	-100	1111 1111 1111 1100 1110 0000
100	150	-50	1111 1111 1111 1110 0111 0000
100	125	-25	1111 1111 1111 1111 0011 1000
100	100	0	0000 0000 0000 0000 0000 0000
125	100	25	0000 0000 0000 0000 1100 1000
150	100	50	0000 0000 0000 0001 1001 0000
200	100	100	0000 0000 0000 0011 0010 0000
300	100	200	0000 0000 0000 0110 0100 0000
500	100	400	0000 0000 0000 1100 1000 0000
900	100	800	0000 0000 0001 1001 0000 0000
1700	100	1600	0000 0000 0011 0010 0000 0000
3250	100	3150	0000 0000 0110 0010 0111 0000

Step 6: Geometric Altitude Data Not Available (§2.2.8.1.7.d)

Keep the Geometric Altitude presence bit at "ONE," and set the Geometric Altitude Validity Flag to "ZERO."

Verify that the reported Binary Decoded Geometric Altitude data (Report Bytes # 15 - 17) is set to all "ZEROs."

2.4.8.1.8 Verification of North / South Velocity (Subsonic) Reporting (§2.2.8.1.8)

Purpose/Introduction:

a. The ADS-B Report Assembly Function **shall** extract the North / South Direction Bit (§2.2.3.2.6.1.8 or §2.2.3.2.6.2.8) and the North / South Velocity subfield (§2.2.3.2.6.1.9 or §2.2.3.2.6.2.9) from the ADS-B Message and provide North / South Velocity information to the user Application in the State Vector report in binary format as defined in Table 2.2.8.1. This format represents a true two's complement format where the MSB has a weight of 2,048 and the LSB has a weight of 0.125. The maximum range of the data is then given by +/- [2*MSB - LSB] or +/- 4,095.875.

b. When valid North / South Velocity data is not available, the North / South Velocity data provided to the user application **shall** be set to ALL ZEROs, and the Airborne Horizontal Validity Flag bit, i.e., bit #5 of byte #3 of the State Vector Report (§2.2.8.1.1.2), **shall** be set to "0" to indicate that the reported Airborne Horizontal Velocity is not valid.

   Otherwise, the Airborne Horizontal Velocity Validity Flag bit, i.e., bit #5 of byte #3 of the State Vector Report, **shall** be set to "1," unless modified by other conditions.

Measurement Procedure:

Step 1: North / South Velocity (Subsonic) Reporting (§2.2.8.1.8.a)

For each case in Table 2-124 below, generate valid Airborne Velocity Messages (Subtype 1, Subsonic) which include the encoded Direction Bit and Velocity data ("ME" Bits 25 - 35 for North / South and Bits 14 - 24 for East / West) for the Decimal North / South and Decimal East / West Velocity values listed, and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding North / South Velocity presence bit (Report Byte #1, Bit 6), and Airborne Horizontal Velocity Validity Flag (Report Byte #3, Bit 5), are "ONEs."

Verify that the reported Binary Decoded North / South Velocity datum (Report Bytes # 20 - 21) matches the corresponding Binary North / South Velocity value in the table.

Table 2-124: North / South Velocity (Subsonic) Test Data

NORTH / SOUTH VELOCITY (SUBSONIC)		
North/South Decimal Velocity (knots)	**East/West Decimal Velocity (knots)**	**Binary Decoded North / South Subsonic Velocity**
-1021	0	1110 0000 0001 1000
-512	0	1111 0000 0000 0000
-256	0	1111 1000 0000 0000
-128	0	1111 1100 0000 0000
-64	0	1111 1110 0000 0000
-32	0	1111 1111 0000 0000
-16	0	1111 1111 1000 0000
-8	0	1111 1111 1100 0000
-4	0	1111 1111 1110 0000
-2	0	1111 1111 1111 0000
-1	0	1111 1111 1111 1000
0	0	0000 0000 0000 0000
1	0	0000 0000 0000 1000
2	0	0000 0000 0001 0000
4	0	0000 0000 0010 0000
8	0	0000 0000 0100 0000
16	0	0000 0000 1000 0000
32	0	0000 0001 0000 0000
64	0	0000 0010 0000 0000
128	0	0000 0100 0000 0000
256	0	0000 1000 0000 0000
512	0	0001 0000 0000 0000
1021	0	0001 1111 1110 1000

Step 2: North / South Velocity (Supersonic) Reporting (§2.2.8.1.8.a)

For each case in Table 2-125 below, generate valid Airborne Velocity Messages (Subtype 2, Supersonic) which include the encoded Direction Bit and Velocity data (“ME” Bits 25 - 35 for North / South and Bits 14 - 24 for East / West) for the Decimal North / South and Decimal East / West values listed, and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding North / South Velocity presence bit (Report Byte #1, Bit 6), and the Airborne Horizontal Velocity Validity Flag (Report Byte #3, Bit 5), are “ONEs.”

Verify that the reported Binary Decoded North / South Velocity datum matches the corresponding Binary North / South Velocity value in the table.

Table 2-125: North / South Velocity (Supersonic) Test Data

NORTH / SOUTH VELOCITY (SUPERSONIC)		
North/South Decimal Velocity (knots)	**East/West Decimal Velocity (knots)**	**Binary Decoded North / South Supersonic Velocity**
-4084	0	1000 0000 0110 0000
-2048	0	1100 0000 0000 0000
-1024	0	1110 0000 0000 0000
-512	0	1111 0000 0000 0000
-256	0	1111 1000 0000 0000
-128	0	1111 1100 0000 0000
-64	0	1111 1110 0000 0000
-32	0	1111 1111 0000 0000
-16	0	1111 1111 1000 0000
-8	0	1111 1111 1100 0000
-4	0	1111 1111 1110 0000
0	0	0000 0000 0000 0000
4	0	0000 0000 0010 0000
8	0	0000 0000 0100 0000
16	0	0000 0000 1000 0000
32	0	0000 0001 0000 0000
64	0	0000 0010 0000 0000
128	0	0000 0100 0000 0000
256	0	0000 1000 0000 0000
512	0	0001 0000 0000 0000
1024	0	0010 0000 0000 0000
2048	0	0100 0000 0000 0000
4084	0	0111 1111 1010 0000

Step 3: North / South Velocity (Subsonic / Supersonic) Data Not Available (§2.2.8.1.8.b)

Keep the North / South Velocity presence bit at "ONE," and set the North / South Velocity validity flag to "ZERO."

Verify that the reported Binary Decoded North / South Velocity datum is set to all "ZEROs."

2.4.8.1.9 Verification of East / West Velocity Reporting (§2.2.8.1.9)

Purpose/Introduction:

a. The ADS-B Report Assembly Function **shall** extract the East / West Direction Bit (§2.2.3.2.6.1.6, or §2.2.3.2.6.2.6) and the East / West Velocity subfield (§2.2.3.2.6.1.7 or §2.2.3.2.6.2.7) from the ADS-B Message and provide East / West Velocity information to the user application in the State Vector report in binary format as defined in Table 2.2.8.1. This format represents a true two's complement format where the MSB has a weight of 2,048 and the LSB has a weight of 0.125. The maximum range of the data is then given by +/- [2*MSB - LSB] or +/- 4,095.875.

b. When valid East / West Velocity data is not available, the East / West Velocity data provided to the user application **shall** be set to ALL ZEROs, and the Airborne Horizontal Velocity Validity Flag bit, i.e., bit # 5 of byte #3 of the State Vector Report (§2.2.8.1.1.2), **shall** be set to "0"to indicate that the reported Airborne Horizontal Velocity is not valid.

   Otherwise, the Airborne Horizontal Velocity Validity Flag bit, i.e., bit #5 of byte #3 of the State Vector Report, **shall** be set to "1," unless modified by other conditions.

Measurement Procedure:

Step 1: East / West Velocity (Subsonic) Reporting (§2.2.8.1.9.a)

For each case in Table 2-126 below, generate valid Airborne Velocity Messages (Subtype 1, Subsonic) which include the encoded Direction Bit and Velocity data ("ME" Bits 25 - 35 for North / South and Bits 14 - 24 for East / West) for the Decimal North / South and Decimal East / West Velocity values listed, and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding East / West Velocity presence bit (Report Byte #1, Bit 6), and the Airborne Horizontal Velocity Validity Flag (Report Byte #3, Bit #5), are "ONEs."

Verify that the reported Binary Decoded East / West Velocity datum (Report Bytes # 22 - 23) matches the corresponding Binary East / West Velocity value in the table.

Table 2-126: East / West Velocity (Subsonic) Test Data

EAST / WEST VELOCITY (SUBSONIC)		
North/South Decimal Velocity (knots)	**East/West Decimal Velocity (knots)**	**Binary Decoded East / West Subsonic Velocity**
0	-1021	1110 0000 0001 1000
0	-512	1111 0000 0000 0000
0	-256	1111 1000 0000 0000
0	-128	1111 1100 0000 0000
0	-64	1111 1110 0000 0000
0	-32	1111 1111 0000 0000
0	-16	1111 1111 1000 0000
0	-8	1111 1111 1100 0000
0	-4	1111 1111 1110 0000
0	-2	1111 1111 1111 0000
0	-1	1111 1111 1111 1000
0	0	0000 0000 0000 0000
0	1	0000 0000 0000 1000
0	2	0000 0000 0001 0000
0	4	0000 0000 0010 0000
0	8	0000 0000 0100 0000
0	16	0000 0000 1000 0000
0	32	0000 0001 0000 0000
0	64	0000 0010 0000 0000
0	128	0000 0100 0000 0000
0	256	0000 1000 0000 0000
0	512	0001 0000 0000 0000
0	1021	0001 1111 1110 1000

Step 2: East / West Velocity (Supersonic) Reporting (§2.2.8.1.9.a)

For each case in Table 2-127 below, generate valid Airborne Velocity Messages (Subtype 2, Supersonic) which include the encoded Direction Bit and Velocity data (“ME” Bits 25 - 35 for North / South and Bits 14 - 24 for East / West) for the Decimal North / South and Decimal East / West values listed, and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding East / West Velocity presence bit (Report Byte #1, Bit #6), and the Airborne Horizontal Velocity Validity Flag (Report Byte #3, Bit #5), are “ONEs.”

Verify that the reported Binary Decoded North / South Velocity datum matches the corresponding Binary East / West Velocity value in the table.

Table 2-127: East / West Velocity (Supersonic) Test Data

EAST / WEST VELOCITY (SUPERSONIC)		
North/South Decimal Velocity (knots)	**East/West Decimal Velocity (knots)**	**Binary Decoded East / West Supersonic Velocity**
0	-4084	1000 0000 0110 0000
0	-2048	1100 0000 0000 0000
0	-1024	1110 0000 0000 0000
0	-512	1111 0000 0000 0000
0	-256	1111 1000 0000 0000
0	-128	1111 1100 0000 0000
0	-64	1111 1110 0000 0000
0	-32	1111 1111 0000 0000
0	-16	1111 1111 1000 0000
0	-8	1111 1111 1100 0000
0	-4	1111 1111 1110 0000
0	0	0000 0000 0000 0000
0	4	0000 0000 0010 0000
0	8	0000 0000 0100 0000
0	16	0000 0000 1000 0000
0	32	0000 0001 0000 0000
0	64	0000 0010 0000 0000
0	128	0000 0100 0000 0000
0	256	0000 1000 0000 0000
0	512	0001 0000 0000 0000
0	1024	0010 0000 0000 0000
0	2048	0100 0000 0000 0000
0	4084	0111 1111 1010 0000

Step 3: East / West Velocity (Subsonic / Supersonic) Data Not Available (§2.2.8.1.9.b)

Keep the East / West Velocity presence bit at “ONE,” and set the East / West Velocity validity flag to “ZERO.”

Verify that the reported Binary Decoded East / West Velocity datum is set to all “ZEROs.”

2.4.8.1.10 Verification of Ground Speed Reporting While on the Surface (§2.2.8.1.10)

Purpose/Introduction:

a. The ADS-B Report Assembly Function **shall** extract the Movement Data (§2.2.3.2.4.2) from the ADS-B Surface Position Message and provide Ground Speed information to the user application in the State Vector report as defined in Table 2.2.8.1. Coding of the Movement information **shall** be the same as that identified for the Movement Data in §2.2.3.2.4.2.

b. When valid Movement data is not available, the ADS-B Report Assembly Function **shall** set the Ground Speed data provided to the user application to ALL ZEROs, and the Surface Ground Speed Validity Flag bit, i.e., bit #4 (LSB) of byte #3 of the State

Vector Report, **shall** be set to "0" to indicate that the reported Surface Ground Speed is not valid.

Otherwise, the Surface Ground Speed Validity Flag bit, i.e., bit #4 (LSB) of byte #3 of the State Vector Report, **shall** be set to "1," unless modified by other conditions.

Measurement Procedure:

Step 1: Ground Speed Reporting (§2.2.8.1.10.a)

For each case in Table 2-136 below, generate valid Surface Position Messages ("Type" codes of 5 through 8), which include the encoded datum ("ME" Bits 6 - 12) for the Decimal Ground Speed (Movement) values listed, and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding Ground Speed (Movement) presence bit (Report Byte #1, Bit #5), and the Ground Speed (Movement) Validity Flag (Report Byte #3, Bit #4), are "ONEs."

Verify that the reported Binary Decoded Ground Speed datum (Report Byte # 35) matches the corresponding value in the table.

Table 2-136: Ground Speed Test Data

GROUND SPEED	
Decimal Ground Speed (knots)	**Binary Decoded Ground Speed (Movement)**
0.000	0000 0001
0.125	0000 0010
0.250	0000 0011
0.375	0000 0100
0.750	0000 0111
0.875	0000 1000
3.000	0000 1111
3.500	0001 0000
11.000	0001 1111
11.500	0010 0000
39.000	0011 1111
40.000	0100 0000
175.000	0111 1100

Step 2: Ground Speed Data Not Available (§2.2.8.1.10.b)

Keep the Ground Speed (Movement) presence bit at "ONE," and set the Ground Speed (Movement) validity flag to "ZERO."

Verify that the reported Binary Decoded Ground Speed (Movement) datum is set to all "ZEROs."

2.4.8.1.11 Verification of Heading While on the Surface Reporting (§Error! Reference source not found.**)**

Purpose/Introduction:

a. The ADS-B Report Assembly Function **shall** extract the Status Bit for Ground Track (§2.2.3.2.4.3) and Ground Track Data (§0) from the ADS-B Surface Position Message and provide Heading while on the surface information to the user application in the State Vector Report in binary format as defined in Table 2.2.8.1. This format represents a true two's complement format where the MSB has a weight of 90 degrees and the LSB has a weight of 1.40625 degrees. The maximum range of the data is then given by +/- [2*MSB - LSB] or +/- 178.59375 degrees. Alternately, the format may be referred to as angular weighted binary.

b. When valid Heading while on the surface data is not available, the ADS-B Report Assembly Function **shall** set the Heading while on the surface data provided to the user application to ALL ZEROs, and the Surface Heading Validity Flag bit, i.e., bit #3 (MSB) of byte #3 of the State Vector Report, **shall** be set to "0" to indicate that the reported Surface Heading is not valid.

Otherwise, the Surface Heading Validity Flag bit, i.e., bit #3 (MSB) of byte #3 of the State Vector Report, **shall** be set to "1," unless modified by other conditions.

Measurement Procedure:

Step 1: Ground Track Reporting (§**Error! Reference source not found.**.a)

For each case in Table 2-137 below, generate valid Surface Position Messages ("Type" codes of 5 through 8), which include the encoded data ("ME" Bits 13 and 14 - 20) for the Decimal Ground Track Status Bit and Ground Track values listed, and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding Ground Track presence bit (Report Byte #1, Bit 4), and the Surface Heading Validity Flag (Report Byte #3, Bit 3), are "ONEs."

Verify that the reported Binary Decoded Ground Track data (Report Byte # 36) matches the corresponding value in the table.

<u>Table 2-137:</u> Ground Track Test Data

GROUND TRACK		
Ground Track Status	**Decimal Ground Track (degrees)**	**Binary Decoded Ground Track**
0	22.5000	0000 0000
0	357.1875	0000 0000
1	0.0000	0000 0000
1	2.8125	0000 0001
1	5.6250	0000 0010
1	11.2500	0000 0100
1	22.5000	0000 1000
1	45.0000	0001 0000
1	90.0000	0010 0000
1	180.0000	0100 0000
1	357.1875	0111 1111

<u>Step 2:</u> <u>Ground Track Data Not Available (§**Error! Reference source not found.**.b)</u>

Keep the Ground Track presence bit at "ONE," and set the Ground Track validity flag to "ZERO."

Verify that the reported Binary Decoded Ground Track datum is set to all "ZEROs."

2.4.8.1.12 Verification of Altitude, Barometric (Pressure Altitude) Reporting (§2.2.8.1.12)

<u>Purpose/Introduction:</u>

a. When Barometric Altitude Data is indicated by the "TYPE" subfield (§2.2.3.2.3.1) of the ADS-B Airborne Position Message, the ADS-B Report Assembly Function **shall** decode Altitude Data (§2.2.3.2.3.4) that has been encoded by the ADS-B transmission device as specified in §2.2.3.2.3.4.1. Binary Altitude data **shall** be provided to the user application in the State Vector report as defined in Table 2.2.8.1. This format represents a true two's complement format where the MSB has a weight of 65,536 and the LSB has a weight of 0.015625. The maximum range of the data is then given by +/- [2*MSB - LSB] or +/- 131,071.984375.

b. When valid Barometric Altitude data is not available, the ADS-B Report Assembly Function **shall** set the Barometric Altitude data provided to the user application to ALL ZEROs, and the Barometric Altitude Validity Flag bit, i.e., bit #2 of byte #3 of the State Vector Report, **shall** be set to "0" to indicate that the reported Barometric Altitude is not valid.

   Otherwise, the Barometric Altitude Validity Flag bit, i.e., bit #2 of byte #3 of the State Vector Report, **shall** be set to "1," unless modified by other conditions.

Measurement Procedure:

Step 1: Barometric (Pressure) Altitude Reporting (§2.2.8.1.12.a)

For each case in Table 2-129 below, generate valid Airborne Position Messages, with “Type” codes of 9 through 18, which include the encoded datum (“ME” Bits 9 - 20) for the Decimal Altitude value listed, with an imbedded “Q” bit (“ME” Bit 16) of “ONE,” and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding Barometric (Pressure) Altitude presence bit (Report Byte #1, Bit #3), and the Barometric (Pressure) Altitude Validity Flag (Report Byte #3, Bit #2), are “ONEs.”

Verify that the reported Binary Decoded Barometric (Pressure) Altitude datum (Report Bytes # 26 - 28) matches the corresponding value in the table.

Table 2-129: Barometric (Pressure) Altitude Test Data

BAROMETRIC (PRESSURE) ALTITUDE (“Q” Bit = “ONE”)	
Decimal Altitude (feet)	**Binary Decoded Barometric (Pressure) Altitude**
-1000	1111 1111 1110 0000 1100 0000
-975	1111 1111 1110 0001 1000 1000
-925	1111 1111 1110 0011 0001 1000
-825	1111 1111 1110 0110 0011 1000
-625	1111 1111 1110 1100 0111 1000
-575	1111 1111 1110 1110 0000 1000
-500	1111 1111 1111 0000 0110 0000
-225	1111 1111 1111 1000 1111 1000
-200	1111 1111 1111 1001 1100 0000
-125	1111 1111 1111 1100 0001 1000
-25	1111 1111 1111 1111 0011 1000
0	0000 0000 0000 0000 0000 0000
25	0000 0000 0000 0000 1100 1000
50	0000 0000 0000 0001 1001 0000
100	0000 0000 0000 0011 0010 0000
200	0000 0000 0000 0110 0100 0000
400	0000 0000 0000 1100 1000 0000
800	0000 0000 0001 1001 0000 0000
1600	0000 0000 0011 0010 0000 0000
3200	0000 0000 0110 0100 0000 0000
6400	0000 0000 1100 1000 0000 0000
12800	0000 0001 1001 0000 0000 0000
25600	0000 0011 0010 0000 0000 0000
49175	0000 0110 0000 0000 1011 1000
49200	0000 0110 0000 0001 1000 0000
50175	0000 0110 0001 1111 1111 1000

Step 2: Barometric (Pressure) Altitude Reporting (§2.2.8.1.12.a)

For each case in Table 2-130 below, generate valid Airborne Position Messages, with "Type" codes of 9 through 18, which include the encoded datum ("ME" Bits 9 - 20) for the Decimal Altitude value listed, with an imbedded "Q" bit ("ME" Bit 16) of "ZERO," and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding Barometric (Pressure) Altitude presence bit (Report Byte #1, Bit 3), and the Barometric (Pressure) Altitude Validity Flag (Report Byte #3, Bit 2), are "ONEs."

Verify that the reported Binary Decoded Barometric (Pressure) Altitude datum (Report Bytes # 26 - 28) matches the corresponding value in the table.

Table 2-130: Barometric (Pressure) Altitude Test Data

BAROMETRIC (PRESSURE) ALTITUDE ("Q" Bit = "ZERO")	
Decimal Altitude (feet)	**Binary Decoded Barometric (Pressure) Altitude**
-1000	1111 1111 1110 0000 1100 0000
-800	1111 1111 1110 0111 0000 0000
-100	1111 1111 1111 1100 1110 0000
0	0000 0000 0000 0000 0000 0000
100	0000 0000 0000 0011 0010 0000
200	0000 0000 0000 0110 0100 0000
400	0000 0000 0000 1100 1000 0000
800	0000 0000 0001 1001 0000 0000
1600	0000 0000 0011 0010 0000 0000
3200	0000 0000 0110 0100 0000 0000
6400	0000 0000 1100 1000 0000 0000
12800	0000 0001 1001 0000 0000 0000
25600	0000 0011 0010 0000 0000 0000
51200	0000 0110 0100 0000 0000 0000
102400	0000 1100 1000 0000 0000 0000
126700	0000 1111 0111 0111 0110 0000

Step 3: Barometric (Pressure) Altitude Data Not Available (§2.2.8.1.12.b)

Keep the Barometric (Pressure) Altitude presence bit at "ONE," and set the Barometric (Pressure) Altitude validity flag to "ZERO."

Verify that the reported Binary Decoded Barometric (Pressure) Altitude datum is set to all "ZEROs."

2.4.8.1.13 Verification of Vertical Rate, Geometric/Barometric (§2.2.8.1.13)

TBD

2.4.8.1.14 Verification of Vertical Rate, Geometric (WGS-84) Reporting (§2.2.8.1.14)

Purpose/Introduction:

a. When Geometric Altitude Rate Data is indicated by the "Source Bit for Vertical Rate" subfield (§2.2.3.2.6.1.10, §2.2.3.2.6.2.10, §2.2.3.2.6.3.10, or §2.2.3.2.6.4.10) the ADS-B Report Assembly Function **shall** extract the Vertical Rate Sign Bit (§2.2.3.2.6.1.11, §2.2.3.2.6.2.11, §2.2.3.2.6.3.11, or §2.2.3.2.6.4.11) and the Vertical Rate subfield (§2.2.3.2.6.1.12, §2.2.3.2.6.2.12, §2.2.3.2.6.3.12, or §2.2.3.2.6.4.12) from the ADS-B Message and provide Vertical Rate, Geometric information to the user application in the State Vector report in binary format as defined in Table 2.2.8.1. This format represents a true two's complement format where the MSB has a weight of 16,384 and the LSB has a weight of 1. The maximum range of the data is then given by +/- [2*MSB - LSB] or +/- 32,767

b. When valid Geometric Altitude Rate data is not available, the ADS-B Report Assembly Function **shall** set the Vertical Rate, Geometric data provided to the user application to ALL ZEROs, and the Vertical Rate Validity Flag bit, i.e., bit #4 of byte #4 of the State Vector Report (§2.2.8.1.1.2), **shall** be set to "0" to indicate that the reported Vertical Rate is not valid.

   Otherwise, the Vertical Rate Validity Flag bit, i.e., bit #1 of byte #3 of the State Vector Report, **shall** be set to "1," unless modified by other conditions.

Measurement Procedure:

Step 1: Vertical Rate, Geometric (WGS-84) Reporting (§2.2.8.1.14.a)

For each case in Table 2-128 below, generate valid Airborne Velocity Messages (Subtype 1) with the Vertical Rate Source ("ME" Bit 36) equal "ZERO" (GNSS or INS Source), and which include the encoded data ("ME" Bit 37 for Vertical Rate Sign Bit, and Bits 38 - 46 for Vertical Rate) for the Decimal Vertical Rate values listed, and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding Geometric Vertical Rate presence bit (Report Byte #1, Bit #2), and the Geometric Vertical Rate Validity Flag (Report Byte #3, Bit #1), are "ONEs."

Verify that the reported Binary Decoded Geometric (WGS-84) Vertical Rate datum (Report Bytes # 24 - 25) matches the corresponding value in the table.

Table 2-128: Geometric (WGS-84) Vertical Rate Test Data

GEOMETRIC (WGS-84) VERTICAL RATE	
Decimal Vertical Rate (ft./min.)	**Binary Decoded Geometric Vertical Rate**
-32704	1111 1000 0000 0100
-16384	1111 1100 0000 0000
-8192	1111 1110 0000 0000
-4096	1111 1111 0000 0000
-2048	1111 1111 1000 0000
-1024	1111 1111 1100 0000
-512	1111 1111 1110 0000
-256	1111 1111 1111 0000
-128	1111 1111 1111 1000
-64	1111 1111 1111 1100
0	0000 0000 0000 0000
64	0000 0000 0000 0100
128	0000 0000 0000 1000
256	0000 0000 0001 0000
512	0000 0000 0010 0000
1024	0000 0000 0100 0000
2048	0000 0000 1000 0000
4096	0000 0001 0000 0000
8192	0000 0010 0000 0000
16384	0000 0100 0000 0000
32704	0000 0111 1111 1100

Step 2: Vertical Rate, Geometric (WGS-84) Data Not Available (§2.2.8.1.14.b)

Keep the Geometric Vertical Rate presence bit at "ONE," and set the Geometric Vertical Rate validity flag to "ZERO."

Verify that the reported Binary Decoded Geometric (WGS-84) Vertical Rate datum is set to all "ZEROs."

2.4.8.1.15 Verification of Barometric Altitude Rate Reporting (§2.2.8.1.15)

Purpose/Introduction:

a. When Barometric Altitude Rate Data is indicated by the "Source Bit for Vertical Rate" subfield (§2.2.3.2.6.1.10, §2.2.3.2.6.2.10, §2.2.3.2.6.3.10, or §2.2.3.2.6.4.10) the ADS-B Report Assembly Function **shall** extract the Vertical Rate Sign Bit (§2.2.3.2.6.1.11, §2.2.3.2.6.2.11, §2.2.3.2.6.3.11, or §2.2.3.2.6.4.11) and the Vertical Rate subfield (§2.2.3.2.6.1.12, §2.2.3.2.6.2.12, §2.2.3.2.6.3.12, or §2.2.3.2.6.4.12) from the ADS-B Message and provide Vertical Rate, Barometric information to the user application in the State Vector report in binary format as defined in Table 2.2.8.1 This format represents a true two's complement format where the MSB has a weight of 16,384 and the LSB has a weight of 1. The maximum range of the data is then given by +/- [2*MSB - LSB] or +/- 32,767.

b. When valid Barometric Altitude Rate data is not available, the ADS-B Report Assembly Function **shall** set the Vertical Rate, Barometric data provided to the user application to ALL ZEROs, and the Vertical Rate Validity Flag bit, i.e., bit #1 of byte #3 of the State Vector Report, **shall** be set to "0"

Otherwise, the Vertical Rate Validity Flag bit, i.e., bit #1 of byte #3 of the State Vector Report, **shall** be set to "1," unless modified by other conditions.

<u>Measurement Procedure:</u>

<u>Step 1:</u> <u>Vertical Rate Reporting (§2.2.8.1.15.a)</u>

For each case in Table 2-131 below, generate valid Airborne Velocity Messages (Subtype 1) with the Vertical Rate Source ("ME" Bit 36) equal "ONE" (Barometric Source), and which include the encoded data ("ME" Bit 37 for Vertical Rate Sign Bit, and Bits 38 - 46 for Vertical Rate) for the Decimal Vertical Rate values listed, and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding Vertical Rate presence bit (Report Byte #1, Bit #2), and the Vertical Rate Validity Flag (Report Byte #3, Bit #1), are "ONEs."

Verify that the reported Binary Decoded Vertical Rate datum (Report Bytes # 29 - 30) matches the corresponding value in the table.

Table 2-131: Vertical Rate Test Data

VERTICAL RATE	
Decimal Vertical Rate (ft./min.)	**Binary Decoded Vertical Rate**
-32704	1111 1000 0000 0100
-16384	1111 1100 0000 0000
-8192	1111 1110 0000 0000
-4096	1111 1111 0000 0000
-2048	1111 1111 1000 0000
-1024	1111 1111 1100 0000
-512	1111 1111 1110 0000
-256	1111 1111 1111 0000
-128	1111 1111 1111 1000
-64	1111 1111 1111 1100
0	0000 0000 0000 0000
64	0000 0000 0000 0100
128	0000 0000 0000 1000
256	0000 0000 0001 0000
512	0000 0000 0010 0000
1024	0000 0000 0100 0000
2048	0000 0000 1000 0000
4096	0000 0001 0000 0000
8192	0000 0010 0000 0000
16384	0000 0100 0000 0000
32704	0000 0111 1111 1100

Step 2: Vertical Rate Data Not Available (§2.2.8.1.15.b)

Keep the Vertical Rate presence bit at "ONE," and set the Vertical Rate Validity Flag to "ZERO."

Verify that the reported Binary Decoded Vertical Rate datum is set to all "ZEROs."

2.4.8.1.16 Verification of the Navigation Integrity Code (NIC) (§2.2.8.1.16)

Purpose/Introduction:

a. The ADS-B Report Assembly Function **shall** extract "TYPE" data from the ADS-B Airborne Position Message (§2.2.3.2.3.1), or from the Surface Position Message (§2.2.3.2.4.1), and provide Navigation Integrity Category (NIC) information to the user application in the State Vector Report as defined in Table 2.2.8.1. Definition of the NIC coding is provided in Table 2.2.8.1.16.

b. When valid NIC data is not available, the NIC data sent to the user application **shall** be set to ALL ZEROs.

Measurement Procedure:

TBD

2.4.8.1.17 Verification of Estimated Latitude (WGS-84) Reporting (§2.2.8.1.17)

Purpose/Introduction:

a. New Latitude Data Received

(1). Airborne or Surface Message Received: - Each time that the Report Assembly Function establishes a new decoded Latitude in accordance with §2.2.8.1.2, the Report Assembly Function **shall** update the Estimated Latitude (WGS-84) data in the State Vector Report with the new Latitude data received.

(2). Airborne or Surface Message Received: - The Estimated Latitude update **shall** be completed by the Report Assembly Function also updating the Report Time of Applicability in the State Vector Report with either the GPS/GNSS UTC Measure Time data (see §2.2.8.4.1) or the Established Receiver Unit Time (see §2.2.8.4.2) whichever is applicable to the Receiving device Report Assembly Function installation requirements.

b. New North / South Velocity Data Received: (Airborne Velocity Message Received)

(1). Each time that an Airborne Velocity Subtype "1" or "2" message is received with valid North / South Velocity data, the Report Assembly Function **shall** compute a new Estimated Latitude (WGS-84) position based on the last known

Estimated Latitude (WGS-84), the last known North / South velocity (**Note:** Not the North / South Velocity data just received), and the time that has elapsed since the last update of the Estimated Latitude (WGS-84).

Accuracy of the Estimated Latitude (WGS-84) computation **shall** be within +/- 20 meters of the theoretical noise free position that could be established based on the previous position, the last known velocity, and the time of travel.

(2). The new Estimated Latitude (WGS-84) computed in b.(1). **shall** be used by the Report Assembly Function to update the Estimated Latitude (WGS-84) data in the State Vector Report.

(3). The Estimated Latitude update **shall** be completed by the Report Assembly Function also updating the Report Time of Applicability in the State Vector Report with either the GPS/GNSS UTC Measure Time data (see §2.2.8.4.1) or the Established Receiver Unit Time (see §2.2.8.4.2) whichever is applicable to the Receiving device Report Assembly Function installation requirements.

c. Estimated Horizontal Position Validity Flag Requirements

When valid estimated Latitude or Longitude position data is not available, the estimated latitude and longitude data provided to the user application **shall** be set to ALL ZEROs and the Estimated Horizontal Position Validity Flag bit, i.e., bit #0 of byte #3 of the

State Vector Report, **shall** be set to “0”to indicate that the reported Estimated Horizontal Position is not valid.

Otherwise, the Estimated Horizontal Position Validity Flag bit, i.e., bit #0 of byte #3 of the State Vector Report, **shall** be set to “1,” unless modified by other conditions.

Measurement Procedure:

Step 1: Estimated Latitude (WGS-84) Updating and Reporting (resulting from received Airborne or Surface Position Message) (§2.2.8.1.17.a(1))

For each case in Table 2-143 below, generate valid Airborne Position Messages, which include the encoded data (“ME” Bits 23 - 39) for the Decimal Latitude value listed, and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding Estimated Latitude presence bit (Report Byte #1, Bit 0), and the Estimated Latitude Validity Flag (Report Byte #3, Bit 0), are “ONEs.”

Verify that the reported Binary Decoded Estimated Latitude (WGS-84) (Report Bytes # 44 - 46) data, match the corresponding value in the table.

Table 2-142: Estimated Longitude Test Data

ESTIMATED LONGITUDE	
Decimal Longitude (degrees)	**Binary Decoded (WGS-84) Estimated Longitude (angular weighted)**
0.000000	0000 0000 0000 0000 0000 0000
0.000037	0000 0000 0000 0000 0000 0001
0.000073	0000 0000 0000 0000 0000 0011
0.000147	0000 0000 0000 0000 0000 0110
0.000294	0000 0000 0000 0000 0000 1101
0.000587	0000 0000 0000 0000 0001 1011
0.001175	0000 0000 0000 0000 0011 0110
0.002350	0000 0000 0000 0000 0110 1101
0.004699	0000 0000 0000 0000 1101 1011
0.009398	0000 0000 0000 0001 1011 0110
0.018797	0000 0000 0000 0011 0110 1100
0.037594	0000 0000 0000 0110 1101 1000
0.075188	0000 0000 0000 1101 1011 0000
0.150375	0000 0000 0001 1011 0110 0000
0.300751	0000 0000 0011 0110 1100 0000
0.601501	0000 0000 0110 1101 1000 0000
1.203003	0000 0000 1101 1011 0000 0000
2.406006	0000 0001 1011 0110 0000 0000
4.812012	0000 0011 0110 1100 0000 0000
9.624023	0000 0110 1101 1000 0000 0000
19.248047	0000 1101 1011 0000 0000 0000
38.496094	0001 1011 0110 0000 0000 0000
76.992188	0011 0110 1100 0000 0000 0000
153.984375	0110 1101 1000 0000 0000 0000
-52.031250	1101 1011 0000 0000 0000 0000
-104.062500	1011 0110 0000 0000 0000 0000
151.875000	0110 1100 0000 0000 0000 0000
-56.250000	1101 1000 0000 0000 0000 0000
-112.500000	1011 0000 0000 0000 0000 0000
135.000000	0110 0000 0000 0000 0000 0000
-90.000000	1100 0000 0000 0000 0000 0000
180.000000	1000 0000 0000 0000 0000 0000

Step 2: Estimated Latitude and Estimated Longitude (WGS-84) Updating and Reporting (resulting from received Airborne or Surface Position Message) (§2.2.8.1.18.a(1))

For each case in Table 2-142 above, generate valid Airborne Position Messages, which include the encoded data ("ME" Bits 23 - 39 for Latitude, and Bits 40 - 56 for Longitude) for the Decimal Latitude and Longitude values listed, and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding Estimated Latitude and Longitude presence bits (Report Byte #1, Bit #0 for Estimated Latitude, and Byte #2, Bit #7 for Estimated Longitude), and the Estimated Latitude / Longitude Validity Fag (Report Byte #3, Bit #0), are "ONEs."

Verify that the reported Binary Decoded Estimated Latitude (WGS-84) (Report Bytes # 44 - 46) data, and the reported Binary Decoded Estimated Longitude (WGS-84) (Report Bytes # 47 - 49) data, match the corresponding values in the table.

Table 2-143: Estimated Latitude Test Data

ESTIMATED LATITUDE	
Decimal Latitude (degrees)	**Binary Decoded (WGS-84) Estimated Latitude (angular weighted)**
0.000000	0000 0000 0000 0000 0000 0000
0.000037	0000 0000 0000 0000 0000 0001
0.000073	0000 0000 0000 0000 0000 0011
0.000147	0000 0000 0000 0000 0000 0110
0.000294	0000 0000 0000 0000 0000 1101
0.000587	0000 0000 0000 0000 0001 1011
0.001175	0000 0000 0000 0000 0011 0110
0.002350	0000 0000 0000 0000 0110 1101
0.004699	0000 0000 0000 0000 1101 1011
0.009398	0000 0000 0000 0001 1011 0110
0.018797	0000 0000 0000 0011 0110 1100
0.037594	0000 0000 0000 0110 1101 1000
0.075188	0000 0000 0000 1101 1011 0000
0.150375	0000 0000 0001 1011 0110 0000
0.300751	0000 0000 0011 0110 1100 0000
0.601501	0000 0000 0110 1101 1000 0000
1.203003	0000 0000 1101 1011 0000 0000
2.406006	0000 0001 1011 0110 0000 0000
4.812012	0000 0011 0110 1100 0000 0000
9.624023	0000 0110 1101 1000 0000 0000
19.248047	0000 1101 1011 0000 0000 0000
38.496094	0001 1011 0110 0000 0000 0000
76.992188	0011 0110 1100 0000 0000 0000
-52.031250	1101 1011 0000 0000 0000 0000
-56.250000	1101 1000 0000 0000 0000 0000
-90.000000	1100 0000 0000 0000 0000 0000

Step 3: Report Time of Applicability Updating and Reporting (resulting from received Airborne or Surface Position Message) (§2.2.8.1.17.a(2), and §2.2.8.1.18.a(2))

Generate a series of valid Airborne Position Messages, similar to the procedure described in Step 1 above, which include the encoded data (“ME” Bits 23 - 39 for Latitude, and Bits 40 - 56 for Longitude) for any suitable Decimal Latitude and Longitude values, and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding presence bits (Report Byte #1, Bit #0 for Estimated Latitude, and Byte #2, Bit #7 for Estimated Longitude), and the Estimated Latitude/Longitude Validity Flag (Report Byte #3, Bit #0), are “ONEs.”

Verify that the Binary Decoded Report Time of Applicability (Report Bytes # 55 - 56) data changes by an average of 0.5 seconds between each message transmission.

Step 4: Estimated Latitude and Estimated Longitude (WGS-84) Updating and Reporting (resulting from received Airborne Velocity Message, Subtype 1) (§2.2.8.1.17.b(1 & 2), and §2.2.8.1.18.b(1 & 2))

Generate an Airborne Velocity Message (Subtype 1), which includes the encoded data ("ME" Bits 25 - 35) for any suitable N/S Velocity, and which includes the encoded data ("ME" Bits 14 - 24) for any suitable E/W Velocity, such that the resultant is a velocity of 180 knots, and a heading of between 25 to 65 degrees. Verify that the ADS-B Receiver/Report Assembly outputs a State Vector Report with the Report Mode set to TWO (binary xxxx 0010). Record the Estimated N/S Velocity (Report Bytes # 50 - 51) as Vns_{est0} (knots), and record the Estimated E/W Velocity (Report Bytes # 50 - 51) as Vew_{est0} (knots).

Within 200 milliseconds, generate any valid Airborne Position Message, which includes the encoded data ("ME" Bits 23 - 39 for Latitude, and Bits 40 - 56 for Longitude) for any suitable Decimal Latitude and Longitude values. Verify that the ADS-B Receiver/Report Assembly outputs a State Vector Report with the Report Mode set to TWO (binary xxxx 0010). Record the Position Time of Applicability (Report Bytes # 40 - 41) as t_0 (seconds), record the Estimated Latitude (Report Bytes # 44 - 46) as Lat_{est0} (degrees), and record the Estimated Longitude (Report Bytes # 47 - 49) as Lon_{est0} (degrees).

One second after the Airborne Position Message, retransmit the same Airborne Velocity Message (Subtype 1) as above. Verify that the ADS-B Receiver/Report Assembly outputs State Vector Report with the Report Mode set to TWO (binary xxxx 0010). Record the updated Estimated Latitude as Lat_{est1} (degrees). Record the updated Estimated Longitude as Lon_{est1} (degrees), and record the updated Velocity Time of Applicability as t_1 (seconds).

Verify that (see Note below):

$$1852 * \text{Absolute}\ [(Lat_{est1} - Lat_{est0}) \times 60 - Vns_{est0} \times (t_1 - t_0 + t_{rng}) / 3600] < 20 \text{ meters.}$$

Verify that (see Note below):

$$1852 * \text{Absolute}\ [(Lon_{est1} - Lon_{est0}) \times 60 - Vew_{est0} \times (t_1 - t_0 + t_{rng}) / 3600] < 20 \text{ meters.}$$

Note: *If $t_1 < t_0$, then the Receiving Installation Time has exceeded the maximum time range (see §2.2.8.4) to restart the time count at zero, then the maximum time range, t_{rng}, must be added to (t_1 - t_0) to make it positive. Otherwise, consider t_{rng} in the equation to be zero.*

Repeat these Step 3 procedures as necessary, using various parameter values, in order to establish the desired level of confidence.

Step 5: Report Time of Applicability Updating and Reporting (resulting from received Airborne Velocity Message, Subtype 1) (§2.2.8.1.17.b(3), and §2.2.8.1.18.b(3))

Generate a series of valid Airborne Velocity (Subtype 1) Messages, similar to the procedure described in Step 3 above, which include the encoded data ("ME" Bits 25 - 35 for N/S Velocity, and "ME" Bits 14 - 24 for E/W Velocity) for any suitable N/S and E/W Velocity values, and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding N/S Velocity presence bit (Report Byte #1, Bit 6), and the Velocity Validity Flag (Report Byte #3, Bit #5), are "ONEs."

Verify that the Binary Decoded Report Time of Applicability (Report Bytes # 55 - 56) data changes by an average of 0.5 seconds between each message transmission.

Step 6: Estimated Latitude and Estimated Longitude (WGS-84) Data Not Available (§2.2.8.1.17.c, and §2.2.8.1.18.c)

Keep the Estimated Latitude and Longitude presence bits at "ONE," and set the Estimated Latitude / Longitude Validity Flag to "ZERO."

Verify that the reported Binary Decoded Estimated Latitude and Estimated Longitude data are set to all "ZEROs."

2.4.8.1.18 Verification of Estimated Longitude (WGS-84) Reporting (§2.2.8.1.18)

Appropriate test procedures are provided in §2.4.8.1.17.

2.4.8.1.19 Verification of Estimated North / South Velocity Reporting (§2.2.8.1.19)

Purpose/Introduction:

a. New North / South Velocity Received: (Airborne Velocity or Surface Position Message Received)

(1). Each time that the Report Assembly Function establishes a new North / South Velocity in accordance with §2.2.8.1.8, the Report Assembly Function **shall** update the Estimated North / South Velocity data in the State Vector Report with the new North / South Velocity data received.

(2). The Estimated North / South Velocity update **shall** be completed by the Report Assembly Function also updating the Report Time of Applicability in the State Vector Report with either the GPS/GNSS UTC Measure Time data (see §2.2.8.4.1) or the Established Receiver Unit Time (see §2.2.8.4.2) whichever is applicable to the Receiving device Report Assembly Function installation requirements.

b. New Latitude Position Data Received: (Airborne Position or Surface Position Message Received)

(1). Each time that the Report Assembly Function establishes a new decoded Latitude in accordance with §2.2.8.1.2, the Report Assembly Function **shall** compute a new Estimated North / South Velocity based on the last known Estimated Latitude (WGS-84), the new Latitude position data just received, and the time that has elapsed since the last update of the Estimated North / South Velocity.

Accuracy of the Estimated North / South Velocity computation **shall** be within +/- 0.3 meters/second of the theoretical noise free Estimated North / South Velocity that could be established based on the previous position, the new position, and the elapsed time of travel between the two positions.

(2). The new Estimated North / South Velocity computed in b.(1). **shall** be used by the Report Assembly Function to update the Estimated North / South Velocity data in the State Vector Report.

(3). The Estimated North / South Velocity update **shall** be completed by the Report Assembly Function also updating the Report Time of Applicability in the State Vector Report with either the GPS/GNSS UTC Measure Time data (see §2.2.8.4.1) or the Established Receiver Unit Time (see §2.2.8.4.2) whichever is applicable to the Receiving device Report Assembly Function installation requirements.

c. Estimated Horizontal Velocity Validity Flag Requirements

When valid estimated North / South or East / West Velocity data is not available, the estimated North / South or East / West Velocity data provided to the user application **shall** be set to ALL ZEROs and the Estimated Horizontal Velocity Validity Flag bit, i.e., bit #7 of byte #4 of the State Vector Report (§2.2.8.1.1.2), **shall** be set to “0” to indicate that the reported Estimated Horzontal Velocity is not valid.

Otherwise, the Estimated Horizontal Velocity Validity Flag bit, i.e., bit #7 of byte #4 of the State Vector Report, **shall** be set to “1,” unless modified by other conditions.

Measurement Procedure:

Step 1: Estimated North / South Velocity Updating and Reporting (resulting from received Airborne Velocity Message) (§2.2.8.1.19.a(1))

Generate valid Airborne Velocity Messages (Subtype 1), which include the encoded data (“ME” Bits 25 - 35) for any valid Decimal North/South Velocity values, and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding Estimated North/South Velocity presence bit (Report Byte #2, Bit #6), and the Estimated Velocity Validity Flag (Report Byte #4, Bit #7), are “ONEs.”

Verify that the reported Binary Decoded Estimated North/South Velocity data (Report Bytes # 50 - 51) match the transmitted North/South Velocity values.

Step 2: Estimated North / South Velocity Updating and Reporting (resulting from received Surface Position Message) (§2.2.8.1.19.a(1))

Generate a series of Surface Position Messages (Subtype 1 or 2), which include encoded data ("ME" Bits 6 - 12) for valid Ground Speed (Movement) values, which include a Ground Track Status ("ME" Bit 13) of "ONE," and which include encoded data ("ME" Bits 14 - 20) for valid Ground Track headings having a significant North/South component, and verify that the ADS-B Receiver/Report Assembly outputs a State Vector Report of Type 0001.

Verify that the North/South Velocity presence bit (Report Byte #1, Bit #6), the Estimated North/South Velocity presence bit (Report Byte #2, Bit #6), the Velocity Validity Flag (Report Byte #3, Bit #5), and the Estimated Velocity Validity Flag (Report Byte #4, Bit #7), are "ONEs."

Verify that for each message the N/S Velocity (Report Bytes # 20 - 21) data matches the Estimated N/S Velocity (Report Bytes # 50 - 51) data.

Step 3: Report Time of Applicability Updating and Reporting (resulting from received Airborne Velocity or Surface Position Message) (§2.2.8.1.19.a(2))

Generate a series of valid Airborne Velocity (Subtype 1) Messages, which include the encoded data ("ME" Bits 25 - 35) for any suitable N/S Velocity values, and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding Estimated North/South Velocity presence bit (Report Byte #2, Bit #6), and the Estimated Velocity Validity Flag (Report Byte #4, Bit #7), are "ONEs."

Verify that the Binary Decoded Report Time of Applicability (Report Bytes # 55 - 56) data changes by an average of 0.5 seconds between each message transmission.

Step 4: Estimated North / South Velocity Updating and Reporting (resulting from received Airborne or Surface Position Message) (§2.2.8.1.19.b(1 & 2))

Generate any valid Surface Position Message, which includes the encoded data ("ME" Bits 6 - 12) for a suitable Decimal Ground Speed (Movement) value, which includes the encoded data ("ME" Bits 14 - 20) for a suitable Decimal Ground Track value, representing a North/South movement and speed of about 25 meters in a three second period, and which includes the encoded data ("ME" Bits 23 - 39) for any suitable starting Decimal Latitude value. Verify that the ADS-B Receiver/Report Assembly outputs a State Vector Report of Type 0001. Record the Position Time of Applicability (Report Bytes # 40 - 41) as t_{Y0} (seconds). Record the Velocity Time of Applicability (Report Bytes # 42 - 43) as t_{V0} (seconds). Record the Estimated Latitude (Report Bytes # 44 - 46) as Lat_{est0}

(degrees). Record the Estimated N/S Velocity (Report Bytes # 50 - 51) as Vns_{est0} (knots), and record the Report Time of Applicability (Report Bytes # 55 - 56) as t_{R0} (seconds).

Three seconds after the first Surface Position Message, generate another valid Surface Position Message, which includes the same encoded data for Decimal Ground Speed (Movement), the same encoded data for Decimal Ground Track, and updated encoded data for a Decimal Latitude value commensurate with the previously recorded Latitude, the N/S Velocity (Vns_{est0}), and the time between updates of the two Surface Position Messages (t_{Y1} - t_{Y0}). Verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001. Record the Position Time of Applicability as t_{Y1} (seconds). Record the Estimated Latitude as Lat_{est1} (degrees), and record the Report Time of Applicability as t_{R1} (seconds).

Verify that $t_{Y0} = t_{V0}. = t_{R0}$.

Verify that $t_{Y1} = t_{V1}. = t_{R1}$.

Verify that:

$$1852 \text{ x Absolute } [(Lat_{est1} - Lat_{est0}) \text{ x } 60 / (t_{Y1} - t_{Y0} + t_{rng}) - Vns_{est0} / 3600]$$

< 0.3 meters/second.

Note: *If $t_{Y1} < t_{Y0}$, then the Receiving Installation Time has exceeded the maximum time range (see §2.2.8.4) to restart the time count at zero, then the maximum time range, t_{rng} , must be added to (t_{Y1} - t_{Y0}) to make it positive. Otherwise, consider t_{rng} in the equation to be zero.*

Repeat these Step 4 procedures as necessary, using various parameter values, in order to establish the desired level of confidence.

Step 5: Report Time of Applicability Updating and Reporting (resulting from received Airborne or Surface Position Message) (§2.2.8.1.19.b(3))

Generate a series of valid Airborne Position Messages, which include the encoded data (“ME” Bits 23 - 39) for any suitable changing Latitude values, and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding Latitude presence bit (Report Byte #0, Bit #0), and the Latitude/Longitude Validity Flag (Report Byte #3, Bit #7), are “ONEs.”

Verify that the Binary Decoded Report Time of Applicability (Report Bytes # 55 - 56) data changes by an average of 0.5 seconds between each message transmission.

Step 6: North / South Velocity Data Not Available (§2.2.8.1.19.c)

Generate a series of valid Airborne Velocity Messages, which include the encoded data (“ME” Bits 25 - 35) for any suitable N/S Velocity values, force an “Estimated N/S Velocity data not available” condition in the ADS-B Receiver, and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the N/S Velocity presence bit (Report Byte #1, Bit #6), and the Estimated N/S Velocity presence bit (Report Byte #2, Bit #6), are “ONEs,” and set the reported Estimated Velocity Validity Flag (Report Byte #4, Bit 7) is a “ZERO.”

Verify that the reported Binary Decoded Estimated N/S Velocity data (Report Bytes # 50 - 51) is set to all “ZEROs.”

2.4.8.1.20 Verification of Estimated East / West Velocity Reporting (§2.2.8.1.20)

Purpose/Introduction:

Note: *The estimation of East / West Velocity is considered to be an optional function to be implemented in the ADS-B Report Assembly Function at the discretion of the implementer. If estimation of East / West Velocity is implemented then the requirements provided in the following subparagraphs a. through b.(3)* ***shall*** *be used as the minimum acceptable performance for such estimation.*

a. New East / West Velocity Data Received: (Airborne Velocity or Surface Position Message Received)

(1). Each time that the Report Assembly Function establishes a new East / West Velocity in accordance with §2.2.8.1.9, the Report Assembly Function **shall** update the Estimated East / West Velocity data in the State Vector Report with the new East / West Velocity data received.

(2). The Estimated East / West Velocity update **shall** be completed by the Report Assembly Function also updating the Report Time of Applicability in the State Vector Report with either the GPS/GNSS UTC Measure Time data (see §2.2.8.4.1) or the Established Receiver Unit Time (see §2.2.8.4.2) whichever is applicable to the Receiving device Report Assembly Function installation requirements.

b. New Longitude Position Data Received: (Airborne or Surface Position Message Received)

(1). Each time that the Report Assembly Function establishes a new decoded Longitude in accordance with §2.2.8.1.6, the Report Assembly Function **shall** compute a new Estimated East / West Velocity based on the last known Estimated Longitude (WGS-84), the new Longitude position data just received, and the time that has elapsed since the last update of the Estimated East / West Velocity.

Accuracy of the Estimated East / West Velocity computation **shall** be within +/- 0.3 meters/second of the theoretical noise free Estimated East / West Velocity that could be established based on the previous position, the new position, and the elapsed time of travel between the two positions.

Note: *The accuracy requirement is stated in the manner given in order to specifically allow the implementation to use estimation techniques such as Kalman filters, alpha-beta trackers, or linear estimation as deemed necessary by the implementer to satisfy the accuracy requirement.*

(2). The new Estimated East / West Velocity computed in b.(1). **Shall** be used by the Report Assembly Function to update the Estimated East / West Velocity data in the State Vector Report.

(3). The Estimated East / West Velocity update **shall** be completed by the Report Assembly Function also updating the Report Time of Applicability in the State Vector Report with either the GPS/GNSS UTC Measure Time data (see §2.2.8.4.1) or the Established Receiver Unit Time (see §2.2.8.4.2) whichever is applicable to the Receiving device Report Assembly Function installation requirements.

c. Estimated Velocity Validity Flag Requirements

When valid estimated North / South or East / West Velocity data is not available, the estimated North / South or East / West Velocity data provided to the user application **shall** be set to ALL ZEROs and the Estimated Horizontal Velocity Validity Flag bit, i.e., bit #7 of byte #4 of the State Vector Report (§2.2.8.1.1.2), **shall** be set to "0" to indicate that the reported Estimated Horzontal Velocity is not valid.

Otherwise, the Estimated Horizontal Velocity Validity Flag bit, i.e., bit #7 of byte #4 of the State Vector Report, **shall** be set to "1," unless modified by other conditions.

Measurement Procedure:

Step 1: Estimated East / West Velocity Updating and Reporting (resulting from received Airborne Velocity Message) (§2.2.8.1.20.a(1))

Generate valid Airborne Velocity Messages (Subtype 1), which include the encoded data ("ME" Bits 14 - 24) for any valid Decimal East/West Velocity values, and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding Estimated East/West Velocity presence bit (Report Byte #2, Bit #5), and the Estimated Velocity Validity Flag (Report Byte #4, Bit #7), are "ONEs."

Verify that the reported Binary Decoded Estimated East/West Velocity data (Report Bytes # 52 - 53) match the transmitted East/West Velocity values.

Step 2: Estimated East / West Velocity Updating and Reporting (resulting from received Surface Position Message) (§2.2.8.1.20.a(1))

Generate a series of Surface Position Messages (Subtype 1 or 2), which include encoded data ("ME" Bits 6 - 12) for valid Ground Speed (Movement) values, which include a Ground Track Status ("ME" Bit 13) of "ONE," and which include encoded data ("ME" Bits 14 - 20) for valid Ground Track headings having a significant East/West component, and verify that the ADS-B Receiver/Report Assembly outputs a State Vector Report of Type 0001.

Verify that the East/West Velocity presence bit (Report Byte #1, Bit #6), the Estimated East/West Velocity presence bit (Report Byte #2, Bit #5), the Velocity Validity Flag (Report Byte #3, Bit #5), and the Estimated Velocity Validity Flag (Report Byte #4, Bit #7), are "ONEs."

Verify that for each message the E/W Velocity (Report Bytes # 22 - 23) data matches the Estimated E/W Velocity (Report Bytes # 52 - 53) data.

Step 3: Report Time of Applicability Updating and Reporting (resulting from received Airborne Velocity or Surface Position Message) (§2.2.8.1.20.a(2))

Generate a series of valid Airborne Velocity (Subtype 1) Messages, which include the encoded data ("ME" Bits 14 - 24) for any suitable E/W Velocity values, and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding Estimated East/West Velocity presence bit (Report Byte #2, Bit #5), and the Estimated Velocity Validity Flag (Report Byte #4, Bit 7), are "ONEs."

Verify that the Binary Decoded Report Time of Applicability (Report Bytes # 55 - 56) data changes by an average of 0.5 seconds between each message transmission.

Step 4: Estimated East / West Velocity Updating and Reporting (resulting from received Airborne or Surface Position Message) (§2.2.8.1.20.b(1 & 2))

Generate any valid Surface Position Message, which includes the encoded data ("ME" Bits 6 - 12) for a suitable Decimal Ground Speed (Movement) value, and the encoded data ("ME" Bits 14 - 20) for a suitable Decimal Ground Track value, representing a East/West movement and speed of about 25 meters in a three second period, and which includes the encoded data ("ME" Bits 40 - 56) for any suitable starting Decimal Latitude (Lat) and Longitude values. Verify that the ADS-B Receiver/Report Assembly outputs a State Vector Report of Type 0001. Record the Position Time of Applicability (Report Bytes # 40 - 41) as t_{X0} (seconds). Record the Velocity Time of Applicability (Report Bytes # 42 - 43) as t_{V0} (seconds). Record the Estimated Longitude (Report Bytes # 44 - 46) as Lon_{est0} (degrees). Record the Estimated E/W Velocity (Report Bytes # 52 - 53) as Vew_{est0} (knots), and record the Report Time of Applicability (Report Bytes # 55 - 56) as t_{R0} (seconds).

Three seconds after the first Surface Position Message, generate another valid Surface Position Message, which includes the same encoded data for Decimal Ground Speed (Movement), the same encoded data for Decimal Ground Track, and updated encoded data for a Decimal Longitude value commensurate with the previously recorded Longitude, the E/W Velocity (Vew_{est0}), and the time between updates of the two Surface Position Messages (t_{X1} - t_{X0}). Verify that the ADS-B Receiver/Report Assembly outputs State Vector Report of Type 0001. Record the Position Time of Applicability as t_{X1} (seconds). Record the Estimated Longitude as Lon_{est1} (degrees), and record the Report Time of Applicability as t_{R1} (seconds).

Verify that $t_{X0} = t_{V0}. = t_{R0}$.

Verify that $t_{X1} = t_{V1}. = t_{R1}$.

Verify that:

$$1852 \times \text{Absolute } [(Lon_{est1} - Lon_{est0}) \times 60 / (t_{X1} - t_{X0} + t_{rng}) - Vew_{est0} / 3600] \cos(Lat)$$

$<$ 0.3 meters/second.

Note: *If $t_{X1} < t_{X0}$, then the Receiving Installation Time has exceeded the maximum time range (see §2.2.8.4) to restart the time count at zero, then the maximum time range, t_{rng} , must be added to (t_{X1} - t_{X0}) to make it positive. Otherwise, consider t_{rng} in the equation to be zero.*

Repeat these Step 4 procedures as necessary, using various parameter values, in order to establish the desired level of confidence.

Step 5: Report Time of Applicability Updating and Reporting (resulting from received Airborne or Surface Position Message) (§2.2.8.1.20.b(3))

Generate a series of valid Airborne Position Messages, which include the encoded data ("ME" Bits 40 - 56) for any suitable changing Longitude values, and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding Longitude presence bit (Report Byte #0, Bit #0), and the Latitude/Longitude Validity Flag (Report Byte #3, Bit 7), are "ONEs."

Verify that the Binary Decoded Report Time of Applicability (Report Bytes # 55 - 56) data changes by an average of 0.5 seconds between each message transmission.

Step 6: East / West Velocity Data Not Available (§2.2.8.1.20.c)

Generate a series of valid Airborne Velocity Messages, which include the encoded data ("ME" Bits 14 - 24) for any suitable E/W Velocity values, force an "Estimated E/W Velocity data not available" condition in the ADS-B Receiver, and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the E/W Velocity presence bit (Report Byte #1, Bit #6), and the Estimated E/W Velocity presence bit (Report Byte #2, Bit #5), are "ONEs," and set the reported Estimated Velocity Validity Flag (Report Byte #4, Bit 7) is a "ZERO."

Verify that the reported Binary Decoded Estimated E/W Velocity data (Report Bytes # 52 - 53) is set to all "ZEROs."

2.4.8.1.21 Verification of Surveillance Status / Discretes Reporting (§2.2.8.1.21)

Purpose/Introduction:

a. The ADS-B Report Assembly Function **shall** extract the Surveillance Status (§2.2.3.2.3.2) from the ADS-B Airborne Position Message (§2.2.3.2.3) and map the surveillance status data into the most significant nibble of the State Vector Report byte on a bit for bit basis as shown in Table 2.2.8.1

b. When valid Surveillance Status data is not available, the ADS-B Report Assembly Function **shall** set the Surveillance Status data provided to the user application to ALL ZEROs.

c. The ADS-B Report Assembly Function **shall** extract the Intent Change Flag (§2.2.3.2.6.1.3 and Figure 2-7a,b) from the ADS-B Airborne Velocity Message (§2.2.3.2.6) and map the Intent Change Flag into the bit "b1" of the least significant nibble of the State Vector Report byte on a bit for bit basis as shown in Table 2.2.8.1.

d. The ADS-B Report Assembly Function **shall** extract the IFR Capability Flag (§2.2.3.2.6.1.4, Figure 2-7a, Figure 2-7b) from the ADS-B Airborne Velocity Message (§2.2.3.2.6) and map the IFR Capability Flag into the bit "b0" of the least significant nibble of the State Vector Report byte on a bit for bit basis as shown in Table 2.2.8.1.

Measurement Procedure:

Step 1: Surveillance Status Updating and Reporting (resulting from received Airborne Position Message) (§2.2.8.1.21.a)

For each case in Table 2-144 below, generate valid Airborne Position Messages, which includes encoded data ("ME" Bits 6 - 7) for the Surveillance Status Test Condition listed, and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding Surveillance Status / Discretes presence bit (Report Byte #3, Bit 3) is a "ONE."

Verify that the reported Binary Decoded Surveillance Status / Discretes data (Report Byte # 54, Bits 5 & 4) match the corresponding bit values indicated in the table.

Table 2-144: Surveillance Status Test Conditions

SURVEILLANCE STATUS / DISCRETES	
Surveillance Status Test Conditions	**Binary Decoded Surveillance Status / Discretes**
No Condition Information	xx00 xxxx
Permanent Alert Condition (Emergency)	xx01 xxxx
Temporary Alert Condition (change in Mode-A Identity Code other than emergency condition)	xx10 xxxx
Special Position Identification (SPI) Condition	xx11 xxxx

Step 2: Surveillance Status Data Not Available (resulting from received Airborne Position Message) (§2.2.8.1.21.b)

Generate a series of valid Airborne Position Messages, force a "Surveillance Status data not available" condition in the ADS-B Receiver, and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding Surveillance Status / Discretes presence bit (Report Byte #3, Bit 3) is a "ONE."

Verify that the reported Binary Surveillance Status / Discretes data (Report Byte # 54, Bits 5 & 4) is set to all "ZEROs."

Step 3: Intent Change Flag Updating and Reporting (resulting from received Airborne Velocity Message) (§2.2.8.1.21.c)

For each case in Table 2-145 below, generate valid Airborne Velocity Messages (Subtype 1), which includes encoded data ("ME" Bit 9) for the Intent Change Flag Test Condition listed, and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding Surveillance Status / Discretes presence bit (Report Byte #3, Bit 3) is a "ONE."

Verify that the reported Binary Decoded Surveillance Status / Discretes data (Report Byte # 54, Bit 1) matches the corresponding bit value indicated in the table.

Table 2-145: Intent Change Flag Test Conditions

SURVEILLANCE STATUS / DISCRETES	
Intent Change Flag Test Conditions	**Binary Decoded Surveillance Status / Discretes**
No Change in Intent	xxxx xx0x
Intent Change	xxxx xx1x

Step 4: IFR Capability Flag Updating and Reporting (resulting from received Airborne Velocity Message) (§2.2.8.1.21.d)

For each case in Table 2-146 below, generate valid Airborne Velocity Messages (Subtype 1), which includes encoded data ("ME" Bit 10) for the IFR Capability

Flag Test Condition listed, and verify that the ADS-B Receiver/Report Assembly outputs State Vector Reports of Type 0001.

Verify that the corresponding Surveillance Status / Discretes presence bit (Report Byte #3, Bit 3) is a "ONE."

Verify that the reported Binary Decoded Surveillance Status / Discretes datum (Report Byte # 54, Bit 0) matches the corresponding bit value indicated in the table.

Table 2-146: IFR Capability Flag Test Conditions

SURVEILLANCE STATUS / DISCRETES	
IFR Capability Flag Test Conditions	**Binary Decoded Surveillance Status / Discretes**
Transmitting aircraft has no capability for applications requiring ADS-B equipage class "A1" or above	xxxx xxx0
Transmitting aircraft has capability for applications requiring ADS-B equipage class "A1" or above	xxxx xxx1

2.4.8.1.22 Verification of Report Mode Reporting (§2.2.8.1.22)

Purpose/Introduction:

The Report Mode is used to indicate the current state of the Report for each ADS-B vehicle being reported. Each time that the State Vector Report is updated, the Report Mode **shall** be updated with the encoding being as shown in Table 2-147:

Table 2-147: Report Mode Encoding

Coding	Report Mode
XXXX 0000	No Report Generation Capability
XXXX 0001	Acquisition Mode (see §2.2.10.2)
XXXX 0010	Track Mode (see §2.2.10.3)
XXXX 0011 through XXXX 1111	Reserved for Future Expansion

Note: *"X" in the table above, denotes "DON'T CARE."*

Measurement Procedure:

Step 1: Acquisition Mode Reporting (§2.2.8.1.22, §2.2.10.2)

Generate two valid Airborne Position Messages within 10 seconds, one **"even"** and one **"odd."**

Verify that the reported Binary Report Mode field (Report Byte #57) is set to "xxxx 0001."

Step 2: Track State Initialization Mode Reporting (§2.2.8.1.22, §2.2.10.3)

Generate one valid Airborne Velocity Message (Subtype 1) within 10 seconds following the last Airborne Position Message provided in Step 1.

Verify that the reported Binary Report Mode field is set to "xxxx 0010."

2.4.8.2 Verification of the ADS-B Mode Status Report (§2.2.8.2)

No specific test procedure is required to validate §2.2.8.2.

2.4.8.2.1 Verification of the Mode Status Report Type and Structure Identification and Validity Flags (§2.2.8.2.1)

Appropriate test procedures are provided in §2.4.8.2.1.1 and §2.4.8.2.1.2.

2.4.8.2.1.1 Verification of Mode Status Report Type and Structure Identification (§2.2.8.2.1.1)

Purpose/Introduction:

The Report Type requirements are provided in §2.2.8.1.1. The Report Structure field is used to indicate the exact data parameters identified in Table 2.2.8.2 that are being provided in the Mode Status report and is intended to provide a methodology for implementers to structure concatenated reports when data for some parameters is not available. This test procedure will be used to verify the correct encoding of the Report Structure (Mode Status Report bits 5 through 24).

Equipment:

Provide a method of supplying the ADS-B receiving system with valid ADS-B Messages.

Measurement Procedure:

Step 1: Incapability of Concatenation:

If the Report Assembly Function is implemented such that the Mode Status Report may be shortened when certain data is not available, skip to Step 2.

If the Report Assembly Function is implemented such that the Mode Status Report is 39 bytes long regardless of data availability across fields, consecutively provide the ADS-B receiving system with valid ADS-B Messages, varying message types appropriately to prompt output of Mode Status Reports. Ensure that in each valid ADS-B Message provided to the receiver, the "AA" field (bits 9 through 32) is set to hexadecimal A60DBE. Verify that in every Mode Status Report provided to the application, bytes 4 through 6 are hexadecimal A60DBE. Verify that the 20-bit Report Structure field is set to ALL ONEs in every Mode Status Report provided to the application. Verify that the Mode Status Report is 38 bytes long. This test procedure is now completed.

Step 2: Capability of Concatenation

Appropriate test procedures to validate this capability are provided in §2.4.8.2.4 through §**Error! Reference source not found.**.

2.4.8.2.1.2 Verification of the Mode Status Report Validity Flags (§2.2.8.2.1.2)

Appropriate test procedures to validate the requirements of this section are provided in §2.4.8.2.4 through §**Error! Reference source not found.**.

2.4.8.2.2 Verification of the Participant Address (§2.2.8.2.2)

Appropriate test procedures reauired to validate the Participant Address (§2.2.3.2.1.1.1) are included in the verification of the "PI" field in §2.4.3.2.1.1.6.

2.4.8.2.3 Verification of the Address Qualifier (§2.2.8.2.3)

Appropriate test procedures required to validate the requiremenets of §2.2.8.2.3 are included in §2.4.8.1.3.

2.4.8.2.4 Verification of the Mode Status Report – Report Time of Applicability (§2.2.8.2.4)

Purpose/Introduction:

Each time that an Individual Mode Status Report is updated, the Report Assembly Function **shall** update the Report Time of Applicability data in the Mode Status Report with either the GPS / GNSS UTC Measure Time data (see §2.2.8.4.1) or the Established Receiver Unit Time (see §2.2.8.4.2), whichever is applicable to the Receiving device Report Assembly Function installation requirements.

Equipment:

The test equipment for this procedure depends on whether the ADS-B receiver under test is meant for Precision Installations or Non-Precision Installations (see §2.2.8.4). For Precision systems, the equipment will need to have the ability to provide GPS/GNSS UTC Measure Time Data via the appropriate interface. For Non-Precision systems, the equipment will include a clock that is appropriately synchronized with the internal clock of the ADS-B receiving system. In both cases, the equipment **shall** have the capability to mark the time when a Mode Status Report is provided to the output buffer.

A method of providing valid ADS-B Messages that are used for constructing Mode Status Reports. Also, provide a method of providing valid Position and Velocity Messages to the ADS-B Receiving system. In all messages provided to the ADS-B receiver, regardless of type, the "AA" field (Message bits 9 through 32) will be set to the same discrete address. The requirement that the "AA" fields be identical is to ensure that the outputted Mode Status Reports are related solely to this test procedure.

Measurement Procedures:

Step 1: Initialization

Provide valid ADS-B Position and Velocity messages to the ADS-B receiving system such that the ADS-B Report Assembly Function enters the Track State (see §2.2.10.4) and is outputting Mode Status Reports to the Report Buffer.

Step 2: Verification of Report Time of Applicability

Provide any of the set of valid ADS-B Messages that are used in producing Mode Status Reports. After one second, provide a valid ADS-B Velocity message to the ADS-B receiving system such that the ADS-B Report Assembly Function is prompted to output a Mode Status Report to the Report Buffer.

Mark the time—via GPS/GNSS UTC for Precision Installations, or the test clock for Non-Precision Installations. Retrieve the resulting Mode Status Report from the Report Buffer. Calculate the time represented in the "Report Time of Applicability" (Report bytes 37 through 38 in the full Mode Status Report) and verify that this time is within 5ms of the previously marked time.

Repeat the process continuously for at least 550 seconds.

2.4.8.2.5 Verification of the Mode Status Report Version Number (§2.2.8.2.5)

Purpose/Introduction:

The ADS-B Report Assembly Function must provide "Version Number" (see §2.2.3.2.7.2.5) data, as received in the Aircraft Operational Status Messages (see §2.2.3.2.7.2), when available, in the Mode Status Report. Otherwise, the Version Number must be assumed to be ZERO.

Measurement Procedure:

Step 1: Initialization

Be able to provide valid ADS-B Aircraft Operational Status Messages to the ADS-B receiving system, from ADS-B Transmitting Systems conforming to both RTCA Document DO-260 and RTCA Document DO-260A, such that the ADS-B Report Assembly Function enters the Track State (see §2.2.10.4) and is outputting Mode Status Reports to the Report Buffer.

Step 2: Verification of Version Number when Data is Not Available

Verify that the ADS-B Aircraft Operational Status Messages are being transmitted from a system conforming to RTCA Document DO-260. Receive the resulting Mode Status Report from the Report Buffer. Verify that the Version Number field (Report Byte 39 in the full Mode Status Report) is set to ALL ZEROs (binary 000).

Step 3: Verification of Version Number

Provide a valid ADS-B Aircraft Operational Status Message to the ADS-B receiving system with the Version Number set as specified in Table A-21, from an ADS-B Transmitting System conformant to RTCA Document DO-260A. Retrieve the resulting Mode Status Report from the Report Buffer. Verify that the Version Number presence bit (Report Byte 2, bit 4) is set to ONE. Verify that the Version Number field (Report Byte 39 in the full Mode Status Report) is set to ONE (binary 001).

2.4.8.2.6 Verification of the Mode Status Report Call Sign (§2.2.8.2.4)

Purpose/Introduction:

The ADS-B Report Assembly Function must extract the Aircraft Identification Character subfields from the ADS-B Flight Identification and Type Message (§2.2.3.2.5.3) for further processing. Each character is encoded in a subset of International Alphabet No. 5 (IA-5) and formatted for the Mode Status Report in accordance with §2.2.8.2.4.

Equipment:

Provide a method of supplying Aircraft Identification Messages to the ADS-B receiving system with the "Identification Character" subfields (Message bits 41 through 88) set as specified in Table 2-148. Also, provide a method of supplying Position and Velocity Messages to the ADS-B Receiving system. In all messages provided to the ADS-B receiver, regardless of type, the "AA" field (Message bits 9 through 32) will be set to the same discrete address. The requirement that the "AA" fields be identical is to ensure that the outputted Mode Status Reports are related solely to this test procedure.

Table 2-148: Mode Status Report Call Sign Encoding

Received Identification Character	Report Encoding
001100	01001100
011010	01011010
010110	01010110
010101	01010101
100000	00100000
110110	00110110
111001	00111001
111100	00111100
110111	00110111
110011	00110011
110101	00110101
000101	01000101
001011	01001011
000011	01000011
000001	01000001
001111	01001111
010001	00010001
011001	00011001

Measurement Procedure:

Step 1: Initialization

Provide valid ADS-B Position and Velocity messages to the ADS-B receiving system such that the ADS-B Report Assembly Function enters the Track State (see §2.2.10.4) and is outputting Mode Status Reports to the Report Buffer.

Step 2: Verification of Call Sign Encoding when Data is Not Available

Retrieve the resulting Mode Status Report from the Report Buffer. If the Call Sign presence bit (Report Byte 0, bit 3) is set to ONE, verify that the "Call Sign" field (Report Bytes 7 through 14 in the full Mode Status Report) is set to ALL ZEROs.

Step 3: Verification of Participant Category Encoding

For each case in Table 2-148 above, provide a valid Aircraft Identification Message to the ADS-B receiving system with each "Identification Character" subfield numbers 1 through 8 (Message bits 41 through 88) set to the same 6-bit encoding as specified in each entry of Table 2-148.

Retrieve the resulting Mode Status Report from the Report Buffer. Verify that the corresponding presence bit (Report Byte 0, bit 3) is set to ONE. Verify that each byte of the "Call Sign" field (Report Bytes 6 through 13 in the full Mode Status Report) is set to the correct value from the "Report Encoding" field of Table 2-148.

2.4.8.2.7 Verification of the Mode Status Report Emitter Category (§2.2.8.2.7)

Purpose/Introduction:

The ADS-B Report Assembly Function must correctly determine the Emitter Category Encoding (Mode Status Report byte #19) from both "TYPE" and "ADS-B Emitter Category" information from the Aircraft Identification and Type Message (§2.2.3.2.5).

Equipment:

A method of providing Aircraft Identification and Type Messages to the ADS-B receiving system with "TYPE" (Message bits 33 through 37) and "ADS-B Emitter Category" (Message bits 38 through 40) fields set as specified in Table 2-149. Also, provide a method of providing Position and Velocity Messages to the ADS-B Receiving system. In all messages provided to the ADS-B receiver, regardless of type, the "AA" field (Message bits 9 through 32) will be set to the same discrete address. The requirement that the "AA" fields be identical is to ensure that the outputted Mode Status Reports are related solely to this test procedure.

Table 2-149: Mode Status Report Emitter Category Meaning

TYPE	ADS-B Emitter Category	Encoding
4	0	0
4	1	1
4	2	3
4	3	5
4	4	6
4	5	7
4	6	8
4	7	10
3	0	0
3	1	11
3	2	12
3	3	16
3	4	15
3	6	13
3	7	14
2	0	0
2	1	20
2	2	21
2	3	22
1	0	0

Measurement Procedure:

Step 1: Initialization

Provide valid ADS-B Position and Velocity messages to the ADS-B receiving system such that the ADS-B Report Assembly Function enters the Track State (see §2.2.10.4) and is outputting Mode Status Reports to the Report Buffer.

Step 2: Verification of Emitter Category Encoding when Data is Not Available

Retrieve the resulting Mode Status Report from the Report Buffer. If the Emitter Category presence bit (Report Byte 0, bit 0) is set to ONE, verify that the "Emitter Category" field (Report Byte 19 in the Mode Status Report) is set to ALL ZEROs.

Step 3: Verification of Emitter Category Encoding

For each case in Table 2-149 above, provide a valid Aircraft Identification and Type Message to the ADS-B receiving system with "TYPE" (Message bits 33 through 37) and "ADS-B Emitter Category" (Message bits 38 through 40) fields set as specified in Table 2-149.

Retrieve the resulting Mode Status Report from the Report Buffer. When the "Encoding" field of Table 2-149 is not 0, verify that the corresponding presence bit (Report Byte 0, bit 0) is set to ONE. If the Emitter Category presence bit (Report Byte 0, bit 0) is set to ONE, verify that the "Emitter Category" field (Report Byte 19 in the Mode Status Report) is set to the correct value from the "Encoding" field of Table 2-149.

2.4.8.2.8 Verification of the A/V Length and Width Codes (§2.2.8.2.8)

Purpose/Introduction:

The ADS-B Report Assemble Function **shall** extract the Aircraft/Vehicle (A/V) Length and Width Codes from the ADS-B Operation Status Message (§2.2.3.2.7.3) when the A/V is on the airport surface. The A/V length and Width Codes **shall** be coded as in Table 2.2.3.2.7.2.11.

Measurement Procedure:

TBD

2.4.8.2.9 Verification of the Mode Status Report Emergency / Priority Status (§2.2.8.2.9)

Purpose/Introduction:

The ADS-B Report Assembly Function will provide Emergency / Priority Status information, when available, in Mode Status Reports.

Equipment:

A method of providing Aircraft Status Messages with any and all possible bit-sets of Message Bits 9 through 11 to the ADS-B receiving system. Also, provide a method of providing Position and Velocity Messages to the ADS-B Receiving system. In all messages provided to the ADS-B receiver, regardless of type, the "AA" field (Message bits 9 through 32) will be set to the same discrete address. The requirement that the "AA" fields be identical is to ensure that the outputted Mode Status Reports are related solely to this test procedure.

Measurement Procedure:

Step 1: Initialization

Provide valid ADS-B Position and Velocity messages to the ADS-B receiving system such that the ADS-B Report Assembly Function enters the Track State (see §2.2.10.4) and is outputting Mode Status Reports to the Report Buffer

Step 2: Emergency / Priority Status - Not Available

Retrieve the resulting Mode Status Report from the Report Buffer. If the Emergency / Priority Status presence bit (Byte 1, bit 6) is set to ONE, verify that the three low order bits of the "Emergency / Priority Status" field (Report Byte 21 in the Mode Status Report) are set to ALL ZEROs.

Step 3: Verification of Emergency / Priority Status Encoding

Provide a valid ADS-B Aircraft Status Message with Message bits 9 through 11 set to 0 (binary 000). After one second, provide a valid ADS-B Velocity message such that a Mode Status Report is output to the Report Buffer.

Retrieve the resulting Mode Status Report from the Report Buffer. Verify that the Emergency / Priority Status presence bit (Byte 1, bit 6) is set to ONE. Verify that the "Emergency / Priority Status" field (Report Byte 21 in the Mode Status Report), bits 0, 1 and 2 are set identically to the provided Aircraft Status Message bits 9, 10 and 11 respectively.

Step 4: Repeat

Repeat Step 3 setting the provided Aircraft Status Message bits 9 through 11 to 1, 2, 3, 4 and 5 (binary 001, 010, 011, etc.).

2.4.8.2.10 Verfication of the Capability Codes (§2.2.8.2.10)

Purpose/Introduction:

a. The ADS-B Report Assemble Function **shall** extract the "Capabiilty Class Codes" data (§2.2.3.2.7.2.3) and the target State and Status Information Message from the ADS-B Operational Status Message (§2.2.3.2.7.2) and provide the Capability Class Codes to the user application in the Mode Status Report in the binary format defined in Table 2.2.8.2.

   Capability Class Codes from the ADS-B Operational Status and the Target State and Status Information Messages, **shall** be mapped bit for bit into the 3-byte long Capability Class Codes field of the ADS-B Mode Status Report as defined in Table 2.2.8.2.10.

b. When valid "Capability Class" data is not available for a given parameter, then the Capability Class data sent to the user application for that parameter **shall** be set to ALL ZEROs.

c. When a Mode Status Report is generated and when the only received update to the "Capability Class" data has come from a Target State and Status Information Message, the reported value of all Capability Class parameters **shall** be based on the most recently received Operational Status Message, except updated with the data (i.e., TCAS parameter) received in the subsequent Target State and Status Information Message.

Measurement Procedure:

TBD

2.4.8.2.11 Verification of the Mode Status Report Operational Mode Data (§2.2.8.2.11)

Purpose/Introduction:

The ADS-B Report Assembly Function must extract the "Operational Mode" (see §2.2.3.2.7.2.4) data from the Aircraft Status Message (see §2.2.3.2.7.2) and correctly format said data into the Mode Status Report "Operational Mode Specific Data" parameter (Report bytes 24 through 25).

Equipment:

A method of providing valid Aircraft Status Messages to the ADS-B receiving system with "OM_4" (Message bits 25 through 28), "OM_3" (Message bits 29 through 32), "OM_2" (Message bits 33 through 35), and "OM_1" (Message bits 36 through 39) fields set as specified in Table 2-155. Also, provide a method of providing valid Position and Velocity Messages to the ADS-B receiving system. In all messages provided to the ADS-B receiver, regardless of type, the "AA" field (Message bits 9 through 32) will be set to the same discrete address. . The requirement that the "AA" fields be identical is to ensure that the outputted Mode Status Reports are related solely to this test procedure.

Table 2-155: Mode Status Report Flight Mode Specific Data

Flight Mode Specific Data				
OM_1	**OM_2**	**OM_3**	**OM_4**	**Encoding**
0001	0010	0100	1000	1000 0100 0010 0001
1110	1101	1011	0111	0111 1011 1101 1110

Measurement Procedure:

Step 1: Initialization

Provide valid ADS-B Position and Velocity messages to the ADS-B receiving system such that the ADS-B Report Assembly Function enters the Track State (see §2.2.10.4) and is outputting Mode Status Reports to the Report Buffer.

Step 2: Verification of Flight Mode Specific Data when Data is Not Available

Retrieve the resulting Mode Status Report from the Report Buffer. If the Operational Mode Data presence bit (Report Byte 1, bit 4) is set to ONE, verify that the "Operational Mode Data" field (Report Bytes 24 through 25 in the Mode Status Report) is set to ALL ZEROs.

Step 3: Verification of Operational Mode Data Encoding

TBD

2.4.8.2.12 Verification of the SV Quality – NAC_P (§2.2.8.2.12)

Purpose/Introduction:

The ADS-B Report Assembly Function **shall** extract the NAC_P data from the ADS-B Operational Status Message (§2.2.3.2.7.2) and from the Target State and Status Information Message (§2.2.3.2.7.1.3.11) and map the NAC_P value bit for bit from the received ADS-B Message to the Mode Status Report in the binary format defined in Table 2.2.8.2. WHAT IF THE TWO NAC_P VALUES ARE DIFFERENT???

Measurement Procedure:

TBD

2.4.8.2.13 Verification of the SV Quality – NAC_V (§2.2.8.2.13)

Purpose/Introduction:

The ADS-B Report Assembly Function **shall** extract the NAC_V data from the ADS-B Airborne Velocity Message (§2.2.3.2.6) and map the NAC_V value bit for bit from the received ADS-B Message to the Mode Status Report in the binary format defined in Table 2.2.8.2.

Measurement Procedure:

TBD

2.4.8.2.14 Verification of the SV Quality – SIL (§2.2.8.2.14)

Purpose/Introduction:

The ADS-B Report Assembly Function **shall** extract the SIL data from the ADS-B Operational Status Message (§2.2.3.2.7.2.8) and from the Target State and Status Information Message (§2.2.3.2.7.1.3.13), and map the SIL Value bit for bit from the received ADS-B Message to the Mode Status Report in the binary format defined in Table 2.2.8.2. WHAT IF THE TWO SIL VALUES ARE DIFFERENT???

Measurement Procedure:

TBD

2.4.8.2.15 Verification of the SV Quality – BAQ Reserved (§2.2.8.2.15)

No specific test procedure is required to validate the requirements of §2.2.8.2.15.

2.4.8.2.16 Verification of the SV Quality NIC_{BARO} (§2.2.8.2.16)

Purpose/Introduction:

The ADS-B Reprt Assembly Function **shall** extract the NIC_{BARO} data from the ADS-B Operational Status Message (§2.2.3.2.7.2.***TBD***) and from the Target State and Status Information Message (§2.2.3.2.7.1.3.12), and map the value of the NIC_{BARO} bit from the received ADS-B Message to the Mode Status Report in the binary format defined in Table 2.2.8.2. The NIC_{BARO} field in the Mode Status Report uses the least significant bit of a one-byte field as a one-bit flag that indicates whether or not the barometric pressure altitude that is provided in the State Vector Report has been cross-checked against another source of altitude. WHAT IF THE TWO NIC_{BARO} VALUES ARE DIFFERENT???

Measurement Procedure:

TBD

2.4.8.2.17 Verification of the True/Magnetic Heading (§2.2.8.2.17)

Purpose/Introduction:

The ADS-B Report Assembly Function **shall** extract the Track/Heading and the Horizontal Reference Direction (§2.2.3.2.7.3.12) flag bits from the Operational Status Message (§2.2.3.2.7.3) and set the True/Magnetic Heading field in the Mode Status Report in the binary format defined in Table 2.2.8.2. This item within the Mode Status Report is used to indicate the nature of the Horizontal Direction information being reported in the State Vector Reports and Target State Reports. This applies to both the aircraft reported Horizontal Direction (in the State Vector Report) as well as the target and/or selected Horizontal Direction (in the Target State Report). The encoding of bits 6 and 7 of the report True/Magnetic Heading field **shall** be as defined in Table 2.2.8.2.17. Bit 6 of the True/Magnetic Heading field indicates when Ground Track is being reported (i.e. set to zero) or when Heading is being reported (i.e., set to one). Bit 7 of the True/Magnetic Heading field indicates when Heading based on True North (i.e. set to zero) or when heading based on Magnetic North (i.e. set to one) is being reported.

Measurement Procedure:

TBD

2.4.8.2.18 Verification of the Vertical Rate Type (§2.2.8.2.18)

Purpose/Introduction:

The ADS-B Report Assembly Function **shall** extract the Vertical Rate Source (§2.2.3.2.6.1.10) data from the ADS-B Airborne Velocity Message (§2.2.3.2.6) and set the Vertical Rate Type in the Mode Status Report in the binary format defined in Table 2.2.8.2. The Vertical Rate Type field uses the least significant bit of a one-byte field in the Mode Status Report. This one-bit flag **shall** be set to ZERO (0) to indicate that the Vertical Rate field in the State Vector Report holds the rate of change of barometric pressure altitude. Or, this one-bit flag **shall** be set to ONE (1) to indicate that the Vertical Rate field holds the rate of change of geometric altitude.

Measurement Procedure:

TBD

2.4.8.3 Verification of the ADS-B On-Condition Report Characteristics (§2.2.8.3)

No specific test procedure is required to validate §2.2.8.3.

2.4.8.3.1.1 Verfication of the Target State Report Type and Structure Identification (§2.2.8.3.1.1)

Purpose/Introduction:

The Report Type requirements are provided in §2.2.8.1.1. The Report Structure field is used to indicate the exact data parameters identified in Table 2.2.8.2 that are being provided in the Target State Report and is intended to provide a methodology for implementers to structure concatenated reports when data for some parameters is not available. This test procedure will be used to verify the correct encoding of the Report Structure (Target State Report bits 5 through 16).

Equipment:

Provide a method of supplying the ADS-B receiving system with valid ADS-B Messages.

Measurement Procedure:

Step 1: Incapability of Concatenation:

If the Report Assembly Function is implemented such that the Target State Report may be shortened when certain data is not available, skip to Step 2.

If the Report Assembly Function is implemented such that the Target State Report is 18 bytes long regardless of data availability across fields, consecutively provide the ADS-B receiving system with valid ADS-B Messages, varying message types appropriately to prompt output of Target State Reports. Ensure that in each valid ADS-B Message provided to the receiver, the "AA" field (bits 9 through 32) is set to hexadecimal A60DBE.

Verify that in every Target State Report provided to the application, bytes 3 through 5 are hexadecimal A60DBE. Verify that the 12-bit Report Structure field is set to ALL ONEs in every Target State Report provided to the application. Verify that the Target State Report is 18 bytes long. This test procedure is now completed.

Step 2: Capability of Concatenation

Appropriate test procedures to validate this capability are provided in §2.4.8.3.1.2 through §2.4.8.3.1.15.

2.4.8.3.1.2 Verification of the Participant Address (§2.2.8.3.1.2)

Appropriate test procedures to validate the Participant Address (§2.2.3.2.1.1.1) are included in the verification of the "PI" field in §2.4.3.2.1.1.6.

2.4.8.3.1.3 Verfication of the Address Qualifier (§2.2.8.3.1.3)

Appropriate test procedures required to validate the requirements of §2.2.8.3.1.3 are included in §2.2.8.1.3.

2.4.8.3.1.4 Verification of the Target State Report Time of Applicability (§2.2.8.3.1.4)

Purpose/Introduction:

Each time that an Individual Target State Report is updated, the Report Assembly Function **shall** update the Report Time of Applicability data in the Target State Report with either the GPS / GNSS UTC Measure Time data (see §2.2.8.4.1) or the Established Receiver Unit Time (see §2.2.8.4.2), whichever is applicable to the Receiving device Report Assembly Function installation requirements.

Equipment:

The test equipment for this procedure depends on whether the ADS-B receiver under test is meant for Precision Installations or Non-Precision Installations (see §2.2.8.4). For Precision systems, the equipment will need to have the ability to provide GPS/GNSS UTC Measure Time Data via the appropriate interface. For Non-Precision systems, the equipment will include a clock that is appropriately synchronized with the internal clock of the ADS-B receiving system. In both cases, the equipment **shall** have the capability to mark the time when a Target State Report is provided to the output buffer.

A method of providing valid ADS-B Messages that are used for constructing Target State Reports. Also, provide a method of providing valid Position and Velocity Messages to the ADS-B Receiving system. In all messages provided to the ADS-B receiver, regardless of type, the “AA” field (Message bits 9 through 32) will be set to the same discrete address. The requirement that the “AA” fields be identical is to ensure that the outputted Target State Reports are related solely to this test procedure.

Measurement Procedures:

Step 1: Initialization

Provide valid ADS-B Position and Velocity messages to the ADS-B receiving system such that the ADS-B Report Assembly Function enters the Track State (see §2.2.10.4) and is outputting Target State Reports to the Report Buffer.

Step 2: Verification of Report Time of Applicability

Provide any valid ADS-B Trajectory Intent Message. After one second, provide a valid ADS-B Velocity message to the ADS-B receiving system such that the ADS-B Report Assembly Function is prompted to output a Target State Report to the Report Buffer.

Mark the time—via GPS/GNSS UTC for Precision Installations, or the test clock for Non-Precision Installations. Retrieve the resulting Target State Report from the Report Buffer. Calculate the time represented in the “Report Time of Applicability” (Report bytes 16 through 17 in the full Target State Report) and verify that this time is within 5 ms of the previously marked time.

Repeat the process continuously for at least 550 seconds.

2.4.8.3.1.5 Verification of Horizontal Intent: Horizontal Data Available and Horizontal Target Source Indicator (§2.2.8.3.1.5)

Purpose/Introduction:

The Data Available and Source Indicator parameter **shall**use the two (2) least significant bits within the byte to encode the parameter values defined in §2.2.3.2.7.1.3.7.

Measurement Procedure:

TBD

2.4.8.3.1.6 Verification of the Horizontal Intent: Target Heading or Track Angle (§2.2.8.3.1.6)

Purpose/Introduction:

The Target Heading and Track Angle parameter **shall** use the least significant bit with the first byte and the 8 bits of the second byte to encode the parameter values defined in §2.2.3.2.7.1.3.8.

Measurement Procedure:

TBD

2.4.8.3.1.7 Verification of the Horizontal Intent: Target Heading/Track Indicator (§2.2.8.3.1.7)

Purpose/Introduction:

The Target Heading or Track Indicator parameter **shall**use the least significant bit within the byte to encode the patameter values defined in §2.2.3.2.7.1.3.9.

Measurement Procedure:

TBD

2.4.8.3.1.8 Verification of the Horizontal Intent: Horizontal Mode Indicator (§2.2.8.3.1.8)

Purpose/Introduction:

The Horizontal Mode Indicator parameter **shall** use the two (2) least significant bits within the byte to encode the parameter values defined in §2.2.3.2.7.1.3.10.

Measurement Procedure:

TBD

2.4.8.3.1.9 Verification of the Horizontal Intent: Reserved for Horizontal Conformance Parameter (§2.2.8.3.1.9)

No specific test procedure is required to validate the requirements of §2.2.8.3.1.9.

2.4.8.3.1.10 Verification of the Vertical Intent: Vertical Data Available and Vertical Target Source Indicator (§2.2.8.3.1.10)

Purpose/Introduction:

The Vertical Data Available and Vertical Target Source Indicator parameter **shall** use the two least significant bits within the byte to encode the parameter values defined in §2.2.3.2.7.1.3.1.

Measurement Procedure:

TBD

2.4.8.3.1.11 Verification of the Vertical Intent: Target Altitude (§2.2.8.3.1.11)

Purpose/Introduction:

The Target Altitude parameter **shall** use the three (3) least significant bits within the first byte and the 8 bits of the second byte to encode the parameter values defined in §2.2.3.2.7.1.3.6.

Measurement Procedure:

TBD

2.4.8.3.1.12 Verification of the Vertical Intent: Target Altitude Type (§2.2.8.3.1.12)

Purpose/Introduction:

The Target Altitude Type parameter **shall** use the least significant bit within the byte to encode the parameter values defined in §2.2.3.2.7.1.3.2.

Measurement Procedure:

TBD

2.4.8.3.1.13 Verification of the Vertical Intent: Target Altitude Capability (§2.2.8.3.1.13)

Purpose/Introduction:

The Target Altitude Capability parameter **shall** use the two least significant bits within the byte to encode the parameter values defined in §2.2.3.2.7.1.3.4.

Measurement Procedure:

TBD

2.4.8.3.1.14 Verification of the Vertical Intent: Vertical Mode Indicator (§2.2.8.3.1.14)

Purpose/Introduction:

The Vertical Mode Indicator parameter **shall** use the two (2) least significant bits within the byte to encode the parameter values defined in §2.2.3.2.7.1.3.5.

Measurement Procedure:

TBD

2.4.8.3.1.15 Verification of the Vertical Intent: Reserved for Vertical Conformance (§2.2.8.3.1.15)

No specific test procedure is required to validate the requirement of §2.2.8.3.1.15.

2.4.8.3.2 Verification of the Air Referenced Velocity Report (§2.2.8.3.2)

Purpose/Introduction:

The Air Referenced Velocity (ARV) Report is an On-Condition Report type that **shall** be provided when air-referenced velocity information is received from a target aircraft.

Measurement Procedure:

TBD

2.4.8.3.2.1 Verification of the ARV Report Type and Structure Identification and Validity Flags (§2.2.8.3.2.1)

No specific test procedure is required to validate §2.2.8.3.2.1.

2.4.8.3.2.1.1 Verification of the ARV Report Type and Structure Identification (§2.2.8.3.2.1.1)

Purpose/Introduction:

The Report Type requirements are provided in §2.2.8.1.1. The Report Structure field is used to indicate the exact data parameters identified in Table 2.2.8.2 that are being provided in the Target State Report and is intended to provide a methodology for implementers to structure concatenated reports when data for some parameters is not available. This test procedure will be used to verify the correct encoding of the Report Structure (ARV Report bits 5 through 16).

Equipment:

Provide a method of supplying the ADS-B receiving system with valid ADS-B Messages.

Measurement Procedure:

Step 1: Incapability of Concatenation:

If the Report Assembly Function is implemented such that the ARV Report may be shortened when certain data is not available, skip to Step 2.

If the Report Assembly Function is implemented such that the ARV Report is 14 bytes long regardless of data availability across fields, consecutively provide the ADS-B receiving system with valid ADS-B Messages, varying message types appropriately to prompt output of ARV Reports. Ensure that in each valid ADS-B Message provided to the receiver, the "AA" field (bits 9 through 32) is set to hexadecimal A60DBE.

Verify that in every ARV Report provided to the application, bytes 3 through 5 are hexadecimal A60DBE. Verify that the 12-bit Report Structure field is set to

ALL ONEs in every ARV Report provided to the application. Verify that the ARV Report is 14 bytes long.

Step 2: Capability of Concatenation

Appropriate test procedures to validate this capability are provided in §2.4.8.3.2.2 through §2.4.8.3.2.7

2.4.8.3.2.1.2 Verification of the Validity Flags (§2.2.8.3.2.1.2)

Purpose/Introduction:

The only Validity Flag defined by these MOPS for the Air Referenced Velocity Report uses the two (2) least significant bits of the one-byte field as shown in Table 2.2.8.3.2.1.2.

The “Heading Valid” flag bit in the ARV report **shall** be set to ONE if the “Heading While Airborne” field contains valid heading information, or set to ZERO if that field is known to not contain valid heading information. The reported heading **shall** be indicated as not valid if the received ADS-B Aircraft Velocity Message (§2.2.3.2.6.3.8 or §2.2.3.2.6.4.8) includes a “Magnetic Heading Status Bit” (§2.2.3.2.6.3.6) indicating that “Magnetic Heading Data is NOT Available.”

The “Airspeed Valid” flag bit **shall** be set to ONE if the “Airspeed” field (§2.2.8.3.2.6) contains valid heading information, or ZERO if that field is known to not contain valid airspeed information. The reported airspeed **shall** be indicated as “Not Valid” if the received ADS-B Aircraft Velocity Message (§2.2.3.2.6.3.8 or §2.2.3.2.6.4.8) includes either a value for the “Airspeed” subfield indicating “No Airspeed Information Available,” or includes a value for the “NAC_V” subfield that is invalid.

Measurement Procedure:

TBD

2.4.8.3.2.2 Verification of the Participant Address (§2.2.8.3.2.2)

Appropriate test procedures to validate the Participant Address (§2.2.3.2.1.1.1) are included in the verification of the “PI” field in §2.4.3.2.1.1.6.

2.4.8.3.2.3 Verification of the Address Qualifier (§2.2.8.3.2.3)

Appropriate test procedures required to validate the requirements of §2.2.8.3.1.3 are included in §2.2.8.1.3.

2.4.8.3.2.4 Verification of the Report Time of Applicability (§2.2.8.3.2.4)

Purpose/Introduction:

a. Each time that an individual Air Referenced Velocity Report is updated, the Report Assembly Function **shall** update the Time of Applicability data in the Air Referenced Velocity Report with either the GPS/GNSS UTC Measure Time data (see §2.2.8.4.1) or the Established Receiver Unit Time (see §2.2.8.4.2), whichever is applicable to the Receiving device Report Assembly Function installation requirements.

b. Report Time of Applicability data **shall** be provided in the Air Referenced Velocity report in binary format as defined in Table 2.2.8.3.2.

Equipment:

The test equipment for this procedure depends on whether the ADS-B receiver under test is meant for Precision Installations or Non-Precision Installations (see §2.2.8.4). For Precision systems, the equipment will need to have the ability to provide GPS/GNSS UTC Measure Time Data via the appropriate interface. For Non-Precision systems, the equipment will include a clock that is appropriately synchronized with the internal clock of the ADS-B receiving system. In both cases, the equipment **shall** have the capability to mark the time when a Target State Report is provided to the output buffer.

A method of providing valid ADS-B Messages that are used for constructing Target State Reports. Also, provide a method of providing valid Position and Velocity Messages to the ADS-B Receiving system. In all messages provided to the ADS-B receiver, regardless of type, the "AA" field (Message bits 9 through 32) will be set to the same discrete address. The requirement that the "AA" fields be identical is to ensure that the outputted Target State Reports are related solely to this test procedure.

Measurement Procedures:

Step 1: Initialization

Provide valid ADS-B Position and Velocity messages to the ADS-B receiving system such that the ADS-B Report Assembly Function enters the Track State (see §2.2.10.4) and is outputting ARV Reports to the Report Buffer.

Step 2: Verification of Report Time of Applicability

Provide any valid ADS-B Trajectory Intent Message. After one second, provide a valid ADS-B Velocity Message to the ADS-B receiving system such that the ADS-B Report Assembly Function is prompted to output a ARV Report to the Report Buffer.

Mark the time—via GPS/GNSS UTC for Precision Installations, or the test clock for Non-Precision Installations. Retrieve the resulting ARV Report from the Report Buffer. Calculate the time represented in the "Report Time of Applicability" (Report bytes 16 through 17 in the full ARV Report) and verify that this time is within 5 ms of the previously marked time.

Repeat the process continuously for at least 550 seconds.

2.4.8.3.2.5 Verification of the Airspeed (§2.2.8.3.2.5)

Appropriate test procedures required to validate the requirements of §2.2.8.3.2.5 are included in the following subparagraphs §2.4.8.3.2.5.1 and 2.4.8.3.2.5.2.

2.4.8.3.2.5.1 Verification of True Airspeed (TAS) Reporting

Purpose/Introduction:

Airspeed **shall** be reported over the range of 0 to 4000 knots. The Airspeed parameter is coded with a fixed data structure using the 4 least significant bits of the first byte and the 8 bits of the second byte of the Airspeed field as identified in Table 2.2.8.3.2. For the case where the source message for the Air-Referenced Velocity information is of the type Aircraft Velocity – Subtype 3 (§2.2.3.2.6.3), a reported resolution of 1 knot is used for Airspeed. This generally applies for Aircraft Airspeeds of 0 to 1000 knots, although under certain conditions, as described in §2.2.3.2.6.3, an Airspeed of up to 1022 knots may be reported with 1 knot resolution. For Airspeeds greater than 1000 knots and where the source message for the Air-Referenced Velocity information is of the type Aircraft Velocity – Subtype 4 (§2.2.3.2.6.4), the two (2) least significant bits are set to a value of ZERO (0) thus providing an actual reported resolution of 4 knots.

Measurement Procedure:

Step 1: True Air Speed (TAS) (Subsonic) Reporting

For each case in Table 2.4.8.3.2.5.1a below, generate valid ADS-B Airborne Velocity Messages (Subtype 3, Subsonic) which includes the Airspeed Type Bit (“ME” Bit 25) equal to “ONE,” and the encoded data (“ME” Bits 26 through 35) for the Decimal True Air Speed (TAS) values listed in the table, and verify that the ADS-B Receiver/Report Assembly outputs ARV Reports

Verify that the corresponding Air Speed presence bit (Report Byte #0, Bit 2), and the Air Speed Validity Flag (Report Byte #2, Bit 1), are “ONEs.”

Verify that the reported Binary Decoded TAS datum (Report Bytes #31 through 32) matches the corresponding True Air Speed value in the table.

Table 2.4.8.3.2.5.1a: True Air Speed (Subsonic) Test Data

TRUE AIR SPEED (SUBSONIC)	
Decimal True Air Speed (knots)	**Binary Decoded True Air Speed (Subsonic)**
0	0000 0000 0000 0000
1	0000 0000 0001 0000
2	0000 0000 0010 0000
4	0000 0000 0100 0000
8	0000 0000 1000 0000
16	0000 0001 0000 0000
32	0000 0010 0000 0000
64	0000 0100 0000 0000
128	0000 1000 0000 0000
256	0001 0000 0000 0000
512	0010 0000 0000 0000
1021	0011 1111 1101 0000

Step 2: True Air Speed (TAS) (Supersonic) Reporting

For each case in Table 2.4.8.3.2.5.1b below, generate valid ADS-B Airborne Velocity Messages (Subtype 4, Supersonic) which includes the Airspeed Type Bit (“ME” Bit 25) equal to “ONE,” and the encoded data (“ME” Bits #26 through 35) for the Decimal True Air Speed (TAS) values listed in the table, and verify that the ADS-B Receiver/Report Assembly outputs ARV Reports.

Verify that the corresponding Air Speed presence bit (Report Byte #0, Bit 2), and the Air Speed Validity Flag (Report Byte #2, Bit 1), are “ONEs.”

Verify that the reported Binary Decoded TAS datum (Report Bytes #31 through 32) matches the corresponding True Air Speed value in the table.

Table 2.4.8.3.2.5.1b: True Air Speed (Supersonic) Test Data

TRUE AIR SPEED (SUPERSONIC)	
Decimal True Air Speed (knots)	**Binary Decoded True Air Speed (Supersonic)**
0	0000 0000 0000 0000
4	0000 0000 0100 0000
8	0000 0000 1000 0000
16	0000 0001 0000 0000
32	0000 0010 0000 0000
64	0000 0100 0000 0000
128	0000 1000 0000 0000
256	0001 0000 0000 0000
512	0010 0000 0000 0000
1024	0100 0000 0000 0000
2048	1000 0000 0000 0000
4084	1111 1111 0100 0000

Step 3: True Air Speed (TAS) (Subsonic / Supersonic) Data Not Available

Keep the Airspeed presence bit at "ONE," and set the Airspeed Validity Flag to "ZERO."

Verify that the reported Binary Decoded TAS datum is set to all "ZEROs."

2.4.8.3.2.5.2 Verification of Indicated Airspeed (IAS) Reporting

Purpose/Introduction:

Airspeed **shall** be reported over the range of 0 to 4000 knots. The Airspeed parameter is coded with a fixed data structure using the 4 least significant bits of the first byte and the 8 bits of the second byte of the Airspeed field as identified in Table 2.2.8.3.2. For the case where the source message for the Air-Referenced Velocity information is of the type Aircraft Velocity – Subtype 3 (§2.2.3.2.6.3), a reported resolution of 1 knot is used for Airspeed. This generally applies for Aircraft Airspeeds of 0 to 1000 knots, although under certain conditions, as described in §2.2.3.2.6.3, an Airspeed of up to 1022 knots may be reported with 1 knot resolution. For Airspeeds greater than 1000 knots and where the source message for the Air-Referenced Velocity information is of the type Aircraft Velocity – Subtype 4 (§2.2.3.2.6.4), the two (2) least significant bits are set to a value of ZERO (0) thus providing an actual reported resolution of 4 knots.

Measurement Procedure:

Step 1: Indicated Air Speed (IAS) (Subsonic) Reporting

For each case in Table 2.4.8.3.2.5.2a below, generate valid ADS-B Airborne Velocity Messages (Subtype 3, Subsonic) which includes the Airspeed Type Bit ("ME" Bit 25) equal to "ZERO," and the encoded data ("ME" Bits 26 through 35) for the Decimal Indicated Air Speed (IAS) values listed in the table, and verify that the ADS-B Receiver/Report Assembly outputs ARV Reports.

Verify that the corresponding Air Speed presence bit (Report Byte #0, Bit 2), and the Air Speed Validity Flag (Report Byte #2, Bit 1), are "ONEs."

Verify that the reported Binary Decoded IAS datum (Report Bytes # 33 through 34) matches the corresponding Indicated Air Speed value in the table.

Table 2.4.8.3.2.5.2a: Indicated Air Speed (Subsonic) Test Data

INDICATED AIR SPEED (SUBSONIC)	
Decimal Indicated Air Speed (knots)	**Binary Decoded Indicated Air Speed (Subsonic)**
0	0000 0000 0000 0000
1	0000 0000 0001 0000
2	0000 0000 0010 0000
4	0000 0000 0100 0000
8	0000 0000 1000 0000
16	0000 0001 0000 0000
32	0000 0010 0000 0000
64	0000 0100 0000 0000
128	0000 1000 0000 0000
256	0001 0000 0000 0000
512	0010 0000 0000 0000
1021	0011 1111 1101 0000

Step 2: Indicated Air Speed (IAS) (Supersonic) Reporting

For each case in Table 2.4.8.3.2.5.2b below, generate valid ADS-B Airborne Velocity Messages (Subtype 4, Supersonic) which includes the Airspeed Type Bit ("ME" Bit 25) equal to "ZERO," and the encoded data ("ME" Bits 26 through 35) for the Decimal Indicated Air Speed (IAS) values listed in the table, and verify that the ADS-B Receiver/Report Assembly outputs ARV Reports.

Verify that the corresponding Air Speed presence bit (Report Byte #0, Bit 2), and the Air Speed Validity Flag (Report Byte #2, Bit 1), are "ONEs."

Verify that the reported Binary Decoded IAS datum (Report Bytes # 33 through 34) matches the corresponding Indicated Air Speed value in the table.

Table 2.4.8.3.2.5.2b: Indicated Air Speed (Supersonic) Test Data

INDICATED AIR SPEED (SUPERSONIC)	
Decimal Indicated Air Speed (knots)	**Binary Decoded Indicated Air Speed (Supersonic)**
0	0000 0000 0000 0000
4	0000 0000 0100 0000
8	0000 0000 1000 0000
16	0000 0001 0000 0000
32	0000 0010 0000 0000
64	0000 0100 0000 0000
128	0000 1000 0000 0000
256	0001 0000 0000 0000
512	0010 0000 0000 0000
1024	0100 0000 0000 0000
2048	1000 0000 0000 0000
4084	1111 1111 0100 0000

Step 3: Indicated Air Speed (IAS) (Subsonic / Supersonic) Data Not Available

Keep the Airspeed presence bit at "ONE," and set the Airspeed Validity Flag to "ZERO."

Verify that the reported Binary Decoded IAS datum is set to all "ZEROs."

2.4.8.3.2.6 Verification of the Airspeed Type (§2.2.8.3.2.6)

Purpose/Introduction:

The Airspeed Type and Validity field in the Air Referenced Velocity report is a 2-bit field that **shall** be encoded as specified in Table 2.2.8.3.2.7. The type of Airspeed being reported **shall** be obtained from the "Airspeed Type" subfield of the ADS-B Aircraft Velocity Message, Subtype 3 (§2.2.3.2.6.3.8) or Subtype 4 (§2.2.3.2.6.4.8). The reported Airspeed **shall** be indicated as "Not Valid" if the received ADS-B Aircraft Velocity Message (§2.2.3.2.6.3.8 or §2.2.3.2.6.4.8) includes either a value for the "Airspeed" subfield indicating "No Airspeed Information Available," or includes a value for the "NAC_V" subfield that is invalid. When set to indicate the "Airspeed Field is Not Valid," the corresponding Validity Flag parameter (§2.2.8.2.2.1.2) **shall** also be set to indicate that the reported Airspeed is not valid.

Measurement Procedure:

TBD

2.4.8.3.2.7 Verification of the Heading While Airborne (§2.2.8.3.2.7)

Purpose/Introduction:

An Aircraft's Heading is reported as the angle measured clockwise from the reference direction (magnetic north) to the direction in which the Aircraft's nose is pointing. The heading field in Air Reference Velocity reports **shall** be encoded using the 2 least significant bits of the first byte and the 8 bits of the second byte of the "Heading While Airborne" field as defined in Table 2.2.8.3.2. The encoding **shall** be the same as that used in the "Magnetic Heading" subfield of the ADS-B Airborne Velocity Message – Subtype 3 as defined in §2.2.3.2.6.3.7.

Measurement Procedure:

Step 1: Magnetic Heading Reporting

For each case in Table 2.4.8.3.2.7 below, generate valid ADS-B Airborne Velocity Messages ("Type" code 19, Subtype 3), which include the encoded data

("ME" Bits 14 and 15 through 24) for the Magnetic Heading Status Bit and the Decimal Magnetic Heading values listed, and verify that the ADS-B Receiver/Report Assembly outputs ARV Reports.

Verify that the corresponding Magnetic Heading presence bit (Report Byte #0, Bit 0), and the Magnetic Heading Validity Flag (Report Byte #2, Bit 0), are "ONEs."

Verify that the reported Binary Decoded Magnetic Heading data (Report Bytes # 37 through 38) match the corresponding value in the table.

Table 2.4.8.3.2.7: Magnetic Heading Test Data

MAGNETIC HEADING		
Magnetic Heading Status	**Decimal Magnetic Heading (degrees)**	**Binary Decoded Magnetic Heading**
0	11.2500	0000 0000 0000
0	359.6484	0000 0000 0000
1	0.0000	0000 0000 0000
1	0.3516	0000 0000 0001
1	0.7031	0000 0000 0010
1	1.4063	0000 0000 0100
1	2.8125	0000 0000 1000
1	5.6250	0000 0001 0000
1	11.2500	0000 0010 0000
1	22.5000	0000 0100 0000
1	45.0000	0000 1000 0000
1	90.0000	0001 0000 0000
1	180.0000	0010 0000 0000
1	359.6484	0011 1111 1111

Step 2: Magnetic Heading Data Not Available

Keep the Magnetic Heading presence bit at "ONE," and set the Magnetic Heading Validity Flag to "ZERO."

Verify that the reported Binary Decoded Magnetic Heading datum is set to all "ZEROs."

2.4.8.4 Verification of the Receiving Installation Time Processing (§2.2.8.4)

No specific test procedure is required to validate §2.2.8.4.

2.4.8.4.1 Verification of Precision Installations (§2.2.8.4.1)

Purpose/Introduction

Receiving devices intended to generate ADS-B reports based on Surface Position Messages received from type 5 or 6 (see §2.2.3.2.3.1) equipment or Airborne Position Messages received from type 9 or 10 (see §2.2.3.2.3.1) equipment **shall** accept GPS/GNSS UTC Measure Time data via an appropriate interface. Such data **shall** be used to establish Time of Applicability data required in §**Error! Reference source not found.** through §2.2.8.1.20, §**Error! Reference source not found.**, §2.2.8.2.4, and §**Error! Reference source not found.**.

UTC Measure Time data **shall** have a minimum range of 300 seconds and a resolution of 0.0078125 (1/128) seconds.

Equipment:

A method of providing Surface Position messages of TYPE 5 or 6 and Airborne Position messages of TYPE 9 or 10 to the ADS-B Receiving Device. Also, a method of providing appropriate messages to prompt output of State Vector reports to the Report Buffer. All messages must have the "TIME" subfield set to ZERO.

Measurement Procedure:

Step 1: Verification of UTC Measure Time Data.

Configure the ADS-B Receiving device to output reports by providing the appropriate messages at the nominal rate, providing GPS/GNSS UTC Measure Time data appropriately. Mark TIME ZERO as the Time of Applicability provided in the first report. Note also the time that the message was provided that prompted the output of the first report.

Continue to provide messages at the nominal rate, extracting the Time of Applicability from each report that is outputted. Verify that time of applicability is properly reported within the accuracies of the established system clock.

300 seconds after the message that prompted the first report, provide a valid Surface Position message with the TYPE subfield set to 5 or 6, and the TIME subfield set to ZERO.

Verify that in the resulting report, the Time of Applicability field does not reflect a value between TIME ZERO and 300 seconds.

Step 2: Repeat:

Repeat Step 1, using Airborne Position Messages of TYPE 9 or 10 instead of the previously specified Surface Position Messages.

2.4.8.4.2 Verification of the Non-Precision Installations (§2.2.8.4.2)

Purpose/Introduction

Receiving devices that are not intended to generate ADS-B reports based on Surface Position Messages received from type 5 or 6 (see §2.2.3.2.3.1) equipment or Airborne Position Messages received from type 9, 10, 20 or 21 (see §2.2.3.2.3.1) equipment may choose not to use GPS/GNSS UTC Measure Time data if there is no requirement to do so by the end user of the ADS-B reports. In such cases, where there is no appropriate time reference, the Receiving device **shall** establish an appropriate internal clock or counter having a maximum clock cycle or count time of 20 milliseconds. The established cycle or clock count **shall** have a range of 300 seconds and a resolution of 0.0078125 (1/128) seconds in order to maintain commonality with the requirements of §2.2.8.4.1.

Equipment:

A method of providing Surface Position messages of TYPE other than 5 or 6 and Airborne Position messages of TYPE other than 9, 10, 20, or 21 to the ADS-B Receiving Device. Also, a method of providing appropriate messages to prompt output of State Vector reports to the Report Buffer. All messages must have the "TIME" subfield set to ZERO.

Measurement Procedure:

Step 1: Verification of Internal Clock Time Data.

Configure the ADS-B Receiving device to output reports by providing the appropriate messages at the nominal rate. Mark TIME ZERO as the Time of Applicability provided in the first report. Note also the time that the message was provided that prompted the output of the first report.

Continue to provide messages at the nominal rate, extracting the Time of Applicability from each report that is outputted. Verify that time of applicability is properly reported within the accuracies of the established system clock.

300 seconds after the message that prompted the first report, provide a valid Surface Position message with the TYPE subfield set to other than 5 or 6, and the TIME subfield set to ZERO.

Verify that in the resulting report, the Time of Applicability field does not reflect a value between TIME ZERO and 300 seconds.

Step 2: Repeat:

Repeat Step 1, using Airborne Position Messages of TYPE other than 9, 10, 20, or 21 instead of the previously specified Surface Position Messages.

2.4.9 Verification of the ADS-B Report Type Requirements (§2.2.9)

No specific test procedure is required to validate §2.2.9.

2.4.9.1 Verification of the ADS-B Receiver Reporting Requirements for Class A Equipage (§2.2.9.1)

Purpose/Introduction:

ADS-B Report Requirements for Class A Equipage are defined in Table 2.2.9.1a. For each required report type all data elements, as defined in §2.2.8.1 through §2.2.8.3 (inclusive of subparagraphs), **shall** be included for which valid information is available (i.e., current information that has been received via one or multiple ADS-B Messages or is available from an onboard data source). Although the report assembly function is required to support all data elements defined for the report types applicable to that Equipage Class, as per Table 2.2.9.1a, reports may be generated that convey only a subset of the report elements. This is a consequence of certain data elements only being applicable while airborne and others that are only applicable while on the surface. Also the ADS-B Messages may not have been received that included the information necessary to report a valid value for a given report data element. For each of the four types of reports there is a set of mandatory data elements that **shall** be included. The required mandatory set of data elements is defined in Table 2.2.9.1b through Table 2.2.9.1e inclusive) for the four report types.

Measurement Procedure:

TBD

2.4.9.1.1 Verification of the ADS-B State Vector Reports for Class A Equipage (§2.2.9.1.1)

The test procedures outlined in §2.4.8.1.1 through §2.4.8.1.22 **shall** be used to validate the requirements of §2.2.9.1.1.

2.4.9.1.2 Verification of the ADS-B Mode Status Reports for Class A Equipage (§2.2.9.1.2)

Purpose/Introduction

Equipage Class A0, A1, A2 and A3 equipment **shall** provide Mode Status Reports as indicated in §2.2.9.1. An example report format is shown in Table 2.2.8.2.

Measurement Procedure:

TBD

2.4.9.1.3 Verification of the ADS-B Target State Reports for Class A Equipage (§2.2.9.1.3)

Purpose/Introduction

a. Equipage Class A0 and A1 equipment are not required to provide Target State Reports.

b. Equipage Class A2 and A3 equipment **shall** provide Target State Reports as indicated in §2.2.9.1. An example report format is shown in Table 2.2.8.3.1.

Measurement Procedure:

a. Equipage Class A0 and A1 equipment are not required to comply with any of the test procedures in §2.4.8.3.

c. As a minimum, equipage Class A3 equipment **shall** perform test procedures outlined in §**Error! Reference source not found.** through §**Error! Reference source not found.** in order to validate the requirements of §2.2.9.1.3.b.

2.4.9.1.4 Verification of the ADS-B Air Referenced Velocity Reports for Class A Equipage (§2.2.9.1.4)

Purpose/Introduction:

a. Equipage Class A0 equipment is not required to provide Air Referenced Reports.

b. Equipage Class A1, A2 and A3 equipment **shall** generate an Air Referenced Velocity Report as indicated in §2.2.9.1. An example report format is shown in Table 2.2.8.3.2.

Measurement Procedure:

TBD

2.4.9.2 Verification of the ADS-B Receiver Report Content Requirements for Class B Equipage (§2.2.9.2)

There are no report requirements for Class B, i.e., Broadcast Only, Equipage.

No specific test procedure is required to validate §2.2.9.2.

2.4.10 Verification of the ADS-B Receiver Report Assembly and Delivery (§2.2.10)

No specific test procedure is required to validate §2.2.10.

2.4.10.1 Verification of the Fundamental Principals of Report Assembly and Delivery (§2.2.10.1)

No specific test procedure is required to validate §2.2.10.1.

2.4.10.1.1 Verification of the General Data Flow (§2.2.10.1.1)

No specific test procedure is required to validate §2.2.10.1.1.

2.4.10.1.2 Verification of the ADS-B Report Organization (§2.2.10.1.2)

Purpose/Introduction

All ADS-B Message receptions and Reports **shall** be organized (i.e., indexed) in accordance with the Participant Address that is transmitted in the "AA" Address Field of all ADS-B transmitted messages (see §2.2.3.2.1.1.1). The Participant Address **shall** be a mandatory element in all ADS-B Reports (see Table 2.2.8.1 Item 1, Table 2.2.8.2 Item 1, and Table 2.2.8.3.1 Item 1).

Equipment Required:

a. Equipment capable of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test through the operational interface.

b. A method of monitoring ADS-B broadcast messages output by the equipment under test.

Measurement Procedure:

Set the Airborne condition and load valid data into all the ADS-B Broadcast messages that can be supported by the equipment under test at a rate ensuring maximum transmission rate for a period of at least five (5) minutes. Ensure that ADS-B Messages will cause reports to be generated by the Report Assembly Function. Halt the transmission of ADS-B Messages and examine the contents of the database of messages and reports and verify that the messages and reports are being organized (i.e., indexed) in accordance with the Participant Address.

2.4.10.1.3 Verification of the ADS-B Message Temporary Retention (§2.2.10.1.3)

Purpose/Introduction:

Unless otherwise specified, all ADS-B Messages and decoded latitudes and longitudes received for a given Participant Address **shall** be appropriately time tagged and temporarily stored for at least 200 seconds unless replaced by a received message of equivalent type. If no new messages have been received from a given Participant for 250 seconds, then all records (including temporary storage) relevant to the Participant Address **shall** be deleted from the Report Output Storage Buffer.

Measurement Procedure:

Step 1: Airborne Mode – 25 Participants

Set up an Airborne scenario and simulation for a minimum of 25 Participants at various altitudes, velocities, initial positions and general directions. Design the simulation to include Participants that are traveling toward, away from, and crossing in the vicinity of, the ADS-B Receiving Device. The simulation must include several random Participants that appear for a short period of time of not less than fifteen (15), and not greater than twenty five (25) seconds, with accompanying issue of “**even**” and “**odd**” encoded Airborne Position Messages, and then disappear from the simulation altogether. These same Participants should be re-introduced to the simulation after an absence of at least 500 seconds.

Configure the ADS-B Transmitting System simulation to transmit Airborne Velocity Messages, Airborne Position Messages, Aircraft Trajectory Intent Messages, Aircraft ID and Type Messages, Aircraft Operational Coordination Messages and Aircraft Operational Status Messages at a rate ensuring maximum transmission rate for a period of at least twenty (20) minutes.

Initiate the simulation and verify that all received data for a given individual Participant is being stored in temporary storage within a single track file. Verify that each entry contains a time tag. Verify that for those Participants that are continuing through out the simulation that updated information replaces old information upon the receipt of the new information. Verify that for those Participants that were introduced for a short period of time between 15 and 25 seconds that each track file for that Participant is retained for at least 250 seconds. Verify that if no new messages are received for a given Participant for a period of 250 seconds, that all data relevant to that Participant is deleted from the Report Output Storage Buffer.

Verify that when this same Participant is re-introduced to the simulation that the new set of data is stored in temporary storage and a new track file initiated with none of the data from the previous track.

Step 2: Surface Mode – 25 Participants

Set up a Surface scenario and simulation for a minimum of 25 Participants at various ground speeds, initial positions and general direction of travel. Design the simulation to include Participants that are traveling toward, away from, and crossing in the vicinity of, the ADS-B Receiving Device. The simulation must include random Participants that appear for a short period of time of not less than fifteen (15), and not greater than twenty five (25) seconds, and then disappear from the simulation altogether. This same Participant should be re-introduced to the simulation after an absence of at least 500 seconds.

Configure the ADS-B Transmitting System simulation to transmit Surface Position Messages, Aircraft ID and Type Messages, and if appropriate Aircraft Operational Status Messages, at a rate ensuring maximum transmission rate for a period of at least twenty (20) minutes.

Initiate the simulation and verify that all received data for a given individual Participant is being stored in temporary storage within a single track file. Verify that each entry contains a time tag. Verify that for those Participants that are continuing through out the simulation that updated information replaces old information upon the receipt of the new information. Verify that for those Participants that were introduced for a short period of time between 15 and 25 seconds that each track file for that Participant is retained for at least 250 seconds. Verify that if no new messages are received for a given Participant for a period of 250 seconds, that all data relevant to that Participant is deleted from the Report Output Storage Buffer.

Verify that when this same Participant is re-introduced to the simulation that the new set of data is stored in temporary storage and a new track file initiated with none of the data from the previous track.

Step 3: Airborne Mode – 100 Participants

Repeat Step 1 above with a minimum of 100 individual Participants with various individual altitudes, velocities, initial positions and general directions.

2.4.10.1.4 Verification of the Participant ADS-B Track Files (§2.2.10.1.4)

Purpose/Introduction

A Track File is defined as the accumulation of reports maintained on a given participant. In the ADS-B case, the Track File refers to the State Vector, Mode Status, and TCP+1 Reports that comprise a set of reports maintained on a given participant.

The ADS-B Report Assembly function **shall** maintain one, and only one, Track File, i.e., set of reports on any given participant.

Measurement Procedure:

Verify that one, and only one Track file is created and maintained for each Participant.

2.4.10.2 Verification of the Report Assembly Initialization State (§2.2.10.2)

Appropriate test procedures for verifying that the Report Assembly Function correctly enters the "Initialization State" are provided in §2.4.10.1.3.

2.4.10.3 Verification of the Report Assembly Acquisition State (§2.2.10.3)

No specific test procedure is required to validate §2.2.10.3.

2.4.10.3.1 Verification of the Report Assembly Acquisition State --- Airborne Participant (§2.2.10.3.1)

Purpose/Introduction

Upon receipt of an ***"even"*** and an ***"odd"*** encoded Airborne Position Message from a given Participant within a ten second period, the Report Assembly Function **shall**:

a. Perform a successful Globally Unambiguous CPR decode of the Participant Position in accordance with §A.1.7.7 of Appendix A,

b. Set the Report Mode to "Acquisition" for the given Airborne Participant in the State Vector Report (see §2.2.8.1) in accordance with §2.2.8.1.22,

c. Structure all possible fields of the State Vector Report for the given Airborne Participant in accordance with §2.2.8.1 (all subsections inclusive),

d. Deliver the first structured State Vector Report for the given Airborne Participant to the Report Output Storage Buffer for subsequent access by the Application Interface on demand,

e. Continue to maintain the integrity of the State Vector Report for the given Airborne Participant in the Report Output Storage Buffer for at least 200 seconds unless replaced by an updated State Vector Report or otherwise specified in the following sections, the conditions of the following subparagraphs **shall** apply:

f. If a new Position Message is not received within a 120 second period, then the Globally Unambiguous CPR decode performed in step a. **shall** be considered to be invalid, and the Report Assembly Function **shall** return to the Initialization State. (In order to proceed to the Track State for this Airborne Participant, the Globally Unambiguous CPR decode will need to be repeated.)

Note: *This action effectively represents a return to the Initialization State with the exception that the return is to step a. above, and the report is retained as per step e. The purpose of this action is to minimize the need to perform the Globally Unambiguous CPR decode since it is not necessary when position messages have been received within the reasonable time limit of 120 seconds. This action is illustrated in Figure 2-16b.*

g. If no new messages have been received from a given Airborne Participant for at least 200 seconds, then all reports relevant to the Participant Address **shall** be deleted from the Report Output Storage Buffer.

Measurement Procedure:

Step 1: Globally Unambiguous CPR Decode

It is not the purpose of this Test procedure to re-test the individual elements of this requirement such as Globally Unambiguous CPR Decode and State Vector Report generation. These elements are tested elsewhere in these procedures.

Therefore, using the Airborne scenario and simulation set up in Step 1 of §2.4.10.1.3 above, verify that for each Participant for which an "**even**" and an "**odd**" pair of encoded Airborne Position Messages is received within a ten (10) second period that the Report Assembly Function correctly performs a successful Globally Unambiguous CPR Decode in accordance with §A.1.7.7 of Appendix A.

Step 2: Report Mode set to Acquisition

Verify that for each Participant in the Airborne scenario and simulation set up in Step 1 of §2.4.10.1.3 above, where you have verified in Step 1 above that an "**even**" and an "**odd**" encoded Airborne Position Message was received within a ten (10) second period that the Report Assembly Function correctly sets the Report Mode to "Acquisition" in the State Vector Report in accordance with the formatting specified in §2.2.8.1.22.

Step 3: State Vector Report Creation

Verify that for each Participant in the Airborne scenario and simulation set up in Step 1 of §2.4.10.1.3 above, where you have verified in Step 1 above that an "**even**" and an "**odd**" encoded Airborne Position Message was received within a ten (10) second period that the Report Assembly Function correctly structures all possible fields of the State Vector Report for the given Airborne Participant in accordance with §2.2.8.1 (all subsections inclusive).

Step 4: Report Output Storage Buffer Initialization

Verify that for each Participant in the Airborne scenario and simulation set up in Step 1 of §2.4.10.1.3 above, where you have verified in Step 1 above that an "**even**" and an "**odd**" encoded Airborne Position Message was received within a ten (10) second period that the Report Assembly Function correctly delivers the first structured State Vector Report for the given Airborne Participant to the Report Output Storage Buffer for subsequent access by the Application Interface, within 500 milliseconds of receipt of the second Airborne Position Message of the "**even**" and "**odd**" pair for the given Airborne Participant.

Step 5: Maintenance of Report Output Storage Buffer

Verify that for each Participant in the Airborne scenario and simulation set up in Step 1 of §2.4.10.1.3 above, where you have verified in Step 1 above that an "**even**" and an "**odd**" encoded Airborne Position Message was received within a ten (10) second period that the Report Assembly Function correctly maintains the integrity of the State Vector Report for the given Airborne Participant in the Report Output Storage Buffer for at least 200 seconds unless:

a. replaced by an updated State Vector Report, or

b. no new messages have been received from a given Airborne Participant for a period of 100 +/- 5 seconds, in which case, verify that all reports relevant to the Airborne Participant Address have been deleted from the Report Output Storage Buffer.

Step 6: New Globally Unambiguous CPR Decode

Verify that for each Participant in the Airborne scenario and simulation set up in Step 1 of §2.4.10.1.3 above, where you have verified in Step 1 above that an "**even**" and an "**odd**" encoded Airborne Position Message was received within a ten (10) second period that the Report Assembly Function correctly maintains the integrity of the State Vector Report for the given Airborne Participant in the Report Output Storage Buffer for at least 200 seconds unless a new Airborne Position Message is received within a 120 second period for the given Airborne Participant.

Verify that when a new Airborne Position Message is received for a given Airborne Participant within a 120 second period, that the Report Assembly Function performs a new Globally Unambiguous CPR Decode as specified in Step 1 above and verify that the new information is correctly updated in the State Vector Report and the Report Output Storage Buffer for the given Airborne Participant.

Verify that when no new Airborne Position Message is received for a given Airborne Participant within a 120 second period, that the Report Assembly Function correctly sets the Report Mode to "Initialization" (No Report Generation Capability mode) in the State Vector Report in accordance with the formatting in §2.2.8.1.22.

<u>Step 7:</u> <u>Purge Participant from the Report Output Storage Buffer</u>

Verify that for each Participant in the Airborne scenario and simulation set up in Step 1 of §2.4.10.1.3 above, where you have verified in Step 1 above that an "**even**" and an "**odd**" encoded Airborne Position Message was received within a ten (10) second period that the Report Assembly Function correctly maintains the integrity of the State Vector Report for the given Airborne Participant in the Report Output Storage Buffer for at least 200 seconds unless replaced by an updated State Vector Report for the given Airborne Participant

Verify that when no new Messages of any type have been received from a given Airborne Participant for at least 200 seconds, that the Report Assembly Function correctly deletes all reports relevant to the given Airborne Participant Address from the Report Output Storage Buffer.

2.4.10.3.1.1 Verification of the Latency, Report Assembly Acquisition State --- Airborne Participant (§2.2.10.3.1.1)

<u>Purpose/Introduction:</u>

Step "d" in §2.2.10.3.1 **shall** be completed within 500 milliseconds of receipt of the second Airborne Position Message of the "**even**" and "**odd**" pair.

<u>Measurement Procedure:</u>

Appropriate test procedures for the verification of this requirement are provided in §2.4.10.3.1, Step 4.

2.4.10.3.2 Verification of the Report Assembly Acquisition State --- Surface Participant (§2.2.10.3.2)

<u>Purpose/Introduction</u>

Upon receipt of an ***"even"*** and an ***"odd"*** encoded Surface Position Message from a given Participant within a ten second period, the Report Assembly Function **shall**:

a. Perform a successful Locally Unambiguous CPR decode of the Participant Position in accordance with §A.1.7.6 of Appendix A,

b. Set the Report Mode to "Track" for the given Surface Participant in the State Vector Report (see §2.2.8.1) in accordance with §2.2.8.1.22,

c. Structure all possible fields of the State Vector Report for the given Surface Participant in accordance with §2.2.8.1(all subsections inclusive),

d. Deliver the first structured State Vector Report for the given Surface Participant to the Report Output Storage Buffer for subsequent access by the Application Interface on demand,

e. Continue to maintain the integrity of the State Vector Report for the given Surface Participant in the Report Output Storage Buffer for at least 200 seconds unless replaced by an updated State Vector Report or otherwise specified in the following sections, and the conditions of the following subparagraphs **shall** apply:

f. If a new Position Message is not received within a 120 second period, then the Locally Unambiguous CPR decode performed in step a. **shall** be considered to be invalid. In order to proceed from the Acquisition State to the Track State, the Locally Unambiguous CPR decode must be repeated.

Note: *This action effectively represents a return to the Initialization State with the exception that the return is to step a. above, and the report is retained as per step e. The purpose of this action is to minimize the need to perform the Locally Unambiguous CPR decode since it is not necessary when position messages have been received within the reasonable time limit of 120 seconds. This action is illustrated in Figure 2-16b.*

g. If no new messages have been received from a given Surface Participant for at least 200 seconds, then all reports relevant to the Participant Address **shall** be deleted from the Report Output Storage Buffer.

Measurement Procedure:

Step 1: Locally Unambiguous CPR Decode

It is not the purpose of this Test procedure to re-test the individual elements of this requirement such as Locally Unambiguous CPR Decode and State Vector Report generation. These elements are tested elsewhere in these procedures.

Therefore, using the Surface scenario and simulation set up in Step 2 of §2.4.10.1.3 above, verify that for each Participant for which an "**even**" and an "**odd**" pair of encoded Surface Position Messages is received within a ten (10) second period that the Report Assembly Function correctly performs a successful Locally Unambiguous CPR Decode in accordance with §A.1.7.6 of Appendix A.

Step 2: Report Mode set to Track

Verify that for each Participant in the Surface scenario and simulation set up in Step 2 of §2.4.10.1.3 above, where you have verified in Step 1 above that an "**even**" and an "**odd**" encoded Surface Position Message was received within a ten (10) second period that the Report Assembly Function correctly sets the Report Mode to "Track" in the State Vector Report in accordance with the formatting specified in §2.2.8.1.22.

Step 3: State Vector Report Creation

Verify that for each Participant in the Surface scenario and simulation set up in Step 2 of §2.4.10.1.3 above, where you have verified in Step 1 above that an "**even**" and an "**odd**" encoded Surface Position Message was received within a ten (10) second period that the Report Assembly Function correctly structures all possible fields of the State Vector Report for the given Surface Participant in accordance with §2.2.8.1 (all subsections inclusive).

Step 4: Report Output Storage Buffer Initialization

Verify that for each Participant in the Surface scenario and simulation set up in Step 2 of §2.4.10.1.3 above, where you have verified in Step 1 above that an "**even**" and an "**odd**" encoded Airborne Position Message was received within a ten (10) second period that the Report Assembly Function correctly delivers the first structured State Vector Report for the given Surface Participant to the Report Output Storage Buffer for subsequent access by the Application Interface, within 500 milliseconds of receipt of the second Surface Position Message of the "**even**" and "**odd**" pair for the given Surface Participant.

Step 5: Maintenance of Report Output Storage Buffer

Verify that for each Participant in the Surface scenario and simulation set up in Step 2 of §2.4.10.1.3 above, where you have verified in Step 1 above that an "**even**" and an "**odd**" encoded Surface Position Message was received within a ten (10) second period that the Report Assembly Function correctly maintains the integrity of the State Vector Report for the given Surface Participant in the Report Output Storage Buffer for at least 200 seconds unless:

a. Replaced by an updated State Vector Report, or

b. No new messages have been received from a given Surface Participant for a period of 100 +/- 5 seconds, in which case, verify that all reports relevant to the Surface Participant Address have been deleted from the Report Output Storage Buffer.

Step 6: New Locally Unambiguous CPR Decode

Verify that for each Participant in the Surface scenario and simulation set up in Step 2 of §2.4.10.1.3 above, where you have verified in Step 1 above that an "**even**" and an "**odd**" encoded Surface Position Message was received within a ten (10) second period that the Report Assembly Function correctly maintains the integrity of the State Vector Report for the given Surface Participant in the Report Output Storage Buffer for at least 200 seconds unless a new Surface Position Message is received within a 120 second period for the given Surface Participant.

Verify that when no new Surface Position Message is received for a given Surface Participant within a 120 second period, that the Report Assembly Function performs a new Locally Unambiguous CPR Decode as specified in Step 1 above and verify that the new information is correctly updated in the State Vector Report and the Report Output Storage Buffer for the given Surface Participant.

Step 7: Purge Participant from the Report Output Storage Buffer

Verify that for each Participant in the Surface scenario and simulation set up in Step 2 of §2.4.10.1.3 above, where you have verified in Step 1 above that an "**even**" and an "**odd**" encoded Surface Position Message was received within a ten (10) second period that the Report Assembly Function correctly maintains the integrity of the State Vector Report for the given Surface Participant in the Report Output Storage Buffer for at least 200 seconds unless replaced by an updated State Vector Report for the given Surface Participant

Verify that when no new Messages of any type have been received from a given Surface Participant for at least 200 seconds, that the Report Assembly Function correctly deletes all reports relevant to the given Surface Participant Address from the Report Output Storage Buffer.

2.4.10.3.2.1 Verification of the Latency, Report Assembly Acquisition State --- Surface Participant (§2.2.10.3.2.1)

Purpose/Introduction

Step "d" in §2.2.10.3.2 **shall** be completed within 500 milliseconds of receipt of the second Surface Position Message of the "**even**" and "**odd**" pair.

Measurement Procedure:

Appropriate test procedures for the verification of this requirement are provided in §2.4.10.3.2, Step 4.

2.4.10.3.3 Verification of the Acquisition State Data Retention (§2.2.10.3.3)

Purpose/Introduction

Upon receipt of any of the messages identified in §2.2.10.2 for any given participant, the received message **shall** either:

a. Use the message as required in §2.2.10.3.1 for Airborne Participants or §2.2.10.3.2 for Surface Participants, or

b. Retain the message for future use as specified in §2.2.10.1.3.

Measurement Procedure:

Upon receipt of any of the messages identified in §2.2.10.2 for any given Participant, verify that the Report Assembly Function checks to ensure that it has not received one half (either "**even**" or "**odd**") of a position message pair from this Participant within a ten second period.

Verify that when the receipt of the message is determined to be the second half (either "**even**" or "**odd**") of a position message pair from this Participant, that the Report Assembly Function uses the message as specified using the Test Procedures in §2.4.10.3.1 for Airborne Participants, or §2.4.10.3.2 for Surface Participants.

If the receipt of the message is determined to NOT be the second half of a position message, then verify that the Report Assembly Function uses the message as specified in using the Test Procedures in §2.4.10.1.3.

2.4.10.4 Verification of the Report Assembly Track State (§2.2.10.4)

No specific test procedure is required to validate §2.2.10.4.

2.4.10.4.1 Verification of the Report Assembly Track State --- Airborne Participant (§2.2.10.4.1)

No specific test procedure is required to validate §2.2.10.4.1.

2.4.10.4.1.1 Verification of the Report Assembly Track State Initialization --- Airborne Participant (§2.2.10.4.1.1)

Purpose/Introduction

Initialization of the Track State for a given Airborne Participant assumes that the Acquisition State has been established for the given Participant in accordance with §2.2.10.3.1.

Upon receipt of a valid Airborne Velocity Information Message (see §2.2.3.2.6) for a given Airborne Participant, the Report Assembly Function **shall**:

a. Set the Report Mode to "Track" for the given Airborne Participant in the State Vector Report (see §2.2.8.1) in accordance with §2.2.8.1.22,

b. Structure all possible fields of the State Vector Report for the given Airborne Participant in accordance with §2.2.8.1 (all subsections inclusive),

c. Deliver the new State Vector Report for the given Airborne Participant to the Report Output Storage Buffer within 500 milliseconds of receipt of the Airborne Velocity Information Message,

d. Maintain the integrity of the State Vector Report for the given Airborne Participant in the Report Output Storage Buffer for 100 +/- 5 seconds unless replaced by an updated State Vector Report or otherwise specified in the following sections,

e. Initiate Assembly of Mode Status Reports:

   (1). The Report Assembly Function **shall** review all messages received from the given Airborne Participant that may have been placed in temporary storage in accordance with §2.2.10.1.3.

   (2). Upon completion of the message review, the Report Assembly Function **shall** structure all possible fields of the Mode Status Report for the given Airborne Participant in accordance with §2.2.8.2 (all subsections inclusive).

   (3). The Report Assembly Function **shall** deliver the new Mode Status Report for the given Airborne Participant to the Report Output Storage Buffer within 500 milliseconds of receipt of the Airborne Velocity Information Message which initialized the Track State.

(4). The Report Assembly Function **shall** maintain the integrity of the Mode Status Report for the given Airborne Participant in the Report Output Storage Buffer 100 +/- 5 seconds unless replaced by an updated Mode Status Report or otherwise specified in the following sections.

f. Initiate Assembly of ADS-B Target State Reports:

(1). The Report Assembly Function **shall** review all messages received from the given Airborne Participant that may have been placed in temporary storage in accordance with §2.2.10.1.3.

(2). Upon completion of the message review, the Report Assembly Function **shall** structure all possible fields of the ADS-B Target State Report for the given Airborne Participant in accordance with §2.2.8.3 (all subsections inclusive).

(3). The Report Assembly Function **shall** deliver the new ADS-B Target State Report for the given Airborne Participant to the Report Output Storage Buffer within 500 milliseconds of receipt of the Airborne Velocity Information Message which initialized the Track State.

(4). The Report Assembly Function **shall** maintain the integrity of the ADS-B Target State Report for the given Airborne Participant in the Report Output Storage Buffer for 100 +/- 5 seconds unless replaced by an updated ADS-B Target State Report or otherwise specified in the following sections.

Measurement Procedure:

Step 1: Set the Report Mode to Track

It is not the purpose of this Test Procedure to re-test the individual elements of previously tested Report Assembly Functions. Start this Test Procedure with the assumption that for a given Airborne Participant, the Acquisition State has been established in accordance with the Test Procedures in §2.4.10.3.1.

Verify that for each Participant in the Airborne scenario and simulation set up in Step 1 of §2.4.10.1.3 above, where you have verified that the Acquisition State has been established, and upon receipt of the first Airborne Velocity Message for the given Participant, verify that the Report Assembly Function correctly sets the Report Mode to "Track" in the State Vector Report in accordance with the formatting in §2.2.8.1.22.

Step 2: Update State Vector Report

Verify that for each Participant in the Airborne scenario and simulation set up in Step 1 of §2.4.10.1.3 above, where you have verified that the Acquisition State has been established, and upon receipt of the first Airborne Velocity Message for the given Participant, verify that the Report Assembly Function correctly structures all possible fields in the State Vector Report in accordance with §2.2.8.1(all subsections inclusive).

Step 3: Update the Report Output Storage Buffer

Verify that for each Participant in the Airborne scenario and simulation set up in Step 1 of §2.4.10.1.3 above, where you have verified that the Acquisition State has been established, and upon receipt of the first Airborne Velocity Message for the given Participant, verify that the Report Assembly Function correctly structures all possible fields in the State Vector Report in accordance with §2.2.8.1 (all subsections inclusive).

Verify that the updated State Vector Report is delivered to the Report Output Storage Buffer within 500 milliseconds of the receipt of the first Airborne Velocity Message for the given Participant.

Step 4: Maintenance of Report Output Storage Buffer

Verify that for each Participant in the Airborne scenario and simulation set up in Step 1 of §2.4.10.1.3 above, where you have verified that the Acquisition State has been established, and upon receipt of the first Airborne Velocity Message for the given Participant, verify that the Report Assembly Function correctly maintains the integrity of the State Vector Report for the given Participant in the Report Output Storage Buffer for a period of 100 +/- 5 seconds unless replaced by an updated State Vector Report.

Step 5: Initiate Assembly of the Mode Status Report

a. Upon receipt of the first Airborne Velocity Message from the Participant, and the “Track” State has been entered as in Steps 1 through 3 above, verify that the Report Assembly Function initiates a complete review of all messages received for the given Participant that have been placed in temporary storage in accordance with §2.2.10.1.3.

b. Upon completion of the review of all messages for the given Participant, verify that the Report Assembly Function correctly structures all possible fields of the Mode Status Report for the given Participant in accordance with §2.2.8.2 (all subsections inclusive).

c. Verify that the Mode Status Report is delivered to the Report Output Storage Buffer within 500 milliseconds of the receipt of the first Airborne Velocity Message that caused the initialization of the “Track” State for the given Participant.

d. Verify that the integrity of the Mode Status Report is maintained for the given Participant in the Report Output Storage Buffer for a period of 100 +/- 5 seconds, unless replaced by an updated Mode Status Report for that Participant.

Step 6: Initiate Assembly of ADS-B Target State Report

a. Upon receipt of the first Airborne Velocity Message from the Participant, and the "Track" State has been entered as in Steps 1 through 3 above, verify that the Report Assembly Function initiates a complete review of all messages received for the given Participant that have been placed in temporary storage in accordance with §2.2.10.1.3.

b. Upon completion of the review of all messages for the given Participant, verify that the Report Assembly Function correctly structures all possible fields of the ADS-B Target State Report for the given Participant in accordance with §2.2.8.3 (all subsections inclusive).

c. Verify that the ADS-B Target State Report is delivered to the Report Output Storage Buffer within 500 milliseconds of the receipt of the first Airborne Velocity Message that caused the initialization of the "Track" State for the given Participant.

d. Verify that the integrity of the ADS-B Target State Report is maintained for the given Participant in the Report Output Storage Buffer for a period of 100 +/- 5 seconds, unless replaced by an updated ADS-B Target State Report for that Participant.

2.4.10.4.1.2 Verification of the Report Assembly Track State Maintenance --- Airborne Participant (§2.2.10.4.1.2)

Purpose/Introduction

The Track State **shall** be maintained for a given Airborne Participant for as long as Airborne Position Messages (see §2.2.3.2.3) and Airborne Velocity Information Messages (see §2.2.3.2.6) are being received from the Participant.

a. Each time that a new Airborne Position Message is received from the given Airborne Participant, the Report Assembly Function **shall**:

(1). Perform a CPR decode of the Participant Position in accordance with §A.1.7.4 and A.1.7.5 of Appendix A,

(2). Update all possible fields of the State Vector Report for the given Airborne Participant in accordance with §2.2.8.1 (all subsections inclusive),

(3). Deliver the updated State Vector Report to the Report Output Storage Buffer within 500 milliseconds of receipt of the new Airborne Position Message, and

(4). Maintain the integrity of the State Vector Report for the given Airborne Participant in the Report Output Storage Buffer for 100 +/- 5 seconds unless replaced by an updated State Vector Report.

b. Each time that a new Airborne Velocity Information Message is received from the Airborne Participant that contains Ground Referenced velocity information, the Report Assembly Function **shall**:

(1). Update all possible fields of the State Vector Report for the given Airborne Participant in accordance with §2.2.8.1 (all subsections inclusive),

(2). Deliver the updated State Vector Report to the Report Output Storage Buffer within 500 milliseconds of receipt of the new Airborne Position Message, and

(3). Maintain the integrity of the State Vector Report for the given Airborne Participant in the Report Output Storage Buffer for 100 +/- 5 seconds unless replaced by an updated State Vector Report.

c. Each time an ADS-B Airborne Velocity Information Message (§2.2.3.2.6) with Subtype = 3 or 4 (i.e., providing Air Referenced Velocity information) is received from the ADS-B Airborne Participant, then the Report Assembly Function **shall**:

(1). Update all possible fields of the Air Referenced Velocity Report for the given ADS-B Airborne Participant in accordance with §2.2.8.3.2 (all subsections inclusive),

(2). Deliver the updated ARV Report to the Report Output Storage Buffer within 500 milliseconds of receipt of the new ADS-B Airborne Velocity Message, and

(3). Maintain the integrity of the ARV Report for the given ADS-B Airborne Participant in the Report Output Storage Buffer for 100 +/- 5 seconds unless replaced by an updated ARV Report or otherwise specified in the following sections.

d. Each time that a new Aircraft Identification and Type Message (see §2.2.3.2.5), Aircraft Trajectory Intent and System Status Message (see §2.2.3.2.7.1) having System Status information, Aircraft Operational Status Message (see §2.2.3.2.7.2), Airborne Velocity Message (§2.2.3.2.6), or Aircraft Status Message (see §2.2.3.2.7.8) is received from the Airborne Participant, the Report Assembly Function **shall**:

(1). Update all possible fields of the Mode Status Report for the given Airborne Participant in accordance with §2.2.8.2 (all subsections inclusive),

(2). Deliver the updated Mode Status Report to the Report Output Storage Buffer within 500 milliseconds of receipt of the new Message, and

(3). Maintain the integrity of the Mode Status Report for the given Airborne Participant in the Report Output Storage Buffer for 100 +/- 5 seconds unless replaced by an updated Mode Status Report.

e. Each time that a new Aircraft Trajectory Intent Message (see §2.2.3.2.7.1) having Target State information is received from the given Airborne Participant, the Report Assembly Function **shall**:

(1). Update all possible fields of the ADS-B Target State Report for the given Airborne Participant in accordance with §2.2.8.3 (all subsections inclusive),

(2). Deliver the updated ADS-B Target State Report to the Report Output Storage Buffer within 500 milliseconds of receipt of the new Message, and

(3). Maintain the integrity of the ADS-B Target State Report for the given Airborne Participant in the Report Output Storage Buffer for 100 +/- 5 seconds unless replaced by an updated ADS-B Target State Report.

Measurement Procedure:

Step 1: Receipt of a new Airborne Position Message

a. Verify that for each Participant in the Airborne scenario and simulation set up in Step 1 of §2.4.10.1.3 above, where you have verified that the Track State has been established, and upon the receipt of a new Airborne Position Message for the given Participant, verify that the Report Assembly Function correctly performs a locally unambiguous CPR decode of the Participant position in accordance with §A.1.7.4 and §A.1.7.5 of Appendix A.

b. Verify that for each Participant in the Airborne scenario and simulation set up in Step 1 of §2.4.10.1.3 above, where you have verified that the Track State has been established, and upon the receipt of a new Airborne Position Message for the given Participant, verify that the Report Assembly Function correctly updates all possible fields of the State Vector Report for the given Airborne Participant in accordance with §2.2.8.1 (all subsections inclusive).

c. Verify that for each Participant in the Airborne scenario and simulation set up in Step 1 of §2.4.10.1.3 above, where you have verified that the Track State has been established, and upon the receipt of a new Airborne Position Message for the given Participant, verify that the Report Assembly Function correctly delivers the updated State Vector Report to the Report Output Storage Buffer within 500 milliseconds of the receipt of the new Airborne Position Message.

d. Verify that for each Participant in the Airborne scenario and simulation set up in Step 1 of §2.4.10.1.3 above, where you have verified that the Track State has been established, and upon the receipt of a new Airborne Position Message for the given Participant, verify that the Report Assembly Function correctly maintains the integrity of the State Vector Report for the given Airborne Participant in the Report Output Storage Buffer for 100 +/- 5 seconds unless replaced by an updated State Vector Report.

Step 2: Receipt of a new Airborne Velocity Message

a. Verify that for each Participant in the Airborne scenario and simulation set up in Step 1 of §2.4.10.1.3 above, where you have verified that the Track State has been established, and upon the receipt of a new Airborne Velocity Message for the given Participant, verify that the Report Assembly Function correctly updates all possible fields of the State Vector Report for the given Airborne Participant in accordance with §2.2.8.1 (all subsections inclusive).

b. Verify that for each Participant in the Airborne scenario and simulation set up in Step 1 of §2.4.10.1.3 above, where you have verified that the Track State has been established, and upon the receipt of a new Airborne Velocity Message for the given Participant, verify that the Report Assembly Function correctly delivers the updated State Vector Report to the Report Output Storage Buffer within 500 milliseconds of the receipt of the new Airborne Velocity Message.

c. Verify that for each Participant in the Airborne scenario and simulation set up in Step 1 of §2.4.10.1.3 above, where you have verified that the Track State has been established, and upon the receipt of a new Airborne Velocity Message for the given Participant, verify that the Report Assembly Function correctly maintains the integrity of the State Vector Report for the given Airborne Participant in the Report Output Storage Buffer for 100 +/- 5 seconds unless replaced by an updated State Vector Report.

<u>Step 3:</u> <u>Receipt of other Messages while in Track State and Creating a Mode Status</u>

a. Verify that for each Participant in the Airborne scenario and simulation set up in Step 1 of §2.4.10.1.3 above, where you have verified that the Track State has been established, and upon the receipt of a new Aircraft Identification and Type Message, Aircraft Trajectory Intent Message, Aircraft Operational Coordination Message, Aircraft Operational Status Message, or Aircraft Status Message for the given Participant, verify that the Report Assembly Function correctly updates all possible fields of the Mode Status Report for the given Airborne Participant in accordance with §2.2.8.2 (all subsections inclusive).

b. Verify that for each Participant in the Airborne scenario and simulation set up in Step 1 of §2.4.10.1.3 above, where you have verified that the Track State has been established, and upon the receipt of a new Aircraft Identification and Type Message, Aircraft Trajectory Intent Message, Aircraft Operational Coordination Message, Aircraft Operational Status Message, or Aircraft Status Message for the given Participant, verify that the Report Assembly Function correctly delivers the updated Mode Status Report to the Report Output Storage Buffer within 500 milliseconds of the receipt of the new Message.

c. Verify that for each Participant in the Airborne scenario and simulation set up in Step 1 of §2.4.10.1.3 above, where you have verified that the Track State has been established, and upon the receipt of a new Aircraft Identification and Type Message, Aircraft Trajectory Intent Message, Aircraft Operational Coordination Message, Aircraft Operational Status Message, or Aircraft Status Message for the given Participant, verify that the Report Assembly Function correctly maintains the integrity of the Mode Status Report for the given Airborne Participant in the Report Output Storage Buffer for 100 +/- 5 seconds unless replaced by an updated Mode Status Report.

Step 4: Creating a Target State Report

a. Verify that for each Participant in the Airborne scenario and simulation set up in Step 1 of §2.4.10.1.3 above, where you have verified that the Track State has been established, and upon the receipt of a new Aircraft Trajectory Intent Message having Target State information, for the given Participant, verify that the Report Assembly Function correctly updates all possible fields of the Target State Report for the given Airborne Participant in accordance with §2.2.8.3 (all subsections inclusive).

b. Verify that for each Participant in the Airborne scenario and simulation set up in Step 1 of §2.4.10.1.3 above, where you have verified that the Track State has been established, and upon the receipt of a new Aircraft Trajectory Intent Message having Target State information, for the given Participant, verify that the Report Assembly Function correctly delivers the updated Target State Report to the Report Output Storage Buffer within 500 milliseconds of the receipt of the new Message.

c. Verify that for each Participant in the Airborne scenario and simulation set up in Step 1 of §2.4.10.1.3 above, where you have verified that the Track State has been established, and upon the receipt of a new Aircraft Trajectory Intent Message having Target State information, for the given Participant, verify that the Report Assembly Function correctly maintains the integrity of the Target State Report for the given Airborne Participant in the Report Output Storage Buffer for 100 +/- 5 seconds unless replaced by an updated Target State Report.

Step 5: Creating an Air Referenced Velocity Report

TBD

2.4.10.4.1.3 Verification of the Report Assembly Track State Termination --- Airborne Participant (§2.2.10.4.1.3)

Purpose/Introduction

a. The Track State **shall** be terminated for a given Airborne Participant if no Airborne Position (see §2.2.3.2.3) or Airborne Velocity Information (see §2.2.3.2.6) Messages have been received from the Participant in 25 +/- 5 seconds.

b. Upon termination of the Track State for a given Airborne Participant, the Report Assembly Function **shall** immediately delete all State Vector, Mode Status, ADS-B Target State, and Air Referenced Velocity Reports that were placed in the Report Output Storage Buffer for the given Participant.

Note: *The track state termination requires deletion of all reports structured for a given participant into the Report Output Storage Buffer. Track state termination does not intend that temporary storage (see §2.2.10.1.3)* *established for the given Participant be deleted. The temporary storage is only deleted if NO ADS-B Messages have been received from the given Participant for 225 +/- 25 seconds.*

c. Upon completion of the preceding step b., the Report Assembly Function **shall** return to the Report Assembly Acquisition State for the given Airborne Participant as specified in §2.2.10.3.1.

Measurement Procedure:

Step 1: TYPE Equal ZERO – Altitude Data Available

For random Participants in the Airborne scenario and simulation set up in Step 1 of §2.4.10.1.3 above, where you have verified that the Track State has been established, induce Airborne Position Messages with the TYPE subfield set to ZERO, and with all 56 bits of the "ME" field set to ZEROs, except that the Barometric Altitude subfield is filled with valid data in accordance with §2.2.3.2.3.4.3.

Verify that for these Participants that the Report Assembly Function correctly updates the State Vector Report with the received Barometric Altitude. Verify that the Barometric Altitude Validity Flag, i.e., bit #3 of byte #4 of the State Vector Report was correctly set to ONE, indicating valid Altitude data.

Step 2: TYPE Equal ZERO – No Altitude Data Available

For random Participants in the Airborne scenario and simulation set up in Step 1 of §2.4.10.1.3 above, where you have verified that the Track State has been established, induce Airborne Position Messages with the TYPE subfield set to ZERO, and with all 56 bits of the "ME" field set to ZEROs.

Verify that for these Participants that the Report Assembly Function correctly discards the received Airborne Position Message and that no change is made to the State Vector Report as a result of the receipt of this Airborne Position Message with TYPE equal ZERO and all other "ME" field bits set to ZERO.

Step 3: Track State Termination

For each Participant in the Airborne scenario and simulation set up in Step 1 of §2.4.10.1.3 above, where you have verified that the Track State has been established, if no Airborne Position or Airborne Velocity Information Message has been received from the Participant for 25 +/- 5 seconds, then verify that for each Participant that the Track State is terminated by deleting all State Vector Reports, Mode Status Reports and ADS-B TCP+1 Reports that were placed in the Report Output Storage Buffer for the given Participant.

Also verify that for this Participant that the Report Assembly Function correctly returns to the Acquisition State as defined in §2.2.10.3.1. Verify that the Report Mode Flag is set to "Acquisition" in the State Vector Report in accordance with the encoding defined in §2.2.8.1.22.

2.4.10.4.2 Verification of the Report Assembly Track State --- Surface Participant (§2.2.10.4.2)

No specific test procedure is required to validate §2.2.10.4.2.

2.4.10.4.2.1 Verification of the Report Assembly Track State Initialization --- Surface Participant (§2.2.10.4.2.1)

Purpose/Introduction

Initialization of the Track State for a given Surface Participant is established in accordance with §2.2.10.3.2.

In addition to the requirements specified in §2.2.10.3.2, the Report Assembly Function **shall** initiate assembly of Mode Status Reports as follows:

a. The Report Assembly Function **shall** review all messages received from the given Surface Participant that may have been placed in temporary storage in accordance with §2.2.10.1.3.

b. Upon completion of the message review, the Report Assembly Function **shall** structure all possible fields of the Mode Status Report for the given Surface Participant in accordance with §2.2.8.2 (all subsections inclusive).

c. The Report Assembly Function **shall** deliver the new Mode Status Report for the given Surface Participant to the Report Output Storage Buffer within 500 milliseconds of receipt of the last received Surface Position Message which initialized the Track State.

d. The Report Assembly Function **shall** maintain the integrity of the Mode Status Report for the given Surface Participant in the Report Output Storage Buffer 100 +/- 5 seconds unless replaced by an updated Mode Status Report or otherwise specified in the following sections.

Measurement Procedure:

a. Upon receipt of an "**even**" and "**odd**" encoded Surface Position Message from a given Surface Participant within a ten (10) second period, verify that the Report Assembly Function correctly sets the Report Mode to "Track" in accordance with the formatting in §2.2.8.1.22.

b. Further verify that the Report Assembly Function initiates a complete review of all messages received for the given Surface Participant that have been placed in temporary storage in accordance with §2.2.10.1.3.

   Upon completion of the review of all messages for the given Surface Participant, verify that the Report Assembly Function correctly structures all possible fields of the Mode Status Report for the given Surface Participant in accordance with §2.2.8.2 (all subsections inclusive).

c. Verify that the Mode Status Report is delivered to the Report Output Storage Buffer within 500 milliseconds of the receipt of the second half of that "even/odd" pair of

Surface Position Messages which caused the initialization of the "Track" State for the given Surface Participant.

d. Verify that the integrity of the Mode Status Report is maintained for the given Surface Participant in the Report Output Storage Buffer for a period of 100 +/- 5 seconds, unless replaced by an updated Mode Status Report for that Participant.

2.4.10.4.2.2 Verification of the Report Assembly Track State Maintenance --- Surface Participant (§2.2.10.4.2.2)

Purpose/Introduction

The Track State **shall** be maintained for a given Surface Participant for as long as Surface Position Messages (see §2.2.3.2.4) are being received from the Surface Participant.

a. Each time that a new Surface Position Message is received from the given Surface Participant, the Report Assembly Function **shall**:

(1). Perform a CPR decode of the Participant Position in accordance with §A.1.7.4 and §A.1.7.6 of Appendix A,

(2). Update all possible fields of the State Vector Report for the given Surface Participant in accordance with §2.2.8.1 (all subsections inclusive),

(3). Deliver the updated State Vector Report to the Report Output Storage Buffer within 500 milliseconds of receipt of the new Surface Position Message, and

(4). Maintain the integrity of the State Vector Report for the given Surface Participant in the Report Output Storage Buffer for 100 +/- 5 seconds unless replaced by an updated State Vector Report or otherwise specified in the following sections.

b. Each time that a new Aircraft Identification and Type Message (see §2.2.3.2.5), Aircraft Operational Status Message (see §2.2.3.2.7.2), or Aircraft Status Message (see §2.2.3.2.7.8) is received from the Surface Participant, the Report Assembly Function **shall**:

(1). Update all possible fields of the Mode Status Report for the given Surface Participant in accordance with §2.2.8.2 (all subsections inclusive),

(2). Deliver the updated Mode Status Report to the Report Output Storage Buffer within 500 milliseconds of receipt of the new Message, and

(3). Maintain the integrity of the Mode Status Report for the given Surface Participant in the Report Output Storage Buffer for 100 +/- 5 seconds unless replaced by an updated Mode Status Report or otherwise specified in the following sections.

Measurement Procedure:

Step 1: Receipt of a new Surface Position Message

a. Verify that for each Surface Participant in the Surface scenario and simulation set up in Step 2 of §2.4.10.1.3 above, where you have verified that the "Track" State has been established, and upon the receipt of a new Surface Position Message for the given Participant, verify that the Report Assembly Function correctly performs a locally unambiguous CPR decode of the Surface Participant position in accordance with §A.1.7.4 and §A.1.7.5 of Appendix A.

b. Verify that for each Surface Participant in the Surface scenario and simulation set up in Step 2 of §2.4.10.1.3 above, where you have verified that the "Track" State has been established, and upon the receipt of a new Surface Position Message for the given Participant, verify that the Report Assembly Function correctly updates all possible fields of the State Vector Report for the given Surface Participant in accordance with §2.2.8.1 (all subsections inclusive).

c. Verify that for each Surface Participant in the Surface scenario and simulation set up in Step 2 of §2.4.10.1.3 above, where you have verified that the "Track" State has been established, and upon the receipt of a new Surface Position Message for the given Participant, verify that the Report Assembly Function correctly delivers the updated State Vector Report to the Report Output Storage Buffer within 500 milliseconds of the receipt of the new Surface Position Message for the given Participant.

d. Verify that for each Surface Participant in the Surface scenario and simulation set up in Step 2 of §2.4.10.1.3 above, where you have verified that the "Track" State has been established, and upon the receipt of a new Surface Position Message for the given Participant, verify that the Report Assembly Function correctly maintains the integrity of the State Vector Report for the Surface Participant in the Report Output Storage Buffer for 100 +/- 5 seconds unless replace by an updated State Vector Report.

Step 2: Receipt of other Messages while in Track State and Creating a Mode Status

a. Verify that for each Surface Participant in the Surface scenario and simulation set up in Step 2 of §2.4.10.1.3 above, where you have verified that the "Track" State has been established, and upon the receipt of a new Aircraft Identification and Type Message, Aircraft Operational Status Message, or Aircraft Status Message for the given Surface Participant, verify that the Report Assembly Function correctly updates all possible fields of the Mode Status Report for the given Surface Participant in accordance with §2.2.8.2 (all subsections inclusive).

b. Verify that for each Surface Participant in the Surface scenario and simulation set up in Step 2 of §2.4.10.1.3 above, where you have verified that the "Track" State has been established, and upon the receipt of a new Aircraft

Identification and Type Message, Aircraft Operational Status Message, or Aircraft Status Message for the given Surface Participant, verify that the Report Assembly Function correctly delivers the updated Mode Status Report to the Report Output Storage Buffer within 500 milliseconds of the receipt of the new Message.

c. Verify that for each Surface Participant in the Surface scenario and simulation set up in Step 2 of §2.4.10.1.3 above, where you have verified that the "Track" State has been established, and upon the receipt of a new Aircraft Identification and Type Message, Aircraft Operational Status Message, or Aircraft Status Message for the given Surface Participant, verify that the Report Assembly Function correctly maintains the integrity of the Mode Status Report for the given Surface Participant in the Report Output Storage Buffer for 100 +/- 5 seconds unless replaced by an updated Mode Status Report.

2.4.10.4.2.3 Verification of the Report Assembly Track State Termination --- Surface Participant (§2.2.10.4.2.3)

Purpose/Introduction

a. The Track State **shall** be terminated for a given Surface Participant if no Surface Position Message (see §2.2.3.2.4) has been received from the Participant in 25 +/- 5 seconds.

b. Upon termination of the Track State for a given Surface Participant, the Report Assembly Function **shall** immediately delete all State Vector and Mode Status Reports that were placed in the Report Output Storage Buffer for the given Participant.

Notes:

1. *The track state termination requires deletion of all reports structured into the Report Output Storage Buffer. Track state termination does not intend that temporary storage (see §2.2.10.1.3) established for the given Participant be deleted. The temporary storage is only deleted if NO ADS-B Messages have been received from the given Participant for 225 +/- 25 seconds.*

2. *ADS-B Surface Participants do not generate Trajectory Intent information; therefore, ADS-B Target State Report assembly is not required for Surface Participants.*

c. Upon completion of the preceding step b., the Report Assembly Function **shall** return to the Report Assembly Acquisition State for the given Surface Participant as specified in §2.2.10.3.2.

Measurement Procedure:

For each Surface Participant in the Surface scenario and simulation set up in Step 2 of §2.4.10.1.3 above, where you have verified that the Track State has been established, if no Surface Position Message has been received from the Surface Participant for 25 +/- 5 seconds, then verify that for each Surface Participant that the Track State is terminated by deleting all State Vector Reports and Mode Status Reports that were placed into the Report Output Storage Buffer for the given Surface Participant.

Also verify that for this Participant that the Report Assembly Function correctly returns to the Acquisition State as defined in §2.2.10.3.2. Verify that the Report Mode Flag is set to "Acquisition" in the State Vector Report in accordance with the encoding defined in §2.2.8.1.22.

2.4.10.5 Verification of the Minimum Number of Participant Track Files (§2.2.10.5)

Purpose/Introduction

In the absence of an applied interference environment and other interference, the ADS-B Report Assembly Function **shall** be capable of:

a. Maintaining the minimum number of track files (see §2.2.10.1.4) of ADS-B participants as specified in Table 2-76 for a given equipage class, and

Table 2-166: Minimum Participant Track File Capacity

Equipage Class of ADS-B Receiving Subsystem	Minimum Number of Participant Track Files
A0	100
A1	200
A2	400
A3	400

b. If the track file capacity of the ADS-B Receiving Subsystem is being exceeded by the number of participants whose messages are being received by the subsystem, then the subsystem may choose to discard track files of those participants that are at farther ranges relative to the receiving subsystem.

Measurement Procedure:

Step 1: Track File Scenario Selection and Initialization

Refer to Table 2-167, below, for information required in the following paragraphs.

Select the Class of ADS-B Receiving equipment that is being tested from the far left column (0) of the table.

For the Class of ADS-B Receiving equipment selected, establish an Airborne scenario and simulation for a the minimum number of participants shown in column 2 of the table. Select various altitudes, velocities, initial positions, and general directions for the participants such that all participants remain within the column 1 given range of the ADS-B receiving equipment under test. Maintain the same number of participants within the column 1 given range of the ADS-B receiving equipment under test for a duration of at least 20 minutes to ensure full execution of the test.

For the Class of ADS-B Receiving equipment selected, establish additional Airborne scenarios and simulations for the minimum number of participants shown in column 4 of the table. Select various altitudes, velocities, initial positions, and general directions for the participants such that all participants remain within the column 3 given range boundary from the ADS-B receiving equipment under test. Maintain the same number of participants within the column 3 given range boundary for at least 20 minutes to ensure full execution of the test.

Table 2-167: Participant Track File Stimulus Requirements

Column (0)	1	2	3	4
Equipage Class of ADS-B Receiving Subsystem	**Range (nmi) for ADS-B Receiving Class**	**Number of Participant Track Files Within Range**	**Extended Range (nmi) for ADS-B Receiving Class (min -to- max)**	**Number of Participant Track Files Within Extended Range**
A0	10	100	10 -to- 15	50
A1	20	200	20 -to- 30	100
A2	40	400	40 -to- 60	200
A3	60	400	60 -to- 90	200

Step 2: Track File Scenario Selection and Initialization

Initiate the simulation and verify that the ADS-B Report Generator function of the ADS-B Receiving equipment under test properly generates and delivers the appropriate State Vector, Mode Status, and TCP + 1 Reports for each Participant that is being tracked.

For the Class of ADS-B Receiving equipment under test, verify that the ADS-B Report Generator function maintains appropriate track files on the minimum number of participants provided in column 2 of Table 2-167. Regardless of the track file capacity of the ADS-B receiving equipment under test, verify that any track files discarded are for participants at greater range than those retained.

2.4.10.6 Verification of the Participant Track File Maintenance in the Interference Environment (§2.2.10.6)

TBD

2.4.10.6.1 Verification of the Track File Maintenance for Class A0 Receiving Devices (§2.2.10.6.1)

Purpose/Introduction

The purpose of this procedure is to verify that the Equipage Class A0 ADS-B Receiving Device Message Processor and Report Assembly functions properly decode at least 90% of valid ADS-B Messages that have been received in the following ATCRBS interference environment:

a. Each of the ADS-B Messages **shall** be valid, and **shall** be overlaid with an ATCRBS MODE-C Reply (see RTCA Document No. DO-181C §2.2.4.1 through 2.2.4.1.6) having the appropriate altitude encoding for an altitude of 50,000 feet,

b. The ATCRBS MODE-C message **shall** overlay the ADS-B Message at any point after the "DF" subfield,

c. The ADS-B Message signal level **shall** be a minimum of MTL + 6 dB and a maximum of -21 dBm, and

d. The ATCRBS MODE-C reply signal level **shall** be 3 dB greater than the ADS-B Message signal level.

<u>Equipment Required:</u>

A method of supplying the equipment under test with ADS-B broadcast messages.

A method of supplying the equipment under test with ATCRBS Mode-C Reply messages in accordance with RTCA Document No. DO-181C, 181B §2.2.4.1 through 2.2.4.1.6.

Digital Delay (Variable from 0 to 100 microseconds in at least 1 microsecond steps)

RF Attenuator (Variable from 0 dB to 30 dB in 2 dB steps)

RF Isolators (or RF Circulators with the third port properly terminated)

RF Splitter/Combiner (2 port, or 3 dB type)

RF Attenuators (Fixed, various attenuation values, as needed)

A method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope.

Wide Band Dual Channel Oscilloscope (HP l7l0B, or equivalent).

A method of monitoring the Output Messages or ADS-B Reports generated by the ADS-B Receiving function.

Configure the equipment in a manner that allows the ADS-B broadcast messages to be delivered to the equipment under test with the ATCRBS Reply messages superimposed on the ADS-B broadcast messages.

Configure the equipment in a manner that allows the ATCRBS Reply messages to be delayed from the beginning of the ADS-B broadcast messages as specified in the following procedures.

Measurement Procedure:

Step 1: Establish ADS-B Broadcast Message Stimulus

Ensure that the RF frequency of the ADS-B Broadcast Message generator is not phase locked to the RF frequency of the ATCRBS Reply generator.

Establish the ADS-B Broadcast messages with the "ME" field set to all ZEROs as indicated in Table 2-168. Refer to Table 2-168 and select the appropriate Set of stimulus to run for the type of equipment being tested as follows:

a. For equipment that can transmit "DF" = 17 and "CA" = 0, use Set 1.

b. For equipment that can transmit "DF" = 17 and "CA" = 4, use Set 2.

c. For equipment that can transmit "DF" = 17 and "CA" = 5, use Set 3.

d. For equipment that can transmit "DF" = 17 and "CA" = 6, use Set 4.

e. For equipment that can transmit "DF" = 17 and "CA" = 7, use Set 5.

f. For equipment that can transmit "DF" = 18 and "CF" = 0, use Set 6. Note that this is the case where the equipment is non-Transponder based.

g. Where an equipment is capable of transmitting several of the cases described in paragraphs a. through f., above, it should suffice that the equipment be tested to only one of the cases since the parity encoding and decoding should work the same for all.

Table 2-168: ADS-B Broadcast Message Stimulus

Column #	**1**	**2**	**3**	**4**	**5**	**6**
	Bit #	**1 --- 5**	**6 -- 8**	**9 -------------- 32**	**33 -------------- 88**	**89 ------ 112**
SET #	**Field Name**	**"DF"**	**"CA" ("CF")**	**"AA" [HEX]**	**"ME" [HEX]**	**"PI" [HEX]**
1		1 0001	000	BB BB BB	ALL ZEROs	AA45B9
2		1 0001	100	AA AA AA	ALL ZEROs	D8D1FB
3		1 0001	101	EE EE EE	ALL ZEROs	CDDE3D
4		1 0001	110	DD DD DD	ALL ZEROs	EF5741
5		1 0001	111	BB BB BB	ALL ZEROs	DCE7D8
6		1 0010	000	AB CD EF	ALL ZEROs	C5A9B6

Set the signal level of the ADS-B Broadcast Messages delivered to the equipment under test to MTL +3 dB where the MTL is that of the receiving equipment under test.

Set the transmission rate of the ADS-B Broadcast Messages to 50 messages per second (i.e., a new message starts every 20 milliseconds).

Note: *There is no jitter imposed on the ADS-B Broadcast Message as there is in the real messages transmitted by ADS-B transmitting functions. This measure has been taken in order to simplify the test when* *superimposing ATCRBS Reply messages on the ADS-B Broadcast message stimulus.*

Step 2: Establish ATCRBS Reply Message Stimulus

Ensure that the RF frequency of the ATCRBS Reply generator is not phase locked to the RF frequency of the ADS-B Broadcast Message generator.

Establish the ATCRBS Reply Messages in accordance with RTCA Document No. DO-181C, §2.2.4.1 through §2.2.4.1.6, for ATCRBS MODE-C Replies having an encoded Altitude that represents an altitude of 50,000 feet.

Set the signal level of the ATCRBS MODE-C Reply messages delivered to the equipment under test to MTL +6 dB where the MTL is that of the receiving equipment under test.

Set the transmission rate of the ATCRBS MODE-C Reply messages to 50 messages per second (i.e., a new message starts every 20 milliseconds).

Step 3: Combine ADS-B and ATCRBS Stimulus Messages

Combine the ADS-B Broadcast and ATCRBS Mode-C Reply messages and provide the message combination to the equipment under test. Figure 2-19 shows a typical configuration of the test stimulus and the equipment under test.

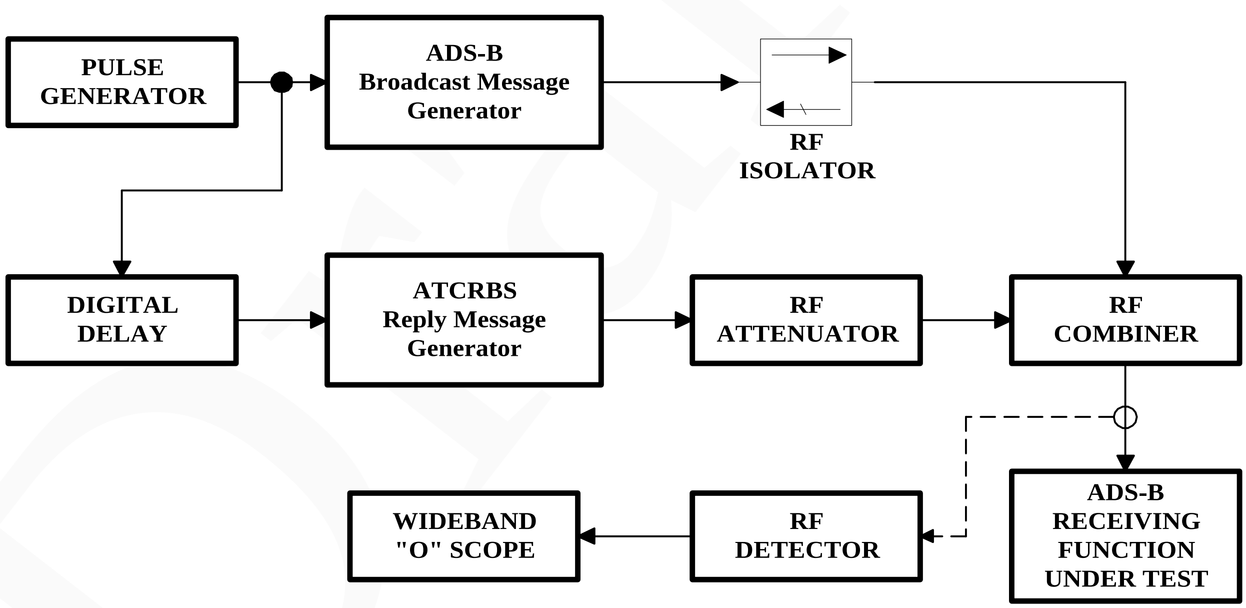


Figure 2-19: Interference Test Configuration

Step 4: Delay ATCRBS Stimulus Messages

a. Delay the ATCRBS Mode-C Reply messages such that the leading edge of the "F1" Framing Pulse of the ATCRBS Mode-C Reply Messages is coincident with bit 9 of the ADS-B Broadcast Messages. Thereby, superimposing the ATCRBS Mode-C Reply Messages over the "AA" field of the ADS-B Broadcast Messages.

Verify that the ADS-B Receiver delivers appropriate Output Messages to the user interface or to the Report Assembly function for at least 90% of the DF=17 and/or DF=18 messages received and that the Output Message formats are consistent with the requirements of §2.2.6.1.1.

b. Delay the ATCRBS Mode-C Reply messages such that the leading edge of the "F1" Framing Pulse of the ATCRBS Mode-C Reply Messages is coincident with bit 33 of the ADS-B Broadcast Messages. Thereby, superimposing the ATCRBS Mode-C Reply Messages over the "ME" field of the ADS-B Broadcast Messages.

Verify that the ADS-B Receiver delivers appropriate Output Messages to the user interface or to the Report Assembly function for at least 90% of the DF=17 and/or DF=18 messages received and that the Output Message formats are consistent with the requirements of §2.2.6.1.1.

c. Delay the ATCRBS Mode-C Reply messages such that the leading edge of the "F1" Framing Pulse of the ATCRBS Mode-C Reply Messages is coincident with bit 64 of the ADS-B Broadcast Messages. Thereby, superimposing the ATCRBS Mode-C Reply Messages over the "ME" field of the ADS-B Broadcast Messages.

Verify that the ADS-B Receiver delivers appropriate Output Messages to the user interface or to the Report Assembly function for at least 90% of the DF=17 and/or DF=18 messages received and that the Output Message formats are consistent with the requirements of §2.2.6.1.1.

d. Delay the ATCRBS Mode-C Reply messages such that the leading edge of the "F1" Framing Pulse of the ATCRBS Mode-C Reply Messages is coincident with bit 89 of the ADS-B Broadcast Messages. Thereby, superimposing the ATCRBS Mode-C Reply Messages over the "PI" field of the ADS-B Broadcast Messages.

Verify that the ADS-B Receiver delivers appropriate Output Messages to the user interface or to the Report Assembly function for at least 90% of the DF=17 and/or DF=18 messages received and that the Output Message formats are consistent with the requirements of §2.2.6.1.1.

Step 5: Change Signal Strength of the ADS-B and ATCRBS Stimulus Messages

Set the signal level of the ADS-B Broadcast Messages delivered to the equipment under test to -36 dBm.

Set the signal level of the ATCRBS MODE-C Reply messages delivered to the equipment under test to -33 dBm.

Repeat Step 4.

Step 6: Change Signal Strength of the ADS-B and ATCRBS Stimulus Messages

Set the signal level of the ADS-B Broadcast Messages delivered to the equipment under test to -21 dBm.

Set the signal level of the ATCRBS MODE-C Reply messages delivered to the equipment under test to -18 dBm.

Repeat Step 4.

2.4.10.6.2 Verification of the Track File Maintenance for Class A1 Receiving Devices (§2.2.10.6.2)

Purpose/Introduction:

Measurement Procedure:

TBD

2.4.10.6.3 Verification of the Track File Maintenance for Class A2 and A3 Receiving Devices (§2.2.10.6.3)

Purpose/Introduction:

Measurement Procedure:

TBD

2.4.11 Verification of Self Test and Monitors (§2.2.11)

No specific test procedure is required to validate §2.2.11.

2.4.11.1 Verification of Self Test (§2.2.11.1)

Purpose/Introduction:

The following Test Procedures **shall** be used to verify that self test transmissions from ADS-B Transmitting equipment comply with the requirements of §2.2.11.1.

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.
Provide a Wide Band Dual Channel Oscilloscope (HP 1710, or equivalent).
Provide a method of detecting and monitoring ADS-B broadcast messages.

Measurement Procedure:

Load valid data into the ADS-B Airborne Position format and ensure that the expected ADS-B transmissions occur.

Monitor all ADS-B broadcast messages for the occurrence of a “TYPE” code = “23.”

Measure the single pulse in the “TYPE” code = “23” message that has the highest RF power and verify that the power does not exceed -40 dBm.

Verify that the average rate of the “TYPE” code = “23” messages does not exceed one in a 10 second interval.

2.4.11.2 Verification of Broadcast Monitoring (§2.2.11.2)

No specific test procedure is required to validate §2.2.11.2.

2.4.11.2.1 Verification of Non-Broadcast Only Equipment (§2.2.11.2.1)

Purpose/Introduction:

The following Test Procedures **shall** be used to verify that the ADS-B Transmitting function properly enunciates the “Fail Warn” state if DF=17 transmissions do not occur at the rates specified in §2.2.3.3 through §2.2.3.3.2.10.

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.
Provide a method of detecting and monitoring ADS-B broadcast messages.

Provide a method of modifying the transmission rates of DF=17 transmitted messages such that the rates do not comply with the rates specified in §2.2.3.3 -through §2.2.3.3.2.10.

Note: *The test procedures provided in the following subparagraphs require the capability to vary the rate of ADS-B transmitted messages. It **shall** be acceptable* *for the manufacturer to demonstrate compliance to the following procedures by software verification.*

Measurement Procedure:

The following procedures **shall** be performed in the absence of other major operations being performed by the ADS-B transmitting function. Specifically, if the ADS-B transmitting function is a subset of the Mode-S transponder, then all interrogations of the transponder **shall** be terminated during the performance of the following tests.

Step 1: Minimum DF=17 transmissions for Airborne Participants

a. Provide the ADS-B transmitting monitoring function with all necessary information to enable the transmitting function to generate the following DF=17 transmitted messages:

(1). Airborne Position Messages (§2.2.3.2.3),

(2). Aircraft Identification and Type Messages (§2.2.3.2.5), and

(3). Airborne Velocity Messages (§2.2.3.2.6)

Verify that the ADS-B transmitting monitoring function properly transmits Airborne Position, Aircraft Identification and Type, and Airborne Velocity Messages at the rates required in §2.2.3.3.2.2, §2.2.3.3.2.4, and §2.2.3.3.2.5

Verify that the ADS-B transmitting monitoring function does not enunciate any “Fail Warn” conditions.

b. Decrease the transmission rate of the Airborne Position Message below the acceptable rate provided in §2.2.3.3.2.2.

Verify that the ADS-B transmission monitoring function properly enunciates the “Fail Warn” state within no more than 1.9 seconds.

Note: *The time chosen is bases on 3 times the accepted maximum time of 0.6 + 100 milliseconds.*

c. Increase the transmission rate of the Airborne Position Message to comply with the rates specified in §2.2.3.3.2.2.

Verify that the ADS-B transmission monitoring function does not enunciate any “Fail Warn” conditions within 1.9 seconds after returning the rate to the acceptable rate.

d. Increase the transmission rate of the Airborne Position Message such that it exceeds the acceptable rate provided in §2.2.3.3.2.2.

Verify that the ADS-B transmission monitoring function properly enunciates the “Fail Warn” state within 1.9 seconds.

e. Decrease the transmission rate of the Airborne Position Message to comply with the rates specified in §2.2.3.3.2.2.

   Verify that the ADS-B transmission monitoring function does not enunciate any “Fail Warn” conditions within 1.9 seconds after returning the rate to the acceptable rate.

f. Decrease the transmission rate of the Aircraft Identification and Type Messages below the acceptable rate provided in §2.2.3.3.2.4.

   Verify that the ADS-B transmission monitoring function properly enunciates the “Fail Warn” state within 15.7 seconds.

g. Increase the transmission rate of the Aircraft Identification and Type Messages to comply with the rates specified in §2.2.3.3.2.4.

   Verify that the ADS-B transmission monitoring function does not enunciate any “Fail Warn” conditions within 5.3 seconds after returning the rate to the acceptable rate.

h. Increase the transmission rate of the Aircraft Identification and Type Messages such that it exceeds the acceptable rate provided in §2.2.3.3.2.4.

   Verify that the ADS-B transmission monitoring function properly enunciates the “Fail Warn” state within 15.7 seconds.

i. Decrease the transmission rate of the Aircraft Identification and Type Message to comply with the rates specified in §2.2.3.3.2.4.

   Verify that the ADS-B transmission monitoring function does not enunciate any “Fail Warn” conditions within 5.3 seconds after returning the rate to the acceptable rate.

j. Repeat steps b through e for Airborne Velocity Messages using the rates specified in §2.2.3.3.2.5.

k. Set the rates of all three messages, e.g., Airborne Position, Aircraft Identification and Type, and Airborne Velocity Messages, such that the rates exceed those specified in §2.2.3.3.2.2, §2.2.3.3.2.4, and §2.2.3.3.2.5 respectively.

l. Verify that the ADS-B transmitting monitoring function properly enunciates the “Fail Warn” state within no more than 1.9 seconds.

m. Set the rates of all three messages, e.g., Airborne Position, Aircraft Identification and Type, and Airborne Velocity Messages, to the rates specified in §2.2.3.3.2.2, §2.2.3.3.2.4, and §2.2.3.3.2.5 respectively.

   Verify that the ADS-B transmission monitoring function does not enunciate any “Fail Warn” conditions within 5.3 seconds after returning the rates to the acceptable rates.

Step 2: Minimum DF=17 transmissions for Surface Participants

a. Provide the ADS-B transmitting monitoring function with all necessary information to enable the transmitting function to generate the following DF=17 transmitted messages:

(1). Surface Position Messages (§2.2.3.2.3),

(2). Aircraft Identification and Type Messages (§2.2.3.2.4), and

Establish sufficient Ground Speed Data to the ADS-B transmitting monitoring function to establish the high rate for Surface Position and Aircraft Identification and Type messages.

Verify that the ADS-B transmitting monitoring function properly transmits Surface Position and Aircraft Identification and Type Messages at the rates required in §2.2.3.3.2.3 and §2.2.3.3.2.4 respectively.

b. Decrease the transmission rate of the Surface Position Message below the acceptable high rate provided in §2.2.3.3.2.3.

Verify that the ADS-B transmission monitoring function properly enunciates the “Fail Warn” state within no more than 1.9 seconds.

c. Increase the transmission rate of the Surface Position Message to comply with the high rates specified in §2.2.3.3.2.3.

Verify that the ADS-B transmission monitoring function does not enunciate any “Fail Warn” conditions within 1.9 seconds after returning the rate to the acceptable rate.

d. Increase the transmission rate of the Surface Position Message such that it exceeds the acceptable high rate provided in §2.2.3.3.2.3.

Verify that the ADS-B transmission monitoring function properly enunciates the “Fail Warn” state within 1.9 seconds.

e. Decrease the transmission rate of the Surface Position Message to comply with the high rates specified in §2.2.3.3.2.3.

Verify that the ADS-B transmission monitoring function does not enunciate any “Fail Warn” conditions within 1.9 seconds after returning the rate to the acceptable rate.

f. Decrease the transmission rate of the Aircraft Identification and Type Messages below the acceptable high rate provided in §2.2.3.3.2.4.

Verify that the ADS-B transmission monitoring function properly enunciates the “Fail Warn” state within 15.7 seconds.

g. Increase the transmission rate of the Aircraft Identification and Type Messages to comply with the high rates specified in §2.2.3.3.2.4.

Verify that the ADS-B transmission monitoring function does not enunciate any “Fail Warn” conditions within 5.3 seconds after returning the rate to the acceptable rate.

h. Increase the transmission rate of the Aircraft Identification and Type Messages such that it exceeds the acceptable high rate provided in §2.2.3.3.2.4.

Verify that the ADS-B transmission monitoring function properly enunciates the “Fail Warn” state within 15.7 seconds.

i. Decrease the transmission rate of the Aircraft Identification and Type Message to comply with the high rates specified in §2.2.3.3.2.4.

Verify that the ADS-B transmission monitoring function does not enunciate any “Fail Warn” conditions within 5.3 seconds after returning the rate to the acceptable rate.

j. Set the rates of both messages, e.g., Surface Position and Aircraft Identification and Type Messages, such that the rates exceed the high rates those in §2.2.3.3.2.3 and §2.2.3.3.2.4, respectively.

Verify that the ADS-B transmitting monitoring function properly enunciates the “Fail Warn” state within no more than 1.9 seconds.

k. Set the rates of both messages, e.g., Surface Position and Aircraft Identification and Type Messages, to the high rates specified in §2.2.3.3.2.3 and §2.2.3.3.2.4, respectively.

Verify that the ADS-B transmission monitoring function does not enunciate any “Fail Warn” conditions within 5.3 seconds after returning the rates to the acceptable rates.

l. Decrease Ground Speed Data to the ADS-B transmitting monitoring function to establish the low rate for Surface Position and Aircraft Identification and Type messages.

Verify that the ADS-B transmitting monitoring function properly transmits Surface Position and Aircraft Identification and Type Messages at the low rates required in §2.2.3.3.2.3 and §2.2.3.3.2.4, respectively.

m. Repeat steps b through e for Surface Position Messages using the low rates specified in §2.2.3.3.2.3 and applying the following exceptions:

(1). The response time to set the “Fail Warn” state **shall** not exceed 15.6 seconds in steps b and d.

(2). The response time to clear the “Fail Warn” state **shall** not exceed 5.4 seconds in steps c and e.

n. Repeat steps f through i for Aircraft Identification and Type Messages using the low rates specified in §2.2.3.3.2.4 and applying the following exceptions:

(1). The response time to set the "Fail Warn" state **shall** not exceed 30.6 seconds in steps f and h.

(2). The response time to clear the "Fail Warn" state **shall** not exceed 10.4 seconds in steps c and e.

Step 3: Maximum DF=17 transmissions for Airborne Participants

a. Provide the ADS-B transmitting monitoring function with all necessary information to enable the transmitting function to generate the following DF=17 transmitted messages:

(1). Airborne Position Messages (§2.2.3.2.3),

(2). Aircraft Identification and Type Messages (§2.2.3.2.5), and

(3). Airborne Velocity Messages (§2.2.3.2.6)

(4). ADS-B Aircraft Trajectory Intent Messages (§2.2.3.2.7.1)

(5). Aircraft Operational Coordination Messages (§**Error! Reference source not found.**)

(6). Aircraft Operational Status Messages (§2.2.3.2.7.2)

(7). Extended Squitter Aircraft Status Messages (Type 28) (§2.2.3.2.7.8)

Verify that the ADS-B transmitting monitoring function properly transmits Airborne Position, Aircraft Identification and Type, Airborne Velocity, Aircraft Trajectory Intent, Aircraft Operational Coordination, Aircraft Operational Status, and Extended Squitter Aircraft Status Messages at the rates required in §2.2.3.3.2.2, §2.2.3.3.2.4, §2.2.3.3.2.5, §2.2.3.3.2.6.1, §**Error! Reference source not found.**, §2.2.3.3.2.6.2, and §2.2.3.3.2.6.3 respectively.

Verify that the ADS-B transmission monitor function does not enunciate any "Fail Warn" conditions.

b. Decrease the transmission rate of the Aircraft Trajectory Intent Messages below the acceptable rate provided in §2.2.3.3.2.6.1.

Verify that the ADS-B transmission monitor function properly enunciates the "Fail Warn" state in no more than 5.3 seconds.

c. Increase the transmission rate of the Aircraft Trajectory Intent Messages to comply with the rates specified in §2.2.3.3.2.6.1.

Verify that the ADS-B transmission monitor function does not enunciate any "Fail Warn" conditions 3.9 seconds after returning the rate to the acceptable rate.

d. Increase the transmission rate of the Aircraft Trajectory Intent Messages such that it exceeds the acceptable rate provided in §2.2.3.3.2.6.1.

   Verify that the ADS-B transmission monitor function properly enunciates the "Fail Warn" state in 5.3 seconds.

e. Decrease the transmission rate of the Aircraft Trajectory Intent Messages to comply with the rates specified in §2.2.3.3.2.6.1.

   Verify that the ADS-B transmission monitor function does not enunciate any "Fail Warn" conditions 3.9 seconds after returning the rate to the acceptable rate.

f. Change the data content of the Aircraft Operational Coordination Message and decrease the transmission rate of the Aircraft Operational Coordination Messages below the acceptable rate provided in §**Error! Reference source not found.**.

   Verify that the ADS-B transmission monitor function properly enunciates the "Fail Warn" state in no more than 6.4 seconds.

g. Change the data content of the Aircraft Operational Coordination Message and increase the transmission rate of the Aircraft Operational Coordination Messages to comply with the rates specified in §**Error! Reference source not found.**.

   Verify that the ADS-B transmission monitor function does not enunciate any "Fail Warn" conditions 4.3 seconds after returning the rate to the acceptable rate.

h. Change the data content of the Aircraft Operational Coordination Message and increase the transmission rate of the Aircraft Operational Coordination Messages such that it exceeds the acceptable rate provided in §**Error! Reference source not found.**.

   Verify that the ADS-B transmission monitor function properly enunciates the "Fail Warn" state in 6.4 seconds.

i. Change the data content of the Aircraft Operational Coordination Message and decrease the transmission rate of the Aircraft Operational Coordination Messages to comply with the rates specified in §2.2.3.3.2.6.1.

   Verify that the ADS-B transmission monitor function does not enunciate any "Fail Warn" conditions 4.3 seconds after returning the rate to the acceptable rate.

j. Wait at least 40 seconds.

   Verify that the ADS-B transmission monitor function does not enunciate any Fail Warn conditions during the wait period.

k. Wait at least 30 seconds, then decrease the rate of the Aircraft Operational Coordination Messages below the acceptable rate provided in §**Error! Reference source not found.**.

Verify that the ADS-B transmission monitor function properly enunciates the "Fail Warn" state in no more than 15.7 seconds.

l. Increase the rate of the Aircraft Operational Coordination Messages to comply with the rates specified in §**Error! Reference source not found.**.

Verify that the ADS-B transmission monitor function does not enunciate any "Fail Warn" conditions 5.3 seconds after returning the rate to the acceptable rate.

m. Increase the transmission rate of the Aircraft Operational Coordination Messages such that it exceeds the acceptable rate provided in §**Error! Reference source not found.**.

Verify that the ADS-B transmission monitor function properly enunciates the "Fail Warn" state in no more than 15.7 seconds.

n. Decrease the transmission rate of the Aircraft Operational Coordination Messages to comply with the rates specified in §**Error! Reference source not found.**.

Verify that the ADS-B transmission monitor function does not enunciate any "Fail Warn" conditions 5.3 seconds after returning the rate to the acceptable rate.

o. Decrease the transmission rate of the Aircraft Operational Status Messages below the acceptable rate provided in §2.2.3.3.2.6.2.

Verify that the ADS-B transmission monitor function properly enunciates the "Fail Warn" state in no more than 5.3 seconds.

p. Increase the transmission rate of the Aircraft Operational Status Messages to comply with the rates specified in §2.2.3.3.2.6.2.

Verify that the ADS-B transmission monitor function does not enunciate any "Fail Warn" conditions 3.7 seconds after returning the rate to the acceptable rate.

q. Increase the transmission rate of the Aircraft Operational Status Messages such that it exceeds the acceptable rate provided in §2.2.3.3.2.6.2.

Verify that the ADS-B transmission monitor function properly enunciates the "Fail Warn" state in 5.3 seconds.

r. Decrease the transmission rate of the Aircraft Operational Status Messages to comply with the rates specified in §2.2.3.3.2.6.2.

Verify that the ADS-B transmission monitor function does not enunciate any "Fail Warn" conditions 3.7 seconds after returning the rate to the acceptable rate.

s. Decrease the transmission rate of the Extended Squitter Aircraft Status Messages below the acceptable rate provided in §2.2.3.3.2.6.3.

   Verify that the ADS-B transmission monitor function properly enunciates the "Fail Warn" state in no more than 3.7 seconds.

t. Increase the transmission rate of the Extended Squitter Aircraft Status Messages to comply with the rates specified in §2.2.3.3.2.6.3.

   Verify that the ADS-B transmission monitor function does not enunciate any "Fail Warn" conditions 2.5 seconds after returning the rate to the acceptable rate.

u. Increase the transmission rate of the Extended Squitter Aircraft Status Messages such that it exceeds the acceptable rate provided in §2.2.3.3.2.6.3.

   Verify that the ADS-B transmission monitor function properly enunciates the "Fail Warn" state in no more than 3.7 seconds.

v. Decrease the transmission rate of the Extended Squitter Aircraft Status Messages to comply with the rates specified in §2.2.3.3.2.6.3.

   Verify that the ADS-B transmission monitor function does not enunciate any "Fail Warn" conditions 2.5 seconds after returning the rate to the acceptable rate.

2.4.11.2.2 Verification of Broadcast Only Equipment (§2.2.11.2.2)

Purpose/Introduction:

The following Test Procedures **shall** be used to verify that the ADS-B Transmitting monitor function properly enunciates the "Fail Warn" state if DF=18 transmissions do not occur at the rates specified in §2.2.3.3 through §2.2.3.3.2.10.

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.
Provide a method of detecting and monitoring ADS-B broadcast messages.

Provide a method of modifying the transmission rates of DF=18 transmitted messages such that the rates do not comply with the rates specified in §2.2.3.3 -through §2.2.3.3.2.10.

Note: *The test procedures provided in the following subparagraphs require the capability to vary the rate of ADS-B transmitted messages. It is explicitly intended that the equipment manufacturer provide the means to accomplish this task under closed Unit conditions.*

Measurement Procedure:

The following procedures **shall** be performed in the absence of other major operations being performed by the ADS-B transmitting monitoring function.

Repeat all of the procedures provided in §2.4.11.2.1 with the exception that all broadcast messages use DF = 18 instead of DF = 17**.**

2.4.11.3 Verification of Address (§2.2.11.3)

No specific test procedure is required to validate §2.2.11.3.

2.4.11.3.1 Verification of Transponder Based Equipment (§2.2.11.3.1)

Transponder Based Equipment **shall** be tested in accordance with the procedures provided in §2.4.11.3.2.

Note: *The requirement to test transponder based equipment is provided herein due to the fact that the test requirements provided in RTCA DO-181C do not test the function adequately.*

2.4.11.3.2 Verification of Non-Transponder Based Equipment (§2.2.11.3.2)

Purpose/Introduction:

The following Test Procedures **shall** be used to verify that the ADS-B Transmitting monitor function properly enunciates the "Fail Warn" condition in the event that the ICAO 24-Bit Address (§2.2.5.1.1) provided to the ADS-B Transmission function is set to ALL ZEROs or ALL ONEs.

Equipment Required:

A method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.
A method of detecting and monitoring ADS-B broadcast messages.

A method of modifying the ICAO 24-Bit Address provided to the Unit Under Test.

Measurement Procedure:

Step 1: Initial Conditions

Establish any state where the ADS-B Transmission Function is operational and indicating no Fail Warn conditions.

Step 2: Address set to ALL ZEROs

Remove power from the Unit Under Test (UUT)

Set the ICAO 24-Bit Address provided to the UUT to ALL ZEROs.

Apply power to the UUT.

Verify that the ADS-B transmission function properly enunciates the "Fail Warn" state within no more than 2.0 seconds.

Step 3: New Initial Conditions

Repeat Step 1.

Step 4: Address set to ALL ONE's

Remove power from the Unit Under Test (UUT)

Set the ICAO 24-Bit Address provided to the UUT to ALL ONE's.

Apply power to the UUT.

Verify that the ADS-B transmission function properly enunciates the "Fail Warn" state within no more than 2.0 seconds.

Step 5: Restore Normal Operations

Establish any state where the ADS-B Transmission Function is operational and indicating no Fail Warn conditions prior to continuing with further testing.

2.4.11.4 Verification of Receiver Self Test Capability (§2.2.11.4)

Purpose/Introduction:

The purpose of this procedure is to verify that the ADS-B Receiving Devices provide sufficient self-test capability to detect a loss of capability to receive ADS-B Messages, structure appropriate ADS-B reports, and make such reports available to the intended user interface. The procedure also verifies that should the receiving device detect that these basic functions cannot be performed properly, then the receiving device properly sets the appropriate "Fail/Warn" indicators to the "Fail/Warn" state.

Equipment Required:

A method of supplying the Receiving function under test with ADS-B Broadcast Messages to include Airborne Position, Airborne Velocity, and Aircraft Identification and Type messages as a minimum.

A method of receiving and storing all Output Messages or Reports generated by the receiving function under test.

A method of analyzing the Output Messages or Reports generated by the receiving function under test.

A method of inducing a fault condition into the Receiving function such that it can no longer properly receive and process ADS-B Broadcast Messages

Note: *The manufacturer* ***shall*** *provide a method of inducing or simulating failure of the ADS-B Broadcast Message reception capability. This may be done by appropriate Software Test provisions or may require that the unit under test be opened in order to provide access to internal circuitry.*

Measurement Procedure:

Step 1: Establish ADS-B Broadcast Message Stimulus

Configure the ADS-B Broadcast Message simulation function to provide the ADS-B receiving function under test with Airborne Position, Airborne Velocity, and Aircraft Identification and Type messages for at least 10 Airborne participants. Each message **shall** be provided at the rates specified in §2.2.3.3.

Verify that the Receiving function under test is generating the appropriate Reports that are expected for the ADS-B Broadcast Messages being provided by the simulation function.

Step 2: Induce Receiver Failure

Induce a failure into the ADS-B Receiving function under test such that ADS-B Broadcast Messages can no longer be received.

Verify that the ADS-B Receiving function properly enunciates the "Fail Warn" state for as long as the failure is induced.

Step 3: Remove Induced Receiver Failure

Remove the induced failure and allow the ADS-B Receiving function under test to return to normal operation.

Verify that the ADS-B Receiving function does not enunciate the "Fail Warn" state 2.0 seconds after removing the induced failure.

2.4.11.5 Verification of Failure Annunciation (§2.2.11.5)

No specific test procedure is required to validate §2.2.11.5.

2.4.11.5.1 Verification of ADS-B Transmission Device Failure Annunciation (§2.2.11.5.1)

Appropriate test procedures to validate §2.2.11.5.1 are provided in §2.4.11.2.1 through §2.4.11.3.2.

2.4.11.5.2 Verification of ADS-B Receiving Device Failure Annunciation (§2.2.11.5.2)

Appropriate test procedures to validate §2.2.11.5.2 are provided in §2.4.11.4.

2.4.11.5.3 Verification of Co-Located ADS-B Transmission and Receiving Device Failure Annunciation (§2.2.11.5.3)

Appropriate test procedures to validate §2.2.11.5.1 are provided in §2.4.11.2.1 through §2.4.11.3.2, and §2.4.11.4.

2.4.12 Verification of Response to Mutual Suppression Pulses (§2.2.12)

No specific test procedure is required to validate §2.2.12.

2.4.12.1 Verification of ADS-B Transmitting Subsystem Response to Mutual Suppression Pulses (§2.2.12.1)

Purpose/Introduction:

The following Test Procedures **shall** be used to verify that the ADS-B Transmitting Subsystem functions properly in the Mutual Suppression environment.

Equipment Required:

Provide a method of loading valid data for ADS-B broadcast messages into the ADS-B equipment under test.

Provide a method of supplying the ADS-B Transmitting function with Mutual Suppression Pulses.

Provide a method of monitoring and recording ADS-B transmissions and the time at which such transmissions are generated with respect to the end of a mutual suppression pulse.

Measurement Procedure:

Step 1: Initialize ADS-B Airborne Participant Transmissions

Provide the ADS-B transmitting function with all necessary information to enable the transmitting function to generate the following DF=17 transmitted messages:

(1). Airborne Position Messages (§2.2.3.2.3),

(2). Aircraft Identification and Type Messages (§2.2.3.2.5), and

(3). Airborne Velocity Messages (§2.2.3.2.6)

Verify that the ADS-B transmitting function properly transmits Airborne Position, Aircraft Identification and Type, and Airborne Velocity Messages at the rates required in §2.2.3.3.2.2, §2.2.3.3.2.4, and §2.2.3.3.2.5.

Step 2: Apply Mutual Suppression

Apply Mutual Suppression pulses of the maximum length that the suppression interface is designed to accept.

Verify that no ADS-B transmissions occur during the suppression period.

Record the transmissions that are generated and verify that transmissions can be output no later than 15 microseconds after the end of the mutual suppression pulse.

2.4.12.2 Verification of ADS-B Receiving Device Response to Mutual Suppression Pulses (§2.2.12.2)

Purpose/Introduction:

The following Test Procedures **shall** be used to verify that the ADS-B Receiving device functions properly in the Mutual Suppression environment.

Equipment Required:

Provide a method of supplying ADS-B Transmitted messages to the ADS-B Receiving function.

Provide a method of supplying the ADS-B receiving function with Mutual Suppression Pulses that can be synchronized to the ADS-B Transmitted messages provided to the ADS-B Receiving function.

Provide a method of monitoring and recording the Receiving function decoded ADS-B Messages or structured ADS-B Reports.

Measurement Procedure:

Step 1: Initialize ADS-B Message Reception

Provide the ADS-B Receiving function with appropriate ADS-B Messages at a minimum rate of two per second and having a signal level of the Receiver MTL + 3 dB.

Verify that the Receiving function decodes at least 99 % of the messages provided to the receiver.

Step 2: Apply Mutual Suppression

a. Apply Mutual Suppression pulses synchronized to start before each ADS-B Message provided to the Receiving function.

Ensure that the duration of each Mutual Suppression pulse exceeds that of the ADS-B Messages being provided to the Receiving function.

Verify that no ADS-B Messages are successfully decoded by the Receiving function.

b. Apply Mutual Suppression pulses that do not over lap any of the ADS-B Messages provided to the Receiving function and are synchronized to finish 15 microseconds prior to the start of each ADS-B Message provided to the Receiving function.

Verify that at least 90 percent of the ADS-B Messages provided to the Receiving function are properly decoded by the Receiving function.

2.4.13 Verification of Antenna System (§2.2.13)

No specific test procedure is required to validate §2.2.13.

2.4.13.1 Verification of Transmit Pattern Gain (§2.2.13.1)

Appropriate installed equipment test procedures to verify the Transmit Pattern Gain are provided in §3.3.4.6.1.

2.4.13.2 Verification of Receiver Pattern Gain (§2.2.13.2)

Appropriate installed equipment test procedures to verify the Receiver Pattern Gain are provided in §3.3.4.6.2.

2.4.13.3 Verification of Frequency Requirements for Transmit and Receive Antenna(s) (§2.2.13.3)

Appropriate installed equipment test procedures to verify the Frequency Requirements are provided in §3.3.4.6.3.

2.4.13.4 Verification of Impedance and VSWR (§2.2.13.4)

Appropriate installed equipment test procedures to verify the Impedance and VSWR are provided in §3.3.4.6.4.

2.4.13.5 Verification of Polarization (§2.2.13.5)

Appropriate installed equipment test procedures to verify the Polarization are provided in §3.3.4.6.5.

2.4.13.6 Verification of Diversity Operation (§2.2.13.6)

No specific test procedure is required to validate §2.2.13.6.

2.4.13.6.1 Verification of Transmitting Diversity (§2.2.13.6.1)

Purpose/Introduction:

This test procedure verifies that an ADS-B Transmitting Subsystem implements transmitting diversity properly by transmitting each required type of ADS-B Message alternately from the top and bottom antenna channels.

Equipment Required:

Provide a method of supplying the ADS-B Transmission function with all data necessary to structure ADS-B Airborne Position, Airborne Velocity, and Aircraft Identification and Type messages. All data **shall** be provided via the operational interfaces.

Provide a method of monitoring the ADS-B Broadcast Messages transmitted by the ADS-B Transmission function.

Measurement Procedure:

Step 1: Broadcast Message Initialization

Provide the ADS-B Transmission function with all data necessary to structure Airborne Position, Airborne Velocity, and Aircraft Identification and Type ADS-B Broadcast Messages.

Step 2: Broadcast Message Verification

Verify that the ADS-B Transmission function properly transmits the appropriate Airborne Position Messages alternately on the Top and Bottom RF ports.

Verify that the ADS-B Transmission function properly transmits the appropriate Airborne Velocity Messages alternately on the Top and Bottom RF ports.

Verify that the ADS-B Transmission function properly transmits the appropriate Aircraft Identification and Type Messages alternately on the Top and Bottom RF ports.

2.4.13.6.1.1 Verification of Transmitting Diversity Channel Isolation (§2.2.13.6.1.1)

Purpose/Introduction:

The purpose of this procedure is to verify that the peak RF power transmitted from the selected antenna exceeds the power transmitted from the non-selected antenna by at least 20 dB.

Equipment Required:

Provide a method of supplying the ADS-B Transmission function with all data necessary to structure ADS-B Airborne Position Broadcast messages. All data **shall** be provided via the operational interfaces.

A method of detecting the RF pulses of the ADS-B Broadcast Message for display on an oscilloscope.
Wide Band Dual Channel Oscilloscope (HP l7l0B, or equivalent).

Measurement Procedure:

Step 1: Broadcast Message Initialization

Provide the ADS-B Transmission function with all data necessary to structure Airborne Position Type ADS-B Broadcast Messages.

Step 2: Broadcast Message Verification

Verify that the ADS-B Transmission function properly transmits the appropriate Airborne Position Messages alternately on the Top and Bottom RF ports.

Step 3: Bottom Channel Isolation Verification

During the time that the Airborne Position Message is actually being transmitted via the Top Channel RF Port, verify that the signal level of any transmission on the Bottom Channel RF Port is at least 20 dB below the signal level of the transmission on the Top Channel RF Port.

Step 4: Top Channel Isolation Verification

During the time that the Airborne Position Message is actually being transmitted via the Bottom Channel RF Port, verify that the signal level of any transmission on the Top Channel RF Port is at least 20 dB below the signal level of the transmission on the bottom Channel RF Port.

2.4.13.6.2 Verification of Receiving Diversity (§2.2.13.6.2)

Appropriate test procedures to verify the performance of §2.2.13.6.2 are provided in §2.4.13.6.2.1 through §2.4.13.6.2.2.

2.4.13.6.2.1 Verification of Full Receiver and Message Processing or Receiver Switching Front-End Diversity (§2.2.13.6.2)

Purpose/Introduction:

This procedure verifies that the ADS-B Receiving function properly implements diversity by demonstrating proper reception of ADS-B Broadcast Messages from either the top antenna, or the bottom antenna, or both antennas. This procedure applies to those configurations that implement Full receiver and message processing function diversity as discussed in §2.2.13.6.2.a. This procedure also apples to those configurations that implement Receiver Switching Front-End diversity as discussed in §2.2.13.6.2.b.

Equipment Required:

Provide a method of supplying the equipment under test with appropriate Airborne Position ADS-B Broadcast Messages.

A method of monitoring the Output Messages and/or ADS-B Reports generated by the ADS-B Receiving function.

RF Splitter/Combiner (2 port, or 3 dB type)

RF Attenuators (Fixed, various attenuation values, as needed)

Measurement Procedure:

Step 1: Test Equipment Configuration

Connect the ADS-B Broadcast Message generator to the RF Splitter input. Connect each output from the RF Splitter to the input of an RF Attenuator. Connect the output of one RF Attenuator to the Top Channel RF input port of the equipment under test. Connect the output of the other RF Attenuator to the Bottom Channel RF input port of the equipment under test.

Step 2: Top Channel is Primary Receiver

Adjust the Top Channel attenuator such that the signal level provided to the Top Channel RF input port is at least 3 dB above the MTL of the equipment under test.

Adjust the Bottom Channel attenuator such that the signal level provided to the Bottom Channel RF input port is 20 dB less than the MTL of the equipment under test.

Configure the ADS-B Broadcast Message generator to provide only Airborne Position messages for a single participant with the position continuously changing in the message.

Verify that the ADS-B Receiving function generates appropriate Output Messages or State Vector Reports for at least 90% of the Airborne Position Messages provided to the Top Channel RF input port.

Step 3: Bottom Channel is Primary Receiver

Adjust the Bottom Channel attenuator such that the signal level provided to the Bottom Channel RF input port is at least 3 dB above the MTL of the equipment under test.

Adjust the Top Channel attenuator such that the signal level provided to the Top Channel RF input port is 20 dB less than the MTL of the equipment under test.

Configure the ADS-B Broadcast Message generator to provide only Airborne Position messages for a single participant with the position continuously changing in the message.

Verify that the ADS-B Receiving function generates appropriate Output Messages or State Vector Reports for at least 90% of the Airborne Position Messages provided to the Bottom Channel RF input port.

Step 4: Top / Bottom Channel Equivalent

Adjust the Bottom Channel attenuator such that the signal level provided to the Bottom Channel RF input port is at least 3 dB above the MTL of the equipment under test.

Adjust the Top Channel attenuator such that the signal level provided to the Top Channel RF input port is at least 3 dB above the MTL of the equipment under test.

Configure the ADS-B Broadcast Message generator to provide only Airborne Position messages for a single participant with the position continuously changing in the message.

Verify that the ADS-B Receiving function generates appropriate Output Messages or State Vector Reports for between 90% and 100% of the Airborne Position Messages provided to the Bottom Channel RF input port.

2.4.13.6.2.2 Verification Receiving Antenna Switching Diversity (§2.2.13.6.2)

Purpose/Introduction:

This procedure verifies that the ADS-B Receiving function properly implements diversity by demonstrating proper reception of ADS-B Broadcast Messages from either the top antenna or the bottom antenna. This procedure applies to those configurations that implement Receiving Antenna switching as discussed in §2.2.13.6.2.c.

Equipment Required:

Provide a method of supplying the equipment under test with appropriate Airborne Position ADS-B Broadcast Messages.

A method of monitoring the Output Messages and/or ADS-B Reports generated by the ADS-B Receiving function.

RF Attenuators (Fixed, various attenuation values, as needed)

Measurement Procedure:

Step 1: Top Channel is Primary Receiver

Connect the ADS-B Broadcast Message generator to the RF Attenuator input. Connect the output of the RF Attenuator to the Top Channel RF input port of the equipment under test.

Adjust the attenuator such that the signal level provided to the Top Channel RF input port is at least 3 dB above the MTL of the equipment under test.

Configure the ADS-B Broadcast Message generator to provide only Airborne Position messages for a single participant with the position continuously changing in the message.

Verify that the ADS-B Receiving function generates appropriate Output Messages or State Vector Reports for at least 45% of the Airborne Position Messages provided to the Top Channel RF input port.

Step 2: Bottom Channel is Primary Receiver

Connect the ADS-B Broadcast Message generator to the RF Attenuator input. Connect the output of the RF Attenuator to the Bottom Channel RF input port of the equipment under test.

Adjust the attenuator such that the signal level provided to the Bottom Channel RF input port is at least 3 dB above the MTL of the equipment under test.

Configure the ADS-B Broadcast Message generator to provide only Airborne Position messages for a single participant with the position continuously changing in the message.

Verify that the ADS-B Receiving function generates appropriate Output Messages or State Vector Reports for at least 45% of the Airborne Position Messages provided to the Bottom Channel RF input port.

2.4.14 Verification of Interfaces (§2.2.14)

No specific test procedure is required to validate §2.2.14.

2.4.14.1 Verification of ADS-B Transmitting Subsystem Interfaces (§2.2.14.1)

No specific test procedure is required to validate §2.2.14.1.

2.4.14.1.1 Verification of ADS-B Transmitting Subsystem Input Interfaces (§2.2.14.1.1)

No specific test procedure is required to validate §2.2.14.1.1.

2.4.14.1.1.1 Verification of Discrete Input Interfaces (§2.2.14.1.1.1)

Appropriate verification of discrete input interfaces to the ADS-B Transmission function was demonstrated during testing of the entire transmission function performed in §2.4.2 and §2.4.3 of this document.

Note: *The manufacturer is required to document all intended data to be input via discrete inputs and ensure full and correct functioning of the ADS-B Transmission function for all inputs at these interfaces. The manufacturer **shall** also demonstrate that appropriate diode isolation is provided for each input interface. Such demonstration can be done by formal documentation of the design such as schematics and Bill of Materials (BOM).*

2.4.14.1.1.2 Verification of Digital Communication Input Interfaces (§2.2.14.1.1.2)

Appropriate verification of digital communication input interfaces to the ADS-B Transmission function was demonstrated during testing of the entire transmission function performed in §2.4.2 and §2.4.3 of this document.

Note: *The manufacturer is required to disclose the interface protocols and error control techniques used with these interfaces and to demonstrate correct functioning of theses interfaces in such regards. Traditionally, analysis and established knowledge of the interface (e.g., ARINC-429) have been sufficient to satisfy these interface integrity requirements.*

2.4.14.1.1.3 Verification of Processing Efficiency (§2.2.14.1.1.3)

Appropriate verification of the processing efficiency of interfaces to the ADS-B Transmission function was demonstrated during testing of the entire transmission function performed in §2.4.2 and §2.4.3 of this document.

2.4.14.1.2 Verification of ADS-B Transmitting Subsystem Output Interfaces (§2.2.14.1.2)

No specific test procedure is required to validate §2.2.14.1.2.

2.4.14.1.2.1 Verification of Discrete Output Interfaces (§2.2.14.1.2.1)

Appropriate verification of discrete output interfaces from the ADS-B Transmission function was demonstrated during testing of the entire transmission function performed in §2.4.2 and §2.4.3 of this document.

Note: *The manufacturer is required to document all intended data to be output via discrete interfaces and ensure full and correct functioning of the ADS-B Transmission function for all outputs at these interfaces. The manufacturer **shall** also demonstrate that appropriate diode isolation is provided for each output interface. Such demonstration can be done by formal documentation of the design such as schematics and Bill of Materials (BOM).*

2.4.14.1.2.2 Verification of Digital Communication Output Interfaces (§2.2.14.1.2.2)

Appropriate verification of digital communication output interfaces from the ADS-B Transmission function was demonstrated during testing of the entire transmission function performed in §2.4.2 and §2.4.3 of this document.

Note: *The manufacturer is required to disclose the interface protocols and error control techniques used with these interfaces and to demonstrate correct functioning of theses interfaces in such regards. Traditionally, analysis and established knowledge of the interface (e.g., ARINC-429) have been sufficient to satisfy these interface integrity requirements.*

2.4.14.2 Verification of ADS-B Receiving Device Interfaces (§2.2.14.2)

No specific test procedure is required to validate §2.2.14.2.

2.4.14.2.1 Verification of ADS-B Receiving Device Input Interfaces (§2.2.14.2.1)

No specific test procedure is required to validate §2.2.14.2.1.

2.4.14.2.1.1 Verification of Discrete Input Interfaces (§2.2.14.2.1.1)

Appropriate verification of discrete input interfaces to the ADS-B Receiving function was demonstrated during testing of the entire receiving function performed in §2.4.4 through §2.4.11 of this document.

Note: *The manufacturer is required to document all intended data to be input via discrete inputs and ensure full and correct functioning of the ADS-B Receiving function for all inputs at these interfaces. The manufacturer **shall** also demonstrate that appropriate diode isolation is provided for each input interface. Such demonstration can be done by formal documentation of the design such as schematics and Bill of Materials (BOM).*

2.4.14.2.1.2 Verification of Digital Communication Input Interfaces (§2.2.14.2.1.2)

Appropriate verification of digital communication input interfaces to the ADS-B Receiving function was demonstrated during testing of the entire receiving function performed in §2.4.4 through §2.4.11 of this document.

Note: *The manufacturer is required to disclose the interface protocols and error control techniques used with these interfaces and to demonstrate correct functioning of theses interfaces in such regards. Traditionally, analysis and established knowledge of the interface (e.g., ARINC-429) have been sufficient to satisfy these interface integrity requirements.*

2.4.14.2.1.3 Verification of Processing Efficiency (§2.2.14.2.1.3)

Appropriate verification of processing efficiency of interfaces to the ADS-B Receiving function was demonstrated during testing of the entire receiving function performed in §2.4.4 through §2.4.11 of this document.

2.4.14.2.2 Verification of ADS-B Receiving Device Output Interfaces (§2.2.14.2.2)

No specific test procedure is required to validate §2.2.14.2.2.

2.4.14.2.2.1 Verification of Discrete Output Interfaces (§2.2.14.2.2.1)

Appropriate verification of discrete output interfaces from the ADS-B Receiving function was demonstrated during testing of the entire receiving function performed in §2.4.4 through §2.4.11 of this document.

Note: *The manufacturer is required to document all intended data to be output via discrete interfaces and ensure full and correct functioning of the ADS-B Receiving function for all outputs at these interfaces. The manufacturer* ***shall*** *also demonstrate that appropriate diode isolation is provided for each output interface. Such demonstration can be done by formal documentation of the design such as schematics and Bill of Materials (BOM).*

2.4.14.2.2.2 Verification of Digital Communication Output Interfaces (§2.2.14.2.2.2)

Appropriate verification of digital communication output interfaces from the ADS-B Receiving function was demonstrated during testing of the entire receiving function performed in §2.4.4 through §2.4.11 of this document.

Note: *The manufacturer is required to disclose the interface protocols and error control techniques used with these interfaces and to demonstrate correct functioning of theses interfaces in such regards. Traditionally, analysis and established knowledge of the interface (e.g., ARINC-429) have been sufficient to satisfy these interface integrity requirements.*

2.4.15 Verification of Power Interruption (§2.2.15)

No specific test procedure is required to validate §2.2.15.

2.4.15.1 Verification of Power Interruption to ADS-B Transmitting Functions (§2.2.15)

Purpose/Introduction:

The purpose of this procedure is to verify that the ADS-B Transmitting equipment regains operational capability to within its operational limits within two seconds after the restoration of power following a momentary power interruption.

Equipment Required:

An equipment capable of loading valid data for ADS-B broadcast messages into the ADS-B Transmitting equipment under test through the operational interface.

Measurement Procedure:

Step 1: Enable Transmission of Airborne Position Messages

Supply the ADS-B Transmission function with the appropriate data necessary to establish Airborne Position Messages.

Verify that the ADS-B Transmission function generates appropriate Airborne Position Messages at the rate specified in §2.2.3.3.1.1 or 2.2.3.3.2.2.

Note: *If the Transmission function uses diversity and the test is being performed on one RF output interface at a time, then the specified rate necessary to satisfy this test is half of that given in §2.2.3.3.1.1 or §2.2.3.3.2.2.*

Step 2: Apply momentary power interrupts

Apply momentary power interrupts to the ADS-B Transmission function under test in accordance with RTCA Document No. DO-160D section 16 (EUROCAE ED-14D, section 16). Then restore the power to normal operating conditions.

Verify that the ADS-B Transmission function resumes generation of appropriate Airborne Position Messages no later than 2.0 seconds after the restoration of normal power.

Step 3: Repeat for additional RF Output Interfaces

If the ADS-B Transmission function implements diversity, then repeat steps 1 and 2 on the additional RF Output Interface.

2.4.15.2 Verification of Power Interruption to ADS-B Receiving Functions (§2.2.15)

Purpose/Introduction:

The purpose of this procedure is to verify that the ADS-B Receiving equipment regains operational capability to within its operational limits within two seconds after the restoration of power following a momentary power interruption.

Equipment Required:

An equipment capable of supplying valid ADS-B broadcast messages to the ADS-B Receiving equipment under test via the appropriate RF interface.

Measurement Procedure:

Step 1: Enable Reception of Airborne Position Messages

Via the receiver RF interface and in the absence of interference, apply valid 1090 MHz Airborne Position Messages at a uniform rate of 2 per second and at a signal level that is at least 15 dB above the MTL of the ADS-B Receiving function.

Verify that the ADS-B Receiving function delivers appropriate Output Messages to the user interface or to the Report Assembly function for all messages received and that the Output Message formats are consistent with the requirements of §2.2.6.1.1.

Step 2: Apply momentary power interrupts

Apply momentary power interrupts to the ADS-B Receiving function under test in accordance with RTCA Document No. DO-160D section 16 (EUROCAE ED-14D, section 16). Then restore the power to normal operating conditions.

Verify that the ADS-B Receiving function resumes generation of appropriate Output Messages to the user interface or to the Report Assembly function no later than 2.0 seconds after the restoration of power.

Then verify that the ADS-B Receiving function continues to deliver appropriate Output Messages to the user interface or to the Report Assembly function for all messages received and that the Output Message formats are consistent with the requirements of §2.2.6.1.1.

Step 3: Repeat for additional RF Output Interfaces

If the ADS-B Receiving function implements diversity, then repeat steps 1 and 2 on the additional RF Input Interface.

2.4.16 Verification of Compatibility with Other Systems (§2.2.16)

No specific test procedure is required to validate §2.2.16.

2.4.16.1 Verification of EMI Compatibility (§2.2.16.1)

Verification of EMI/EMC/HIRF/LIGHTNING compatibility is performed during Environmental testing in accordance with RTCA Document No. DO-160D (EUROCAE ED-14D) with the test procedures provided in section 2.3 of this document.

2.4.16.2 Verification of Compatibility with GPS Receivers (§2.2.16.2)

Verification of compatibility with GPS Receivers is demonstrated during verification of EMI/EMC/HIRF/LIGHTNING compatibility performed during Environmental testing in accordance with RTCA Document No. DO-160D (EUROCAE ED-14D) with the test procedures provided in section 2.3 of this document.

2.4.16.3 Verification of Compatibility with Other Navigation Receivers and ATC Transponders (§2.2.16.3)

Verification of compatibility with Other Navigation Receivers and ATC Transponders is demonstrated during verification of EMI/EMC/HIRF/LIGHTNING compatibility performed during Environmental testing in accordance with RTCA Document No. DO-160D (EUROCAE ED-14D) with the test procedures provided in section 2.3 of this document.

2.4.17 Verification of Traffic Information Services – Broadcast (TIS-B) (§2.2.17)

No specific test procedure is required to validate the requirements of §2.2.17.

2.4.17.1 Verification of TIS-B Introduction (§2.2.17.1)

No specific test procedure is required to validate the requirements of §2.2.17.1.

2.4.17.2 Verification of the TIS-B Format Structure (§2.2.17.2)

TBD

2.4.17.2.1 Verification of the "DF" Downlink Format (§2.2.17.2.1)

TBD

2.4.17.2.2 Verification of the "CF" Control Field (§2.2.17.2.2)

TBD

2.4.17.2.3 Verification of the "AA" Address Announced Field (§2.2.17.2.3)

TBD

2.4.17.2.4 Verification of the "ME" Message Extended Squitter Field (§2.2.17.2.4)

TBD

2.4.17.2.5 Verification of the "PI" Parity/Identify Field (§2.2.17.2.5)

TBD

2.4.17.3 Verification of TIS-B Messages (§2.2.17.3)

TBD

2.4.17.3.1 Verification of TIS-B Fine Airborne Position Message (§2.2.17.3.1)

TBD

2.4.17.3.1.1 Verification of the Relationship to ADS-B Format (§2.2.17.3.1.1)

TBD

2.4.17.3.1.2 Verification of the ICAO/Mode A Flag (IMF) (§2.2.17.3.1.2)

TBD

2.4.17.3.2 Verification of TIS-B Fine Surface Position Message (§2.2.17.3.2)

TBD

2.4.17.3.2.1 Verification of the Relationship to ADS-B Format (§2.2.17.3.2.1)

TBD

2.4.17.3.2.2 Verification of the ICAO/Mode A Flag (IMF) (§2.2.17.3.2.2)

TBD

2.4.17.3.3 TIS-B Identification and Category Message (§2.2.17.3.3)

TBD

2.4.17.3.3.1 Verification of the Relationship to ADS-B Format (§2.2.17.3.3.1)

TBD

2.4.17.3.3.2 Verification of the Application (§2.2.17.3.3.2)

TBD

2.4.17.3.4 Verification of TIS-B Airborne Velocity Message (§2.2.17.3.4)

TBD

2.4.17.3.4.1 Verification of the Relationship to ADS-B Format (§2.2.17.3.4.1)

TBD

2.4.17.3.4.2 Verification of ICAO/Mode A Flag (IMF) (§2.2.17.3.4.2)

TBD

2.4.17.3.4.3 Verification of Navigation Integrity Category (NIC) Supplement (§2.2.17.3.4.3)

TBD

2.4.17.3.4.4 Verification of the Navigation Accuracy Coding (NAC) (§2.2.17.3.4.4)

TBD

2.4.17.3.4.5 Verification of the Surveillance Integrity Level (SIL) (§2.2.17.3.4.5)

TBD

2.4.17.3.5 Verification of the TIS-B Coarse Position Message (§2.2.17.3.5)

TBD

2.4.17.3.5.1 Verification of the ICAO/Mode A Flag (IMF) (§2.2.17.3.5.1)

TBD

2.4.17.3.5.2 Verification of the Service Volume ID (SVID) (§2.2.17.3.5.2)

TBD

2.4.17.3.5.3 Verification of the Pressure Altitude (§2.2.17.3.5.3)

TBD

2.4.17.3.5.4 Verification of the Ground Track Status (§2.2.17.3.5.4)

TBD

2.4.17.3.5.5 Verification of the Ground Track Angle (§2.2.17.3.5.5)

TBD

2.4.17.3.5.6 Verification of the Ground Speed (§2.2.17.3.5.6)

TBD

2.4.17.3.5.7 Verification of the Encoded Latitude (§2.2.17.3.5.7)

TBD

2.4.17.3.5.8 Verification of the Encoded Longitude (§2.2.17.3.5.8)

TBD

2.4.17.3.6 Verification of the TIS-B Management Messages (§2.2.17.3.6)

TBD

2.4.17.4 Verification of TIS-B Message Processing and Report Generation (§2.2.17.4)

TBD

2.4.17.4.1 Verification of TIS-B Message-to-Track Correlation (§2.2.17.4.1)

TBD

2.4.17.4.1.1 Verification of TIS-B Messages Having a 24-Bit Address (§2.2.17.4.1.1)

TBD

2.4.17.4.1.2 Verification of TIS-B Messages Having Mode A Code and Track Number (§2.2.17.4.1.2)

TBD

2.4.17.4.2 Verification of TIS-B Position Message Decoding (§2.2.17.4.2)

TBD

2.4.17.4.3 Verification of TIS-B Track Update (§2.2.17.4.3)

TBD

2.4.17.4.4 Verification of TIS-B Track Initiation (§2.2.17.4.4)

TBD

2.4.17.4.5 Verification of TIS-B Track Drop (§2.2.17.4.5)

TBD

2.4.17.4.6 Verification of TIS-B Report Generation (§2.2.17.4.6)

TBD

3.0 Installed Equipment Performance

This section states the minimum acceptable level of performance for the equipment when installed in the aircraft. Installed performance requirements are the same as contained in section 2.2, which are verified through bench and environmental testing. Some system attributes and performance aspects may be affected by the physical installation (e.g. antenna patterns can affect system transmit and receive performance). System integrators might have several options when connecting to aircraft sensors or data sources. Some sources might lack the necessary range, resolution or accuracy to support the desired applications. This section identifies system attributes which installation techniques and choices might affect, beyond the equipment manufacturer's ability to compensate.

Note: *Installation of non-transponder based 1090 MHz ADS-B equipment in airplanes equipped with Mode-S transponders is prohibited. The transmission of squitters in addition to TCAS interrogation responses contributes unnecessary RF energy to the spectral environment. TCAS systems (in other airplanes) cannot take advantage of hybrid surveillance on the ADS-B data, since the non-transponder data cannot be validated by TCAS interrogation. ADS-B data is not directly available to ground interrogators as when read from transponder registers.*

3.1 Installed Equipment Considerations

A complete ADS-B system consists of five (5) functional elements:

1. Data sources for aircraft position, velocity, flight plan, status, etc.
2. ADS-B transmitter
3. ADS-B receiver
4. Report Generator
5. Applications

Each of these elements must meet the minimum requirements for an application in order for operational approval to be granted for that application. Table 3-1 is an example of a system that meets the minimum requirements for 3 generic applications. Additional guidance for determining requirements is contained in following paragraphs.

Table 3-1: Example System

Application	Data Source	ADS-B Equipment Class
VFR (e.g. Aid to Visual Acquisition)	VFR GPS (AC20-138 Compliant)	B1/Type 1 (*see Note*)
IFR (e.g. Aid to Terminal Separation and Sequencing)	TSO C129a, Class A2 GPS Receiver	A2/Type 1 (*see Note*)
Special IFR (e.g. Closely Spaced Parallel Approaches)	TSO C129a, Class A1 GPS Receiver	A3/Type 2 (*see Note*)

Note: *The type designation refers to the Receiver Report Generator type and is included here as an example of equipment labeling and is not to imply any specific interface is required. The developer is free to choose any of the interface types so long as it is properly documented and meets the end-to-end system requirements.*

3.1.1 Data Sources

Data sources necessary to support an application **shall** meet the requirements of the operational environment (e.g. The source of ADS-B navigation data must be approved for IFR navigation if the ADS-B application is to be approved for IFR operations.), and **shall** meet the accuracy, range, and resolution requirements of the appropriate ADS-B equipage category.

3.1.2 ADS-B Transmit Power

For aircraft that operate at altitudes in excess of 15,000 feet MSL or having a normal cruise speed of 175 KIAS or more, the ADS-B transmitter **shall** have a minimum effective radiated power (ERP) at the antenna of 125 watts (§2.2.2.1.1.2 and §2.2.2.1.1.3). For A0 and B equipage class aircraft operating exclusively below 15,000 feet MSL and having a normal cruise speed below 175 KIAS, the ADS-B transmitter **shall** have a minimum effective radiated power (ERP) at the antenna of 70 watts (§2.2.2.1.1.1)

All configurations of ADS-B transmitters may be used for VFR applications. IFR applications require transmission and/or reception of State Vector and full Mode Status messages. Some applications may require support for specific On-Condition messages.

3.1.3 ADS-B Receiver

The receiver **shall** be capable of supporting the message types required by application.

The receiver sensitivity limits the expected range of the installed system. The sensitivity of the installed receiving equipment should be appropriate to the minimum range requirement for the ADS-B equipage class. Receivers having a Minimum Trigger Level (MTL) of –74 dBm are capable of supporting applications at ranges up to 20 nautical miles. Receivers having a MTL of –79 dBm are capable of supporting applications at ranges up to 40 nautical miles. Receivers having a MTL of –84 dBm are capable of supporting applications at ranges beyond 80 nautical miles.

3.1.4 Report Generator

The report generator function **shall** be capable of accepting all message types and generating all reports appropriate to the intended applications. Special attention may be necessary for Type 1 interfaces to ensure that the equipment is properly matched to the application requirements.

3.1.5 Applications

Applications comprise any use of ADS-B data. Applications **shall** be developed in accordance with approved standards if standards exist. If approved standards do not exist, the developer **shall** propose a standard early in the development process to support approval of the operational concept and identify operational limitations.

First time operational approval for the use of installed ADS-B equipment in a given application will be accomplished via the Type Certificate (TC) or Supplemental Type Certificate (STC) approval process. Subsequent installations may be approved via the TC, STC, or field approval process. It is incumbent upon the developer to show that the system meets the requirements of the application. Operating limits of the system **shall** be included in an approved aircraft/rotorcraft flight manual supplement (AFMS/RFMS).

3.2 Equipment Installation

3.2.1 Aircraft Environment

Equipment **shall** be installed such that environmental conditions do not exceed the manufacturer's specifications during normal operations.

3.2.2 Aircraft Power Source

The supply voltage and allowable variation **shall** not exceed the manufacturer's specifications during normal operations. Equipment voltage and frequency tolerance characteristics **shall** be compatible with an aircraft power source of appropriate category as specified in RTCA/DO-160D.

3.2.2.1 Power Fluctuation

The equipment **shall** retain memory of variable data through aircraft power transfer, which occurs during normal operation. Typical power transfer involves switching from external power to internal power, either battery or APU generator, or to engine driven generator(s). The equipment **shall** not require re-initialization for power transfer (i.e. power loss) for a period up to 0.5 second maximum. Power transfer **shall** not latch a failure indication. Momentary failure indications, during switching, are allowed.

3.2.3 Accessibility

Controls, indicators, and displays provided for in-flight use **shall** be readily accessible and/or readable from the pilot's normal seated position. If two pilots are required to operate the aircraft, the controls must be readily accessible from each pilot's seated position. Adequate protection must be provided to prevent inadvertent turnoff of the equipment.

3.2.4 Display Visibility

If there is a control panel display, then appropriate flight crew member(s) must have an unobstructed view of displayed data when in the seated position. The brightness of any display must be adjustable to levels suitable for data interpretation under all cockpit ambient lighting conditions ranging from total darkness to reflected sunlight.

Note: *Visors, glare shields or filters may be an acceptable means of obtaining daylight visibility.*

3.2.5 Indicators

If visual indicators are installed, they **shall** be visible and readable from the pilot's normal seated position. If two pilots are required to operate the aircraft, indicators **shall** be visible from each pilot's seated position. The brightness of any indicator must be adjustable to levels suitable under all cockpit ambient lighting conditions ranging from total darkness to reflected sunlight. If an indication is distracting, a means to cancel it should be provided.

3.2.6 Alerts

If appropriate to an application, a means to alert the crew **shall** be provided. Aural alerts **shall** provide a mechanism by which they can be prioritized with respect to other aircraft system alerts (e.g. audio inhibit input and output discretes). Aural alerts **shall** include a means by which they can be silenced.

3.2.7 Failure Protection

Probable failures of the ADS-B equipment must not degrade the normal operation of equipment or systems connected to it. The failure of connected equipment or systems must not degrade normal operation of the ADS-B equipment except for loss of functions that are directly dependent upon the failed equipment.

3.2.8 Failure Indication

The ADS-B system operational status **shall** be available to the crew. Failures of the ADS-B transmitter and receiver **shall** be annunciated to the crew. Though acceptable, dedicated ADS-B transmit and receive failure indicators are not required. Text messages, displayed to the crew until acknowledged, are acceptable. Systems which combine transmit and receive functions in a common unit may use a single annunciation to indicate a failure. When an ADS-B function is hosted in another system, the host system failure annunciation is adequate to indicate loss of ADS-B function (e.g. If the transponder also transmits ADS-

B squitters, loss of ADS-B transmission is logically assumed with a TRANSPONDER FAIL indication.). Otherwise, transmitter and receiver failure warnings **shall** be independent (§2.2.11.5).

3.2.9 Interference Effects

The equipment **shall** not be the source of objectionable conducted or radiated interference nor be adversely affected by conducted or radiated interference from other equipment or systems installed in the aircraft. If these systems are installed, check for interference when operating on TACAN channels 60 to 72; DME channels 65 to 67 (1089 - 1091 MHz paired with VHF frequency 133.8 to 134.05)

Note: *Electromagnetic compatibility problems noted after installation of this equipment may result from such factors as the design characteristics of previously installed systems or equipment and the physical installation itself. The installing facility is responsible for resolving incompatibilities between the ADS-B equipment and previously installed equipment in the aircraft.*

3.3 Antenna Installation

3.3.1 General Considerations

Antenna gain and pattern characteristics are major contributors to the system data link performance. The location and number of antennas required for aircraft ADS-B systems is determined by the equipage class. Class A1, A2, and A3 require antenna diversity and must have transmitting and receiving capability on both the top and bottom of the aircraft. Diverse use of the installed antennas **shall** comply with the requirements of §2.2.13.6 and may be demonstrated by analysis.

If the ADS-B transmitter function is hosted in a Mode-S transponder, the antennas **shall** comply with the requirements of RTCA Document Number DO-181C.

If the ADS-B receiver function is hosted in a TCAS computer, the antennas **shall** comply with the requirements of RTCA Document Number DO-185A.

3.3.2 Transmission Lines

Transmission lines to the antennas **shall** have impedance, power handling, and loss characteristics in accordance with the equipment manufacturer’s specifications. The VSWR, as seen through the transmission lines to the antenna(s), **shall** be within the limits specified by the manufacturer.

When a transmission line is included as a part of the installation, all minimum installed system performance requirements stated in section 2.2, must be met. Test results provided by the equipment manufacturer may be accepted in lieu of tests performed by the equipment installer.

3.3.3 Antenna Location

Antennas **shall** be mounted as near as practical to the center line of the fuselage. Antennas **shall** be located to minimize obstruction to their fields in the horizontal plane.

Note: *Where possible, it is recommended that the antennas be mounted on the forward part of the fuselage, thereby minimizing blockage due to the vertical stabilizer and engine nacelles.*

3.3.3.1 Minimum Distance from Other Antennas

The spacing between any ADS-B antenna and any transponder (Mode-S or ATCRBS) antenna **shall** be sufficient to provide a minimum of 20dB of isolation between the two antennas.

Note: *If both antennas are conventional omni-directional matched quarter-wave stubs, 20 dB of isolation is obtained by providing a spacing of at least 51 cm (20 in.) between the centers of the two antennas. If either antenna is other than a conventional stub, the minimum spacing must be determined by measurement.*

3.3.3.2 Mutual Suppression

If other equipment installed in the aircraft operates at or near 1090 MHz, such as DME, the need for mutual suppression **shall** be determined. When mutual suppression is used, the requirements of §2.2.12 **shall** be met. There **shall** be no more than one active 1090 MHz ADS-B transmitter per aircraft at any time.

3.3.4 Antenna Gain Performance

Gain performance of the ADS-B antenna(s) is tested to verify that the installed antenna gain is not degraded from §2.2.13 requirements, beyond an acceptable value. Transmit antenna(s) **shall** be located such that a receiving system reliably receives data from the transmitting aircraft at the minimum range appropriate to the equipage category, as stated in Table 3-2. Receive antenna(s) **shall** be located such that a receiving system reliably receives data from a transmitting aircraft at the minimum range appropriate to the equipage category, as stated in Table 3-2. If a traffic display is installed, reliable data reception is indicated by traffic target acquisition range and smooth movement of traffic targets, without excessive “pop-up,” “drop-out,” or position “jumps.”

Note: *Typical ADS-B antennas have areas of reduced gain, directly above or below the antenna, such that no signal can be received from transmitters in the “cone of silence” or “uncertainty cone.” Reliable data reception from these areas is not required. Approval of operational applications should consider this limitation.*

Table 3-2: Minimum Ranges for Receiving Reliability

Equipage		Required Range (NM)
Class	**Type**	
A0	Minimum	10
A1	Basic	20
A2	Enhanced	40
A3	Extended	90*
A3+	Extended Desired	120*

* For each equipage class, the value shown in Table 3-2 corresponds to forward directional coverage. Port and starboard coverage may be one half of this value; aft may be one third of this value. (Ref. RTCA/DO-242A Table 3-2(a))

3.3.4.1 Gain Performance Verification

Gain performance can be verified using one or a combination of four distinct procedures:

(a) full scale antenna range measurements,

(b) scaled model measurements,

(c) theoretical calculations,

(d) distance-area calculations, to ensure that the location of the antenna on the aircraft does not unduly degrade its gain performance.

This procedure(s) **shall** be performed on final installed equipment with all appropriate connections and antenna in order to demonstrate proper operation of the final installation.

3.3.4.1.1 Success Criteria

At an elevation angle of zero degrees relative to the fuselage reference plane, the gain of the forward +/- 45 degree azimuth sector of both the top and bottom antennas **shall** be no more than one dB below the gain of the antenna when installed on a standard ground plane as specified in §2.2.13. The radiation pattern gain, at zero degrees elevation, **shall** be within 3 dB of the gain of the ground-plane-installed antenna over 90% of the remainder of its azimuth coverage. The verification procedures of §2.4.13.1 through §2.4.13.5 **shall** be performed on final installed equipment with all appropriate connections and antenna in order to demonstrate proper operation of the final installation.

Note: *Antenna system performance tests are specified to accommodate the most stringent envisioned applications. Operational approval of proposed applications must consider installed antenna system performance. Installations that do not fully comply with the above requirements may be approved for particular operations based on the safety implications of the application.*

3.3.4.2 Full Scale Anechoic Antenna Range Measurements of Gain

The gain characteristics of the antenna as mounted on the actual airframe may be measured directly in a calibrated anechoic antenna test range using standard controlled procedures for such measurements. Gain characteristics determined in this way require no further validation.

Note: *Anechoic range measurements are generally impractical for determining full antenna gain patterns for large aircraft. However, such techniques may be practical for qualifying certain sub-regions of the coverage pattern or for validating model measurements or theoretical calculations.*

3.3.4.3 Scaled Model Measurements of Gain

Aircraft models for antenna measurements are normally 1/10 to 1/40 scale. Scale selection is dependent upon considerations such as availability of equipment, and antenna scaling, with larger models resulting in greater accuracy.

Only the major structural features of the airframe need be constructed. Details such as windows, doors, turbines, etc. are not required. The outside skin should be of conductive material. Typically, the fuselage and engine nacelles are modeled from metal tubing and/or shaped metal screening; wings and stabilizers can be modeled from flat metal plates. Movable control surfaces are not required unless they will have significant effects upon the antenna pattern.

Notes:

1. *In general, obstructions that subtend angles at the antenna of less than a few degrees in elevation or azimuth need not be modeled. However, smaller obstructions such as other antennas, that are located within a few wavelengths of the antenna under test, may have to be modeled because they can act as resonant scatterers and could have a significant effect on the radiation pattern.*

2. *If the swept area of propeller blades exceeds the limits given in (1) above, the blades can be worst-case modeled by a flat metal disk of radius proportional to blade length. If the radiation pattern using disks for propellers satisfies the success criteria, it can be assumed that the pattern modulation caused by the rotating blades will not significantly degrade the ADS-B system performance.*

3.3.4.4 Model Tests

Mount the scaled model antenna in the center of a ground plane whose radius is equal in wavelengths to the ground plane used for testing the full scale antenna.

Using a calibrated anechoic antenna test range, confirm that the gain of the scaled antenna (including possible multiple radiating elements, splitting or combining networks, impedance, and mutual coupling effects) is within 2 dB of the full-scale antenna gain, for all azimuth and elevation angles for which the gain of the full-scale antenna is within 6 dB of the peak gain.

Mount the scaled model antenna on the aircraft model at the intended installation location.

Measure the antenna gain for all azimuth angles (for top and bottom antennas).

Confirm that the scaled antenna meets the success criteria of §3.3.4.1.1 above.

3.3.4.5 Theoretical Calculations of Antenna Gain

The gain characteristics of the antenna as mounted on the actual airframe may be determined by a combination of radiation pattern calculations, and measurements designed to validate those calculations. When using such techniques to determine the gain of a multi-element antenna, it is necessary to show that the calculations include the inherent characteristics of the antenna elements and their drivers, splitters, or combining networks and any effects due to mutual coupling between those elements.

3.3.4.5.1 Validation of Theoretical Calculations

If radiation pattern calculations are used to prove the success criteria of §3.3.4.1.1 above, the manufacturer of the antenna must provide corroborating data demonstrating the success of the calculation technique in predicting the antenna gain on an airframe roughly similar in size and complexity to the airframe under qualification. Such data must be obtained by comparison with selected gain measurements made

(a) on a full-size airframe using a calibrated ramp test antenna range, or

(b) on a scaled model airframe as indicated in 3.3.4.4.

3.3.4.5.2 Distance Area Calculations

The extent to which the antenna installation minimizes obstructions in the horizontal plane and minimizes effects of reflecting objects, may be judged by the distance to such objects and their sizes. If the distances and sizes satisfy the condition given here, then the antenna installation may be considered validated with regard to antenna gain. The condition is: For target aircraft at zero degree elevation angle and at azimuth bearing between –90 degrees and +90 degrees,

$$\frac{A_1^2}{l^2 D_1^2} + \sum \frac{A_2^2 G_2^{\,l}}{l^2 D_2^2 G_2} + \sum \frac{A_3 G_3^{\,l}}{4p D_3^2 G_3} < 0.02$$

where $l = 0.9$ ft. is the free space wavelength at 1090 MHz. The first term is applicable only if there is a metallic obstruction between the target and the ADS-B antenna. The distance in feet to the obstruction is denoted D_1 and the area in ft^2 of the obstruction projected in the direction of the ADS-B antenna is denoted A_1. The second term is a summation over flat metallic reflectors, if any, that are oriented so as to cause a specular reflection between the ADS-B antenna and the target. The distance to the reflector, in feet, is denoted D_2, the area, in square feet, of the reflector, projected in the direction of the ADS-B antenna is denoted A_2, the antenna gain in the direction of the reflector is denoted G'_2 and is dimensionless (i.e. gain in dB = 10 log G'_2), and the antenna gain in the direction of the target is denoted G_2 and is dimensionless. The third term is a summation over all other metallic objects that may cause reflections between the ADS-B antenna and the target.

The parameters D_3, A_3, G'_3, and G_3 have the same meanings as in the second term. In the case of other aircraft antennas in view of the ADS-B antenna, a minimum value for A = 0.22 square feet is to be used if the actual area of the antenna is less than 0.22 square feet.

3.3.4.5.3 Dynamic Response

The antenna(s) **shall** be located such that operation of the equipment is not adversely affected by aircraft maneuvering or changes in attitude encountered in normal flight operations.

Note: *Class A0 installations are not required to install multiple (e.g. top fuselage and bottom fuselage) antennas.*

3.3.4.6 Installed Equipment Antenna System

3.3.4.6.1 Verification of Transmit Pattern Gain (§2.2.13.1)

Purpose/Introduction:

The purpose of this procedure is to verify that the gain of an omni-directional transmit antenna is not less than the gain of a matched quarter-wave stub minus 3 dB over 90 percent of a coverage volume from 0 to 360 degrees in azimuth and from 5 to 30 degrees above the ground plane when installed at center of 1.2 meter (4 feet) diameter (or larger) flat circular ground plane.

This procedure should be performed in the laboratory environment to demonstrate that the ADS-B Transmitting Subsystem properly delivers RF ADS-B Messages to the free space medium via the expected installation connections and radiating antenna.

This procedure **shall** be performed on final installed equipment with all appropriate connections and antenna in order to demonstrate proper operation of the final installation.

Equipment Required:

Provide a method of generating ADS-B Airborne Position Broadcast.

Calibrated quarter-wave stub Sense Antenna of known gain. (See Figure 3-1)

Appropriate Couplers and Connectors as required

Coaxial Connection of known attenuation (shown in Figure 3-1 as Coax #2)

Appropriate Attenuators as required

HP 8753E Spectrum Analyzer (or equivalent capability)

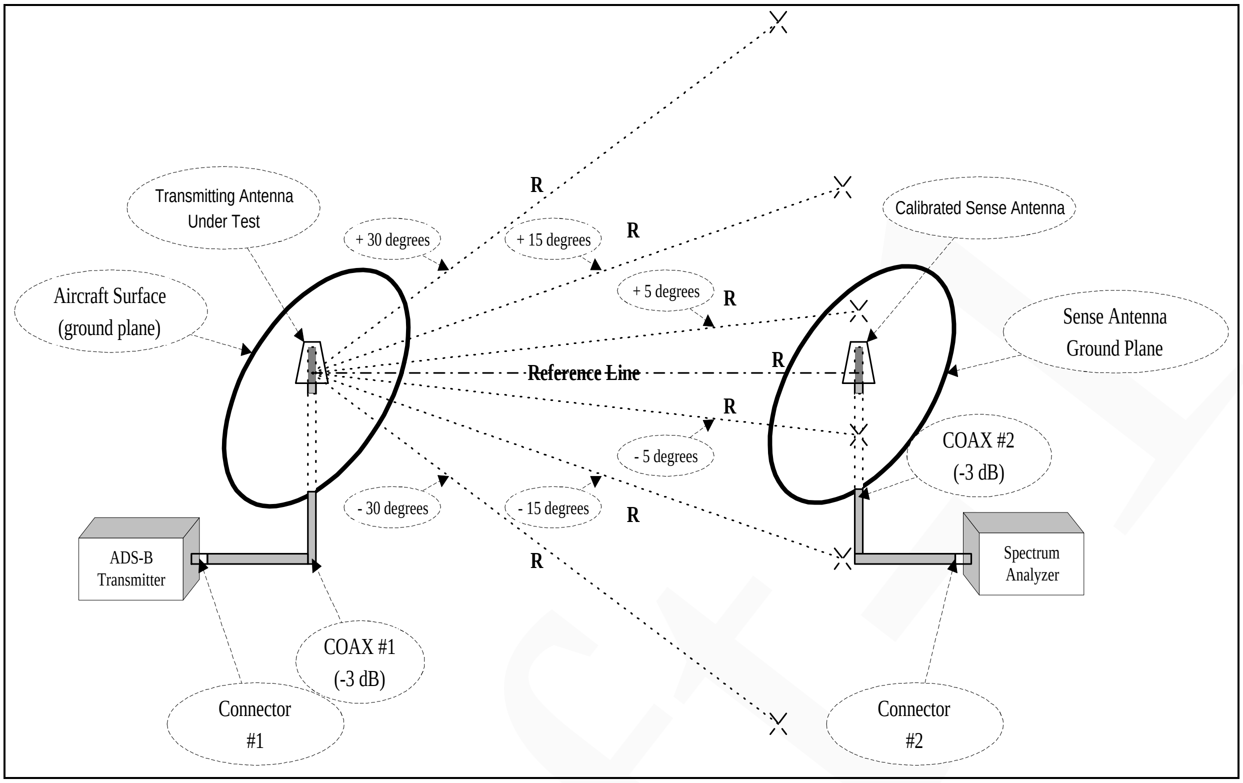


Figure 3-1: Antenna Test Configuration

Measurement Procedure:

Step 1: Understand the Equation

Define:

P_out = Transmitted Power (**in watts**) Measured at the ADS-B Broadcast Message Generator output connector in watts

Loss_TX = **attenuation** (**in dB**) provided by connection of the ADS-B Broadcast Message Generator to the Transmitting Antenna. This includes the cable (i.e., Coax #1 in Figure 3-1) and connectors

G_tx = gain (**in dB**) of the transmitting antenna

R = Distance between the transmitting antenna and the receiving antenna in meters

Path_Loss = attenuation (**in -dB**) of a 1090 MHz signal in free space for distance = R

$= [\lambda/(4\pi R)]^2 = [(300/1090)/(4\pi R)]^2 = [(2.19020564 \text{ X } 10^{-2})/R]^2$

$= 20*\log(2.19020564 \text{ X } 10^{-2}) - 20*\log(R)$

$= - 33.1903022 - 20*\log(R)$

G_rx	=	gain (**in dB**) of the receiving or Calibrated Sense Antenna
Loss_RX	=	**attenuation** (**in dB**) provided by connection of the Calibrated Sense Antenna to the Spectrum Analyzer. This includes the cable (i.e., Coax #2 in Figure 3-1) and connectors and should be calibrated to 3 dB
P_rx_dBw	=	Power (in **dBw**) received at the Spectrum Analyzer
P_rx_dBm	=	P_rx_dBw - 30 = Power (in **dBm**) received at the Spectrum Analyzer

Then the expected power of the 1090 MHz signal received at the Spectrum Analyzer is given by the following equation.

EQUATION 1:

P_rx_dBw = 10*log(P_out) **-** Loss_TX **+** G_tx **+** Path_Loss **+** G_rx **-** Loss_RX

= 10*log(P_out) - Loss_TX + G_tx -33.1903022 -20*log(R) + G_rx - Loss_RX

Specifying a Range of 3 meters (i.e., the distance between the antennas along the reference line shown in Figure 3-1) to be used as the Range in the following procedure provides the following Equation 2.

P_rx_dBw = 10*log(P_out) - Loss_TX + G_tx - 33.1903022 - 9.54242509 + G_rx - Loss_RX

EQUATION 2:

P_rx_dBw = 10*log(P_out) - Loss_TX + G_tx - 42.73272729 + G_rx - Loss_RX

Note: *If the measurement distance, R, is different from 3 meters, then Equation 2 must be recomputed for the new R and the recomputation must be based on Equation 1. Equation 1 is based on the fact that there are 1852 meters in one nautical mile. Also, there are 6076.1 feet in one nautical mile. Therefore, for the purpose of these computations, there are 3.280831533 feet per meter.*

The Effective Radiated Power (ERP) emitted from the Transmitting Antenna is then given by Equation 3 as follows:

EQUATION 3:

ERP_dBw = P_rx_dBw + 42.73272729 - G_rx + Loss_RX

Note: *Whenever the need to measure radiated RF power is established, the question arises in regards to the permissible level of radiation that can be sustained by personnel making the measurements. This document addresses such concerns in the following paragraph of this note.*

Assume that the maximum Effective Radiated Power from the Transponder or ADS-B Transmitting Subsystem is 500 W (26.98970004 dBW) as specified in §2.2.2.1.2 of this document and §2.2.3.2.d of RTCA Document No. DO-181C.

Then, using portions of equation 2 or 3 from above, the radiated power at 3 meters is given as follows:

P_3m_dBW	=	*ERP - 42.73272729*
	=	*26.98970004 dBW -42.73272729*
P_3m_dBW	=	*-15.74302725 dBW*

then the power at 3 meters in watts is as follows:

*10*log(P_3m_W)*	=	*-15.74302725*
P_3m_W	=	$(-1.574302725)^{10}$
	=	*0.02665 W*
	=	*26.65 mW*

This would appear to be a minimum amount of power: however, it does not readily translate into Maximum Permissible Exposure ***(MPE)*** *limits which are typically used to determine hazard levels.*

Consulting FCC OET Bulletin 65, Edition 97-01, August, 1997, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields," provides information as provided in the following paragraphs.

Section 2, equation 3, page 19 of the bulletin provides the following equation for the prediction of RF fields:

$$S = \frac{EIRP}{4pR^2}$$

where:

S = power density (in appropriate units, e.g. mW/cm²)
EIRP = equivalent (or effective) isotropically radiated power (inappropriate units, e.g .mW)
R = distance to the center of radiation of the antenna (appropriate units, e.g., cm)

Applying this equation at 3 meters to the maximum radiated power (e.g., 500 W) allowed for transponders or ADS-B Transmitting functions provides the following results:

$$S = \frac{(500\ W)(1000\ mW/W)}{4p(300\ cm)^2}$$

$$= 0.44209706\ mW/cm^2$$

Appendix A, Table 1(A) of the bulleting then provides MPE limits for Occupational/Controlled Exposure as follows:

Frequency Range (MHz)	=	*300 - 1500*
Electric Field Strength (E) (V/m)	=	*Not Applicable*
Magnetic Field Strength (H) (A/M)	=	*Not Applicable*

Power Density (S) (mW/cm^2) = *f/300*
Averaging Time, S ***(minutes)*** = *6*

Therefore, the MPE exposure for an average of 6 minutes at 1090 MHz is:

S_MPE_1090 = *(1090)/300* = *3.63333333... mW/cm^2*

Note that this limit value is 8.2184 times greater than the power density at 3 meters computed above as 0.44209706 mW/cm^2.

Next, the time of exposure must be considered. Page 11 of the bulletin addresses this concern with the equation:

$$S\ S_{exp}t_{exp} = S_{limit}t_{avg}$$

where:

S_{exp} = *power density of exposure (mW/cm^2)*
S_{limit} = *appropriate power density MPE limit (mW/cm^2)*
t_{exp} = *allowable time of exposure for S_{exp}*
t_{avg} = *appropriate MPE averaging time*

Taking into the consideration that the transponder or ADS-B Transmitting Subsystem will never exceed a transmitting duty cycle of 5%, the allowable time of exposure is computed from the above equation as follows:

$$(0.44209706\ mW/cm^2)*X*(0.05) = (1090/300\ mw/cm^2)(6\ minutes)$$

$$X = \frac{(1090/300\ mw/cm^2)(6\ minutes)}{(0.44209706\ mW/cm^2)(0.05)}$$

$$X = 986.209\ minutes$$

or

$$X = \mathbf{16.4368\ hours}$$

These calculations have demonstrated that the expected power density of the transponder or ADS-B transmitting function at 3 meters is well within the allowable MPE. The calculations also demonstrate that the time of 16.44 hours of exposure to present a possible hazard is considerably longer than any time necessary to perform the test procedures address in this subparagraph.

Step 2: Measure the Output Power of the ADS-B Transmitting function or device

On the Aircraft (or other applicable installation), disconnect the ADS-B Transmitting Subsystem to Antenna connection at the ADS-B Transmitting Subsystem unit connector.

Using appropriate attenuators, connectors, and coaxial cable of known attenuation of 3 dB and impedance of 50 ohms, connect the Spectrum Analyzer to the ADS-B Transmitting Subsystem.

Note: *The use of attenuators is strongly recommended such that the RF receiver front end of the Spectrum Analyzer is not destroyed. If such happens, it is* *probable that the individual performing the test will not be performing similar tests in the future.*

Configure the ADS-B Transmitting function to transmit ADS-B Surface Position Messages.

Using the Spectrum Analyzer set at a center frequency of 1090 MHz, capture the strongest (i.e., highest RF power) pulse in an ADS-B Surface Position Message Pulse Train. Then measure the frequency and pulse power.

Verify that the frequency is at 1090 MHz +/- 1.0 MHz.

For Class A0 equipment, verify that the output power is at least 70 watts (i.e., 18.45098040 dBw, or -11.54901960 dBm). Log the measurement as P_out.

For Class A1, A2, and A3 equipment, verify that the output power is at least 125 watts (i.e., 20.96910013 dBw, or -9,0308999870 dBm). Log the measurement as P_out.

Step 3: Re-connect Aircraft Installation

Disconnect the Spectrum Analyzer from the ADS-B Transmitting Subsystem.

Restore the normal aircraft (or other) installation connection of the ADS-B transmitting antenna to the ADS-B Transmitting Subsystem.

Step 4: Establish Measurement Reference #1

Refer to Figure 3-1.

Using an appropriate strong nylon string or similar, secure the string to the Calibrated Sensing Antenna and to the Aircraft Antenna under test such that the two antenna are exactly 3 meters apart along the reference line shown in Figure 3-1. Make sure that the two antennas are at the same height from a relatively level surface. Note this position of the Calibrated Sensing Antenna as the **baseline** position.

Then, move the Calibrated Sensing Antenna to a point that is 5 degrees above the baseline position while maintaining the Calibrated Sensing Antenna perpendicular to the string with the string being tight but not stretched. Note this position as the **#1 Reference** Position.

Configure the ADS-B Transmitting function to transmit ADS-B Surface Position Messages.

Using the Spectrum Analyzer set at a center frequency of 1090 MHz, capture the strongest (i.e., highest RF power) pulse in an ADS-B Surface Position Message Pulse Train. Then measure and note the pulse power.

For Class A0 equipment, verify that the ERP (see Equation 3) is at least 70 watts (i.e., 18.45098040 dBw, or -11.54901960 dBm). Log the measurement as ERP_dBw.

For Class A1, A2, and A3 equipment, verify that the ERP (see Equation 3) is at least 125 watts (i.e., 20.96910013 dBw, or -9,0308999870 dBm). Log the measurement as ERP_dBw.

Step 5: Circular Measurements

Keeping the Calibrated Sensing Antenna at 5 degrees above the baseline position as specified in Step 4, move the Calibrated Sensing Antenna in the horizontal plane in approximately 45 degree steps such that new positions are established at approximately 45, 90, 135, 180, 225, 270, and 315 degrees relative to **#1 Reference** Position.

At each new position, repeat the power measurement taken in Step 4 and log the results in dBw.

Verify that the maximum deviation between any two measurements taken in Step 4 and this Step does not exceed 1 dBw.

Step 6: Establish new reference #2

Repeat Step 4 with the Calibrated Sensing Antenna moved to a position that is 15 degrees above the **baseline** position. Note this position as the **#2 Reference** Position.

Repeat the power measurement made in Step 4.

Verify that the maximum difference between the measurement and that taken in Step 4 does not exceed 1 dBw.

Repeat Step 5 about the **#2 Reference** Position while maintaining the Calibrated Sensing Antenna at 15 degrees above the baseline position.

Verify that the maximum deviation between any two measurements taken in this Step does not exceed 1 dBw.

Step 7: Establish new reference #3

Repeat Step 4 with the Calibrated Sensing Antenna moved to a position that is 30 degrees above the baseline position. Note this position as the **#3 Reference** Position.

Repeat the power measurement made in Step 4.

Verify that the maximum difference between the measurement and that taken in Step 4 does not exceed 1 dBw.

Repeat Step 5 about the **#3 Reference Position** while maintaining the Calibrated Sensing Antenna at 30 degrees above the baseline position.

Verify that the maximum deviation between any two measurements taken in this Step does not exceed 1 dBw.

Step 8: Establish new reference #4

Repeat Step 4 with the Calibrated Sensing Antenna moved to a position that is 5 degrees below the baseline position. Note this position as the **#4 Reference** Position.

Repeat the power measurement made in Step 4.

Verify that the maximum difference between the measurement and that taken in Step 4 does not exceed 1 dBw.

Repeat Step 5 about the #4 Reference Position while maintaining the Calibrated Sensing Antenna at 5 degrees below the baseline position.

Verify that the maximum deviation between any two measurements taken in this Step does not exceed 1 dBw.

Step 9: Establish new reference #5

Repeat Step 4 with the Calibrated Sensing Antenna moved to a position that is 15 degrees below the baseline position. Note this position as the **#5 Reference** Position.

Repeat the power measurement made in Step 4.

Verify that the maximum difference between the measurement and that taken in Step 4 does not exceed 1 dBw.

Repeat Step 5 about the **#5 Reference** Position while maintaining the Calibrated Sensing Antenna at 15 degrees below the baseline position.

Verify that the maximum deviation between any two measurements taken in this Step does not exceed 1 dBw.

Step 10: Establish new reference #6

Repeat Step 4 with the Calibrated Sensing Antenna moved to a position that is 30 degrees below the baseline position. Note this position as the **#6 Reference** Position.

Repeat the power measurement made in Step 4.

Verify that the maximum difference between the measurement and that taken in Step 4 does not exceed 1 dBw.

Repeat Step 5 about the **#6 Reference** Position while maintaining the Calibrated Sensing Antenna at 30 degrees below the baseline position.

Verify that the maximum deviation between any two measurements taken in this Step does not exceed 1 dBw.

3.3.4.6.2 Verification of Receiver Pattern Gain (§2.2.13.2)

Purpose/Introduction:

The purpose of this procedure is to verify that the gain of an omni-directional antenna should is not less than the gain of a matched quarter-wave stub minus one dB over 90% of a coverage volume from 0 to 360 degrees in azimuth and -15 to +20 degrees in elevation when installed at the center of a 1.2 m (4 ft.) diameter (or larger) circular ground plane that can be either flat or cylindrical.

This procedure **shall** be performed on final installed equipment with all appropriate connections and antenna in order to demonstrate proper operation of the final installation.

Equipment Required:

Provide the same equipment capability as that provided in §3.3.4.6.1.

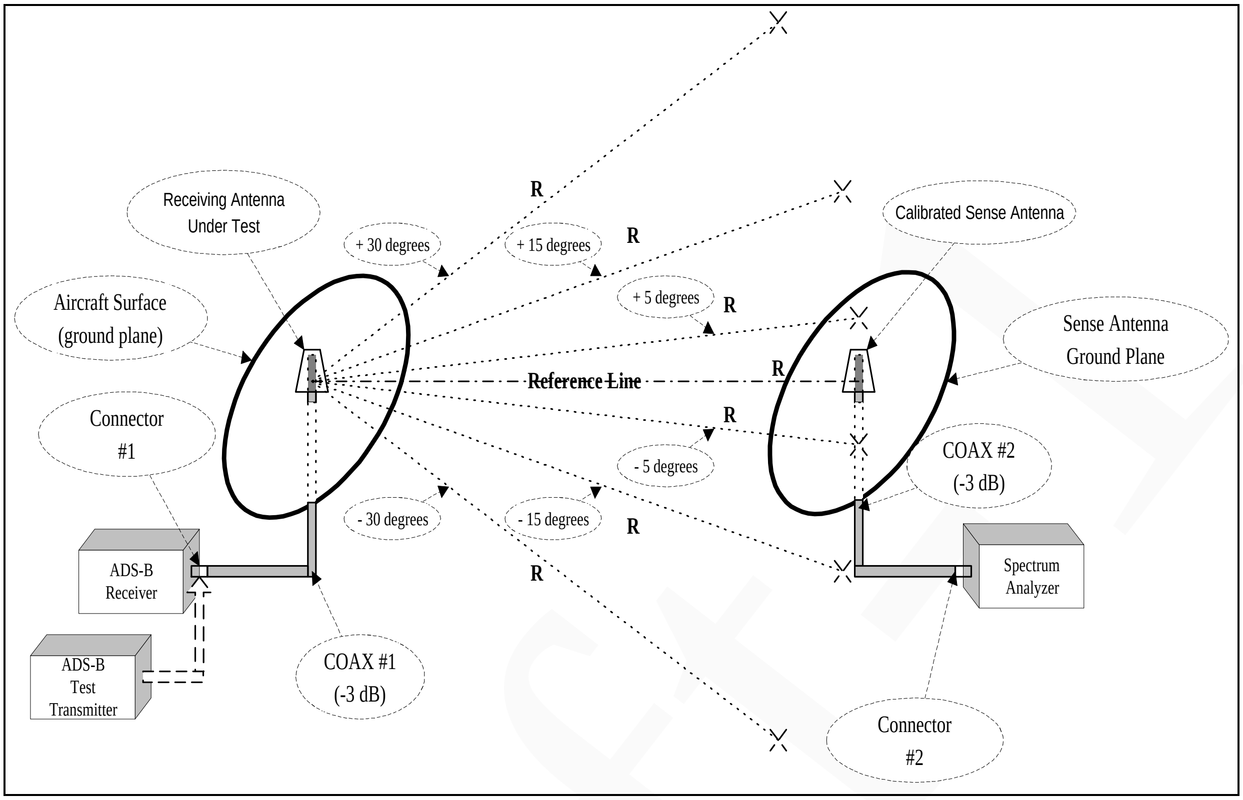


Figure 3-2: Antenna Test Configuration

Measurement Procedure:

Note: *Figure 3-2, above, is exactly the same as Figure 3-1 provided in §3.3.4.6.1 with the exception that:*

a. The ADS-B Transmitter in Figure 3-1 has been replaced with an ADS-B Receiver and an ADS-B Test Transmitter that is to be patched in for this test procedure.

b. The Transmitting Antenna under Test in Figure 3-1 has been replaced with a Receiving Antenna under Test.

Step 1: Install ADS-B Transmission Capability

On the Aircraft (or other applicable installation), disconnect the ADS-B Receiving Device to Antenna connection at the ADS-B Receiving device unit connector.

For Class A0 Receiver installations, install a ADS-B Test Transmitting device having a minimum RF power of least 70 watts (i.e., 18.45098040 dBw, or -11.54901960 dBm) ***plus*** 3 dB. If additional cabling or connectors are required to make the connection, then the added attenuation must be accounted for when applying the equations given in §3.3.4.6.1 in this procedure.

For Class A1, A2, and A3 Receiver installations, install a ADS-B Test Transmitting device having a minimum RF power of least 125 watts (i.e., 20.96910013 dBw, or -9,0308999870 dBm) ***plus*** 3 dB. If additional cabling or connectors are required to make the connection, then the added attenuation must be accounted for when applying the equations given in §3.3.4.6.1 in this procedure.

At this point, the ADS-B Receiving device of the ADS-B Receiving installation has been replaced with an appropriate RF source such that the radiated pattern of the receiving antenna installation can be verified. The premise here is that if the radiated pattern is good, then so is the reception pattern.

Step 2: Perform Radiated Pattern Tests

Using the equations given in §3.3.4.6.1, with appropriate modifications if necessary, repeat steps 2 through 10 of §3.3.4.6.1.

Step 3: Restore Original Installation

Disconnect and remove the ADS-B Test Transmitter and restore the original installation of the ADS-B Receiving device.

3.3.4.6.3 Verification of Frequency Requirements for Transmit and Receive Antenna(s) (§2.2.13.3)

Procedures to properly verify the frequency of ADS-B Transmitting installations are provided in §3.3.4.6.1, step 2.

Procedures to properly verify the frequency of ADS-B Receiving installations are provided in §3.3.4.6.2 by verification of the transmission frequency capability.

3.3.4.6.4 Verification of Impedance and VSWR (§2.2.13.4)

Purpose/Introduction:

The purpose of this procedure is to verify that the VSWR produced by the antenna when terminated in a 50 ohm transmission line does not exceed 1.5:1 at 1090 MHz.

Equipment Required:

Appropriate Couplers and Connectors as required. Coaxial Connection of known attenuation (shown in Figure 3-1 and Figure 3-2 as Coax #2). Appropriate Attenuators as required. HP 8562E Network Analyzer (or equivalent capability)

Measurement Procedure:

Step 1: Install Network Analyzer

For ADS-B transmitting installations, disconnect the ADS-B Transmitting Subsystem to Antenna connection at the ADS-B Transmitting Subsystem unit connector.

For ADS-B receiving installations, disconnect the ADS-B Receiving device to Antenna connection at the ADS-B Receiving device unit connector.

Using appropriate attenuators, connectors, and coaxial cable of known attenuation and impedance, connect the Network Analyzer to the cable end of the Antenna connection (i.e., the connector just removed from the ADS-B Transmitting or Receiving device).

Note: *The use of attenuators is strongly recommended such that the RF front end of the Network Analyzer is not destroyed. If such happens, it is probable that the individual performing the test will not be performing similar tests in the future.*

Step 2: Perform Impedance and VSWR Measurements

Using the Network Analyzer, measure the impedance of the antenna installation at a frequency of 1090 MHz.

Verify that the impedance does not exceed 50 ohms.

Using the Network Analyzer, measure the Voltage Standing Wave Ratio (VSWR) of the antenna installation at a frequency of 1090 MHz.

Verify that the VSWR does not exceed 1.5:1.

3.3.4.6.5 Verification of Polarization (§2.2.13.5)

Procedures to properly verify that the ADS-B Transmitting antenna is vertically polarized are provided in §3.3.4.6.1.

Procedures to properly verify that the ADS-B Receiving antenna is vertically polarized are provided in §3.3.4.6.2.

3.4 Flight Environment Data Sources

Aircraft systems and/or sensors, which supply flight environment data to the ADS-B system, **shall** be selected to meet the accuracy, range, and resolution requirements appropriate to the equipage category. (Accuracy, range, and resolution may be shown to be adequate by analysis.)

3.4.1 Navigation Uncertainty Category (NUC)

The system **shall** report (and adjust, if necessary) NUC values appropriate to the navigation source (including its operational mode) that supplies data to the ADS-B system. NUC value varies with navigation source selection and the selected sensor's current performance. If the aircraft has multiple navigation systems, NUC can vary with system selection and the mode of operation (e.g. Inertial Navigation with DME or GPS augmentation). The reported NUC value must vary to track navigation uncertainty (NUC) as it increases or decreases, corresponding to navigation system accuracy.

3.4.2 Altitude

Barometric Pressure Altitude relative to a standard pressure of 1013.25 millibars (29.92 in.Hg.) **shall** be supplied to the ADS-B system . Altitude data, which is correctable for local barometric pressure, **shall** not be supplied to the ADS-B system. The ADS-B system and the ATC transponder (if installed) **shall** derive Pressure Altitude from the same sensor (e.g. air data computer or encoding altimeter).

3.4.3 Surface/ Air (Vertical) Status

Aircraft systems or sensors providing vertical status to the ADS-B system **shall** be implemented such that they provide a reliable indication that the aircraft is on the ground or airborne. When considering likely failure modes, the system should fail to the "air" mode where possible (e.g. air/ground relay should relax to the "air" mode).

3.5 Aircraft / Vehicle Data

ADS-B Messages contain information describing the aircraft or vehicle that is transmitting. It is a responsibility of the installer to insure that the vehicle information provided to the ADS-B system is correct.

3.5.1 Fixed Data

Data which does not change during operation, are selected or loaded at installation (e.g. ADS-B Emitter Category, ICAO address). Fixed data **shall** accurately represent the individual airplane/vehicle characteristics or registration information. If ADS-B and a Mode-S transponder are installed, both **shall** use the same ICAO address (whenever both are operating).

3.5.2 Variable Data

Controls used by the pilot/crew for data entry (e.g. flight number, call sign, emergency status) **shall** correctly perform their intended functions.

Note: *Where regulations permit variation of the 24 bit Mode-S and /or ADS-B address, ADS-B and a Mode-S transponder* ***shall*** *use the same ICAO address (whenever both are operating).*

3.5.3 On-condition Sensors

Aircraft systems or sensors used to trigger on-condition messages **shall** be selected and implemented such that they provide a reliable indication of the specific condition(s) to be reported.

3.5.4 Class Code (basic)

Class code information **shall** be set to accurately transmit the capability of the system as it is installed. Class code can vary between aircraft depending upon installed options and equipment variations

3.5.5 Capability Class Data

Capability class data include en route, terminal area, approach and landing, and surface operations capability information supplied by installed applications. Capability class data must respond to changes in the availability of operational mode data (§2.2.5.1.24 – §2.2.5.1.35).

3.6 Flight Test Procedures

This guidance material offers examples of flight test procedures for demonstration of performance of selected functions.

Flight testing of installed systems may be desirable to confirm or supplement bench and ground tests of installed performance.

Flight tests are not necessary to evaluate functions that encode, communicate, and decode messages, assemble reports, or generate displays, except for the radio frequency functions associated with transmission and reception of ADS-B Messages.

3.6.1 Displayed Data Readability

Determine that normal conditions of flight do not significantly affect the readability of displayed data.

3.6.2 Interference Effects

For those aircraft systems and equipment that can only be tested in flight, determine that no operationally significant conducted or radiated interference exists. Evaluate all reasonable combinations of control settings and operational modes.

Note: *Electromagnetic interference flight tests are often conducted on all electronic systems in one test series, using procedures established by the aircraft manufacturer. If such tests included the ADS-B equipment, no further tests are required. (e.g. ADS-B functionality added to an existing transponder and/or TCAS installation)*

3.6.3 Surveillance Testing

The surveillance flight test is designed to verify that the installed ADS-B system is capable of transmitting and/or receiving ADS-B squitter messages from other aircraft. The following suggested procedures are typical flight test plans that could be followed in a region of low air traffic density: but any other test that supplies equivalent data would be acceptable.

ADS-B system testing requires verification of transmission and reception of ADS-B Messages at the minimum range for the equipage class. If testing an aircraft installation ("Subject") that broadcasts only, the receiving equipment ("Target") must provide a means to display message information, received from the Subject, to the operator.

Shorter range (10 - 20 NM) operational requirements may be demonstrated using a ground based Target system. Longer range operation might require an airborne Target system. Typically the airborne Target aircraft will fly a holding pattern at a designated fix and within 3000 feet of the Subject aircraft altitude.

Fly the Subject aircraft straight and level at the minimum operational range and verify that data from the Subject are received reliably by the Target system. If the Subject system has receive capability, verify that the Subject system reliably reports information about the Target. (e.g. displays Target at appropriate range and altitude with correct identification)

Note: *It is not intended that reception of individual squitter messages be verified.*

Fly the Subject aircraft in a figure 8 pattern, at the minimum operational range, at bank angles consistent with normal operations, at a constant altitude, and verify that transmitted data are received reliably by the Target system. If the Subject system has receive capability, verify that the Subject system reliably reports information about the Target during maneuvering. (e.g. displays Target at appropriate range and altitude with correct identification)

4.0 Operational Characteristics and Functional Requirements

A description of 1090 MHz ADS-B System operation is followed by functional requirements for the System.

4.1 System Operation

This subsection describes the operation of a generic/hypothetical ADS-B system during typical phases of flight operations. The phases considered are: pre-flight, taxi out, take off/departure, en route, approach, landing/taxi, and shutdown. A transport aircraft is assumed, possessing a full complement of sensors to allow reliable detection of various phases of flight. Less complicated systems or aircraft might incorporate fewer modes of operation and variations on mode selection logic.

4.1.1 General Operation: Transmitting Subsystem

The system has multiple operating modes to vary the amount and type of data transmitted as appropriate to the operating environment and to minimize traffic on the radio frequency data link(s). Mode selection should be automated to the greatest practical degree to reduce crew work load and enhance system utility.

Pre-flight: Electrical power is applied to the airplane, thus powering the ADS-B system components. The ADS-B function performs internal power up self tests, selects the transmitter to Standby mode, if available, and begins to collect data about own ship for transmission.

Firm data such as tail number or 24-bit ICAO address is loaded or reloaded. Flight number, if used, is set to all zeros as a result of the power having been removed for a time in excess of the transient switching interval protection. The system, sensing that the aircraft is on the ground, attempts to acquire a new flight number (flight number sometimes will change whenever the aircraft is on the ground). System power might not be interrupted. Position (latitude/longitude/altitude) is acquired and State Vector messages are prepared and refreshed as required to maintain current information ready for transmission.

Taxi Out: When the crew selects “on” or the ADS-B function detects a taxi, or imminent operational condition (e.g. an engine oil pressure discrete + brake release + doors closed while on the ground) the Surface mode is selected and squitter transmission commences, transmitting State Vector and Partial Mode Status messages (flight identification). Squitters might be transmitted at a reduced rate while on the ground. (General aviation airplanes might sense a GPS ground speed /position exceeding an accuracy threshold.)

Note: *Regulations might preclude automatic squitter commencement during taxi, limiting transmissions to the movement area. Crew action may be required to begin squitter transmissions. Transmitter power should not be reduced during surface operations, in order to maintain probability of reception in competition with proximate airborne transmitters.*

Take off / Departure: When the ADS-B function detects a take off (e.g., speed (IAS or Ground Speed) in excess of an appropriate minimum) the Air mode is selected.

Transmitted message type and squitter rate are adjusted as appropriate. The on-ground status is broadcast until the ADS-B function detects an airborne condition (e.g. landing gear WOW/squat switch) or associated conditions are met to override a malfunctioning squat switch.

En route: Continue transmitting in Air mode.

Approach: Continue transmitting in Air mode. When the aircraft transitions to approach (e.g. flaps set appropriately for landing and speed reduced accordingly), the Air mode is continued and appropriate messages to support on-condition reports may be sent.

Landing / Taxi in: When the ADS-B function detects a landing configuration (e.g. gear down (general aviation airplanes could use flap position only, or allow pilot selection), the Air mode is continued and appropriate messages to support on-condition reports may be sent. Surface mode is not entered until the ADS-B function detects an on-ground condition (e.g. landing gear Weight On Wheels/squat switch). (General aviation airplanes might use an appropriate IAS or Ground Speed, corresponding to minimum stall speed, dirty.) Logic should be biased toward the air mode in case of a squat switch failure.

Shutdown: When the crew selects "Stand-by" squitter ceases.

Note: *Regulations might limit squitter during taxi, to the movement area. Crew action may be required to inhibit transmission of squitters.*

4.1.2 General Operation: Receiving Subsystem

The ADS-B system receive function performs two tasks. A radio frequency receiver detects squitters from external sources and decodes messages. A report generator collects and organizes the individual messages into reports and outputs the reports on a data bus(s) to user applications. The most likely application is a cockpit display of traffic information (CDTI). Other applications might include a conflict detector to inform the pilot if separation from other traffic is predicted to be less than desired. A logical extension of the conflict detector is advisory information for maintaining the desired separation distance.

This section describes the operation of a generic/hypothetical ADS-B system receiver. Unlike the ADS-B transmitter, the receiver operation varies only slightly with the phase of flight. The RF squitter receiver continues to detect and decode any and all recognizable ADS-B Messages. The report generator accepts control inputs from applications which allow it to filter out messages which are not of importance to the application. Filtering allows for more efficient use of the available computing resources.

Pre-flight: Electrical power is applied to the airplane, thus powering the ADS-B system components. The ADS-B function performs internal power up self tests. The ADS-B receiver monitors the 1090 MHz frequency for squitters from other aircraft and generates reports for user systems such as a Cockpit Display of Traffic Information (CDTI). Receiver sensitivity may be reduced in the Surface mode. The report generator collects data about own ship such as tail number or ICAO address, used to recognize its own squitter transmissions. Position (latitude/longitude/altitude) is acquired and continuously updated for message filtering based on range or altitude and for conflict detection. The report generator may accept filter criteria from ADS-B applications and send to each application only the appropriate traffic reports.

Taxi Out: The receiver decodes messages and supplies them to the report generator. The report generator, having received filter information from the CDTI, sends it reports only on traffic, which is within the CDTI-selected range and altitude. The report generator, also having received filter information from a concurrently executing conflict detection application, sends it messages only from traffic whose position and altitude is consistent with aircraft or vehicles in the airport traffic pattern or movement area. (Report filter criteria may differ between applications.)

Take off / Departure: (same as preflight and taxi out except receiver sensitivity is at maximum in the Air mode.)

En route: The receiver decodes messages and supplies them to the report generator. The report generator, having received a range selection from the CDTI, sends it reports only on traffic which is within the CDTI-selected range and altitude. The report generator, having received different filter information from another concurrently executing application, might send that further application reports on all traffic with an altitude greater than some threshold, (possibly selected to reject traffic in overflown airport patterns or on the surface) or near own altitude and within a given range.

Approach: The receiver decodes messages and supplies them to the report generator. The report generator, having received a range selection from the CDTI, sends it reports only on traffic which is within the CDTI-selected range and altitude. The report generator, having received approach filter information from another concurrently executing ADS-B application, might send that further application only reports consistent with aircraft in the airport traffic pattern.

Landing / Taxi in: The receiver decodes messages and supplies them to the report generator. The report generator, having received a range selection from the CDTI, sends its reports on traffic that is within the CDTI-selected range and altitude. Having received landing filter information from another concurrently executing ADS-B application that detected Gear down (i.e. "Landing"), the generator includes reports on traffic that is on the surface. On touch down, the application filter criteria might be revised to reject airborne traffic above the local pattern altitude.

Shutdown: The receiver decodes messages and supplies them to the report generator until power is removed or a standby mode is selected.

4.2 Operating Modes

4.2.1 Operating Modes: Transmit

The 1090 MHz ADS-B system has two modes of operation, surface and air. Operational modes control variable link characteristics such as message types to be transmitted and squitter rates. Switching between modes is accomplished automatically as required in §2.2.3.2.1.1.2. Operational mode selection may be determined by reference to State Vector (SV) data elements such as speed. It is possible to force the system to either mode while the aircraft is on the ground for testing (§2.2.11.1).

4.2.1.1 Surface Mode

Surface mode is used on the ground but might be extended to low altitudes during take-off or approach. In the Surface mode of operation, the system transmits State Vector messages and partial Mode Status (Flight Identification) at a reduced squitter rate and possibly with reduced receiver sensitivity levels. When the 1090 MHz ADS-B System is implemented using a transponder, it is possible for a Mode-S ground sensor to command an airborne system to operate in the surface mode for brief periods of time (ref. RTCA/DO-181C; §2.2.16.2.6.2.5.2).

4.2.1.2 Air Mode

In the Air mode of operation, the system transmits all message types appropriate to its equipment class at the designated rates and power output level.

4.2.2 Automatic Operation

The system transmits the required squitters for the equipment class, without crew intervention. Own aircraft ADS-B position and velocity messages are formatted and transmitted without crew member inputs or adjustments such as mode selection or tuning. Similarly, ADS-B Messages from other sources are received, formatted into reports, and output to user systems, or displays, without crew member intervention. (Mode selection on CDTI or other displays is acceptable since they are not considered part of the ADS-B function.)

An exception is the Participant Address (ICAO 24-bit address). In most installations, the address does not change and is "hard wired" at installation. Where permitted by regulatory authorities, this address may be input by the crew.

Certain messages related to Mode Status and On-Condition reports may be triggered by crew actions that satisfy the conditions for the automatic generation of an associated message.

ADS-B System validity status is available to the crew, as required in §2.2.11.5.

Crew member input of Mode Status (MS) information, where practical, (e.g., flight number) is acceptable. The capability to acquire all message elements automatically is desirable. Automatic acquisition of data reduces crew work load and avoids data entry errors. Supplemental information may be entered via associated equipment.

4.3 Self Test

4.3.1 Receive

If the system performs self tests, testing should indicate the ability to receive ADS-B messages.

If the system generates test squitter transmissions to verify the ADS-B receiver function, the self test signal level at the antenna end of the transmission line **shall** not exceed –40 dBm as required in §2.2.11.1.

4.3.2 Transmit

If the system performs self tests, testing should indicate the ability to send ADS-B Messages. That ability implies the availability of the required message elements, whether derived internal to the system or provided by other aircraft systems. The ability to send messages also implies the availability of the 1090 MHz data link transmitter.

Note: *The presence of valid incoming message(s) (from other than own ship) is not required to indicate the availability of a data link. The ADS-B system may rely on the link system flags, valids, self test etc. to determine availability. (ADS-B self test failure, attributed to a data link failure, should nominate the data link in a BIT message.)*

4.3.2.1 Broadcast Monitor

If the 1090 MHz ADS-B System is not implemented using a transponder, a squitter monitor verifies that the ADS-B transmitter generates squitter transmissions at a nominal rate. The transmitter is considered to have failed when the monitor has detected squitter failure. (ref. 2.2.11.2)

4.3.2.2 Address Monitor

If the 1090 MHz ADS-B System is not implemented using a transponder, a Participant Address monitor is provided. In the event that the ADS-B-transmitted Participant Address is all zeros or all ones, the system declares a failure. (§2.2.11.3)

4.3.2.3 Failure Annunciation

An output is provided to indicate the validity/non-validity of the ADS-B system. Failure to generate squitters at the nominal rate, a failure detected by self-test, or a failure of the ICAO address verification causes the output to assume the invalid state. Momentary power interrupts should not cause the output to latch in the invalid state. The detection of a failure is annunciated to the flight crew. (§2.2.11.5)

4.4 Controls

4.4.1 Power On/Off (Optional)

The system should be powered whenever primary electrical power is available. Circuits powering various system components or functions may be protected by individual circuit breakers. Components or functions may receive power from multiple sources or busses (e.g. 115 vac and 28vdc).

Aircraft with limited electrical system capacity may employ system power controls for energy conservation.

4.4.2 Manual Test (Optional)

The system should provide a means for a manually initiated test of the system report generation function(s).

4.4.2.1 Traffic Report

The manual test should cause the system to output a report of a "Test" traffic target such that the "Test" target appears on an associated CDTI display at a specified bearing and distance from the own-aircraft symbol.

4.4.2.2 State Vector Report

The test should include a means for the crew or maintenance personnel to verify a subset of parameters in the own-aircraft SV report data. The verifiable parameters should include: Position (Latitude, Longitude), Pressure Altitude, and Speed. (e.g. The "Test" target displays own aircraft altitude, heading (or ground track) and speed (IAS or Ground Speed) while applying a constant offset to own aircraft latitude and/or longitude.)

4.4.3 Participant Address (Optional)

At the manufacturer's option, a means may be provided to alter the unique participant address of the aircraft, within an allocated block of ICAO 24-bit addresses.

Note: *The system architecture will determine if the ICAO 24-bit address is entered into the data link unit or an associated peripheral device.*

4.4.4 Flight Number (Optional)

At the manufacturer's option, a means may be provided for the flight crew to enter the flight identification number or registration ("N" number, or equivalent).

Note: *The system architecture will determine if flight identification or registration number is entered into the data link unit or an associated peripheral device.*

4.4.5 1090 MHz ADS-B Link Control (Optional)

At the manufacturer's option, a means may be provided for the flight crew to disable the 1090 MHz ADS-B link. Disabling results in the cessation of transmission and/or reception of ADS-B Messages on 1090 MHz. Control of transmission and reception of any other installed ADS-B systems is independent of the 1090 MHz ADS-B system status.

4.4.6 Standby

A means **shall** be provided for the flight crew to select a standby mode in which squitter transmissions are inhibited.

4.4.7 Mode Control

The transmit function will accept appropriate data for on-condition or event driven message transmissions, as appropriate to the equipment capability classification. At the manufacturer's option, a means may be provided for the flight crew to enter this data (e.g. Minimum Fuel, No Communications, Unlawful Interference, etc.)

Control of Surface and Air mode switching **shall** not be available to the flight crew.

4.4.8 Barometric Altitude

A means **shall** be provided for the flight crew to inhibit the broadcast of barometric altitude if directed to do so by ATC.