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RTCA Special Committee 186, Ad Hoc Working Group On DO-242A MASPS

Meeting #4

Draft Text for DO-242A
Relating to "NIC/NAC/NUC" and State Vector Report Content

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SUMMARY
This paper is offered in support of action items 2-5, 2-7, and 3-5. The working group may wish to discuss different parts of this paper at different times, in connection with those different action items. **In action item 2-5, I was asked to propose text clarifying the required SV report content in §3.4.3.1.** **In action item 2-7, I was asked to propose MASPS changes to address issue paper #18 concerning the transmission of own-ship heading at Vstop.** **In action item 3-5, I was given the task to propose changes to §2.1.2.2.4, the description of NUC, and to conduct a teleconference to review those draft changes. That teleconference was conducted last Friday, 2001 March 17. This paper shows my revised draft, after that teleconference.** **A previous draft of this paper has been presented to WG-3, as that working group's paper 1090-WP-3-12.**

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2.1 General Requirements

2.1.1 General Performance

2.1.1.1 Consistent Quantization of Data

When the full resolution of available aircraft data cannot be accommodated within an ADS-B message, a common quantization algorithm shall (R2.1) be used to ensure consistent performance across different implementations. To minimize uncertainty, a standard algorithm for rounding/truncation is required for all parameters. For example, if one system rounds altitude to the nearest 100 feet and another truncates, the same measured altitude could be reported as different values.

2.1.1.2 ADS-B Report Characteristics

The output of ADS-B shall (R2.2) be standardized so that it can be translated without compromising accuracy. The ADS-B reports should support surface and airborne applications anywhere around the globe and should support chock-to-chock operations without the need for pilot adjustments or calibration.

2.1.1.3 Expandability

Applications envisioned for using the information provided by ADS-B are not fully developed. In addition, the potential for future applications to need information from an ADS-B is considered fairly high. Therefore the ADS-B system defined to meet the requirement in this MASPS needs to be flexible and expandable. Any broadcast technique should have excess capacity to accommodate increases and changes in message structure, message length, message type and update rates.

Note*:The update rate is the effective received update rate as measured at the receiving end system application (e.g., the automation system interface by ADS ground processing), not the transmission rate of the ADS-B system.*

This MASPS identifies different report parameters with different update rates. In some cases the resolution of the parameters may be different depending on the intended use. Ideally, the system should be designed so that message types, message structures, and report update rates can be changed and adapted by system upgrades.

2.1.1.4 Time of Applicability

The time of applicability of ADS-B reports indicates the time at which the reported values were valid. Time of applicability shall (R2.3) be provided in all reports. Requirements on the accuracy of the time of applicability are addressed in Section 3.

2.1.2 Information Transfer Requirements

The ADS-B system shall (R2.4) be capable of transmitting messages containing the information specified in the following subsections. This MASPS does not specify a particular message structure or encoding technique. The information specified in the following subsections can be sent in one or more messages in order to meet the report update requirements specified in Section 3.

2.1.2.1 Identification

The basic identification information to be conveyed by ADS-B shall (R2.5) include the following elements:

- Call sign
- Address
- Category

The ADS-B system design shall (R2.6) accommodate a means to ensure anonymity whenever pilots elect to operate under flight rules permitting an anonymous mode. (Most on-IFR flight operations do not require one to fully disclose either the A/V call sign or address. This feature is provided to encourage voluntary equipage and operation of ADS-B by ensuring that ADS-B messages will not be traceable to an aircraft if the operator requires anonymity.)

2.1.2.1.1 Call Sign

ADS-B shall (R2.7) be able to convey an aircraft call sign of up to 7 alphanumeric characters in length [6]. For aircraft/vehicles not receiving ATS services and military aircraft the call sign is not required.

2.1.2.1.2 Address

The ADS-B systems design shall (R2.8) include a means (e.g., an address) to 1, correlate all ADS-B messages transmitted from the A/V and 2, differentiate from other A/Vs in the operational domain.

Those aircraft requesting ATC services will be required in some jurisdictions to use the same 24-bit address for all CNS systems. Aircraft with Mode S transponders using an ICAO 24 bit address shall (R2.9) use the same 24-bit address for ADS-B. All aircraft/vehicle addresses shall (R2.10) be unique within the operational domain(s) applicable.

Notes:

1. *For example, all surface vehicles for a given airport need to have unique addresses only within range of the airport; vehicle addresses may be reused at other airports.*
2. *Correlation of ADS-B messages with transponder codes will facilitate the integration of radar and ADS-B information on the same A/V during transition.*

2.1.2.1.3 Category

2.1.2.2 State Vector

The reported state vector for an A/V includes the three-dimensional position and velocity referenced to an accepted world-wide reference system. Some elements of the A/V's acceleration (turn indication and other rapid changes in velocity) may be included in the reported state vector.

The accuracy of the state vector information affects its utility for surveillance applications. Accuracy requirements for surveillance applications using ADS-B are based on the uncertainty in each state vector element that is required to support a given application.

Factors that affect state vector accuracy include:

- Errors in the navigational sensor system. For applications using ADS-B data, the measuring system is the aircraft/vehicle's navigation system. The error in the measured state vector will vary widely depending on the navigation source or sources used.
- Errors in the ADS-B reporting system. Additional error may be added due to the resolution of the reported state vector element (that is, the minimum increment that can be reported).
- Errors in the time of applicability. Because the A/V is moving, the reported state vector needs to meet latency requirements.
- Errors introduced by processing. Errors may also be introduced through the processing of the state vector data. These may be introduced, for example, from coordinate conversions and round-off errors in representing position and time values.

Aircraft/vehicle state vector information shall (R2.12) include the following elements:

1. Three-dimensional position
2. Three-dimensional velocity
3. Airborne turn indication
4. Navigation ~~uncertainty~~ integrity category
5. Navigation accuracy category

All non-stationary ADS-B subsystem installations shall (R2.13) provide dynamic state vector reporting.

2.1.2.2.1 Position

Position information shall (R2.14) be transmitted in a form that can be translated, without loss of accuracy and integrity, to latitude, longitude, and barometric altitude and geometric height.

All geometric position elements shall (R2.15) be referenced to the WGS-84 ellipsoid.

2.1.2.2.1.1 Horizontal Position

Horizontal latitude and longitude position shall (R2.16) be reported as a geometric position.

2.1.2.2.1.2 Altitude

Barometric pressure altitude is the reference for vertical separation within the NAS and ICAO airspace. Both barometric pressure altitude and geometric altitude (height above the WGS-84 ellipsoid) shall (R2.17) be reported, if available. Some applications may have to compensate if only one source is available. However, when an A/V is operating on the airport surface, the altitude is not required to be reported, provided that the A/V indicates that it is on the surface.

2.1.2.2.1.2.1 Pressure Altitude

Barometric pressure altitude is the reference for vertical separation within the NAS and ICAO airspace. Barometric pressure altitude shall (R2.18) be reported referenced to standard temperature and pressure.

2.1.2.2.1.2.2 Geometric Altitude

Geometric altitude is defined as the length of the line segment that extends from the current aircraft position to the surface of minimum altitude above or below a plane tangent to the earth's ellipsoid as defined by WGS-84 [7]. It is positive for aircraft positions above that surface, and negative for positions below the ellipsoid surface.

2.1.2.2.1.2.3 Altitude Range

Altitude shall (R2.19) be provided with a range from -1,000 ft up to +100,000 ft. For fixed or tethered objects, the altitude of the highest point should be reported.

2.1.2.2.2 Velocity Vector

The transmitting A/Vaircraft shall (R2.20) provide the following information:

1.• Horizontal Velocity Vector

2.• Vertical Rate

ADS-B geometric velocity information shall (R2.21) be referenced to WGS-84 [7].

2.1.2.2.2.1 Horizontal Velocity Vector

The horizontal velocity vector components are defined as the north-south and east-west velocity relative to the WGS-84 earth ellipsoid. Reported ranges shall (R2.22) be [0-250] knots on the surface and [0-4000] knots airborne.

2.1.2.2.2.2 Altitude Rate

Altitude Rate shall (R2.23) be designated as climbing or descending and shall be reported up to 32,000 feet per minute (fpm). Barometric altitude rate is defined as the current rate of change of barometric altitude. Likewise, The geometric altitude rate of the state vector is the rate of change of geometric altitude.measured along the line from the origin of the WGS-84 reference system to the current position of the A/V. For NUC_P NAC_P values 8 9 and 910, geometric altitude rate shall (R2.24) be reported. For other NUC NAC_P values, barometric altitude rate or inertially augmented barometric altitude rate shall (R2.25) be reported.

2.1.2.2.3 Airborne Turn Indication

An Airborne turn indication shall (R2.26) be designated as turning right, turning left, or not turning.

2.1.2.2.4 ~~Navigation Uncertainty Category~~Navigation Uncertainty Integrity and Accuracy Categories

Uncertainty categories for the state vector navigation variables are characterized by Navigation Integrity Category (NIC) and Navigation Accuracy Categories (NAC_P, NAC_V) for position and velocity, respectively.

2.1.2.2.4.1 Navigation ~~Uncertainty~~ Integrity Category

The Navigation ~~Uncertainty~~ Integrity Category (~~NUC~~NIC) is reported so that surveillance applications may determine whether the reported position has an acceptable level of integrity ~~and accuracy~~ for the intended use.

Note: "NIC" and "NAC_P" as used in this MASPS replace the earlier term, "NUC_P", used in the first edition of this MASPS [<<ref. to DO-242, dated February 19, 1998>>].

Table 2-1(a) defines the navigation integrity categories that transmitting ADS-B participants shall (R2.xxx) use to describe the integrity of positional information in ADS-B messages from those participants.

~~The GPS/WAAS MOPS (RTCA DO-229) [14] defines a Horizontal Protection Level (HPL) which must be computed dynamically by all receivers.~~ The ~~Horizontal Protection Level~~horizontal containment radius (Rc) is the ~~primary~~ basis for assigning the ~~NIC~~ Navigation Integrity Category as shown in Table 2-1a. ~~HPL is defined~~This containment radius is defined in DO-235A [<<reference to ~~23~~DO-236A>>] as "the radius of a circle, centered on the estimated position, such that the probability of the true position lying outside the circle without being detected ~~in the horizontal plane (local plane tangent to the WGS-84 ellipsoid), which its center being at the true position, which describes the region which is assured to contain the indicated horizontal position." The probability that the indicated position lies outside this circle~~ is 10^{-5} per ~~flight~~ hour." ~~for NIC values 1 to 10, inclusive, or 10^{-7} per flight hour for proposed future NIC values of 11 or 12. (See Figure 2-1).~~

~~The vertical position for NIC values of 1 to 7 is provided by a barometric altimeter providing barometric pressure altitude that meets certified accuracy within the accuracy of the certification category [18, 19]. If barometric pressure altitude is not available or lacks integrity an indication will be provided in the report.~~

~~The navigation integrity category to be used for the source of navigation data being reported is summarized in Table 2-1a.~~

Table 2-1(a). Navigation ~~Uncertainty~~ Integrity Categories ~~— Position~~(NIC)

NIC [Notes 2, 3]	Integrity Level		Comments		
	Horizontal Containment Radius, Rc	Probability of Exceeding Containment	Corresponding DO-236A RNAV Limit	Other Comment	Notes
0	Unknown	—	—	No Integrity	
1	≤ 20 nmi	1×10^{-5}	RNP-10 RNAV		
2	≤ 8 nmi	1×10^{-5}	RNP-4 RNAV		[4]
2.5	≤ 4 nmi		RNP-2 RNAV		[3]
3	≤ 2 nmi	1×10^{-5}	RNP-1 RNAV		
4	≤ 1 nmi	1×10^{-5}	RNP-0.5 RNAV		
4.5	≤ 0.6 nmi	1×10^{-5}	RNP-0.3 RNAV		[3]
5	≤ 0.5 nmi	1×10^{-5}		e.g., NPA, DME-DME, etc.	
6	≤ 0.2 nmi	1×10^{-5}			
7	≤ 0.1 nmi	1×10^{-5}		e.g., RAIM - GPS	
8	≤ 75 m	1×10^{-5}		Future System	
9	≤ 25 m	1×10^{-5}		e.g., WAAS HPL	
10	≤ 7.5 m	1×10^{-5}		e.g., LAAS HPL	
11	TBD	1×10^{-7}	Reserved for future expansion		
12	TBD	1×10^{-7}			
13	TBD	TBD	Reserved		
14	TBD	TBD			
15	TBD	TBD			

Notes for Table 2-1(a):

1. *The ~~NUC_P~~ NIC is reported by an aircraft because there will not be a uniform level of navigation equipage among all users. Although GNSS is intended to be the primary source of navigation data used to report ADS-B horizontal position, it is anticipated that during initial uses of ADS-B or during temporary GNSS outages an alternate source of navigation data may be used by the transmitting A/V for ADS-B position information. The integration of alternate navigation sources is a function that must be performed by a navigation set that is certified to use multiple sources, which then is responsible for supplying the corresponding containment integrity ~~(i.e., HPL)~~. It is important to point out that this is not a function that can be performed by the ADS-B equipment.*

2. *"NIC" in this column corresponds to "NUC_P" of Table 2-1(a) in the first version of this MASPS, DO-242, dated February 19, 1998.*

3. *The NIC codes in this table do not necessarily impose a requirement on how each code should be encoded in the messages transmitted over the air on any particular ADS-B data link. In this table, fractional NIC codes such as "2.5" and "4.5" are used to emphasize the need for interoperability between implementations that conform to this version of this MASPS, RTCA DO-242A, and those that conform to the first version of this MASPS, RTCA DO-242.*

4. The containment radius for NIC = 2 has been changed (from the corresponding radius for NUC_P = 2 in the first edition of this MASP) so as to correspond to the RNP-4 RNAV limit of DO-236A, rather than the RNP-4 limit of the earlier DO-236. This is because the RNP-5 number has been dropped from the ICAO standard RNP values.

3.The horizontal protection level is the integrity level used by GNSS sets and is the primary determinant of the current integrity performance of the navigation system. This supports the determination of the aircraft's RNP as specified in DO-236. (It should be noted that the RNP integrity level [10^{-5}] is intended for airborne aircraft navigation, thus for two independent aircraft the joint probability should be on the order of 10^{-10}.) The columns marked Horizontal and Vertical Error are grayed for NUC levels 1-7 because these values are information [i.e., not required outputs of GNSS receivers.] For NUC levels 8-9 the Horizontal Protection Level is grayed because in the approach and surface navigation regime protection levels are increased [e.g., 10^{-7} or higher] to reflect single aircraft protection with respect to fixed objects. These protection levels are yet to be defined by RTCA. This leaves the Horizontal and Vertical Errors as the primary performance parameters for NUC levels 8-9. In the approach and surface navigation regime the horizontal and vertical errors are highly correlated — thus a single NUC category will suffice for both.

4.The stringent probability of HPL shown in Table 2-1a was derived assuming that a GPS integrity failure could affect 100 aircraft at the same time [15]. See references [8, 14, 15] for examples and a discussion of containment integrity. Additional guidance on dynamically determining the estimated position uncertainty is provided in Appendix C of [8]. Some older navigation systems may not be able to dynamically determine the estimated position uncertainty; in such cases, pre-set value appropriate to the source should be provided to the ADS-B system.

The coded representations of NIC shall (R2.xxx) be such that

(a) equipment that conforms to this MASPS will recognize the equivalent NUC_P codes from the first edition of this MASPS, and

(b) equipment that conforms to the first edition of this MASPS will treat the coded representation of NIC as if they were the corresponding "NUC_P" values from the first edition of this MASPS [<<DO-242>>].

In the case of fractional NIC codes from Table 2-1(a), the coded representation shall (R2.xxx) be such that equipment that does not recognize fractional NIC codes will interpret them as the largest integer NIC (or NUC_P) codes that are less than or equal to those fractional NIC codes.

Note 1: For example, the encoding of integer values of NIC in newer ADS-B transmitting equipment shall be such that it will be recognized as the corresponding integer values of NUC_P by older ADS-B receiving equipment. Likewise, the encoding of fractional NIC values in newer ADS-B transmitting equipment shall be such that that those values will be interpreted by older ADS-B receiving as the corresponding integer NUC_P values.

Note 2: One possible way to achieve this is to place the bit pattern for the integer part of each NIC code in the same parts of ADS-B messages as were used for the "NUC_P" codes in messages sent from equipment that conformed to the first edition of this MASPS. The fractional part of the NIC code would then be placed in message bit positions that were not used by equipment that conformed to the first edition of this MASPS.

2.1.2.2.4.2 Navigation Accuracy Category – Position (NAC_P)~~Navigation Uncertainty Category - Velocity~~

The Navigation Accuracy Category for Position (NAC_P) is reported so that surveillance applications may determine whether the reported position has an acceptable level of accuracy for the intended use.

Note 1: "NIC" and "NAC_P" as used in this MASPS replace the earlier term, "NUC_P", used in the first edition of this MASPS [<<ref. to DO-242, dated February 19, 1998>>].

Table 2-1(b) defines the navigation accuracy categories that transmitting ADS-B participants shall (R2.xxx) use to describe the accuracy of positional information in ADS-B messages from those participants.

Note 2: The Estimated Position Uncertainty (EPU) used in Table 2-1(b) is a 95% accuracy bound. The horizontal EPU is defined as the radius of a circle, centered on the reported position, such that the probability of the actual position being outside the circle is 0.05. The vertical EPU is likewise defined as a vertical position limit, such that the probability of the actual vertical position differing from the reported vertical position by more than that limit is 0.05.

Table 2-1(b). Navigation Accuracy Categories for Position.

NAC_P	Horizontal EPU	Vertical EPU	Comment
0	≥ 10 nmi	Pressure Altitude	Accuracy Unknown
1	< 10 nmi	Pressure Altitude	RNP-10 Accuracy
2	< 4 nmi	Pressure Altitude	RNP-4 Accuracy
3	< 2 nmi	Pressure Altitude	RNP-2 Accuracy
4	< 1 nmi	Pressure Altitude	RNP-1 Accuracy
5	< 0.3 nmi	Pressure Altitude	RNP-0.3 Accuracy
6	< 0.1 nmi	Pressure Altitude	e.g., GPS – SPS with SA
7	< 0.05 nmi	Pressure Altitude	e.g., GPS – SPS (SA off)
8	< 30 m	Pressure Altitude	
9	< 10 m	< 15 m	e.g., SBAS
10	< 3 m	< 4 m	e.g., WAAS
11-15	TBD	TBD	

2.1.2.2.4.3 Navigation Accuracy Category – Velocity (NAC_V)

The velocity ~~uncertainty~~ accuracy category of the least accurate velocity component being supplied by the reporting A/V's source of velocity data shall (R2.27) be as indicated in Table -2--1(c)~~b~~:

Table 2-1(c)~~b~~. Navigation ~~Uncertainty~~ Accuracy Categories – Velocity

NAC_V ~~NUC_R~~	Horizontal Velocity Error (95%)	Vertical Velocity Error (95%)
0	Unknown or ≥ 10 m/s	Unknown or ≥ 50 feet per second
1	< 10 m/s	< 50 fps
2	< 3 m/s	< 15 fps
3	< 1 m/s	< 5 fps
4	< 0.3 m/s	< 1.5 fps

Notes to Table 2-1(c):

1. *When an inertial navigation system is used as the source of velocity information, error in velocity with respect to the earth (or to the WGS-84 ellipsoid used to represent the earth) is reflected in the NAC_V value.*
2. *When any component of velocity is flagged as not available (e.g., vertical rate – see Table 3-5~~3.4-1~~) the value of NAC_V will apply to the other components that are supplied.*

Commentary:

Navigation sources, such as GNSS and inertial, provide a direct measure of velocity which can be significantly better than that which could be obtained by position differences.

2.1.2.3 Status and Intent Information

Status and intent information is used to support ATS and A/V to A/V applications. Elements include:

1. Emergency/Priority Status (ATS)
2. Current Intent
3. Trajectory Change Intent (current and future, for A/V to A/V and ATS)

Note: The information in this subsection is provided a s a guidance to system designers and manufacturers. This information is in the process of evolving into final requirements.

2.1.2.3.1 Emergency/Priority Status

The ADS-B system shall (R2.28) be capable of supporting broadcast of emergency and priority status. Status shall (R2.29) include the following:

- No emergency / Not reported
- General emergency
- Lifeguard/medical
- Minimum fuel
- No communications
- Unlawful interference

2.1.2.3.2 Current Intent

Note: Several intent variables are being considered for broadcast by ADS-B. Current intent information may include ~~target~~ selected altitude, desired track, intent status, and/or other variables to be determined by ongoing studies.

~~Target~~ Selected altitude *is the desired barometric altitude or flight level for level-off during a climb or descent phases, or the desired barometric altitude or flight level during a constant altitude flight segment.*

There are two types of selected altitude, coming from two possible on-board sources for selected altitude:

(a) the selected altitude coming from a Mode Control Panel (MCP) or Flight Control Unit (FCU), which often is the altitude to which the aircraft has most recently been cleared by ATC, o

(b) the selected altitude coming from a Flight Management System (FMS), which is usually the altitude of the next waypoint in a flight plan that has been entered into the FMS.

In Mode S transponders equipped for Downlink of Aircraft Parameters (DAPs), it is expected that both types of selected altitude may be obtained by a secondary surveillance radar's interrogation of the transponder's register

Desired track *is the anticipated ground track direction for horizontal turn completion, or the intended ground track during a constant flight leg segment.*

Intent status *is a binary flag for onboard lateral compliance and a binary flag for onboard vertical compliance, indicating whether the current path is consistent with the broadcast intent variables described above.*

2.1.2.3.3 Trajectory Change Intent (Current and Future)

Track extrapolations based on the use of intent data alone are increasingly inaccurate as look-ahead times are increased. The state vector can be augmented with trajectory change points (i.e., intent information) for applications on the receiving A/V or ATS to:

a) support stable separation predictions for long look-ahead times, and in monitoring required operational separations and

b) re-plan flight paths when necessary to resolve detected conflicts (deconfliction) while minimizing deviations from planned flight trajectories.

The ADS-B system shall (R2.30) provide the capability to exchange Trajectory Change Point (TCP) and Trajectory Change Point + 1 (TCP+1) data defined below. ADS-B transmissions shall (r2.31) indicate the ability of the transmitting participant to engage in path monitoring and/or de-confliction operations. The transmitting A/V shall (R2.32) also indicate its capability to use intent information received from other participants.

For certain pairwise operations, an addressed crosslink may be used external to the ADS-B system.

2.1.2.3.3.1 Current Trajectory Change Point (TCP)

The TCP from the transmitting aircraft is the point in three-dimensional space where the current operational trajectory is planned to change, and estimated remaining flight time to that point. A TCP transmission indicates that the aircraft intends to fly directly, via a great circle route, to that point. The TCP is defined as a four-element vector consisting of the following:

- Latitude (WGS-84)
- Longitude (WGS-84)
- Altitude (pressure altitude or flight level)
- Time to go (TTG) to the indicated point in space

The TCP required received update rate may be lower than for the state vector. The rate shall (R2.33) be sufficient to ensure continuous positive assessment by the receiving aircraft at least 2 minutes (5 minutes within the range limitations specified in Table 2-3) prior to reaching closes point of approach for class A2 (A3) equipage. In the event of an immediate trajectory change generated via the RNav, new TCP information should be issued immediately.

The augmentation data should be provided as data transmitted indicating planned changes in trajectory. These indications should be provided as TCP information and TCP+1 information described below. This data is required only from participants intending operations based on some level of cooperative conflict management. The TCP and TCP+1 should be used to convey information operationally significant to separation and conflict management. Points constructed by RNav equipment to generate curvilinear paths (e.g., curved transitions between flight legs) should not be conveyed as TCP information.

System designs should be flexible enough to support parameters that might not be available from all ADS-B participating A/Vs. Information acquisition of intent information is provided in Appendix L.

2.1.2.3.3.2 Next Trajectory Change Point (TCP+1)

De-confliction is most efficient when adjustments to the flight path can be minimized. Knowledge of planned changes to the current path is needed to support the conflict management tools for stable operational re-planning required due to any conflict that may be predicted.

For the de-confliction capability, additional augmenting information should be provided to determine any change in horizontal and/or vertical flight path planned. The aircraft planning the change shall (R2.34) issue the TCP+1 information at least 5 minutes prior to commencing the trajectory change associated with the TCP. The TCP+1 data to be supplied should provide the target or predicted altitude, the target horizontal coordinates and the estimated time remaining from the time of generation of the message to the estimated time to arrive at TCP+1. Upon initiation of the flight path change at TCP, the TCP+1 should increment to become the new TCP. TCP+1 information shall (R2.35) be provided until commencing the change maneuver. The TCP+1 required transmission rate shall (R2.36) be the same as that of the TCP.

Notes:

1. *TCP and TCP+1 data are provided by broadcast media to supply real-time, event-related data to proximate air and ground systems involved in advanced air operations requiring real time intent detail. Details of more complete flight plan or detailed procedures are conveyed, when required, via addressed datalink media.*
2. *No TCP is needed for speed changes along a trajectory. The data indicating the time to go for TCP and TCP+1 should include any results of planned or predicted changes. For RNav equipment capable of such predictions or scheduling, the time data should include the impacts. Less capable equipment should provide the best estimate available. Air or Ground systems receiving the TCP/TCP+1 data should be capable of applying these data as appropriate to their respective applications in conflict management, sequencing, spacing or conformance.*
3. *TCP and TCP+1 data are envisioned in current planning future procedures in the terminal area and transitions between en route flight regimes to enhance sequencing in arrival and departure. These data are intended for applications by both air and ground systems. The ADS-B system will enable the delivery of TCP and/or TCP+1 data when required by the procedures supported by the RNav onboard the transmitting participant. Receiving participants would use the transmitted capability codes to determine pair-wise compatibility with their respective applications.*

   For example, at shorter ranges, a pair of points (TCP and TCP+1) could be issued in conjunction with Terminal Maneuvering Area metering operations and/or when maneuvering to join or depart published procedures.
4. *Lateral TCPs are fly-by points unless indicated to be fly-over. TCP and tCP+1 points are intended to convey trajectory target and trajectory change only. Accordingly, they are not necessarily RNav flight plan waypoints. They must be represented only in binary data form. Example TCPs are top of descent, reach climb altitude or intercept points used to capture procedures or join the flight plan.*
5. *Under some common operational sequences an aircraft may be manually departing or returning to an RNav flight plan. An example case would result from a period of vectored operation by ATS. In such cases the application should determine when to assume the intent is "direct-to" or if the aircraft is operating with a different intent.*

2.1.2.4 Capability Class Codes

Capability class codes are used to indicate the capability of a participant to support engagement in specific operations. Known specific capability class codes are listed below. However, this is not an exhaustive set and provision should be made for future expansion of available class codes, including appropriate combinations thereof.

- No application capability (e.g., broadcast only)
- CDTI based traffic display capability
- TCAS/ACAS installed and operational

- Collision Avoidance
- Terminal Station Keeping
- Free Flight / Cooperative Separation in Overflight
- Oceanic Cooperative Separation
- Simultaneous Approaches
- Blind Taxi
- Runway Incursion

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3.2.2 Participant Architecture Examples

3.2.3 Equipage Classifications

As illustrated above, ADS-B equipment must be integrated into platform architectures according to platform characteristics, capabilities desired and operational objectives for the overall implementation. The technical requirements of this MASPS have been derived from consolidation of the scenarios presented in Section 2 within the context of the use of the <<more text, not copied here>>.

3.2.3.1 Interactive Aircraft/Vehicle ADS-B Subsystems (Class A)

Functional capabilities of interactive aircraft/vehicle subsystems are indicated in the context diagram of Figure 3-4. These subsystems accept own-platform source data, exchange appropriate ADS-B messages with other interactive ADS-B System participants, and assemble ADS-B reports supporting own-platform applications. Such interactive aircraft subsystems, termed Class A subsystems, are further defined by equipage classification according to the provided user capability. The following types of Class A subsystems are defined (Table 3-1):

- Class A0: Supports minimum interactive capability for participants. Broadcast ADS-B messages are based upon own-platform source data. ADS-B messages received from other aircraft support generation of ADS-B reports which are used by on-board applications (e.g., CDTI for aiding viusal acquisition of other-aircraft tracks by the own-aircraft's air crew). This equipage class may also support interactive ground vehicle needs on the airport surface.
- Class A1: Supports all class A0 functionality and additionally supports ADS-B conflict avoidance. Class A1 is intended for operation in IFR designated airspace.
- Class A2: Supports all class A1 functionality and additionally provides extended range and information processing to support optimized separation applications. This service requires the broadcast and receipt of trajectory change point data (TCP).

- Class A3: Supports all class A2 functionality and additionally supports flight path deconfliction. Class A3 subsystems support longer look-ahead times with longer operational ranges than class A2. Class A3 has the ability to broadcast and receive strategic planning information such as future trajectory change point data (TCP+1).

Table 3-1. Subsystem Classes and Their Features.

Class	Subsystem	Capability	Features	Comments
Interactive Aircraft/Vehicle Participant Subsystesm (Class A)				
A0	Minimum Interactive Aircraft/Vehicle	Aid to Visual Acquisition	Lower Tx power and less sensitive Rx than Class A1 permitted	Minimum Interactive capability with CDTI.
A1	Basic Interactive Aircraft	A0 plus Conflict Avoidance	Standard Tx and Rx	Provides ADS-B based conflict avoidance and interface to current TCAS surveillance algorithms/display.
A2	Enhanced Interactive Aircraft	A1 plus Separation Assurance and Sequencing	Standars Tx power and more sensitive Rx. Interface with avionics source required for TCP data.	Baseline for separation management employing intent information.
A3	Extended Interactive Aircraft	A2 plus Flight Path Deconfliction Planning	Higher Tx power and more sensitive Rx. Interface with avionics source required for TCP and TCP+1 data.	Extends planning horizon for strategis separation emplying intent information.
Broadcast-Only Participant Subsystems (Class B)				
B1	Aircraft Broadcast Only	Supports visual acquisition and conflict avoidance for other participants	Tx power may be matched to coverage needs. NAV 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 the airport surface	Tx power matched to surface coverage needs. High accuracy NAV input required.	Enables vehicle to be seen by Class A and Class C users.
B3	Fixed Obstruction	Supports visual acquis ition and conflict avoidance	Fixed coordinates. No NAV input required. Collocation with obstruction not required with appropriate broadcast coverage.	Enables NAV hazard to be detected by Class A users.
Ground Receive Subsystems (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 nmi. Terminal coverage out to 60 nmi.
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 nmi. Surface coverage out to 5 nmi.
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.

3.2.3.2 Broadcast-Only Subsystems (Class B)

Some ADS-B system participants may not need to be provided information from other participants but do need to broadcast their state vector and associated data. Class B subsystems meet the needs of these participants. Class B subsystems are defined as follows (Table 3-1):

- Class B1: Aircraft broadcast-only subsystem, as shown in Figure 3-3. Class B1 subsystems require an interface with own-platform navigation systems. Two types of equipage, corresponding to equivalent transmit powers and information capabilities as those of class A0 and A1, are permitted within this class. Use of the lower power alternative is determined by the same aircraft operational limits as those given for class A0.

- Class B2: Ground vehicle broadcast-only ADS-B subsystem. Class B2 subsystems require a high-accuracy source of navigation data and a nominal 5 nmi effective broadcast range. Surface vehicles qualifying or ADS-B equipage are limited those that operate within the surface movement area.
- Class B3: Fixed obstacle broadcast-only ADS-B subsystem. Obstacle coordinates may be obtained from available survey data. Collocation of the transmitting antenna with the obstruction is not required as long as broadcast coverage requirements are met. Fixed obstacles qualifying for ADS-B are structures and obstructions identified by ATS authorities as a safety hazard.

3.2.3.3 Ground Receive-Only Subsystems (Class C)

Surveillance state vector reports, mode-status reports, and on-condition reports are available from ADS-B system participants within the coverage domain of ground ADS-B receive-only, or Class C subsystems. The following Class C subsystems are defined (Table 3-1):

- Class C1: Ground ATS receive-only ADS-B subsystems for en route and terminal area applications. Class C1 subsystems should meet continuity and availability requirements determined by the ATS provider.
- Class C2: Ground ATS Receive-Only ADS-B Ground ATS receive-only ADS-B subsystems applications. Class C2 subsystems have more stringent accuracy and latency requirements than Class C1 systems. Class C2 systems may be required, depending upon the ADS-B System design, to recognize and process additional ADS-B message formats not processed by Class C1 subsystems.
- Class C3: Flight following surveillance is available from this equipage class for use by private operations planning groups or for provision of flight following and SAR.

3.3 System Requirements

3.3.1

3.3.2

3.3.3 ADS-B Data Exchange Requirements

3.3.3.1 Report Accuracy, Update Period, and Acquisition Range

Report accuracy, update period and acquisition range requirements are …

3.4 ADS-B Report Definitions

3.4.1 Report Assembly Design Considerations

3.4.2 ADS-B Message Exchange Technology Considerations in Report Assembly

3.4.3 Specific ADS-B Report Definitions

3.4.3.1 State Vector Report

The state vector (SV) report contains information about an aircraft or vehicle's current kinematic state as well as a measure of the state vector quality. Specific requirements for a participant to supply data for and/or generate this report subgroup will vary according to the intended capability of each participant. Paragraph 3.4.4 defines the required capabilities for each Subsystem Class defined in Section 3.2.2. Contents of the state vector are summarized in Table 3-5. Required update rates for this report, described by operational capability and operating range, are given in Section 3.3.3.

The surveillance SV report for each acquired participant contains the participant address for correlation purposes. Geometric based state vector information is referenced to the WGS-84 ellipsoid and consists of latitude, longitude, height above the ellipsoid, horizontal velocity, geometric altitude rate, Navigation Integrity Category (NIC), and Navigation Accuracy Category for position (NAC_P). Other state vector information ~~consists of~~includes pressure altitude, pressure altitude rate, ~~and~~ airspeed, and heading. These elements provide backup surveillance in the event of interruption of geometric referenced information, or as default information for participants with limited navigation capabilities. ~~For some operational capabilities the state vector report includes ground referenced rate of turn or speed change rate.~~

Pressure altitude, which is currently reported by aircraft in SSR Mode C and Mode S, will also be transmitted in ADS-B messages. The pressure altitude reported in ADS-B (SV element ~~11~~8a) shall (R3.34) be derived from the same source as the pressure altitude reported in Mode C and Mode S for aircraft with both transponder and ADS-B.

Time-critical state vector elements are those ~~defined in note 3~~indicated by bullets in the "Time-Critical SV Elements" column of Table 3-5. For systems utilizing segmented messages for SV data, time-critical state vector elements not updated in the current received message shall (R3.35) be estimated when the report is updated; otherwise SV elements shall (R3.35) be updated as new data is received.

State vector elements indicated by "R" in the "required from surface participants" column of Table 3-5 shall (R3.xxx) be transmitted by ADS-B participants that indicate that they are on the surface. Likewise, SV elements indicated by "R" in the "required from airborne participants" column shall (R3.xxx) be transmitted by ADS-B participants that do not indicate that they are on the surface. If a transmitting ADS-B participant does transmit the state vector elements indicated by "O" (for optional) in these columns, then it shall (R3.xxx) indicate that is transmitting those optional elements in the appropriate subfield of the messages that it transmits to support the MS report.

The time of applicability relative to local system time shall (R3.37) be updated with each State Vector report update. For other elements of the SV report, the report assembly function shall (R3.38) either provide updates when data is received or indicate "no data available" if ~~none is~~no data are received in the preceding 10 second period.

The NIC, NAC_P, and NAC_V ~~NUC~~ data elements shall (R3.39) be those determined by the originating participant as defined in Section 2.1.2.2.4. The ADS-B state vector reports for each participant shall (R3.40) be available to applications as soon as that participant is detected.

The "Report Mode" SV element provides a positive indication when SV acquisition is complete and all applicable data sets and modal capabilities have been determined for the participant or that a default condition is determined by the Report ~~Generator~~ Assembly function.

Table 3-5. State Vector Report Elements.

	SV Elem. #	Contents [Notes]	Time-Critical SV Elements	Required from surface participants	Required from airborne participants	Reference Section
ID	1	Participant Address		R	R	2.1.2.1.2
Geometric Position	2a	Latitude (WGS-84)	•	R	R	2.1.2.2.1.1
	2b	Longitude (WGS -84)	•	R	R	
	2c	Horizontal Position Valid	•	R	R	
	3a	Geometric Altitude [1]	•	O	N	2.1.2.2.1.2.2
	3b	Geometric Altitude Valid [1]	•	O	N	
Geometric Velocity	4a	North Velocity [1]	•	R	N	2.1.2.2.2.1
	4b	East Velocity [1]	•	R	N	
	4c	Horizontal Velocity Valid [1]	•	R	N	
	5a	Ground Speed		N	R	2.1.2.2.2.1
	5b	Ground Speed Valid		N	R	
	5c	Ground Track Angle [2]		N	R	
	5d	Ground Track Angle Valid		N	R	
	6a	Geometric Vertical Rate [1]		O	N	2.1.2.2.2.2
	6b	Geometric Vertical Rate Valid [1]		O	N	
Integrity, Accuracy	7a	NIC, Navigation Integrity Category		R	R	2.1.2.2.4.1
	7b	NAC_P, Navigation Accuracy Category for Position		R	R	2.1.2.2.4.2
	7c	NAC_V, Navigation Accuracy Category for Velocity		R	R	2.1.2.2.4.3
Air Data and Heading	8a	Barometric Pressure Altitude	•	R	N	2.1.2.2.1.2.1
	8b	Pressure Altitude Valid	•	R	N	
	8c	Pressure Altitude Rate	•	R	N	2.1.2.2.2.2
	9a	Airspeed (TAS or IAS) [1, 2]		O	N	
	9b	Airspeed Valid [1]		O	N	
	10a	Heading (True or Magnetic) [1, 2, 3, 4]		O	R	
	10b	Heading Valid [1, 3, 4]		O	R	
Turn	11	Turn Indication [1]		O	O	2.1.2.2.3
TOA	12	Time Of Applicability – Time-Critical Data	•	R	R	2.1.1.4
Rep. Mode	13	Report Mode (Report Assembly Function Mode For This Target: Acquisition, Track, Or Default)		R	R	

Notes for Table 3-5:

[1] SV elements marked "O" for "optional," if provided at all, need not be transmitted at the same update rate as elements marked "R" for "required." Whether or not a participant is transmitting an optional SV element shall be indicated in the "SV Report Modes" element of the MS report.

[2]~~1. Time-critical State Vector data.~~

~~2. An indication that no data is available should be provided if the data is not available.~~

~~3. To be provided in the SV report for airborne participants.~~

~~4. To be provided in the SV report for surface participants.~~

~~5.~~ Data reference frame (True or Magnetic, TAS or IAS) is provided in the Mode Status Report.

[3] An ADS-B participant on the airport surface may transmit heading rather than track angle. [This is especially useful at low ground speeds, for which a GNSS-derived track angle may be unreliable.] A surface participant that transmits heading in lieu of track angle should so indicate by sending messages to support MS report element 7c, the "heading being reported" flag.

[4] An ADS-B participant that is stopped (not moving) on the airport surface transmits it heading (rather than its track angle, which is meaningless) while it is stopped.

3.4.3.2 Mode Status and Partial Mode Status Reports

The mode-status (MS) report contains current operational information about the transmitting participant. This information includes participant type, current intent (Trajectory Change Point), mode specific parameters and status data needed for certain pairwise operations. These elements require lower update rates than the SV report. Specific requirements for a participant to supply data for and/or generate this report subgroup will vary according to the equipage class of each participant. Paragraph 3.4.4 defines the required capabilities for each Equipage Class defined in Section 3.2.2. Classes define the level of MS information to be exchanged from the source participant to support correct classification onboard the user system.

The Partial Mode-Status (MS-P) report contains a subset of the Mode-Status report information consisting of elements excepting intent and coordination information. The Partial Mode-Status information comprises items 1-6 of Table 3-6.

The Mode-Status report for each acquired participant contains the unique participant address for correlation purposes, static and operational mode information and Time of Applicability. Contents of the Mode-Status report are summarized in Table 3-6.

The static and operational mode data includes the following information:

- Class Codes – used to indicate capability of participant to support engagement in specific operations (e.g., None, CDTI based Aid to Visual Acquisition, Collision Avoidance, Terminal Station Keeping, Free Flight / Cooperative Separation in Overflight, Oceanic Cooperative Separation, Simultaneous Approaches, Blind Taxi, Runway Incursion).
- Operational Mode Specific Parameters – e.g., Speed target, Mag/True track, IAS/TAS.

For each participant the Mode-status report shall (R3.41) be updated and made available to ADS-B applications any time a new message containing all, or a portion of, its component information is accepted from that participant. For all applications other than Aid to Visual Acquisition the required MS report must be available to qualify for ADS-B operations.

The time of applicability relative to local system time shall (R3.42) be updated with every Mode-status report update. For all elements of MS report the assembly function shall (R3.43) provide update when received or indicate "no data available" is none is received in the preceding 10 second period.

Table 3-6. Mode-Status (MS) and Partial Mode-Status (MS-P) Report Definition.

	Element Number	MS	MS-P	Contents [Notes]	Reference Section
ID	1	•	•	Participant Address	2.1.2.1.2
	2	•	•	Call sign (up to 8 alpha-numeric characters)	2.1.2.1.1
	3	•	•	Participant Category	2.1.2.1.3
	4	•	•	Surveillance Support Code (Normal or Default) [2]	
	5	•	•	Emergency/Priority Status	2.1.2.3.1
	6	•	•	Application Class Codes 6a: CDTI display enabled 6b: TCAS enabled	2.1.2.4
SV Report Modes	7a	•		Geometric altitude being reported	
	7b	•		Airspeed being reported	
	7c	•		Heading being reported	
	7d-7h			(Reserved for future use)	
TCP	7a	•		TCP Latitude	2.1.2.3.2
	7b	•		TCP Longitude	2.1.2.3.2
	7c	•		TCP Altitude	2.1.2.3.2
	7d	•		TCP Time To Go (TTG)	2.1.2.3.2
	8	•		Operational Mode Specific Data	
	9	•		Flight Mode Specific Data [3]	
TOA	10	•		Time of Applicability	2.1.1.4

Notes for Table 3-6:

~~*1.Aircraft category defined in Section 2 of this MASPS.*~~

~~*1.Items 1-6 comprise the Partial Mode-status Report.*~~

~~3.~~1. "Normal" means that for the stated application class codes (field 6), all data are reliable. "Default" means that the transmitting ADS-B participant advises that some transmitted data are not reliable or unavailable.

~~4.~~2. Flight mode specific data will be defined in a lower level of documentation and be included through revision to the MASPS. Examples are: touchdown speed and pair-wise operational capabilities.

3.4.3.3 On-Condition Reports

3.4.3.3.1 TCP+1 Report

3.4.4 Minimum ADS-B Report Requirements for Equipage Classes

Equipage classes are defined to accommodate tiered capabilities according to increasingly complex operational objectives while preserving basic inter-operability between classes. Equipage decisions are determined on the basis the operational approval desired. Each equipage class discussed in Table 3-1 is required to receive messages and process the recovered information into specific ADS-B reports according to the applicable capability. This section defines the required ADS-B report capabilities for each class.

For certain pair-wise operations, more data is required to support the desired applications than that provided by the state vector alone. Table 3-3 states general requirements to perform or support certain operational capabilities. The receiving participant must determine the pair-wise capabilities available between own and the transmitting (other) participant. This capability is determined by reading the class code (item 6) defined in the Mode-status report. Therefore, this section also identifies the transmitted information required from each class operating within the ADS-B system.

3.4.4.1 Interactive Aircraft/Vehicle Subsystems (Class A)

Table 3-8(a) defines requirements for the contents of ADS-B reports to be provided by the report assembly function in Equipage Class A receiving ADS-B subsystems.

Table 3-8(a). Class A Equipment ADS-B Report Contents.

	Interactive Aircraft/Vehicles Operational Capabilities					
Equipage Class	Aid to Visual Acquisition	Conflict Avoidance	Separation Assurance and Sequencing	Flight Path Deconfliction Planning	Simultaneous Approaches	Airport Surface
	ADS-B Output Reports Required					
A0 **Basic VFR** Aircraft / Ground Vehicles	SV	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
A1 **Basic IFR** Aircraft (Note 1) and Ground Vehicles	SV MS (Note 4)	SV MS (Note 4)	Not Applicable	Not Applicable	SV MS (Note 4)	SV MS (Note 4)
A2 **Enhanced IFR** Aircraft Only	SV MS (Note 5)	SV MS (Note 5)	SV MS (Note 5)	Not Applicable	SV MS (Note 5)	SV MS (Note 5)
A3 **Extended Capability** Aircraft Only	SV MS (Note 5) TCP+1	SV MS (Note 5) TCP+1	SV MS (Note 5) TCP+1	SV MS (Note 5) TC+1	SV MS (Note 5) TCP+1	SV MS (Note 5) TCP+1

Notes for Table 3-8(a):

1. *ADS-B Collision Avoidance can be performed without acquiring Mode-Status data. Mode-Status data is needed in applications which determine separation assessment based on the data provided in Partial Mode-Status report. Such assessments and predictions are performed well outside the operational conditions of Collision Avoidance.*
2. *Numbers (#) refer to data elements in Table ~~3.4-1~~3-5, ~~3.4-2~~3-6, and ~~3.4-3~~3-7.*
3. *All SV (state vector) entries require elements 1 through 17.*
4. *Mode-Status elements 1 though 6 and 12 required.*
5. *Mode-Status elements 1 though 12 required.*
6. *Not applicable for ground vehicles.*

Table 3-8(b) defines requirements for the contents of ADS-B messages to be transmitted by Equipage Class A transmitting ADS-B subsystems.

Table 3-8(b). Class A Equipment Broadcast Information Required.

	Interactive Aircraft/Vehicles Operational Capability					
Equipage Class	Aid to Visual Acquisition	Conflict Avoidance	Separation Assurance and Sequencing	Flight Path Deconfliction Planning	Simultaneous Approaches	Airport Surface
	Required Transmitted Message Information for each Equipage Class					
A0 **Basic VFR** Aircraft / Ground Vehicles	SV data (Note 2) MS data (Note 3)	SV data (Note 2) MS data (Note 3)	Not Applicable	Not Applicable	Not Applicable	SV data (Note 8) MS data (Note 3)
A1 **Basic IFR** Aircraft (note 1) and Ground Vehicles	SV data (Note 2) MS data (Note 4)	SV data (Note 2) MS data (Notes 4 & 7)	Not Applicable	Not Applicable	SV data (Note 2) MS data (Notes 4 & 7)	SV data (Note 8) MS data (Note 4)
A2 **Enhanced IFR** Aircraft Only	SV data (Note 2) MS data (Note 5)	SV data (Note 2) MS data (Note 5)	SV data (Note 2) MS data (Note 5)	SV data (Note 2) MS data (Note 5)	SV data (Note 2) MS data (Note 5)	SV data (Note 8) MS data (Note 5)
A3 **Extended Capability** Aircraft Only	SV data (Note 2) MS data (Note 5) OC data (Note 6)	SV data (Note 2) MS data (Note 5) OC data (Note 6)	SV data (Note 2) MS data (Note 5) OC data (Note 6)	SV data (Note 2) MS data (Note 5) OC data (Note 6)	SV data (Note 2) MS data (Note 5) OC data (Note 6)	SV data (Note 8) MS data (Note 5) OC data (Note 6)

Notes for Table 3-8(b):

1. *Message content required to support report Element # in Tables 3.4-1, 3.4-2, and 3.4-3. Only the appropriate information need be broadcast.*
2. *Contents to support SV element 1 through 15.*
3. *Contents to support MS elements 1 through 4.*
4. *Contents to support MS elements 1 through 6.*
5. *Contents to support MS elements 1 through 11.*
6. *Contents to support OC elements 1 though 5.*
7. *Contents to support SV elements 1, 2, 3, 5-8, 10, 14.*

3.4.4.2 Broadcast Only Subsystems (Class B)

A broadcast-only subsystem is not required to generate ADS-B reports . Table 3-9 indicates the required information to support users in locating and identifying the transmitting participant. Certification of these classes is required to support the overall quality and safe usage of information used in ADS-B dependent applications.

Table 3-9. Class B equipment ADS-B Information Transmission.

	User Applications to be Supported		
Equipage Class	Aid to Visual Acquisition	Conflict Avoidance	Airport Surface
	Transmitted Information Required		
B1 Aircraft Broadcast Only	SV (Note 2) MS #1, 3, 4, 6	SV (Note 2) MS #1, 2. 3, 4, 6	SV (Note 2) MS #1, 3, 4, 6
B2 Ground Vehicle Broadcast Only	SV (Note 2) MS (Note 4)	SV (Note 2) MS (Note 4)	SV (Note 2) MS (Note 4)
B3 Fixed Obstruction Broadcast Only	SV (Note 3) MS (Note 4)	SV (Note 3) MS (Note 4)	SV (Note 3) MS (Note 4)

Notes for Table 3-9:

1. *Numbers (#) refer to data elements in Tables 3-5, 3-6, and 3-7.*
2. *State Vector elements 1-9, 11, and 14 required.*
3. *State Vector elements 1 though 6 required.*
4. *Mode-Status elements 1, 3, 4 required.*
5. *On the airport surface, aircraft are not required to report altitude, but must indicate that they are on the surface.*
6. *Ground vehicles are not required to broadcast altitude or altitude rate.*

3.4.4.3 Receive-Only Subsystems (Class C)

Table 3-10 defines ADS-B reports required in ground applications.

Table 3-10. Class C Equipment ADS-Report Contents.

	Receive-Only Operational Capabilities					
Equipage Class	Aid to Visual Acquisition	Conflict Avoidance	Separation Assurance and Sequencing	Flight Path Deconfliction Planning	Simultaneous Approaches	Airport Surface
	Required Transmitted Message Information for each Equipage Class					
C1 ATS En Route and Terminal	All Elements	All Elements	All Elements	All Elements	Not Applicable	Not Applicable
C2 Approach and Surface	All Elements	All Elements	All Elements	Not Applicable	All Elements	All Elements
C3 Flight Following User-Operator Custom Applications	All Elements	Not Applicable	All Elements	Not Applicable	Not Applicable	All Elements

Note for Table 3-10:

"All elements" consists of every element of the State Vector, Mode-Status, and On-Condition reports.