

RTCA Special Committee 186, Working Group 5

ADS-B UAT MOPS Maintenance

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Potential UAT MOPS Changes to Include Equipage Class A1S
In Response to Action Item 23-05

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Summary
To address Action Item 23-05 from Meeting #23 of WG-5, this Working Paper identifies changes that will need to be made to include a new Equipage Class, A1S. This class transmits at a Medium power level (like Equipage Class A1H) and uses only one antenna (like Equipage Class A0). Only places in the body of the MOPS are identified. There may also need to be many changes in Appendix K when and if the performance parameters of this new Equipage Class are quantified.

This Working Paper includes a marked up copy of the current draft of DO-282B, identifying suggested changes that would be necessary to add a new Equipage Class called A1S. This class transmits Medium Power and uses only one antenna. It is assumed that the transmit performance lies somewhere between that of Classes A0 and A1H. Thus, the transmit performance is assumed to be the same as Class A1L equipment. The receive performance is assumed to be the same as Class A0. Ideally, these performance estimates will be verified via simulation. If such verification is done, the results should be documented in a revised version of Appendix K.

It is assumed that there should also be a new Equipage Class called B1S, which would have transmission properties the same as Class A1S, but with no receiver. If this is not the case, the associated changes can easily be removed.

The proposed changes are all highlighted in **gray**. To aid the reader, the locations of the changes are listed below.

SECTIONS

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In addition, there are two editorial comments on pages 16 and 80, which are highlighted in green.

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 the tests, except as specifically allowed.

2.1.9 Integration with Other Avionics Equipment

In the event that UAT functions are partially or wholly incorporated within other avionics equipment, the design **shall** be partitioned such that any abnormal equipment operation does not adversely affect other function unrelated to UAT. Loss of UAT capability **shall** not inhibit other functions of the equipment.

2.1.10 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. Guidance can be found in 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.

2.1.11 Equipage Classes

UAT equipment is categorized into aircraft system equipage classes as defined in [Table 3-1](#) of RTCA DO-242A (ADS-B MASPS). For UAT equipment, the installed performance of these equipment classes **shall** be defined by [Table 2-1](#).

The ADS-B MASPS “A1” equipment has been divided into **three** classes, based on the maximum altitude that the aircraft is operated under. For A1 aircraft that always operate below 18,000 feet MSL, the “A1 Low” class and “A1 Single Antenna” class are created, and abbreviated throughout this document as “A1L” and “A1S,” respectively. For A1 aircraft that have no altitude operating restrictions, the “A1 High” class is created, and abbreviated throughout this document as “A1H.” The only equipment performance difference between classes A1L and A1H is the Transmitter RF output power, as shown in [Table 2-1](#).

The remainder of the interactive aircraft/vehicle classes (A0, A2, and A3) are as defined in RTCA DO-242A.

For “B” class aircraft that always operate below 18,000 feet MSL, the “B0” and “B1S” classes are created. For “B” class aircraft that have no altitude operating restrictions, the “B1” class is available. The ADS-B MASPS “B0” class (broadcast-only aircraft) is defined as having transmitter characteristics and payload capability identical to the UAT A0 interactive aircraft class. The ADS-B MASPS “B1S” class (broadcast-only aircraft) is defined as having transmitter characteristics and payload capability identical to the UAT A1S interactive aircraft class. The ADS-B MASPS “B1” class (broadcast-only aircraft) is defined as having transmitter characteristics and payload capability identical to the UAT A1H interactive aircraft class.

The characteristics of the ADS-B MASPS “B2” class (broadcast-only ground vehicle) are defined in [Table 2-1](#).

The characteristics of the ADS-B MASPS “B3” class (broadcast-only fixed or moveable obstacle) are defined in [Table 2-1](#). The payload capability supports the surface position, height of highest point, and identification (including Emitter Category) of the obstacle, so that both State Vector and Mode Status reports must be supported. Moveable obstacles require a position source. A moveable obstacle is one that can change its position, but only slowly, such that its horizontal velocity may be ignored. See §2.2.6.1.2 of this document for the payload characteristics.

Requirements for Class ‘C’ ground-based receive-only equipment are not addressed in this document. See Appendix D for guidance in ground-based receiver performance.

Table 2-1: UAT Installed Equipment Classes

Description	Equipage Class	Tx RF Power Delivered to Antenna System	Intended Antenna Diversity (when Airborne for Classes A & B0-B1)	
			Transmit	Receive
Aircraft	A0	Low Power <i>(Altitude always below 18,000 feet)</i>	Single Antenna (see Note 4)	Single Antenna (see Note 4)
	A1L		Alternating every 2 sec.	Alternating every second
	A1S	Medium Power <i>(Altitude always below 18,000 feet)</i>	Single Antenna (see Note 4)	Single Antenna (see Note 4)
	A1H	Medium Power	Alternating every 2 sec.	Alternating every second
	A2	Medium Power	Alternating every 2 sec.	Dual Receiver
	A3 (extended range)	High Power	Alternating every 2 sec.	Dual Receiver
Tx-Only Airborne Vehicle	B0	Low Power <i>(Altitude always below 18,000 feet)</i>	Single Antenna (see Note 4)	n/a
	B1S	Medium Power	Single Antenna (see Note 4)	Single Antenna (see Note 4)
	B1	Medium Power	Alternating every 2 sec.	n/a
Surface Vehicle	B2	+28 to +32 dBm	Single Antenna	n/a
Obstacle	B3	+30 dBm (minimum)	Single Antenna	n/a

Notes:

1. See §2.1.12 for definition of Transmitter RF power levels.

2. *Transmitter RF power requirement depends on the aircraft maximum altitude capability. Low-altitude aircraft (< 18,000 feet max altitude) need not support the higher-power transmitter requirements due to line-of-site limitations.*
3. *Top antenna is not required if use of a single antenna does not degrade signal propagation. This allows for single antenna installation on radio-transparent airframes.*
4. *For a single-antenna installation, antenna gain pattern performance should be shown at least equivalent to that of a quarter-wave resonant antenna mounted on the fuselage bottom surface.*
5. *See §2.2.6.1.2 for definition of payload transmission requirements for each equipment class.*
6. *Equipment Classes AIS and BIS define aircraft with medium power and a single antenna on the bottom. [I don't think this note is necessary.]*

2.1.12 Transmitting Subsystem

A UAT Transmitting Subsystem is classified according to the unit's range capability and the set of parameters that it is capable of transmitting. [Table 2-2](#) shall define the transmitter power levels. Power levels are measured in terms of power presented to the transmitting antenna.

Table 2-2: Transmitter Power Requirements

Power Classification	Minimum Power at Antenna	Maximum Power at Antenna
Low	7.0 watts (+38.5 dBm)	18 watts (+42.5 dBm)
Medium	16 watts (+42 dBm)	40 watts (+46 dBm)
High	100 watts (+50 dBm)	250 watts (+54 dBm)

Note: *These transmitter power requirements are referenced to the power delivered to the antenna, and assume transmit antenna gain of 0 dB. Alternate means that demonstrates equivalent performance can be approved. Refer to Appendix E for guidance.*

Performance is specified over full environmental range for desired equipment application.

2.1.13 Receiving Subsystem

No distinction in receiver sensitivity by category is made; all receivers have the same sensitivity requirements. The receiver sensitivity is -93 dBm at the receiver antenna for 90% Message Success Rate for Long ADS-B Messages, and -91 dBm at the receiver antenna for 90% Message Success Rate of Ground Uplink (ground-to-air) messages.

Performance is specified over full environmental range for desired equipment application.

2.2.6.1.2 ADS-B Payload Type Allocation

One of the ADS-B Payload Type Codes in the range of “0” through “6” specified in [Table 2-10](#) shall be assigned to each of the 4 Payload Selections (PS) as shown in [Table 2-63](#).

Table 2-63: Payload Type Code Allocation

Equipment Class	PS-A	PS-B	PS-C	PS-D
A0,A1L,A1S,A1H,B0,B1S,B1	1	0	2	0
A1H, B1 (see Note 2)	3	6	0	6
A2	1	4	4	4
A3	1	4	5	4
B2, B3	1	0	0	0

Notes:

1. This schedule is to be followed regardless of the unavailability of any payload fields.
2. Optional Payload Type Code assignment if the installation can support transmission of Target State information.

2.2.6.1.3 Message Transmission Cycle (Transmitter Diversity)

A message transmission cycle of 16 seconds is defined to ensure a proper mix of message payloads for installations that support ADS-B Message transmission from dual (diversity) antennas (§2.1). When an aircraft is determined to be in the AIRBORNE condition (§2.2.4.5.2.5.1), transmissions shall occur through Top (T) (if so equipped) and Bottom (B) antennas each Message Transmission Cycle as shown in [Figure 2-8](#).

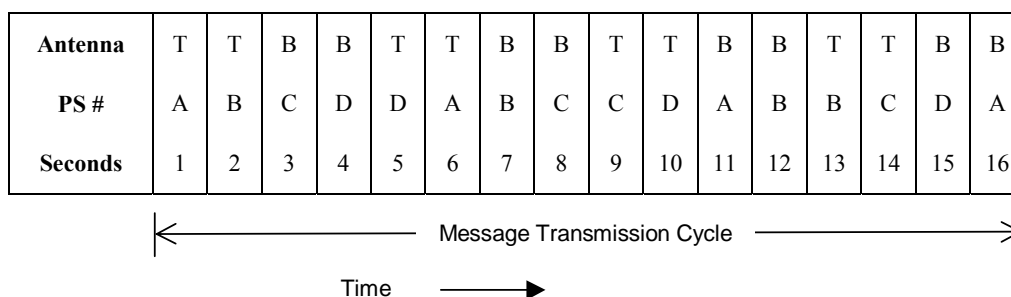


Figure 2-8: Transmitter Antenna Use for Diversity Installations

Notes:

1. There is no requirement that transmission cycle boundaries be aligned among A/Vs; it is used only to ensure proper mix of transmitted message types.
2. For receivers with antenna diversity provided by switching according to §2.2.8.1, this transmission pattern ensures that each payload type is communicated via each possible transmit/receive antenna combination (T/T, T/B, B/T, B/B) once during each 16 second cycle. It also minimizes the maximum spacing between any two transmissions of the same type.

Table 2-64: UAT ADS-B Transmitter Input Requirements

Element #	Input Data Element	Relevant Paragraph	Data Lifetime (seconds)	Applicable UAT Equipment Class						
				A0, B0	A1L, A1S, B1S	A1H, B1	A2	A3	B2	B3
1	ICAO 24-bit Address	2.2.4.5.1.3.1	n/a	M	M	M	M	M	M ⁽¹⁾	M ⁽¹⁾
2	Address Selection (ICAO vs Temporary)	2.2.4.5.1.3.1 2.2.4.5.1.3.2	60	Input required only if installation is to have selectable address						
3	Latitude ⁽²⁾	2.2.4.5.2.1	2	M	M	M	M	M	M	M
4	Longitude ⁽²⁾	2.2.4.5.2.1	2	M	M	M	M	M	M	M
5	Altitude Type Selection (Barometric vs Geometric)	2.2.4.5.2.2	60	O	O	O	O	O	n/a	M
6	Barometric Pressure Altitude	2.2.4.5.2.3	2	M	M	M	M	M	n/a	n/a
7	Geometric Altitude	2.2.4.5.2.3	2	M	M	M	M	M	n/a	M
8	NIC	2.2.4.5.2.4	2	M	M	M	M	M	M	M
9	Automatic AIRBORNE / ON-GROUND Indication	2.2.4.5.2.5	2	O	O	M	M	M	n/a	n/a
10	North Velocity ⁽²⁾	2.2.4.5.2.6.1	2	M	M	M	M	M	M	M
11	East Velocity ⁽²⁾	2.2.4.5.2.6.3	2	M	M	M	M	M	M	M
12	Ground Speed	2.2.4.5.2.6.2	2	O	O	M	M	M	O	n/a
13	Track Angle	2.2.4.5.2.6.4	2	O	O	M	M	M	n/a	n/a
14	Heading	2.2.4.5.2.6.4	2	O	O	M	M	M	n/a	n/a
15	Barometric Vertical Rate	2.2.4.5.2.7.1.1 2.2.4.5.2.7.1.3	2	M	M	M	M	M	n/a	n/a
16	Geometric Vertical Rate ⁽²⁾	2.2.4.5.2.7.1.1 2.2.4.5.2.7.1.3	2	O	O	O	O	O	n/a	n/a
17	A/V Length and Width, and POA	2.2.4.5.2.7.2	n/a	M	M	M	M	M	M	M
18	UTC 1 PPS Timing ⁽²⁾	2.2.4.5.2.8	2	M	M	M	M	M	M	M
19	Emitter Category	2.2.4.5.4.1	n/a	M	M	M	M	M	M	M
20	Call Sign	2.2.4.5.4.2	60	M	M	M	M	M	O	O
21	Emergency / Priority Status Selection	2.2.4.5.4.4	60	M	M	M	M	M	O	n/a
22	SIL	2.2.4.5.4.6	60	M	M	M	M	M	M	M
23	NAC _P ⁽²⁾	2.2.4.5.4.9	2	M	M	M	M	M	M	M
24	NAC _V ⁽²⁾	2.2.4.5.4.10	2	M	M	M	M	M	n/a	n/a
25	NIC _{BARO}	2.2.4.5.4.11	2	Can be internally "hard coded"		M	M	M	n/a	n/a
26	CDTI Traffic Display Capability	2.2.4.5.4.12.1	60	M	M	M	M	M	n/a	n/a
27	TCAS Installed and Operational	2.2.4.5.4.12.2	60	M	M	M	M	M	n/a	n/a
28	TCAS/ACAS Resolution Advisory Flag	2.2.4.5.4.13.1	18	Required only if ADS-B Transmitting Subsystem is intended for installation with TCAS/ACAS; otherwise can be "hard coded"						
29	IDENT Selection	2.2.4.5.4.13.2	60	M	M	M	M	M	M	n/a
30	"Receiving ATC Services" Flag	2.2.4.5.4.13.3	60	M	M	M	M	M	M	n/a
31	"True/Magnetic Indicator" Flag	2.2.4.5.4.14	60	n/a	n/a	O	M	M	M	n/a
32	Heading / Track Indicator	2.2.4.5.6.1.1	60	n/a	n/a	O	M	M	n/a	n/a
33	Target Source Indicator (Horizontal)	2.2.4.5.6.1.2	60	n/a	n/a	O	M	M	n/a	n/a
34	Horizontal Mode Indicator (Horizontal)	2.2.4.5.6.1.3	60	n/a	n/a	O	M	M	n/a	n/a
35	Target Heading or Track Angle	2.2.4.5.6.1.5	60	n/a	n/a	O	M	M	n/a	n/a
36	Target Altitude Type	2.2.4.5.6.2.1	60	n/a	n/a	O	M	M	n/a	n/a
37	Target Source Indicator (Vertical)	2.2.4.5.6.2.2	60	n/a	n/a	O	M	M	n/a	n/a
38	Mode Indicator (Vertical)	2.2.4.5.6.2.3	60	n/a	n/a	O	M	M	n/a	n/a
39	Target Altitude Capability	2.2.4.5.6.2.4	60	n/a	n/a	O	M	M	n/a	n/a
40	Target Altitude	2.2.4.5.6.2.5	60	n/a	n/a	O	M	M	n/a	n/a
41	Radio Altitude	2.2.4.5.2.5.1	2	O	O	O	O	O	n/a	n/a
42	Pressure Altitude Disable	2.2.4.5.2.2	n/a	M	M	M	M	M	n/a	n/a
43	Airspeed	2.2.4.5.2.5.1	2	O	O	O	O	O	n/a	n/a
44	Flight Plan ID	2.2.4.5.4.2	60	M	M	M	M	M	n/a	n/a

O = Optional

M = Mandatory (the equipment must have the ability to accept the data element)

Notes: ⁽¹⁾ Non-Aircraft Identifier may be assigned by Regulatory Authority.
⁽²⁾ If input is not directly accessible, a means to verify the encoding must be demonstrated.

[Note: Columns for A0, B0, AIL, AIS and BIS could be combined since the entries are identical.]

2.2.7.2 Time Registration and Latency

This subparagraph contains requirements imposed on the ADS-B Transmitting Subsystem relative to two parameters. The first relates to the obligation of the transmitter to ensure position data in each ADS-B Message relates to a standard *Time of Applicability (TOA)*. The second relates to the obligation of the transmitter to reflect new ADS-B Message data available at the transmitter input into the transmitted ADS-B Message itself. This requirement is expressed as a *cutoff time* by which any updated data presented to the UAT transmitter should be reflected in the message output. Rules for Time of Applicability and cutoff time vary depending on the quality of SV data being transmitted and whether the transmitter is in the UTC Coupled state. The *Precision* or *Non-Precision* condition for reporting SV data is determined according to the criteria below:

- a. Precision condition is in effect when:
 1. The “NAC_P” value is “10” or “11,” or
 2. The “NIC” value is “9,” “10” or “11”
- b. Otherwise, the Non-Precision condition is in effect.

2.2.7.2.1 Requirements When in Non-Precision Condition and UTC Coupled

When the UAT Transmitting Subsystem is in the Non-Precision Condition, and is UTC Coupled:

- a. At the time of the ADS-B Message transmission, position information that is encoded in the “LATITUDE” and “LONGITUDE” fields, and in the “ALTITUDE” field, when it conveys a Geometric Altitude, **shall** be applicable as of the start of the current 1 second UTC Epoch.
- b. All other updated ADS-B Message fields that are provided at the ADS-B equipment input interface at least 200 milliseconds prior to the time of a scheduled ADS-B Message transmission that involves those fields, **shall** be reflected in the transmitted message.

Notes:

1. *Specifically, any extrapolation of position performed should be to the start of the 1-second UTC Epoch and not the time of transmission.*
2. *Velocity information cannot be extrapolated and may therefore have additional ADS-B imposed latency (generally no more than one extra second).*

2.2.7.2.2 Requirements When in Precision Condition and UTC Coupled

When the UAT Transmitting Subsystem is in the Precision Condition, and is UTC Coupled:

Table 2-65: Selectivity Rejection Ratios

Frequency Offset from Center	Minimum Rejection Ratio (Undesired/Desired level in dB)	
	Equipment Class A0, A1L, A1S, A1H, A2	Equipment Class A3
-1.0 MHz	10	30
+1.0 MHz	15	40
(±) 2.0 MHz	50	50
(±) 10.0 MHz	60	60

Note: This requirement establishes the receiver's rejection of off channel energy.

2.2.8.2.4 Receiver Tolerance to Pulsed Interference

The receiver **shall** be capable of receiving messages in the presence of interference from on channel and off channel sources of pulsed interference, such as DME/TACAN and JTIDS/MIDS. Informative Appendix G indicates, in Table G-2, the levels and pulse density of interference scenarios, against which UAT has been designed to operate effectively, as reported in Appendix K. The UAT receiver must also be tolerant of pulsed interference from other L-Band systems operating and located on the aircraft. These may include 1030 MHz ATCRBS/Mode S interrogation signals from on-board TCAS and 1090 MHz ATCRBS/Mode S reply signals from on-board ATCRBS/Mode S Transponders.

The UAT receiver may experience pulsed interference from DME/TACAN channels operating in the internationally allocated 978 MHz to 1215 MHz frequency range. The receiver **shall** be tolerant to pulsed interference from DME/TACAN. The receiver **shall** meet the reception probability dictated under the following conditions:

- a. For all equipment classes:

The receiver **shall** be capable of achieving 99% reception probability of ADS-B Messages when the desired signal level is between -90 dBm and -10 dBm when subjected to DME/TACAN interference under the following conditions: DME/TACAN pulse pairs at a nominal rate of 3,600 pulse pairs per second at either 12 or 30 microseconds pulse spacing at a level of -36 dBm for any 1 MHz channel frequency between 980 MHz and 1215 MHz inclusive.

- b. For the A0, A1L, A1S, A1H, and A2 equipment classes:

1. The receiver **shall** be capable of achieving 90% reception probability of ADS-B Messages when the desired signal level is between -87 dBm and -10 dBm when subjected to DME/TACAN interference under the following conditions: DME/TACAN pulse pairs at a nominal rate of 3,600 pulse pairs per second at a 12 microseconds pulse spacing at a level of -56 dBm and a frequency of 979 MHz.
2. The receiver **shall** be capable of achieving 90% reception probability of ADS-B Messages when the desired signal level is between -87 dBm and -10 dBm when

subjected to DME/TACAN interference under the following conditions: DME/TACAN pulse pairs at a nominal rate of 3,600 pulse pairs per second at a 12 microseconds pulse spacing at a level of -70 dBm and a frequency of 978 MHz.

- c. For the A3 equipment class:
 1. The receiver **shall** be capable of achieving 90% reception probability of ADS-B Messages when the desired signal level is between -87 dBm and -10 dBm when subjected to DME/TACAN interference under the following conditions: DME/TACAN pulse pairs at a nominal rate of 3,600 pulse pairs per second at a 12 microseconds pulse spacing at a level of -43 dBm and a frequency of 979 MHz.
 2. The receiver **shall** be capable of achieving 90% reception probability of ADS-B Messages when the desired signal level is between -87 dBm and -10 dBm when subjected to DME/TACAN interference under the following conditions: DME/TACAN pulse pairs at a nominal rate of 3,600 pulse pairs per second at a 12 microseconds pulse spacing at a level of -79 dBm and a frequency of 978 MHz.
- d. For all equipment classes, following a 21 microsecond pulse at a level of 0 dBm and at a frequency of 1090 MHz, the receiver **shall** return to within 3 dB of normal sensitivity level within 12 microseconds.

Note: *A receiver meeting the requirements of the above paragraphs will perform adequately in the presence of DME/TACAN, JTIDS/MIDS, and co-site interference as reported in Appendix K.*

2.2.8.2.5 Receiver Tolerance to Overlapping ADS-B Messages (Self Interference)

A Successful Message Reception rate of 90% or better, for the stronger of two overlapping desired messages, **shall** result when the level of the stronger message is no weaker than -80 dBm and the stronger message is at least X dB above the weaker message, when the stronger message and weaker message are aligned in time.

Where the value of X is:

4 dB for Equipment Classes A0, A1L, A1S, A1H, and A2

9 dB for Equipment Class A3

Notes:

1. *The different values across equipment classes reflect the fact that Class A3 receivers will utilize a narrow filter that degrades demodulation performance slightly in order to gain added rejection from adjacent channel DME ground stations.*
2. *Signal values ensure both the desired and undesired signal levels are above the noise floor.*

2.2.8.2.6 Rate of False “Trigger”

- a. With no signal input, the ADS-B Receiver **shall** experience no more than 50 ADS-B Message triggers per second.

- b. With no signal input, the ADS-B Receiver **shall** experience no more than 2 Ground Uplink Message triggers per minute.

Note: *Detection of either the ADS-B or Ground Uplink synchronization sequence is referred to as a “trigger.”*

2.2.8.2.7 Trigger Processing Rate

Receiver trigger processing rate requirements are as follows:

- a. Equipment Classes A3, A2 and A1H receivers **shall** be capable of successfully processing at least 1000 trigger events per second.
- b. Equipment Classes A1S, A1L and A0 receivers **shall** be capable of successfully processing at least 900 trigger events per second.

2.2.8.3 Receiver Message Processing

2.2.8.3.1 Criteria for Successful Message Reception

2.2.8.3.1.1 ADS-B Messages

Upon detection of the ADS-B synchronization sequence, the receiver **shall** decode the ADS-B Message according to the procedure specified below:

- a. The receiver **shall** attempt to decode the message in the Long format using hard decision decoding with no erasures allowed. The decoder **shall** correct no more than 7 errors. If the RS decoder determines that there are no residual errors after completing the decoding process, then a Successful Message Reception **shall** be declared.
- b. Otherwise, the receiver **shall** attempt to decode the message in the Basic format using hard decision decoding with no erasures allowed. The decoder **shall** correct no more than 6 errors. If the RS decoder determines that there are no residual errors after completing the decoding process, AND the first 5 bits of the payload (the “PAYLOAD TYPE CODE” field) are ALL ZEROS, AND the Long decoding process fails, then a Successful Message Reception **shall** be declared.
- c. Otherwise, no message reception **shall** be declared.

Notes:

1. *This procedure discriminates the Basic versus Long Message format by using the characteristics of the RS code without an explicit length indicator.*
2. *To avoid misinterpreting the contents of Long Message reception declared to be successful, the receiver should discard any Message that has a “PAYLOAD TYPE CODE” field equal to ZERO. See Appendix M for the probability of such an event occurring (the probability is less than 10^{-9}).*
3. *Appendix M provides the analytic determination of the Undetected Message Error Rate (UMER) achieved through use of the RS coding. Due to the straightforward calculation of the UMER and the fact that the UMER is quite low, no explicit requirement/test is needed for a “False Message Reception Rate” test.*

2.2.10.2 Capacity for Successful Message Reception

Receiving subsystems **shall** demonstrate the ability to perform Successful Message Reception at the message input rates specified in [Table 2-66](#).

Table 2-66: Message-to-Completed Report Assembly Throughput Requirements

Equipment Class of ADS-B Receiving Subsystem	Measurement Interval	Required Number of Input Messages	
		Ground Uplink	Basic/Long ADS-B
A0, A1L, AIS	1 second	32	600
	10 milliseconds	N/A	20
A1H, A2, A3	1 second	32	700
	10 milliseconds	N/A	20

Note: A random mix of non-overlapping 20% Basic Messages and 80% Long Messages should be used in the assessment of this requirement.

2.2.10.3 Applicable Messages

Applicable Messages are defined as those requiring Report Assembly. Successful Messages are deemed to be Applicable Messages according to the criteria below:

- a. For Successful Message Reception of ADS-B Messages of PAYLOAD TYPE ZERO (binary 0 0000) through TEN (binary 0 1010), one of the following two criteria **shall** apply:
 1. All Successful Message Receptions are *Applicable Messages*, OR
 2. All Successful Message Receptions are from targets within the “Range Limit” (in NM) **for up to** the “Target Limit” number of targets, where “Range Limit” and “Target Limit” are listed in [Table 2-67](#) by equipment class. If the “Target Limit” number of targets is exceeded within the “Range Limit,” such that ADS-B Messages are discarded, then all such discarded ADS-B Messages **shall** be at greater range than any reported ADS-B Messages.

Table 2-67: Range Criteria for ADS-B Messages

Equipment Class	Range Limit (NM)	Target Limit
A0/A1S	15	250
A1L	30	300
A1H/A2	60	500
A3	150	650

- b. For Successful Message Reception of Ground Uplink Messages, one of the following two criteria **shall** apply:
1. All Successful Message Receptions, OR
 2. Only those Successful Message Receptions from ground stations within the range criteria from [Table 2-68](#).

Table 2-68: Range Criteria for Ground Uplink Messages

Equipment Class	Minimum Number of Ground Uplink Reports Required (per second)
A0/A1S	16 closest to ownship
A1L	16 closest to ownship
A1H/A2	16 closest to ownship
A3	16 closest to ownship

2.2.10.4 Message Reception-to-Report Completion Time

All ADS-B Applicable Messages **shall** be output from the Report Assembly Function within 200 milliseconds of message input.

All Ground Uplink Applicable Messages **shall** be output from the Report Assembly Function within 500 milliseconds of message input.

2.2.11 Special Requirements for Transceiver Implementations

2.2.11.1 Transmit-Receive Turnaround Time

A transceiver **shall** be capable of switching from transmission to reception within 2 milliseconds.

Note: *Transmit to receive switching time is defined as the time between the optimum sampling point of the last information bit of one transmit message and the optimum sampling point of the first bit of the synchronization sequence of the subsequent receive message.*

2.2.11.2 Receive-Transmit Turnaround Time

A transceiver **shall** be capable of switching from reception to transmission within 2 milliseconds.

Note: *Receive to transmit switching time is defined as the time between the optimum sampling point of the last information bit of one receive message and the optimum sampling point of the first bit of the synchronization sequence of the subsequent transmit message.*

Table 2-96: Payload Type and Tx Antenna Selection versus Equipment Class

Equipment Class →	A0, A1S, B0, B1S	A1L, A1H, B1		A1H, B1 (w/TS)		A2		A3	
		Antenna	Bot	Top	Bot	Top	Bot	Top	Bot
1	1		1		3		1		1
2	0		0		6		4		4
3	2	2		0		4		5	
4	0	0		6		4		4	
5	0		0		6		4		4
6	1		1		3		1		1
7	0	0		6		4		4	
8	2	2		0		4		5	
9	2		2		0		4		5
10	0		0		6		4		4
11	1	1		3		1		1	
12	0	0		6		4		4	
13	0		0		6		4		4
14	2		2		0		4		5
15	0	0		6		4		4	
16	1	1		3		1		1	

2.4.6.2 Verification of ADS-B Message Transmit Timing (§2.2.6.2)

No specific test procedure is required to validate §2.2.6.2.

2.4.6.2.1 Verification of The Message Start Opportunity (MSO) (§2.2.6.2.1)

Purpose/Introduction:

ADS-B Messages **shall** be transmitted at discrete Message Start Opportunities (MSO) chosen by a pseudo-random process. The specific pseudo-random number (R) chosen by an aircraft depends on the aircraft's current position and on the previously chosen random number $R(m-1)$. Let:

$$N(0) = 12 \text{ L.S.B.'s of the most recent valid "LATITUDE"}$$

$$N(1) = 12 \text{ L.S.B.'s of the most recent valid "LONGITUDE"}$$

where the "LATITUDE" and "LONGITUDE" are as defined in §2.2.4.5.2.1.

Using $N(0)$ and $N(1)$ the procedure below **shall** be employed to establish the transmission timing for the current UAT frame m .

$$\text{When } m = 0, R(0) = N(0) \bmod 3200$$

$$\text{When } m \geq 1, R(m) = \{ 4001 R(m-1) + N(m \bmod 2) \} \bmod 3200$$

1. When in the first frame after power up, and whenever the Vertical Status is determined to be in the AIRBORNE condition, the transmitter **shall** be in the *full MSO range* mode, where the MSO is determined as follows:

$$\text{MSO} = 752 + R(m)$$

Table 2-98: UAT ADS-B Transmitter Input Requirements

Element #	Input Data Element	Relevant Paragraph	Data Lifetime (seconds)	Applicable UAT Equipment Class						
				A0, B0	A1L, A1S, B1S	A1H, B1	A2	A3	B2	B3
1	ICAO 24-bit Address	2.4.4.5.1.3.1	n/a	M	M	M	M	M	M ⁽¹⁾	M ⁽¹⁾
2	Address Selection (ICAO vs Temporary)	2.4.4.5.1.3.1 2.4.4.5.1.3.2	60	Input required only if installation is to have selectable address						
3	Latitude ⁽²⁾	2.4.4.5.2.1	2	M	M	M	M	M	M	M
4	Longitude ⁽²⁾	2.4.4.5.2.1	2	M	M	M	M	M	M	M
5	Altitude Type Selection (Barometric vs Geometric)	2.4.4.5.2.2	60	O	O	O	O	O	n/a	M
6	Barometric Pressure Altitude	2.4.4.5.2.3	2	M	M	M	M	M	n/a	n/a
7	Geometric Altitude	2.4.4.5.2.3	2	M	M	M	M	M	n/a	M
8	NIC	2.4.4.5.2.4	2	M	M	M	M	M	M	M
9	Automatic AIRBORNE / ON-GROUND Indication	2.4.4.5.2.5	2	O	O	M	M	M	n/a	n/a
10	North Velocity ⁽²⁾	2.4.4.5.2.6.1	2	M	M	M	M	M	M	M
11	East Velocity ⁽²⁾	2.4.4.5.2.6.3	2	M	M	M	M	M	M	M
12	Ground Speed	2.4.4.5.2.6.2	2	O	O	M	M	M	O	n/a
13	Track Angle	2.4.4.5.2.6.4	2	O	O	M	M	M	n/a	n/a
14	Heading	2.4.4.5.2.6.4	2	O	O	M	M	M	n/a	n/a
15	Barometric Vertical Rate	2.4.4.5.2.7.1.1 2.4.4.5.2.7.1.3	2	M	M	M	M	M	n/a	n/a
16	Geometric Vertical Rate ⁽²⁾	2.4.4.5.2.7.1.1 2.4.4.5.2.7.1.3	2	O	O	O	O	O	n/a	n/a
17	A/V Length and Width, and POA	2.4.4.5.2.7.2	n/a	M	M	M	M	M	M	M
18	UTC 1 PPS Timing ⁽²⁾	2.4.4.5.2.8	2	M	M	M	M	M	M	M
19	Emitter Category	2.4.4.5.4.1	n/a	M	M	M	M	M	M	M
20	Call Sign	2.4.4.5.4.2	60	M	M	M	M	M	O	O
21	Emergency / Priority Status Selection	2.4.4.5.4.4	60	M	M	M	M	M	O	n/a
22	SIL	2.4.4.5.4.6	60	M	M	M	M	M	M	M
23	NAC _P ⁽²⁾	2.4.4.5.4.9	2	M	M	M	M	M	M	M
24	NAC _V ⁽²⁾	2.4.4.5.4.10	2	M	M	M	M	M	n/a	n/a
25	NIC _{BARO}	2.4.4.5.4.11	2	Can be internally "hard coded"		M	M	M	n/a	n/a
26	CDTI Traffic Display Capability	2.4.4.5.4.12.1	60	M	M	M	M	M	n/a	n/a
27	TCAS Installed and Operational	2.2.4.5.4.12.2	60	M	M	M	M	M	n/a	n/a
28	TCAS/ACAS Resolution Advisory Flag	2.4.4.5.4.13.1	18	Required only if ADS-B Transmitting Subsystem is intended for installation with TCAS/ACAS; otherwise can be "hard coded"						
29	IDENT Selection	2.4.4.5.4.13.2	60	M	M	M	M	M	M	n/a
30	"Receiving ATC Services" Flag	2.4.4.5.4.13.3	60	M	M	M	M	M	M	n/a
31	"True/Magnetic Indicator" Flag	2.4.4.5.4.14	60	n/a	n/a	O	M	M	M	n/a
32	Heading / Track Indicator	2.4.4.5.6.1.1	60	n/a	n/a	O	M	M	n/a	n/a
33	Target Source Indicator (Horizontal)	2.4.4.5.6.1.2	60	n/a	n/a	O	M	M	n/a	n/a
34	Horizontal Mode Indicator (Horizontal)	2.4.4.5.6.1.3	60	n/a	n/a	O	M	M	n/a	n/a
35	Target Heading or Track Angle	2.4.4.5.6.1.5	60	n/a	n/a	O	M	M	n/a	n/a
36	Target Altitude Type	2.4.4.5.6.2.1	60	n/a	n/a	O	M	M	n/a	n/a
37	Target Source Indicator (Vertical)	2.4.4.5.6.2.2	60	n/a	n/a	O	M	M	n/a	n/a
38	Mode Indicator (Vertical)	2.4.4.5.6.2.3	60	n/a	n/a	O	M	M	n/a	n/a
39	Target Altitude Capability	2.4.4.5.6.2.4	60	n/a	n/a	O	M	M	n/a	n/a
40	Target Altitude	2.4.4.5.6.2.5	60	n/a	n/a	O	M	M	n/a	n/a
41	Radio Altitude	2.4.4.5.2.5.1	2	O	O	O	O	O	n/a	n/a
42	Pressure Altitude Disable	2.4.4.5.2.2	n/a	M	M	M	M	M	n/a	n/a
43	Airspeed	2.4.4.5.2.5.1	2	O	O	O	O	O	n/a	n/a
44	Flight Plan ID	2.4.4.5.4.2	60	M	M	M	M	M	n/a	n/a

O = Optional

M = Mandatory (the equipment must have the ability to accept the data element)

Notes: ⁽¹⁾ Non-Aircraft Identifier may be assigned by Regulatory Authority.
⁽²⁾ If input is not directly accessible, a means to verify the encoding must be demonstrated.

Table 2-101: Selectivity Rejection Ratios

Center Frequency Offset, f_0	Continuous Wave Interference Level (dBm)		Vector Signal Analyzer Range
	Equipment Class A0, A1L, A1S A1H, A2	Equipment Class A3	
-1.0 MHz	-83	-63	-50 dBm
+1.0 MHz	-78	-53	-45 dBm
± 2.0 MHz	-43	-43	-35 dBm
± 10.0 MHz	-33	-33	-25 dBm

2.4.8.2.4 Verification of Receiver Tolerance to Pulsed Interference (§2.2.8.2.4)

Purpose/Introduction:

The receiver **shall** be capable of receiving messages in the presence of interference from on channel and off channel sources of pulsed interference, such as DME/TACAN and JTIDS/MIDS. Informative Appendix G indicates, in Table G-2, the levels and pulse density of interference scenarios, against which UAT has been designed to operate effectively, as reported in Appendix K. The UAT receiver must also be tolerant of pulsed interference from other L-Band systems operating and located on the aircraft. These may include 1030 MHz ATCRBS/Mode S interrogation signals from on-board TCAS and 1090 MHz ATCRBS/Mode S reply signals from on-board ATCRBS/Mode S Transponders.

The UAT receiver may experience pulsed interference from DME/TACAN channels operating in the internationally allocated 978 MHz to 1215 MHz frequency range. The receiver **shall** be tolerant to pulsed interference from DME/TACAN. The receiver **shall** meet the reception probability dictated under the following conditions:

a. For all equipment classes:

The receiver **shall** be capable of achieving 99% reception probability of ADS-B Messages when the desired signal level is between -90 dBm and -10 dBm when subjected to DME/TACAN interference under the following conditions: DME/TACAN pulse pairs at a nominal rate of 3,600 pulse pairs per second at either 12 or 30 microseconds pulse spacing at a level of -36 dBm for any 1 MHz channel frequency between 980 MHz and 1215 MHz inclusive.

b. For the A0, A1L, A1S, A1H, and A2 equipment classes:

1. The receiver **shall** be capable of achieving 90% reception probability of ADS-B Messages when the desired signal level is between -87 dBm and -10 dBm when subjected to DME/TACAN interference under the following conditions: DME/TACAN pulse pairs at a nominal rate of 3,600 pulse pairs per second at a 12 microseconds pulse spacing at a level of -56 dBm and a frequency of 979 MHz.
2. The receiver **shall** be capable of achieving 90% reception probability of ADS-B Messages when the desired signal level is between -87 dBm and -10 dBm when subjected to DME/TACAN interference under the following conditions: DME/TACAN pulse pairs at a nominal rate of 3,600 pulse pairs per second at a

2.4.8.2.5 Verification of Receiver Tolerance to Overlapping ADS-B Messages (Self Interference) (§2.2.8.2.5)

Purpose/Introduction:

A Successful Message Reception rate of 90% or better, for the stronger of two overlapping desired messages, **shall** result when the level of the stronger message is no weaker than -80 dBm and the stronger message is at least X dB above the weaker message, when the stronger message and weaker message are aligned in time.

Where the value of X is:

4 dB for Equipment Classes A0, A1L, **A1S**, A1H, and A2

9 dB for Equipment Class A3

Notes:

1. *The different values across equipment classes reflect the fact that Class A3 receivers will utilize a narrow filter that degrades demodulation performance slightly in order to gain added rejection from adjacent channel DME ground stations.*
2. *Signal values ensure both the desired and undesired signal levels are above the noise floor.*

This test verifies the compliance of the UAT receiver with the requirements for reception of overlapping Long ADS-B Messages.

Equipment Required:

Desired Message Signals:

Provide a method of supplying the UUT with two sources of desired Long ADS-B Messages that are aligned in time to within 5 microseconds, with the following characteristics:

Message Source 1

- RF Power Level: -80 dBm

Message Contents:

- Payload Type Code = 1
- Address Qualifier = 0
- ICAO address: 0x000001
- Fill remaining payload with pseudo-random payload data, and valid FEC Parity field per §2.2.3.1.3.
- Message Rate: 100 per second

Message Source 2

- RF Power Level: -68 dBm

Message Contents:

- Payload Type Code = 1
- Address Qualifier = 0
- ICAO address: 0x000002

Measurement Procedure:

This test procedure requires monitoring the trigger signal from the receiver. This is an output that occurs upon detection of the synchronization sequence of an input message. Separate outputs are required for the synchronization trigger resulting from an ADS-B Basic or Long Message synchronization sequences and Ground Uplink Message synchronization sequences.

Step 1: ADS-B Message Trigger Rate Verification

Disconnect all connections to the receiver antenna port of the ADS-B Receiving System. If diversity receiving is implemented, disconnect all inputs to both antenna ports. For an interval of 5 minutes, count the number of ADS-B Message Triggers. Verify that the rate is 50 per second or less.

Step 2: Ground Uplink Message Trigger Rate Verification

Disconnect all connections to the receiver antenna port of the ADS-B Receiving System. If diversity receiving is implemented, disconnect all inputs to both antenna ports. For an interval of 10 minutes, count the number of Ground Uplink Message Triggers. Verify that the rate is 2 per minute or less.

2.4.8.2.7 Verification of Trigger Processing Rate (§2.2.8.2.7)Purpose/Introduction:

Receiver trigger processing rate requirements are as follows:

- a. Equipment Classes A3, A2 and A1H receivers **shall** be capable of successfully processing at least 1000 trigger events per second.
- b. Equipment Classes A1S, A1L and A0 receivers **shall** be capable of successfully processing at least 900 trigger events per second.

Desired Message Signals:

Provide a method of supplying the UUT with two sources of desired Long ADS-B Messages. Each signal source generates messages according to a periodic schedule based on a 28 MSO period for Equipment Classes A3, A2 and A1H and a 24 MSO period for Equipment Classes A1S, A1L and A0. For each Equipment Class the period must be repeated exactly 101 times each second. The contents of the messages are as follows:

Message Contents for All Message Sources:

- Payload Type Code = 1
- Address Qualifier = 0
- ICAO Address = see below
- Payload is filled with pseudorandom data. The pseudorandom generator should have a long enough period so that no data is repeated during the course of this test.

Note: It is acceptable to employ a limited set of “canned” messages based on pseudorandom number generator. The number of stored messages should be somewhat larger than the number of messages required for a second’s worth of testing. If the number of each type of stored message is prime with respect to the number of messages needed each second, the overlap between two sources will be randomized on a second-by-second basis.

- Valid FEC Parity is provided.

Transmission Schedule and Power Level for Each Message Source:

For Equipment Classes A3, A2 and A1H

Table 2-102: Tx Schedule and Power Level for A3, A2 and A1H Message Sources

Message Source	Transmission Schedule (MSO within each 28 MSO period)	ICAO Address	Power Level (dBm)
1	0, 4, 8, 12, 16, 20, 24	0x000001	- 80
2	5, 13, 21	0x000002	- 65

For Equipment Classes A1S, A1L and A0

Table 2-103: Tx Schedule and Power Level for A1S, A1L and A0 Message Sources

Message Source	Transmission Schedule (MSO within each 28 MSO period)	ICAO Address	Power Level (dBm)
1	0, 4, 8, 12, 16, 20	0x000001	- 80
2	5, 13, 21	0x000002	- 65

Measurement Procedure:

In each case the beginning of the first transmission period is MSO = 752. (This causes all the ADS-B Messages to fall within the ADS-B segment of each second.)

For Equipment Classes A3, A2 and A1H verify that the UUT reports reception of at least 400 messages with ICAO address 0x000001 and at least 300 messages with ICAO address 0x000002 per second.

For Equipment Classes A1S, A1L and A0 verify that the UUT reports reception of at least 300 messages with ICAO address 0x000001 and at least 300 messages with ICAO address 0x000002 per second.

2.4.8.3 Verification of Receiver Message Processing (§2.2.8.3)

No specific test procedure is required to validate §2.2.8.3.

2.4.10 Verification of Receiver Subsystem Capacity and Throughput Requirements (§2.2.10)

Appropriate test procedures required to validate the requirements in §2.2.10 are included in §2.4.10.2, §2.4.10.3 and §2.4.10.4.

2.4.10.1 Verification of Fundamental Principals of Report Assembly (§2.2.10.1)

No specific test procedure is required to validate §2.2.10.1.

2.4.10.2 Verification of Capacity for Successful Message Reception (§2.2.10.2)

Purpose/Introduction:

Receiving subsystems shall demonstrate the ability to perform Successful Message Reception at the message input rates specified in [Table 2-66](#).

Equipment Required:

Provide a means to generate an RF test signal consisting of the appropriate number and proportion of unique, valid Long and Basic ADS-B Messages, and Ground Uplink Messages, for the equipment class, with the following characteristics:

a. Number of messages:

The messages consist of 32 Ground Uplink Messages per second, and **either** 600 ADS-B Messages per second (for equipment classes A0, A1S and A1L), **or** 700 ADS-B Messages per second (for equipment classes A1H, A2, and A3).

b. Proportion of ADS-B Messages:

The ADS-B Messages should be proportioned such that 80% are Long messages (approximately 10% each for Payload Type Codes 1 through 6, and 5% each for Payload Type Codes 7 through 10), and 20% are Basic messages (Payload Type Code 0).

c. Message Spacing:

One Uplink message is placed in each Uplink time slot.

During each 1-second interval, 20 of the ADS-B Messages should be uniformly spaced without overlap over a 10 millisecond “peak” interval. The remaining portion of the ADS-B Messages should be uniformly spaced over the remainder of the ADS-B Segment of each second. The start time of the peak interval in the first second of the test is 200 milliseconds after the UTC time mark signal. In each subsequent second, the start time of the peak interval is delayed by an additional 100 milliseconds. The start time of the peak interval is reset to 200 milliseconds after every 8th second.

Measurement Procedures:

The equipment under test must provide a means to confirm the reception of each of the messages contained in the RF test signal. Suitable means could include the delivery of

responsible for resolving incompatibilities between the ADS-B equipment and previously installed equipment in the aircraft.

3.1.11 Mutual Suppression

UAT ADS-B equipment **shall** interface to the mutual suppression bus. The UAT **shall** drive the mutual suppression bus during UAT transmissions so that other L Band systems installed in the aircraft can desensitize their receivers during UAT transmissions. Installations with ATCRBS or Mode S transponders **shall** insure that the transponder is connected to the mutual suppression bus to prevent unsolicited replies from being generated by the transponder during UAT transmissions. UAT equipment **shall** not receive from the mutual suppression bus.

3.2 Installed Equipment Performance Requirements

The installed equipment shall meet the requirements of §2.1 and §2.2 in addition to, or as modified by, the requirements stated below.

3.2.1 Antenna Installation

3.2.1.1 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. Classes A1L, A1H, A2, and A3 require antenna diversity and must have transmit and receiving capability on both the top and bottom of the aircraft. Exceptions may be made for installations on radio-transparent airframes. Class A0 and A1S installations do not require antenna diversity. Compliance of the installed antennas with the requirements of §2.1.11 may be demonstrated by analysis.

If the ADS-B Transceiver shares antennas with a Mode S or ATCRBS transponder, the antennas **shall** additionally comply with the requirements of the applicable transponder standards (currently for Mode S – RTCA Document Number DO-181C, and for ATCRBS, TSO-C74C), and the Diplexer **shall** comply with the requirements of §2.2.14.3 of this document.

3.2.1.2 Transmission Lines

Transmission lines between the equipment and the antennas shall have impedance, power handling, and loss characteristics in accordance with the equipment manufacturer's specifications. The VSWR at 978 MHz, as seen through the transmission lines to the antenna(s), shall not exceed 1.7:1.

All minimum installed system performance requirements stated in §2.2, must be met with the transmission line installed. Test results provided by the equipment manufacturer may be accepted in lieu of tests performed by the equipment installer.

3.2.1.3 Antenna Polarization

The ADS-B Transmit and Receive antennas shall be predominantly vertically polarized.

3.2.1.4 Antenna Location

Antennas shall be mounted as near as practical to the centerline of the fuselage. Antennas shall be located to minimize obstruction to their fields in the horizontal plane. Antenna locations should be selected such that, with the aircraft configured in a level-flight attitude, at least one antenna should be visible at all times over the full range of 360 degrees of azimuth, to the fullest extent possible. Viewing distance for this action should be appropriate for the airframe, and clear of all aircraft extremities, such as twice the wingspan.

Note: *The potential of UAT sharing existing transponder antennas is discussed in Appendix E of this document. Further validation of this potential is required.*

3.2.1.5 Minimum Distance from Other Antennas

The spacing between any ADS-B antenna and any DME 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.*

3.2.1.6 Minimum Reception Range

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 3-1](#). 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 signals from transmitters in these areas are substantially reduced. Reliable data reception from these areas is not required.*

Table 3-1: Minimum Ranges for Receiving Capability

Equipage		Required Range (NM)
Class	Type	
A0	Minimum	10
A1L, A1S, A1H	Basic	20
A2	Enhanced	40
A3	Extended	90 (120 desired)

Note: *The range values shown in [Table 3-1](#) correspond to encounters between like-equipped aircraft. See RTCA DO-242A Table 3-2(b) for range values between other combinations of equipment classes. The Class A3 required range is for head-to-head encounters. A3 equipment is allowed to have reduced range at other encounter angles. See RTCA DO-242A Table 3-2(a) for allowed range reductions.*

$$\begin{aligned}
 S_{exp} &= \text{power density of exposure (mW/cm}^2\text{)} \\
 S_{limit} &= \text{appropriate power density MPE limit (mW/cm}^2\text{)} \\
 t_{exp} &= \text{allowable time of exposure for } S_{exp} \\
 t_{avg} &= \text{appropriate MPE averaging time}
 \end{aligned}$$

Taking into the consideration that the ADS-B Transmitting Subsystem will never exceed a transmitting duty cycle of .05% (one message per second, which does not exceed 500 microseconds duration), the allowable time of exposure is computed from the above equation as follows:

$$(0.221 \text{ mW/cm}^2) * X * (0.0005) = (978/300 \text{ mw/cm}^2)(6 \text{ minutes})$$

$$X = \frac{(978/300 \text{ mw/cm}^2)(6 \text{ minutes})}{(0.221 \text{ mW/cm}^2)(0.0005)}$$

$$X = 177 \times 10^3 \text{ minutes}$$

or

$$X = 2,950 \text{ hours}$$

These calculations have demonstrated that the expected power density of the ADS-B Transmitting Subsystem at 3 meters is well within the allowable MPE.

Step 2: Measure the Output Power of the ADS-B Transmitting Subsystem

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.

Configure the ADS-B Transmitting Subsystem to transmit ADS-B Surface Position Messages.

Using the Spectrum Analyzer set at a center frequency of 978 MHz, capture the power envelope of ADS-B Message transmission.

Verify that the frequency is at 978 MHz \pm 20 PPM.

For Class A0 and A1L equipment, verify that the output power is at least 7 watts (i.e., +38.5 dBm). Log the measurement as P_out.

For Class **A1S**, A1H and A2 equipment, verify that the output power is at least 15.8 watts (i.e., +42.0 dBm). Log the measurement as P_out.

For Class A3 equipment, verify that the output power is at least 100 watts (i.e., +50.0 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 Subsystem 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 Subsystem to transmit ADS-B Surface Position Messages.

Using the Spectrum Analyzer set at a center frequency of 978 MHz, capture the power envelope of an ADS-B Message transmission. Measure and note the power.

For Class A0 and A1L equipment, verify that the output power is at least 7 watts (i.e., +38.5 dBm). Log the measurement as ERP_dBm.

For Class **A1S**, A1H and A2 equipment, verify that the output power is at least 15.8 watts (i.e., +42.0 dBm). Log the measurement as ERP_dBm.

For Class A3 equipment, verify that the output power is at least 100 watts (i.e., +50.0 dBm). Log the measurement as ERP_dBm.

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**.

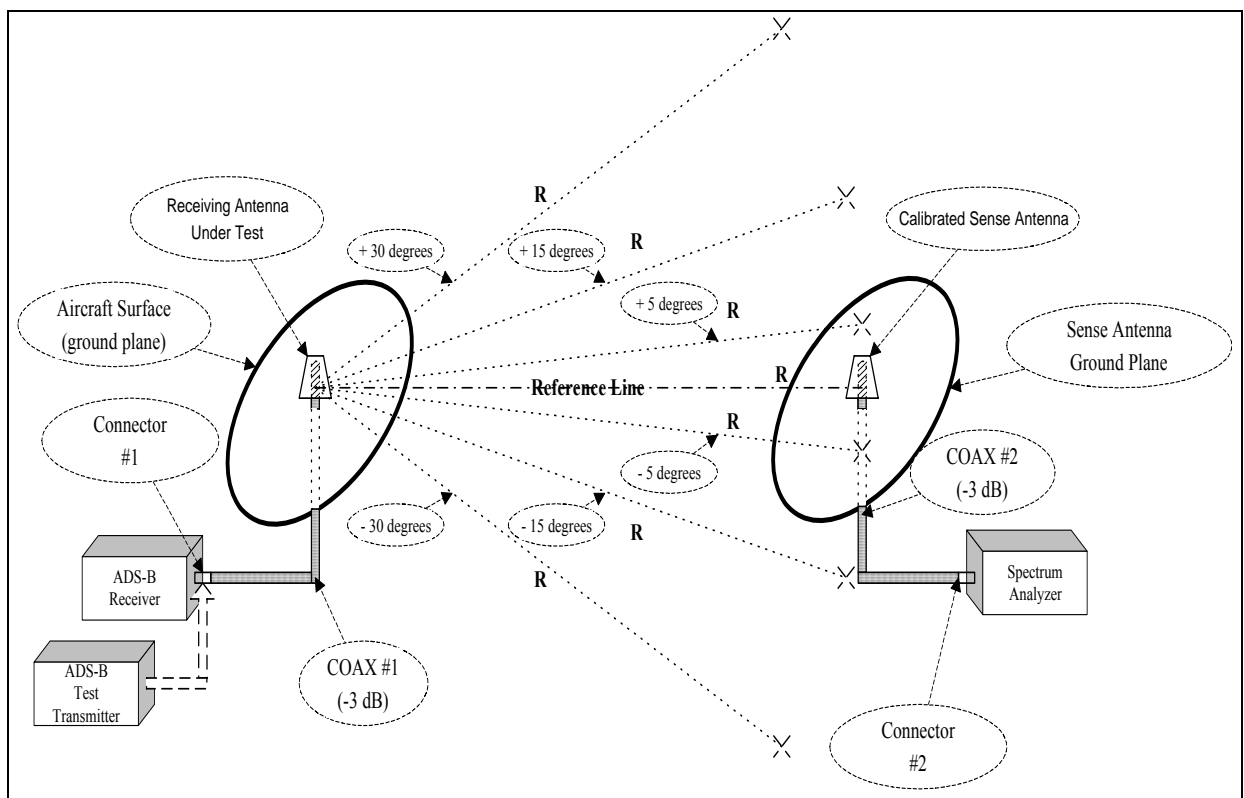


Figure 3-2: Antenna Test Configuration

Measurement Procedure:

Note: *Figure 3-2, above, is exactly the same as Figure 3-1 provided in §3.4.1.7.3 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 Subsystem to Antenna connection at the ADS-B Receiving Subsystem unit connector.

For Class A0 and A1L Receiver installations, install an ADS-B Test Transmitting device having a minimum RF power of at least 7 watts (i.e., +38.5 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 §3.4.1.7.3 in this procedure.

For Class A1S, A1H and A2 Receiver installations, install an ADS-B Test Transmitting device having a minimum RF power of at least 15.8 watts (i.e., +42.0 dBm) **plus** 3 dB. If additional cabling or connectors are required to make