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Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance - Broadcast (ADS-B)

Draft of Change 1

Change 1 to RTCA DO-260
MM DD, 2006

Prepared by: SC-186

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Foreword

This report was prepared by Special Committee 186 (SC-186) and approved by the RTCA Program Management Committee (PMC) on MM DD, 2006.

RTCA, Incorporated is a not-for-profit corporation formed to advance the art and science of aviation and aviation electronic systems for the benefit of the public. The organization functions as a Federal Advisory Committee and develops consensus based recommendations on contemporary aviation issues. RTCA's objectives include but are not limited to:

- coalescing aviation system user and provider technical requirements in a manner that helps government and industry meet their mutual objectives and responsibilities;
- analyzing and recommending solutions to the system technical issues that aviation faces as it continues to pursue increased safety, system capacity and efficiency;
- developing consensus on the application of pertinent technology to fulfill user and provider requirements, including development of minimum operational performance standards for electronic systems and equipment that support aviation; and
- assisting in developing the appropriate technical material upon which positions for the International Civil Aviation Organization and the International Telecommunications Union and other appropriate international organizations can be based.

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Executive Summary

The update to the *Minimum Operational Performance Standards (MOPS) for the 1090 MHz Automatic Dependent Surveillance – Broadcast (ADS-B)* systems, published by RTCA on September 13, 2000 as RTCA/DO-260, contained herein as RTCA/DO-260 Change 1, has been produced to reflect changes that have resulted in requirements for ADS-B transmitting systems. RTCA/DO-260 was developed in accordance with the *Minimum Aviation System Performance Standards (MASPS) for Automatic Dependent Surveillance – Broadcast (ADS-B)*, which was published by RTCA on February 19, 1998 as RTCA/DO-242. Even during the development of DO-260, it was always the intention of RTCA and the International community to update the initial 1090ES MOPS with the addition of enhanced reception techniques, as well as improved definitions of navigational accuracy and integrity measurements, and system integrity levels, among other things. However, prior to the updating of such information, it was necessary to update the ADS-B MASPS on which those standards were to be based. On June 25, 2002, RTCA published the updated ADS-B MASPS as RTCA/DO-242A, and the revision of the 1090ES MOPS was also begun. On April 10, 2003, RTCA published RTCA/DO-260A as the update to the 1090ES MOPS which was intended to replace RTCA/DO-260 and all of its requirements.

When RTCA/DO-260 was published in September 2000, the International community began to refine and adapt the requirements contained therein into ICAO Standards and Recommended Practices (SARPs) for all International States to use. The initial 1090ES SARPs were adapted and published by ICAO into Annex 10 with Amendment 77, which became effective on November 28, 2002.

With the publication of the 1090ES SARPs, a trial program was started by Australia for transmit-only 1090ES equipment for the purpose of evaluating ADS-B for supplying surveillance in areas of their country where no radar exists. As this program progressed, operational experience was gained and data was collected on the implementations of 1090ES equipment, which in turn shed light on some issues within the ADS-B MOPS documents that outlined the requirements. This initial Australian program relied solely on aircraft avionics that were based on the initial 1090ES MOPS, RTCA/DO-260.

One of the initial issues uncovered by the Australian trials were errors reported in the airborne/on-the-ground status of ADS-B equipped aircraft. It was found that there were errors in the determination of the "on-the-ground" condition of the aircraft. After an extensive analysis of the collected data and of the algorithms defined in RTCA/DO-260 (and by that time also in DO-260A), it was determined that there had been errors introduced in both documents which could lead an ADS-B system to indicate that an aircraft was on-the-ground, when in fact, it was still airborne. **This problem had to be corrected**.

Another issue that was a concern for ground stations and other users of position data from RTCA/DO-260 transmitters, was that the Navigational Uncertainty Category (NUC) in DO-260-based systems could be based either on accuracy or integrity measurements. It was deemed necessary for the benefit of receivers of RTCA/DO-260 transmitted position information that the NUC be based on integrity, and not accuracy. To correct this problem, a statement in DO-260,

§2.2.3.2.3.1.2 and §2.2.3.2.4.1.2, which indicated that "if the Horizontal Protection Limit (HPL) was not available from a navigation source, then the TYPE Code of the respective 1090ES ADS-B Airborne or Surface Position Message could be based on the 95% bound on the horizontal and vertical position error identified in Table 2-11," had to be changed to not allow NUC to be based on HFOM. Additionally, the column in Table 2-11 that gave the "95% containment radius for horizontal and vertical position error" needed to be removed to eliminate possible confusion.

In order to correct these problems prior to the MOPS being updated for manufacturers that are building equipment, specifically for those systems that were being built for transmit-only compliance to RTCA/DO-260 in the Australian trials, corrections were written for the basic requirements, and for the test procedures which verify those requirements, for both RTCA/DO-260 and for RTCA/DO-260A, and attached as an Appendix to the first Technical Standard Order (TSO) that was written for 1090ES ADS-B systems, and published as TSO C166 by the Federal Aviation Administration (FAA) on September 20, 2004.

Additionally, with the development and publication of RTCA/DO-260A, it was recognized that in the United States, ground systems required the information transmitted in the Mode 3/A, or "4096" code. In DO-260A, the 1090ES ADS-B TEST Message (TYPE Code=23, SUBTYPE=7) was identified to contain this Mode 3/A Code. With the publication of TSO C166, and its attached Appendix, a change was also identified for DO-260-compliant transmit-only systems to optionally transmit this 1090ES ADS-B TEST Message. This transmission would assist with the identification of these aircraft if they enter the United States airspace.

Since no 1090ES equipment was submitted in the United States for certification for DO-260-compliant transmit-only systems under TSO C166, the FAA has determined that it is in the best interest of the aviation community to update TSO C166, and eliminate any reference to systems that only comply with DO-260. This update resulted in the removal of the section of the Appendix that was included with TSO C166 which specifically identified those changes to DO-260 that were necessary for any State that wishes to implement a DO-260-compliant transmit-only ADS-B system. To insure that this set of changes would be included when implementing DO-260 compliant transmit-only ADS-B systems, these changes were extracted and are published in this document as Change 1 to RTCA/DO-260.

Since the publication of RTCA/DO-260A in March 2003, ICAO has also been in the process of updating the ICAO 1090ES SARPs to include those requirements identified in DO-260A. These updated SARPs are expected to become effective in November 2007. It has also been recognized by the International community that systems based solely on the requirements of DO-260 and the initial 1090ES SARPs published in Annex 10, Amendment 77, are not sufficient to provide robust receiver/decoder systems for reception of 1090ES ADS-B information. Therefore, the updated 1090ES SARPs recommend (and it is required by FAA TSO C166A) that 1090ES ADS-B receiver systems must be based on the requirements of the updated 1090ES SARPs, which are the same as RTCA/DO-260A, Change 1. Therefore, the receiver/decoder requirements of DO-260 have not been updated since all receiver/decoder implementations will need to adhere to DO-260A, Change 1 and the latest available version of TSO C166.

Change 1 to RTCA/DO-260

Extended Squitter Automatic Dependent Surveillance – Broadcast (ADS-B) Equipment Operating on the Radio Frequency of 1090 Megahertz (MHz)

This Change Document prescribes the changes to RTCA Document No. RTCA/DO-260, "*Minimum Operational Performance Standards for 1090 MHz Automatic Dependent Surveillance – Broadcast (ADS-B)*," issued September 13, 2000 that will be required for those manufacturers that will produce 1090ES equipment for broadcast-only. Manufacturers that will produce 1090ES equipment which will include the ADS-B receive capability must comply with RTCA/DO-260A, Change 1, and the latest available version of FAA TSO C166.

(1.1) In RTCA/DO-260, replace section §2.2.3.2.1.1.2, subparagraph "c," including Table 2-9A, with the following:

c. Air/Ground Determination

(1). If a transmitting ADS-B participant is not equipped with a means, such as a weight-on-wheels switch, to determine whether it is airborne or on the surface, and that participant's Emitter Category (§2.2.3.2.5.2) is one of the following, then it **shall** set its Air/Ground State to "Airborne," and broadcast the Airborne Position Message (§2.2.3.2.3):

- Unknown Emitter Category
- Light Aircraft
- Rotorcraft
- Glider or Sailplane
- Lighter Than Air
- Unmanned Aerial Vehicle
- Ultralight, Hang Glider or Paraglider
- Parachutist or Skydiver
- Point Obstacle
- Cluster Obstacle
- Line Obstacle

Notes:

1. *Because of the unique operating capabilities of "Lighter-Than-Air" vehicles, i.e., balloons, an operational "Lighter-Than-Air" vehicle will always report the "Airborne" State, unless the "ON-GROUND" State is specifically declared in compliance with subparagraph "(4)" below.*
2. *Because of the fact that it is important for Fixed Ground or Tethered Obstacles to report altitude, such objects will always report the "Airborne" state.*
3. *Because of the unique capabilities of Rotorcraft, i.e., hover, etc., an operational Rotorcraft will always report the "Airborne" state unless the "ON-GROUND" state is specifically declared in compliance with subparagraph "(4)" below.*

4. An automatic means of determining air/ground status may include Weight-on-Wheels discrete, Airspeed, Ground Speed, Radio Altitude, or other appropriate data sources.

(2). If a transmitting ADS-B participant's Emitter Category (§2.2.3.2.5.2) is one of the following, then that participant **shall** set its Air/Ground State to the "ON-GROUND" condition and broadcast the Surface Position Message (§2.2.3.2.4):

- Surface Vehicle – Emergency
- Surface Vehicle – Service

(3). If a transmitting ADS-B participant is not equipped with a means, such as a weight-on-wheels switch, to determine whether it is airborne or on the surface, and its ADS-B Emitter Category (§2.2.3.2.5.2) is not one of those listed under tests (1) or (2) above (i.e., the participant's Emitter Category is either: Small, Large, High Vortex Large, Heavy, Highly Maneuverable, or Space/Trans-Atmospheric), then the following tests will be performed to determine whether to broadcast the Airborne or Surface Position Messages.

a. If the participant's Radio Height (RH) parameter is available, and RH < 50 feet, and at least Ground Speed (GS) or Airspeed (AS) is available, and the available GS < 100 knots, or the available AS < 100 knots, then that participant **shall** broadcast the Surface Position Message (§2.2.3.2.4).

   If all three parameters are available, the decision to broadcast the Airborne or Surface Position Messages **shall** be determined by the logical "AND" of all three parameters.

b. Otherwise, if Radio Height (RH) is not available, and if the participant's Ground Speed (GS) and Airspeed (AS) are available, and GS < 50 knots and AS < 50 knots, then that participant **shall** broadcast the Surface Position Message (§2.2.3.2.4).

c. Otherwise, the participant **shall** broadcast the Airborne Position Message (§2.2.3.2.3).

(4). If a transmitting ADS-B participant is equipped with a means, such as a weight-on-wheels switch, to determine automatically whether it is airborne or on the surface, then such information **shall** be used to determine whether to broadcast the Airborne Position Message (§2.2.3.2.3), or the Surface Position Message (§2.2.3.2.4).

(1.2) In RTCA/DO-260, section §2.2.3.2.3.1, replace Table 2-11 with the following table, and delete Note #4 after Table 2-11:

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

Type Code	Format	Horizontal Protection Limit, HPL	Altitude Type	NUC_P
0	No Position Information		Baro Altitude or No Altitude Information	0
1	Identification (Category Set D)		*Not Applicable*	
2	Identification (Category Set C)		*Not Applicable*	
3	Identification (Category Set B)		*Not Applicable*	
4	Identification (Category Set A)		*Not Applicable*	
5	Surface Position	HPL < 7.5 m	No Altitude Information	9
6	Surface Position	HPL < 25 m	No Altitude Information	8
7	Surface Position	HPL < 185.2 m (0.1 NM)	No Altitude Information	7
8	Surface Position	HPL ≥ 185.2 m (0.1 NM)	No Altitude Information	6
9	Airborne Position	HPL < 7.5 m	Baro Altitude	9
10	Airborne Position	7.5 m ≤ HPL < 25 m	Baro Altitude	8
11	Airborne Position	25 m ≤ HPL < 185.2 m (0.1 NM)	Baro Altitude	7
12	Airborne Position	185.2 m (0.1 NM) ≤ HPL < 370.4 m (0.2 NM)	Baro Altitude	6
13	Airborne Position	380.4 m (0.2 NM) ≤ HPL < 926 m (0.5 NM)	Baro Altitude	5
14	Airborne Position	926 m (0.5 NM) ≤ HPL < 1852 m (1.0 NM)	Baro Altitude	4
15	Airborne Position	1852 m (1.0 NM) ≤ HPL < 3704 m (2.0 NM)	Baro Altitude	3
16	Airborne Position	7.704 km (2.0 NM) ≤ HPL < 18.52 km (10 NM)	Baro Altitude	2
17	Airborne Position	18.52 km (10 NM) ≤ HPL < 37.04 km (20 NM)	Baro Altitude	1
18	Airborne Position	HPL ≥ 37.04 km (20 NM)	Baro Altitude	0
19	Airborne Velocity	*Not Applicable*	*Difference between "Baro Altitude" and "GNSS Height (HAE)"*	*N/A*
20	Airborne Position	HPL < 7.5 m	GNSS Height (HAE)	9
21	Airborne Position	HPL < 25 m	GNSS Height (HAE)	8
22	Airborne Position	HPL ≥ 25 m	GNSS Height (HAE)	0
23	Reserved for Test Purposes			
24	Reserved for Surface System Status			
25 - 27	Reserved			
28	Extended Squitter Aircraft Status			
29	Aircraft Trajectory Intent (i.e., Current/Next Trajectory Change Point)			
30	Aircraft Operational Coordination			
31	Aircraft Operational Status			

(1.3) In RTCA/DO-260, replace section §2.2.3.2.3.1.2 with the following:

If HPL (or HIL) is not available from the sensor, then the 1090 MHz Extended Squitter equipment may use other means to establish an appropriate HPL (e.g. HPL based upon known RAIM protection threshold). When this derived HPL is established, this information **shall** be used to encode NUC. If the 1090 MHz Extended Squitter equipment is not able to establish an appropriate HPL and a valid position is reported, then the NUC **shall** be encoded to indicate that the integrity containment is unknown (i.e., TYPE Code 18).

(1.4) In RTCA/DO-260, replace section §2.2.3.2.4.1.2 with the following:

If HPL (or HIL) is not available from the sensor, then the 1090 MHz Extended Squitter equipment may use other means to establish an appropriate HPL (e.g. HPL based upon known RAIM protection threshold). When this derived HPL is established, this information **shall** be used to encode NUC. If the 1090 MHz Extended Squitter equipment is not able to establish an appropriate HPL and a valid position is reported, then the NUC **shall** be encoded to indicate that the integrity containment is unknown (i.e., TYPE Code 8).

(1.5) In RTCA/DO-260 section §2.2.3.2.7.1, which was entitled "Aircraft Trajectory Intent" Messages, was completely replaced with the publication of RTCA/DO-260A. Manufacturers are directed not to implement any of the requirements in RTCA/DO-260 section §2.2.3.2.7.1 or any of its subsections.

(1.6) In RTCA/DO-260, section §2.2.3.2.7.2, which was entitled "Aircraft Operational Coordination" Messages, was completely deleted with the publication of RTCA/DO-260A. Manufacturers are directed not to implement any of the requirements in RTCA/DO-260 section §2.2.3.2.7.2 or any of its subsections.

(1.7) **Implementation of the requirement for Mode A broadcast is optional for 1090 MHz Extended Squitter Transmit-Only, Class B1 equipment complying with the Minimum Performance Standards in RTCA/DO-260. If a manufacturer elects not to implement this requirement, then no change is required for RTCA/DO-260, section §2.2.3.2.7.4, and no transmission of the TYPE "23" TEST Message is required. However, if a manufacturer elects not to implement this optional requirement, the following statement must be included in the limitations section of their Installation Manual:**

> "**Note:** This equipment does not support 1090 MHz Extended Squitter broadcast of the Mode A Code, and therefore may not support future air-ground ADS-B applications that will require this information for safe separation of aircraft in non-radar environments."

If a manufacturer elects to implement this requirement, then in RTCA/DO-260, replace section §2.2.3.2.7.4 with the following:

2.2.3.2.7.4 TYPE "23" ADS-B Event – Driven Messages for "TEST"

TYPE "23" ADS-B Messages **shall** be used for Test Purposes. "TEST" Messages **shall** be used exclusively for the broadcast of information in support of bench and/or certification testing of 1090 MHz ADS-B systems, or for the broadcast of information of interest only to local ADS-B ground applications. "TEST" Message broadcasts will not result in an ADS-B report being generated onboard any other ADS-B equipped aircraft, nor is the specific information being included in the "TEST" Message expected to be generally codified within internationally accepted standards. "TEST" Messages containing information of interest only to local ADS-B ground applications are intended to be used in support of technical or operational evaluations, or in support of local operational requirements.

These MOPS define two categories of use for "TEST" Messages, SUBTYPE=0 and SUBTYPE=7. "TEST" messages of SUBTYPEs 1 through 6 are reserved.

2.2.3.2.7.4.1 "TEST" Messages with SUBTYPE = 0

"TEST" Messages with SUBTYPE=0 **shall** be used only for messages in support of bench and or certification testing of 1090 MHz ADS-B systems. The format for the "TEST" Messages with SUBTYPE=0 shall be as shown in Figure 2.2.3.2.7.4-1.

	"TEST MESSAGE (TYPE=23 and SUBTYPE=0)"		
Msg. Bit #	33 37	38 40	41 88
"ME" Bit #	1 5	6 8	9 56
Field Name	Type = 23 [5]	Subtype = 0 [3]	Unformatted Test Data [48]
	MSB LSB	MSB LSB	MSB LSB

Figure 2.2.3.2.7.4-1: Format of "TEST" Messages with SUBTYPE=0

2.2.3.2.7.4.2 "TEST" Messages with SUBTYPE = 7

Notes:

1. *The "TEST" Message with SUBTYPE=7 is provided as a transitional feature to aid operation of ground ATC automation systems that use the Mode A code for flight plan correlation. The requirement for this message may be removed from future versions of these MOPS.*

2. The "TEST" Message with SUBTYPE=7 is not applicable to Class B2 equipment.

"TEST" Messages with SUBTYPE=7 **shall** be used for the broadcast of the Mode A, 4096, code currently assigned to the aircraft. The format for "TEST" Messages with SUBTYPE=7 **shall** be as shown in Figure 2.2.3.2.7.4-2. The Mode A Code subfield **shall** be coded as defined in RTCA DO-181C, §2.2.13.1.2.b and §2.2.4.1.2. Starting with "ME" bit 9, the sequence **shall** be C1, A1, C2, A2, C4, A4, ZERO, B1, D1, B2, D2, B4, D4.

"TEST" Messages with SUBTYPE=7 **shall not** be broadcast when the aircraft is in the "On-Ground" status (§2.2.3.2.1.1.2).

	"TEST MESSAGE (TYPE=23 and SUBTYPE=7)"			
Msg. Bit #	33 37	38 40	41 53	54 88
"ME" Bit #	1 5	6 8	9 21	22 56
Field Name	Type = 23 [5]	Subtype = 7 [3]	Mode A Code [13]	Reserved [35]
	MSB LSB	MSB LSB	MSB LSB	MSB LSB

Figure 2.2.3.2.7.4-2: Format of "TEST" Messages with SUBTYPE=7

2.2.3.2.7.4.2.1 "TEST" Messages with SUBTYPE=7, Global Enable/Inhibit

Provision **shall** be made for a global parameter to control the transmission of the "TEST" Message with SUBTYPE=7. This parameter **shall** specify one of the following conditions:

a. Inhibit transmission of the SUBTYPE 7 TEST message
b. Enable transmission of the SUBTYPE 7 TEST message
c. Enable transmission of the SUBTYPE 7 TEST message with a geographic filter (§2.2.3.2.7.4.2.2)

For this version of these MOPS, the parameter **shall** be set as specified in subparagraph "c," above.

2.2.3.2.7.4.2.2 "TEST" Messages with SUBTYPE=7, Geographic Filter

Note: *Geographic filtering is used as a means to automatically enable or inhibit the broadcast of the "TEST" Message with SUBTYPE=7 which conveys the Mode A Code of the aircraft. The following paragraphs define the minimum level of geographic filtering necessary to satisfy this requirement. More sophisticated geographic filtering techniques may be used provided they can be demonstrated to enable the broadcast of "TEST" Messages with SUBTYPE=7 when the aircraft is operating within US airspace and inhibited when operating outside the general boundaries of North America (plus Hawaii).*

The broadcast of "TEST" Messages with SUBTYPE=7 **shall** be enabled only if the geographic conditions specified in Table 2.2.3.2.7.4.2.2 are satisfied. The broadcast of "TEST" Messages with SUBTYPE=7 **shall** be inhibited if the current position is not available.

Table 2.2.3.2.7.4.2.2: "TEST" Messages with SUBTYPE=7, Geographic Filters

1	(Latitude-A1 $\leq$ $Lat_{current}$ $\leq$ Latitude-A2 (north positive), AND Longitude-A1 $\leq$ $Lon_{current}$ $\leq$ Longitude-A2 (east positive))
	OR
2	(Latitude-B1 $\leq$ $Lat_{current}$ $\leq$ Latitude-B2 (north positive), AND Longitude-B1 $\leq$ $Lon_{current}$ $\leq$ Longitude-B2 (east positive))
	OR
3	(Latitude-C1 $\leq$ $Lat_{current}$ $\leq$ Latitude-C2 (north positive), AND Longitude-C1 $\leq$ $Lon_{current}$ $\leq$ Longitude-C2 (east positive))

Where $Lat_{current}$ and $Lon_{current}$ define the current aircraft position.

Latitude and Longitude with a resolution of 0.1 degree or better **shall** be used for the purpose of determining whether the criteria specified in Table 2.2.3.2.7.4.2.2 are satisfied.

For this version of these MOPS:

Latitude – A1 = 18.0 degrees	Latitude – A2 = 75.0 degrees
Longitude – A1 = - 170.0 degrees	Longitude – A2 = - 65.0 degrees
Latitude – B1 = reserved	Latitude B2 = reserved
Longitude – B1 = reserved	Longitude B2 = reserved
Latitude – C1 = reserved	Latitude – C2 = reserved
Longitude – C1 = reserved	Longitude – C2 = reserved

Notes:

1. Negative longitudes listed above are synonymous with west longitude.

2. Additional geographic areas may be used if desired to better define the specified operating area.

(1.8) In RTCA/DO-260, replace section §2.2.3.3.2.7 with the following:

The "TEST" ADS-B Event-Driven Messages with SUBTYPE = "0" **shall** be broadcast NOT MORE THAN ONCE each time the Event Driven Test Information is updated to the transponder.

When enabled (§2.2.3.2.7.4.2.2), the "TEST" ADS-B Event-Driven Messages with SUBTYPE = "7" **shall** be broadcast at random intervals that are uniformly distributed over the range of 11.8 to 12.2 seconds from the time of transmission of the previous "TEST" Message with SUBTYPE=7.

(1.9) In RTCA/DO-260, add section §2.2.5.1.44 with the following:

2.2.5.1.44 Mode A (4096) Code

The ADS-B Transmitting Subsystem **shall** accept the own vehicle Mode A (4096) Code from the transponder function and use such data to establish the Mode A Code subfield transmitted in the ADS-B "TEST" Message as specified in §2.2.3.2.7.4.

(1.10) In RTCA/DO-260, replace section §2.4.3.2.1.1.2.1, Test Procedure Step 4, with the following:

For transponder based ADS-B transmitting systems that have automatic detection of on the ground status and have ground speed, airspeed or radio altitude available, the following procedure applies. For ADS-B Transmitting Systems for installations without automatic means of determining on the ground status, the following procedure shall verify that the "CA" field remains set to 6 throughout the procedure.

Set up the ADS-B transmitting system as in step 1 with on the ground status externally provided to the ADS-B transmitting system and additionally provide radio altitude input. Use a value greater than 50 feet. Vary the "Emitter Category" data input through the range of Emitter Category Sets that the system is capable. Verify that the ADS-B transmitting system correctly broadcasts each extended squitter message type with the "CA" field equal to 5 for all Emitter Category Set "A" codes 2 through 6 as specified in Table 2-9B.

Repeat the procedure given in the previous paragraph, except change the radio altitude data to a value less than 50 feet. Verify for each extended squitter type that the reported "CA" field equals 4.

Maintain the radio altitude data at a value less than 50 feet and if the system is capable of accepting ground speed data input, provide ground speed data greater than 100 knots to the

ADS-B transmitting system. Verify for each extended squitter type that the reported "CA" field equals 5 for Emitter Category Set "A," codes 2 through 6.

Maintain the radio altitude data at a value less than 50 feet and set the ground speed to a value less than or equal to 100 knots. Verify for each extended squitter type that the reported "CA" field equals 4.

Maintain the radio altitude data at a value less than 50 feet and the ground speed at 100 knots or less. If the system is capable of accepting airspeed data input, provide airspeed data greater than 100 knots to the ADS-B transmitting system. Verify for each extended squitter type that the reported "CA" field equals 5 for Emitter Category Set "A," codes 2 through 6.

Maintain the radio altitude data at a value less than 50 feet and the ground speed at a value less than or equal to 100 knots. Set the airspeed to a value less than or equal to 100 knots. Verify for each extended squitter type that the reported "CA" field equals 4.

(1.11) In RTCA/DO-260, replace section §2.4.3.2.1.1.2.1, Test Procedure Step 5, with the following.

The following procedure verifies that ADS-B Transmitting Systems without automatic detection of "On-The-Ground" status and capable of inputting radio altitude, ground speed, or airspeed, correctly reports "CA" Field equal to SIX (6), even when Surface Position Message broadcast is determined according to the requirements of §2.2.3.2.1.1.2 (c). Set up the ADS-B Transmitting System as in Step 1 above. For ADS-B Transmitting Systems with automatic means of determining "On-The-Ground" status, and capable of inputting radio altitude, ground speed or airspeed, provide external input to set the system to "Airborne" status and verify that the "CA" Field remains equal to FIVE (5) throughout this procedure.

For ADS-B Transmitting Systems capable of accepting radio altitude input, ground speed or airspeed, provide radio altitude data, ground speed and airspeed data to the ADS-B transmitting system according to the values defined in Table 2-84 or in the case of no data, stop providing the data as indicated. Verify that the system broadcasts extended squitters with the "CA" Field equal to SIX (6) for each test condition in Table 2-84.

(1.12) In RTCA/DO-260, in section §2.4.3.2.1.1.2.2, Test Procedure Step 3, rename the test Step to "Air/Ground Status Determination – Input Data Variation" and replace Table 2-84 with the following:

Table 2-84: Vertical Status Determination

Vertical Status Determination					
Test	**Emitter Category / Coding**	**Ground Speed (knots)**	**Airspeed (knots)**	**Radio Altitude (feet)**	**Resulting Vertical Status**
1	A/2 – 6, B/7	100	100	50	AIRBORNE
2	A/2 – 6, B/7	100	50	25	AIRBORNE
3	A/2 – 6, B/7	50	100	25	AIRBORNE
4	A/2 – 6, B/7	50	50	50	AIRBORNE
5	A/2 – 6, B/7	99	99	49	ON-GROUND
6	A/2 – 6, B/7	50	25	No Data	AIRBORNE
7	A/2 – 6, B/7	25	50	No Data	AIRBORNE
8	A/2 – 6, B/7	49	49	No Data	ON-GROUND
9	A/2 – 6, B/7	No Data	25	No Data	AIRBORNE
10	A/2 – 6, B/7	25	No Data	No Data	AIRBORNE
11	A/2 – 6, B/7	100	No Data	25	AIRBORNE
12	A/2 – 6, B/7	No Data	100	25	AIRBORNE
13	A/2 – 6, B/7	99	No Data	49	ON-GROUND
14	A/2 – 6, B/7	No Data	99	49	ON-GROUND
15	A/2 – 6, B/7	25	No Data	50	AIRBORNE
16	A/2 – 6, B/7	No Data	25	50	AIRBORNE
17	A/2 – 6, B/7	No Data	No Data	25	AIRBORNE
18	A/2 – 6, B/7	No Data	No Data	No Data	AIRBORNE

(1.13) In RTCA/DO-260, in section §2.4.3.2.1.1.2.2, Test Procedure Step 4, rename the test step to "Air/Ground Status Validation – ON-GROUND Override." In the last sentence of the paragraph of Step 4, change the reference from Table 2-84 **to** Table 2-85, and replace Table 2-85 with the following.

Table 2-85: On-Ground Override

ON-GROUND Override					
Test	**Emitter Category / Coding**	**Ground Speed (knots)**	**Speed (knots)**	**Radio Altitude (feet)**	**Resulting Vertical Status**
1	A/2 – 6, B/7	100	100	50	ON-GROUND
2	A/2 – 6, B/7	100	100	51	AIRBORNE
3	A/2 – 6, B/7	100	101	50	AIRBORNE
4	A/2 – 6, B/7	101	100	50	AIRBORNE
5	A/2 – 6, B/7	No Data	100	50	ON-GROUND
6	A/2 – 6, B/7	No Data	100	51	AIRBORNE
7	A/2 – 6, B/7	No Data	101	50	AIRBORNE
8	A/2 – 6, B/7	No Data	No Data	50	ON-GROUND
9	A/2 – 6, B/7	No Data	No Data	51	AIRBORNE
10	A/2 – 6, B/7	100	No Data	50	ON-GROUND
11	A/2 – 6, B/7	101	No Data	50	AIRBORNE
12	A/2 – 6, B/7	100	No Data	51	AIRBORNE
13	A/2 – 6, B/7	100	No Data	No Data	ON-GROUND
14	A/2 – 6, B/7	101	No Data	No Data	AIRBORNE
15	A/2 – 6, B/7	No Data	100	No Data	ON-GROUND
16	A/2 – 6, B/7	No Data	101	No Data	AIRBORNE
17	A/2 – 6, B/7	100	101	No Data	AIRBORNE
18	A/2 – 6, B/7	101	100	No Data	AIRBORNE
19	A/2 – 6, B/7	100	100	No Data	ON-GROUND
20	A/2 – 6, B/7	No Data	No Data	No Data	ON-GROUND

(1.14) In RTCA/DO-260, replace the entire section §2.4.3.2.3.1 with the following:

Purpose/Introduction:

This test procedure verifies that the ADS-B Transmitting System correctly outputs Airborne Position Messages with the correct TYPE subfield data content in Message Bits 33 through 37 in DF 17 Messages for Transponder Based Systems and DF 18 Messages for Non Transponder Based Systems. The ME field of the Airborne Position Message contains the TYPE subfield in bits 1 through 5 which is utilized to categorize the navigational integrity of the position information. The ADS-B Transmitting System determines and outputs the TYPE subfield based upon the input it receives from the possible Navigational sources that may interface to the system. The ADS-B Transmitting System may receive the TYPE subfield directly through an external interface instead of dynamically determining the TYPE subfield. Whatever the implementation, the test cases must exercise all of the resulting TYPE code possibilities. If an ADS-B Transmitting System can only generate a subset of the possible Airborne Position Message Types, then only those test cases required to produce the possible Type codes shall be tested. The test configuration is based on the type(s) of Navigational System(s) that may interface to the ADS-B Transmitting System and the data it provides.

Measurement Procedure:

Step 1: Verification of Type Codes 9 through 18 and 20 through 22 with GNSS/Baro Altitude

Configure the ADS-B Transmitting Subsystem to transmit Airborne Position Messages by providing position information at the nominal update rate. Provide the data externally at the interface to the ADS-B System. Set the ADS-B Transmitting Subsystem to Airborne status. Provide valid non-zero barometric pressure altitude data and GNSS altitude data to the ADS-B System. For each integrity category supported, verify that the TYPE subfield in the ADS-B Airborne Position Message correctly matches the TYPE subfield value from the integrity containment depicted in Table 2-11. The TYPE code may be derived by the Horizontal Protection Limits (HPL) contained in Table 2-11, or the Horizontal Integrity Limit (HIL), or another means which establishes an appropriate HPL (e.g., HPL based upon known RAIM protection threshold). To test all of the possible resulting TYPE codes that could be produced from the Navigational source, degradation of the position data from the Navigation source may require an alarm or alert condition that must be sensed by the ADS-B Transmitting System. The TYPE subfield shall contain values in the range from 9 through 18.

Verify that TYPE codes 9 and 10 cannot be set if the unit under test is not provided with either a GNSS Time Mark (see subparagraph 2.2.5.1.6) or UTC data unless the Non-Coupled Case of position estimation (see subparagraph 2.2.3.2.3.7.2.2 for Latitude, and subparagraph 2.2.3.2.3.8.2.2 for Longitude) is implemented.

Note: *UTC data is not acceptable to be used in place of GNSS Time Mark (see subparagraph 2.2.5.1.6) due to the fact that UTC data may not be available for any possible time up to 200 milliseconds after the leading edge of the GNSS Time Mark. Therefore, UTC data may not be used to establish TYPE codes 9 and 10.*

Stop providing input of barometric altitude to the ADS-B Transmitting System and continue providing GNSS Altitude data. If the ADS-B Transmitting Subsystem supports broadcasting TYPE Codes 20 and 21, verify that the TYPE subfield in the ADS-B Airborne Position Message correctly matches the TYPE subfield value from the integrity containment depicted in Table 2-11 for TYPE codes 20 and 21. If GNSS Altitude data is provided, but it is not possible to determine the integrity containment, then verify that the TYPE Code subfield is set to 22.

Verify that TYPE codes 20 and 21 cannot be set if the unit under test is not provided with either a GNSS Time Mark (see subparagraph 2.2.5.1.6) or UTC data, unless the Non-Coupled Case of position estimation (see subparagraph 2.2.3.2.3.7.2.2 for Latitude, and subparagraph 2.2.3.2.3.8.2.2 for Longitude) is implemented.

Note: *UTC data is not acceptable to be used in place of GNSS Time Mark (see subparagraph 2.2.5.1.6) due to the fact that UTC data may not be available for any possible time up to 200 milliseconds after the leading edge of the GNSS Time Mark. Therefore, UTC data may not be used to establish TYPE codes 20 and 21.*

Step 2: Verification of Type Codes 20 through 22 with GNSS Altitude

This step **shall** be performed for all ADS-B Transmitting Subsystems capable of broadcasting GNSS Altitude data. Configure the ADS-B Transmitting Subsystem to transmit ADS-B Airborne Position Messages. Disconnect the barometric altitude source to the ADS-B Transmitting System so that only GNSS altitude data is available. For each integrity category supported, verify that the TYPE Code subfield in the ADS-B Airborne Position Message correctly matches the TYPE Code subfield value from the integrity containment depicted in Table 2-11 for TYPE codes 20 through 22. The TYPE Code may be derived by the Horizontal Protection Limits (HPL) contained in Table 2-11, or the Horizontal Integrity Limit (HIL), or another means which establishes an appropriate HPL (e.g., HPL based upon known RAIM protection threshold). To test all of the possible resulting TYPE Codes that could be produced from the Navigational source, degradation of the position data from the Navigation source may require an alarm or alert condition that must be sensed by the ADS-B Transmitting Subsystem. If the Vertical Protection Limit (VPL) and HPL, or HIL vary

independently, test all possible resultant TYPE Codes from the variations and verify that the higher HPL or HIL values are used to determine the TYPE Code.

(1.15) In RTCA/DO-260, replace the entire section §2.4.3.2.4.1 with the following:

Purpose/Introduction:

This test procedure verifies that the ADS-B Transmitting System correctly outputs ADS-B Surface Position Messages with the correct TYPE Code subfield data content in Message Bits 33 through 37 in DF 17 Messages for Transponder Based Systems and DF 18 Messages for Non Transponder Based Systems. The ME field of the Ads-B Surface Position Message contains the TYPE Code subfield in bits 1 through 5 which is utilized to categorize the navigational integrity of the position information. The ADS-B Transmitting Subsystem determines and outputs the TYPE Code subfield based upon the input it receives from the possible Navigational sources that may interface to the system. The ADS-B Transmitting Subsystem may receive the TYPE Code subfield directly through an external interface instead of dynamically determining the TYPE Code subfield. Whatever the implementation, the test cases must exercise all of the resulting TYPE Code possibilities. If an ADS-B Transmitting Subsystem can only generate a subset of the possible Ads-B Surface Position Message TYPE Codes, then only those test cases required to produce the possible TYPE Codes **shall** be tested. The test configuration is based on the type(s) of Navigational System(s) that may interface to the ADS-B Transmitting Subsystem and the data it provides.

Measurement Procedure:

Step 1: Verification of Type Codes 5 through 8

Configure the ADS-B Transmitting Subsystem to transmit Ads-B Surface Position Messages by providing position information at the nominal update rate. Provide the data externally at the interface to the ADS-B Subsystem. Set the ADS-B Transmitting Subsystem to "On-Ground" status. Provide appropriate Ground Speed information to the ADS-B Subsystem in order to establish the high rate of transmission for the ADS-B Surface Position Message. For each integrity category supported, verify that the TYPE Code subfield in the ADS-B Surface Position Message correctly matches the TYPE Code subfield value from the integrity containment depicted in Table 2-11. The TYPE Code may be derived by the Horizontal Protection Limits (HPL) contained in Table 2-11, or the Horizontal Integrity Limit (HIL), or another means which establishes an appropriate HPL (e.g., HPL based upon known RAIM protection threshold). To test all of the possible resulting TYPE Codes that could be produced from the Navigational source, degradation of the position data from the Navigation source may require an alarm or alert condition that must be sensed by the ADS-B Transmitting Subsystem. The TYPE Code subfield **shall** contain values in the range from 5 through 8.

(1.16) In RTCA/DO-260, replace the entire section §2.4.3.2.4.1.1 with the following:

Purpose/Introduction:

This test procedure verifies that the ADS-B Transmitting Subsystem correctly outputs ADS-B Surface Position Messages with the correct TYPE Code subfield data content in Message Bits 33 through 37 in DF 17 Messages for Transponder Based Systems and DF 18 Messages for Non Transponder Based Systems. The ME field of the ADS-B Surface Position Message contains the TYPE Code subfield which is utilized to categorize the navigational integrity of the position information. If an ADS-B Transmitting Subsystem can only generate a subset of the possible ADS-B Surface Position Message TYPE Codes, then only those test cases required to produce the possible TYPE Codes **shall** be tested. The test configuration is based on the type of Navigational System that interfaces to the ADS-B Transmitting Subsystem and the data it provides.

Measurement Procedure:

Configure the ADS-B Transmitting Subsystem to transmit ADS-B Surface Position Messages by providing position information at the nominal update rate. Provide the data externally at the interface to the ADS-B Subsystem. Set up the system to enable broadcast of ADS-B Surface Position Messages at the nominal rate. Set the ADS-B Transmitting Subsystem to "On Ground" status. For each integrity category supported, verify that the TYPE Code subfield in the ADS-B Surface Position Message correctly matches the TYPE Code subfield value from the integrity containment depicted in Table 2-11. The TYPE Code may be derived by either the Horizontal Protection Limits (HPL), contained in Table 2-11, or the Horizontal Integrity Limit (HIL), or another means which establishes an appropriate HPL (e.g., HPL based upon known RAIM protection threshold). To test all of the possible resulting TYPE Codes that could be produced from the Navigational source, degradation of the position data from the Navigation source may require an alarm or alert condition that must be sensed by the ADS-B Transmitting Subsystem. The TYPE Code subfield **shall** contain values in the range from 5 through 8.

(1.17) Implementation of this Test Procedure is only required if the manufacturer has elected to implement the requirements of Change 1.7 of this Change document to RTCA/DO-260. If a manufacturer elects not to implement that optional requirement, then no change is required for RTCA/DO-260, section §2.4.3.2.7.4.

If a manufacturer elects to implement that requirement, then in RTCA/DO-260, replace section §2.4.3.2.7.4 with the following:

2.4.3.2.7.4 Verification of TYPE "23" ADS-B Event-Driven Messages for "TEST" (§2.2.3.2.7.4)

The appropriate test procedures required to validate the requirements of §2.2.3.2.7.4 are provided in §2.4.3.2.7.4.2 through §2.4.3.2.7.4.2.2.

2.4.3.2.7.4.1 Verification of "TEST" Messages with Subtype = 0 (§2.2.3.2.7.4.1)

No specific test procedure is required to validate §2.2.3.2.7.4.1.

2.4.3.2.7.4.2 Verification of "TEST" Messages with Subtype = 7 (§2.2.3.2.7.4.2)

Purpose/Introduction:

"TEST" Messages with SUBTYPE=7 **shall** be used for the broadcast of the Mode A, 4096, Code currently assigned to the aircraft. The format for "TEST" Messages with SUBTYPE=7 **shall** be as specified in Figure 2.2.3.2.7.4-2. The Mode A Code subfield **shall** be coded as defined in RTCA DO-181C, §2.2.13.1.2.b and §2.2.4.1.2. Starting with "ME" bit 9, the sequence **shall** be C1, A1, C2, A2, C4, A4, ZERO, B1, D1, B2, D2, B4, D4.

"TEST" Messages with SUBTYPE=7 **shall not** be broadcast when the aircraft is in the "On-Ground" status (§2.2.3.2.1.1.2).

Measurement Procedure:

Step 1: Verification of the Broadcast of Mode A, 4096, Code – Airborne Status

Configure the ADS-B Transmitting Subsystem to transmit TYPE "23" ADS-B "TEST" Messages. Provide the data externally at the interface to the ADS-B Transmitting Subsystem. Set the ADS-B Transmitting Subsystem to Airborne status. Input a "TEST" Message with TYPE=23, SUBTYPE=7 as per RTCA DO-181C, §2.2.13.1.2.b and §2.2.4.1.2, where beginning with "ME" bit 9 the sequence **shall** be C1, A1, C2, A2, C4, A4, ZERO, B1, D1, B2, D2, B4, D4. Verify that the input Mode A Code is reflected in the next broadcast of the "TEST" Message with SUBTYPE=7.

Step 2: Verification of the Non-Broadcast of Mode A, 4096, Code – On Ground Status

Configure the ADS-B Transmitting Subsystem to transmit TYPE "23" ADS-B "TEST" Messages. Provide the data externally at the interface to the ADS-B Transmitting Subsystem. Set the ADS-B Transmitting Subsystem to "On Ground" status. Input a "TEST" Message with TYPE=23, SUBTYPE=7 as per RTCA DO-181C, §2.2.13.1.2.b and §2.2.4.1.2, where beginning with "ME" bit 9 the sequence **shall** be C1, A1, C2, A2, C4, A4, ZERO, B1, D1, B2, D2, B4, D4. Verify that **no** "TEST" Message with TYPE=23, SUBTYPE=7 is broadcast.

2.4.3.2.7.4.2.1 Verification of "TEST" Messages with Subtype = 7, Global Enable/Inhibit (§2.2.3.2.7.4.2.1)

The test procedures required to validate the requirements of §2.2.3.2.7.4.2.1 are included in §2.4.3.2.7.4.2.2.

2.4.3.2.7.4.2.2 Verification of "TEST" Messages with Subtype = 7, Geographic Filter (§2.2.3.2.7.4.2.2)

Purpose/Introduction:

The broadcast of "TEST" Messages with SUBTYPE=7 **shall** be enabled only if the geographic conditions specified in Table 2.2.3.2.7.4.2.2 are satisfied. The broadcast of "TEST" Messages with SUBTYPE=7 **shall** be inhibited if the current position is not available. Latitude and Longitude with a resolution of 0.1 degree or better **shall** be used for the purpose of determining whether the criteria specified in Table 2.2.3.2.7.4.2.2 are satisfied. For this version of these MOPS:

Latitude-A1 = 18.0 degrees	Latitude-A2 = 75.0 degrees
Longitude-A1 = –170.0 degrees	Longitude-A2 = –65.0 degrees

Measurement Procedure:

Step 1: Verification of Enabling on Preset Geographic Lat/Lon – Inside the Box

Configure the ADS-B Transmitting Subsystem to create Airborne Position Messages. Configure the ADS-B Transmitting Subsystem to transmit TYPE "23" ADS-B "TEST" Messages with SUBTYPE=7. Provide the data externally at the interface to the ADS-B Transmitting Subsystem. Set the ADS-B Transmitting Subsystem to Airborne status. Through the appropriate Navigation Data Source interface, provide the ADS-B Transmitting Subsystem with Latitude and Longitude values, where:

$$18^{o} \leq Lat_{current} \leq 75^{o}$$
and
$$-170^{o} \leq Lon_{current} \leq -65^{o}$$

Verify that the ADS-B Transmitting Subsystem begins, and continues transmitting TYPE "23" ADS-B "TEST" Messages with SUBTYPE=7.

Step 2: Verification of Enabling on Preset Geographic Lat/Lon – Outside the Box

Configure the ADS-B Transmitting Subsystem as in Step 1 above. Through the appropriate Navigation Data Source interface, provide the ADS-B Transmitting Subsystem with Latitude and Longitude values, where:

$$18^{o} > Lat_{current}$$
and
$$-170^{o} \leq Lon_{current} \leq -65^{o}$$

Verify that the TYPE "23" ADS-B "TEST" Message with SUBTYPE=7 is **not** being broadcast.

Repeat this step for each of the following additional four cases:

1	$Lat_{current} > 75^{o}$	**and**	$-170^{o} \leq Lon_{current} \leq -65^{o}$
2	$18^{o} \leq Lat_{current} \leq 75^{o}$	**and**	$-170^{o} > Lon_{current}$
3	$18^{o} \leq Lat_{current} \leq 75^{o}$	**and**	$Lon_{current} > -65^{o}$
4	Position information is not available.		

In each of the above four cases, verify that the TYPE "23" ADS-B "TEST" Message with SUBTYPE=7 is **not** being broadcast.

Step 3: Verification of Inhibiting on Crossing the Boundary of the Box

Repeat Step 1 above and verify that the ADS-B Transmitting Subsystem begins, and continues transmitting TYPE "23" ADS-B "TEST" Messages with SUBTYPE=7. Now update the Latitude and Longitude information individually with each of the five cases in Step 2 above, and verify that the broadcast of the TYPE "23" ADS-B "TEST" Message with SUBTYPE=7 is properly terminated when the Latitude and Longitude specified in each individual case in Step 2 is provided.

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