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Department of Transportation
**Federal Aviation Administration**
Aircraft Certification Service
Washington, D.C.

**TSO-C199**

Effective
Date: 10/10/14

# Technical Standard Order

**Subject:** ***Traffic Awareness Beacon System (TABS)***

**1. PURPOSE** This technical standard order (TSO) is for manufacturers applying for a TSO authorization (TSOA) or letter of design approval (LODA). In it, we the Federal Aviation Administration, (FAA) tell you what Minimum Performance Standards (MPS) your Traffic Awareness Beacon System (TABS) must first meet for approval and identification with the applicable TSO marking. TABS devices are distinctly different from other transponders. TABS devices are intended for voluntary equipage on aircraft exempted from carrying a transponder or Automatic Dependent Surveillance - Broadcast (ADS-B) equipment, such as gliders, balloons and aircraft without electrical systems. TABS devices do not meet the transponder or ADS-B requirements defined in 14 CFR § 91.215, and 14 CFR § 91.225 respectively. TABS equipment built to the minimum requirements of this TSO will enable an aircraft to be visible to other aircraft equipped with:

- Traffic Advisory System (TAS) as defined in TSO-C147()
- Traffic Alert and Collision Avoidance System I (TCAS I) as defined in TSO-C118()
- Traffic Alert and Collision Avoidance System II, (TCAS II), as defined in TSO-C119d
- ADS-B IN capability as defined in TSO-C154c, TSO-C166b, and TSO-C195b

**2. APPLICABILITY** This TSO affects new applications submitted after its effective date.

**3. REQUIREMENTS** TABS requirements are derived from existing transponder and ADS-B requirements. Equipment meeting only the minimum TABS requirements will provide the capability to be seen by other aircraft equipped with traffic advisory systems but may not support detection by ground surveillance systems relying on full transponder functionality. A designer building equipment to meet this TSO may decide to incorporate more capability than what is outlined in this TSO as long as it meets the applicable requirements in the referenced standards (e.g., RTCA/DO-181E). New models of the TABS identified and manufactured on or after the effective date of this TSO must meet the MPS qualification and documentation requirements for the applicable equipment class defined by this TSO.

**a. Functionality** TABS equipment developed under this TSO are intended to make aircraft with an installed device visible to TAS, TCAS I, TCAS II and ADS-B IN equipped aircraft. TABS functionality is divided into four categories: the transponder function, altitude source function, ADS-B OUT function, and position source function.

Class A TABS:

- Includes the transponder, altitude source, and ADS-B OUT functionality; refer to subparagraphs (1), (2), and (3) below.
- Consists of a Class A device, or a TSO-C112e and TSO-C166b compliant device.

Class B TABS:

- Includes the Global Navigation Satellite System (GNSS) position source functionality; refer to subparagraph (4) below.
- Consists of a Class B device, or a TSO-C129a, TSO-C145d, TSO-C146d, TSO-C196b, TSO-C204, TSO-C205 or TSO-C206 compliant GPS.

TABS may include an ADS-B IN function but it is not required. If implemented, the ADS-B IN function should meet the performance specified in TSO-C195b as well as TSO-C154c, TSO-C166b, or both. TABS is intended to make the aircraft a valid TIS-B and ADS-R client.

**(1)** The transponder functionality must meet a subset of the requirements in RTCA, Inc. document RTCA/DO-181E, *Minimum Operational Performance Standards for Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment*, dated March 17, 2011, section 2, for a Level 2, Class 2 transponder as modified by **Appendix 1**.

**(2)** The altitude source functionality must meet the requirements of TSO-C88b, *Automatic Pressure Altitude Reporting Code-Generating Equipment*, dated February 6, 2007.

**(3)** The ADS-B OUT function must meet a subset of the requirements found in RTCA, Inc. document RTCA/DO-260B, *Minimum Operational Performance Standards for 1090 MHz Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Services-Broadcast (TIS-B)*, dated Dec 2, 2009, including Corrigendum-1, section 2, dated December 13, 2011, Class B0 as modified by **Appendix 1**. The system must be built such that it transmits Navigation Integrity Code (NIC), Navigation Accuracy Category for Position (NACp), Navigation Accuracy Category for Velocity (NACv), Geometric Vertical Accuracy (GVA), and Safety Integrity Level (SIL) values appropriate for the GNSS receiver used.

**(4)** The position source function must use a GNSS receiver that meets the requirements defined in **Appendix 1**. The intent of this TSO is to allow the use of commercially available GNSS position sources. The receiver must be capable of using SBAS provided corrections and health messages as defined in **Appendix 1**, in order to provide a means to prevent the TABS from transmitting false or misleading information. The receiver may continue to provide position when outside of SBAS coverage or when using unmonitored satellites. TABS Class B position sources may not be used for certified navigation equipment.

**b. Failure Condition Classifications** Failure of the Class A function defined in paragraph **3.a** of this TSO is a minor failure condition for malfunctions causing hazardously misleading information. Loss of the Class A function defined in paragraph **3.a** of this TSO is a minor failure condition. Design the system to at least these failure condition classifications. Class B equipment is intended to be met by commercially available GNSS and is unlikely to be designed specifically to support a minor hazard classification. Class B equipment suitability for supporting the function in paragraph **3.a** of this TSO is established by performing the functional

and environmental testing in **Appendix 2** and **Appendix 3** of this TSO with no further analysis required.

**c. Functional Qualification** Demonstrate the required performance under the test conditions specified in **Appendix 2** of this TSO.

**d. Environmental Qualification** For Class A equipment, demonstrate the required performance under the test conditions specified in RTCA/DO-181E section 2.3 and RTCA/DO-260B, including Corrigendum-1, section 2.3, dated December 13, 2011, using standard environmental conditions and test procedures appropriate for airborne equipment. You may use a different standard environmental condition and test procedure other than RTCA/DO-160G, provided the standard is appropriate for the TABS. For Class B equipment, demonstrate the required performance under the test conditions specified in **Appendix 3**.

> **Note:** The use of RTCA/DO-160D, (with Changes 1 and 2 only) or earlier versions is generally not considered appropriate and will require substantiation via the deviation process as discussed in paragraph **3.g** of the TSO.

**e. Software Qualification** If the article includes software, develop the software according to RTCA, Inc. document RTCA/DO-178C, *Software Considerations in Airborne Systems and Equipment Certification*, dated December 13, 2011, including referenced supplements as applicable, to at least the software level consistent with the failure condition classification defined in paragraph **3.b** of this TSO. You may also develop the software according to RTCA, Inc. document RTCA/DO-178B, dated December 1, 1992, if you follow the guidance in AC 20-115C, *Airborne Software Assurance*, dated July 19, 2013 This requirement applies to Class A equipment only. Class B equipment is exempt from software qualification defined in this paragraph.

**f. Electronic Hardware Qualification** If the article includes complex custom airborne electronic hardware, develop the component according to RTCA, Inc. document RTCA/DO-254, *Design Assurance Guidance for Airborne Electronic Hardware*, dated April 19, 2000, to at least the design assurance level consistent with the failure condition classification defined in paragraph **3.b** of this TSO. For custom airborne electronic hardware determined to be simple, RTCA/DO-254, paragraph 1.6 applies. This requirement applies to Class A equipment only. Class B equipment is exempt from electronic hardware qualification defined in this paragraph.

> **Note**: The certification liaison process objectives will be considered satisfied after FAA review of the applicable life cycle data.

**g. Deviations** We have provisions for using alternate or equivalent means of compliance to the criteria in the MPS of this TSO. If you invoke these provisions, you must show that your equipment maintains an equivalent level of safety. Apply for a deviation under the provision of 14 CFR § 21.618.

**4. MARKING**

**a.** Mark at least one major component permanently and legibly with all the information in 14 CFR § 45.15(b). The marking must include the serial number and functional equipment class in accordance with paragraph 3.

**b.** Also, mark the following permanently and legibly, with at least the manufacturer's name, subassembly part number, and the TSO number:

**(1)** Each component that is easily removable (without hand tools); and,

**(2)** Each subassembly of the article that you determined may be interchangeable.

**c.** If the article includes software and/or airborne electronic hardware, then the article part numbering scheme must identify the software and airborne electronic hardware configuration. The part numbering scheme can use separate, unique part numbers for software, hardware, and airborne electronic hardware.

**d.** You may use electronic part marking to identify software or airborne electronic hardware components by embedding the identification within the hardware component itself (using software) rather than marking it on the equipment nameplate. If electronic marking is used, it must be readily accessible without the use of special tools or equipment.

**5. APPLICATION DATA REQUIREMENTS** You must give the FAA Aircraft Certification Office (ACO) manager responsible for your facility a statement of conformance, as specified in 14 CFR § 21.603(a)(1) and one copy each of the following technical data to support your design and production approval. LODA applicants must submit the same data (excluding paragraph **5.g**) through their civil aviation authority.

**a**. A Manual(s) containing the following:

**(1)** Operating instructions and equipment limitations sufficient to describe the equipment's operational capability.

**(2)** Describe in detail any deviations.

**(3)** Installation procedures and limitations sufficient to ensure that the TABS, when installed according to the installation or operational procedures, still meets this TSO's requirements. Limitations must identify any unique aspects of the installation.

**(a)** The limitations must include the following statement: "This article meets the minimum performance and quality control standards required by a technical standard order (TSO). Installation of this article requires separate approval."

**(b)** The limitation must also include the following statement: "This device does not meet requirements for use in transponder rule airspace as defined in 14 CFR §91.215 and ADS-B rule airspace as defined in 14 CFR § 91.225."

**(4)** For each unique configuration of software and airborne electronic hardware, reference the following:

**(a)** Software part number including revision and design assurance level;

**(b)** Airborne electronic hardware part number including revision and design assurance level;

**(c)** Functional description; and,

**(5)** A summary of the test conditions used for environmental qualifications for each component of the article. For example, a form as described in RTCA/DO-160G, *Environmental Conditions and Test Procedures for Airborne Equipment, Appendix 1*.

**(6)** Schematic drawings, wiring diagrams, and any other documentation necessary for installation of TABS equipment.

**(7)** List of replaceable components, by part number, that makes up the TABS. Include vendor part number cross-references, when applicable.

**b.** Instructions covering periodic maintenance, calibration, and repair, for the continued airworthiness of TABS equipment. Include recommended inspection intervals and service life, as appropriate.

**c.** If the Class A article includes software: a plan for software aspects of certification (PSAC), software configuration index, and software accomplishment summary. This requirement does not apply to Class B devices.

**d.** Nameplate drawing with the information required by paragraph **4** of this TSO.

**e.** Identify functionality or performance contained in the article not evaluated under paragraph **3** of this TSO (that is, non-TSO functions). Non-TSO functions are accepted in parallel with the TSO authorization. For those non-TSO functions to be accepted, you must declare these functions and include the following information with your TSO application:

**(1)** Description of the non-TSO function(s), such as performance specifications and software, hardware, and environmental qualification levels. Include a statement confirming that the non-TSO function(s) don't interfere with the article's compliance with the requirements of paragraph **3**.

**(2)** Installation procedures and limitations sufficient to ensure that the non-TSO function(s) meets the declared functions and performance specification(s) described in paragraph **5.e.(1)**.

**(3)** Instructions for continued performance applicable to the non-TSO function(s) described in paragraph **5.e.(1).**

**(4)** Interface requirements and applicable installation test procedures to ensure compliance with the performance data defined in paragraph **5.e.(1).**

**(5)** Test plans, analysis and results, as appropriate, to verify that performance of the hosting TSO article is not affected by the non-TSO function(s).

**(6)** Test plans, analysis and results, as appropriate, to verify the function and performance of the non-TSO function(s) as described in paragraph **5.e.(1).**

**f.** The quality system description required by 14 CFR § 21.608, including functional test specifications. The quality system should ensure that you will detect any change to the approved design that could adversely affect compliance with the TSO MPS, and reject the article accordingly. (Not required for LODA applicants.)

**g.** Material and process specifications list.

**h.** List of all drawings and processes (including revision level) that define the article's design.

**i.** Manufacturer's TSO qualification report showing results of testing accomplished according to paragraph **3.c** of this TSO.

**6. <u>MANUFACTURER DATA REQUIREMENTS</u>** Besides the data given directly to the responsible ACO, have the following technical data available for review by the responsible ACO:

**a.** Functional qualification specifications for qualifying each production article to ensure compliance with this TSO.

**b.** Equipment calibration procedures.

**c.** Schematic drawings.

**d.** Wiring diagrams.

**e.** Material and process specifications.

**f.** The results of the environmental qualification tests conducted according to paragraph **3.d** of this TSO.

**g.** If the article includes software, the appropriate documentation defined in the version of RTCA/DO-178 specified by paragraph **3.e** of this TSO, including all data supporting the applicable objectives in Annex A, Process Objectives and Outputs by Software Level This requirement applies only to Class A equipment, it does not apply to Class B equipment.

**h**. If the article contains non-TSO function(s), you must also make available items **6.a** through **6.g** as they pertain to the non-TSO function(s).

## 7. FURNISHED DATA REQUIREMENTS

**a.** If furnishing one or more articles manufactured under this TSO to one entity (such as an operator or repair station), provide one copy or on-line access to the data in paragraphs **5.a** and **5.b** of this TSO. Add any other data needed for the proper installation, certification, use, or for continued compliance with the TSO, of the TABS.

**b.** If the article contains declared non-TSO function(s), include one copy of the data in paragraphs **5.f.(1)** through **5.f.(4).**

## 8. HOW TO GET REFERENCED DOCUMENTS

**a.** EUROCAE Documents: Order EUROCAE documents by calling Tel : +33 1 40 92 79 30 / Fax : +33 1 46 55 62 65 or e-mailing eurocae@eurocae.net. EUROCAE documents can also be downloaded by going to http://boutique.eurocae.net/catalog/

**b.** EUROCONTROL Documents: EUROCONTROL, STA/R/460/0001/1, *Study to Address the Detection and Recognition of Light Aircraft in the Current and Future ATM Environment, Issue 1.0, Final Report*, dated 31 March 2005

**c.** EUROCONTROL Surveillance Document Library: https://www.eurocontrol.int/articles/surveillance-library

**d.** FAA Documents**:** You can find a current list of Technical Standard Orders (TSOs) and Advisory Circulars (ACs) on the FAA Internet website Regulatory and Guidance Library at http://rgl.faa.gov/. You will also find the TSO Index of Articles at the same site.

**e.** FCC Documents: Federal Communication Commission document OET Bulletin 65 Ed 97-01, *Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields* is available on the internet at: http://transition.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet65/oet65.pdf

**f.** RTCA Documents: Order RTCA documents from RTCA Inc., 1150 18th Street NW, Suite 910, Washington, D.C. 20036. Telephone (202) 833-9339, fax (202) 833-9434. You can also order copies online at www.rtca.org

**g.** US Code of Federal Regulations (CFR) Documents: Order copies of 14 CFR parts 21, 45 and 91 from the Superintendent of Documents, Government Printing Office, P.O. Box 979050, St. Louis, MO 63197. Telephone (202) 512-1800, fax (202) 512-2250. You can also download copies online at: http://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/

**h.** UK Public Health Documents Public Health England document HPA-RPD-031, *Exposure to EMFs from Lightweight Aviation Transponders*, dated September 2007, ISBN 978-0-85951-605-1, can be obtained on line by going to: http://www.hpa.org.uk/Publications/Radiation/HPARPDSeriesReports/HpaRpd031/

**i.** *Global Positioning System Signals, Measurements, and Performance*, Ganga-Jamuna Press, by Pratap Misra and Per Enge. ISBN: 0-9709544-0-9

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# Appendix 1. Traffic Awareness Beacon System Requirements

## A1 Introduction

### A1.1 TABS Intent

**A1.1.1** The intent of a TABS is to increase safety within the National Air Space (NAS) by encouraging the voluntary equipage of a low cost, compact, easy to install device that will allow other aircraft equipped with collision avoidance systems and traffic advisory systems to track and display the TABS aircraft. TABS are intended to be used on aircraft that are exempted from carrying a transponder or Automatic Dependent Surveillance - Broadcast (ADS-B) equipment, such as gliders, balloons and aircraft without electrical systems. TABS devices do not meet the transponder requirements defined in 14 CFR § 91.215, and 14 CFR § 91.225. A TABS will allow these exempted aircraft to be visible to other aircraft equipped with:

- Traffic Advisory System (TAS) as defined in TSO-C147()
- Traffic Alert and Collision Avoidance System I (TCAS I) as defined in TSO-C118()
- Traffic Alert and Collision Avoidance System II, (TCAS II), as defined in TSO-C119d
- Aircraft with ADS-B IN capability as defined in TSO-C154c, TSO-C166b, and TSO-C195b

**A1.1.2** TABS is designed to:

- Reply to ATCRBS Mode C, and Mode S UF=0, 4, 5, 20 and 21 interrogations.
- Not reply to ATCRBS Mode A interrogations
- Not reply to Mode S UF=11, and 16 interrogations.
- Incorporate TSO-C88b, *Automatic Pressure Altitude Reporting Code-Generating Equipment*.
- Transmit ADS-B Messages: Aircraft Identification and Category, Airborne Position, Airborne Velocity, Emergency Priority Status Message, and Aircraft Operational Status.
- Optionally provide Surface Position Messages.
- Optionally use a commercial GNSS source meeting the requirements of this TSO.

**A1.1.3** TABS can potentially act as a low cost platform for other aviation applications. Although additional capabilities are beyond the scope of this TSO, TABS may include additional functions such as data loggers, search and rescue transmitter, or provide flight information services.

## A1.2 Requirements

**A1.2.1** TABS requirements are derived from existing Mode S transponder and 1090 MHz Extended Squitter ADS-B requirements. A designer building equipment to meet this TSO may decide to incorporate the full transponder and ADS-B capability by using a device that meets TSO-C112e and TSO-C166b. If electing to implement full functionality, they must demonstrate that functionality against the unmodified test procedures in RTCA/DO-181E and RTCA/DO-260B, including Corrigendum-1, dated December 13, 2011. Designers that wish to take advantage of the reduced transponder requirements afforded to TSO-C199 Class A devices must meet the modified requirements outlined in paragraphs **A1.2.3** Transponder Function Requirements, **A1.2.4** Altitude Source Function Requirements, and **A1.2.5** ADS-B OUT Function Requirements in this appendix in their entirety. Designers wishing to take advantage of the Class B reduced GNSS requirements will need to meet the requirements outlined in paragraphs **A1.2.6** GNSS Position Source Function Requirements.

**A1.2.2** MOPS text is used here with the permission from RTCA. Table 1 provides notes in italics and parenthesis explaining how to read the tables that modify the text in the source documents.

| (Source document reference) | Modified text for this TSO |
|---|---|
| (This is a copy of the original text from the source document. Material to be deleted from this original text is marked with ~~strikethrough formatting~~.) | (This is the requirement for this TSO. Modifications to the source text are marked in **bold and underlined** to assist in identifying changes). |

***Table 1 (Source document reference) (type of change)***

### A1.2.3 Transponder Function Requirements Derived From DO-181E (For Class A Devices)

**A1.2.3.1** The transponder function must meet the Minimum Performance Standards (MPS) qualification and documentation requirements in RTCA, Inc. document RTCA/DO-181E, section 2, for a Level 2, Class 2, transponder as modified below.

**A1.2.3.1.1** Flight Crew Control Functions Changes

**A1.2.3.1.2** A cost factor in any device is the control and display functions to interface with the human operator. TABS display and control requirements are a subset of those required for transponders. Some user controls are allowed via an external device prior to flight (e.g., a personal electronic device (PED)). If the system is powered by batteries, display of available battery life is recommended. Table 2 provides an overview of flight crew control functions.

| Operation mode | Required Controls | Required Indicators |
|---|---|---|
| In flight<br>(i.e., control head) | - Power,<br>- Emergency (3/A code 7700)<br>- IDENT (optional) | Power on,<br>Transponder Fail<br>ADS-B Fail<br>Battery indicator (optional) |
| Non flight (optional in flight)<br>(i.e., Personal Electronic Device PED) | - Set 4096 code,<br>- Set Flight ID | Display of 4096 code,<br>Display of Flight ID |
| Maintenance actions<br>(allowed in non-flight conditions only) | - Set ICAO 24 bit aircraft address,<br>- Set implementation specific configuration | Display of ICAO 24 bit aircraft address,<br>Display of implementation specific configuration.<br>Display software version (optional) |

***Table 2 Summary of Control and Indication Requirements by Operation Mode***

**A1.2.3.1.3** RTCA/DO-181E, section 2.1.7 a, Flight Crew Control Functions, is amended as shown in Table 3.

| DO-181E text | Modified text for this TSO |
|---|---|
| The following functions Shall be provided<br><br>a. A means of selecting each of the ATCRBS 4096 reply code~~s, and of~~ indicating the code selected. | The following functions SHALL be provided **as indicated in items a-f.**<br>a. A means of selecting **and displaying** the ATCRBS 4096 code **on the ground SHALL be required. A means of selecting and displaying the ATCRBS 4096 code in flight is optional. A means of setting the Mode 3/A code to 7700 (emergency), either by entering in the value or an automated means such as a switch, SHALL be provided. A means of setting an alternate 4096 code other than the primary 4096 code, either by entering in the value or an automated means such as a switch, SHALL be provided.** |

***Table 3 DO-181E section 2.1.7 a amendment***

**A1.2.3.1.4** RTCA/DO-181E, section 2.1.7 b, Flight Crew Control Functions, is amended as shown in Table 4.

| DO-181E text | Modified text for this TSO |
|---|---|
| The following functions Shall be provided<br><br>b. A means of selecting the air/ground state:<br>1) An automatic means ~~Shall be the only acceptable means~~ to determine the air/ground state.<br>2) If an automatic means is not ~~available~~, the transponder Shall ensure that the air/ground state is Airborne | The following functions SHALL be provided **as indicated in items a-f.**<br>b. A means of selecting the air/ground state:<br>1) An automatic means to determine the air/ground state **is recommended**.<br><br>2) If an automatic means is not **implemented**, the transponder SHALL ensure that the air/ground state is Airborne. |

***Table 4 DO-181E section 2.1.7 b amendment***

**A1.2.3.1.5** RTCA/DO-181E, section 2.1.7 c, Flight Crew Control Functions, is amended as shown in Table 5.

| DO-181E text | Modified text for this TSO |
|---|---|
| The following functions Shall be provided<br><br>c. A means of selecting the condition in which all transponder functions, other than transmission on the reply frequency and associated self-testing, are operational (i.e., the Standby condition). Return to normal operation from this condition Shall be possible within five seconds. | The following functions SHALL be provided **as indicated in items a-f.**<br>c. A means of selecting the condition in which all transponder functions, other than transmission on the reply frequency and associated self-testing, are operational (i.e., the Standby condition) **is not required**. **However if provided,** return to normal operation from Standby condition SHALL be possible within five seconds." |

***Table 5 DO-181E section 2.1.7 c amendment***

**A1.2.3.1.6** RTCA/DO-181E, section 2.1.7 d, Flight Crew Control Functions, is amended as shown in Table 6.

| DO-181E text | Modified text for this TSO |
|---|---|
| The following functions Shall be provided<br><br>d. A means of initiating the IDENT (SPI) feature. | The following functions SHALL be provided **as indicated in items a-f.**<br>d. A means of initiating the IDENT (SPI) feature **is optional**. |

***Table 6 DO-181E section 2.1.7 d amendment***

### A1.2.3.2 Reply Rate Capability Changes

**A1.2.3.2.1** This section reduces the minimum reply rate capability of the TABS consistent with the interrogation acceptance based on two assumptions. The following rationale describes how the modified reply rates were chosen.

**A1.2.3.2.1.1** Assumption 1. The worst case Mode C interrogation count in a 100 millisecond interval from one ATCRBS radar is approximately 14 interrogations. Four ATCRBS radar overlapping beam dwells in a second is approximately 53 Mode C interrogations. The Mode C interrogation acceptance rate from 10 TCAS I units is approximately 15 interrogations per second. This represents a total demand on the TABS of 68 Mode C replies per second for this example.

**A1.2.3.2.1.2** Assumption 2. The worst case Mode S reply rate is primarily derived from the expected interrogation pattern of a set of 50 nearby TCAS II units all equipped with hybrid surveillance. The radar load from only roll-call interrogations would be small and would require networked sensors, otherwise the Mode S ground interrogation acceptance rate from radar systems would be zero.

**A1.2.3.2.2** Based on assumption 1 and 2, RTCA/DO-181E section 2.2.3.4 Reply Rate Capability is changed as follows:

**A1.2.3.2.2.1** RTCA/DO-181E, section 2.2.3.4.1 a, ATCRBS Reply Rate Capability is amended as shown in Table 7.

| DO-181E text | Modified text for this TSO |
|---|---|
| The transponder **Shall** be able to continuously generate at least ~~**500**~~ ATCRBS 15-pulse replies per second. | The transponder Shall be able to continuously generate at least **100** ATCRBS 15-pulse replies per second. |

***Table 7 DO-181E section 2.2.3.4.1 a amendment***

**A1.2.3.2.2.2** RTCA/DO-181E, section 2.2.3.4.1 c, ATCRBS Reply Rate Capability is amended as shown in Table 8.

| DO-181E text | Modified text for this TSO |
|---|---|
| For Class 2 equipment, the transponder **Shall** be capable of a peak reply rate of ~~**1000**~~ ATCRBS 15-pulse replies per second for a duration of 100 milliseconds. | For Class 2 equipment, the transponder **SHALL** be capable of a peak reply rate of **150** ATCRBS 15-pulse replies per second for a duration of 100 milliseconds. |

***Table 8 DO-181E section 2.2.3.4.1 c added***

**A1.2.3.2.2.3** RTCA/DO-181E, section 2.2.3.4.2 a, Mode S Reply Rate Capability is amended as shown in Table 9.

| DO-181E text | Modified text for this TSO |
|---|---|
| A transponder equipped for only short Mode S downlink formats (DF), Shall have the following minimum reply rate capabilities:<br>~~**50**~~ Mode S replies in any 1-second interval.<br>~~**18**~~ Mode S replies in a 100-millisecond interval.<br>~~**8**~~ Mode S replies in a 25-millisecond interval.<br>~~**4**~~ Mode S replies in a l.6-millisecond interval. | A transponder equipped for only short Mode S downlink formats (DF), **SHALL** have the following minimum reply rate capabilities:<br>**29** Mode S replies in any 1-second interval.<br>**10** Mode S replies in a 100-millisecond interval.<br>**5** Mode S replies in a 25-millisecond interval.<br>**3** Mode S replies in a l.6-millisecond interval. |

***Table 9 DO-181E section 2.2.3.4.2 a amendment***

**A1.2.3.2.2.4** RTCA/DO-181E, section 2.2.3.4.2 b, Mode S Reply Rate Capability is amended as shown in Table 10.

| DO-181E text | Modified text for this TSO |
|---|---|
| A transponder equipped for long Mode S reply formats Shall be able to transmit as long replies:<br>At least ~~16~~ of the 50 Mode S replies in any 1-second interval.<br>At least ~~6~~ of the 18 Mode S replies in a 100 millisecond interval.<br>At least ~~4~~ of the 8 Mode S replies in a 25 millisecond interval.<br>At least 2 of the 4 Mode S replies in a l.6 millisecond interval. | A transponder equipped for long Mode S reply formats SHALL be able to transmit as long replies:<br>At least **10** of the 29 Mode S replies in any 1-second interval.<br>At least **4** of the 10 Mode S replies in a 100 millisecond interval.<br>At least **3** of the 5 Mode S replies in a 25 millisecond interval.<br>At least 2 of the 4 Mode S replies in a l.6 millisecond interval. |

***Table 10 DO-181E section 2.2.3.4.2 b amendment***

### A1.2.3.3 Reply Rate Limiting Changes

**A1.2.3.3.1** The modifications in this section address reply rate limiting for ATCRBS and Mode S reply rates consistent with previous the section.

**A1.2.3.3.2** RTCA/DO-181E, section 2.2.7.3.1, ATCRBS Reply Rate Limiting is amended as shown in Table 11.

| DO-181E text | Modified text for this TSO |
|---|---|
| A sensitivity-reduction reply rate limit Shall be incorporated in the transponder for ATCRBS replies. The limit Shall be capable of being adjusted between ~~**500**~~ continuous ATCRBS ~~Mode A and~~ Mode C replies per second and the maximum continuous rate of which the transponder is capable, or ~~**2000**~~ replies per second, whichever is less, without regard to the number of pulses in each reply. Sensitivity reduction Shall apply only to the receipt of ATCRBS~~, ATCRBS/Mode S All-Call, and ATCRBS-Only All-Call~~ interrogations. | A sensitivity-reduction reply rate limit SHALL be incorporated in the transponder for ATCRBS replies. The limit **SHALL** be capable of being adjusted between **100** continuous ATCRBS Mode C replies per second and the maximum continuous rate of which the transponder is capable, or **200** replies per second, whichever is less, without regard to the number of pulses in each reply. Sensitivity reduction SHALL apply only to the receipt of ATCRBS interrogations. |

***Table 11 DO-181E section 2.2.7.3.1 amendment***

**A1.2.3.4** RTCA/DO-181E, section 2.2.13.1.2 c, Variable Direct Data is amended as shown in Table 12.

| DO-181E text | Modified text for this TSO |
|---|---|
| c. On-the-Ground Condition<br>The transponder ~~**Shall**~~ report the automatically determined on-the-ground state as determined by the aircraft in the Flight Status (FS), Vertical Status (VS), and Capability (CA) fields (see §2.2.14.4.15, §2.2.14.4.42, and §2.2.14.4.6), except when reporting airborne status when on-the-ground is reported to the transponder under the conditions specified in §2.2.18.2.7. | c. On-the-Ground Condition<br>The transponder **may** report the automatically determined on-the-ground state as determined by the aircraft in the Flight Status (FS), Vertical Status (VS), and Capability (CA) fields (see §2.2.14.4.15, §2.2.14.4.42, and §2.2.14.4.6), except when reporting airborne status when on-the-ground is reported to the transponder under the conditions specified in §2.2.18.2.7. |

***Table 12 DO-181E section 2.2.13.1.2 c amendment***

**A1.2.3.5** RTCA/DO-181E, section 2.2.13.1.2 d, Variable Direct Data is amended as shown in Table 13.

| DO-181E text | Modified text for this TSO |
|---|---|
| d. Special Position Identification (SPI)<br>~~In the ATCRBS mode, an SPI pulse **Shall** be transmitted upon request, following a Mode A reply.~~ In the FS field of Mode S replies, an equivalent of the ATCRBS SPI pulse **Shall** be transmitted upon ~~the same request~~. The code is transmitted for 18 ±1.0 seconds after initiation and can be reinitiated at any time. | d. Special Position Identification (SPI)<br>In the FS field of Mode S replies, an equivalent of the ATCRBS SPI pulse **shall** be transmitted upon **request if the optional IDENT flight crew control is implemented per A1.2.3.1.6 of this TSO.** The code is transmitted for 18 ±1.0 seconds after initiation and can be reinitiated at any time. |

***Table 13 DO-181E section 2.2.13.1.2 d amendment***

**A1.2.3.6** RTCA/DO-181E, section 2.2.13.1.2 e, Variable Direct Data is amended as shown in Table 14.

| DO-181E text | Modified text for this TSO |
|---|---|
| e. Aircraft Identification Data<br>If the aircraft uses a flight number for aircraft identification, a means **Shall** be provided for the variable aircraft identification to be inserted by the pilot while on the ground, ~~or during flight. The means for modifying and displaying aircraft identification **Shall** be a simple crew action independent of the entry of other flight data.~~ | e. Aircraft Identification Data<br>If the aircraft uses a flight number for aircraft identification, a means **SHALL** be provided for the variable aircraft identification to be inserted by the pilot while on the ground. **A means may be provided for modifying aircraft identification in flight**. |

***Table 14 DO-181E section 2.2.13.1.2 e amendment***

**A1.2.3.7** Interrogation Acceptance Protocol Changes (All-Call reply capability)

**A1.2.3.7.1** The transponder All-Call interrogation reply acceptance requirements are reduced to reply only to ATCRBS Mode C (P1-P3) interrogations. The purpose is to reduce the reply rate of TABS while maintaining TCAS and TAS interoperability. The requirements of this TSO are identical to RTCA/DO-181E except for the changes shown below.

**A1.2.3.7.2** RTCA/DO-181E, section 2.2.18.2.2 b, Interrogation Acceptance Protocol (Figure 2-12) is amended as shown in Table 15.

| DO-181E text | Modified text for this TSO |
|---|---|
| All-Call Address – If the address extracted from the received interrogation consists of 24 ONEs and UF=11, the transmission is a Mode S-Only All-Call and the received interrogation Shall **be** accepted ~~according to "i" below unless the lockout protocol is in effect. Mode S-Only All-Call Shall not be accepted (no replies) when in the on-the-ground state (consistent with the CA, VS and FS fields)~~ | All-Call Address –If the address extracted from the received interrogation consists of 24 ONEs and UF=11, the transmission is a Mode S-Only All-Call and the received interrogation SHALL **not** be accepted. |

***Table 15 DO-181E section 2.2.18.2.2 b amendment***

**A1.2.3.7.3** RTCA/DO-181E, section 2.2.18.2.2 c, Interrogation Acceptance Protocol (Figure 2-12) is amended as shown in Table 16.

| DO-181E text | Modified text for this TSO |
|---|---|
| ATCRBS/Mode S All-Call – An ATCRBS/Mode S All-Call interrogation (1.6 microseconds $P_4$) Shall be ~~accepted unless the $T_D$ timer is running or side lobe suppression is in effect or when in the "on-the-ground" state (consistent with the CA, VS and FS fields).~~ | ATCRBS/Mode S All-Call – An ATCRBS/Mode S All-Call interrogation (1.6 microseconds $P_4$) SHALL **not** be accepted. |

***Table 16 DO-181E section 2.2.18.2.2 c amendment***

**A1.2.3.8** RTCA/DO-181E, section 2.2.18.2.2 g, Interrogation Acceptance Protocol, paragraph g, All-Call Lockout Conditions is amended as shown in Table 17.

| DO-181E text | Modified text for this TSO |
|---|---|
| All-Call Lockout Conditions – On receipt of a Mode S-Only All-Call (UF=11) ~~containing an Interrogator Code (IC and CL fields) corresponding to the designator of a running $T_L$~~ timer, the interrogation Shall not be accepted. ~~unless the contained PR code is 8 through 12 and the "on-the-ground" report (CA, VS or FS field) does not include the ground condition. Upon receipt of a Mode S-Only All-Call (UF=11) containing II=0, the interrogation **Shall** be accepted if the $T_D$ timer is not running or if the received PR code is 8 through 12 and the "on-the-ground" report (CA, VS or FS field) does not include the ground condition.~~ | All-Call Lockout Conditions – On receipt of a Mode S-Only All-Call (UF=11) the interrogation SHALL **not** be accepted. |

***Table 17 DO-181E section 2.2.18.2.2 g amendment***

**A1.2.3.9** RTCA/DO-181E, section 2.2.18.2.2 i, Interrogation Acceptance Protocol Stochastic All-Calls should not be implemented in Class A TABS.

**A1.2.3.10** Two new sections are added here to explicitly define interrogation acceptance criteria for TABS.

**A1.2.3.10.1** RTCA/DO-181E, section 2.2.18.2.2 L, Interrogation Acceptance Protocol (Figure 2-12) is added as shown in Table 18.

| DO-181E text | Modified text for this TSO |
|---|---|
| None | **ATCRBS Mode A Rejection – ATCRBS Mode A interrogations (P1-P3 spacing 8 microseconds) SHALL not be accepted. Recovery from a Mode A interrogation shall adhere to the requirements of section 2.2.7.2 defined for recovery from a desensitizing pulse.** |

***Table 18 DO-181E section 2.2.18.2.2 L addition***

**A1.2.3.10.2** RTCA/DO-181E, section 2.2.18.2.2 m, Interrogation Acceptance Protocol (Figure 2-12) is added to as shown in Table 19. This change reduces the range at which addressed Mode S ground interrogations would be replied to. The intent is to reduce the reply rate of the TABS. Sensitivity to TCAS interrogations are not affected.

| DO-181E text | Modified text for this TSO |
|---|---|
| None | **Ground-to-Air Mode S Acceptance – Mode S interrogations, excluding UF=0 SHALL be accepted at the Mode S MTL (§2.2.2.4 b) +3dB ± 1dB.** |

***Table 19 DO-181E section 2.2.18.2.2 m addition***

**A1.2.3.11** RTCA/DO-181E, section 2.2.18.2.3, Interrogation Reply Coordination is amended as shown in Table 20.

| **DO-181E text** | |
|---|---|
| The transponder SHALL generate replies as follows, except when in the on-the-ground state: | |
| Interrogations | Replies |
| ATCRBS Mode A | 4096 Codes |
| ATCRBS Mode C | Altitude Codes |
| ATCRBS Mode A/Mode S All-Call | Reply is DF=11 |
| ATCRBS Mode C/Mode S All-Call | Reply is DF=11 |
| Mode S-only All-Call (UF=11) | Reply is DF=11 |
| **Modified text for this TSO** | |
| The transponder SHALL generate replies as follows, except when in the on-the-ground state: | |
| Interrogations | Replies |
| ATCRBS Mode A | **SHALL not reply** |
| ATCRBS Mode C | Altitude Codes |
| ATCRBS Mode A/Mode S All-Call | **SHALL not** Reply |
| ATCRBS Mode C/Mode S All-Call | **SHALL not** Reply |
| Mode S-only All-Call (UF=11) | **SHALL not** Reply |

***Table 20 DO-181E section 2.2.18.2.3 amendment***

**A1.2.3.12** RTCA/DO-181E, section 2.2.18.2.4, Lockout Protocol should not be implemented in Class A TABS.

**A1.2.3.13** RTCA/DO-181E, section 2.2.18.2.5, Multisite Lockout Protocol should not be implemented in Class A TABS.

**A1.2.3.14** RTCA/DO-181E, section 2.2.18.2.7, Flight Status and Vertical Status Protocols amended as shown in Table 21.

| DO-181E text | Modified text for this TSO |
|---|---|
| Mode S-equipped aircraft Shall report details of their flight status. The source of and the rules for such reports are as follows:<br>a. Alert – The transponder Shall transmit the 4096 identification code ~~in ATCRBS Mode A replies and~~ in the ID field of downlink format DF=5. ~~This code can be changed by the pilot, and~~ when a change is made an alert condition Shall be established. If the identification code is changed to 7500, 7600 or 7700, the alert condition Shall be permanent. If the identification code is changed to any other value, the alert condition Shall be temporary and self-canceling after 18 ±1 seconds ($T_C$ timer). The $T_C$ timer Shall be retriggered and continued for 18 ±1 seconds after any change has been accepted by the transponder function. The alert condition Shall be reported in the FS field. The permanent alert condition Shall be terminated and replaced by a temporary alert condition when the identification code is set to a value other than 7500, 7600 or 7700. | Mode S-equipped aircraft SHALL report details of their flight status. The source of and the rules for such reports are as follows:<br>a. Alert – The transponder SHALL transmit the 4096 identification code in the ID field of downlink format DF=5. When a change is made an alert condition SHALL be established. If the identification code is changed to 7500, 7600 or 7700, the alert condition SHALL be permanent. If the identification code is changed to any other value, the alert condition SHALL be temporary and self-canceling after 18 ±1 seconds ($T_C$ timer). The $T_C$ timer SHALL be retriggered and continued for 18 ±1 seconds after any change has been accepted by the transponder function. The alert condition SHALL be reported in the FS field. The permanent alert condition SHALL be terminated and replaced by a temporary alert condition when the identification code is set to a value other than 7500, 7600 or 7700. |

***Table 21 DO-181E section 2.2.18.2.7 amendment***

**A1.2.3.15** RTCA/DO-181E, section 2.2.18.2.9, All-Call Reply Protocol should not be implemented in Class A TABS.

**A1.2.3.16** RTCA/DO-181E, section 2.2.19.1, Minimum Level 2 Transponder Requirements amended as shown in Table 22.

| DO-181E text | Modified text for this TSO |
|---|---|
| The operational functions described in §1.4.3.2 require that this transponder Shall, in addition to the functions of the Level 1 transponder:<br>a. Process uplink and downlink formats DF=16, UF=DF=20 and 21 (Figure 2-14).<br>The format UF=16 ~~is optional.~~<br>~~Note:UF=16 is supported by transponders connected to an on-board operational TCAS (see §2.2.22).~~<br>b. ~~Receive broadcast transmissions from sensors (§2.2.19.1.11).~~<br>c. Follow the protocols for:<br>~~Comm-A (see §2.2.19.1.10).~~<br>Comm-B (see §2.2.19.1.12).<br>~~Comm-U/V (air-air) (see §2.2.19.1.16).~~<br>~~Multisite message operation (see §2.2.19.2).~~<br>Report Codes 4 through 7 in the CA field (see §2.2.14.4.6).<br>TCAS crosslink capability (see §2.2.19.1.18). | The operational functions described in §1.4.3.2 require that this transponder SHALL, in addition to the functions of the Level 1 transponder:<br>a. Process uplink and downlink formats DF=16, UF=DF=20 and 21 (Figure 2-14).<br>The format UF=16 **SHALL not be accepted. TABS SHALL not be installed with an onboard TCAS system.**<br>b. **Requirement Deleted.**<br>c. Follow the protocols for:<br>Comm-B (see §2.2.19.1.12.1 – §2.2.19.1.12.3).<br>Report Codes 4 through 7 in the CA field (see §2.2.14.4.6).<br>TCAS crosslink capability (see §2.2.19.1.18). |

***Table 22 DO-181E section 2.2.19.1 amendment***

**A1.2.3.17** RTCA/DO-181E, section 2.2.19.1.3, Information Transfer should not be implemented in Class A TABS.

**A1.2.3.18** RTCA/DO-181E, section 2.2.19.1.4, Interrogation-Reply Coordination is amended per Table 23. Equipment using Minimum Level 2 Transponder Requirements SHALL follow the text in DO-181E as written.

| **DO-181E text** | |
|---|---|
| The transponder SHALL generate replies to interrogations as follows: | |
| Interrogation | Reply |
| ATCRBS Mode A (see Note) | ~~4096 Codes~~ |
| ATCRBS Mode C (see Note) | Altitude Codes |
| ATCRBS/Mode S All-Calls (see Note) | ~~DF=11~~ |
| UF=4 and UF=5 | as below |
| UF=11 (see Note) | ~~DF=11~~ |
| UF=20 and UF=21 | as below |
| Broadcast | None |
| **Modified text for this TSO** | |
| The transponder SHALL generate replies to interrogations as follows: | |
| Interrogation | Reply |
| ATCRBS Mode A (see Note) | **SHALL not reply** |
| ATCRBS Mode C (see Note) | Altitude Code |
| ATCRBS/Mode S All-Calls (see Note) | **SHALL not reply** |
| UF=4 and UF=5 | as below |
| UF=11 (see Note) | **SHALL not reply** |
| UF=20 and UF=21 | as below |
| Broadcast | None |

***Table 23 DO-181E section 2.2.19.1.4 amendment***

**A1.2.3.19** The Lockout Protocol described in RTCA/DO-181E, section 2.2.19.1.5 should not be implemented in Class A TABS.

**A1.2.3.20** The UM Protocol described in RTCA/DO-181E, section 2.2.19.1.9, should not be implemented in Class A TABS.

**A1.2.3.21** The Comm-A Protocol described in RTCA/DO-181E, section 2.2.19.1.10, should not be implemented in Class A TABS.

**A1.2.3.22** The Broadcast Protocol described in RTCA/DO-181E, section 2.2.19.1.11 should not be implemented in Class A TABS.

**A1.2.3.23** The Air-Initiated Comm-B Protocol described in RTCA/DO-181E, section 2.2.19.1.12.4 should not be implemented in Class A TABS.

**A1.2.3.24** The Comm-B Broadcast Protocol described in RTCA/DO-181E, section 2.2.19.1.12.5 should not be implemented in Class A TABS.

**A1.2.3.25** The Updating the Data Link Capability Report described in RTCA/DO-181E, section 2.2.19.1.12.6.3 should not be implemented in Class A TABS.

**A1.2.3.26** The Change of Aircraft Identification described in RTCA/DO-181E, section 2.2.19.1.13.e should not be implemented in Class A TABS.

**A1.2.3.27** Linked Comm-A Coding described in RTCA/DO-181E, section 2.2.19.1.14 should not be implemented in Class A TABS.

**A1.2.3.28** The Comm-U/V Protocol described in RTCA/DO-181E, section 2.2.19.1.16, should not be implemented in Class A TABS.

**A1.2.3.29** The Data Handling Interfaces described in RTCA/DO-181E, section 2.2.19.1.17, should not be implemented in Class A TABS.

**A1.2.3.30** The Multisite Message Protocol described in RTCA/DO-181E, section 2.2.19.2 should not be implemented in Class A TABS.

**A1.2.3.31** Surveillance Identifier (SI) requirements contained in RTCA/DO-181E, section 2.2.24.2 should not be implemented in Class A TABS.

**A1.2.3.32** The Elementary Surveillance (ELS) Compliant Transponder, requirements in RTCA/DO-181E, section 2.2.24 do not apply to TABS equipment. TABS SHALL not claim ELS compliance. Changes made to ELS registers do not need to be indicated via a Comm-B broadcast. If one or more of the ELS registers are supported, then section 2.2.24 requirements SHALL apply except sections 2.2.24 b 4, 2.2.24 c, 2.2.24.2, 2.2.24.3.2.5, and 2.2.24.3.4 do not apply.

**A1.2.3.33** The Enhanced Surveillance (EHS) Compliant Transponders, requirements in RTCA/DO-181E, section 2.2.25 do not apply to TABS. TABS equipment SHALL not claim EHS compliance. Changes made to EHS registers do not need to be indicated via a Comm-B broadcast. If one or more of the EHS registers are supported, then section 2.2.25 requirements SHALL apply except sections 2.2.25.1.2.4 and 2.2.25.2.3 do not apply. Also, section 2.2.25, paragraph 6 *"Transponder capable of supporting EHS…"*, must support ELS per **A1.2.3.32** of this TSO.

### A1.2.4 Altitude Source Function Requirements (For Class A Devices)

**A1.2.4.1** The altitude source function must meet the performance requirements of TSO-C88b, *Automatic Pressure Altitude Reporting Code-Generating Equipment*, dated February 6, 2007. It is recommended that the altitude source provide 25 foot or better resolution.

### A1.2.5 ADS-B OUT Function Requirements Derived From DO-260B, including Corrigendum-1, (For Class A Devices)

**A1.2.5.1** The ADS-B OUT function must be 1090 Extended Squitter (ES) OUT, to support TCAS surveillance. The 1090ES OUT function must meet the Minimum Performance Standards (MPS) qualification and documentation requirements in RTCA/DO-260B, *Minimum Operational Performance Standards for 1090 MHz Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Services – Broadcast (TIS-B),* dated December 2, 2009, including Corrigendum-1, section 2, dated December 13, 2011, for a Class B0 ADS-B OUT transmitter with the following modifications.

**A1.2.5.2** RTCA/DO-260B, including Corrigendum-1, section 2, dated December 13, 2011, Paragraph 2.2.2.1 c, Mode S Transponder Based Transmitters is amended as shown in Table 24.

| DO-260B text | Modified text for this TSO |
|---|---|
| If the ADS-B transmitter is based on Mode S transponders, then for transponder functions it Shall comply with RTCA/DO-181D (EUROCAE ED-73C) for each class of transponder specified in the latest version of FAA TSO C112 (ETSO 2C112) | ~~If the ADS-B transmitter is based on Mode S transponders, then for~~ **The** transponder function~~s~~ SHALL comply with RTCA/DO-181E (EUROCAE ED-73**E**) for each class of transponder specified in the latest on of FAA TSO C112 (ETSO 2C112), except where modified by **Appendix 1** of this TSO. |

***Table 24 DO-260B section 2.2.2.1 c amendment***

**A1.2.5.3** The output power SHALL be as specified in RTCA/DO-260B, including Corrigendum-1, dated Dec 13, 2011, section 2.2.2.2.10.1.a. for Class A0 and B0 equipment. The RF Peak Output power SHALL be at least 18.5 dBW (70 watts).

**A1.2.5.4** Broadcast of the, ADS-B Surface Position Messages defined in RTCA/DO-260B including Corrigendum-1, section 2.2.3.2.4 is optional.

**A1.2.5.5** RTCA/DO-260B including Corrigendum-1, section 2.2.3.2.7.2, Aircraft Operational Status Messages is amended as shown in Table 25.

| DO-260B text | Modified text for this TSO |
|---|---|
| The "Aircraft Operational Status Message" is used to provide the current status of the aircraft. The format of the Aircraft Operational Status Message shall be as specified in Figure 2-11, while further definition of each of the subfields is provided in the subsequent paragraphs. | The "Aircraft Operational Status Message" is used to provide the current status of the aircraft. The format of the Aircraft Operational Status Message shall be as specified in Figure 2-11, while further definition of each of the subfields is provided in the subsequent paragraphs. **Broadcast of Aircraft Operational Status Message subtype=1, Surface Messages, is optional.** |

***Table 25 Aircraft Operational Status Message***

**A1.2.5.6** When TABS is installed with a position source meeting the Class B requirements of this TSO and transmitting a valid position, the transmitted NIC SHALL be set to 6 (0.5 NM), reference RTCA/DO-260B including Corrigendum-1, dated December 13, 2011, section 2.2.8.1.6. The transmitted SIL SHALL be set to 1, (1x10-3/ hr), reference RTCA/DO-260B including Corrigendum-1, dated December 13, 2011, section 2.2.5.1.40. When TABS is installed with a position source compliant with TSO-C145, TSO-C146, TSO-C196, TSO-C204, TSO-C205 or TSO- 206, NIC and SIL SHALL be set in accordance with RTCA/DO-260B

including Corrigendum-1, dated December 13, 2011. When position is not valid, NIC and SIL SHALL be set to zero.

**A1.2.5.7** The System Design Assurance (SDA), SHALL be set to 1 reference RTCA/DO-260B, including Corrigendum-1, dated December 13, 2011, section 2.2.5.1.50. The probability of an undetected fault causing transmission of false or misleading information SHALL be $\leq 1x10^{-3}$.

**A1.2.5.8** Navigation Accuracy Category for Position, (NACp) SHALL be derived from the Horizontal Figure of Merit (HFOM) in accordance with RTCA/DO-260B, including Corrigendum-1, dated December 13, 2011, section A.1.4.9.9, however, TABS Class B position sources may not provide HFOM directly. When HFOM is not available directly, HFOM SHALL be derived from Horizontal Dilution of Precision (HDOP) according to the following formula: HFOM = 2 * HDOP * User Equivalent Range Error (UERE), where the UERE is 6 meters. This UERE is based on typical single frequency (L1) receiver performance and an assumption of mid-latitude atmospheric propagation. Although the real-time UERE may fluctuate, this assumption is sufficient to support the TABS use case. (Ref *Global Positioning System Signals, Measurements and Performance* by Pratap Misra and Per Enge, copyright 2001).

**A1.2.5.9** When a TABS is installed with a position source meeting the Class B requirements of this TSO and transmitting valid position, the transmitted Navigation Accuracy Category for Velocity, (NACv) SHALL be set to 1 (10 m/s) reference RTCA/DO-260B including Corrigendum-1, dated December 13, 2011, section 2.2.5.1.19. When position is not valid, NACv SHALL be set to zero.

**A1.2.5.10** Geometric Vertical Accuracy (GVA) SHALL be derived from Vertical Figure of Merit, (VFOM) in accordance with RTCA/DO-260B including Corrigendum-1, dated December 13, 2011, section 2.2.3.2.7.2.8. Class B position sources may not provide VFOM directly. When VFOM is not available directly, VFOM SHALL be derived from Vertical Dilution of Precision (VDOP) according to the following formula: VFOM = 2 * VDOP * UERE where the UERE is 6 meters.

**A1.2.5.11** The Type Code 31, Operational Status Message, subfield "Airborne Capability Class Code" SHALL be changed to indicate the device is a TABS.

**A1.2.5.11.1** The Operational Status Message SHALL be modified to indicate that it meets the performance standards of this TSO. DO-260B, including Corrigendum-1, dated December 13, 2011, paragraph 2.2.18.4.7 and figure 2-40 is modified by this TSO. Message bits 53-54, (ME Bits 21-22), SHALL describe the capabilities of the TABS per Table 26. Set bit 54 to 1 (one) to indicate that either TABS Class A, Class B, or both classes of equipment are installed.

| Bit 53 | Bit 54 | Description |
|---|---|---|
| 0 | 0 | Not TABS equipped |
| 0 | 1 | TABS Equipped |
| 1 | 0 | TABS device (reserved for future use) |
| 1 | 1 | TABS device (reserved for future use) |

***Table 26 DO-260B Airborne Capability Class Message format***

### A1.2.6 GNSS Position Source Function Requirements (For Class B Devices)

**A1.2.6.1** Manufacturers may use commercial off the shelf (COTS) GNSS position sources to meet the performance of this TSO as long as the sensor meets the requirements in this section. The position source must be capable of using Satellite-Based Augmentation System (SBAS) corrections and health messages to detect and correct satellite range errors. In areas where SBAS is not available or out of service, the TABS may continue to operate. The regional airspace authority will determine what operational impacts this may have on air-to-ground usage of TABS equipment. The GPS constellation experiences a significant ramp error approximately once a year. During these events, a chipset which uses SBAS will detect and either correct or exclude the faulty satellite. Refer to RTCA/DO-229D when interpreting SBAS related requirements.

**A1.2.6.2** The GNSS position source SHALL provide a GPS only solution for use by the TABS ADS-B function. The FAA has not evaluated the performance of other GNSS systems for use in support of aviation intended functions. This TSO will be updated once sufficient analysis has been done to show that other GNSS are appropriate for use by TABS equipment. Note, the GPS only solution refers to the use of the GPS satellite constellation, it does not exclude augmentation of the GPS solution, such as provided by SBAS or GBAS systems.

**A1.2.6.3** The GNSS horizontal position error SHALL not exceed 30 meters, 95th percentile, when the Horizontal Dilution of Precision (HDOP) is 2.5 or less. The GNSS position source SHALL either transmit a Horizontal Figure of Merit (95%) (HFOM) or a HDOP metric.

> **Note**: The 30m horizontal position fixing error requirement assumes a UERE of 6 meters, consistent with section **A1.2.5.8**.

**A1.2.6.4** The GNSS position source SHALL detect a pseudorange step greater than 700 meters. If a step of greater than 700 meters is detected, measurements from the affected satellite SHALL be excluded.

**A1.2.6.5** The GNSS position source SHALL be capable of transmitting horizontal velocity measurements more accurate than 10 m/s, 95th percentile.

**A1.2.6.6** The GNSS position source SHALL not transmit false or misleading data in the presence of broadband interference. There is no minimum interference rejection requirement for TABS equipment and loss of position in the presence of interference is acceptable behavior.

**A1.2.6.7** The GNSS position source SHALL not use SBAS corrections when the SBAS satellite is broadcasting message type 0.

**A1.2.6.8** The GNSS position source SHALL exclude satellites with UDREI=15 reported in the SBAS fast corrections.

**A1.2.6.9** The GNSS position source SHALL apply SBAS fast and long term corrections when available.

**A1.2.6.10** The GNSS position source SHALL be capable of transmitting geometric altitude, Height Above the Ellipsoid (HAE), measurements more accurate than 45 meters, 95th percentile when the Vertical Dilution of Precision (VDOP) is 3.7 or less. The GNSS position source SHALL either transmit a Vertical Figure of Merit (95%) (VFOM) or a Vertical Dilution of Precision (VDOP) metric.

> **Note**: The 45m vertical position fixing error requirement assumes a UERE of 6 meters, consistent with section **A1.2.5.10.**

### A1.2.7 Antenna Function Requirements

**A1.2.7.1** The requirements for transponder antennas are specified in TSO-C112e. The requirements for GNSS antennas are specified in TSO-C190. The antennas should be designed to meet the performance specified in the applicable TSO. However, the TABS may benefit significantly in installation costs from implementations where the antennas are integrated in the TABS equipment. Small degradations in antenna performance may be acceptable as a trade-off for installation cost.

**A1.2.7.2** Antennas may be installed internally on aircraft that are transparent to radio frequencies. An internal antenna may not be appropriate on aircraft with a metal hull. If an antenna is installed internally, testing will need to be conducted to ensure the TABS is not negatively impacted and installation guidance must accompany the unit to ensure the system is properly fitted to the aircraft.

**A1.2.7.3** Because TABS may be installed on a radio frequency (RF) transparent fuselage near a pilot or passenger, or in a cockpit in close proximity to a pilot or passenger, consideration must be given to antenna placement to ensure it does not pose a hazard to humans or combustible materials. Manufacturers must provide installation guidance describing the minimum safe distance the antenna can be to the nearest human body or if applicable, combustible material. **Appendix 3** of this TSO provides a more in depth discussion of this subject based on FCC and European documents.

### A1.2.8 Form factor and power

**A1.2.8.1** An ideal implementation of the TABS would be a single integrated unit with minimal connections to the airframe, such as; mechanical mounting, power, and static air source. Where the equipment might be shared between multiple airframes, the mechanical mounting could incorporate an airframe specific configuration module (containing such items as the ICAO 24 bit aircraft address), and be designed such that no tools are required to remove or install the TABS.

**A1.2.8.2** Low power consumption design is important. Designs specifically intended for long term battery operation are ideal. If the TABS is battery powered, it should be designed to provide system integrity commensurate with the failure condition category / classification stated in para **3.b**.

# Appendix 2. Test Requirements

## A2 Testing Introduction

### A2.1 Testing Intent

**A2.1.1** This appendix provides an acceptable means to verify the major functions of the TABS.

**A2.1.2** The TABS is not intended to accept and reply to any UF=11 All-Call interrogations. RTCA/DO-181E tests like 2.4.2.1 Step 6 that use the Mode S Only All-Call interrogation (UF=11) will need to use a different interrogation, such as a UF=0 interrogation.

### A2.2 Testing Requirements

**A2.2.1** The tests defined here are derived from tests in the reference documents or written here to ensure compliance with the intended capabilities of TABS equipment. These tests are one acceptable means to demonstrate the equipment meets the functional requirements defined in **Appendix 1** of this TSO. Functionality not modified by **Appendix 1** should be verified by the test outlined in the applicable standards, e.g. RTCA/DO-181E.

**A2.2.2** Table 27 provides notes in italics and parenthesis explaining how to read the tables that modify the text in the source documents.

| (Source document reference) | Modified text for this TSO |
|---|---|
| (This is a copy of the original text from the source document. Material to be deleted from this original text is marked with ~~strikethrough formatting~~.) | (This is the requirement for this TSO. Modifications to the source text are marked in **bold and underlined** to assist in identifying changes). |

***Table 27 (Source document reference) (type of change)***

#### A2.2.3 Testing Transponder Function Requirements Derived From DO-181E (For Class A Devices)

**A2.2.3.1** Testing of the transponder function of the TABS should follow the tests outlined in RTCA, Inc. document RTCA/DO-181E, *Minimum Operational Performance Standards for Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment*, dated March 17, 2011, section 2.3, 2.4, and 2.5, with the following exceptions:

**A2.2.3.1.1 Testing of Flight Crew Control Functions**

**A2.2.3.1.2** Testing should verify the requirements of RTCA/DO-181E, as modified by paragraph **A1.2.3.1.2** of this TSO have been properly incorporated.

**A2.2.3.1.3** Testing should verify changes made to para 2.1.7 a, in RTCA/DO-181E, per section **A1.2.3.1.3** have been properly incorporated.

**A2.2.3.1.3.1** Testing should verify the requirements of **A1.2.3.1.3**, by performing the test outlined in RTCA/DO-181E section 2.5.4.11. Test results should verify that the 4096 code can be set while on the ground. If the 4096 code can be set in flight, testing should verify the 4096 code can be set while in the air (weight-off-wheels condition) per RTCA/DO-181E section 2.5.4.11.

**A2.2.3.1.3.2** Testing should verify the requirements of **A1.2.3.1.3**, by performing the test outlined in RTCA/DO-181E section 2.5.4.11. Testing should verify that a means of selecting and transmitting Mode 3/A code 7700 (emergency) is provided and tested per RTCA/DO-181E section 2.5.4.11.

**A2.2.3.1.3.3** Testing should verify the requirements of **A1.2.3.1.3**, by performing the test outlined in RTCA/DO-181E section 2.5.4.11. Testing should also verify that a means of selecting and transmitting an alternate Mode 3/A codes is provided and tested per RTCA/DO-181E section 2.5.4.11.

**A2.2.3.1.4** Testing should verify the requirements of **A1.2.3.1.4**, by performing the test outlined in RTCA/DO-181E 2.5.4.3.b. Test results should verify aircraft without a means of determining air/ground state, reports in-the-air at all times. Aircraft with an automatic means to determine the air/ground state, must verify that the air/ground state is set properly. Perform the test outlined in RTCA/DO-181E 2.5.4.3.b. If capable of determining the air-ground state, test results should verify the aircraft reports in-the-air when in the air, and on-the-ground when on the ground.

**A2.2.3.1.5** Testing should verify the requirements of **A1.2.3.1.5**, have been properly incorporated. If a means of selecting the Standby condition is provided, testing should verify return to normal operation from standby condition is within five seconds.

**A2.2.3.1.6** Testing should verify the requirements of **A1.2.3.1.6**, have been properly incorporated. If a means of initiating the IDENT (SPI) feature is installed, testing shall verify it functions properly per RTCA/DO-181E section 2.5.4.3. (see Also **A1.2.3.5**and **A2.2.3.5**)

**A2.2.3.2 Testing Reply Rate Capability Changes**

**A2.2.3.2.1** This section provides test criteria for the reply rate changes based on assumptions made in section **A1.2.3.2.1**.

**A2.2.3.2.2** Testing should verify changes made to **A1.2.3.2.2**, have been correctly incorporated into TABS equipment.

**A2.2.3.2.2.1** Testing should verify the requirements of **A1.2.3.2.2.1**, of this TSO have been satisfied. Testing outlined in DO-181E, section 2.3.2.2.3 step 1 should verify that the transponder be able to continuously generate at least 100 ATCRBS 15-pulse replies per second.

**A2.2.3.2.2.2** Testing should verify the requirements of **A1.2.3.2.2.2**, of this TSO have been satisfied. Testing outlined in DO-181E, section 2.3.2.2.3 step 3 should verify that the transponder is capable of a peak reply rate of 150 ATCRBS 15-pulse replies per second for a duration of 100 milliseconds.

**A2.2.3.2.2.3** Testing should verify changes made to RTCA/DO-181E section 2.2.3.4.2.a have been correctly incorporated into TABS equipment per **A1.2.3.2.2.3**.

**A2.2.3.2.2.3.1** Testing should verify the requirements of RTCA/DO-181E, section 2.2.3.2.4.2.a, as modified by paragraph **A1.2.3.2.2.3** of this TSO have been satisfied. Testing outlined in DO-181E, section 2.3.2.2.3 step 2 should verify that the transponder provide at least 29 short Mode S replies in any 1-second interval.

**A2.2.3.2.2.3.2** Testing should verify the requirements of RTCA/DO-181E, section 2.2.3.2.4.2.a, as modified by paragraph **A1.2.3.2.2.3** of this TSO have been satisfied. Testing outlined in DO-181E, section 2.3.2.2.3 step 3 should verify that the transponder provide at least 10 short Mode S replies in a 100-millisecond interval.

**A2.2.3.2.2.3.3** Testing should verify the requirements of RTCA/DO-181E, section 2.2.3.2.4.2.a, as modified by paragraph **A1.2.3.2.2.3** of this TSO have been satisfied. Testing outlined in DO-181E, section 2.3.2.2.3 step 4 should verify that the transponder provide at least 5 short Mode S replies in a 25-millisecond interval.

**A2.2.3.2.2.3.4** Testing should verify the requirements of RTCA/DO-181E, section 2.2.3.2.4.2.a, as modified by paragraph **A1.2.3.2.2.3** of this TSO have been satisfied. Testing outlined in DO-181E, section 2.3.2.2.3 step 5 should verify that the transponder provide at least 3 short Mode S replies in a l.6-millisecond interval.

**A2.2.3.2.2.4** Testing should verify changes made to RTCA/DO-181E section 2.2.3.4.2.b have been correctly incorporated into TABS equipment per **A1.2.3.2.2.4**.

**A2.2.3.2.2.4.1** Testing should verify the requirements of RTCA/DO-181E, section 2.2.3.2.4.2.b, as modified by paragraph **A1.2.3.2.2.4**, of this TSO have been satisfied. Testing outlined in DO-181E, section 2.3.2.2.3 step 2 should verify that the transponder provide at least 10 of the 29 Mode S replies as long format replies in any 1-second interval.

**A2.2.3.2.2.4.2** Testing should verify the requirements of RTCA/DO-181E, section 2.2.3.2.4.2.b, as modified by paragraph **A1.2.3.2.2.4**, of this TSO have been satisfied. Testing outlined in DO-181E, section 2.3.2.2.3 step 3 should verify that the transponder provide at least 4 of the 10 Mode S replies as long format replies in a 100-millisecond interval.

**A2.2.3.2.2.4.3** Testing should verify the requirements of RTCA/DO-181E, section 2.2.3.2.4.2.b, as modified by paragraph **A1.2.3.2.2.4**, of this TSO have been satisfied. Testing outlined in DO-181E, section 2.3.2.2.3 step 4 should verify that the transponder provide at least 3 of the 5 Mode S replies as long format replies in a 25-millisecond interval.

**A2.2.3.2.2.4.4** Testing should verify the requirements of RTCA/DO-181E, section 2.2.3.2.4.2.b, as modified by paragraph **A1.2.3.2.2.4**, of this TSO have been satisfied. Testing outlined in DO-181E, section 2.3.2.2.3 step 5 should verify that the transponder provide at least 2 of the 4 Mode S replies as long format replies in a l.6-millisecond interval

**A2.2.3.3 Testing Reply Rate Limiting Changes**

**A2.2.3.3.1** Testing should verify the requirements of RTCA/DO-181E, section 2.2.7.3.1, as modified by paragraph **A1.2.3.3.1**, of this TSO have been satisfied. Testing outlined DO-181E section 2.4.2.2.5 step 1 should be performed to verify the unit does not reply to Mode A interrogations.

**A2.2.3.3.2** Testing should verify the requirements of RTCA/DO-181E, section 2.2.7.3.1, as modified by paragraph **A1.2.3.3.2** of this TSO have been satisfied. Testing outlined in

DO-181E section 2.4.2.2.5 step 1 should be performed to verify the unit is capable of between 100 continuous ATCRBS Mode C replies per second and the maximum continuous rate of which the transponder is capable, or 200 replies per second, whichever is less, without regard to the number of pulses in each reply. Sensitivity reduction SHALL apply only to the receipt of ATCRBS interrogations.

**A2.2.3.4** Testing should verify the requirements of RTCA/DO-181E, section 2.2.13.1.2 c, as modified by paragraph **A1.2.3.4** of this TSO have been satisfied. Testing should show airborne status is set to in the air unless the aircraft is air/ground determination capable. If the aircraft can determine air/ground state, testing should show this capability determines on the ground when on the ground and in the air when in the air.

**A2.2.3.5** Testing should verify the requirements of RTCA/DO-181E, section 2.2.13.1.2 d, as modified by paragraph **A1.2.3.5** of this TSO have been satisfied. If the aircraft is capable of providing SPI, follow the test outlined in **A2.2.3.1.6** of the TSO to verify it functions properly per RTCA/DO-181E section 2.5.4.3. (See also, section **A1.2.3.1.6** and **A2.2.3.1.6**

**A2.2.3.6** Testing should verify the requirements of RTCA/DO-181E, section 2.2.13.1.2 e, as modified by paragraph **A1.2.3.6** of this TSO have been satisfied. Testing should show the Aircraft ID loaded while on the ground is broadcast. If aircraft ID can be changed in flight, testing should verify aircraft ID can be changed in flight and the new aircraft ID is broadcast.

**A2.2.3.7 Testing of Interrogation Acceptance Protocol Changes (All-Call reply capability)**

**A2.2.3.7.1** Except where noted here, testing of the Interrogation Acceptance Protocol capability should follow that called out in RTCA/DO-181E. Testing of the Interrogation Acceptance Protocol capability should be modified from those called out in RTCA/DO-181E to meet the changes made in **A1.2.3.7.1**.

**A2.2.3.7.2** Testing should verify the requirements of RTCA/DO-181E, section 2.2.18.2.2 b, as modified by paragraph **A1.2.3.7.2** of this TSO have been satisfied. Various tests in RTCA DO-181E section 2.4 utilize the Mode S Only All-Call interrogation and expected reply to execute the test procedure. A discrete interrogation should be used as a substitute for these test procedures. Testing outlined in RTCA/DO-181E, section 2.5.4.2 should verify that UF=11 interrogations are not accepted.

**A2.2.3.7.3** Testing should verify the requirements of RTCA/DO-181E, section 2.2.18.2.2 c, as modified by paragraph **A1.2.3.7.3** of this TSO have been satisfied. Testing outlined in RTCA/DO-181E, section 2.5.4.2 should verify that an ATCRBS/Mode S All-Call interrogation (1.6 microseconds $P_4$) is not accepted. The pulse decoder tests in section 2.4.2.5 for ATCRBS/Mode S All-Call interrogation acceptance shall be modified to verify no ATCRBS/Mode S All-Call interrogations that meet the criteria for acceptance in RTCA DO-181E, section 2.2.6.2, produce a reply.

**A2.2.3.8** Testing of the requirements of RTCA/DO-181E, Interrogation Acceptance Protocol, per section 2.5.4.4 and 2.5.4.5 are not required per **A1.2.3.8** of this TSO.

**A2.2.3.9** Testing of the requirements of RTCA/DO-181E, Stochastic All-Calls, per 2.5.4.13 is not required per **A1.2.3.9** of this TSO.

**A2.2.3.10** Testing should verify the modified Mode S MTL requirements added to RTCA/DO-181E, per section **A1.2.3.10**. Test to ensure paragraph 2.2.18.2.2 L, and 2.2.18.2.2 m, have been properly incorporated.

**A2.2.3.10.1** Testing outlined in RTCA/DO-181E, section 2.4.2 should verify that ATCRBS Mode A interrogations (P1-P3 spacing 8 microseconds) are not accepted per **A1.2.3.10.1**. Various tests in RTCA DO-181E section 2.4 utilize Mode A interrogations to execute the test procedure. Mode C interrogations should be used as a substitute for these test procedures. The pulse decoder tests in DO-181E, section 2.4.2.5 for Mode A interrogation acceptance shall be modified to verify that no Mode A interrogations that meet the criteria for acceptance in DO-181E, section 2.2.6.2 produce a reply. Requirement for recovery from a Mode A interrogation per **A1.2.3.10.1** shall be tested according to DO-181E section 2.4.2.6, Step 1 except using a Mode A interrogation from the master and a Mode C interrogation from the slave.

**A2.2.3.10.2** Testing should verify the requirements added to RTCA/DO-181E, paragraph 2.2.18.2.2 m, have been properly incorporated per section **A1.2.3.10.2**. Verify the requirement added by this TSO, by performing the test procedure in RTCA/DO-181E, section 2.4.2.1. step 6, using a UF=0 to verify the Mode S MTL in section 2.2.2.4 b and UF=4, 5, 20 and 21 to verify the modified MTL per **A1.2.3.10.2**.

**A2.2.3.11** Testing should verify the requirements of RTCA/DO-181E, Interrogation Reply Coordination, section 2.2.18.2.3, as modified by **A1.2.3.11** of this TSO are satisfied. Testing outlined in DO-181E section 2.5.4.2 shall be modified to verify the unit does not reply to ATCRBS Mode A interrogations. Test ATCRBS Mode A/Mode S All-Calls, ATCRBS Mode C/Mode S All-Calls or UF=11 interrogations per testing outlined in **A2.2.3.7**and **A2.2.3.10**.

**A2.2.3.12** Testing of RTCA/DO-181E, Lockout Protocol, section 2.2.18.2.4, is not required since TABS devices do not reply to All-Call interrogations per **A1.2.3.12** of this TSO. Testing using interrogations in RTCA/DO-181E section 2.5.4.4 should be performed to verify the unit properly replies to interrogations containing lockout commands from ground interrogations.

**A2.2.3.13** Testing of RTCA/DO-181E, Multisite Lockout Protocol, section 2.2.18.2.5, is not required since TABS devices do not reply to All-Call interrogations per **A1.2.3.13** of this TSO. Testing using interrogations in RTCA/DO-181E section 2.5.4.5 should be performed to verify the unit properly replies to interrogations containing multisite lockout commands from ground interrogations.

**A2.2.3.14** Testing should verify the requirements of RTCA/DO-181E, Flight Status and Vertical Status Protocols, section 2.2.18.2.7, as modified by **A1.2.3.14** of this TSO are satisfied. Testing outlined in DO-181E section 2.5.4.7 should be performed to verify the unit sets the flight status bits properly consistent with the capabilities provided for Mode 3/A code entry per **A1.2.3.1.3**.

**A2.2.3.15** Testing the requirement of RTCA/DO-181E, All-Call Reply Protocol, section 2.2.18.2.9, as modified by **A1.2.3.15** is not required. Testing outlined in DO-181E section 2.5.4.8 does not need to be performed since the TABS does not support the All-Call Protocol.

**A2.2.3.16** Testing should verify the Level 2 Transponder Requirements of RTCA/DO-181E, Minimum Level 2 Transponder Requirements, section 2.2.19.1, as

modified by **A1.2.3.16** of this TSO are satisfied. Testing outlined in RTCA/DO-181E section 2.5.3 should be performed to verify the unit performs per design specifications. Also, testing outlined in RTCA/DO-181E section 2.5.4.17 should be performed to verify the unit does not process DF=16 messages.

**A2.2.3.17** No test is required to verify the requirements of RTCA/DO-181E, Information Transfer, section 2.2.19.1.3, per **A1.2.3.17**.

**A2.2.3.18** Testing should verify the requirements of RTCA/DO-181E, Interrogation-Reply Coordination, section 2.2.19.1.4, as modified by **A1.2.3.18** are met. Use tests in **A2.2.3.7** and **A2.2.3.10** in this TSO to verify the TABS does not reply to ATCRBS Mode A, ATCRBS/Mode S All Calls and UF=11 interrogations.

**A2.2.3.19** Testing of the requirements of RTCA/DO-181E, Lockout Protocol, section 2.2.19.1.5, per section 2.5.4.4, are not required per **A1.2.3.19** of this TSO. Testing should verify the TABS does not perform the UM Protocol per RTCA/DO-181E section 2.5.4.18.

**A2.2.3.20** Since TABS do not support the Comm-B protocol except for GICB extraction requests, the requirements of RTCA/DO-181E, UM Protocol, section 2.2.19.1.9, do not apply, per **A1.2.3.20**. Using a subset of the interrogations identified in RTCA/DO-181E section 2.5.4.18, select 12 interrogations with UF 4, 5, 20 and 21 and containing DI=0, 1 and 7 and verify that the reply contains UM field of ZERO.

**A2.2.3.21** Testing of the requirements of RTCA/DO-181E, Comm-A Protocol, section 2.2.19.1.10, per section 2.5.4.15 are not required per **A1.2.3.21** of this TSO. Testing should verify the TABS does not perform the Com-A Protocol per RTCA/DO-181E section 2.5.4.15.

**A2.2.3.22** Testing of the requirements of RTCA/DO-181E, Broadcast Protocol, section 2.2.19.1.11, as modified by **A1.2.3.22** is not required since TABS do not support this protocol.

**A2.2.3.23** Testing of the requirements of RTCA/DO-181E, Air-Initiated Comm-B Protocol, section 2.2.19.1.12.4, per section 2.5.4.18 is not required per **A1.2.3.23**. To verify GICB extraction requirements, perform the portion of the test procedure of RTCA/DO-181E, section 2.5.4.18 using interrogation patterns 1 to 24, to test the transponder in state 1 of the test matrix to verify proper reply content.

**A2.2.3.24** Testing the requirements of RTCA/DO-181E, Comm-B Broadcast Protocol, section 2.2.19.1.12.5, per 2.5.4.21 is not required per **A1.2.3.24**.

**A2.2.3.25** Testing should verify the requirements of RTCA/DO-181E, Updating the Data Link Capability Report, section 2.2.19.1.12.6.3, as modified by **A1.2.3.25**. Testing should verify the TABS does not perform the Updating the Data Link Capability Report per RTCA/DO-181E, section 2.5.4.33.

**A2.2.3.26** Testing should verify the requirements of RTCA/DO-181E, Change of Aircraft Identification, section 2.2.19.1.13 e, as modified by **A1.2.3.26**. Testing should verify the TABS does not perform the Change of Identification per RTCA/DO-181E, section 2.5.4.19.

**A2.2.3.27** Testing the requirements of RTCA/DO-181E, Linked Comm-A Coding, section 2.2.19.1.14, per 2.5.4.15, is not required per **A1.2.3.27**.

**A2.2.3.28** Testing the requirements of RTCA/DO-181E, Comm-U/V Protocol, section 2.2.19.1.16, per 2.5.4.17, as modified by **A1.2.3.28** is not required.

**A2.2.3.29** Testing the requirements of RTCA/DO-181E, Data Handling Interfaces, section 2.2.19.1.17, per 2.5.4.20, as modified by **A1.2.3.29** is not required.

**A2.2.3.30** Testing the requirements of RTCA/DO-181E, Multisite Message Protocol, section 2.2.19.2, per section 2.5.4.5, as modified by **A1.2.3.30** is not required.

**A2.2.3.31** Testing the requirements of RTCA/DO-181E, Surveillance Identifier (SI), section 2.2.24.2, per 2.6.2, as modified by**A1.2.3.31** is not required.

**A2.2.3.32** Testing the requirements of RTCA/DO-181E, Elementary Surveillance Capability, section 2.2.24 as modified by **A1.2.3.32** is not required**.** If one or more ELS registers are supported, test per RTCA/DO-181E, section 2.6.

**A2.2.3.33** Testing the requirements of RTCA/DO-181E, Enhanced Surveillance Capability, section 2.2.25.3.2, as modified by **A1.2.3.33** is not required. If the unit is Enhanced Surveillance Capability capable test per RTCA/DO-181E, section 2.7.

### A2.2.4 Testing Altitude Source Function Requirements

**A2.2.4.1** Testing of the Altitude Source Function should follow that called out in TSO-C88b, *Automatic Pressure Altitude Reporting Code-Generating Equipment*, dated February 6, 2007.

### A2.2.5 Testing ADS-B OUT Function Requirements (For Class A Devices)

**A2.2.5.1** Testing should verify the ADS-B system performs its intended function per RTCA/DO-260B, Minimum Operational Performance Standards for 1090 MHz Automatic Dependent Surveillance – Broadcast (ADS-B) and Traffic Information Services – Broadcast (TIS-B), dated December 2, 2009, including Corrigendum-1, dated December 13, 2011, except as modified by section **A1.2.5**. Testing should follow the tests outlined in RTCA/DO-260B, including Corrigendum-1, dated December 13, 2011, section 2.3 and 2.4 with the following exceptions:

**A2.2.5.2** Per section **A1.2.5.2**, testing of transponder functions should follow the requirements in section **A1.2.3** and **A2.2.3** of this TSO.

**A2.2.5.3** Testing should verify the System RF Peak Power Output has a peak output level of at least 18.5 dBW (70 watts) per **A1.2.5.3**, reference RTCA/DO-260B, including Corrigendum-1, dated December 13, 2011, RF Peak Power, section 2.2.2.2.10.1 a. Testing outlined in DO-260B, section 2.3.2.2.6.1 step 5 should verify the unit under test provides a peak output power level of at least 18.5 dBW (70 watts).

**A2.2.5.4** If the optional ADS-B Surface Position Messages function is provided, per section, **A1.2.5.4**, testing should verify the ADS-B Surface Position Message is correctly populated and broadcast per RTCA/DO-260B section 2.4.3.2.1.2.2.

**A2.2.5.5** If the optional Typecode 31, subtype 1, Aircraft Operational Status Messages is provided per section **A1.2.5.5**, testing should verify the Aircraft Operational Status Messages is correctly populated and broadcast per RTCA/DO-260B section 2.4.3.2.7.2

**A2.2.5.6** Per section **A1.2.5.6**, testing should verify that NIC=6, and SIL=1 when using position from a Class B position source using test procedures in RTCA/DO-260B, including Corrigendum-1, dated December 13, 2011, sections 2.4.8.1.5, 2.4.5.1.40.

**A2.2.5.7** Testing should verify the System Design Assurance (SDA) is set to 1 to verify the requirement in section **A1.2.5.7**, reference RTCA/DO-260B, including Corrigendum-1, dated December 13, 2011, System Design Assurance (SDA), section 2.2.5.1.50.

**A2.2.5.8** Per section **A1.2.5.8**, testing should verify that Navigation Accuracy Category for Position (NACp) is set according to RTCA/DO-260B including Corrigendum-1, dated December 13, 2011, section 2.4.3.2.7.1.3.8. Testing should verify that the NACp is set appropriately when the position source is providing HDOP and not HFOM.

**A2.2.5.9** If a TABS Class B position source is installed, verify Navigation Accuracy Category Velocity (NACv) is set to 1 (10 m/s) per **A1.2.5.9**.

**A2.2.5.10** Verify Geometric Vertical Accuracy (GVA) is set per **A1.2.5.10**. Testing outlined in RTCA/DO-260B, including Corrigendum-1, dated December 13, 2011, section 2.4.3.2.7.2.8 should verify GVA is set appropriately when the position source is providing VDOP and not VFOM.

**A2.2.5.11** Verify Type Code 31, Airborne Capability Class Message indicates the unit under test is a TABS per **A1.2.5.11**.

### A2.2.6 Testing of GNSS Position Source Function Requirements (For Class B Devices)

**A2.2.6.1** A TABS incorporating a position source that is compliant with TSO-C129, TSO-C145, TSO-C146, TSO-C196, TSO-C204, TSO-C205, or TSO-C206 must also meet the additional ADS-B criteria defined in AC 20-165A Appendix 2, to include any required testing. GNSS position sources that are not compliant with an existing GNSS TSO will need to meet the requirements in paragraph **A1.2.6** of this TSO and verify it meets the minimum requirements by performing the tests outlined in section **A2.2.6** of this TSO. The following tests were derived from a reduced set of requirements and associated tests found in RTCA/DO-229D.

**A2.2.6.2 GPS Only Solution.**

**A2.2.6.2.1** Per para **A1.2.6.2**, verify that the position source provides a GPS-SBAS or GPS Only solution for use by Class A TABS.

**A2.2.6.3 Position Accuracy Tests.**

**A2.2.6.3.1** Two tests are used to verify the horizontal position accuracy to ensure the requirement in para **A1.2.6.3** is met. The first test is a 24 hour static scenario using live satellite signals. The second test uses a GNSS simulator to generate a scenario incorporating both static and dynamic aircraft maneuvers.

**A2.2.6.3.2 24 Hour Accuracy Test.**

**A2.2.6.3.2.1** The equipment SHALL be tested over a 24-hour period using live GPS satellite signals at a surveyed location. The equipment SHALL use an antenna representative of

what will be used in an actual airborne installation. The horizontal position error SHALL be computed for each position estimate output by the equipment.

**A2.2.6.3.2.2** Monitor the sensor provided HFOM and VFOM, or HFOM and VFOM derived from the sensor provided HDOP and VDOP per paragraphs **A1.2.5.8** and **A1.2.5.10.** In order to pass the test, the horizontal position error must be less than 30 meters for at least 95% of the samples and the horizontal accuracy reported must be greater than the actual position error for at least 95% of the samples. In order to pass the test, the vertical position error must be less than 45 meters for at least 95% of the samples and the vertical accuracy reported must be greater than the actual position error for at least 95% of the samples.

**A2.2.6.3.2.3** The horizontal position error SHALL not exceed 0.5 NM at any time during the test.

**A2.2.6.3.2.4** Only those position outputs that are reported as valid by the equipment need to be considered for the accuracy evaluation. In order to pass the test, 99.9% of the position outputs must be reported as valid, excluding those position reports prior to the first position fix.

**A2.2.6.3.3 GPS Simulator-based Accuracy Tests.**

**A2.2.6.3.3.1** The equipment SHALL be tested using a GPS simulator scenario that includes both static and dynamic aircraft maneuvers. The horizontal and vertical position errors SHALL be computed for each position estimate output by the equipment.

**A2.2.6.3.3.2** Monitor the sensor provided HFOM and VFOM, or HFOM and VFOM derived from the sensor provided HDOP and VDOP per paragraphs **A1.2.5.8** and **A1.2.5.10.** In order to pass the test, the horizontal position error must be less than 30 meters for at least 95% of the samples and the horizontal accuracy reported must be greater the actual position error for at least 95% of the samples. In order to pass the test, the vertical position error must be less than 45 meters for at least 95% of the samples and the vertical accuracy reported must be greater than the actual position error for at least 95% of the samples.

**A2.2.6.3.3.3** The horizontal position error SHALL not exceed 0.5 NM at any time during the test.

**A2.2.6.3.3.4 Simulator Scenario Details**

**A2.2.6.3.3.4.1** Only those position outputs that are reported as valid by the equipment need to be considered for the accuracy evaluation. In order to pass the test, 99.9% of the position outputs must be reported as valid, excluding those position reports prior to the first position fix.

**A2.2.6.3.3.4.2** The simulator scenario SHALL use the standard 24 satellite constellation in RTCA/DO-229D Appendix B. The initial position and time should be chosen to ensure the satellite geometry supports the test Pass/Fail criteria and the HDOP is close to 2.5 and VDOP is close to 3.7.

**A2.2.6.3.3.4.3** The simulation SHALL include both stationary and dynamic portions, as follows:

**A2.2.6.3.3.4.3.1** At least 10 minutes of stationary position.

**A2.2.6.3.3.4.3.2** A sequence of different maneuvers, including acceleration to a constant velocity, climbs, descents, and turns.

**A2.2.6.3.3.4.3.2.1** A series of turns should be included to ensure a constantly changing velocity to expose any effects of filtering on the position output.

**A2.2.6.3.3.4.3.3** At least 10 minutes of accelerated maneuvers SHALL be simulated.

**A2.2.6.3.3.4.3.4** Aircraft dynamics are as follows: ground speed = 200kt, horizontal acceleration = 0.58g, vertical acceleration of 0.5g.

**A2.2.6.3.3.4.4** The simulated satellite signals SHALL be set to -134 dBm while position measurements are taken. Signal powers may be increased at the beginning of the scenario to allow for initial acquisition.

**A2.2.6.3.3.4.5** Simulated signals SHALL include ranging errors for atmospheric effects (troposphere and ionosphere) that adhere to approved models. Refer to DO-229D Appendix A Section A.4.2.4 and IS-GPS-200G dated September 5, 2012.

**A2.2.6.3.3.4.6** No interference needs to be simulated.

**A2.2.6.4 Verification of Step Detector.**

**A2.2.6.4.1** The step detector SHALL be tested under static and dynamic conditions to successfully demonstrate the requirement in **A1.2.6.4** is met. If the manufacturer can show by inspection that its equipment's step detection mechanism is insensitive to the type of step (a change in navigation data or a sudden change in code phase), only one type of step need be tested. Nominal satellite signal power (-128 dBm) may be used during these tests.

**A2.2.6.4.2 Static Test.**

**A2.2.6.4.2.1** The step detector test in RTCA/DO-229D section 2.5.3.1 SHALL be performed, with the following exceptions:

**A2.2.6.4.2.2** In order to pass the test, the satellite with the step error should be removed from the position solution within 10 seconds of introducing the pseudorange step AND the horizontal position error of all the valid positions is not to exceed 200 meters throughout the entire test.

**A2.2.6.4.2.3** Instead of introducing a step error on the hardest-to-detect satellite, the test must be performed by introducing a step error on each satellite individually. The pass criteria should be met for each case.

**A2.2.6.4.3 Dynamic Test.**

**A2.2.6.4.3.1** Repeat the Static Test using nominal aircraft dynamics. Nominal aircraft dynamics are defined to be ground speed = 200 kt and horizontal acceleration = 0.58 g. These dynamics can be simulated as a series of turns. The pass criteria from the static test SHALL be used.

**A2.2.6.5 Velocity Accuracy Tests.**

**A2.2.6.5.1** The velocity accuracy tests specified AC 20-138D Appendix 4, sections 4-2, 4-3 and 4-4 SHALL be performed per the requirement in **A1.2.6.5** and show the unit provides an accuracy of 10 m/s or less, at least 95% of the time. It is assumed that the GPS position source does not provide a velocity accuracy output and the TABS will broadcast NACv = 1. Only the tests required to demonstrate a NACv = 1 need be run.

**A2.2.6.6 Interference Tests.**

**A2.2.6.6.1** The equipment SHALL be tested using simulated GPS signals mixed with an interfering signal of gradually increasing power until the equipment loses position to verify the requirement outlined in para **A1.2.6.6**. The horizontal position accuracy will be evaluated.

**A2.2.6.6.2 Simulator Scenario Details.**

**A2.2.6.6.2.1** Use the same simulator scenario set up found in **A2.2.6.3.3.4** with the following exceptions:

**A2.2.6.6.2.2** The interfering signal SHALL be broadband noise with bandwidth of 20 MHz centered on 1575.42 MHz. The initial power spectral density SHALL be -170.5 dBm/Hz (-97.5 dBm total power).

**A2.2.6.6.2.3** The scenario may to be extended to allow sufficient time for increasing interference power.

**A2.2.6.6.3 Test Procedure**

**A2.2.6.6.3.1** Step 1 The interfering signal SHALL initially be turned off.

**A2.2.6.6.3.2** Step 2 The simulator scenario SHALL be engaged and the satellites' RF SHALL be turned on.

**A2.2.6.6.3.3** Step 3 The equipment SHALL be powered on and initialized. It is assumed that the receiver has obtained a valid almanac for the simulator scenario to be tested prior to conducting these tests.

**A2.2.6.6.3.4** Step 4 The receiver SHALL be allowed to reach steady state. When the receiver has reached steady state, an interfering broadband noise signal of -170.5 dBm/Hz SHALL be applied.

**A2.2.6.6.3.5** Step 5 The interference power SHALL be maintained until the accuracy has reached steady-state. Position measurements and validity indications SHALL be recorded during this interval.

**A2.2.6.6.3.6** Step 6 The power of the interfering signal SHALL be increased by 2 dB and maintained for 200 seconds.

**A2.2.6.6.3.7** Step 7 Go to Step 5 and repeat until the receiver is unable to maintain a position fix.

**A2.2.6.6.4 Pass/Fail Criteria**

**A2.2.6.6.4.1** The horizontal position errors SHALL be computed for each position estimate output by the equipment.

**A2.2.6.6.4.2** The horizontal position error SHALL not exceed 0.5 NM at any time during the test.

**A2.2.6.6.4.3** Only those position outputs that are reported as valid by the equipment need to be considered for the accuracy evaluation. There is no minimum interference rejection requirement for TABS equipment and loss of position in the presence of interference is acceptable behavior.

**A2.2.6.7 Verification of SBAS Message Type 0**

**A2.2.6.7.1** Test to verify the GNSS position source does not use SBAS corrections when the SBAS satellite is broadcasting message type 0 per **A1.2.6.7**.

**A2.2.6.7.2 Simulator Scenario Details**

**A2.2.6.7.2.1** The simulator scenario SHALL use the standard 24 satellite constellation in RTCA/DO-229D Appendix B

**A2.2.6.7.2.2** A single SBAS satellite SHALL be simulated with a fast corrections (MT 2-5) update rate of 6 seconds.

**A2.2.6.7.2.3** At 500 seconds into the scenario, the SBAS satellite SHALL start broadcasting message type 0 for 60 seconds. The message type 0 broadcast SHALL contain message type 2 data (if appropriate for the SBAS service being simulated).

**A2.2.6.7.2.4** The scenario SHALL have a static user position.

**A2.2.6.7.2.5** The simulated satellite signals SHALL be set to a nominal power level (-128 dBm).

**A2.2.6.7.2.6** Simulated signals SHALL include ranging errors for atmospheric effects (troposphere and ionosphere) that adhere to approved models. Refer to DO-229D Appendix A Section A.4.2.4 and IS-GPS-200G dated September 5, 2012.

**A2.2.6.7.2.7** No interference needs to be simulated.

**A2.2.6.7.3 Test Procedure**

**A2.2.6.7.3.1** Step 1 The simulator scenario SHALL be engaged and the satellites' RF SHALL be turned on.

**A2.2.6.7.3.2** Step 2 The equipment SHALL be powered on and initialized. It is assumed that the receiver has obtained a valid almanac for the simulator scenario to be tested prior to conducting the tests.

**A2.2.6.7.3.3** Step 3 Monitor the receiver output for the indication of SBAS use. Verify that the receiver indicates that SBAS is not in use before an SBAS satellite has been acquired.

**A2.2.6.7.3.4** Step 4 Allow the receiver to reach steady state navigation. Verify that the receiver indicates that SBAS is in use before proceeding to the next step.

**A2.2.6.7.3.5** Step 5 500 seconds into the scenario, the SBAS satellite SHALL start broadcasting message type 0.

**A2.2.6.7.3.6** Step 6 Monitor the receiver output for the indication of SBAS use. Verify that the receiver indicates that SBAS is not used within 8 seconds.

**A2.2.6.8 Exclusion of satellites identified by SBAS as unhealthy**

**A2.2.6.8.1** Test to verify the GNSS position source excludes satellites with UDREI=15 reported in the SBAS fast corrections per **A1.2.6.8**. The ability of the position source to exclude unhealthy satellites based on the SBAS UDREI will be tested by injecting a ramp error on a satellite measurement and subsequently broadcasting a SBAS UDREI of 15 ("do not use") for that satellite.

**A2.2.6.8.2 UDREI = 15 in Fast Corrections message (MT 2-5, 24)**

**A2.2.6.8.2.1** The equipment SHALL be tested to verify that the UDREI data contained in the SBAS fast corrections messages (MT 2-5, 24) is used to exclude unhealthy satellites.

> **Note:** The test does not assume that the receiver outputs an indication that the unhealthy satellite has been removed from the position solution. Instead it uses a pass criteria based on horizontal position error.

**A2.2.6.8.2.2 Simulator Scenario Details**

**A2.2.6.8.2.2.1** The simulator scenario SHALL use the standard 24 satellite constellation in RTCA/DO-229D Appendix B.

**A2.2.6.8.2.2.2** A single SBAS satellite SHALL be simulated with a fast corrections (MT 2-5, 24) update rate of 6 seconds. The integrity information message (MT 6) SHALL not be broadcast.

**A2.2.6.8.2.2.3** The simulation start time and location SHALL be such that the resulting HDOP is close to 5.0.

**A2.2.6.8.2.2.4** The simulation SHALL use nominal aircraft dynamics, defined to be ground speed = 200 kt and horizontal acceleration = 0.58 g. These dynamics can be simulated as a series of turns.

**A2.2.6.8.2.2.5** The scenario SHALL allow the receiver time to achieve steady state navigation before introducing any satellite errors.

**A2.2.6.8.2.2.6** The scenario SHALL introduce a ramp error on each simulated GPS satellite individually, as follows:

**A2.2.6.8.2.2.6.1** Step 1 A 5 m/s ramp error SHALL be introduced on the simulated GPS satellite.

**A2.2.6.8.2.2.6.2** Step 2 Six seconds after the introduction of the ramp error, the simulated SBAS satellite SHALL broadcast a UDREI of 15 for the GPS satellite in the fast correction message.

**A2.2.6.8.2.2.6.3** Step 3 The ramp error SHALL be applied until one of the following conditions occur:

- The horizontal position error of a valid position output exceeds 0.5 NM; or
- The ramp error exceeds 2000 m; or
- The affected GPS satellite is excluded from the solution.

**A2.2.6.8.2.2.6.4** Step 4 Allow the receiver time to return to steady state before repeating steps 1 - 3 on the next satellite.

**A2.2.6.8.2.2.7** The simulated satellite signals SHALL be set to -134 dBm while position measurements are taken. Signal powers may be increased at the beginning of the scenario to allow for initial acquisition.

**A2.2.6.8.2.2.8** Simulated signals SHALL include ranging errors for atmospheric effects (troposphere and ionosphere) that adhere to approved models. Refer to DO-229D Appendix A Section A.4.2.4 and IS-GPS-200G dated September 5, 2012.

**A2.2.6.8.2.2.9** No interference needs to be simulated.

**A2.2.6.8.2.3 Pass/Fail Criteria**

**A2.2.6.8.2.3.1** The test SHALL be run on two different space-time scenarios. The two scenarios SHALL be sufficiently separated to ensure that different satellite geometry is presented to the receiver.

**A2.2.6.8.2.3.2** The horizontal position errors SHALL be computed for each position estimate output by the equipment during the test.

**A2.2.6.8.2.3.3** The horizontal position error SHALL not exceed 0.5 NM at any time during the test.

**A2.2.6.8.2.3.4** Only those position outputs that are reported as valid by the equipment need to be considered for the accuracy evaluation.

**A2.2.6.9 Testing GNSS Position Source SBAS Fast and Long Term Corrections**

**A2.2.6.9.1** Application of Fast Corrections (MT 2-5, 24) and Long-Term Corrections (MT 24, 25) The equipment SHALL be tested to verify that fast corrections and long-term corrections are applied properly per **A1.2.6.9**.

**A2.2.6.9.2 Simulator Scenario Details**

**A2.2.6.9.2.1** The simulator scenario SHALL use the standard 24 satellite constellation in RTCA/DO-229D Appendix B.

**A2.2.6.9.2.2** A single SBAS satellite SHALL be simulated with a fast corrections (MT 2-5, 24) update rate of 6 seconds and standard long-term corrections (MT 24, 25) update rate of 120 seconds.

**A2.2.6.9.2.3** The simulation start time and location SHALL be such that the resulting HDOP is close to 5.0.

**A2.2.6.9.2.4** The simulation SHALL use nominal aircraft dynamics, defined to be ground speed = 200 kt and horizontal acceleration = 0.58 g. These dynamics can be simulated as a series of turns.

**A2.2.6.9.2.5** The scenario SHALL introduce a bias and ramp error on a single satellite selected so that the range error will result in the maximum horizontal position error if not corrected by SBAS. The SBAS long-term corrections will be applied to correct the bias error. At each 6 second update, SBAS fast corrections will be provided to correct the ramp error for the affected satellite, as follows:

**A2.2.6.9.2.5.1** STEP 1 A 70 meter bias SHALL be introduced on the simulated GPS satellite. Provide SBAS long-term corrections to correct the bias term. The bias magnitude was chosen to approximate the maximum value that can be corrected by the δaf0 term in a type 25 message (using velocity code 0).

**A2.2.6.9.2.5.2** STEP 2 Start the scenario broadcasting MT25 with the correction for the bias error introduced on the selected satellite.

**A2.2.6.9.2.5.3** STEP 3 Allow the receiver time to acquire the GPS and SBAS satellites and obtain a steady-state differential fix, including sufficient time to acquire a type 25 message for the selected GPS satellite.

**A2.2.6.9.2.5.4** STEP 4 Inject a 5 m/s ramp error on the selected satellite in the same direction as the bias error.

**A2.2.6.9.2.5.5** STEP 5 At each 6 second update, provide SBAS fast corrections equivalent to the size of the growing ramp error.

**A2.2.6.9.2.5.6** STEP 6 The ramp error SHALL be applied until the ramp error plus bias error reaches 325 meters. Maintain the error of 325 meters for 5 minutes.

**A2.2.6.9.2.6** The simulated satellite signals SHALL be set to -134 dBm while position measurements are taken. Signal powers may be increased at the beginning of the scenario to allow for initial acquisition.

**A2.2.6.9.2.7** Simulated signals SHALL include ranging errors for atmospheric effects (troposphere and ionosphere) that adhere to approved models. Refer to DO-229D Appendix A Section A.4.2.4 and IS-GPS-200G dated September 5, 2012.

**A2.2.6.9.2.8** No interference needs to be simulated.

**A2.2.6.9.3 Pass/Fail Criteria**

**A2.2.6.9.3.1** The horizontal and vertical position errors SHALL be computed for each position estimate output by the equipment during the test.

**A2.2.6.9.3.2** Monitor the sensor provided HFOM and VFOM, or HFOM and VFOM derived from the sensor provided HDOP and VDOP per paragraphs **A1.2.5.8** and **A1.2.5.10**. Compare the HFOM against the horizontal position error for each valid position estimate. Compare the VFOM against the vertical position error for each valid position estimate. In order to pass the test, the horizontal and vertical position accuracy output must be greater the actual position error at least 95% of the time. Analyze the position estimates to determine if the fast corrections and long-term corrections are being applied correctly.

**A2.2.6.9.3.3** Only those position outputs that are reported as valid by the equipment need to be considered for the accuracy evaluation.

**A2.2.6.9.3.4** The test only needs to be run using a single space/time scenario.

**A2.2.6.10** Test the GNSS position source requirements in section **0** by running the test outlined in section **A2.2.6.3.3**.

## Appendix 3. Environmental Testing for Class B Equipment

### A3 Environmental Test Considerations

**A3.1** The environmental tests and performance requirements described in this subsection provide a laboratory means of determining the overall performance characteristics of the equipment under conditions representative of those that may be encountered in actual aeronautical operations.

**A3.2** The following test procedures must be run when performing environmental testing on Class B Equipment. Class B equipment only needs to be tested under DO-160D change 3 or later Environmental Test, Section 4 Temperature and Altitude, and Section 5 Temperature Variation Testing.

**A3.3** The test procedure set forth below is considered satisfactory for use in determining equipment performance under environmental conditions. Although specific test procedures are cited, it is recognized that other methods may be preferred. These alternative procedures may be used if the manufacturer can show that they provide at least equivalent information. In such cases, the procedures cited herein should be used as one criterion in evaluating the acceptability of the alternative procedures.

> **Note:** The intent of this section is to minimize the testing of Commercial Off The Shelf (COTS) devices.

**A3.4** Class B Equipment System Test

**A3.4.1** Equipment Required: A representative antenna of what will be installed in an actual airborne TABS.

**A3.4.2** Figure 1 provides a representation of the test setup.

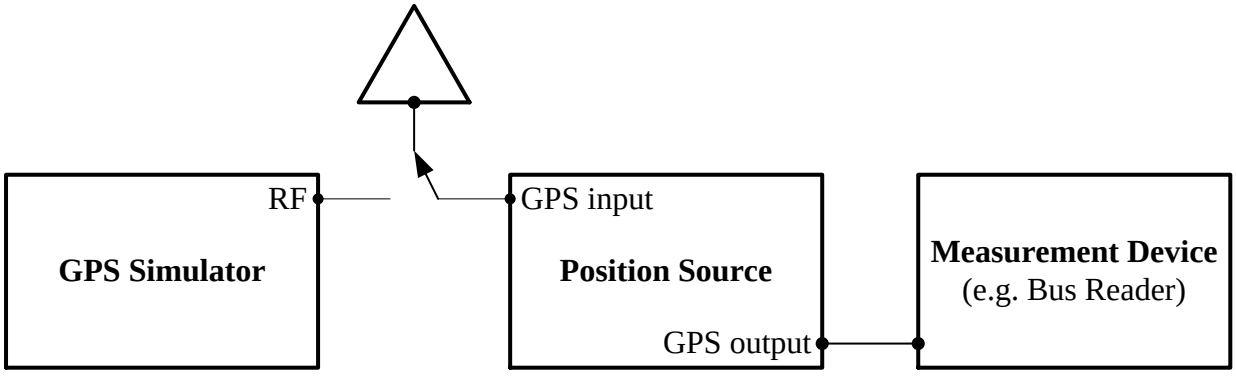


***Figure 1: Test Setup***

**A3.4.3** Measurement Procedure:

**A3.4.3.1** Set the test equipment to measure the output of the Position Source.

**A3.4.3.1.1** Verify the position information output by the GPS to the TABS is correct for:

**A3.4.3.1.1.1** The latitude and longitude of the surveyed location when connecting the device to a live (e.g. rooftop) antenna, or;

**A3.4.3.1.1.2** The output by the GPS simulator for the scenario outlined in Section **A2.2.6.3.3**

**A3.4.3.1.2** Using the test setup in **A3.4.2**, monitor the sensor provided HFOM, or HFOM derived from the sensor provided HDOP per paragraph **A1.2.5.8.** This output SHALL be compared against the horizontal position error for each valid position estimate. In order to pass the test, the horizontal position accuracy output must be greater than the actual position error for at least 95% of the samples. The horizontal position error SHALL not exceed 0.5 NM at any time during the test.

## Appendix 4. Considerations for Radio Frequency (RF) Exposure Safety

### A4 Introduction

**A4.1** This appendix provides information related to ensuring RF exposure safety of TABS equipment. Because a TABS may be used in close proximity to the pilot or passengers, RF exposure levels must be determined to ensure safe operation of the device. This appendix does not attempt to provide a means to show compliance with RF exposure standards. The intent of this appendix is to highlight the need for manufacturers and system integrators to ensure the potential risks due to RF exposure is properly addressed and ultimately ensure a TABS is safe to use. Ensuring safe distance between TABS transmitting equipment and human occupants is an installation issue and does not affect the MPS defined in this TSO, but it should be considered during installation

### A4.2 RF Exposure Safety Considerations

**A4.2.1** Rules covering safe RF exposure levels are governed by the locality where the TABS will be used. This appendix references Federal Communications Commission (FCC) guidelines used in the US. References to EUROCONTROL and United Kingdom documents are also provided. While the referenced European documents have no legal standing in the US, they may provide a better understanding of the risk RF exposure may pose. There may be other useful documents, this appendix references three, they are:

- Federal Communications Commission Office of Engineering & Technology, OET Bulletin 65 Edition 97-01, *Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields*, dated August 1997
- EUROCONTROL, STA/R/460/0001/1, *Study to Address the Detection and Recognition of Light Aircraft in the Current and Future ATM Environment, Issue 1.0, Final Report*, dated 31 March 2005
- Health Protection Agency, HPA-RPD-031, *Exposure to EMFs from Lightweight Aviation Transponders*, dated September 2007

### A4.3 FCC Guidelines

**A4.3.1** Guidelines found in FCC OET Bulletin 65 Edition 97-01, provide a distinction between mobile devices and portable devices.

**A4.3.2** **Mobile Devices**. Depending on how the TABS is installed, it may be considered a mobile device. Mobile devices are intended to operate at least 20 cm (about 7.9 inches) away from the user or nearby persons. Due to their proximate location to humans, these devices can be evaluated based on maximum permissible exposure (MPE). A description of mobile devices can be found in OET Bulletin 65 Edition 97-01, pages 14, 40 and 73.

**A4.3.3** **Portable Devices**. Depending on how the TABS is installed, it may be considered a portable device. FCC guidance indicates portable devices are intended to operate within 20 cm (about 7.9 inches) of the user or nearby persons. These devices are evaluated

based on limits for specific absorption rate (SAR). Because these devices are closer to humans, SAR calculations are much more complicated. SAR calculations are explained in OET Bulletin 65 Edition 97-01, section 2 and appendix A. Portable devices are defined and described in OET Bulletin 65 Edition 97-01, pages 14, 40, 73 and 74.

## A4.4 EUROCONTROL LAST Study Final Report

**A4.4.1** The TABS is not a direct derivative of the European work on the Light Aviation SSR Transponder, (LAST), but it benefits from the research and study done for it. As part of the LAST research, the United Kingdom (UK) Civil Aviation Authority (CAA) commissioned the UK National Radiological Protection Board (NRPB), now the Radiation Protection Division of the Health Protection Agency (HPA) to study potential health risks of LAST equipment. This study is documented in the restricted report: "Cooper TG and Mann SM (1998). *Exposure to Pulsed UHF Radiation Transmitted by Racal Lightweight Transponder*. Contract Report NRPB-M954." A brief summary of this report can be found in EUROCONTROL, STA/R/460/0001/1 section 6.5 page 24. The UK CAA commissioned the HPA for another study, which is documented below.

## A4.5 UK Health Protection Agency LAST Study

**A4.5.1** The UK CAA also commissioned a study from the HPA that looked at RF exposure risks of light weight transponder devices titled HPA-RPD-031, *Exposure to EMFs from Lightweight Aviation Transponders*. The HPA study of the RF exposure from a LAST device is useful as a baseline set of data in characterizing the RF exposure risk from the TABS.

### A4.5.2 Maximum power.

**A4.5.2.1** The HPA study considered two power levels for the LAST, see HPA-RPD-031, section 2.2.2 and Table 1, page 3, note: the label LPST is used instead of LAST. Table 28 summarizes transponder, TABS, and LAST device power specifications:

| Device | Minimum Output Power | | Maximum Output Power | |
|---|---|---|---|---|
| | dBW | watts | dBw | watts |
| DO-181E Class 1 | 21.0 | 125 | 27.0 | 500 |
| DO-181E Class 2 | 18.5 | 70 | 27.0 | 500 |
| TABS | 18.5 | 70 | 27.0***** | 500***** |
| LAST 1 | 18.5 | 70 | 19.0 | 80 |
| LAST 2 | 14.5 | 25 | 15.0 | 30 |

***Table 28 Power classes of transponder, TABS and LAST Summary***

***** Note, the maximum output power for the TABS has not been separately specified, the maximum power available for the LAST 1 is more suitable, and allows safe operation closer to the operator.

**A4.5.2.2** The analysis of the TABS must be based on the maximum possible power the design will allow, therefore limiting the maximum possible power while maintaining the required minimum power will allow optimal options for use of the TABS in proximity to operators and the general public.

### A4.5.3 Reply rate limit.

**A4.5.3.1** The HPA study considers a reply rate limit that matched that of the standard transponder. The TABS has been tailored to allow a lower reply rate limit; these are presented in Table 29 for comparison. The data in Table 29 is taken from Tables 2 and 3 in the HPA study.

| Transmission | Transponder 2007 | | European Traffic 2020 | | TABS | |
|---|---|---|---|---|---|---|
| | count | µsec RF | count | µsec RF | count | µsec RF |
| Mode A/C replies | 500 | 3375 | 475.3 | 3208.3 | 100 | 675 |
| Short Mode S replies | 34 | 1020 | 27 | 810 | 19 | 570 |
| Long Mode S replies | 16 | 928 | 3.6 | 208.8 | 10 | 580 |
| Short squitters | 1 | 30 | 1 | 30 | 1 | 30 |
| Long squitters | 2.2 | 127.6 | 2.2 | 127.6 | 3.7 | 156.6 |
| Total µsec RF | | 5480.6 | | 4384.7 | | 2011.6 |
| Duty cycle | | 0.55% | | 0.44% | | 0.20% |

***Table 29 Reply rates of transponder, LAST and TABS Summary***

**A4.5.3.2** Analysis of the TABS may be required by the FCC to be based on the maximum possible reply rate the design will allow, therefore limiting the maximum possible reply rate while maintaining the required minimum reply rate will allow optimal options for use of the TABS in proximity to operators and the general public.

### A4.5.4 Time averaged power.

**A4.5.4.1** The HPA study calculates the average power from the duty cycle such as in Table 29 above, and peak power output such as in Table 28 above. Combining this information in Table 30 is the time averaged power for the LAST and TABS. The values in Table 30 are based on the transponder reply rate for the LAST and reply rate limit specified for the TABS. The time average power is calculated for two power levels for the TABS, one at the maximum power permitted by the MOPS and the other at a restricted power to a level more suitable for a portable device like the TABS. The table shows the normal values (see section **A1.2.5.3**). The TABS maximum and restricted time average power are 1.03 and 0.166 watts respectively.

| Device | Peak Power (watts) | Time Average Power (watts) |
|---|---|---|
| LAST 1 | 80 | 0.44 |
| LAST 2 | 30 | 0.164 |
| TABS maximum | 500 | 1.01 |
| TABS restricted | 80 | 0.161 |

***Table 30 Time averaged power of LAST and TABS***

**A4.5.5 LAST RF exposure results summary.**

**A4.5.5.1** The HPA study concentrates on determining the SAR associated with the LAST. Calculating the SAR of the TABS will be consistent with the more rigorous requirements of the FCC associated with a portable device. A portable device is allowed within 20 cm of the body (see references in section A4.3.3 above), so there is a greater burden to show that the device will be safe for pilots, operators, and the general public.

**A4.5.5.2** The analysis of the LAST referenced in the HPA report, HPA-RPD-031 has promising results for the implementation of a TABS as a device that may be operated on small aircraft close to humans. This may be particularly true if the implementation adheres to the reply rate limits specified in this TSO, and limits the possible maximum power to approximately 80 watts. Under these conditions the TABS has time averaged power similar to the 30 watt maximum LAST transponder. Review of the material in HPA-RPD-031, particularly sections 4 and 5, may provide valuable insight in the evaluation of any TABS design for RF exposure levels.

**A4.5.5.3** Compliance with FCC regulations is necessary for the licensing and approval of RF transmitting devices in the US and will help assure the RF emission exposure safety of the TABS.