



Department of Transportation
Federal Aviation Administration
Aircraft Certification Service
Washington, DC

TSO-C154d

Effective
Date: {mm/dd/yy}

Technical Standard Order

Subject: Universal Access Transceiver (UAT) Automatic Dependent Surveillance - Broadcast (ADS-B) Equipment Operating on the Radio Frequency of 978 Megahertz (MHz)

1. PURPOSE. This technical standard order (TSO) is for manufacturers applying for a TSO authorization (TSOA) or letter of TSO design approval (LODA). In it, we (the Federal Aviation Administration, (FAA)) tell you what minimum performance standards (MPS) your Universal Access Transceiver (UAT) ADS-B equipment and/or UAT diplexers must meet for approval and identification with the applicable TSO marking.

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

a. TSO-C154c will also remain effective until 18 months after the effective date of an amendment to Title 14, Code of Federal Regulations (14 CFR) 91.225 and 91.227 to allow installation and use of ADS-B Out equipment manufactured under this TSO for compliance with those rules. After that date, we will no longer accept applications for TSO-C154c.

b. UAT ADS-B equipment and/or UAT diplexers approved under a previous TSOA may still be manufactured under the provisions of its original approval.

Note: UAT ADS-B equipment produced to TSO versions before TSO-C154c does not comply with the operating rule requirements of §§ 91.225 and 91.227.

3. REQUIREMENTS. New models of UAT ADS-B equipment and/or UAT diplexers identified and manufactured on or after the effective date of this TSO must meet the requirements in RTCA/DO-282C, *Minimum Operational Performance Standards (MOPS) for Universal Access Transceiver (UAT) Automatic Dependent Surveillance - Broadcast (ADS-B)*, Section 2, dated June 23, 2022.

a. Functionality.

(1) This TSO's standards apply to equipment intended to transmit and receive broadcast messages about an aircraft's position (latitude, longitude, and altitude), velocity, integrity, and

other parameters. Similarly-equipped operators will share these messages with one another and with ground-based facilities, such as air traffic services. These message parameters form the basis for various ADS-B, ADS-B Rebroadcast Service (ADS-R), and Traffic Information Services – Broadcast (TIS-B) reports. The UAT ADS-B equipment may also support additional features as shown in RTCA/DO-282C Section 1.4.7.

(2) This TSO supports two major classes of UAT ADS-B equipment. Class A equipment consists of transmit and receive subsystems. Class B equipment contains a transmit subsystem only.

(a) **Class A equipment** includes Classes A1H, A1S, A2 and A3 as defined in RTCA/DO-282C. We require UAT airborne Class A equipment to receive ADS-B, ADS-R, TIS-B, and Flight Information Service – Broadcast (FIS-B) messages; deliver ADS-B, ADS-R, TIS-B, and FIS-B reports; and transmit ADS-B messages. Class A equipment can also be defined as transmit only or receive only.

(b) **Class B equipment** includes Classes B1 and B1S as defined in RTCA/DO-282C. Class B equipment is only required to transmit ADS-B messages.

(3) This TSO also supports an optional frequency diplexer. The diplexer allows an Air Traffic Control Radar Beacon System (ATCRBS) or Mode S transponder and the UAT equipment developed under this TSO to share an antenna.

Note: Since the diplexer requirements did not change from RTCA/DO-282B to RTCA/DO-282C, a TSO-C154c diplexer may be used with TSO-C154d equipment.

(4) This TSO only addresses broadcasting messages from transmit subsystems and assembling reports in receiver subsystems. It does not address applications that use the information in reports. TSO-C195b and later revisions, *Avionics Supporting Automatic Dependent Surveillance - Broadcast (ADS-B) Aircraft Surveillance Applications (ASA)*, provide standards for ADS-B aircraft surveillance applications.

(5) Do not add ADS-B message elements outside of the message requirements outlined in Section 2 of RTCA/DO-282C or populate message fields reserved for future use.

b. Failure Condition Classifications.

(1) Unannounced failure of the function defined in paragraph 3.a of this TSO resulting in incorrect reports to onboard applications or broadcast of incorrect ADS-B messages is a *major* failure condition.

(2) Loss of the function defined in paragraph 3.a of this TSO is a *minor* failure condition.

(3) Design the system to at least these failure condition classifications.

Note: The major failure condition for transmission of incorrect ADS-B messages is based on use of the data by other aircraft or Air Traffic Control for separation services.

(4) Failure conditions do not apply to the UAT diplexer because it is a mechanical device with no active components.

c. Functional Qualification. Demonstrate the required functional performance under the test conditions specified in RTCA/DO-282C, Section 2.4.

d. Environmental Qualification. Demonstrate the required performance under the test conditions specified in RTCA/DO-282C, Section 2.3 using standard environmental conditions and test procedures appropriate for airborne equipment. You may use a different standard environmental condition and test procedure than RTCA/DO-160G, *Environmental Conditions and Test Procedures for Airborne Equipment*, dated December 8, 2010, provided the standard is appropriate for UAT ADS-B equipment.

Note: The use of RTCA/DO-160D (with Changes 1 and 2 only, without Change 3 incorporated) or earlier versions is generally not considered appropriate and will require substantiation via the deviation process as discussed in paragraph 3.g of this TSO.

e. Software Qualification. If the article includes software, develop the software according to 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 design assurance level consistent with the failure condition classification defined in paragraph 3.b of this TSO.

f. Electronic Hardware Qualification. If the article includes complex custom airborne electronic hardware, then develop the component according to 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 Section 1.6 applies.

g. Deviations. We have provisions for using alternate or equivalent means of compliance with 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 pursuant to 14 CFR 21.618.

4. MARKING.

a. Mark at least one major component permanently and legibly with all of the information in 14 CFR 45.15(b). The marking must include the serial number. Include equipment class and article name, unless the classes and article name are identified in the installation instructions or by software.

b. 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.

c. 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.

d. Transmitting and receiving components must be permanently and legibly marked. The following table explains how to mark components. Find the equipment class in RTCA/DO-282C Section 2.1.11.

<i>If component can:</i>	<i>Mark it with:</i>	<i>Sample marking pattern:</i>
Transmit and receive	Equipment class it supports	Class A1H
Transmit, but not receive	Equipment class it supports	Class B1 or Class A3 - Transmit Only
Receive, but not transmit	Equipment class it supports	Class A2 - Receive Only
Perform the optional frequency diplexer function developed under this TSO	The words "UAT Diplexer," Maximum amplitude attenuation between the antenna port (A) and UAT port (U) of the diplexer, and Maximum amplitude attenuation between the antenna port (A) and transponder port (T) of the diplexer	UAT Diplexer A/U -0.x dB A/T -0.x dB

e. If the equipment supports optional features identified in RTCA/DO-282C Section 1.4.7, the equipment must be marked with the ID Code(s) for all supported optional features in accordance with RTCA/DO-282C, Section 1.4.7, Table 1-1.

f. As a courtesy to operators and repair stations, and with the permission of RTCA, Inc., we have included a copy of RTCA/DO-282C Sections 1.4.7, 2.1.11, and 2.1.12 in appendix A of this TSO.

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. Manuals containing the following:

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

(2) Detailed description of any deviations.

(3) Installation procedures and limitations sufficient to ensure that the UAT ADS-B equipment and/or UAT diplexer, when installed according to the installation or operational procedures, still meets this TSO's requirements. Limitations must identify any unique aspects of the installation. The limitations must also include a note with the following statement: "This article meets the minimum requirements of TSO-C154d. Installation of this article requires separate approval." The installation manual must also identify information security review and mitigation strategies for any interface by which the equipment makes use of a non-trusted connectivity where the installation could potentially have aircraft information security vulnerabilities as described in RTCA/DO-282C, Section 1.7. RTCA/DO-326A, *Airworthiness Security Process Specification*, dated August 6, 2014, and RTCA/DO-356A, *Airworthiness Security Methods and Considerations*, dated June 21, 2018 provide guidance for analyzing the threat of intentional unauthorized electronic interaction.

(a) For UAT diplexers, include the following limitation in the installation procedures:

The installer is responsible to ensure the insertion of the UAT diplexer does not cause the cable attenuation allowance between the transponder output and the antenna input to be exceeded.

Note: Since the diplexer requirements did not change from RTCA/DO-282B to RTCA/DO-282C, installation procedures may permit a TSO-C154c diplexer to be used with TSO-C154d equipment.

(b) For UAT systems that rely on detection of Mode A codes from an onboard ATCRBS transponder, include the following limitation in the installation procedures:

This UAT ADS-B equipment must not be installed on an aircraft that also contains a Mode S capable transponder.

Note: Mode S capable transponders do not transmit replies to ATCRBS-Only all-call interrogations and therefore will send significantly less Mode A replies than ATCRBS transponders. In some locations, a Mode S-capable transponder may not transmit any Mode A replies for significant periods. UAT devices that rely on detection of Mode A codes contained within Mode A replies triggered by ground interrogators must only be paired with ATCRBS-only transponders.

(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; and
- (c)** Functional description.

(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 A.

(6) Schematic drawings, wiring diagrams, and any other documentation necessary for installation of the UAT ADS-B equipment and/or UAT diplexer.

(7) By-part-number list of replaceable components that makes up the UAT ADS-B equipment and/or UAT diplexer. Include vendor part number cross-references, when applicable.

b. Instructions covering periodic maintenance, calibration, and repair, to ensure that the UAT ADS-B equipment and/or UAT diplexer continues to meet the TSO approved design. Include recommended inspection intervals and service life, as appropriate.

c. If the article includes software: a plan for software aspects of certification (PSAC), software configuration index, and a software accomplishment summary.

d. If the article includes simple or complex custom airborne electronic hardware: a plan for hardware aspects of certification (PHAC), a hardware verification plan, top-level drawing, and hardware accomplishment summary (or similar document, as applicable).

e. A drawing depicting how the article will be marked with the information required by paragraph 4 of this TSO.

f. Identify functionality or performance contained in the article not evaluated under paragraph 3 of this TSO (defined as non-TSO functions). Non-TSO functions can be accepted in parallel with the TSOA. 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, failure condition classifications, software, hardware, and environmental qualification levels. Include a statement confirming that the non-TSO function(s) do not interfere with the article's compliance with the requirements of paragraph 3 of this TSO.

(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.f.(1) of this TSO.

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

(4) Interface requirements and applicable installation test procedures to ensure compliance with the non-TSO function(s) performance data defined in paragraph 5.f.(1) of this TSO.

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

(6) Test plans and analysis, as appropriate, to verify that the function and performance of the non-TSO function(s) are as described in paragraph 5.f.(1) of this TSO.

g. The quality manual required by 14 CFR 21.608, including functional test specifications. The quality system must 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. Applicants who currently hold TSOAs must submit revisions to the existing quality manual as necessary (not required for LODA applicants).

h. A description of your organization as required by 14 CFR 21.605.

i. Material and process specifications list.

j. A list of all drawings and processes (including revision level) that define the article's design.

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

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

Note: The following data for a LODA applicant may be made available for review through its CAA. Refer to the applicable bilateral agreement for specific details regarding access to this data.

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

b. Article 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 RTCA/DO-178C, including all data supporting the applicable objectives in Annex A, *Process Objectives and Outputs by Software Level*.
- h. If the article includes complex custom airborne electronic hardware, the appropriate hardware life-cycle data in combination with design assurance level, as defined in RTCA/DO-254, Appendix A, Table A-1. For simple custom airborne electronic hardware, the following data are required: test cases or procedures, test results, test coverage analysis, tool assessment and qualification data, and configuration management records, including problem reports.
- i. If the article contains non-TSO function(s), you must also make items **6.a** through **6.h** of this TSO available as they pertain to the non-TSO function(s).

7. FURNISHED DATA REQUIREMENTS.

- a. When 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 continued compliance with the TSO of the UAT ADS-B equipment and/or UAT diplexer.
- 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)** of this TSO.
- c. If the article contains software, include one copy of the Open Problem Report (OPR) summary.

8. HOW TO GET REFERENCED DOCUMENTS.

- a. Order RTCA documents from RTCA, Inc., 1150 18th Street NW, Suite 910, Washington, DC 20036. Telephone: (202) 833-9339; fax: (202) 833-9434. You can also order copies online at www.rtca.org.
- b. Order copies of 14 CFR parts 21, 45, and 91 from the Superintendent of Documents, Government Publishing Office, PO Box 979050, St. Louis, MO 63197-9000. Telephone: (202) 512-1800, fax: (202) 512-2104. You can also order copies online at www.gpo.gov, or find an electronic version at the FAA's online Dynamic Regulatory System (DRS), <https://drs.faa.gov>.

c. You can find a current list of TSOs and advisory circulars at <https://drs.faa.gov>. You will also find the TSO Index of Articles at the same site.

Patrick R. Mullen
Manager, Technical Innovation Policy Branch
Policy & Innovation Division
Aircraft Certification Service

s

Appendix A. UAT ADS-B Equipment Marking Scheme

Purpose. This appendix contains relevant portions of RTCA/DO-282C regarding labeling schemes as a courtesy to operators and repair stations.

Table 1 – Excerpts from RTCA/DO-282C
(Reprinted with the permission of RTCA, Inc.)

1.4.7 ADS-B Configuration Identification

Each ADS-B Transmitting Subsystem configuration is described by its equipage class and its optional features. The equipage classes are defined in Table 2-1. The optional features are defined below, with the corresponding ID Codes shown in Table 1-1. The current ADS-B Transmitting Subsystem configuration is identified by the equipage class followed by the ID codes for the optional features it supports.

Example 1 – For a Class A1 single antenna ADS-B transmitter/receiver that incorporates Unmanned/Remotely-Piloted Aircraft Systems and High Velocity and/or Altitude Operation: the ADS-B Transmitting Subsystem configuration would be identified as “Class A1S, uv”.

Note: For ADS-B systems where “Class” or “optional features” might be changed through an approved software update, a means to display the ADS-B Transmitting Subsystem equipage identification electronically may be necessary.

Some ADS-B systems may support optional features:

- **ADS-B Wx Pilot Reports (PIREPs)** – ADS-B equipment implementing support for broadcast of ADS-B Wx PIREP data adhere to the requirements in §2.2.4.5.9.1.5.
- **ADS-B Wx Air Reports (AIREPs)** – ADS-B equipment implementing support for broadcast of ADS-B Wx AIREP data adhere to the requirements in §2.2.4.5.10.1.
- **Unmanned/Remotely-Piloted Aircraft Systems (UAS/RPAS)** – ADS-B equipment implementing support for unmanned or remotely piloted aircraft operations will adhere to the requirements in §2.2.4.5.9.1.4.
- **High Velocity and/or Altitude (HVA) Operation** – ADS-B equipment implementing support for high velocity and/or high-altitude operations adhere to the requirements in §2.2.4.5.11.

These features and corresponding identification codes (may be used by certification authorities for equipment marking purposes) are summarized in Table 1-1.

Table 1-1: ADS-B Optional Features

Optional Features	ID Code
ADS-B Wx PIREPs	p
ADS-B Wx AIREPs	w
Unmanned/Remotely-Piloted Aircraft Systems	u
High Velocity and/or Altitude Operation	v

2.1.11 Equipage Classes

UAT equipment is categorized into aircraft system equipage classes as defined in RTCA DO-338. The installed performance of the UAT equipment classes **shall** be as defined in Table 2-1.

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

The remainder of the interactive aircraft/vehicle classes (A0, A2, and A3) are as defined in RTCA DO-338. It is recognized that since Class “A” includes both transmitting and receiving subsystems, there may very well be implementations that consist of separate equipment for the transmit and receive functions. Implementing the transmitter function of Class “A” can be satisfied by providing the capabilities included in §2.1.12. Similarly, implementing the receiver function of Class “A” can be satisfied by providing the capabilities included in §2.1.13.

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

The characteristics of the “B2” class (broadcast-only ground vehicle) are defined in Table 2-1.

The characteristics of the “B3” class (broadcast-only fixed or moveable obstacle) are defined in Table 2-1. The payload capability supports the surface position, height of highest point, and identification (including Emitter Category) of the obstacle, so that both State Vector and Mode Status reports must be supported. Moveable obstacles require a position source. A moveable

obstacle is one that can change its position, but only slowly, such that its horizontal velocity may be ignored. See §2.2.6.1.2 of this document for the payload characteristics.

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

Table 2-2: UAT Installed Equipment Classes

Description	Equipage Class	Tx RF Power Delivered to Antenna System	Intended Antenna Diversity (when Airborne for Classes A & B0-B1)	
			Transmit	Receive
Aircraft	A0	Low Power (Altitude always below 18000 feet)	Single Antenna (see Note 4)	Single Antenna (see Note 4)
	A1L		Alternating every 2 sec.	Alternating every second
	A1S	Medium Power	Single Antenna (see Note 4)	Single Antenna (see Note 4)
	A1H	Medium Power	Alternating every 2 sec.	Alternating every second
	A2	Medium Power	Alternating every 2 sec.	Dual Receiver
	A3	High Power	Alternating every 2 sec.	Dual Receiver
Transmit-Only Aircraft / Vehicle	B0	Low Power (Altitude always below 18000 feet)	Single Antenna (see Note 4)	n/a
	B1S	Medium Power	Single Antenna (see Note 4)	n/a
	B1	Medium Power	Alternating every 2 sec.	n/a
Surface Vehicle	B2	+28 to +32 dBm	Single Antenna	n/a
Obstacle	B3	+30 dBm (minimum)	Single Antenna	n/a

Notes:

1. See §2.1.12 for definition of Transmitter RF power levels.
2. Transmitter RF power requirement depends on the aircraft maximum altitude capability. Low-altitude aircraft (< 18,000 feet max altitude) need not support the higher-power transmitter requirements due to line-of-site limitations.
3. Top antenna is not required if use of a single antenna does not degrade signal propagation. This allows for single antenna installation on radio-transparent airframes.

4. *For single-antenna installations, antenna gain pattern performance should be at least equivalent to that of a quarter-wave resonant antenna mounted on the fuselage bottom surface.*
5. *See §2.2.6.1.2 for definition of payload transmission requirements for each equipment class.*

2.1.12 Transmitting Subsystem

An ADS-B Transmitting Subsystem is classified according to the unit's range capability and the set of message parameters that it is capable of transmitting. Transmitter power levels **shall** be as defined in Table 2-2. Power levels are specified in terms of power presented at the transmitting antenna.

Table 2-3: Transmitter Power Requirements

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

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

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