

Understanding Compliance with Automatic Dependent Surveillance – Broadcast (ADS–B) Out

White Paper

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Executive Summary

Automatic Dependent Surveillance–Broadcast (ADS–B) Out is a key component in the Federal Aviation Administration (FAA) and European Aviation Safety Agency's (EASA) Next Generation (NextGen)/Single European Sky ATM Research (SESAR) airspace modernization programs. This document discusses Universal Avionics' guide to ADS–B Out compliance based on analysis of the applicable regulations and associated Advisory Circulars (AC). FAA compliance is mandatory by January 1, 2020, and in some areas of the world, it is already a requirement today.

In analyzing international ADS–B regulations, researchers at Universal Avionics found the requirements to be similar in most operating environments that require ADS–B Out. This White Paper will concentrate on the FAA specific regulations and guidance requiring compliance in the National Airspace System (NAS). However, regional requirements for worldwide operations are also discussed when applicable.

What is ADS–B?

ADS–B, or Automatic Dependent Surveillance–Broadcast, is a surveillance technology that provides Air Traffic Control (ATC) with a more accurate picture of the aircraft's three-dimensional position in the enroute, terminal, approach and surface environments. The aircraft broadcasts its identification, position, altitude, velocity and other information. ADS–B ground stations receive these broadcasts and present them on a controller's display similar in nature to a radar return.

Benefits of ADS–B

ADS–B allows ATC to monitor and separate aircraft more efficiently and with more precision. ADS–B expands surveillance services into areas where little or no radar coverage currently exists. In addition, the FAA intends to decommission terminal radar sites in several areas in order to save the expenses associated with radar system maintenance, and reducing dependence upon traditional radar.

The technology has the potential to provide improved situational awareness to pilots and ATC through ADS–B In and other future applications

ADS–B System Installation Requirements

The minimum required equipment to support ADS–B Out for FAA approval includes:

- Extended Squitter Mode S Transponder or Universal Access Transceiver (UAT) System
- TSO-C146c approved Flight Management System (FMS)
- Possible additional cockpit annunciations
- Miscellaneous wiring

Transponder/UAT

In FAR 91.227 published in August 2010, the FAA requires the ADS–B Out transmission or receiving equipment to be approved using either TSO-C154c (UAT) or TSO-C166b (1090Mhz Extended Squitter Transponder).

Extended Squitter Mode S Transponder equipment compliant with TSO-C166b will be required to operate in Class A airspace in accordance with FAR 91.225, whereas UAT is designed for low altitude operations.

Annunciation

TSO-C166b and TSO-C154c require the ADS–B system to distinguish between a position source (ADS–B Out function failure) and an ADS–B equipment (transponder) failure and provide advisory notification to the flight crew. This advisory notification may be either in the form of discrete annunciations (lights), transponder control head annunciation or messages posted to a cockpit display. Refer to AC 20-165B section 3.7.2.1, which provides the guidance for failure annunciations. The installation manual for the transponder or UAT device will also provide additional information regarding proper annunciations.

ADS–B Out will be required in the U.S. National Airspace System (NAS) by 1 January 2020.

This includes:

- Class A, B and C
- Class E airspace within the 48 contiguous states and the District of Columbia at and above 10,000 feet MSL, excluding the airspace at and below 2,500 feet above the surface
- Class E airspace at and above 3,000 feet MSL over the Gulf of Mexico from the coastline of the United States out to 12 NM
- Around those airports identified in 14 CFR part 91 Appendix D

For aircraft equipped with a Universal Avionics Radio Control Unit (RCU), this requirement can be satisfied with an RCU software upgrade to Software Control Number (SCN) 1016.0.7 or later. FMS SCN 1001.1 also has additional annunciation capability for ADS-B failures for those installers wishing to use this method.

Please consult the installation manual for additional information on these outputs. A list of specific transponders that have been tested with the Universal Avionics RCU, is available through Customer Support.

SBAS–FMS

TSO-C146c Satellite-Based Augmentation System–Flight Management Systems (SBAS–FMS) such as the Universal Avionics SBAS–FMS, are designed to provide rule-compliant performance both with and without SBAS augmentation to support worldwide operations. There are two types of ADS–B installations – referred to as precision and non-precision. The difference between these two types of installations is the use of GPS time. A non-precision installation does not require the use of GPS time while a precision does. For a precision installation (using GPS time), an FMS with SCN 1000.7/1100.7 and Precision Approach Subsystem (PAS) SCN 10.3 or later is required. This version of software will also support installations that do not require GPS time. For installations that do not require GPS time, any version of SCN 1000.X and PAS 10.X or SCN 1001.0/1101.0 may be used.

A typical TSO-C129a approved FMS or GPS does not output the data required by AC 20-165B or meet the accuracy, latency, and integrity requirements. Substantial analysis and/or upgrades to meet the requirements of AC 20-165B Appendix 2 would be required to demonstrate compliance for older generation GPS engines, and those devices will be required to use the SAPT prediction tool or equivalent prior to dispatch. Some of these older sensors may be capable of adequately performing most of the time with the current robust GPS constellation. However, once older GPS satellites fail, the older generation GPS sensors will likely be subject to large Receiver Autonomous Integrity Monitoring (RAIM) holes, requiring diversions or cancellations of the flight depending upon conditions. The FAA has only guaranteed (in coordination with the U.S. Air Force) the constellation will be maintained to the IFOR minimum constellation.

It is possible to apply for an exemption to FAR 91.227. However, the FAA will require a plan that ensures the aircraft (or aircraft fleet) will be rule compliant within a reasonable period of time. The application for exemption may be denied without recourse. If the aircraft is not rule compliant, it may be excluded from airspace requiring ADS–B at any time ATC workload does not permit it; similar in nature to airspace requiring transponders today. You will be restricted from dispatching if your current RAIM tool shows a RAIM hole (non-compliant performance) over your departure or destination at the time of takeoff or arrival. Universal Avionics does not recommend this approach.

There is no intention by the FAA to change the rule or its implementation date. This was discussed with FAA in Washington, D.C. as a part of the Equip 2020 working group agenda. As noted in this White Paper, the performance requirements cannot currently be met by any GPS sensor 100% of the time other than a qualified SBAS sensor such as the Universal Avionics SBAS–FMS, which can provide rule compliant performance over 99% of the time. Other SA aware GPS sensors may be usable with the SAPT prediction tool required for dispatch.

Appendix 4 of AC 20-138D, Airworthiness Approval of Positioning and Navigation Systems, covers Global Navigation Satellite Systems (GNSS) tests to support ADS–B. The information in this appendix describes bench test procedures that can be used as an acceptable means to establish that the GNSS equipment meets the required outputs described in AC 20-165B. This appendix only addresses those ADS–B parameters that require specific tests since the GNSS TSOs (C146 and C129) do not adequately address all parameters required to support ADS–B Out.

Universal Avionics Service Letter No. 2855 describes AC 20-138D compliance with FMS SCN 100X.X/110X.X. Note; SCN 1000.7/PAS SCN 10.3 or later will be required to correctly interface to the version of the Rockwell Collins TDR-94(D) Mode S Transponder or equivalent that is ADS–B compliant. Universal Avionics operators seeking ADS–B compliance should contact Customer Support for a complete overview of the specific equipage requirements for their aircraft.

Wiring

Additional wiring will frequently be required for retrofit installations to provide a data path between the FMS data and the transponder. Additional wiring may also be desired for discrete external failure annunciations or via the FMS (requires SCN 1001.1). AC 20-165B requires individual ADS-B/Transponder failure annunciations unless the system architecture only allows for one. In this case, additional approved AFMS language is necessary to allow the flight crew to discriminate between a transponder and ADS-B Out failure.

For more information: www.uasc.com/ads-b

Regional Regulatory Requirements

Mandated compliance to ADS-B technology is growing. Airworthiness agencies worldwide have issued rules and requirements pertaining to ADS-B equipage, as summarized below.

Country/Authority	Published Material Re: ADS-B Equipage
United States	In 2010, the FAA issued a new rule contained in Title 14 of the Code of Federal Regulations (14 CFR) part 91, §§ 91.225 and 91.227. This rule requires ADS-B Out performance when operating in designated classes of airspace within the NAS after 1 January 2020.
EUROCONTROL/EASA	AMC 20-24 mandates ADS-B Out in production in June 8, 2016 and for entire European airspace (retrofit) by January 7, 2020. ADS-B approval for non-radar coverage areas requires new transponder standard RTCA DO-260B. AMC 20-24 states DO-260A transponder is sufficient. However, Universal Avionics has found that EASA may establish the certification baseline via CRI and require the DO-260B transponder regardless of the existing AMC 20-24. ADS-B in radar coverage areas can be accomplished with a DO-260A transponder.
Canada/Transport Canada	<ul style="list-style-type: none">• Transport Canada Advisory Circular (AC) No. 700-009 Issue 2• EASA AMC 20-24
Australia	<ul style="list-style-type: none">• Guidance material: CAO 20.18, Amend Order No. 3, dated December 2009• Mandates ADS-B Out for upper airspace (\geqFL290) in December 2013
Hong Kong	<ul style="list-style-type: none">• Guidance material: Airworthiness Notice 102F, Issue 2, 28 February 2011• Implement the use of ADS-B Out:<ul style="list-style-type: none">• After 31 December 2013 for aircraft flying over Performance-Based Navigation (PBN) routes L642 or M771 between FL290 and FL410• After 31 December 2014 for aircraft flying within Hong Kong FIR between FL290 and FL410• Must meet DO-260 (Version 0) requirements of ICAO Annex 10 and ICAO Doc 9871 Chapter 2, or DO-260A (Version 1) requirements of ICAO Doc 9871 Chapter 3• Means of compliance per EASA AMC 20-24 or CASA CAO 20.18 Appendix XI
Singapore	<ul style="list-style-type: none">• Guidance material: CAAS AIC 14, 28 December 2010• Implement the use of ADS-B Out after 12 December 2013 within certain parts of the Singapore FIR (\geqFL290)• Must meet EASA AMC 20-24 or CASA CAO 20.18 Appendix XI, otherwise must fly at <FL290
Other Asia Pacific Regulatory Agencies	<ul style="list-style-type: none">• Expected to follow ADS-B Avionics Requirements template per APANPIRG Conclusion 21/39

Approval Process

United States

On 30 August 2010, the FAA issued a Policy Memo, titled "Approval for ADS-B Out Systems". AC 90-114 references this memo. This Policy Memo states that until further notice, ADS-B Out equipment meeting the requirements of TSO-C166b or TSO-C154c should only be installed as OEM production equipment, OEM Service Bulletin or Supplemental Type Certificate (STC). Subsequent FAA policy as noted below, allows a field approval based upon an STC approved data showing the sensor/transmitter pair is approved.

AC 20-165B further states that all ADS-B Out compliant systems must include the transmitter/receiver equipment as well as all interfacing equipment. This means devices driving aircraft position, heading, etc., such as a Universal Avionics SBAS-FMS, must be included in that STC as a part of the complete STC package. A substantial system safety analysis for the entire system must also be performed as a part of the STC process, showing the overall system and its components comply with the requirements and performance standards outlined in AC 20-165B.

The STC process outlined by AC20-165B requires the first installation to demonstrate FMS performance during a flight test. Follow-on installations do not require a flight test. This flight test is approximately one hour in duration and requires the aircraft to perform certain maneuvers, altitude changes, and configuration changes during the flight.

A recording is made by the FAA at the applicant's request, and that recorded data is then analyzed to see if it meets the performance requirements. The parameters of interest are as follows:

- NACp – Navigation Accuracy Category for Position, which specifies the accuracy of a reported aircraft's position
- NACv – Navigation Accuracy Category for Velocity, which specifies the accuracy of a reported aircraft's velocity
- NIC – Navigation Integrity Category, which specifies an integrity containment radius around an aircraft's reported position
- SIL – Source Integrity Level indicates the probability of the reported horizontal position exceeding the containment radius defined by the NIC
- SDA – System Design Assurance indicates the probability of an aircraft malfunction causing false or misleading information to be transmitted

For more information on how NACp, NACv, NIC, SIL, and SDA are calculated, refer to TSO-C166b and TSO-C154c. To be acceptable in the United States, the following performance has to be demonstrated:

- NACp ≥ 8
- NACv ≥ 1
- NIC ≥ 7
- SIL ≥ 3
- SDA ≥ 2

A Letter of Authorization (LOA) will be required for approval to operate outside of U.S. airspace upon completion of the ADS-B STC. This policy will require that Universal Avionics provide installers with data not normally required for an FMS installation that does not support ADS-B Out. Customers or installers pursuing an ADS-B Out STC should contact Universal Avionics for system safety analysis data required to support the analysis discussed above. The certification package is available to Authorized Dealers and Integrators on UniNet.

Field Approvals

FAA has recently updated its policies for ADS-B Out to allow for field approvals. If you can make use of previously installed SBAS sensors and transponders using previously approved data that you have legal access to from the data owner, then a field approval may be permitted using normal Form 337 procedures. Coordinate with your FSDO in advance when utilizing the FAA policy allowing for ADS-B Out via field approval. Refer to FAA Policy Memo AFS-360_2016-03-02, Installation Approval for ADS-B OUT Systems, for additional information.

EUROCONTROL/EASA

A Letter of Authorization is required for "N" registered aircraft operating outside the U.S. airspace in areas requiring ADS-B Out. At this time, analysis of EASA requirements vs. FAA requirements shows that meeting FAA performance requirements will suffice for EASA compliance.

It should be noted that no air traffic provider in Europe has officially stipulated the NIC/NAC requirements for ADS-B Out compliance. However, meeting FAA standards should be acceptable for European compliance based upon current information.

Universal Avionics will monitor EASA requirements for harmonization with the FAA to better aid its customers in understanding the requirements for ADS-B Out in various airspaces around the world.

Canada/Transport Canada

Transport Canada, the Canadian regulatory authority, has approved ADS-B 5 NM separation standard in non-radar airspace. This approval was based on their assessment of a comprehensive safety case developed by NAV CANADA. To be eligible for ADS-B service, operators must have approval from Transport Canada and they must advise NAV CANADA they have Transport Canada approval.

In accordance with the approved safety case, eligibility for ADS-B separation service is based on satisfying two conditions:

- The aircraft meets a minimum performance to transmit ADS-B messages for the purpose of applying the separation standard; and,
- The flight crew is qualified in the operation of the equipment and the operational practices of the ADS-B airspace.

Condition 1 is satisfied if the Aircraft Flight Manual (AFM) or AFM Supplement (AFMS) contains a statement indicating compliance with the EASA Acceptable Means of Compliance (AMC) 20–24 for ADS-B, or Transport Canada Advisory Circular (AC) No. 700-009 Issue 2.

Condition 2 is satisfied if flight crews know, understand and apply the contents of NAV CANADA's ADS-B Hudson Bay Implementation information pamphlet. The pamphlet was designed to address the knowledge requirements identified in the approved safety case.

There is no longer a requirement for air operators or private operators to obtain Operations Specification 609 or 610 in order to obtain ADS-B surveillance services from NAV CANADA while operating in Canadian airspace.

Australian Air Services

Currently, ADS-B is required for operations above FL 290 in Australia's airspace. At this time, the current mandate is for all aircraft operating under IFR rules to be equipped with ADS-B Out by February 2, 2017. Additional implementation dates and operating areas include:

- **2014 – IFR Forward fit:** Any aircraft that is first registered on or after 6 February 2014 and is operated under the IFR must carry serviceable ADS-B transmitting equipment that complies with the CASA Civil Aviation Order (CAOs) 20.18
- **2016 – IFR for Western Australia:** On and after 4 February 2016, an aircraft that is operated under the IFR in Airspace that is Class A, B, C or E and within the arc of a circle that starts 500 NM true north from Perth aerodrome and finishes 500 NM true east from Perth Airport must carry serviceable ADS-B transmitting equipment that complies with Civil Aviation Order 20.18
- **2017 – All IFR aircraft:** On and after 2 February 2017, any aircraft that is first registered before 6 February 2014 and is operated under the IFR must carry serviceable ADS-B transmitting equipment that complies with CAO 20.18
- For foreign registered aircraft, please see NFRM 1305AS and CASA 61/14 – Direction – use of ADS-B in foreign aircraft engaged in private operations (F2014L0058)

ADS-B Out FAQ

The FAA final rule mandates ADS-B Out only. Is this correct?

Yes, only ADS-B Out is mandated, and only within certain airspace. Title 14 CFR § 91.225 defines the airspace within which these requirements apply.

What equipment is required by the new FAA rule?

The rule specifies ADS-B Out equipment comply with either TSO-C154c Universal Access Transceiver (UAT) or TSO-C166b (Mode S Transponder). However, to operate in Class A airspace, aircraft are required to equip with an Extended Squitter Mode S Transponder certification to TSO-C166b. Universal Avionics has determined that only certain products approved to TSO-C146 (AR) "Stand-Alone Airborne Navigation Equipment Using the Global Positioning System Augmented by the Satellite-Based Augmentation System," will meet the aircraft position sensor requirements.

Do my current avionics meet the performance requirements of the rule?

Your Universal Avionics Authorized Dealer or Integrator can help you determine if your current equipment will meet the performance requirements of the rule and can advise you on available options and costs associated with any required upgrades.

What Universal Avionics equipment will be required for ADS-B Out compliance?

A TSO-C146 FMS with SCN 1000.7/1100.7 and Precision Approach Subsystem (PAS) 10.3 or later. If the aircraft is equipped with Universal Avionics RCU, the RCU will require RCU SCN 1016.0.7.

What will it cost to purchase and install ADS-B Out equipment?

Please contact Universal Avionics or an Authorized Dealer/Integrator for pricing for installation or upgrading your existing FMS or RCU. In addition, contact the manufacturer of your transponder for upgrade solutions that may be available.

Do I need to modify my transponder?

Modification of some Mode S transponders to meet the regulations may be possible. Older transponders are probably not upgradable and will require replacement. Whether or not a transponder is upgradable is a question for the transponder manufacturer or supplier to determine.

Must my position source be GPS?

Any position source that meets the performance standards of the rule (14 CFR § 91.227) can be submitted for certification. However, SBAS TSO-C146 () is currently the only available positioning source known to meet all of the requirements as defined in the ADS-B Out rule, although any GPS sensor meeting AC 20-165B appendix 2 requirements may qualify. Your installer will need to verify that any GPS sensor used for ADS-B Out meets all the data output requirements.

Does the GPS antenna transmit ADS-B data?

No. ADS-B Out data is transmitted by the Extended Squitter Mode S Transponder.

How did implementation of ADS-B affect the airspace in the Gulf of Mexico?

Before ADS-B, surveillance was not available in the Gulf of Mexico at low altitudes or beyond 200 NM from the coast. Now with ADS-B in place, ATC can provide 5 NM separation to low-flying aircraft and to aircraft traversing the Gulf, provided the aircraft have certified ADS-B Out equipage. Other agencies governing various airspaces worldwide are considering or have plans to provide separation services using ADS-B Out.

Is an STC required for ADS-B Out approval?

Yes and No. If the ADS-B Out system is the first installation of a GNSS source and a transponder then a TC or STC is required. If previous data from a TC or STC for a GNSS source and transponder pairing is available for use, then it may be possible to approve the ADS-B OUT system by means of a Form 337 Field Approval process.

This requirement does not apply to FMS equipment installed by field approval that is not part of an ADS-B Out solution.

Reference List

- RTCA/DO-282B, Minimum Operational Performance Standards for Universal Access Transceiver (UAT) Automatic Dependent Surveillance–Broadcast (ADS-B)
- RTCA/DO-260B, Minimum Operational Performance Standards for 1090 MHz Automatic Dependent Surveillance– Broadcast (ADS-B)
- TSO C-154c and TSO C-166B
- TSO C195a, Avionics Supporting Automatic Dependent Surveillance–Broadcast (ADS-B) Aircraft Surveillance Applications
- AC 20-165B, Airworthiness Approval of Automatic Dependent Surveillance–Broadcast (ADS-B)
- AC 20-138C, Airworthiness Approval of Positioning and Navigation Systems
- AC 20-172A, Airworthiness Approval for ADS-B in Systems and Applications
- AC 90-114 change 1, Automatic Dependent Surveillance– Broadcast (ADS-B) Operations
- FAA Policy Memo AFS-360_2016-03-02, Installation Approval for ADS-B OUT Systems, Dated 02 March 2016
- Universal Avionics Service Letter No. 2847, WAAS/SBAS Flight Management Systems Compliance with AC 20-165B, Revision D

Acronyms

- ADS-B: Automatic Dependent Surveillance–Broadcast
- AC: Advisory Circular
- AIC: Aeronautical Information Circulars
- AMC: Acceptable Means of Compliance (EASA)
- ATC: Air Traffic Control
- CAAS: Civil Aviation Authority of Singapore
- CAO: Civil Aviation Order (Australia)
- CASA: Civil Aviation Safety Authority (Australia)
- CFR: Code of Federal Regulations
- EASA: European Aviation Safety Agency
- FAA: Federal Aviation Administration
- FMS: Flight Management System
- GPS: Global Positioning System
- ICAO: International Civil Aviation Organization
- NAS: National Airspace System
- NextGen: Next Generation
- OEM: Original Equipment Manufacturer
- SBAS: Satellite-Based Augmentation System
- SCN: Software Control Number
- STC: Supplemental Type Certificate
- TSO: Technical Standard Order
- UAT: Universal Access Transceiver
- WAAS: Wide Area Augmentation Systems

About Universal Avionics

Universal Avionics is a leading manufacturer of innovative avionics systems offered as retrofit and forward-fit solutions for the largest diversification of aircraft types in the industry. Markets served include Business, Special Missions, Government/Military, Airline (regional/commercial), Helicopter and OEM.

To learn more about Universal Avionics, visit www.uasc.com/company/about-us.



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