



# Advisory Circular

**AC 21-45(0)**

**APRIL 2007**

## **AIRWORTHINESS APPROVAL OF AIRBORNE AUTOMATIC DEPENDENT SURVEILLANCE BROADCAST EQUIPMENT**

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### **1. REFERENCES**

Refer to Appendix A to this AC.

### **2. PURPOSE**

This AC is intended to define the airborne component of the 1090 Megahertz Extended Squitter Automatic Dependent Surveillance Broadcast (ADS-B) data link for use in Australia, and provide guidance and advice for the airworthiness approval of aircraft equipment proposed to support that use.

### **3. STATUS OF THIS AC**

This is the first AC to be written on this matter.

*Advisory Circulars are intended to provide advice and guidance to illustrate a means, but not necessarily the only means, of complying with the Regulations, or to explain certain regulatory requirements by providing informative, interpretative and explanatory material.*

*Where an AC is referred to in a 'Note' below the regulation, the AC remains as guidance material.*

*ACs should always be read in conjunction with the referenced regulations.*

**4. DEFINITIONS AND ACRONYMS**

AC	CASA Advisory Circular
ADS-B	Automatic Dependent Surveillance - Broadcast
AEEC	Airlines Electronic Engineering Committee
AFM	Aircraft Flight Manual
ARINC	Aeronautical Radio, Inc
ATC	Air Traffic Control
ATSO	Australian Technical Standard Order
BARO	Barometric sourced data
EASA	European Aviation Safety Agency
ETSO	EASA Technical Standard Order
EUROCAE	European Organisation for Civil Aviation Equipment
FAA	Federal Aviation Administration (of the United States)
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HAE	Height Above Ellipsoid
HFOM	Horizontal Figure of Merit
HIL	Horizontal Integrity Limit
HPL	Horizontal Protection Limit
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
JAA	Joint Aviation Authority of Europe
JTSO	JAA Technical Standard Order
MASPS	Minimum Aviation System Performance Standards
MEL	Minimum Equipment List
MMR	Multi Mode Receiver
MODE S	Mode Select (a transponder format to allow discrete interrogation and data link capability/ selective interrogation mode of SSR)
MOPS	Minimum Operational Performance Standards
MSL	Mean Sea Level
NAC	Navigation Accuracy Category
NAC <sub>P</sub>	Navigation Accuracy Category for Position
NIC	Navigation Integrity Category

NUC	Navigation Uncertainty Category
POH	Pilot's Operating Handbook
RAIM	Receiver Autonomous Integrity Monitoring
RTCA	RTCA, Inc (formerly Radio Technical Committee for Aeronautics)
SIL	Surveillance Integrity Level
SPI	Special Position Identification
SSR	Secondary Surveillance Radar
TSOA	FAA Technical Standard Order Authorisation
TSO	FAA Technical Standard Order

## 5. BACKGROUND

**5.1** ADS-B is a surveillance application that periodically transmits aircraft parameters, such as identification, pressure altitude, position and position integrity, via a broadcast data link that is available to any receiver, either airborne or ground-based, within range of the transmitter.

**5.2** ADS-B information is broadcast without any knowledge of which users may be receiving it and without the expectation of an acknowledgement or reply.

**5.3** As an automatic system, ADS-B requires no flight crew or controller action for the information to be transmitted. The surveillance-type information broadcast is dependent on the aircraft's navigation system and the broadcast capability of the source emitter.

**5.4** An ADS-B "out" system consists of the following components:

- (a) a transmitting subsystem that includes message generation and transmission functions at the source aircraft; and
- (b) the data link broadcast medium.

**5.5** The sources of the transmitted information, as well as the user applications, are not considered to be part of the ADS-B system, but their performance needs to be considered when defining overall ADS-B system performance.

## 6. APPLICABILITY

**6.1** This AC is applicable to all Australian aircraft and visiting foreign aircraft wishing to transmit ADS-B information in Australia.

## 7. RELATED AUSTRALIAN READING MATERIALS

- AC 21-15(0) Supplementary Type Certificate - Certification
- AC 21-36(0) Global Navigation Satellite System (GNSS) Equipment: Airworthiness Guidelines
- AC 21-601(0) Australian Technical Standard Order Authorisation
- ATSO-C1004 Airborne Mode A/C Transponder Equipment with Extended Squitter Automatic Dependent Surveillance – Broadcast (ADS-B) Transmit Only Equipment
- ATSO-C1005 Airborne Stand-Alone Extended Squitter Automatic Dependent Surveillance – Broadcast (ADS-B) Transmission Capability

*Note 1: Appendix A to this AC contains a list of ADS-B documentation references.*

*Note 2: Visit the CASA website [www.casa.gov.au/rules/1998casr](http://www.casa.gov.au/rules/1998casr) for access to the ACs.*

## 8. FUNCTIONAL REQUIREMENT

### 8.1 ADS-B Avionics

8.1.1 For an aircraft to be ADS-B capable, it requires:

- appropriate data sources, and
- an ADS-B transmitter to broadcast the data in a predetermined standard format.

### 8.2 ADS-B Transmitter

8.2.1 The ADS-B transmitter needs to comply with the minimum performance standards detailed in RTCA Document DO-260A Para 2.2.

8.2.2 For ADS-B data to be universally usable, it needs to be transmitted in the formats and characteristics defined in the following standards:

- ICAO Annex 10, Amendment 77;
- RTCA/DO-260; or
- RTCA/DO-260A.

8.2.3 To be useable for ATC surveillance in a “radar like” manner, ADS-B transmitters must transmit the following minimum data set:

- **Position** (in extended squitter surface position message and in extended squitter airborne position message);
- **Position Integrity Information** (e.g. NUC, NIC etc, value transmitted in the “TYPE” code in extended squitter surface position message and in extended squitter airborne position message);
- **Pressure Altitude** (in extended squitter airborne position message, GNSS height may also be transmitted in this message when barometric altitude is not available);
- **Identity** (in extended squitter identity and category message); and
- **Version Number, SIL and NAC<sub>P</sub>** in aircraft operational status message, if the avionics equipment is RTCA/DO-260A compliant.

**8.2.4** To provide a more comprehensive data set to other stations, transmission of the following data is highly desirable, as it is used by the Australian ATC system:

- SPI Indication (in Surveillance Status Subfield of ADS-B airborne position messages);
- Emergency Flag (in Surveillance Status Subfield of ADS-B airborne position messages);
- Emergency Priority Status Information (may be broadcast in Extended Squitter Aircraft Status Message, RTCA/DO-260 or RTCA/DO-260A, or the Target State and Status Message RTCA/DO-260A);
- Velocity Information (Extended Squitter Velocity Message or Surface Position Message);
- GNSS height (GNSS Altitude Difference From Barometric Altitude in Extended Squitter Velocity Message); and
- Vertical rate (in Extended Squitter Velocity Message).

*Note: Transmission of SSR ATC 4 digit octal Mode A code in ADS-B messages is not required. It may however, be transmitted in "Test messages" in accordance with RTCA/DO-260A.*

**8.2.5** Additional ADS-B data, defined in ICAO Annex 10, Amendment 77 or RTCA/DO-260 or RTCA/DO-260A, may also be transmitted.

**8.2.6** Equipment marked as compliant with ATSO-C1004, ATSO-C1005, TSO-C166, or TSO C166a, are considered capable of transmitting data described above in the correct formats.

**8.2.7** Transponders marked as compliant with the following standards:

- AEEC – ARINC 718A;
- TSO C112;
- ED73B;
- JTSO-2C112a; or
- ETSO-2C112a

may be capable of transmitting this information in the correct formats. Functional testing of the installation would be required to confirm compliance.

**8.2.8** ADS-B transmitters should also be compliant with the following :

- For transmitters that also operate as ATC transponders:
  - ATSO-C1004 (Type G1 only);
  - ATSO-1C74c;
  - TSO-C112 and compliant with RTCA/DO-181C; or
  - EUROCAE ED73B or RTCA/DO-181C.
- Non-transponder ADS-B transmitters:
  - ATSO-C1005.

**8.2.9** RTCA/DO-260 compliant ADS-B transmitters use the Horizontal Protection Limit/Horizontal Integrity Limit (HPL/HIL) data from the GNSS receiver as the highest priority data source for determination of Navigation Uncertainty Category (NUC).

For RTCA/DO-260 compliant transmitters, ADS-B transmitters may use the Horizontal Figure of Merit (HFOM) data from the GNSS receiver during periods of HPL non-availability due to operational reasons (e.g. satellite geometry, etc).

For RTCA/DO-260A compliant transmitters, HPL is used for determination of Navigation Integrity Category (NIC) and HFOM is used for determination of Navigation Accuracy Category (NAC).

**8.2.10** It is desirable that the flight crew are able to disable the ADS-B function on instruction from ATC without disabling the operation of the ATC transponder function.

**8.2.11** Transmitter antenna installation needs to comply with guidance for installation of ATC transponders to ensure satisfactory functioning.

### **8.3 ADS-B data sources (Mandatory)**

**8.3.1** The following section describes the minimum data necessary for ADS-B transmitters to function in the ATC environment (for more detailed requirements including references see Appendix B to this AC). Each category is essential to ensure the message being transmitted has all the relevant data necessary to enable separation to be calculated. Failure to comply may render the prospective operator unable to obtain the benefits of ADS-B separation.

#### **8.4 Positional data**

**8.4.1** Accurate positional data is essential for the ADS-B system to operate in a “radar like manner” and be the basis for the allocation of separation between aircraft. Valid GNSS data input provides an acceptable accuracy and integrity for separation purposes with the delivery of position information at a periodic interval of less than or equal to 1 second.

**8.4.2** GNSS equipment compliant with TSO-C145a, TSO-C146a or an equivalent standard acceptable to CASA are suitable for use with ADS-B.

**8.4.3** Particular navigation packages that do not have a TSOA, but can be demonstrated to achieve the accuracy and integrity values required, may be acceptable to CASA. In assessing the suitability of GNSS avionics that do not have a TSO-C145a/146a authorisation, CASA may consider the system differences to the standards documented in RTCA/DO-229C (or later version), with particular regard to the following criteria:

- The system’s capability of delivering position information with a periodic interval of at least one second; and
- The system can continuously output the HPL value to the ADS-B transmitter or notify the pilot of an interruption due to availability issues (RAIM); and
- If the system is intended primarily as a pilot navigation system with positional information being provided to the ADS-B system, it needs to meet the requirements of AC 21-36(0); and
- The system takes advantage of GPS selective availability being set to zero.

## 8.5 Positional integrity data

**8.5.1** HPL integrity data needs to be provided to the ADS-B transmitter from the GNSS receiver on the same interface as the positional data. This data is typically available as ARINC429 label 130.

**8.5.2** HFOM data shall be provided to the transponder on the same interface as the HPL data. HFOM typically uses ARINC429 label 247.

A RTCA/DO-260A compliant installation will use the HFOM value to calculate NAC.

In some cases, such as during rare periods of inadequate satellites, HPL may not be delivered to the interface. In this case, a RTCA/DO-260 compliant installation may use the HFOM value to generate NUC during the period of HPL non-availability.

**8.5.3** In the case of RTCA/DO-260A compliant installations, the SIL is intended to reflect the integrity of the navigation source of the position information broadcast. Where position integrity is based on HPL and the SIL cannot be unambiguously determined and set dynamically, the value should be set to 2. During periods where HPL is not available, the NIC should be set to 0 (zero), and the NAC should reflect the accuracy of the broadcast position.

## 8.6 Pressure altitude

**8.6.1** Pressure altitude provided to transponders is to be in accordance with existing requirements for ATC transponders. It is preferable that 25 foot altitude encoding is used. This data is typically available on ARINC429 label 203.

## 8.7 Identity

**8.7.1** Identity information is to be provided to the transponder so that the information is identical to the filed flight plan. This information may be provided from:

- a flight management system;
- a pilot control panel; or
- for aircraft which always operates with the same flight identity (e.g. using registration as a callsign), it may be programmed into equipment at installation.

## 8.8 ADS-B data sources (Desirable)

**8.8.1 GNSS altitude.** GNSS altitude should be provided from an approved GNSS receiver to the ADS-B transmitter. Typically this data is available as GNSS Height (HAE) ARINC429 label 370 or GNSS Alt (MSL) ARINC429 label 076.

**8.8.2 Vertical rate (GNSS or Barometric).** Vertical rate may be provided from either a GNSS receiver or from a pressure source:

- GNSS vertical rate should be provided from an approved GNSS receiver, and is typically available as ARINC429 label 165, or
- Barometric vertical rate. Barometric (BARO) vertical rate is typically available as ARINC429 label 212.

*Note: The most accurate source should be used.*

**8.8.3 Velocity Information.** Ground speed from an approved GNSS receiver in the form of East/West Velocity and North/South Velocity should be provided. This would be typically available as ARINC429 label 174.

**8.8.4 SPI Indication.** For ATC transponders, the SPI capability is integrated into the transponder functionality and is controlled from the transponder control panel. For non transponder implementations, a discrete input or a control panel may be provided to trigger the SPI indication.

**8.8.5 Emergency indicator.** For ATC transponders the emergency declaration capability is integrated into the transponder functionality and is controlled from the transponder control panel. For non transponder implementations a discrete input or a control panel may be provided to trigger the emergency and/or to indicate the type of emergency.

## **9. DESIGN, DEVELOPMENT AND APPROVAL OF AIRCRAFT MODIFICATIONS**

### **9.1 Compliance**

**9.1.1** When utilising this guidance material for the approval of an ADS-B installation, in accordance with Regulation 35 of CAR 1988 or a Supplemental Type Certificate under CASR Subpart 21.E, the following need to be considered:

- The applicant will need to submit, to CASA, a compliance statement that shows how the criteria of this guidance material has been satisfied, together with evidence resulting from the activities described in this section.
- Compliance with the airworthiness requirements for intended function and safety may be demonstrated by equipment qualification, safety analysis of the interface between the ADS-B equipment and data sources, equipment cooling verification and ground tests. To support the approval application, design data will need to be submitted showing that the requirements for ADS-B operation have been complied with.
- The safety analysis of the interface between the ADS-B system and its data sources should show no unwanted interaction under normal or fault conditions.

**9.1.2** FAA AC 120-86 provides additional guidance by providing general information and acceptable methods of compliance for the certification, airworthiness, and operational approval of certain aircraft surveillance systems and selected associated aviation applications.

**9.1.3** A self-evaluation checklist to assist in determining compliance is included at Appendix C to this AC.

### **9.2 Ramp Test**

**9.2.1** The functionality for ADS-B “out” application may be demonstrated by ground testing, using ramp test equipment where appropriate, that verifies:

- system operation;
- the aircraft derived data in the transmitted messages including integrity data; and
- functioning of system fault detectors if any fitted.

### **9.3 Equivalent Installations**

**9.3.1** A current list of approved equipment can be found at Appendix D.

### **9.4 Flight Manual**

**9.4.1** The Aircraft Flight Manual (AFM) or the Pilot’s Operating Handbook (POH), whichever is applicable, should provide at least the following information:

- A statement that the transponder system(s) complies with the criteria of ICAO Annex 10 Amendment 77 regarding extended squitter and any necessary procedures for expected operations (e.g. the need to enter Flight ID) for use with ATC.

## **9.5 Minimum Equipment List (MEL)**

**9.5.1** The MEL should indicate that ADS-B OUT is not mandatory (at this time).

## **9.6 Maintenance**

**9.6.1** Maintenance tests should include a periodic verification check of aircraft ADS-B data including the ICAO 24 bit aircraft address (colloquially known as the 24-bit Mode S address) using suitable ramp test equipment. A check of the ICAO 24 bit aircraft address should be made in the event of a change of the registration mark of the aircraft (this is especially necessary following change in State of registration) or whenever a transponder is replaced.

**9.6.2** Where possible, maintenance tests should check the correct functioning of system fault detectors (if any).

**9.6.3** The maximum period between ADS-B maintenance tests of the ADS-B transmitter should be the same as for ATC transponders and all transponders fitted to the aircraft should be checked.

## **9.7 Crew Operating Instructions**

**9.7.1** Crew Operating Instructions for the ADS-B system should emphasise the need to use the ICAO-defined format for entry of the Aircraft Identification or Registration mark as applicable to the flight. The shortened format commonly used by airlines (a format used by International Air Transport Association (IATA)) is not compatible with the ground systems of the air traffic services.

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APPENDIX A

REFERENCES

AUSTRALIAN

Source	Title	Reference	Version	Date
CASA	Certification and airworthiness requirements for aircraft and parts	CASR Part 21		December 2005
	Approval of design of modification or repair	Regulation 35 of CAR 1988		December 2005
	Supplemental Type Certificate - Certification	AC 21-15	(0)	August 1999
	Global Navigation Satellite System (GNSS) Equipment: Airworthiness Guidelines	AC 21-36	(0)	April 2005
	Australian Technical Standard Order Authorisation	AC 21-601	(0)	July 2005
	Airborne Mode A/C Transponder Equipment with Extended Squitter Automatic Dependent Surveillance – Broadcast (ADS-B) Transmit Only Equipment	ATSO-C1004		October 2003
	Airborne Stand-Alone Extended Squitter Automatic Dependent Surveillance – Broadcast (ADS-B) Transmission Capability	ATSO-C1005		December 2004

INTERNATIONAL

Source	Title	Reference	Version	Date
ICAO	Aeronautical Communications (Digital Data Communication Systems)	Annex 10 Volume III	Amdt. 77	July 2002
	Aeronautical Communications (Surveillance Radar and Collision Avoidance Systems)	Annex 10 Volume IV	Amdt. 77	July 2000
	Manual of the Secondary Surveillance Radar System (SSR)	Doc 9684 AN/951	Third Edition	2004
	Procedures for Air Traffic Services - Air Traffic Management (PANS-ATM)	Doc 4444	Amdt 4	24 November 2005
EUROCAE / RTCA	Guidelines for Approval of the Provision and Use of Air Traffic Services Supported by data communications	EUROCAE ED 78A, or		December 2000
		RTCA/DO-264		December 2000
	MASPS for Required Navigation Performance (RNP) Area Navigation	EUROCAE ED-75B or		December 2003
		RTCA/DO-236B		October 2003
	MASPS for ADS-B	RTCA/DO-242A		June 2002
	MOPS for 1090MHz for ADS-B	EUROCAE ED-102, or		November 2000
		RTCA/DO-260/260A		September 2000/ April 2003
Minimum Operational Performance Specification for Secondary Surveillance Radar Mode S Transponders	EUROCAE ED-73B		January 2003	
Minimum Aviation System Performance	RTCA/DO-289		September 2003	

	Standards for Aircraft Surveillance Applications (ASA)			
	Minimum Operational Performance Specification for Air Traffic Control Radar Beacon System/ Mode Select (ATCRBS/Mode S) Airborne Equipment	RTCA/DO-181C		June 2001
	Minimum Aviation System Performance Standards for Surveillance Transmit Processing (STP)	RTCA/DO/302		December 2006
	Safety, Performance and Inter-operability Requirements Document for the ADS-B Non-Radar-Airspace (NRA) Applications	RTCA/DO/303		December 2006
FAA	Technical Standard Order for Mode S Extended Squitter  <i>Note: This standard of transponder does not provide the full functionality required. However, the RTCA/Document has been updated to DO-181C that defines an acceptable standard. It is expected that the FAA TSO will be updated</i>	TSO-C112 (Based on RTCA/DO-181)		February 1986
	Extended Squitter Automatic Dependent Surveillance - Broadcast (ADS-B) and Traffic Information Service - Broadcast (TIS-B) Equipment Operating on the Radio Frequency of 1090 Megahertz (MHz)	TSO-C166 TSO-C166a		September 2004 December 2006
	Guidelines for Design Approval of Aircraft Data communications	AC 20-140		August 1999
	Aircraft Surveillance Systems and Applications	AC 120-86		September 2005
EASA/JAA	Minimum Operational Performance Specification for SSR Mode S Transponders. (Adopts Eurocae ED-73A).  <i>Note: This JTSA is being updated to version B based on EUROCAE document ED-73B.</i>	ETSO-2C112a, formerly JTSA-2C112a		24 October 2003

**APPENDIX B**

**ADS-B OUT DATA**

**Table 1: Required Characteristics of Mandatory ADS-B “Out” Data**

Item	Parameter	Range	Minimum Resolution	Accuracy Limits	Maximum Data Age at Transmission	Remarks ADS-B transmitter specification
1	Identity/Call Sign	8 characters	N/A	N/A	60 seconds	ICAO Annex 10, Vol IV, para 3.1.2.9
2	Position	Any latitude and longitude on earth		-	2 seconds	ICAO Annex 10, Vol IV, para 3.1.2.8.6.6 and Vol III, Part I, App to Chap 5 para 2.3.2.3
3	Pressure Altitude	-1000 ft to maximum certificated altitude of aircraft plus 5000 ft	100 ft (Gillham’s code) or 25 ft as provided by the source	As the installed sensor	2 seconds	ICAO Annex 10, Vol IV, para 3.1.2.6.5.4 referenced to 1013.25 hPa and Vol III, Part I, App to Chap 5 para 2.3.2.4
4	Integrity Value	Value 0-9	1	N/A	2 seconds	ICAO Annex 10, Vol III, Part I, App to Chap 5 para 2.3.1

**Table 2: Required Characteristics of Desirable ADS-B “Out” Data**

1	SPI Indication					
2	Emergency Flag					
3	Emergency Type Indicator					
4	Velocity Information		-	-	2 seconds	ICAO Annex 10, Vol IV, para 3.1.2.8.6.6 and Vol III, Part I, App to Chap 5 para 2.3.5
5	GNSS Height					
6	Vertical rate (GNSS/BARO)					

**APPENDIX C**

**SELF EVALUATION CHECKLIST**

ADS-B Transmitter Manufacturer & Model number	
GNSS positional source Manufacturer & Model number	
GNSS receiver TSO	TSO C145a/ TSO C146a / Other
If not TSO C145a or TSO C146a compliant	<ul style="list-style-type: none"> <li>• Not required until June 2012, refer CAO 20.18. Confirm supports Fault Detection Exclusion (FDE)</li> <li>• Confirm outputs HPL or HIL</li> <li>• Is BARO aiding provided to GNSS receiver?</li> </ul>
Transmitter Message formats compliant with (Circle one)	<ul style="list-style-type: none"> <li>• ICAO Annex 10, Amendment 77; or</li> <li>• DO-260; or</li> <li>• DO-260A or TSO C166</li> </ul>
Transmitter characteristics compliant with (Circle one)	<ul style="list-style-type: none"> <li>• ATSO-C1004 (Type G1 only); or</li> <li>• ATSO-1C74c</li> <li>• TSO-C112 and compliant with DO-181c; or</li> <li>• ETSO-2C11;2 or</li> <li>• ED73B or DO-181</li> <li>• ATSO-C1005</li> </ul>
HPL is provided to ADS-B transmitter on same interface as GNSS positional data and tested	YES/NO
Suitable barometric encoder (pressure altitude) data provided to transmitter and tested?	YES/NO
Uses aircrafts own ATC transponder antenna?	YES/NO
If not using the aircrafts own ATC antenna, has antenna been mounted in accord with transponder mounting rules?	YES/NO
Flight ID source installed and tested? (Circle one)	Programmed/ pilot entry panel/ Flight Management System interface
Optional data supported and tested (Circle those verified)	SPI indication Emergency flag Ground track / Ground speed velocity vector Emergency type indicator GNSS height GNSS vertical rate BARO vertical rate

**APPENDIX D****APPROVED EQUIPMENT**

The current list of approved equipment can be found at the following website address:  
<http://casa.gov.au/rules/1998casr/021/021c45eqptlist.pdf>