Australian Government
Civil Aviation Safety Authority

DISCUSSION PAPER

DP 1701AS

Voluntary fitment of ADS-B technology in VFR aircraft

Date	December 2017
Project number	AS 16/06
File ref	D17/179498

Audience

This discussion paper will be of interest to:

- owners, operators and pilots of VFR aircraft
- operators and pilots of:
  - remotely piloted aircraft
  - balloons
- regional airline operators
- sport and recreational pilots
- organisations and associations:
  - Aerial Application Association of Australia
  - Air Sports Australia Confederation
  - Aircraft Electronics Association
  - Airservices Australia
  - Australian Aircraft Owners and Pilots Association
  - Australian Association of Flight Instructors
  - Australian Ballooning Federation
  - Australian Federation of Air Pilots
  - Australian Licensed Aircraft Engineers' Association
  - Australian Maritime Safety Authority
  - Australian Parachuting Federation
  - Australian Warbirds Association Limited
  - Aviation Maintenance Repair and Overhaul Business Association Inc.
  - Gliding Federation of Australia
  - Hang Gliding Federation of Australia
  - Honourable Company of Air Pilots
  - Recreational Aviation Australia (RAAus)
  - Regional Aviation Association of Australia
  - Royal Federation of Aero Clubs Australia
  - Royal Flying Doctor Service
  - Sport Aviation Association of Australia.

Response date

The Civil Aviation Safety Authority (CASA) is responsible under the *Civil Aviation Act 1988* for, amongst other functions, developing and promulgating appropriate, clear and concise aviation safety standards. CASA must, where appropriate, consult with government, commercial, industrial, consumer and other relevant bodies and organisations in the performance of this function and the exercise of its powers.

Civil Aviation Act 1988 Subsection 9(1)(c) and Section 16

This discussion paper contains options that may be pursued in a future regulatory change proposal e.g. Notice of Proposed Rule Making (NPRM). These documents all form part of the consultation process.

No action will be taken until all responses and submissions have been considered. To ensure clear and relevant safety standards, CASA needs the benefit of your knowledge as an aviator, aviation consumer and/or provider of related products and services.

You can help by completing the online response form by 23 February 2018.

Foreword

Flight crew must be vigilant to see and avoid other aircraft, particularly when operating in non-controlled airspace. ‘See and avoid’ is most effective when flight crew have prior warning of a potential conflict and know exactly where to look. Helpful information can be provided by air traffic control (ATC) or an on-board system. However, this depends on aircraft being electronically ‘visible’ by some means. A conventional transponder will make an aircraft visible on ATC secondary surveillance radar (SSR) or a larger aircraft's aircraft collision avoidance system (ACAS); however, large parts of Australia are not within SSR coverage and most non-airline aircraft are not fitted with ACAS.

CASA believes that automatic dependent surveillance - broadcast (ADS-B) technology is an appropriate solution for improving aircraft visibility. All aircraft operating under the instrument flight rules (IFR) are already required to carry ADS-B transmitting equipment (ADS-B OUT). There is also an extensive ADS-B ground receiver network that enhances ATC's ability to provide surveillance services in even the remotest parts of Australia. ADS-B receiver technology (ADS-B IN) is now available that provides an in-cockpit graphical presentation of ADS-B information from surrounding aircraft and, depending on the particular equipment, can provide visual or aural alerts about potential collisions. However, the full benefits to our airspace system of ADS-B are not achievable at present because very few VFR aircraft have voluntarily fitted with ADS-B technology.

This discussion paper explores ways to increase the voluntary fitment rate across the VFR fleet by allowing a greater choice of ADS-B technologies to be considered 'fit for purpose' for VFR operations. CASA believes that increasing the fitment rate of ADS-B technology in VFR aircraft will further enhance safety by increasing the visibility of aircraft to ATC and other aircraft. While the discussion paper focuses on the ADS-B OUT component, we believe the ideal end state is where the maximum number of both VFR and IFR aircraft are fitted with ADS-B OUT and ADS-B IN equipment.

We recognise the valuable contribution that industry consultation provides to the regulatory development process and so we have issued this DP to help inform CASA as to the appropriate ADS-B equipment standards for fitment in VFR aircraft.

It is important to note that the responses to this DP will not predispose CASA to a particular solution for VFR aircraft. Following the DP consultation period, preferred solutions will be subject to further consultation prior to any voluntary VFR equipment standards being adopted.

CASA recognises that many VFR pilots value the safety benefits of ADS-B however; the cost of installing ADS-B equipment may be prohibitive. CASA hopes that by exploring ADS-B compatible technologies, a safe and effective solution may be available at a reduced cost to allow for greater participation within the ADS-B system.

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1.1 Introduction

1.1.1 See and avoid

The requirement for flight crew to use the 'see-and avoid' approach has well understood limitations, particularly when a pilot is not specifically aware of, or alerted to, a potential conflict. A 1991 Bureau of Air Safety (BASI) investigation[1] concluded that:

> *Unalerted see-and-avoid has a limited place as a last resort means of traffic separation at low closing speeds but is not sufficiently reliable to warrant a greater role in the air traffic system*.

According to the BASI report, traffic information from ATC or pilot-to-pilot communication increases the probability of a pilot sighting other traffic, with the probability increasing further if a pilot knows exactly where to look. For operations in non-controlled airspace and large sections of Class E airspace, there are significant factors that prevent a pilot being alerted to the presence of conflicting aircraft:

- ATC does not provide continuous flight following for VFR aircraft, unless requested to do so, and often cannot detect unknown VFR aircraft with conventional radar due to limits in coverage.
- Frequency congestion can prevent pilots from making timely traffic broadcast reports that may assist other pilots to avoid conflicts.
- Due to conflicting needs to communicate with ATC or with the company/flying organisation, it is not always possible for aircraft in potential conflict to send and receive the information they need to avoid conflict.

Electronic alerting systems have the potential to supplement verbal alerts as a means of directing pilots to know exactly where to look for conflicting aircraft. For example, aircraft that meet a certain threshold[2] are required to be fitted with an ACAS. The traffic display on an ACAS is used by pilots to determine the position of other aircraft in non-controlled environments. Other pilots—particularly in the gliding community—use devices such as FLARM[3] to improve their ability to see and avoid.

Anecdotal evidence exists about the usefulness of an ACAS display for determining the position of aircraft in the non-controlled environment and aiding pilots to sight conflicting aircraft. Devices like FLARM are valuable aids—particularly in the gliding community— for mitigating the limitations of see-and-avoid and reducing the risk of collision when aircraft operate in proximity with each other.

[1] https://www.atsb.gov.au/media/4050593/see_and_avoid_report_print.pdf
[2] Aircraft weighing more than 15,000 kg or carrying more than 30 passengers.
[3] FLARM (Flight Alarm) is a low-cost collision avoidance system originally designed for gliders.

While on-board surveillance systems such as ACAS and FLARM improve pilots' ability to see-and-avoid, they are unlikely to be broadly adopted as a general-purpose aircraft detection capability as:

- ACAS is expensive (with a cost upwards of US$8,000) and is generally utilised only in airline aircraft.
- Many VFR aircraft—including gliders—are not or cannot be fitted with a transponder, which is essential for detection by ACAS.
- FLARM uses proprietary encrypted transmissions that are detectable only by other aircraft equipped with FLARM, and so cannot be detected by ATC surveillance or ACAS.

Note: Issues with compatibility were highlighted in an ATSB Aviation Short Investigations[4], which summarised several near-collision events in non-controlled airspace. This included one situation in which a SAAB 340 aircraft equipped with ACAS came within proximity of a glider, despite the SAAB making traffic broadcasts.

1.1.2 ADS-B

CASA considers that ADS-B technology addresses the compatibility and cost issues that make ACAS and FLARM unsuitable for broad adoption. ADS-B has already been adopted as the cornerstone of Australia's air traffic surveillance coverage, with all IFR aircraft having to be fitted with ADS-B OUT technology. Airservices Australia have supported this by installing more than 70 receiving stations across Australia.

ADS-B OUT is based on the global navigation satellite system (GNSS), in which an aircraft receives data from GNSS satellites and then broadcasts information about its identification, position, altitude, speed and other relevant data. ADS-B OUT (the transmitter) can be designed to be visible to ACAS, ATS surveillance systems and ADS-B IN (the receiver), because ADS-B transmissions are neither proprietary nor encrypted. As with ACAS and ATS surveillance systems, ADS-B IN enables the detection and display of information from aircraft that broadcast an ADS-B OUT signal. This capability can range from aural traffic alerts to a cockpit display presented in a radar-like form.

ADS-B OUT equipment is becoming more portable, making it a potentially attractive solution for gliders, remotely piloted aircraft systems (RPAS) and other aircraft that have previously been unable to power a traditional transponder.

[4] https://www.atsb.gov.au/publications/2016/ab-2016-085/

1.2 Industry proposal for reduced cost

1.2.1 ASTRA proposal

The Australian Strategic Air Traffic Management (ASTRA) group—the original industry proponent of the ADS-B program—wrote to CASA in 2016 proposing several options for reduced cost ADS-B systems. ASTRA submitted that these systems could provide significant safety and efficiency benefits, including:

- increased visibility of, and between, aircraft exposed to the risk of collision with other air traffic
- increased visibility to ATC of VFR aircraft used for sport, recreation, small training, and some private and business purposes, leading to:
  - greater situational awareness for controllers
  - improved traffic information
  - improved alerting, position and flight monitoring
  - improved service delivery
- enhanced management and monitoring of emergency situations, including search and rescue
- provision of an incentive for the broader fitment of ACAS, or traffic advisory system (TAS), in aircraft not required to have such equipment
- provision of an incentive for the broader fitment and use of ADS-B IN equipment, and the consequential development of operational skills in this technology by all types of operators and across all industry sectors.

Recognising the potential benefits of such a proposal, CASA established Project AS 16/06[5] to review the proposal, with later stages to identify appropriate performance standards and, if appropriate, make any necessary changes to CASA's regulations, standards and advisory material.

1.2.2 CASA review

As part of Project AS 16/06, CASA invited members of industry to participate in a 'low cost ADS-B working group'. Participants were selected to ensure broad representation (see Appendix A for a list of representatives), with the working group meeting on 29 August 2016 to discuss the broad concept of reduced cost ADS-B for VFR aircraft.

Based on an initial review, CASA concurred with ASTRA's assessment that increased use of ADS-B technology would deliver safety and efficiency benefits to the Australian aviation industry. CASA considered that the ideal 'system' would have four components:

- ADS-B OUT, to broadcast aircraft position
- ADS-B IN, to detect and display information from aircraft broadcasting ADS-B OUT

[5] Automatic dependent surveillance - broadcast (ADS-B) equipment suitable for voluntary fitment and use in aircraft operated in accordance with the VFR. See https://www.casa.gov.au/standard-page/project-1606-automatic-dependent-surveillance-broadcast-ads-b-equipment-suitable

- ACAS, although not directly based on ADS-B technology, would play a complementary role by monitoring the airspace around an aircraft for other aircraft equipped with compatible transmitting equipment and warning pilots about collision threats
- ATS surveillance, through the use of ground stations that detect ADS-B OUT broadcasts, to display the information to air traffic controllers.

The four components would operate together to enable benefits such as:

- enhanced situation awareness
- enhanced traffic information capabilities
- conflict alerting or traffic avoidance advice
- enhanced search and rescue alerting.

A considerable proportion of this system is already in place with all IFR aircraft in Australia required to be fitted with ADS-B OUT equipment. There is also an extensive ADS-B ground station network in place across Australia and many larger passenger-carrying aircraft are already equipped with ACAS. The missing elements of this system are extensive ADS-B OUT capability across the VFR community and adoption of ADS-B IN capability by both the IFR and VFR communities.

1.3 Issues for consideration

Low cost[6] technologies to detect ADS-B transmissions and display information for pilot situation awareness are becoming more available in the market place. These can range from hand-held tablets that link to portable wallet-sized ADS-B receivers, through to integrated ADS-B OUT/IN systems that can be panel-mounted in an aircraft. However, the current technical specifications for ADS-B OUT are designed for IFR operations in controlled airspace. These requirements preclude several low-cost ADS-B solutions that may be suitable for use in VFR aircraft. This discussion paper seeks comment from industry and the public on:

- options to reduce the cost of installation, use and maintenance of ADS-B equipment in VFR aircraft
- standards for ADS-B equipment suitable for VFR aircraft, additional to the existing IFR standards, such as:
  - allowing fitment of ADS-B equipment authorised to FAA TSO-C199
  - allowing fitment of ADS-B equipment that satisfies functional and performance requirements described in this discussion paper, but without formal authorisation under a technical standard order (TSO)
- a proposal to work with industry to prepare Australian Technical Standards Orders (ATSOs), or other approvals for ADS-B devices
- permissible use of various ADS-B configurations in different situations, and indicative equipment costs.

[6] When compared to an ACAS.

1.4 Considerations

As outlined below, there are a number of relevant considerations when discussing this issue and developing a policy position.

1.4.1 CASA policy on ADS-B equipment

VFR fitment to remain voluntary

CASA does not intend to regulate the mandatory fitment of ADS-B equipment in VFR aircraft at this time. However, in considering feedback from industry in response to this discussion paper we would be mindful that any VFR equipment option resulting from this project would continue to be acceptable in the event that fitment of ADS-B equipment in VFR aircraft was mandated at some time in the future.

Continued validity of the existing CAO 20.18 ADS-B equipment configuration

CAO 20.18 specifies the minimum performance standards for ADS-B OUT equipment in different situations. These standards are consistent with those adopted by other countries and support the application of ATS surveillance-based separation (e.g. 3 NM or 5 NM between equipped aircraft).

When considering ADS-B OUT standards for VFR aircraft, including standards that may apply in certain classes of controlled airspace, CASA does not intend to amend the ADS-B standards currently specified for IFR aircraft.

Ideal ADS-B configuration for VFR aircraft

Despite this discussion paper considering additional standards for ADS-B OUT equipment, CASA believes the ideal ADS-B equipment configuration for VFR aircraft is equipment that meets the existing CAO 20.18 standards because such equipment would be useable without restriction in any airspace.

1.4.2 ADS-B equipment compatibility

1090ES or UAT

Any standard for ADS-B OUT in VFR aircraft should be compatible with standards already in use in Australia. There are two types of ADS-B transmission system currently in use in different parts of the world:

- the 1090 MHz extended squitter (1090ES) system
- the 978 MHz universal access transceiver (UAT) system.

Australia, along with a majority of countries, uses the 1090ES system. The UAT system is an alternative to 1090ES, used by some small aircraft in the United States of America (USA). While the UAT system offers increased functionality when compared with 1090ES (i.e. additional transmission of weather information, aeronautical information etc.), it would not be a viable option in Australia because of the cost of investing in the UAT ground stations needed to make UAT transmissions detectable by ADS-B equipment (and vice versa), and by ATC.

ADS-B, ACAS and surveillance systems

The United Kingdom has an industry standard for low-cost electronic conspicuity devices (CAP 1391). Electronic conspicuity devices operate on the 1090ES system; however, they are not designed to respond to ACAS interrogations, and hence would not be detectable by ACAS-equipped aircraft. As CASA considers that ADS-B equipment should be visible to as many airspace users as possible, we are not considering an electronic conspicuity-type device. This discussion paper only considers technologies that enable an aircraft to be seen by:

- ACAS
- aircraft ADS-B IN equipment
- ATC ADS-B ground stations
- Mode S SSR (in some configurations).

2 Installation and continuing airworthiness of ADS-B equipment

To reduce the costs associated with installing ADS-B equipment, CASA is looking at options to relax or modify the existing installation requirements for ADS-B equipment in VFR aircraft according to the type and category of aircraft.

2.1 Fixed installation in aircraft

2.1.1 Certain type-certificated aircraft

In addition to the conventional installation methods prescribed under Part 21 of CASR, CASA proposes that a CAR 30 or Part 145 organisation may install ADS-B equipment in type-certificated aircraft in the circumstances mentioned below. The installation, in the appropriate circumstances, would be considered a 'minor modification' that would not require an engineering order or other formal installation approval.

We propose this installation option would only apply in the following circumstances:

- the aircraft is a non-pressurised aeroplane or helicopter of less than 5,700kg MTOW
- the aircraft will not be used for RPT or charter operations
- the aircraft will be limited to VFR operations in Australian airspace while the equipment remains installed
- the CAR 30 or Part 145 organisation has installation instructions from the original equipment manufacturer in conjunction with acceptable guidance material and it is satisfied that engineering design approval is not necessary to effect the installation in accordance with the relevant acceptable maintenance data[7]
- all installations are consistent with type certificate holder approved data
- the equipment is either directly connected to the aircraft static air source, or an existing or replacement pressure altitude encoder or air data computer [8, 9]
- the installation is carried out in accordance with the manufacturer's instructions and acceptable guidance material, or acceptable maintenance data
- there is no change to the aircraft structure or detrimental effect on the electrical load analysis (refer CASA Airworthiness Bulletin 24-007 - Electrical Load Analysis), beyond installation of the device and tray, wiring to the device and its antenna(s) and replacement of existing wiring and components that would be permitted in the course of maintenance
- there is no electromagnetic interference and the installation does not change the electromagnetic compatibility of the aircraft (refer Appendix A of Advisory Circular (AC) 21-53)

[7] Acceptable maintenance data would be an approved model list supplemental type certificate (AML-STC), approved modification that covers the target aircraft, or even an AC providing adequate instruction e.g. FAA AC 43.13-2

[8] If the altitude encoder for ADS-B is separate to that supplied to a mode S transponder, or if co-located with a mode C transponder, the ADS-B messages would probably need to use downlink format 18 (DF=18).

[9] Interconnection to any other equipment would require an additional installation design approval.

- a certification is entered in the aircraft log book or aircraft maintenance records citing the acceptable maintenance data used for the installation
- an approved flight manual supplement is inserted without modification into the aircraft flight manual. Alternatively and without modification, the applicable manufacturer's operating instructions are placed in the aircraft on completion of the installation
- existing applicable requirements for additional external antenna positions, electrical load analysis, weight and balance data are satisfied
- the installation is subject to initial and periodic testing as required by Civil Aviation Order 100.5, any applicable instructions for continuing airworthiness and the manufacturer's installation and operation instructions.

2.1.2 Other aircraft

Recreational aviation Australia-registered aircraft

For aircraft registered by the Recreational Aviation Australia (RAAus), CASA proposes that installation of ADS-B equipment would be acceptable under self-administration arrangements.

Gliders

For gliders, CASA proposes that installation of ADS-B equipment would be acceptable under self-administration arrangements and the other sections of this discussion paper as applicable.

See the section below about portable installations.

VH-registered amateur-built aircraft

For VH-registered aircraft constructed and operated under an amateur-built aircraft acceptance (ABAA) or experimental amateur built (EAB) category, CASA proposes installation of ADS-B equipment would be acceptable:

- under existing self-administration arrangements, by the amateur aircraft builder or other authorised person(s)
- by a CAR 30 or Part 145 organisation using personnel otherwise authorised to perform the installation with acceptable maintenance data.

VH-registered light sport aircraft

For VH-registered light sport aircraft (LSA), CASA proposes installation of ADS-B equipment should be acceptable using a method specified by the LSA manufacturer using the technical data provided by the original equipment manufacturer (OEM).

Other VFR aircraft

For military, historic, and other VFR aircraft (including RAAus aircraft and RPAS), CASA proposes installation of ADS-B equipment would be acceptable under any of the following circumstances:

- self-administration arrangements
- by a CAR 30 or Part 145 organisation

  or

- using personnel otherwise authorised to perform the installation of equipment with acceptable maintenance data.

2.1.3 Installation costs and savings

For type-certificated aircraft, the primary cost saving arises from avoiding the need for an engineering order. CASA estimates these savings would be in the range of $550.00 - $1,500.00.

For aircraft that are not eligible for the relaxed installation options, CASA estimates the cost of installation of ADS-B equipment in a type-certificated VFR aircraft to range from $1,200.00 - $3,000.00. This cost will vary with:

- the time (with associated *per hour* charge) required to:
  - remove, move and/or replace existing equipment or fittings
  - establish the necessary power and air data sources
  - fit and test the new ADS-B equipment
- installation hardware
- determining if existing equipment (e.g. the existing transponder) can be utilised for the ADS-B installation
- the scope of the update - whether or not ADS-B is being installed in conjunction with a more extensive upgrade of the aircraft's avionics.

For installation in the other types of aircraft mentioned in this section, these costs can be reduced or even avoided in circumstances where self-installation is allowable or a portable device can be utilised.

2.2 Portable installations

There are certain situations in which it would be acceptable to CASA for the ADS-B OUT device to be installed in a portable manner. CASA proposes to allow portable ADS-B OUT devices:

- for aircraft not fitted with an engine driven electrical system capable of continuously powering at least an ADS-B device with an RF output power of at least 18.5 dBW (70 W)

  or
- in other aircraft for operations below 10,000 ft in Classes D, E and G airspace.[10]

CASA proposes portable ADS-B OUT devices must comply with one of the technical standards identified in this discussion paper for ADS-B OUT equipment, with the exception that the device's output power needs only to be sufficient for the device detectable by ACAS or ADS-B IN equipment at line-of-sight range of at least 20 km.[11] CASA's expectation would be for the manufacturer to provide a statement identifying the technical standard to which the device complies and a statement attesting that the detection range has been practically demonstrated.

[10] Aircraft above 10,000ft are not speed limited. The restriction on portable ADS-B installations in this airspace is to ensure that ADS-B transmissions are always reliable enough, and powerful enough, to be detectable by two high speed aircraft on converging paths with sufficient time to take avoiding action.
[11] If necessary, the device should have operating and fitment instructions for achieving the specified detection range.

The proposed minimum detection range is intended to enable one-minute's notice of a possible conflict in the case of two aircraft on converging paths with both travelling at the airspace speed limit of 250 knots.

2.3 Maintenance

For any ADS-B equipment option mentioned in this discussion paper, CASA's expectation is for the equipment to be maintained in accordance with the manufacturer's requirements.

3 ADS-B equipment authorised to TSO-C199 standards/requirements

FAA TSO-C199 covers minimum performance standards for a low-cost traffic awareness beacon system (TABS). TABS equipment operates on the 1090ES system and is designed to be visible:

- to other aircraft fitted with a TAS or ACAS
- to other aircraft fitted with ADS-B IN capability
- ATC ADS-B ground stations.

In the USA, FAA TSO-C199 equipment will be available only to aircraft exempt from the transponder and ADS-B requirements specified in USA 14CFR regulations 91.215 and 91.225/227. However, the FAA recognised the potential for this specification to serve wider purposes outside USA airspace.

Considering a TABS is capable of being detected by all types of aircraft or ground systems (albeit with some limitations), CASA considers TSO-C199 a potential means for achieving fitting ADS-B equipment on VFR aircraft at a reduced cost.

TSO-C199 Proposal

CASA proposes equipment authorised in accordance with TSO-C199 as an ADS-B acceptable equipment configuration for:

- VFR aircraft with an MTOW of 5,700 kg or less
- aircraft other than those used for RPT or charter operations.

As is standard practice, CASA would automatically accept a TABS that has been authorised under TSO-C199 by a Part 21 *recognised country*.[12] In accordance with TSO-C199 specifications:

- The TABS would be required to output a source integrity limit (SIL) appropriate to the capability of the GNSS position source.
- Both Class A and Class B TABS would be acceptable (subject to relevant operating restrictions as described under scope of operations at Section 6.

Scope of operations and indicative cost of equipment

Section 6 will discuss the proposed scope of operations for equipment using an authorised TABS based on specific capability and will provide indicative costs of various types of ADS-B OUT equipment.

[12] Recognised countries include Canada, France, Germany, Netherlands, New Zealand, the United Kingdom and the United States of America.

4 Allowing ADS-B OUT equipment that satisfy the specific functional and performance requirements

For VFR aircraft that are not type certificated and have an MTOW less than 5,700 kg, CASA would be prepared to recognise the following ADS-B equipment or TABS without requiring formal authorisation:

- a TABS that meets the performance requirements of TSO-C199
- transmitting equipment that meets one of the following performance standards:
  - the performance standards specified in Appendix B
  - TSO-C166() (transponder or non-transponder equipment)
  - TSO-C112d implementing the optional RTCA/DO-260B functionality
  - RTCA/DO-260A or later
  - European Aviation Safety Agency (EASA) Acceptable Means of Compliance (AMC) 20-24
  - EASA Certification Specifications and Acceptable Means of Compliance for Airborne Communications, Navigation and Surveillance (CS-ACNS)
- GNSS position source equipment meeting one of the following performance standards:
  - the performance standards specified in Appendix B
  - 14CFR regulation 91.227 of United States 14CFR (excluding UAT functionality)
  - (E)TSO-C145a, (E)TSO-C146a, or TSO-C196a (or later versions)
  - (E)TSO-C129 if it incorporates fault detection and exclusion (FDE) and HPL features
- pressure altitude code-generating equipment meeting the performance standards of TSO-C88a.

In order for non-certified ADS-B equipment to be an acceptable equipment configuration, CASA proposes an alternative mechanism involving the equipment manufacturer, the equipment installer, and an aircraft operator, whereby:

- the equipment manufacturer:
  - provides reasonable assurance that the equipment meets the performance standards outlined in the applicable technical standards (this may be a statement of compliance or equivalent)
  - provides reasonable assurance of its ability to provide continuing airworthiness support for the equipment
  - maintains a service difficulty reporting mechanism to capture incident information and to notify affected operators of potential difficulties.
- the equipment installer:
  - is permitted to carry out maintenance (e.g. an approved maintenance organisation)
  - ensures that the equipment is serviceable
  - carries out the installation in accordance with the appropriate maintenance data
  - ensures that the installation is compatible with the configuration of the aircraft
  - certifies and records the installation in the aircraft's maintenance records.
- the aircraft operator:
  - takes reasonable steps to confirm the suitability of non-certified equipment

- ensures the initial and continuing airworthiness of the non-certified equipment
- reports service difficulties to the manufacturer
- ensures the equipment is installed by a person qualified to carry out the maintenance
- ensures the installation is documented in the aircraft maintenance records
- ensures the necessary flight manual supplements or instructions are included in the flight documents.

Note: The aircraft operator may have assistance from another person or body/entity to meet these responsibilities, e.g. an approved design organisation.

ADS-B equipment or TABS outlined in this proposal will be transmitting information that other aircraft, and potentially ATC, rely on for safety decision making. Additionally, transmissions from a faulty device have the potential to cause interference with essential equipment within the fitted aircraft and to other aircraft and ATC.

To ensure the required outcome is achieved, CASA considers it is necessary to have an effective, risk-based and proportionate mechanism that enables flexibility around enabling non-approved equipment configurations.

Scope of operations and indicative cost of equipment

The proposed scope of operations for equipment mentioned in this section, along with indicative costs of various types of ADS-B OUT equipment, are discussed in section 6.

5 Working with industry to prepare Australian Technical Standard Orders (ATSOs) for ADS-B devices

CASA would be willing to work with Australian manufacturers to create a useful ADS-B OUT product suitable for the Australian environment. CASA would expect an ATSO for VFR ADS-B to include specifications that ensure visibility of the ADS-B OUT device by:

- ACAS
- ADS-B IN equipment
- ADS-B ground stations.

6 Proposed operations with various ADS-B configurations and indicative equipment costs

6.1 Use and indicative cost of equipment

Table 1 provides indicative costs of ADS-B OUT equipment of different types. The prices shown exclude goods and services tax (GST) and do not include installation costs.

As mentioned earlier in this discussion paper, existing CAO 20.18 standards for ADS-B OUT equipment and equipment suitable for operations in controlled airspace remain will remain CASA's preference for installation in VFR aircraft.

The range of TABS equipment is small at present and may be because the relevant TSO was only recently released and a limited market. CASA believes that providing incentive and options for utilising TABS in parts of Australian airspace will generate interest from equipment manufacturers and encourage other aviation regulators to provide similar usage options.

Table 1: Proposed use and indicative costs for ADS-B OUT equipment

Type	Certification Basis	Target Sector	Useable airspace class	Representative examples with indicative cost (US$ converted to A$ at 0.75:1). GST and installation costs excluded
Mode S ADS-B transponder	ADS-B transmitting equipment: Authorised to TSO-C166() or RTCA/DO-260; GNSS position source: Authorised to TSO-C145, TSO-C146, TSO-C196, or TSO-C129 with FDE and HPL (CAO 20.18-compliant)	Any VFR aircraft	C, D, E or G	Garmin GTX 335 (US$2,995.00/A$3,993.00) Appareo Stratus ESG (US$2995.00//A$3,993.00) Trig TT22 with TN70 (A$2,975 + A$2,975 = A$5950.00) Avidyne AXP340 (US$3,295.00/A$4,393.00) Bendix King KT74 (US$2,975.00/A$3,966.00)
Mode S ADS-B transponder	Compliant with CFR 91.227 (excluding UAT standards) or CASA equivalent	Experimental amateur built (ABAA) LSA (RAAus-registered) Gliders	C, D, E or G	Existing Dynon Skyview upgraded with SV-XPNDR-262 transponder and GPS module SV-GPS-2020 (SIL=3). (US$1800.00 + US$590.00 = US$2390.00/A$3,186.00) Existing Garmin G3X display system upgraded with GTX-35R transponder and G 20A GPS (US$2,450.00 + US$955 = US$3405.00/A$4540.00) Note: the cost of this option would

Type	Certification Basis	Target Sector	Useable airspace class	Representative examples with indicative cost (US$ converted to A$ at 0.75:1). GST and installation costs excluded
				be reduced if the existing installation already includes an ADS-B compliant transponder uAvionix EchoESX Mode S Transponder with SkyFYX GNSS position source (US$1699 + US$499 = US$2198/A$2,930.00
Mode S transponder with TABS	ADS-B transmitting equipment: Authorised to TSO-C166() or RTCA/DO-260A; GNSS position source: Compliant with TSO-C199	Any VFR aircraft	E or G	Trig TT21/TT22/TT31 with TN72 Class B TABS (SIL=1) {Trig TT22 with TN72 (with TA70 antenna): A$2,975 + ~US$677/A$900 = A$3,875.00} Existing Dynon Skyview upgraded with SV-XPNDR-262 transponder and GPS module SV-GPS-250 (SIL=1). (US$1800.00 + US$200.00 = US$2000.00/A$2,666.00)
Stand-alone TABS	Compliant with TSO-C199	Experimental amateur built (ABAA) LSA (RAAus-registered) Gliders RPAS	E or G	uAvionix ping200si (US$3999/A$5,332.00) Enigma TABS (~A$2,400.00)

6.2 Information and indicative pricing for ADS-B IN equipment

The majority of this discussion paper has focused on standards for ADS-B OUT equipment because ADS-B OUT is transmitting information that other aircraft, and potentially air traffic controllers, will rely on to make decisions about safety. Transmissions from a faulty device can potentially cause interference with essential equipment in the fitted aircraft and to other aircraft and ATS.

CASA intends to ensure regulatory standards are not an impediment for aircraft operators fitting and using ADS-B IN equipment.

ADS-B IN equipment is the ideal end state for ADS-B equipage in aircraft not already fitted with ACAS. As earlier defined, ADS-B IN enables an aircraft to detect and display information from aircraft broadcasting ADS-B OUT. ADS-B IN capability can range from aural traffic alerts to a detailed graphical display of traffic information in a radar-like form or 'cockpit display of traffic information' (CDTI).

The following table provides indicative costs of ADS-B IN equipment of different types. The prices shown exclude GST and do not include installation costs. It should be noted that in order for an aircraft's position to be displayed on an ADS-B IN device the aircraft requires ADS-B OUT to be fitted.

Representative ADS-B IN receivers - tablet or EFIS panel also required display traffic information	Indicative cost in A$ (GST excl.) (US$ converted to A$ at 0.75:1)
Garmin GDL39 3D Portable ADS-B	$1,200.00
Existing Dynon Skyview upgraded with a new SV-ADSB-472 (ADS-B Traffic and Weather Receiver)	$1,060 (US$795.00)
Dual GPS Solutions XGPS190	$1,299.00

6.3 Use of ADS—B in RPAS

As discussed elsewhere in this discussion paper, CASA anticipates ADS—B technology would be utilised in RPAS in a similar way to other types of aircraft, giving similar benefits and limitations.

The number of RPAS is growing rapidly in Australia— as of early October 2017, there were 1,147 CASA-registered RPAS certificate holders in Australia. However, as not all RPAS require a CASA certificate, the total number of RPAS in Australia is unknown but is likely to be many times more than the number of currently certificated systems.

Use of ADS—B equipment in RPAS may be beneficial for situation awareness and conflict avoidance. In particular, an RPAS operator using ADS-B IN would have an increased ability to detect conflicting aircraft and thus take timely avoiding measures.

However, unregulated use of ADS—B OUT in RPAS may result significant issues— including system saturation, untrained users mis-selecting configuration settings, cluttering of ATS surveillance systems and nuisance ACAS alerts. Therefore, we would consider usage limits for ADS—B OUT in RPAS. Options include limiting use to:

- authorised commercial operations
- RPAS of a particular weight category
- situations where there is a clear benefit for the RPAS being electronically visible (for example: operations above the normal vertical limits for recreational RPAS use).

Appendix A

Representation on the low cost ADS-B working group

The following organisations are represented on the low cost ADS-B working group:

- Aeronautical Engineers Australia (AEA)
- Air Sport Australia Confederation (ASAC)
- Aircraft Operators and Pilots Association (AOPA)
- Airservices Australia
- Australian Maritime Safety Authority (AMSA)
- Australian Warbirds
- Aviation Maintenance Repair and Overhaul Business Association (AMROBA)
- Capital Aircraft Services
- Department of Infrastructure and Regional Development
- Enigma Avionics
- Garmin Australia
- Gliding Federation of Australia (GFA)
- Honourable Company of Air Pilots
- Memko Engineering
- Recreational Aviation Australia (RAAus)
- Regional Aviation Association of Australia (RAAA).

Appendix B

Proposed alternative performance standards for automatic dependent surveillance-broadcast (ADS-B) OUT equipment

B.1 Introduction

The following proposed standards are adapted from those in FAA 14CFR regulation 91.227.

B.2 Broadcast performance requirements

ADS-B OUT equipment installed in aircraft has an acceptable standard for broadcast of ADS-B position if the equipment meets the functional performance requirements in:

- (E)TSO-C166( ) or a later version as in force from time to time (transponder or non-transponder equipment)
- TSO-C112d implementing the optional RTCA/DO-260B functionality
- RTCA/DO-260A or later
- EASA acceptable means of compliance (AMC) 20-24
- CS-ACNS.

B.3 Broadcast link and power requirements

ADS-B OUT equipment installed in aircraft is of an acceptable standard for broadcast of ADS-B position if the equipment meets the following broadcast link and power requirements:

- Where installed in an aircraft with an engine driven electrical system capable of continuously powering the relevant class of ADS-B equipment mentioned in this sub-paragraph, ADS-B OUT equipment has an acceptable standard if it meets the antenna and power output requirements of Class A0, A1, A1S, A2, A3, B0, B1S, or B1 equipment as defined in TSO-C166.
- For aircraft not fitted with an engine driven electrical system capable of continuously powering at least an ADS-B device with an RF output power of at least 18.5 dBW (70 W), ADS-B OUT equipment has an acceptable standard if it power output and or equipment installation or placement instructions are such that the ADS-B OUT transmissions are detectable by ACAS or ADS-B IN equipment at a line-of-sight range of at least 20 km.

B.4 ADS-B OUT Performance Requirements for NAC_P, NAC_V, NIC, and SIL

ADS-B OUT equipment is of an acceptable standard if it is capable of the following:

- The aircraft's navigation accuracy category for position (NAC_P) is at least 5
- The aircraft's navigation accuracy category for velocity (NAC_V) is at least 1
- The aircraft's navigation integrity category (NIC) is at least 6
- The aircraft's source integrity level (SIL) is at least 2
- Changes in NAC_P, NAC_V, and SIL are broadcast within 10 seconds
- Changes in NIC are broadcast within 12 seconds.

B.5 Minimum broadcast message element set for ADS-B OUT

ADS-B OUT equipment is of an acceptable standard if it broadcasts the following information, as defined in TSO-C166:

- position (in extended squitter surface position message and in extended squitter airborne position message)
- position integrity information (e.g. NIC value transmitted in the 'TYPE' code in extended squitter surface position message and in extended squitter airborne position message)
- SIL
- NAC_P
- pressure altitude
- aircraft identification, including
  - the Mode 3/A transponder code - specified by ATC, otherwise as appropriate for the airspace
  - the aircraft's call sign
  - the aircraft’s assigned 24-bit address.

B.6 Recommended additional broadcast message element set for ADS-B OUT

To provide a more comprehensive data set to other stations, transmission of the following data is highly desirable:

- SPI indication
- emergency flag
- emergency priority status information
- velocity information
- GNSS height
- vertical rate
- aircraft category
- other ADS-B data as defined in ICAO Annex 10, Volumes III and Volume IV, Amendment 85 or later or RTCA/DO-260A or a later version.

B.7 Pilot interaction

ADS-B OUT equipment is of an acceptable standard if the pilot is able to:

- turn the equipment on and off
- operate or enter information for the following message elements:
  - the Mode 3/A transponder code
  - the aircraft's call sign
  - the SPI (IDENT) function, if provided in the equipment installation.

B.8 ADS-B latency requirement

ADS-B OUT equipment is of an acceptable standard if it is capable of the following:

- The aircraft can transmit its geometric position no later than 2.0 seconds from the time of measurement of the position to the time of transmission.
- Within the 2.0 total latency allocation, a maximum of 0.6 seconds can be uncompensated latency.[13]
- The aircraft transmits its position and velocity at least once per second while airborne or while moving on the airport surface.
- The aircraft transmits its position at least once every 5 seconds while stationary on the airport surface.

[13] The aircraft compensates for any latency above 0.6 seconds up to the maximum 2.0 seconds total by extrapolating the geometric position to the time of message transmission.