Australian Government
Department of Transport and Regional Services

AIRSERVICES AUSTRALIA

Australian Government
Civil Aviation Safety Authority

Joint Consultation Paper

Transition to Satellite Technology for Navigation & Surveillance

A proposal for change incorporating proposed amendments to Civil Aviation Orders 20.18, 82.1, 82.3 and 82.5

Who this Joint Consultation Paper applies to
It is expected that this proposal will affect the following members of the aviation community:
Pilots, Passengers, Air Traffic Controllers, Aircraft Owners, Aircraft Maintenance Engineers and Aircraft Operators.

Issued as part of the process of public consultation by
Airservices Australia, the Australian Defence Force, the Civil Aviation Safety Authority, and the Department of Transport and Regional Services

July 2007

Foreword

Context of this Joint Consultation Paper

This Joint Consultation Paper sets out a proposal for the wider application of satellite technology for navigation and surveillance in Australia, and the required rules to support the proposal. It also discusses the surveillance and navigation requirements of the Australian aviation industry. Industry comment on this paper and the vision it sets out will be crucial to the development of a final position on the future of Australia's civil aviation navigation and surveillance systems.

How you can help us

The Aviation Policy Group (APG) is made up of the heads of Airservices Australia, the Civil Aviation Safety Authority (CASA), the Department of Transport & Regional Services (DOTARS), and the Royal Australian Air Force (RAAF). The APG is a forum that coordinates action at a strategic level across the aviation portfolio and planning for the longer term infrastructure and policy framework for Australian aviation.

To ensure sound decision making, we need the benefit of your knowledge as an aviator, aviation consumer and/or provider of related products and services **by completing the Joint Consultation Paper Response Form and returning it to DOTARS by the closing date of Friday 31 October 2007**.

We would like to thank you for your interest in this proposal and emphasise that no rule changes will be undertaken until all responses and submissions received by the closing date have been considered.

Australian Government
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3 August 2007

Executive Summary

The four Australian Government aviation bodies are considering the transition of Australia's aviation industry to satellite navigation and surveillance in order to overcome the limitations of the aging technology currently in use. This goal is consistent with the International Civil Aviation Organization (ICAO) Global Air Traffic Management Operational Concept.

The proposal relies on wide-spread fitment of Automatic Dependent Surveillance Broadcast (ADS-B) and Global Navigation Satellite Systems (GNSS) avionics to ensure that aircraft currently equipped with transponders continue to receive at least the same levels of Air Traffic Services (ATS) provided today with secondary radar, and to obtain maximum benefits from the new technologies. The synergy between modern navigation and surveillance technology is recognised: ADS-B avionics are dependent on GNSS equipment for position data; the same GNSS equipment can be used for navigation, and cost savings can be achieved through installation of both avionics systems at the same time.

It is proposed that the major elements of transition would be completed in the 2012/14 timeframe, enabling the industry to benefit from the savings that will result from not having to replace a considerable percentage of existing surveillance and navigation facilities that by then will have reached their end of life. This includes the 11 enroute radars and a large number of the Non-Directional Beacon (NDB) and VHF Omni-directional Radio Range (VOR) navaids. To succeed, the proposal needs to be implemented before these legacy systems reach a point beyond which they can no longer be reliably maintained.

After transition, aircraft operating in Australia will rely primarily on ADS-B for enroute surveillance, GNSS for enroute and non-precision approach navigation and, in many cases, moving map ADS-B traffic displays for situational awareness and surveillance from the cockpit. A network of ground-based systems, including primary and secondary radars along the east coast, and a reduced network of NDBs and VORs at regional airports as well as Distance Measuring Equipment (DMEs), will ensure safe operations in the event that the satellite-based system is not available to individual or all aircraft. The 39 ADS-B ground stations in the network will be installed by 2009 under separate programs already underway. The proposal itself will not increase the ADS-B coverage already planned, but will enable inexpensive and rapid extension of coverage should it be required in the future. ADS-B will provide a platform for significant changes to the future ATM system as new procedures based on ADS-B are introduced.

The widespread deployment of ADS-B in Australia will provide a tangible benefit to Australia's security and border protection operations. This will be achieved by assisting Defence and other authorities to rapidly identify and differentiate cooperative aircraft conducting legitimate operations from non-cooperative aircraft detected via traditional microwave radar and other means. Australian authorities including Defence will then be able to optimise efforts to detect and track suspect aircraft as a precursor to preventing illegal and/or terrorist activities.

The 2012/14 timing will enable infrastructure replacement savings to be used to assist the transition of light aircraft to use of these technologies via a cross-industry funding

arrangement for the supply and fitment of ADS-B avionics. Should the proposal not be adopted or be delayed, it will be necessary to begin replacing existing ground-based systems at their end of life. It is likely that this would reduce the funding available to assist light aircraft to transition, and erode the operational and commercial benefits offered by transition to satellite technology. ADS-B and GNSS are now recognised worldwide as the key to a sustainable and efficient aviation industry, and the issue is becoming one of timing rather than one of technology.

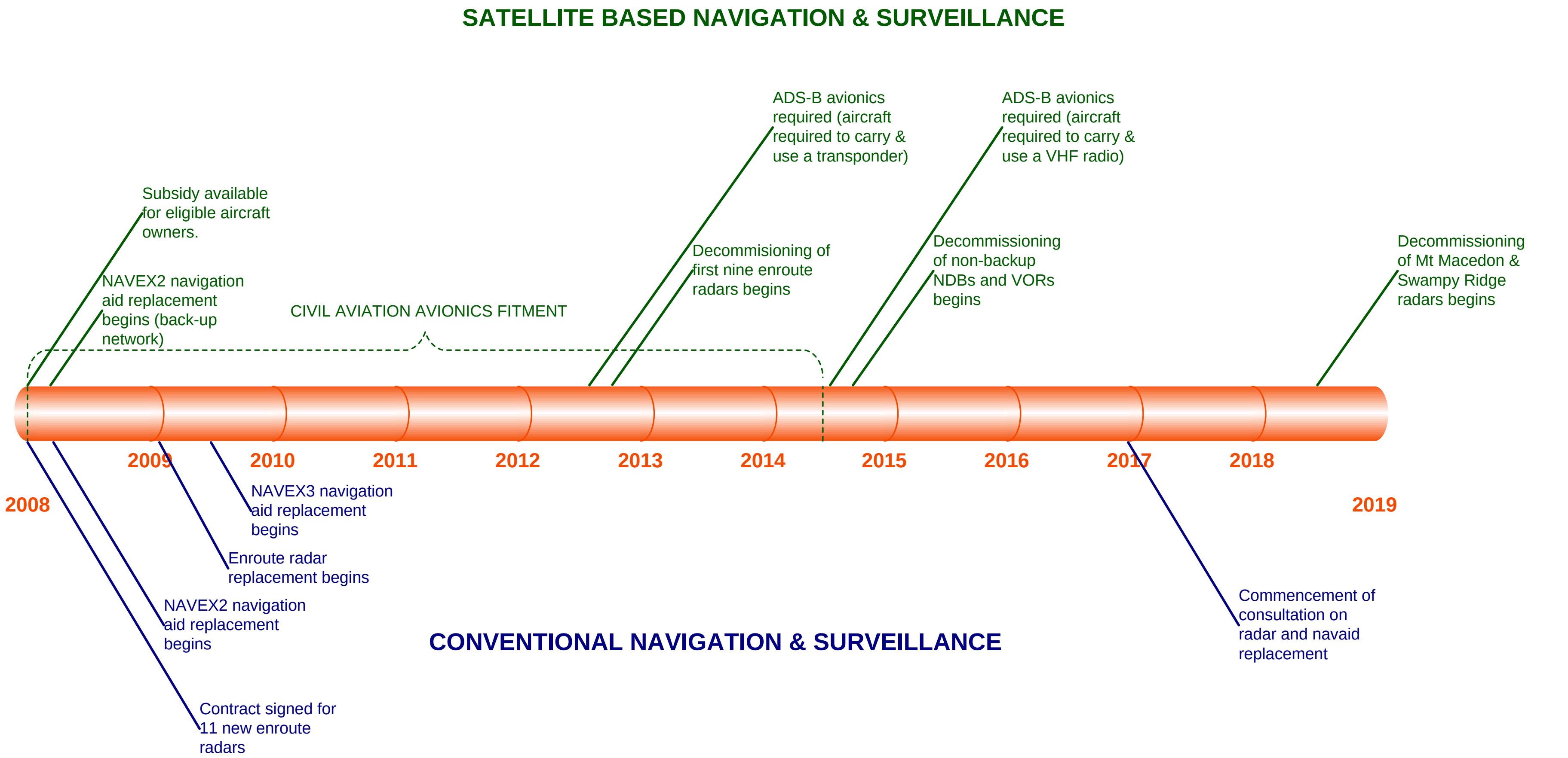

Figure 1: Indicative Time Lines (GREEN: Satellite Technology; BLUE: Conventional Technology)

Contents

Abbreviations

ABIT	ADS-B Implementation Team (ASTRA)
ACARS	Aircraft Communications, Addressing & Reporting System
ACP	Aeronautical Communications Panel (of ICAO)
ADF	Australian Defence Force
ADF	Automatic Direction Finder/Finding
ADS-B	Automatic Dependent Surveillance Broadcast
ADS-C	Automatic Dependent Surveillance Contract
AEW&C	Airborne Early Warning & Control
AIP	Aeronautical Information Publication
AMSL	Above Mean Sea Level
APANPIRG	Asia Pacific Air Navigation Planning & Implementation Regional Group (of ICAO)
APG	Aviation Policy Group
APV	Approach with Vertical Guidance
ASFA	Aviation Safety Foundation of Australia
ASMGCS	Airport Surface Movement Guidance & Control System
ASP	Aeronautical Surveillance Panel
ASTRA	The Australian Strategic Air Traffic Management Group
ATC	Air Traffic Control
ATLAS	The Australian Transition to Satellite Technology
ATM	Air Traffic Management
ATS	Air Traffic Services
ATSO	Australian Technical Standard Order
BOM	Bureau of Meteorology
CAA	Civil Aviation Authority (of the UK)
CAO	Civil Aviation Orders
CAR	Civil Aviation Regulations 1988
CASA	Civil Aviation Safety Authority
CASR	Civil Aviation Safety Regulations 1998
CDTI	Cockpit Display of Traffic Information
CFIT	Controlled Flight Into Terrain
CNS	Communication, Navigation, Surveillance
CTAF(R)	Common Traffic Advisory Frequency (Radio required)
DME	Distance Measuring Equipment
DOTARS	Department of Transport & Regional Services
DP	Discussion Paper
DSNA	Directorate of Air Navigation Services (of France)
ES	Extended Squitter
EUROCAE	European Organisation for Civil Aviation Equipment
FAA	Federal Aviation Administration (of the USA)
FIR	Flight Information Region
GA	General Aviation
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HF	High Frequency
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules

ILS	Instrument Landing System
JCP	Joint Consultation Paper
JORN	Jindalee Over the Horizon Radar Network
LAME	Licensed Aircraft Maintenance Engineer
Mode S	Mode Select
MTOW	Maximum Take Off Weight
NFRM	Notice of Final Rule Making
NDB	Non-Directional Beacon
NextGen	Next Generation Air Transportation System (of the USA)
NG	Next Generation (Boeing 737)
NM	Nautical Mile
NOTAM	Notice to Airmen
NPRM	Notice of Proposed Rule Making
PANS	Procedures for Air Navigation Services (ICAO publication)
PBN	Performance Based Navigation
RAAF	Royal Australian Air Force
RAPAC	Regional Airspace Advisory Committee
RFG	Requirements Focus Group
RNAV	Area Navigation
RNP	Required Navigational Performance
RPT	Regular Public Transport
RTCA	Radio Technical Commission for Aeronautics (of the USA)
SAR	Search & Rescue
SASP	Separation & Airspace Safety Panel (of ICAO)
SOR	Summary of Responses
SSR	Secondary Surveillance Radar
TAAATS	The Australian Advances Air Traffic System
TAWS	Terrain Awareness and Warning System
TCAS	Traffic Alert & Collision Avoidance System
TSO	Technical Standard Order
UAP	ADS-B Upper Airspace Program
UAT	Universal Access Transceiver
UAV	Unmanned Aerial Vehicle
VCA	Violation of Controlled Airspace
VDL	VHF Data Link
VFR	Visual Flight Rules
VHF	Very High Frequency
VOR	VHF Omni-directional Radio Range
WAM	Wide Area Multilateration

Definitions

In this document:

ADS-B IN	means the reception of ADS-B reports by an aircraft
ADS-B OUT	means the transmission of ADS-B reports
Surveillance	means monitoring of the positions of aircraft and other objects for the purpose of air traffic management.

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The Process

1 The Consultation Process

Publication of this Joint Consultation Paper (JCP) is part of the formal consultation process on the proposal to introduce standards and other required changes for the wider use of satellite technology for air navigation and surveillance in Australia. All comments made in response to this JCP will be considered by CASA during any subsequent rulemaking process.

The proposal for carriage and use of Automatic Dependent Surveillance Broadcast (ADS-B) and Global Navigation Satellite System (GNSS) avionics detailed in this paper is based on several years of development by industry and government organisations working collaboratively through ASTRA, the Australian Strategic Air Traffic Management Group. Through its ADS-B and GNSS Implementation Teams (ABIT and GIT), ASTRA has established a joint industry / government forum to identify strategic options, develop proposals, and address technical and operational issues surrounding ADS-B and GNSS implementation, and to coordinate the efforts of stakeholders.

Airservices Australia, the Australian Defence Force (ADF), the Civil Aviation Safety Authority (CASA) and the Department of Transport & Regional Services (DOTARS) all contribute to ASTRA's efforts. However, ASTRA can only provide recommendations and it is the role of the four agencies and other stakeholders to consider their implementation and resourcing options.

The heads of the four aviation agencies are committed to working cooperatively with the aviation community to maintain and enhance aviation safety. Meeting together as the Aviation Policy Group (APG)[1], they have considered the ASTRA proposal and directed their staff to develop the proposal for wider consultation. This JCP has been developed by the four government agencies as the prime consultation document.

Key to the proposal is the use of ADS-B as the principal surveillance technology, and therefore as a replacement for some radars. Since 2001, Australian government agencies and other groups have distributed information and consulted widely on the issues surrounding the carriage and use of ADS-B avionics. In addition to ASTRA forums, agencies have presented information to a wide number of forums, including Regional Airspace Advisory Committee (RAPAC) meetings, various meetings of aviation industry bodies, and public forums at aviation events.

CASA, with industry assistance, issued a Discussion Paper (DP) on ADS-B implementation in 2004 for public comment. A Summary of Responses (SOR) to the DP was published in 2005. The SOR stated that almost all responses to the DP welcomed the introduction of ADS-B to the Australian Air Traffic Management (ATM) system and noted that there was strong support expressed for a staged implementation over the next seven years. CASA also noted that many respondents pointed to the potential benefits of ADS-B and other new technologies facilitating

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[1] The APG is made up of the heads of Airservices Australia, CASA, DOTARS, and the Royal Australian Air Force (RAAF).

major changes to current practices. Both the DP and SOR may be viewed at http://rrp.casa.gov.au/project/as0403.asp.

Notice of Proposed Rule Making (NPRM) 0601AS was published by CASA on 17 November 2006. The NPRM proposed amendments to Civil Aviation Orders (CAOs) 20.18, 82.1, 82.3 and 82.5 to include operational and technical standards supporting the voluntary fitment of ADS-B equipment in Australian aircraft, and in foreign-registered aircraft operating into Australia.

The majority of the respondents to the NPRM supported the proposals put forward in the NPRM, and the Notice of Final Rule Making (NFRM) including the final version of the CAOs was published by CASA on the website on 19 April 2007.

CASA has now reissued the CAOs and the effect is that operational and technical standards for aircraft fitment of ADS-B avionics in Australia have been established. Fitment of avionics is voluntary; however those aircraft operators who decide to equip their aircraft with ADS-B will gain with safety enhancement and by the provision of improved ATM services. The standards, together with the guidance material, will enable aircraft operators to go ahead with avionics purchase and aircraft fitment in the knowledge that installations that comply with the standards will ensure inter-operability with the ADS-B ground stations now being rolled out by Airservices.

This JCP builds upon the earlier consultation by CASA to put a 'whole-of-government' proposal to industry for the future use of ADS-B and GNSS in the Australian aviation environment.

What will be done with your comments?

At the end of the response period for public comments, all submissions will be analysed, evaluated and considered by the four agencies in formulating a policy position, on which the Ministers for Defence and Transport & Regional Services will be briefed. A summary of the responses to the JCP will be published.

Each comment and submission received in response to this JCP will be registered, but will not be individually acknowledged unless specifically requested. However, the names of contributors will be published in the subsequent summary of responses, except where specifically requested not to do so.

Synopsis of Change Proposals

2 Purpose of this Joint Consultation Paper

This JCP has been produced to describe present and proposed navigation and surveillance ATM facilities in Australia. The JCP outlines the agreed whole-of-government intention for the transition to satellite based navigation and surveillance; the benefits, costs and other issues arising from this proposal; the backup networks that will be retained to mitigate possible satellite system failures; and international developments in the same areas.

Airservices, with input from the aviation industry, must shortly replace Australia's aging navigation and surveillance infrastructure. The four agencies are seeking industry comment on the proposal to invest in airborne navigation and surveillance infrastructure instead of replacement of legacy navaids and en route radars.

The purpose of this JCP is to set out the issues surrounding the transition to satellite technology for surveillance and navigation in Australia, to detail proposed rules and requirements, and to seek further public comment.

As detailed in Section 1, this JCP follows earlier industry consultation on ADS-B implementation and distribution of ADS-B education material by CASA. These earlier documents include descriptions of ADS-B technology and operations, and are available from the CASA website addresses below.

> *CASA: Discussion Paper – Carriage and Use of ADS-B Avionics, DP 0410AS, December 2004*
> (http://rrp.casa.gov.au/dp/dp0410as.pdf)
>
> *CASA: Summary of Responses to DP 0410AS, September 2005*
> (http://rrp.casa.gov.au/sor/sor0410as_v3.pdf)
>
> *CASA: ADS-B Pilot Information Package, March 2006*
> (http://casa.gov.au/pilots/download/ADS-B.pdf).
>
> *CASA: Notice of Proposed Rulemaking, NPRM 0601AS, November 2006*
> (http://rrp.casa.gov.au/nprm/nprm0601as.pdf)
>
> *CASA: Notice of Final Rulemaking, NFRM 0601AS, April 2007*
> (http://rrp.casa.gov.au/nfrm/nfrm0601as.pdf)

3 Background

Locally and internationally, the bodies that provide global aviation oversight have recognised ADS-B and GNSS as key elements of ATM worldwide. The International Civil Aviation Organization (ICAO) has recognised ADS-B as a major element of future air traffic management worldwide. At the eleventh ICAO Air Navigation Conference (ANConf/11, a meeting of all ICAO states) in 2003, it was resolved:

> *That ICAO and States:*
>
> *a) recognize ADS-B-as an enabler of the global ATM operational concept bringing substantial safety and capacity benefits;*
>
> *b) support the cost-effective early implementation of packages of ground and airborne ADS-B applications, noting the early achievable benefits from new ATM applications; and*
>
> *c) ensure that implementation of ADS-B is harmonized, compatible and interoperable with respect to operational procedures, supporting data link and ATM applications.*
>
> *That States:*
>
> *a) note that a common element in most of the approaches currently adopted for early implementation of ADS-B is the selection of the SSR Mode S extended squitter as the initial data link; and*
>
> *b) take into account this common element to the extent possible in their national and regional implementation choices in order to facilitate global interoperability for the initial introduction of ADS-B.*

At the March 2007 Worldwide Symposium on Performance of the Air Navigation System, ICAO also stated that regions must include Performance Based Navigation (PBN) implementation goals in their regional plans, and work to implement Area Navigation (RNAV) and Required Navigation Performance (RNP) operations. This will not be possible without a commitment to implementation of GNSS.

Australia's aviation authorities are soon to decide on the replacement of important components of Australia's navigation and surveillance infrastructure for civil aviation. It is essential that any replacement systems ensure that Australia continues to have a safe and efficient ATM system that meets user expectations, including global interoperability. The timing of the radar and navaid replacement decision puts Australia in a unique position to comply with ICAO's endorsement of implementation of ADS-B and PBN, while ensuring that the majority of the aviation industry can participate.

The key decision is:

- To replace existing 'conventional' ground-based navigation and surveillance units – including Secondary Surveillance Radar (SSR) facilities, VHF Omni-directional Radio range (VOR) and Non-Directional Beacon (NDB) navigation aids – with new facilities of the same type; or

- Alternatively, to facilitate a transition to satellite technology while retaining a backup network of conventional systems. In particular this would see greater use of GNSS for navigation and wider application of ADS-B to provide surveillance services. Under this proposal, the fund that would otherwise have been used to replace radars and navaids would be used to support avionics fitment of many aircraft.

4 Australian Navigation & Surveillance Facilities

Australia’s aging ground-based navigation and surveillance infrastructure provides the aviation industry with a unique opportunity to transition to satellite-based technology, due to the convergence of end-of-life of both radar and navaid systems.

For many years, it has been expected that GNSS would revolutionise air transport navigation globally and reduce the reliance on ground-based navigation aids. As a result, life extension work was done on many Australian navaids in lieu of complete replacement, in anticipation of their imminent retirement. Unfortunately the expected GNSS revolution has not yet eventuated, with “only-means” GNSS navigation only being approved in Australia in 2006 and limited industry uptake to date. As a consequence, unless uptake of suitable GNSS receivers can be accelerated in Australia, the aged navigation infrastructure will need to be fully replaced in the next few years, at a cost of many tens of millions of dollars.

At the same time, Australia’s secondary-only enroute radar network (that provides enroute surveillance from Cairns to Adelaide, as well as at Perth) is being extended beyond the end of its design life.

It will be possible, if replacement of the navaids and enroute radars can be avoided, to make an equivalent investment in airborne navigation and surveillance infrastructure, thereby ensuring that the majority of the aviation industry can take advantage of the benefits offered by ‘next generation’ surveillance and navigation technology.

To delay the transition by another five to ten years would require investment in new radars and navaids, reducing the available funding for avionics. If this were to happen, uniform transition to satellite technology across the whole industry, and in particular the opportunity to use savings to assist the transition of light aircraft, would not occur as described in this proposal.

4.1 Examination of Alternatives

As early as 2001, the aviation industry through ASTRA began investigating innovative solutions to address the problems posed by the aging navigation and surveillance infrastructure, and the opportunities presented by new aircraft trends. At the same time, Airservices Australia began work on a trial of airborne and ground ADS-B technology in the Burnett Basin region of Queensland. The Burnett Basin trial successfully demonstrated that ADS-B performed at least as well as radar for surveillance; that 1090 MHz Extended Squitter (1090ES) ADS-B avionics could be successfully installed in aircraft from home-built Jabirus to airliners and helicopters; that ADS-B ground stations could be bought and commissioned for approximately one-tenth the cost of enroute radar; and provided CASA with the basis to approve 5 NM separation by Air Traffic Control (ATC) between suitably equipped aircraft. This set the foundation for possible replacement of enroute radars with ADS-B ground stations.

Implementation of ADS-B as the surveillance technology of choice also offers a solution to the issue of aging navigation infrastructure. ADS-B avionics are reliant on GNSS for position information, so all aircraft equipped with ADS-B must also be fitted with GNSS avionics. During 2006, CASA approved GNSS avionics that meet certain specified requirements for use for navigation without fall-back to ground-based navaids. Therefore, once sufficient numbers of Australian aircraft are ADS-B equipped, it will be possible to consider reducing Australia's navaid and radar networks to 'backup' systems.

4.2 Cross Industry Business Case & Cost Benefit Analysis

To provide a better understanding of the implications of a transition to satellite technology, ASTRA commissioned the development of a Cross Industry Business Case & Cost Benefit Analysis that looked at whole-of-industry costs and benefits. This study aligned with the ADS-B and GNSS implementations considered in CASA's 2004 Discussion Paper on the subject, but is not representative of the timeframe for ADS-B implementation discussed in this JCP.

A new study, aligned with the ADS-B and GNSS implementation outlined in this JCP, and using updated estimates to reflect developments since the original study, has been undertaken by Access Economics. This new study also considered ICAO and Eurocontrol ATM business case models and their application to the Australian environment. The final report on the study is available from the Airservices website (www.airservicesaustralia.com).

The new study reaffirmed the results of the earlier analysis, and determined that, at this time, a transition to satellite technology for navigation and surveillance for civil aviation will result in considerable savings.

5 Benefits of Transition to Satellite Technologies

Existing navigation and surveillance infrastructure for aviation (even the latest radars and navaids) has some limitations:

- The majority of aircraft will continue to have limited or no access to RNAV or RNP operations;
- Poor access to surveillance services over the majority of the continent will continue for aircraft who want or need these services using traditional transponders;
- Implementation of new surveillance (if it was directed by the Office of Airspace Regulation) would be at a cost of up to $10 million per site for radar or wide-area multilateration (plus transponder equipage);

- Continued reliance on unalerted see and avoid for Regular Public Transport (RPT), and other, operations at uncontrolled airports; and
- Divergence from US and European ATM plans.

An aviation environment based on ADS-B and GNSS provides a platform for future benefits and innovation, which are difficult to quantify. However, some more immediate potential benefits of a transition to a satellite-based ADS-B and GNSS environment are listed below. Many of these are expanded further in this JCP, as are the potential risks of a transition to new technology.

- Low cost surveillance, in particular the ability to extend the surveillance network at relatively low marginal cost;
- Environmental benefits, through improved aircraft access to preferred routes and levels, more efficient diversions around restricted areas and weather, and increased accuracy of navigation (reduced fuel burn and reduced greenhouse gas emissions);
- Lower cost operations through use of RNAV with very high integrity;
- Reduced asset base for Airservices (for both navigation and surveillance), which will have a flow-on effect on fees and charges passed on to the aviation community;
- Faster realisation of benefits from other Airservices ADS-B projects, such as the efficiency and safety improvements expected from Airservices' ADS-B Upper Airspace Program (UAP);
- An "agile" surveillance system that can be rapidly deployed nationally or internationally in the event of natural disaster, or local short-term changes to traffic levels;
- Improved in-flight emergency response and search and rescue with greater certainty about last known position (also leading to earlier medical intervention), and the capability to monitor flight paths of search aircraft;
- Improved operational efficiency for RPT operations (greater availability of optimal flight levels and preferred routes due to accurate aircraft position information for ATC and pilots, as well as reduced separation standards);
- Reduced Violations of Controlled Airspace (VCA), as controllers have more accurate information on aircraft position, heading and call-sign;
- As more aircraft are ADS-B equipped they will have access to radar-like safety nets across the continent. These include cleared level and route adherence monitoring, short term conflict alerts, and danger area infringement and minimum safe altitude warnings;
- Ability to provide surveillance across the Flight Information Region (FIR) boundary with neighbouring Air Navigation Service Providers;
- Improved communication and situational awareness for pilots and controllers;

- Potential for reduction of Controlled Flight Into Terrain (CFIT) due to more accurate navigation and availability of accurate GNSS to drive terrain displays;
- Improved traffic visibility and hence improved situational awareness for pilots (through the application of ADS-B receivers) and for air traffic controllers;
- Greater potential for dynamic re-sectorisation to cater for advanced demand and capacity management;
- Safer operations into regional airports; and,
- Potential for the introduction of electronic traffic (air-to-air) alerting for all classes of aircraft, but principally for passenger-carrying aircraft operating outside radar or ADS-B ground station coverage, which will provide a long term reduction in the risk of mid-air collisions and near miss incidents.

5.1 Traffic Growth Implications

The proposal to transition to satellite technology as outlined in this paper only considers replacement of existing surveillance coverage with a new technology. It does not consider any expansion of ground-based surveillance coverage. It should be noted however, that ADS-B equipped aircraft will be visible to the 39 ADS-B ground stations that Airservices is installing to provide full surveillance coverage above 30,000 ft. When in range of these ground stations, ADS-B equipped aircraft will be able to access some ATC services – such as traffic and navigation advisories – if they desire them, but more importantly will be visible to the ATM system in the event of in-flight emergency (or their last known position will be recorded in the event of an accident).

Air traffic is forecast to increase at a rate of 4% per year in Australia. This is likely to create a demand for extension of surveillance coverage in order to maintain safety and provide added capacity. Increasing surveillance coverage will be relatively inexpensive if the requirement occurs after the industry has transitioned to satellite technology. ADS-B ground stations, as well as costing nominally one-tenth that of radar, can be installed in a matter of days in sites where communications links are already available – providing a new agility in the provision of surveillance services. Procurement and installation of new radars at a green-fields site could take several years. An equivalent ADS-B installation could be done in months.

6 Costs of Transition to Satellite Technologies

In considering the benefits outlined in Section 5, it must be recognised that there are also substantial costs associated with a transition from a radar and navaid based paradigm to a satellite based model. A major cost of the transition is associated with the requirement for the installation and carriage of additional airborne equipment, as well as the need to maintain that equipment. Avionics purchase and installation will be a one-off cost. While maintenance costs will be ongoing, they will be typically no more than for today's ATC transponder and navigation equipment.

The cost of the required ground-based infrastructure is approximately one-tenth of equivalent legacy radars and navaids; although against this the costs of avionics for affected aircraft must be considered. It is important to recognise that the less expensive ground infrastructure will result in on-going savings, as these systems must be replaced approximately every 15 years. In addition the cost of new (or extended) surveillance is reduced once the aircraft installation is complete. Further information on ground and airborne infrastructure costs are included in Section 9.

There are also other considerations for a transition to new technology. These include national security implications, which are different for new and old systems, and are covered further in **Appendix B**. In addition, there is potential for performance levels to reduce during the transition from one system state to another following change. Under the Common Risk Framework that is being developed jointly by Australia's aviation authorities, appropriate mitigators for any performance degradation will be put in place. It should also be noted that Australia already has experience in the transition requirements for air traffic controllers and pilots through implementation of the UAP.

7 Aviation Change Management – CASA Consultation Processes

Arising from the consensus that was evident in the ASTRA forums, and following the legislated requirements for aviation change management, CASA established a CASA/industry working group to develop a DP on the Carriage and Use of ADS-B Avionics. The DP was published in December 2004 and industry invited to comment. In September 2005 CASA published a SOR to the DP.

This new JCP reflects changes in the aviation environment since the release of CASA's DP and SOR. These changes include:

a. CASA approval of certain GNSS avionics for "only-means" Instrument Flight Rules (IFR) navigation (without recourse to ground-based navaids).

b. Increasing numbers of Australian and international aircraft operating in Australia equipped with ADS-B (more than 30% of international flights into Australia are now ADS-B equipped and receiving ADS-B services).

c. Announcement of ADS-B programmes by the United States, Canada and Europe, very closely aligned with Australia's plans.

d. ICAO promulgation of standards and procedures for the operational use of ADS-B technology.

The implications of these changes are discussed further in this paper.

8 The Proposal for Change

8.1 Overview

In line with the four agencies' commitment to coordinated planning across the aviation portfolio, the objectives of this transition to satellite based navigation and surveillance are:

- To facilitate widespread carriage and use of ADS-B and GNSS avionics, including regulatory requirements for certain operations, to increase the safety and efficiency of the Australian ATM system, and align Australia with international technical and operational developments in ATM.

- Transition timing that facilitates the participation of all affected aircraft, including provision of cross-industry funding for owners of aircraft with a Maximum Take Off Weight (MTOW) less than or equal to 5,700 kg; and

- Implementation of the foundation for electronically enhanced see and avoid for all RPT operations.

The key elements of change proposed to meet these objectives are as follows:

- From 28 June 2012, ADS-B avionics would be required for all civilian IFR operations, and for all civilian Visual Flight Rules (VFR) operations that currently require carriage and use of a transponder. Some exemptions would be available. This will achieve several objectives, primarily:

    - Potential for electronic see-and-avoid protection for all high-capacity RPT operations to a better standard than afforded by transponders and Traffic Alert & Collision Avoidance Systems (TCAS);

    - Ability for Airservices to decommission enroute radars after sufficient aircraft have been ADS-B equipped, thereby ensuring savings are available for cross-industry funding for aircraft owners.

- From 26 June 2014, ADS-B avionics would also be required for all civilian VFR operations that currently require carriage and use of a VHF radio, subject to security implications and cost benefit risk analysis. The objectives of this second phase of ADS-B and GNSS implementation are:

    - Potential for electronic see-and-avoid protection for all medium to low-capacity RPT operations;

    - Ability for Airservices to decommission non-backup navaids after sufficient aircraft are GNSS equipped, thereby ensuring funding is available for cross-industry funding for aircraft owners.

- Airservices would begin to decommission enroute radars from 2012 and non-backup navaids, on condition, from 2014. However, the use of enroute radar at specific areas most reliant on its coverage would be prolonged for as long as practicable.

- From 21 June 2018, ADS-B avionics would be required for military aircraft operations in civil airspace, although some operations will be exempt, as is current practice.

Many aircraft would not be affected by the proposed requirements for ADS-B avionics. There would be no requirements for operations in a majority of Australian airspace, e.g. at most Common Traffic Advisory Frequency (CTAF) airports and in much Class G airspace below 5,000 ft. Aircraft that cannot power the avionics, such as gliders, would be exempted from mandatory requirements.

8.2 Present Navigation Systems

Airservices operates and maintains a network of approximately 285 NDBs, 93 VORs, 73 Distance Measuring Equipments (DME) and 29 Instrument Landing Systems (ILS). These navaids provide navigation information for pilots for both enroute and approach operations, and influence the separation standards used for ATC. The Department of Defence maintains a number of navaids including 11 NDBs, as well as a VOR and a DME at Oakey.

Surveillance services for enroute and terminal area air traffic management are provided using nineteen radars provided by Airservices Australia, nine air traffic control radars provided by the Department of Defence, and a number (currently ten, rising to 39 in 2007/08) of ADS-B ground stations.

8.3 Present Surveillance Systems

Terminal area surveillance is provided in the airspace within an approximately 30 to 50 NM radius around major airports by eight terminal area radars operated by Airservices. Nine terminal area radars operated by the Department of Defence provide surveillance within an approximate 90 NM radius of each location. These radars comprise both primary radar sensors and SSR sensors, enabling them to detect both cooperative (transponder equipped) and uncooperative aircraft.

Enroute radar surveillance is provided by eleven SSR only sensors operated by Airservices, and the SSR coverage of most of the nine radars operated by Defence. This provides enroute radar surveillance coverage along the east coast in a band about 400 NM across that stretches from Cairns to Adelaide, plus areas around Perth and Darwin. These radars provide cooperative surveillance, i.e. they can only detect signals from aircraft equipped with SSR transponders.

Enroute surveillance using ADS-B was introduced during 2006 and is now being extended across the area of the continent that is not covered by SSR. A network of 28 ground stations will provide continuous surveillance coverage above 30,000 ft. These ADS-B stations provide cooperative surveillance, i.e. they can only detect signals from ADS-B equipped aircraft. In most instances the ADS-B avionics equipment is the same unit as the SSR transponder (e.g. combined ADS-B/SSR avionics units are standard fit on all new Airbus and Boeing jets).

The combined enroute radar and ADS-B coverage is illustrated in Figure 3 below. This full ADS-B coverage is currently being implemented under UAP.

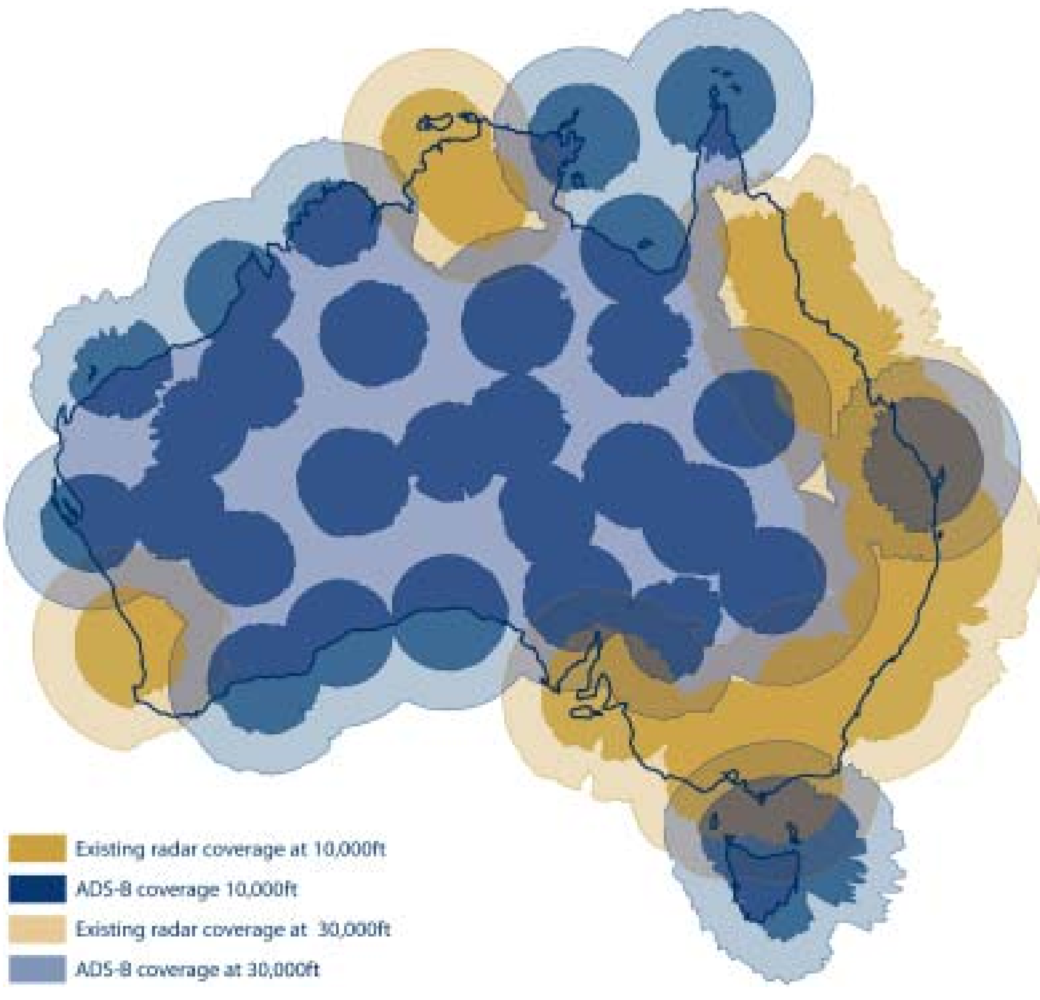

Figure 3: Australian Radar and ADS-B Coverage

An additional 11 ADS-B ground stations will be co-located with the enroute radars during 2008, to provide full continental ADS-B coverage taking the total number of ground stations to 39. It is important to note that no additional ground stations will be required to support mandatory requirements for carriage and use of ADS-B, although coverage of the Australian FIR, from sites within Australia and neighbouring States is expected to grow.

8.4 Future Navigation Systems

RNAV capabilities allow an aircraft to choose any course of flight, rather than being restricted to navigation directly to and from navaids. In Australia, RNAV is typically enabled by GNSS or inertial navigation systems. This can improve aircraft and airspace efficiency through shorter flight distances, reduced congestion, and allowing aircraft with instrument flight plans into airports without ground navaids. A significant benefit of RNAV operations is reduced environmental impact, which is becoming increasingly important in Australia and internationally.

RNP is a more demanding form of RNAV. ICAO defines RNP as "a statement of the navigation performance necessary for operation within a defined airspace". In order to use RNP procedures, an aircraft must be able to determine how accurately its navigation system is performing and alert the pilot in the event that the performance degrades beyond the level required by the procedure being flown.

Increasingly, RNAV and RNP routes, airspace and procedures are being designed, and modern airliners (including airliners regularly operated in Australia such as the A320 and B737NG) meet very stringent RNP requirements, through the combined use of GNSS and inertial navigation solutions, without recourse to ground-based navaids. Operators want to use these capabilities to save time and fuel, and help reduce the environmental impact of aircraft operations.

A 2002 study by Booz Allen Hamilton[2] identified that ground-based navaids, in particular NDBs, cannot support RNAV. They determined that Australia requires a satellite-based navigation system to meet future needs.

RNAV and RNP capabilities are starting to become available for smaller aircraft, including those traditionally viewed as General Aviation (GA) aircraft. ICAO is expected to recognise the same GNSS avionics that CASA has approved for only-means navigation as RNP capable.

There is a synergy between the move to only-means satellite navigation and the introduction of ADS-B, because it is the satellite navigation system that is the source of the position data being broadcast by ADS-B transmitters. Widespread fitment of GNSS avionics will increase GA access to RNAV and eventually RNP operations. A single installation activity reduces costs and associated aircraft downtime.

8.5 Future Backup Navigation Network

In the expectation that most aircraft will in time be equipped with suitable GNSS navigation avionics (as part of the ADS-B avionics system), Airservices proposes to decommission just under half of the existing NDBs and VORs, ensuring that a 'backup' network of some 165 navaids remains. This backup network would provide

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2 Booz Allen Hamilton, *Global Navigation Satellite Systems Technical Audit and Cost Benefit Analysis*, Canberra, Australia, 2002.

a continuation of navigation services in the event of a GNSS failure. It has been designed to ensure that IFR operations can continue if GNSS is unavailable.

8.6 Future Surveillance Systems

The present terminal area radar infrastructure supporting the major airports will continue to consist of combined primary and secondary radar sensors for at least the next 15 to 20 years. Airservices' present terminal area radars are approaching their end of life, and in mid-2006 Airservices signed a contract for eight replacement combined primary and secondary radars, which will be delivered and installed over the next couple of years.

Similarly, the Department of Defence plans to continue to provide combined primary and secondary radars at the locations they currently serve, replacing existing units as necessary when they reach end of life.

These terminal area radars typically provide primary radar coverage to 50 or 90 NM, and SSR coverage to 200 or 250 NM. As well as serving as the principal surveillance system for terminal area operations, they will provide an important backup to the future enroute surveillance system in the airspace with highest traffic density.

Enroute surveillance over the major part of the continent will be by ADS-B, as indicated by the blue regions on Figure 3. This is an area where, prior to 2006, no surveillance services were available.

In the areas previously covered by the eleven enroute radars operated by Airservices, the plan is to implement a service life extension program to extend the life of these radars to about 2012, and then standardise on ADS-B for enroute surveillance over the whole continent. The resultant enroute coverage would be identical to that shown in Figure 3, except that it would all be provided by ADS-B, rather than by a mixture of SSR and ADS-B.

To mitigate the risks of increased failure rates as the present enroute radars age, ADS-B ground stations will be installed to operate in parallel with the radars during the transition period until the radars are decommissioned. These ADS-B ground stations will be installed during 2008.

While previous airport surveillance systems have not contributed to terminal area or enroute ATC surveillance, this will not be true in future. Airservices has ordered Airport Surface Movement and Guidance Control Systems (ASMGCS) for Sydney, Brisbane and Melbourne airports which include ADS-B receivers. These ADS-B receivers will have considerable off-airport coverage that will be used to contribute to the overall terminal area and enroute ATC surveillance picture.

8.7 Summary of proposed changes to infrastructure

Table 1 summarises the proposed changes to existing navigation and surveillance infrastructure, and compares it with the infrastructure that will be maintained for the foreseeable future. Systems not affected by this proposal, such as DME and ILS, are not included in this table.

	CURRENT INFRASTRUCTURE	PROPOSED INFRASTRUCTURE
Radars		
Terminal Area	8	8
Enroute[3]	11	2
[Defence]	[9]	[9]
Navaids		
VORs	88	45
NDBs	200	120
ADS-B ground stations	28	39

Table 1: A Comparison of Navigation & Surveillance Infrastructure

8.8 Backup surveillance network

Even when ADS-B surveillance is available throughout the entire enroute upper airspace, the combined primary and secondary radar coverage from the terminal area radars operated by Airservices and the Department of Defence will continue to provide a backup, with the coverage shown in Figure 4, for the foreseeable future.

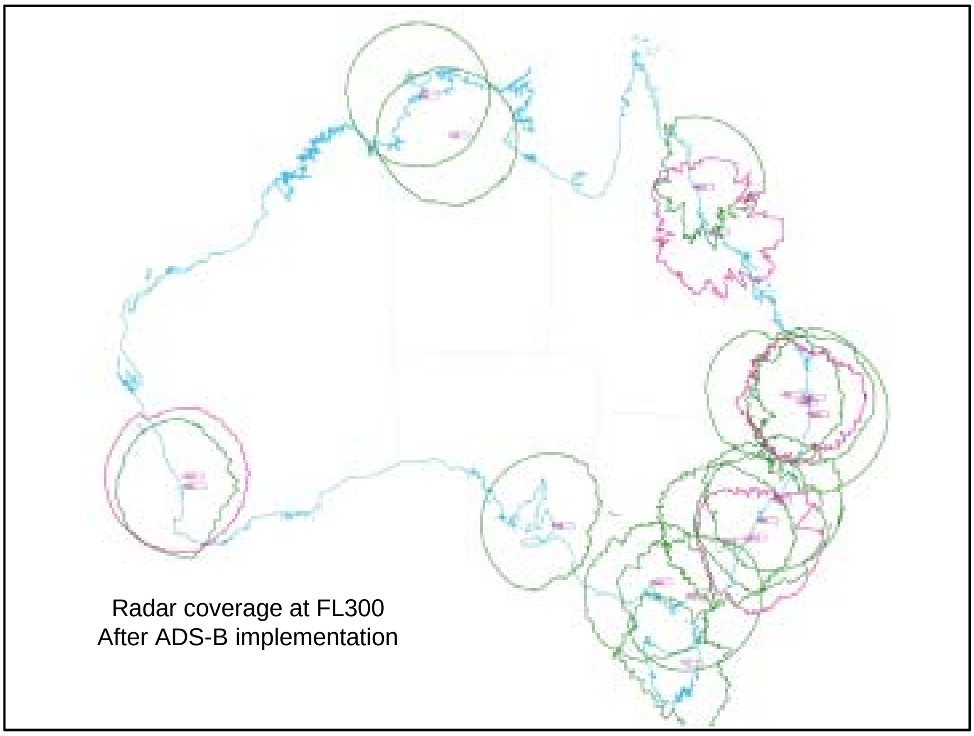

Figure 4: Backup Radar Coverage at 30,000 ft with Enroute Surveillance Provided by ADS-B

[3] Airservices will use parts from nine enroute radars, as they are progressively decommissioned, to extend the life of the Macedon and Swampy Ridge radars as described in Section 9.2. Before 2018, a decision will be made to replace or decommission these last two enroute radars, in conjunction with industry and Government.

8.9 Air-to-air applications

As well as providing a viable low cost alternative to traditional enroute surveillance, ADS-B implementation provides a foundation for air-to-air applications that can be conducted either independently or in complement with traditional ATC. ADS-B receivers and airborne ADS-B applications are currently in development around the world. Many of these applications, including ADS-B based merging and spacing and in-trail procedures, are seen as essential in addressing the airspace and air route congestion problems that are foreseen for many parts of the world.

Widespread ADS-B OUT equipage sets the required environment for future operations based on electronically enhanced air-to-air surveillance. These future operations will help to ensure that airspace and airport efficiency (as well as safety) can be maintained despite traffic growth.

ADS-B has the potential to provide pilots with dramatically improved situational awareness that can be used for tactical decision making in addition to traffic avoidance. TCAS is unable to provide similar capability due to limitations of range, azimuth accuracy and displayed data. TCAS will remain a last line of defence collision avoidance tool. ICAO is working on standards to enhance TCAS using ADS-B signals.

9 Managing the Transition

9.1 Funding the future civil navigation & surveillance infrastructure

In the main in Australia, the cost of providing civil navigation and surveillance services, including installation and maintenance of radars and navaids, is entirely borne by civil aviation, in particular operators of IFR flights. Airservices provides navigation and surveillance infrastructure as well as air traffic management, the cost of which is recovered from enroute and terminal charges to airspace users. Airservices does not receive Government or budget funding for provision of these services.

Consistent with existing industry funding arrangements, there is a basis for Airservices' customers to meet the cost of the fitment of aircraft that must be equipped for IFR operations and for VFR operations that currently require a transponder, because that will facilitate the eventual decommissioning of navaids and enroute radars which will in turn result in lower enroute and terminal area charges.

When the argument is based primarily on safety and has no infrastructure implications, the choice of a source of funding is less clear. However, it is expected that inclusion of a requirement for ADS-B carriage by aircraft engaged in VFR operations that require VHF radio carriage in the scope of the cross-industry funding will provide significant safety benefits in regional areas where ATC is not provided.

It should be noted that the Defence budget provides a contribution to the national surveillance and navigation infrastructure, primarily through the provision of navaids and ATC radars at selected Defence locations. These facilities are built to meet Defence needs and are usually made available to civil users at little (if any) cost.

9.2 Ground systems transition

Airservices will begin the installation of ADS-B ground stations at the 11 enroute radar sites during 2007. At the same time, a comprehensive life extension program will be implemented for the enroute radars, with the intention of maintaining these radars in service until at least 2012, which is approximately five years beyond their planned retirement date (at commissioning). The ADS-B ground stations will provide a back-up for the radars, which will ensure that full ATC services can be provided for ADS-B equipped aircraft in the event of radar failure or prolonged outage during the transition period.

Airservices will ensure full availability of the enroute radars until after most civilian aircraft are required to be ADS-B equipped (mid-2012). This will be facilitated in part from cannibalisation of the old terminal area radars, which are currently being replaced with new Mode S radars.

At present there is considerable overlap between many of the enroute radars and nearby terminal area radars, except for two areas between Melbourne and Adelaide, and south of Cairns (as can be seen in Figure 4). To ensure maximum surveillance coverage for non ADS-B equipped aircraft (legacy aircraft) during the transition period, the Macedon and Swampy Ridge enroute radars will be decommissioned last. The retention of these radars provides the coverage described in Figure 5.

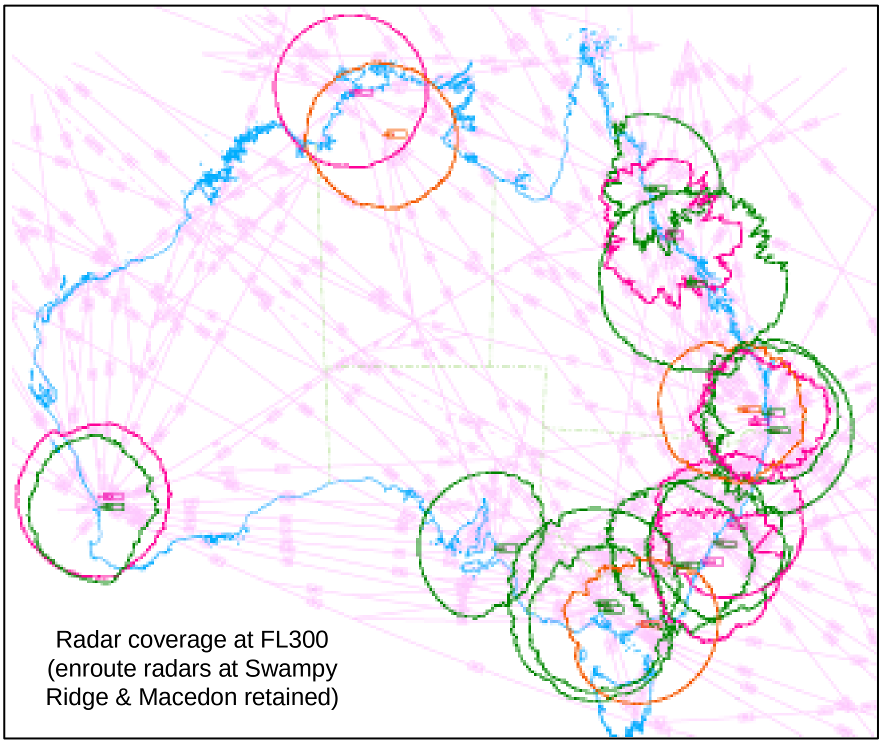

Figure 5: Transition Radar Coverage at 30,000 ft with Enroute Surveillance provided by ADS-B plus two Enroute Radars

Re-use of parts from the radars that are progressively decommissioned after 2012 may enable the life of these two radars to be extended to approximately 2018 to assist transition. During or before 2018, a decision will be made to either replace these radars or decommission them. This decision will be made in consultation with industry and on the basis of an integrated civil and military approach to surveillance.

Airservices has already commenced a program to replace the 165 navaids that form the backup network. A life extension program will be developed for the navaids that are not part of the backup network, to ensure that they can continue to provide navigation services until 2014. Some of the navaids will be approaching 50 years old at that point, so the life extension program will likely include replacement of some navaids that are impossible to maintain.

Airservices' established consultative processes have been followed in the development of the backup navaid network. The process of community consultation and notification that will be followed prior to the decommissioning of any navaids under this proposed programme will be consistent with the process that has been used for many years.

The cost of the two life extension programs will be recovered from airspace users through fees and charges. While analysis is still being conducted, it is expected that these programs will cost approximately one-third of the projected cost for full replacement of the enroute radars and navaids. Some risks to service continuity arise when extending technology life in this way.

9.3 Ground systems cost and funding

In Australia, the cost of providing the infrastructure required for civil aviation navigation and surveillance, as well as the air traffic management service, is funded by Airservices' customers. While many VFR pilots benefit from some of the infrastructure – particularly for night operations – there are no Airservices enroute charges for VFR operations. The large majority of Airservices' funding comes from its airline customers.

When new ATC infrastructure or staffing levels are required, the additional costs are passed on to Airservices' customers through enroute and terminal charges. This is also true for the costs associated with replacement infrastructure or life extension programmes. Equally, by reducing the cost basis of its assets, Airservices could reduce its enroute and terminal charges.

An increasing number of IFR aircraft operating in Australian airspace are now GNSS and ADS-B equipped. These aircraft are less and less reliant on ground-based infrastructure for navigation and surveillance services. In time, it may be difficult for Airservices to charge these operators for facilities they do not use.

Replacement costs for legacy infrastructure are approximately $60 million for enroute radars and $30 million for non-backup navaids. Ongoing maintenance is in the order of $2.5 million per year. By comparison, the 11 ADS-B ground stations will cost approximately $3 million, with annual maintenance costs of approximately $130,000.

9.4 Airborne systems transition

The bulk of aircraft would transition in the 2008–2014 period to meet operational needs and the proposed regulatory requirements for ADS-B OUT equipage. However, as is the case today for carriage of radar transponders and navigation equipment, some aircraft will not be affected by the proposed changes to infrastructure and regulation.

Formal exemptions from carriage of ADS-B avionics may be available after regulatory requirements come into effect. Today, exemptions for transponder carriage are detailed in the Australian Aeronautical Information Publication (AIP). Some aircraft, for example most gliders, do not have engine driven electrical systems. AIP Gen 6.1.2 states:

> *All aircraft, except aircraft operating to the VFR which are not fitted with an engine driven electrical system capable of continuously powering a transponder, must be fitted with a serviceable Mode A/C or Mode S SSR transponder when operating in Class E airspace.*

AIP Gen 6.2.1 states:

> *General exemptions against the requirement for carriage of SSR transponders are in force for aircraft certified without an engine-driven electrical system; eg, balloons, gliders and antique aircraft.*

CASA stated in their 2005 Summary of Responses to the 2004 ADS-B Discussion Paper that:

> *Applications for exemption from any future requirements for carriage of ADS-B equipment would be considered in a similar manner to existing arrangements for other equipment.*

Exemptions to Australian Civil Aviation Regulations are administered by CASA. It is not expected that general exemptions for glider or any other operations will need to be varied in support of a transition to satellite technology, or that aircraft will be required to carry equipment which they cannot power.

Specific exemptions against the requirement for carriage of ADS-B avionics, for the portions of flights subject to a clearance, may be available subject to agreement with the relevant ATC unit as is the case with unserviceable transponders today. This will cater for military aircraft that cannot be suitably equipped and aircraft with unserviceable ADS-B avionics.

9.5 Defence Aircraft

While some Defence aircraft are already ADS-B equipped, the current Defence Capability Plan project allocations and ten year investment cycle effectively ensure that the majority of the aircraft in the Defence fleet that will require ADS-B fitment to ensure interoperability with the civilian fleet will not be equipped until 2018. For Defence, avionics equipment of new, yet to be delivered, platforms are not easily varied until in service. Defence also has an extensive capability and fleet changeover planned during 2010 to 2018, and seeks to avoid carrying out nugatory implementation work during this period. Future aircraft acquisitions are expected to incorporate ADS-B capabilities.

In support of this timeframe, Airservices proposes to maintain the Macedon and Swampy Ridge enroute radars to assist Defence transition, as described in Section 9.2. Defence aircraft will be managed using the extensive radar coverage provided by the Terminal Area Radars, as well as military ATC radars. In the very rare cases where

Defence aircraft will operate in airspace without radar coverage (after 2014, where there had previously been enroute radar coverage), procedural ATC techniques will be used.

Defence fleet operations represent approximately 2.1% of total annual operations managed by Airservices. The relatively low occurrence and national interests of these operations mean that there are advantages to the Defence fleet transitioning to ADS-B carriage on a slightly longer timeframe that best suits their planning cycles, without significant disruption to civil or military aircraft aviation operations.

It is expected that access to airspace for legacy aircraft (including Defence aircraft) will be little changed from what it is today, and the services provided by ATC will be similar to those presently available. This is not to say that these aircraft will be able to avail themselves of the benefits available to ADS-B aircraft. For example, ADS-B aircraft over outback Western Australia will be able to be separated by as little as 5 NM, while non ADS-B legacy aircraft will be constrained to services based on today's procedural separation standards of up to 10 minutes (80 NM) depending on aircraft equipage.

Even so, in many situations unequipped aircraft are likely to obtain 'trickle-down' benefits – if the bulk of the traffic is ADS-B equipped and able to be managed with reduced separations, the effect can be to increase the airspace and flexibility available to legacy aircraft, compared to today's situation where all aircraft in that airspace are managed procedurally.

When it is determined that the benefits of ADS-B equipage for Defence are sufficient to justify equipping their older aircraft, the business case for equipage will need to be managed on an aircraft-by-aircraft basis.

9.6 Airborne systems cost and funding

The relative costs of legacy ground-based infrastructure and satellite technology provide an opportunity to support GA participation in the transition through provision of cross-industry funding to facilitate light aircraft equipage with approved avionics. This could be managed as a cross-industry funding transfer via Airservices, whereby enroute charges are maintained at today's levels for a set period, and the additional funds that are not required to maintain or replace the asset base can be passed on to light aircraft owners in the form of cross-industry funding.

Provision of ADS-B OUT capability, including installation, is expected to cost less than $10,000 for a typical GA VFR aircraft. Provision of ADS-B OUT and 'sole-means' GNSS navigation, including installation, is expected to cost less than $15,000 for a typical GA IFR aircraft. Obviously costs will vary with the individual choice of avionics and complexity of installation in the particular aircraft, as will the value to the owner of replacing existing avionics made redundant by the new equipment. It should be noted that these figures are based on relatively small quantities of avionics in the near term, and may not be representative of high-volume production costs. CASA equipment surveys indicate that under the proposal outlined in this document, approximately 7,000 light aircraft will be required to equip with ADS-B avionics by mid-2012, with an additional 4,000 aircraft equipped by mid-2014[4].

Significant work has been done by the ASTRA ABIT5 on the concept of cross-industry funding to ensure light aircraft access to airspace where ADS-B avionics are required. A cut-off point of 5,700 kg MTOW was agreed, with any affected Australian aircraft with an MTOW less than or equal to 5,700 kg eligible for the cross-industry funding.

For more sophisticated aircraft, the costs increase relative to the scale of integration required and the size and type of operation of the aircraft. Many of the ADS-B related costs for large aircraft operators were quantified for ASTRA during the development of the ADS-B Cross Industry Business Case (which is available from http://www.astra.aero[6]), and are still relevant.

9.7 Cross-Industry Funding

A key issue for all sectors of the aviation community will be the cost of ADS-B avionics. In the event that the proposed transition timing is agreed, and CASA issues a mandate for ADS-B avionics that would support decommissioning of enroute radars and navaids, it is proposed that Airservices would facilitate a cross-industry funding arrangement.

Essentially, Airservices' customers would fund the acquisition and installation of approved avionics for light aircraft. This would not involve any additional charges to customers, and will be 'revenue-neutral' to Airservices.

Airservices would draw upon the savings achieved through not replacing existing enroute radar and navigation aids until the avionics costs were covered. Once the avionics costs are met, the ongoing savings would be passed on to customers.

The funding would provide avionics for aircraft with a MTOW less than or equal to 5,700 kg, and would be managed via a voucher system with the following characteristics:

- A voucher would be issued after formal application was made by the aircraft owner along with a certified true copy of the maintenance release. The voucher would be redeemable when accompanied by evidence of permanent installation of acceptable avionics and provision of the avionics serial numbers.

- There would be no 'new-for-old' avionics exchange requirements, and any replaced equipment would remain the property of the owner.

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[4] Note that since the CASA equipment surveys were undertaken, the number of aircraft on the Civil Register has decreased by approximately 4% due to the Part 47 implementation process, therefore these numbers may be over-estimated.

[5] ABIT includes representatives from Airservices, CASA, DOTARS, Defence, international airlines, domestic airlines, regional airlines, airports, general aviation, sports aviation, recreational aviation, avionics manufacturers & installers, flying training, and search & rescue.

[6] Note that ASTRA's Cross Industry Business Case considered different time frames for a transition to satellite technology, and is therefore not relevant to this Joint Consultation Paper in its entirety.

- Vouchers would only be issued for airworthy aircraft on an Australian civil aircraft register, and no voucher would be issued for aircraft already equipped with acceptable avionics.

- A voucher with a maximum value of $15,000 would be issued for IFR aircraft to support the installation of ADS-B OUT avionics and TSO-C146 GNSS navigation equipment. IFR status will be determined from the aircraft's latest maintenance release.

- A voucher with a maximum value of $10,000 would be issued for VFR aircraft to support the installation of ADS-B OUT avionics driven by a TSO-C145 GNSS engine.

- Vouchers would be valid for three years from date of issue and would not be issued for applications received after 30 December 2013.

- The maximum voucher values would decrease to $13,500 & $9,000 respectively (90% of their original value) for applications received between 1 July 2011 and 30 December 2013. This measure is to assist in spreading the installation workload to earlier dates.

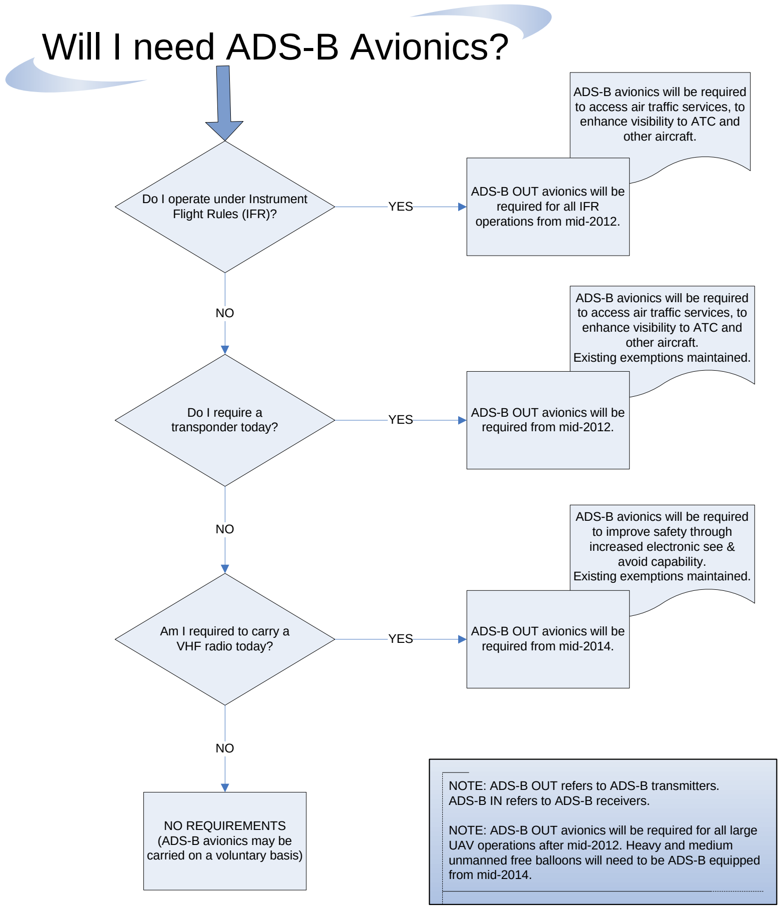
Note: Airservices would observe strict privacy protocols in using and verifying information provided for cross-industry funding purposes only.

Cross industry funding vouchers would also be provided for aircraft with a MTOW greater than 5,700 kg, where the aircraft was solely used for charitable or humanitarian purposes.

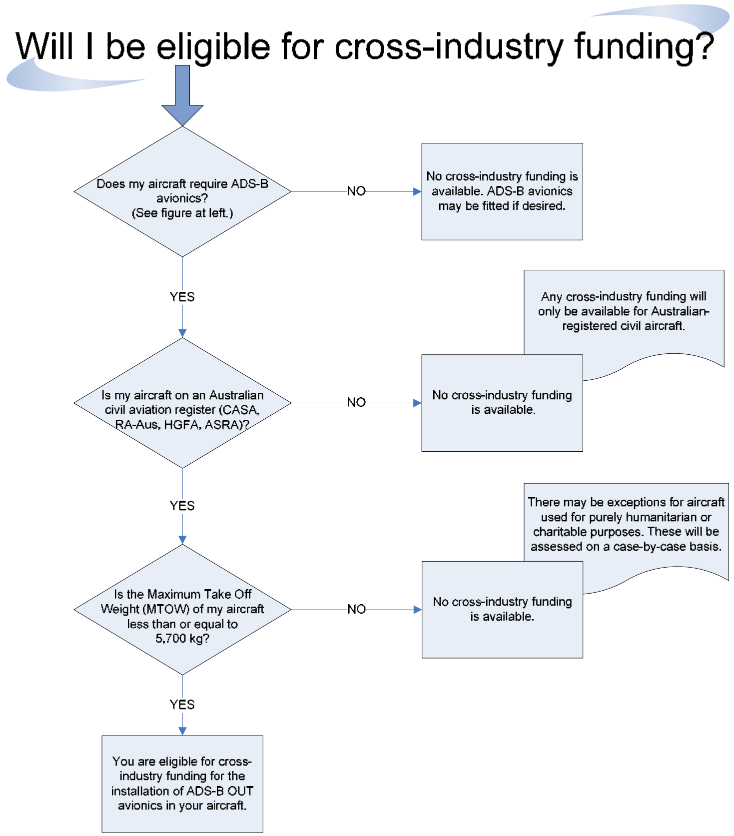
9.8 Pilot Training Requirements

Pilot training and operational material relevant to the use of ADS-B and GNSS has already been published. Pilot booklets on ADS-B and GNSS are readily available from CASA.

10 Overview of Proposed Rules and Cross-industry Funding

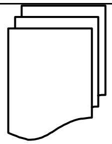


Final requirements will be subject to industry consultation, which may result in some changes.

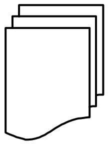


Final eligibility will be subject to industry consultation which may result in some changes.

International Standards

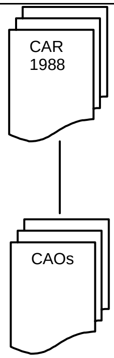


ICAO Annex 10 &
PANS-ATM



ICAO Annex 2,
ICAO Annex 4,
ICAO Annex 10,
ICAO Annex 11,
ICAO Annex 15,
& PANS-ATM
(Amendments effective
November 2007)

Amendments to Civil Aviation Orders – Carriage & Use of ADS-B Avionics



Objectives

- Achieving improved ATM system safety and efficiency, and associated economic benefits for all airspace users through facilitation of a transition to satellite-based navigation and surveillance; and
- Providing clear, simple and practical requirements and regulatory guidelines for the carriage and use of ADS-B avionics.

Key Proposed Changes

- Phased introduction of requirements for the carriage and use of ADS-B avionics;
- From mid-2012, ADS-B OUT avionics will be required for all IFR operations, large Unmanned Aerial Vehicles (UAVs), and for all VFR operations that require carriage and operation of a transponder; and
- From mid-2014, ADS-B OUT avionics will also be required for all heavy and medium unmanned free balloons and, with some exceptions, VFR operations for which carriage and use of VHF radio is required.

11 Regulatory Considerations

The objective of this consultation is to produce a clear, coherent position on the transition to greater reliance on satellite technology for navigation and surveillance. This will assist CASA to produce clear, simple and practical regulations and regulatory guidelines for the carriage of these avionics that will maintain or improve the safety of operations. It is planned that standards will ultimately be promulgated in the Civil Aviation Safety Regulations 1998 (CASR).

A major aviation infrastructure change requires the management of risk by aircraft operators, the ATM service provider and the safety regulator. It demands that a regulatory platform be established to ensure that at least equivalent safety to that provided by the current infrastructure is maintained. Without regulatory action to develop suitable standards and operational procedures, as well as avionics fitment requirements, ADS-B could not be introduced into the Australian ATM system with confidence that safety is maintained and maximum cost benefit outcomes could not be achieved.

Transition from the Civil Aviation Regulations 1988 (CAR) to the CASR is underway although, at present, the majority of aircraft operational standards are still promulgated in the CARs and CAOs. Recently the CAOs were amended to include provisions for carriage and use of ADS-B avionics. It is proposed that future rules for mandatory carriage and use of ADS-B will also initially be promulgated as amendments to CAO 20.18, 82.1, 82.3 and 82.5. It is planned that all ADS-B rules will be transferred into the operational CASR Parts when they are made or during their post-implementation review.

11.1 Reasons for regulatory change

The main driver for change is the requirement to find a suitable replacement for Australia’s aging navigation and surveillance infrastructure that caters for increasing traffic, changing airspace and evolving ATM requirements, while keeping Australia in line with international ATM developments and requirements. Regulatory change is required to ensure that the safety and efficiency of the ATM system is maintained or improved while the industry is transitioning from one technology to another.

Regulatory requirements for carriage and use of ADS-B and GNSS avionics are necessary to ensure that enough aircraft are equipped with alternative means of navigation and surveillance to enable eventual decommissioning of aging infrastructure. This is turn will ensure that funding is available (in the form of savings from the avoided cost of ground infrastructure replacement) to fund the required airborne infrastructure. Should aircraft equipage continue to be on a voluntary basis only, it is unlikely that sufficient aircraft will be equipped in time to avoid replacement of the ground infrastructure, therefore precluding the availability of any funding for avionics.

11.2 Operational Requirements

Aircraft that do not carry or operate ADS-B transmitting equipment cannot be detected by an ADS-B ground station. This situation may have direct effect on the ability of ADS-B surveillance to achieve a required level of risk mitigation. If ADS-B is to replace or enhance other technologies in various roles, then mandatory carriage and operation of ADS-B OUT in some circumstances will ensure visibility of traffic to ADS-B surveillance.

It is proposed that ADS-B ground stations will be used in Australia for enroute ATM surveillance in lieu of traditional radar, necessitating the introduction of rules for ADS-B visibility that replicate the current rules for radar visibility. Today, with some exceptions, aircraft in Class A, C and E airspace must carry and use transponders and VHF radios. This is a requirement to access the airspace, and it is also proposed to apply to ADS-B from June 2012.

Similarly, VHF radio is required for safety reasons in some Class G airspace today – essentially airspace above 5,000 ft and for operations at CTAF(R) aerodromes. At present, operations in this airspace rely primarily on pilot position reports and see-and-avoid techniques to manage traffic, but carriage of ADS-B would enhance awareness of proximate traffic through display of aircraft on the ATC system and/or use of ADS-B cockpit displays.

It is proposed that rules for mandatory use of ADS-B wherever VHF is required would be introduced in June 2014. These rules will result in improved safety, particularly for passenger-carrying transport aircraft operating into regional airports, arising from the ability of such aircraft that become equipped with ADS-B IN to detect the presence of smaller aircraft that are ADS-B OUT equipped.

The proposal is as follows:

- Initially ADS-B OUT avionics will continue to be carried on a voluntary basis, with air traffic services provided as they are today.
- From 28 June 2012, ADS-B OUT avionics will be required for all IFR operations, large UAVs, and for all civilian VFR operations that currently require carriage and use of a transponder. Some exemptions would be available.
- From 26 June 2014, ADS-B OUT avionics will also be required for all civilian VFR operations that currently require carriage and use of a VHF radio, subject to security implications and cost benefit risk analysis. Some exemptions would continue to be available. The requirement for ADS-B OUT would also be extended to heavy and medium unmanned free balloons.
- Airservices will begin to decommission enroute radars from 2012 and non-backup navaids, on condition, from 2014. However, the use of enroute radar at specific areas most reliant on its coverage would be prolonged for as long as practicable.
- From 21 June 2018, ADS-B avionics will be required for military aircraft operations in civil airspace, although some operations will be exempt, as is current practice.

Many aircraft would not be affected by the proposed requirements for ADS-B avionics. There would be no requirements for operations in a majority of Australian airspace, e.g. at most CTAF airports and in much Class G airspace below 5,000 ft. Aircraft that cannot power the avionics, such as gliders, would be exempted from mandatory requirements.

This phased implementation recognises that the pace of change must be managed to ensure that operators and maintenance organisations have sufficient time to fit affected aircraft at minimum cost and, where possible, during planned maintenance downtime.

11.3 Technical Requirements

CASA has already published standards for ADS-B avionics and for GNSS navigators suitable for only-means navigation. Australia has followed the recommendations of ICAO in using the 1090 MHz (Mode S) ES as the globally interoperable datalink for ADS-B. In Australia, 1090 MHz ES will be the ADS-B link for all aircraft in all airspace where carriage and use of ADS-B avionics is required.

12 Affected Parties

Those potentially affected by the transition to satellite technology for surveillance and navigation include:

- Passengers, pilots, air traffic controllers and aircraft maintenance engineers;
- Aircraft operators and owners;
- Aircraft maintenance organisations;
- Aircraft and avionics manufacturers;
- Airservices Australia;
- Australian Defence Force;
- Australian Search & Rescue;
- Australian Transport Safety Bureau; and
- CASA.

13 Regulatory Change Proposals

The prime functions of the APG are to coordinate action across the whole aviation portfolio, and to plan the longer term infrastructure and policy framework required to support and advance Australian aviation. This JCP has been developed in light of these primary functions.

13.1 Framework

It is proposed that ADS-B and GNSS avionics be required to be carried by a wide variety of aircraft in order to gain access to nominated airspace.

In the future it is intended that CASR Part 91 – *General Operating and Flight Rules* – will regulate the majority of operations, while the regulatory framework currently being implemented will see regulations for sport and recreational operations separately promulgated in the proposed CASR Part 103. Regulations for UAVs and unmanned free balloons are contained in CASR Part 101. Provision relevant to foreign operators will be regulated under Part 129 when issued.

Until such time as Parts 91, 103 and 129 are made, it is proposed that rules for the carriage and use of ADS-B avionics applicable to Australian aircraft will be promulgated in CAO 20.18. The rules will consist of directions published by amendment of subsection 9B of the order. Technical specifications are already contained in Appendix XI to the same order. These directions will also apply to foreign registered aircraft operating in Australia through a direction in CAOs 82.1, 82.3 and 82.5. Although some aircraft are already equipped, regulatory proposals are required to ensure that enough aircraft are equipped to render the enroute radars and a large percentage of the NDBs and VORs redundant.

The proposed amendments to the CAOs are set out in **Appendix C** of this JCP.

13.2 Operational Requirements (from mid-2012)

Proposed regulations will require ADS-B OUT avionics carriage from mid-2012 equivalent to Australian requirements for carriage and use of Mode A/C transponders today.

13.3 Operational Requirements (from mid-2014)

Proposed regulations will require ADS-B OUT avionics carriage from mid-2014 equivalent to Australian requirements for carriage and use of VHF radios today.

14 Benefits and Impacts

The four agencies consider that implementation of satellite based navigation and surveillance offers considerable economic, environmental, security and safety benefits to the community and the aviation industry. The extent of the benefits and costs accruing will depend on the type of aircraft, number of aircraft, type of operations and location. The benefits will accrue as more aircraft are fitted with the avionics equipment.

14.1 Costs

The following key quantifiable costs need to be considered for the transition to satellite based navigation and surveillance. They need to be balanced against the expected ongoing safety and economic benefits, including an expected reduction in mortality rates in the longer term and infrastructure cost savings over the legacy ATM system.

- Avionics purchase and installation (with considerable variation in costs depending on aircraft type);

- Costs associated with Supplementary Type Certificates (STC) and other approvals;
- Cost of ADS-B ground station installation and maintenance;
- Cost of radar replacement and maintenance (for comparison with ADS-B);
- Cost of radar and navaid decommissioning.

There may be some unquantifiable cost associated with the transition.

14.2 Benefits

The transition to satellite based navigation and surveillance will result in both quantifiable and unquantifiable benefits. Key quantifiable benefits include:

- Prevention of aviation fatalities:
  - Improved Search and Rescue, with earlier medical intervention, through utilising the better position, tracking and identity information provided by an ADS-B system;
  - A reduction in CFIT accidents, through fitment of high-quality GNSS navigators to aircraft (in conjunction with the ADS-B avionics), required to provide high quality position information for the ADS broadcast, combined with a moving map terrain display;
  - A long term reduction in the risk of mid air collisions, especially those involving small VFR GA aircraft, through fitment of traffic displays and using aircraft position data from the ADS-B broadcasts, which will enable aircraft-to-aircraft collision avoidance.

- Benefits from moving from procedural airspace to ADS-B surveillance airspace:
  - Greater availability of optimal flight levels due to reduced separation standards will facilitate small reductions in aircraft operating costs, and some benefits in terms of passenger time;
  - More optimal flight through introduction of User Preferred Routes (UPRs) – for which ADS-B is one of several enabling technologies – will marginally reduce operating costs and flight times;
  - More accurate diversions around weather, restricted areas or volcanic ash, etc;
  - Reduced communications costs for FANS-equipped aircraft, compared to current automatic position advice (ADS-C);
  - More accurate flight following will deliver some operating cost reductions and benefits to passengers in terms of improved on-time performance;
  - Improved traffic information and situational awareness will enable more efficient approach and departure operations from non-radar aerodromes.

- Realisation of the full benefits of UAP.

- Improved data and information on aircraft – and ground vehicle – movement for airlines and airports will increase airport operational efficiency.

Other anticipated benefits cannot be quantified:

- The scope for innovation provided by satellite based technology.
- Increased airspace total system safety and reduction in overall system risk through more accurate navigation and surveillance;
- Improved in-flight emergency response (from ATC and other aircraft);
- Enhanced see and avoid benefits in non-radar airspace, through optional ADS-B IN cockpit displays;
- Improved pilot and ATC situational awareness;
- Improved accident investigation capabilities due to expanded surveillance;
- Reduced risk of runway incursions, where ADS-B data is used for surface movement surveillance;
- Additional ATC safety net functionalities enabled by ADS-B, including cleared level and route adherence monitoring, short term conflict alerts, and danger area infringement and minimum safe altitude warnings;
- Improved pilot / ATC communication;
- Reduced VCAs;
- Safer ATC tactical and vectoring operations;
- Improved fleet information and co-ordination possibilities;
- Reduced greenhouse gas emissions due to increased fuel efficiency;
- Enhanced surveillance may allow ADF and Coastwatch to more easily rule out friendly aircraft and concentrate on aircraft of potential concern;
- Because a higher proportion of aircraft will be known, incidents generated by communication breakdowns (due to unserviceable radios, pilot selection of the wrong frequency, or incorrect radio volume) will be reduced;
- There may be future potential to share ADS-B information across FIR boundaries to reduce current FIR boundary risks;
- Cross FIR-boundary surveillance will reduce the impact of coordination errors.

15 Quantification of Key Safety Benefits

The widespread carriage of a GNSS receiver to provide ADS-B position data, when coupled to optional moving map navigation displays or Cockpit Displays of Traffic Information (CDTIs), could improve pilot situational awareness in some circumstances and has the potential to avoid some CFIT and midair collision fatal accidents, as well as ‘near misses’. Recognising the value of the GNSS position data for other purposes, the Australian Technical Standard Order ATSO-C1005 makes specific provision for a data port to enable the ADS-B avionics to provide current position to other systems onboard the aircraft. In addition, because aircraft fitted with ADS-B OUT avionics will be broadcasting their position, altitude and identity, there is the potential for an increased role for Air Traffic Services (ATS) and other aircraft in avoiding accidents outside radar coverage. This may be through intervention or by providing improved in-flight emergency assistance to aircraft in distress.

In order to estimate the safety benefits afforded by ADS-B, CASA conducted an analysis of the potential for ADS-B and related technologies in the prevention of several key fatal accident categories. There has been no attempt (due to the complexity of the task) to further quantify all of the expected safety benefits, in particular the impact of 'incidents'. In addition to work by CASA, the Australian Maritime Safety Authority (AMSA) has estimated the Search & Rescue (SAR) benefit due to more efficient last position reporting and therefore more rapid medical assistance to survivors expected through a national network of ADS-B base stations.

15.1 Search and Rescue

AMSA expects improved search and rescue response times, through more accurate and timely location of aircraft, from ADS-B transmitted data, especially in areas not presently under radar coverage. Based on historical accident data, AMSA has estimated 2-3 fatalities could be prevented per annum, assuming wide geographical coverage of ADS-B base stations and a high proportion of the general aviation fleet fitted[7].

15.2 CFIT Accidents

CASA conducted an analysis of 26 'normal operation' CFIT accidents that occurred between 1991 and 2000. Of these, 23 involved the pilot losing visual reference to the external environment through deterioration of the weather, a situation where a terrain display in the cockpit may have assisted with situational awareness. Analysis concluded that up to 13 CFIT accidents (i.e. 50%) and 26 fatalities (50%) could have been prevented if the pilot had been able to effectively utilise information from a moving map terrain display in the cockpit and taken avoidance action.

Effective utilisation of the terrain information would require training and experience. Pilot training conducted in the US Federal Aviation Administration's (FAA) 'Capstone' ADS-B and GNSS program in Alaska assessed trained pilots as being 59% effective at utilising the avionics to prevent accidents, i.e. 40% of preventable accidents would still occur unless pilots were better trained or became more proficient with time. Therefore, it seems reasonable to assume that at least 30% of typical Australian 'normal' CFIT accidents could be prevented with the ADS-B enabled terrain awareness technologies.

This analysis was presented to ABIT in June 2005[8] and is available at http://astra.aero/ABIT/index.aspx. Prior to publication, CASA sought independent review of these findings by the Aviation Safety Foundation of Australia (ASFA) and the US-based Flight Safety Foundation. Both organisations reviewed the analysis and expressed their support for the paper. The analysis was also endorsed by ASTRA in May 2005.

In cost-benefit work carried out by the FAA in 2005[9] to estimate the effectiveness of an ADS-B derived display of navigation and terrain information to aircraft not already equipped with a Terrain Awareness and Warning System (TAWS), the FAA concluded that the safety effectiveness was approximately 53 % in adverse weather conditions and approximately 18% when no adverse conditions prevail.

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[7] ABIT/3 WP7: *ADS-B Implications for Search and Rescue*, AMSA, 2004.
[8] ABIT/6 IP1: *Safety impacts of the ADS-B LAP: Potential for prevention of CFIT accidents*, CASA, 2005.
[9] *NAS-Wide ADS-B Benefits, Basis of Estimate, August 2005*, FAA, 2005.

15.3 Midair Collisions

From an analysis of the historical midair collision accident record, CASA considers that ADS-B avionics fitted to a high proportion of the light aircraft fleet in Australia should prove to be an effective additional mitigator in the prevention of midair collisions in the long term. A similar but more complex analysis of midair collision 'near misses' would likely reveal that many of these could also be prevented. Effective utilisation of the traffic information provided by the moving map displays would require pilot training and experience, which would increase over time.

To obtain maximum safety benefits to both general aviation and air transport operations, fleet fitment of ADS-B transmitting equipment would need to be high, and many aircraft would need to carry cockpit traffic displays to receive the transmitted signals. The development of low power and light weight avionics for sport aircraft will help deliver the maximum benefit from ADS-B.

Although the analysis does not examine potential midair collisions involving regular public transport aircraft, since none have occurred, it did examine a number of passenger-carrying and fatal charter collisions. Most of these were amenable to prevention using this technology. CASA therefore considers that widespread fitment of the light aircraft fleet should also result in reduced collision risk for air transport operations, particularly in the vicinity of aerodromes with a mixture of operations. This analysis was also presented to ABIT in June 2005[10] and is available at http://astra.aero/ABIT/index.aspx. The analysis also received favourable review from ASFA and the Flight Safety Foundation and was endorsed by ASTRA in May 2005.

In a finding similar to CASA's conclusion, and following recent work to estimate the effectiveness of ADS-B to reduce the risk of midair collisions, the FAA has concluded that ADS-B should be approximately 72.3% effective at reducing collision risk, provided that each aircraft in a collision pair is equipped with ADS-B OUT and at least one of the aircraft is equipped with ADS-B IN[11].

16 Cost-Benefit Analysis

Airservices, with the support of the APG, commissioned Access Economics to conduct a whole of industry cost-benefit analysis of the implementation of requirements for ADS-B and GNSS avionics. This analysis concluded that significant savings would be result from the transition to satellite technology. The full report is available from http://www.dotars.gov.au/ and http://www.airservicesaustralia.com/.

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[10] ABIT/6 IP2: *Safety impacts of the ADS-B LAP: Potential for prevention of midair collision accidents,* CASA, 2005.

[11] *NAS-Wide ADS-B Benefits, Basis of Estimate, August 2005*, FAA, 2005.

17 Implementation and Review

Following consideration of the responses to this JCP, the four agencies will brief the Ministers for Defence and Transport & Regional Services on their proposed position. With Ministerial approval, CASA will then be able to prepare and make public a NFRM, including a consolidation of comments received and the whole of government response.

Supporting activity by CASA, such as industry consultation through release of a DP and a resulting SOR, has already commenced. Development and distribution of an ADS-B education package has already been completed as a result of CASA's support for Airservices' ADS-B UAP.

Monitoring and review of the new rules will be conducted on an ongoing basis during the implementation/transition phases. Thereafter, following the commencement of the applicable CASR Parts, monitoring and review will be conducted on an as required basis by the Government.

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Joint Consultation Paper Response Form

Please complete your response by *31 October 2007*
and return it by one of the following means:

Fax Attn: ADS-B Proposal (02) 6274 7804

Post ADS-B Proposal, Office of Airspace Management,
Department of Transport and Regional Services
GPO Box 594
Canberra ACT 2601

Email ADSB@dotars.gov.au
(use the response format in this consultation paper)

Your Details

Please provide relevant information and indicate your acceptance or otherwise of the proposal presented in this JCP by ticking [✓] the appropriate box below.

Your name (optional): ______________________________ ARN* (if known): _______

Organisation: ______________________________ ARN* (if known): _______

Address: ____

____

* Aviation Reference Number, usually your CASA-issued license or certificate number

Your contact number (optional): ___________ (to enable the APG to contact you as required)

Do you consent to having your name published as a respondent to this JCP?
YES [ ] NO [ ]

Signed: ______________________________ Date: ______________

How are you responding to this questionnaire / proposal, i.e. whose views are represented in your response?

☐ Private individual ☐ Aviation industry body/ association ☐ Staff association/ union ☐ Government agency/authority/ department/ council ☐ Aviation business owner/ service provider ☐ Other

Please advise your <u>main</u> involvement in aviation:

☐ Passenger/ public consumer of aviation services ☐ Air crew for passenger-carrying activities ☐ Air crew for non-passenger-carrying activities ☐ Ground support for passenger-carrying activities ☐ Ground support for non-passenger-carrying activities ☐ Other (specify below*)

*** Details:** ____

Are you satisfied with the consultation on this issue?

☐ very satisfied ☐ Satisfied ☐ No opinion ☐ Dissatisfied ☐ Very dissatisfied

Key Change Proposals (refer to Section 8.1)

The four government agencies invite you to advise your comments on the subject matter proposed in this JCP by indicating your preference by ticking [✓] the appropriate box and commenting below:

Proposed timing of transition to satellite technology for navigation and surveillance
[ ] acceptable without any changes
[ ] acceptable but would be improved if changes were made
[ ] not acceptable but would be acceptable if changes were made
[ ] not acceptable under any circumstance
[ ] no opinion

Additional explanation (and, if appropriate, an estimate of any consequential impacts including costs):
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Requirements for carriage and use of ADS-B avionics from mid-2012
[ ] acceptable without any changes
[ ] acceptable but would be improved if changes were made
[ ] not acceptable but would be acceptable if changes were made
[ ] not acceptable under any circumstance
[ ] no opinion

Additional explanation (and, if appropriate, an estimate of any consequential impacts including costs):
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Requirements for carriage and use of ADS-B avionics from mid-2014
[ ] acceptable without any changes
[ ] acceptable but would be improved if changes were made
[ ] not acceptable but would be acceptable if changes were made
[ ] not acceptable under any circumstance
[ ] no opinion

Additional explanation (and, if appropriate, an estimate of any consequential impacts including costs):
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Use of funds that would otherwise be spent on navaids and enroute radars to provide cross-industry funding for fitment of ADS-B and GNSS avionics in aircraft with MTOW ≤ 5,700 kg
[ ] acceptable without any changes
[ ] acceptable but would be improved if changes were made
[ ] not acceptable but would be acceptable if changes were made
[ ] not acceptable under any circumstance
[ ] no opinion

Additional explanation (and, if appropriate, an estimate of any consequential impacts including costs):
____
____
____

General and Specific Comments

Your response to the draft CAO amendments:

Having read the draft CAO amendments concerning ADS-B (**Appendix C**) are there specific issues you wish to see addressed? Please indicate by specifying the relevant section, any change that you believe will add value and a short explanation of your reason for proposing the change.

CAO	Change(s) that you consider appropriate (please suggest change)	Explanation
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Any Additional Comments

Thank you. Your response ensures balanced consideration by the four government agencies of the interest of the aviation community and consumers.

Appendix A: References

Airservices Australia, National Airspace System Discussion Paper, Version 1.4, 7 August 2006

ASTRA, Australian ATM Strategic Plan, Edition 2, 18 August 2003

CASA Pilot Guide, Automatic Dependent Surveillance—Broadcast (ADS-B), 28 March 2006

CASA Discussion Paper, DP0410AS, Carriage and use of Automatic Dependent Surveillance—Broadcast (ADS-B) avionics, 6 December 2004

CASA Summary of Response Document, SOR0410AS, Carriage and Use of Automatic Dependent Surveillance—Broadcast (ADS-B) Avionics, 16 September 2005

Ministerial Statement DOTARS06/155WT, Warren Truss MP, Airspace management and reform in Australia, 14 September 2006

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Appendix B: Common Questions & Answers

1 The Wider Application of ADS-B for Surveillance

Q: *Airservices' UAP requires 28 ADS-B ground stations to provide additional air traffic surveillance (contiguous coverage above 30,000 feet) and this JCP proposes to replacement of the 11 enroute radars with ADS-B. As consultation on this proposal is still on-going, why did Airservices purchase an additional 20 duplicated ADS-B ground stations in December 2006?*

A: Airservices purchased additional ground stations for co-location with the 11 enroute radars; near several Department of Defence radar sites; and for additional non-radar locations, in particular sites that will provide surveillance of the FIR boundary. To provide sufficient time for the industry to equip with ADS-B and GNSS avionics in the event that the proposal for the transition to satellite technology is approved, the current enroute radars will need to be extended beyond their design life, so events such as lightning strike may result in longer radar down-time due to component obsolescence, for example. Co-locating ADS-B ground stations with the enroute radars will ensure that surveillance services can continue to be provided for equipped aircraft by ADS-B ground stations in the event of radar down-time, or during extended maintenance periods. The ADS-B data will also be used to improve radar tracking performance.

Q: *Will there be any proving period during the transition to use of ADS-B and GNSS? Will old and new systems be operated in tandem to ensure that the new systems are at least equivalent to the old systems?*

A: Since the beginning of the Burnett Basin ADS-B trial, Airservices has been collecting and analysing data on the performance and capability of ADS-B and GNSS. As the number of commissioned UAP ADS-B ground stations increases, the amount of data analysed will increase exponentially and performance monitoring will be ongoing.

In addition, during 2008 Airservices will commence installation of ADS-B ground stations co-located with enroute radars. This parallel operation of surveillance systems will allow transition from one system to the other over a period of years.

2 Operational Implications for Aircraft Owners and Pilots

Q: *What are the benefits to the owners of aircraft required to fit ADS-B OUT capability and to any other stakeholder in Australia's CNS/ATM infrastructure?*

A: Expected benefits to aircraft owners and other CNS/ATM stakeholders are detailed in Sections 5, 14 and 15 of this JCP.

Q: *Will I need to be ADS-B equipped to be able to fly within 250 NM (rated coverage) of the proposed ADS-B ground stations?*

A: The proposed requirements for the carriage and use of ADS-B and GNSS avionics will be related to the nature of the operation, rather than proximity to ADS-B ground stations. For details of the requirements see the proposed rules in **Appendix C** of this JCP.

Q: *Will ADS-B avionics be required to fly in Class E airspace?*

A: Requirements for ADS-B carriage and use in different classes of airspace will vary according to the aircraft and the operation. Proposed requirements are based on the rules applying to transponders (from 2012) and VHF radio (from 2014) – refer to the proposed rules in **Appendix C** of this JCP.

Q: *Who will pay for the cost of the ADS-B and GNSS avionics and their installation and maintenance?*

A: The four government agencies propose that cross industry funding be provided to subsidise the cost of ADS-B and GNSS avionics purchase and installation for aircraft with a MTOW less than or equal to 5,700 kg as detailed in Sections 9.7 and 10. The cross-industry funding is intended to cover the costs associated with purchase and installation of the basic level of equipment required to transmit ADS-B data suitable for use by ATC. Some owners may wish to install more sophisticated equipment, although they would need to bear any additional expense.

Approximately 11,000 aircraft would be eligible for cross-industry funding. Owners of aircraft with a MTOW greater than 5,700 kg would not be eligible for any cross-industry funding for avionics.

On-going maintenance costs would be borne by aircraft owners. For many owners, ADS-B and GNSS avionics would replace older transponder and Automatic Direction Finding (ADF) equipment, with a resulting reduction in total maintenance costs.

Q: *What new air traffic services will be available to me?*

A: Initially, there will be an extension of ‘radar-like’ services and safety nets enabled by ADS-B equipage to many aircraft that are not able to access these services in some parts of Australia today. In time it is expected that completely new ADS-B enabled services will become available, including services based on air-to-air surveillance as described in Section 8.9.

Q: *What will happen if my aircraft cannot be equipped in time to meet the equipage deadlines?*

A: Access to certain areas of controlled airspace currently requires aircraft to be equipped with an SSR transponder. However, procedures exist to manage un-equipped aircraft in these areas. These are similar to the procedures used in non radar airspace, which is still the major part of the country.

All of the areas presently covered by primary radar, and a large part of the area presently covered by SSR, will continue to be covered by these systems for at least another fifteen to twenty years.

From 2012, with the scope increasing in 2014, access to certain airspace for certain operations will require ADS-B avionics. ATM will be based on the widespread carriage of this capability, but as with the present SSR avionics rules, procedures will exist to manage un-equipped aircraft that have been exempted from requirements to operate ADS-B avionics. This is acceptable so long as these aircraft do not constitute a large percentage of the total traffic.

Q: *I understand that after the enroute radars have been decommissioned that there will actually be very little reduction in the total volume of airspace seen by radar and that for that reason the military fleet of aircraft are not required to fit ADS-B. If that is the case, then why is it mandatory for civil aircraft to fit ADS-B?*

A: There are many reasons that Department of Defence aircraft ADS-B fitment requirements will differ from civil aviation requirements, including the type of operations they undertake, Defence funding arrangements and existing fleet upgrade plans.

Defence participation or otherwise is not determined by radar surveillance. The different timeframe proposed for Defence fitment as opposed to civil aviation reflects that imposing the same timetable on Defence would impose unacceptable costs on the taxpayer. It should also be noted that cross-industry funding scheme would be available to assist many civil aircraft owners with ADS-B and GNSS fitment.

This will be manageable from an air traffic management perspective because Defence aircraft make up a very small percentage of managed aircraft.

Q: *Can the ADS-B ground station see my Mode S transponder and if so, why do I need to fit ADS-B?*

A: Some Mode S transponders have ADS-B capability and others do not. A Mode S transponder alone is not sufficient to support ADS-B transmissions since appropriate data (such as GPS position) must be provided to the transponder, and the transponder must be capable of transmitting ‘Extended Squitter’ ADS-B messages.

Q: What is the difference between a transponder and ADS-B?

A: Transponders respond to interrogations from a radar whereas ADS-B systems transmit autonomously. An ADS-B transmitter can be a stand-alone unit or it may be a feature of a transponder. Mode S transponders do transmit ‘short squitter’ messages without interrogation but these do not include position, identity or velocity information.

Q: If I can use stand-alone GPS for navigation do I still need other navigation equipment?

A: Depending on the type of operation that is to be undertaken, some navigation equipment (such as ADF) may become redundant. Required navigation equipment will continue to be detailed in the AIP.

Q: If the ADS-B separation standard is the same as the radar separation standard, and if runway capacity is finite, then how will ADS-B allow greater numbers of aircraft to be managed?

A: In Australia, beyond providing ATC visibility in the same way as radar at a much lower cost, the primary contribution of ADS-B will be to airspace efficiency (and hence reduced environmental impact) rather than airspace capacity. This will be because ATC will have the ability to apply radar-like separation between aircraft in airspace where currently there is no surveillance and procedural separation is applied.

Where ADS-B surveillance is simply a replacement for radar surveillance, airspace capacity can be increased because of the much greater accuracy of ADS-B surveillance in comparison to radar. In addition, where it is used for airport surface movement surveillance, ADS-B can increase airport capacity, especially in bad weather.

Q: Will gliders, ultra-lights and hot air balloons have to be fitted with ADS-B OUT avionics?

A: ADS-B requirements will be dependent on the airspace in which an aircraft operates. For example, no requirements are proposed in ‘standard’ CTAFs or the bulk of airspace below 5,000 ft AMSL. General exemptions will also be available as described in Section 9.4 (for example where an aircraft is unable to power the avionics).

Q: What training will I have to undertake? Will there be sufficient ground based navigation aids left in place so that I can maintain proficiency?

A: Training requirements for ADS-B operation are similar to the requirements for transponder operation, and training information has already been distributed to all pilots and will continue to be available from CASA's website.

Current training requirements for the use of GNSS for navigation will continue, and there will be enough ground navaids in the backup network to ensure that pilot proficiency can be maintained.

Q: Will all of the IFR flight planning options available to me now, remain available under the future arrangements?

A: Yes.

Q: Will foreign aircraft operating Australia also be required to carry and use ADS-B and GNSS avionics?

A: Yes. The body that represents international airlines supports ADS-B and GNSS implementation. The International Air Transport Association (IATA) strongly supports the cost-effective early implementation of ADS-B. IATA has noted several times that "IATA Member airlines have expressed their desire to use ADS-B at the earliest time." IATA has supported ICAO work on ADS-B through the Asia Pacific Air Navigation Planning & Implementation Regional Group (APANPIRG) and has stated that they are supportive of ADS-B mandates from as early as 2010. They have also stated that any cost benefit studies for deployment of ADS-B out should ignore the cost of airliner avionics fitment, because the aircraft of their member airlines will be equipped as a matter of course, in order to meet a range of future applications.

3 Safety and Reliability of ADS-B and GNSS

Q: What is the performance of ADS-B in comparison to radar?

A: Airservices was required to carry out significant assessment of the performance of ADS-B in comparison to radar in order to be granted approval to use ADS-B for the provision of 5 NM separation. It was found that the performance of ADS-B is equivalent or better than radar for all of the major parameters of performance as a surveillance system. Equivalent redundancy and failure protection/recovery systems and techniques are available.

Airservices' comparison of significant parameters of radar and ADS-B, using the ICAO Doc 9689-AN/953 methods showed that the use of ADS-B for separation is as safe as using radar. Since then, ICAO studies have confirmed that ADS-B can be used for 'radar-like' applications and an ICAO circular addressing the safe use of ADS-B for separation has been written. Formal ICAO provisions for operations with ADS-B have been prepared and the amendments to ICAO standards and recommended procedures will be effective from November 2007.

Q: *What is the performance of GNSS in comparison to ground navaids?*

A: Prior to issuing approval for the use of appropriate GNSS for only-means navigation in 2006, CASA undertook a detailed safety assessment of the technology. This assessment clearly identified that use of TSO C145/146 GNSS only for navigation is at least as safe as use of ground navaids such as NDBs.

Similarly, the balance of risk associated with unexpected GPS failure for a pilot flying an aircraft with a single GNSS receiver only is no different from the balance of risk for a pilot flying an aircraft with only a single ADF, as many navaids are pilot-monitored and outages can therefore be unexpected.

Q: *What is the cumulative total of GPS signal outage expected in any 12 month period? How does this compare with a typical radar installation? Is there a significant increase in risk to aviation safety if during times of GPS outage, aircraft will lose their navigational capability at the same time as air traffic control lose their surveillance capability?*

A: GPS outages (or instances of poor geometry) are typically of short duration – in the order of 5-20 minutes. Radar outages can last for several days to weeks, depending on the reason for outage (regular maintenance outages are much less for ADS-B than for radar because the ADS-B system is fully duplicated and has no mechanical rotating components).

Airservices has tools for predicting GPS outages; there is no equivalent for radar failure. In busy traffic areas, radar will provide adequate surveillance back-up when ADS-B cannot be used.

Q: *Could Wide Area Multilateration be seen as a more appropriate surveillance technology than ADS-B?*

A: Wide Area Multilateration (WAM) is sometimes seen as a useful transition strategy towards implementation of ADS-B surveillance, because it can be used to determine the position (through triangulation) of aircraft that are transponder or ADS-B equipped. Multilateration is better suited to terminal area surveillance than enroute surveillance due to the large number of multilateration sites and geometry required to ensure surveillance over a very large area. For enroute surveillance, the cost of WAM could be comparable to radar, especially when the environmental implications of multiple sites are considered (in comparison to one for radar or ADS-B).

WAM does not yet have regulatory approval for ATC surveillance in Australia, although work has begun in ICAO forums to establish multilateration separation standards.

Q: *What is the likelihood that ADS-B may not be available to allow provision of adequate surveillance for air traffic services? Even if it is unlikely to happen, what will happen if ADS-B cannot be used to provide adequate surveillance for air traffic services?*

A: The likelihood that ADS-B cannot support surveillance services is low. Airservices has tools that will predict outages due to poor GPS geometry. In such an event the proposed backup radar network will continue to be available.

Q: *Is there sufficient manpower to handle the fitment of ADS-B and GNSS avionics to all aircraft for which it is a requirement by mid-2012?*

A: Most aircraft will need installation of ADS-B avionics to be signed off by an appropriate Licensed Airframe Maintenance Engineer (LAME). The transition to satellite technology will represent a challenging task for the available LAMEs. This is an important issue that has implications for more than just ADS-B implementation and will need careful management by the industry. CASA will consider innovative solutions to this issue. It is important to note the distinction between carrying out avionics installation – which could be done by skilled people recruited from outside the aviation industry – and signing off that installation, which requires a LAME or authorised person.

Q: *How many aircraft will be required to be ADS-B equipped?*

A: Approximately 12,000 aircraft.

Q: *Will the switch to GNSS navigation in Australia affect air traffic control route structures and separation standards?*

A: GNSS is already used for navigation in Australia. A greater reliance on GNSS will increase the availability of flexible routes. In the future there will be potential to reduce lateral separation standards based on the RNAV and/or RNP capability of aircraft.

Q: *Will I be forced to use GNSS navigation equipment?*

A: No. A backup network of conventional navigation aids will remain in place, although it will be thinned out compared to today.

Q: How accurate is the current GPS signal?

A: GPS signal accuracy can be affected by atmospheric and environmental conditions, and GPS receiver accuracy can also be affected by GPS constellation geometry. Under normal conditions, GPS receiver position will be accurate to within 5-10 m. ADS-B requires a GPS horizontal protection limit within 0.5 NM (~900 m).

Q: Can the GPS signal be made more accurate and what are Australia's plans for GNSS augmentation?

A: There are many different options to improve GNSS accuracy through augmentation, and different options are being considered in Australia. More information is available from the CASA and Airservices websites.

Q: What are the implications of international GNSS technology advances for Australia's transition to satellite technology?

A: At present, the only fully operational GNSS constellation is the US GPS constellation. Several additional satellite navigation systems are expected to be publicly available before 2012. Europe's Galileo GNSS is entirely independent of GPS and is expected to be available to the public by 2012. Both Galileo and the next generation of GPS Block III satellites are expected to be more advanced, more efficient and more reliable than the current GPS constellation, and avionics manufacturers have published timeframes for development of avionics that receive and interpret their signals.

Advancement of GNSS technology is expected to allow its use for all phases of flight, including precision approach and a new class of approach known as approach with vertical guidance (APV).

It is important to note that next generation GNSS technology that utilises Galileo or GPS III is not a prerequisite for ADS-B implementation. These future constellations will improve navigational accuracy, provide a redundant GNSS solution, and provide increased functionality, but 5 NM ATC separation using ADS-B is approved today based on GPS alone.

Q: There are several different types of ADS-B Link. Why is Australian implementing 1090 MHz ADS-B?

A: There are three possible choices of communications link for ADS-B: 1090 MHz ES, Universal Access Transceiver (UAT) and VHF Data Link Mode 4 (VDL-4). ICAO has determined that the globally interoperable link of choice for ADS-B will be 1090 MHz, and the vast majority of ADS-B equipped aircraft are equipped with 1090 MHz ES ADS-B avionics. For these reasons, Australia has also selected 1090 MHz.

The FAA ADS-B link decision is to use 1090 MHz ES for air transport and high performance GA aircraft (for operations above 24,000 ft) and to allow low performance general aviation aircraft to use either 1090 MHz ES or UAT avionics. The FAA have stated that UAT was selected for GA because of its lower cost, its greater uplink capacity, and to avoid 1090 MHz congestion. However, the use of 1090 MHz in upper airspace will require many GA aircraft to adopt this link.

UAT operates in the same band as 1090 MHz ES although on a different frequency. The technology uses random downlink transmission of ADS-B data (within a synchronised time window) and reserves a certain part of the available time for uplink transmissions from ADS-B ground stations to aircraft. The data transmitted to aircraft can include:

- Positional data for unequipped aircraft, detected by FAA ATC radars
- Graphical Weather data from the FAA's NexRad weather radar network
- Notices to Air Men (NOTAMs)

The data is only received by aircraft within line of sight of the UAT ground stations. The data translation and re-broadcast capability significantly increases the ground station cost in comparison to the 1090 MHz receive-only ground stations used in Australia.

In the USA, there are also private companies that offer NOTAM and weather data to GA pilots. The delivery mechanism is via numerous methods including satellite, sat phone, VHF data link etc.

In the Australian context, the transmission of NOTAM and weather data is desirable – but consultation to date indicates that the GA industry is not willing to fund the infrastructure costs to provide it. To provide a weather service would require a provider to assemble and package the information before it can be broadcast. The Bureau of Meteorology (BOM) may be able to undertake this task, but it is likely to need funding or to charge for the service. The BOM already provides weather services to airline operations offices so there is no airline interest in broadcast weather.

The hardware needed for GA aircraft to receive weather data costs in the order of $US5,000 for the antenna, receiver and display. Subscription services for aviation weather packages start at approximately $US30 per month.

The data transmitted from an aircraft equipped with UAT avionics is essentially the same as 1090 MHz ES.

Airservices experience, including during preparation for the Burnett Basin trial does not support the position that UAT is a cheaper option than 1090 MHz ES.

Q: *What are the advantages and disadvantages of using UAT, or using a mixed UAT and 1090 MHz environment?*

A: The advantages of deploying UAT in Australia compared to the interoperable 1090 MHz link can be summarised as:

- USA GA market forces may drive prices down, although this is also expected to occur with GA 1090 MHz ES solutions for high-flying aircraft;
- Its ability to support uplink if data uplink services are offered and funded, although it is unclear how these services and the required ground stations would be funded.

The disadvantages of deploying UAT in Australia compared to the interoperable 1090 MHz link can be summarised as:

- UAT ground stations are transmitters and receivers. They are more complex and more expensive than Australia's ADS-B receive only ground stations.
- ICAO standards are being developed for UAT, but these standards have not yet been published. This is in the process of resolution.
- Under the FAA system there will be no interoperability between large and small aircraft except via a UAT ground station (translation station). Interoperability will only be ensured for aircraft within sight of a translation station. The ADS-B receiver transmitter (translator) requires line of sight coverage to the aircraft – and line of sight is limited by the curvature of the earth (at lower altitudes, the shorter the line of sight from a ground station). If either aircraft is outside the line of sight, there is no interoperability. If this system were deployed in Australia, interoperability would exist only in areas where a ground station is deployed. To achieve coverage of all aircraft ABOVE 5,000 ft in Australia would require in excess of 150 ground stations. Coverage at lower levels would require many more ground stations.

4 Security Implications of ADS-B and GNSS

Q: *What are the security implications of ADS-B performance in comparison to radar? For example, is ADS-B more or less susceptible to jamming, compared to radar?*

A: When considering the security implications of a transition to a satellite based infrastructure, ADS-B ground infrastructure should be compared to radar infrastructure. Australian ADS-B ground stations are installed in buildings and facilities with security protection identical to that provided to VHF air-ground radio outlets or radars. The risk of a break-in or malicious damage is therefore the same for ADS-B ground stations and VHF outlets. In addition, ADS-B systems are small and unobtrusive and are less likely targets for vandalism or other security threats than radar systems. In the event of damage, they can be replaced quickly.

The reliability, availability and redundancy of ADS-B should be compared to that of primary and secondary ATC radars. A primary objective of radar system design is to have no single point of failure; this is also true for ADS-B ground stations and communications links.

The Achilles heel for ADS-B reliability and susceptibility is GPS because ADS-B surveillance depends on GPS. At this time, there are no inertial based ADS-B position data sources and reliance must be placed in GPS; hence all current ADS-B solutions depend on GPS. The ATC system has been modified to present predictions of any GPS outages to air traffic controllers so that procedural separation standards can be established in such an event. If the surveillance system fails, The Australian Advanced Air Traffic System (TAAATS) processing automatically transitions to present Flight Plan Tracks to controllers thus preserving situational awareness. The radar backup network will remain and, in future years, additional GNSS capabilities such as Galileo will reduce reliance on GPS.

FALSE TRACKS

Radar systems can generate false tracks or positions through track splits, reflections and multi-path errors. These are well understood radar irregularities.

ADS-B systems do not generate as many false tracks as radar systems. The radar phenomena of reflections, track splits and multi-paths do not affect ADS-B data.

SPOOFING

Spoofing ADS-B and radar is illegal in Australia. Both radar and ADS-B can be intentionally spoofed – spoofing is the act of creating false and potentially misleading aircraft track symbols on controllers' air situation displays. It is a little easier to generate false ADS-B tracks than for radar, although a number of anti-spoofing features exist in the design of ADS-B.

ATM SYSTEM CHECKS

Controllers are very skilled at identifying false tracks. This has been demonstrated over many years because of their experience with radar track splits, reflections and multi-paths. In addition, TAAATS performs reasonableness checks and generates alerts when a reported position (radar or ADS-B) doesn't match the flight plan.

Identification of false tracks – regardless of how or where they are generated – is not a new skill for air traffic controllers.

DENIAL OF SERVICE

Radars can be jammed. Data-links from radars to ATC systems can be disturbed. Site power can be disturbed. These actions can result in loss of service. ADS-B can also be jammed (it operates on the same frequency as ATC radars). Data-links from ADS-B ground stations to ATC systems can be disturbed. Transmission of excessive ADS-B messages could jam an ADS-B ground station. These actions can result in loss of service.

For jamming by a ground-based source to be successful, the jammer needs to be relatively near the ADS-B or radar site. Other adjacent ADS-B ground stations may have the ability to provide coverage in this case. Australia's ADS-B ground station distribution design has considerable overlap at 30,000 ft.

Denial of service could occur in a region if GPS were illegally or inadvertently jammed. In the future, Galileo may provide some level of mitigation.

TAAATS will display a flight plan track if the ADS-B or radar data is lost. ATC procedures exist to allow traffic management to continue in the event of loss of surveillance, and controllers are trained to be able to operate the service in the event of loss of any facility.

AIRCRAFT TRACKING

It is legal for anyone to use a receiver to track aircraft in Australia

Aircraft can be tracked today using passive reception of aircraft SSR transponders if those transponders are triggered to transmit by radar interrogation. This technique has been used for some years by inexpensive noise monitoring systems. More recently, multilateration systems have become available to perform a similar function.

HF and VHF receivers are often used by enthusiasts to monitor aircraft communications, including position reports.

Aircraft that use Aircraft Communications Addressing & Reporting Systems (ACARS) can already be tracked by "listening" to ACARS traffic, which is also available via the internet.

ADS-B provides more data to those wishing to track aircraft, including velocity and flight identity. It can be noted that all aircraft with TCAS (the collision warning system) already broadcast their unique identity every second.

Relatively inexpensive (~£500) ADS-B receiving equipment is now available to display the position of aircraft on a home PC or laptop. This capability presents a level of risk – although the risk already exists, because a large number of commercial aircraft already broadcast ADS-B data (more than 5,000 aircraft worldwide are already broadcasting ADS-B data).

The risks associated with tracking of aircraft (including airliners) are therefore already present.

Q: Will ADS-B make any contribution to national security?

A: ADS-B and SSR are 'cooperative' surveillance systems, in that they require an aircraft to carry certain avionics and to have this equipment switched on. Aircraft that pose security threats must be assumed to be non cooperative, in that they could be expected to switch off ADS-B equipment. ADS-B, like SSR, is therefore not a reliable system for the initial detection of aircraft that pose a security threat, and non cooperative surveillance systems are required for this application.

Non cooperative surveillance systems usually detect the presence of aircraft using signals reflected by aircraft fuselages. Examples include ground based microwave primary radars, airborne microwave primary radars (e.g. Defence's Wedgetail AEW&C project) and HF over the horizon radars (e.g. Defence's Jindalee Over the Horizon Radar Network, JORN). They do not rely on the operation of any equipment on aircraft.

Non cooperative surveillance systems attempt to detect ALL aircraft, but do not provide a reliable means of identification of the detected aircraft, and are not always effective in the detection of composite aircraft or slow-moving targets. A non cooperative surveillance system that may detect hundreds of aircraft but is not able to then sort out the large number of legitimate 'friendly' aircraft from the small number of 'threat' aircraft is of itself of little value, and to be effective needs to be operated in conjunction with other systems that aid identification. While any additional information – such as that provided by ADS-B – will not provide any absolute certainty about the identity of aircraft, it can help to provide additional information that will add to the surveillance picture.

IDENTIFICATION

Air defence systems attempt to identify aircraft detected by non cooperative surveillance systems by correlation with other information from a variety of sources, including flight plans and cooperative surveillance data from the civil ATC system.

ADS-B promises to make a contribution to the efficiency and effectiveness of this identification task, as it provides more information than any other cooperative surveillance system. It provides precise latitude, longitude, altitude, horizontal velocity and vertical velocity, updated one or two times a second, plus the aircraft Flight Identification (e.g. QFA1 or VHABC) and a unique 24 bit airframe identification that can be used with a database to establish the country of registration, aircraft registration, aircraft type and aircraft operator. The precision of the position data enhances reliable correlation with aircraft detections from non cooperative surveillance systems.

Regardless of ADS-B implementation, air defence systems will always need to consider uncooperative targets.

ADS-B SPOOFING AND SECURITY

As described above, the air defence system starts by using non cooperative surveillance to detect the presence of aircraft, and then uses a variety of sources of information to attempt to reliably identify each of the detected aircraft. An ADS-B track that has erroneous position information is likely to be seen as suspicious in the air defence system, because it will not correlate with any non cooperative detections or with any flight plan. Furthermore, if the non cooperative detection from the spoofing aircraft is in an area that is of security concern, this track will be regarded as suspicious anyway because it will not be able to be identified.

CONTINUED NON-COOPERATIVE SURVEILLANCE

Australia’s air traffic control radar system will continue to provide non cooperative (primary radar) surveillance in the vicinity of many cities for the foreseeable future. Replacement primary radars have recently been ordered for Cairns, Brisbane, Coolangatta, Sydney, Canberra, Melbourne, Adelaide and Perth. These radars provide surveillance to a radius of 50 miles around these cities. In addition Defence have primary radars at Darwin, Tindal, Townsville, Oakey, Williamtown, East Sale and Gin Gin (north of Perth), with a range of approximately 90 NM. All these radars feed into the air defence system, to supplement other dedicated air defence radars, AEW&C etc. There is no proposed reduction in primary radar coverage.

DEFENCE USE OF ADS-B

The US Air Force have demonstrated that data from ADS-B ground stations can be easily reformatted to Link 16 format and displayed on the radar screens of fighter aircraft performing intercepts. The value of this information is the same as discussed above – it enables the pilot to improve the reliability of identification of legitimate aircraft among a number that the airborne radar may have detected. This demonstration is described in the paper: *ADS-B to Link-16 Gateway Demonstration: An Investigation of a Low-Cost ADS-B Option for Military Aircraft, April 2004, George S. Borrelli, The MITRE Corporation*.

Q: Will all aircraft need to be ADS-B equipped to make any contribution to national security?

A: Universal fitment is not required for security benefits. The contribution that ADS-B can make to improving the efficiency of identification of aircraft detected by non cooperative surveillance begins when the first aircraft is ADS-B equipped, and increases proportionally as more aircraft become ADS-B equipped. It does not require all aircraft to be equipped. These benefits are already available from the more than 400 civil aircraft that are operating with ADS-B in Australia today.

Q: Will all Department of Defence aircraft need to be ADS-B equipped to ensure security benefits?

A: Australian Defence aircraft are not considered a threat to Australia’s security, and it does not compromise the effectiveness of the air defence system if these aircraft are not ADS-B equipped. Rather, the reverse could be true in some circumstances – if Defence aircraft were to be broadcasting ADS-B data, this could compromise their Defence role. For this reason, any Defence aircraft that are fitted with ADS-B would always have the capability to turn it off for certain operations.

5 Future Plans in Other Countries

Q: Are other Aviation Administrations using ADS-B to supplement radar coverage or as a direct substitute for radar?

A: Australia's ADS-B plans have not been developed in isolation. Many nations including Canada, China, France, Indonesia, Singapore, Thailand, the UK and US are implementing ADS-B programs, some of them very similar to Australia's (all of these programmes use 1090 MHz ES technology as proposed for Australia). More detail is provided on some key international plans:

THE UNITED STATES

In June 2006, Marion Blakey, the Administrator of the FAA launched the Next Generation Air Transportation System (NextGen). NextGen aims to address current and future airspace congestion and inefficiencies through the creation of a flexible and scalable air transportation system built on new technologies and new capabilities. The FAA views ADS-B as a critical foundational capability of the NextGen program, and sees ADS-B as an essential component of a long-term programme of addressing projected increases in aviation traffic. They also see the potential for major advances in air traffic management as the innovation opportunities provided by ADS-B are exploited.

The FAA's proposal will see 1090 MHz ES ADS-B mandatory for all operations above 24,000 ft, with requirements to carry ADS-B (either 1090 MHz ES or UAT avionics) in a lot of airspace at lower levels. Under a service agreement, the FAA will have ADS-B 1090 MHz-UAT rebroadcast stations across installed continental USA, which will enable rationalisation of many secondary surveillance radars. It should be noted that one of the service proposals under consideration by the FAA considers 1090 MHz only.

While the FAA implementation of ADS-B under NextGen is different from Australian plans in terms of rationale and scale, it is also similar in many ways, including mandatory requirements for carriage of ADS-B avionics for access to certain airspace; rationalisation of legacy infrastructure, leaving a backup network for coverage in the event of GPS failure; and a focus on future air-to-air applications for improved efficiency and safety.

When the FAA begins their consultation with the US civil and military aviation industries, Australia will closely monitor the process and the outcomes.

CANADA

NavCanada's CEO John Crichton announced in July 2006 that Canada is taking the first steps towards ADS-B implementation with a $C10 million investment to provide communications and ADS-B surveillance over the 250,000 square nautical miles of Hudson Bay airspace. ADS-B is anticipated to provide millions of dollars in savings to NavCanada's customers as it is progressively rolled out across the nation, and ultimately replaces traditional enroute surveillance.

NavCanada expects ADS-B to become operational over Hudson Bay in 2008 and anticipates an ADS-B mandate in some airspace.

UNITED KINGDOM

The UK's Civil Aviation Authority (CAA) is proposing to improve the technical interoperability of all aircraft in UK airspace, by introducing requirements for all sectors of the aviation industry – from gliders to military aircraft and airliners – to be equipped with Mode S (1090 MHz) transponders. The consultative documentation released by the CAA also considers mandatory ADS-B, but in any case, suggests that in the event that a Mode S mandate is implemented, aircraft owners should strongly consider "future-proofing" their aircraft through installing a fully ADS-B capable Mode S transponder in their aircraft.

The UK plans are still in the consultative phase.

FRANCE

The French Directorate of Air Navigation Services (DSNA) is currently deploying ADS-B for air-ground surveillance for Réunion Island (in the Indian Ocean) and expects to commence deployment in New Caledonia.

Q: Are there any global ADS-B coordination activities?

A: ICAO panels are working on a range of ADS-B related activities including:

- Further enhancement of published ADS-B technical standards for Mode S 1090 MHz ES (Aeronautical Surveillance Panel, ASP)
- Further enhancement of agreed ADS-B based separation standards, including work in support of a 3 NM separation standard for ADS-B (Separation & Airspace Safety Panel, SASP)
- Production of implementation guidance and deployment plans (the ADS-B Task Force of the Asia/Pacific Air Navigation Planning & Implementation Regional Group, APANIRG)
- Development of technical standards for VDL-4 and UAT (Aeronautical Communications Panel, ACP)

In Asia Pacific, the ADS-B Task Force and APANPIRG have been particularly active and have been inclusive of industry. APANPIRG resolved that ADS-B applications should come on line in Asia Pacific commencing 2006.

Australia is leading the transition to ADS-B for surveillance because Australia's surveillance needs are different from the surveillance needs of the rest of the world. The risks of this leadership are mitigated to an extent by the use of proven ADS-B technology.

6 ADS-B IN

Q: Is CASA planning to make ADS-B IN mandatory?

A: There are no plans for requirements for ADS-B receivers and traffic displays, although it is expected that many aircraft owners will see benefit from fitment of this equipment.

Q: What is the timetable for CASA to produce technical standards for the fitment of ADS-B In and operational standards for its use?

A: ICAO and the EUROCAE/RTCA Requirements Focus Group (RFG) are currently considering technical and operational requirements for ADS-B receivers and traffic displays. CASA will be guided by international developments to ensure global interoperability.

Q: What is the estimated cost of fitting ADS-B IN avionics?

A: The cost of procurement and installation of ADS-B receivers and traffic displays will vary widely depending on the aircraft, the type of avionics and the certification requirements.

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Appendix C: Proposed Legislative Changes

Civil Aviation Order 20.18 Amendment Order (No. X) 2007

1 Name of instrument

This instrument is *Civil Aviation Order 20.18 Amendment Order (No.X) 2007*.

2 Commencement

This instrument commences on the day after it is registered.

3 Amendment of Civil Aviation Order 20.18

Schedule 1 amends Civil Aviation Order 20.18.

Schedule 1 Amendment

[1] After paragraph 9B.4

insert

9B.5 On and after 28 June 2012, an aircraft must carry and operate ADS-B transmitting equipment that complies with an approved equipment configuration if the aircraft is

(a) operating under the I.F.R.; or

(b) operating under the V.F.R while required to carry and operate a secondary surveillance radar transponder; or

(c) a large UAV.

9B.6 On and after 26 June 2014, an aircraft must carry and operate ADS-B transmitting equipment that complies with an approved equipment configuration if it is:

(a) operating under the I.F.R.; or

(b) operating under the V.F.R while required to carry and operate VHF radiotelephony equipment, unless it is not equipped with an engine-driven electrical system capable of continuously powering the equipment; or

(c) a large UAV; or

(d) a medium unmanned free balloon; or

(e) a heavy unmanned free balloon.

9B.7 ADS-B transmitting equipment carried by an aircraft to which paragraph 9B. 5 or 9B.6 applies, must operate continuously unless the pilot in command is otherwise directed or approved by air traffic control.

Civil Aviation Order 82.1 Amendment Order (No. X) 2007

1 Name of instrument

This instrument is *Civil Aviation Order 82.1 Amendment Order (No.X) 2007*.

2 Commencement

This instrument commences on the day after it is registered.

3 Amendment of Civil Aviation Order 82.1

Schedule 1 amends Civil Aviation Order 82.1.

Schedule 1 Amendment

[1] After paragraph 5.7

delete paragraph 5.8 and insert

5.8 An operator must ensure that an aircraft engaged in charter operations or aerial work operations carries and operates automatic dependent surveillance – broadcast equipment in accordance with subsection 9B of Civil Aviation Order 20.18.

Civil Aviation Order 82.3 Amendment Order (No. X) 2007

1 Name of instrument

This instrument is *Civil Aviation Order 82.3 Amendment Order (No.X) 2007*.

2 Commencement

This instrument commences on the day after it is registered.

3 Amendment of Civil Aviation Order 82.3

Schedule 1 amends Civil Aviation Order 82.3.

Schedule 1 Amendment

[1] After paragraph 10.7

delete paragraph 10.8 and insert

10.8 An operator must ensure that an aircraft engaged in regular public transport operations carries and operates automatic dependent surveillance – broadcast equipment in accordance with subsection 9B of Civil Aviation Order 20.18.

Civil Aviation Order 82.5 Amendment Order (No. X) 2007

1 Name of instrument

This instrument is *Civil Aviation Order 82.5 Amendment Order (No.X) 2007*.

2 Commencement

This instrument commences on the day after it is registered.

3 Amendment of Civil Aviation Order 82.5

Schedule 1 amends Civil Aviation Order 82.5.

Schedule 1 Amendment

[1] After paragraph 10.7

delete paragraph 10.8 and insert

10.8 An operator must ensure that an aircraft engaged in regular public transport operations carries and operates automatic dependent surveillance – broadcast equipment in accordance with subsection 9B of Civil Aviation Order 20.18.