Regulation Impact Statement

Aircraft avionics equipage mandates for satellite-based IFR navigation, Mode S/ADS-B transponders and forward fitment of TCAS II version 7.1

Proposed amendment to Civil Aviation Order (CAO) 20.18 and Regulation 262AA-AJ of the Civil Aviation Regulations 1988 (CAR 1988)

Summary

The 2009 Aviation White Paper set out a plan for upgraded air navigation and communication systems (Infrastructure 2009). This regulation impact statement considers the White Paper plan, including a requirement for most aircraft carrying fare paying passengers to have satellite navigation equipment, the latest radar equipment, automated surveillance broadcast systems and traffic collision avoidance equipment.

Navigation, surveillance and communication systems are important for avoiding aircraft accidents including mid-air collisions, controlled flight into terrain and collisions between aircraft and ground based vehicles within aerodromes. In addition, the navigation, surveillance and communication systems through the management of air traffic impact on the efficiency of aviation businesses with the length of flights, amount of fuel used and the congestion at aerodromes affected.

The proposed navigation and communication equipment regulations are aimed at improving aviation safety and efficiency and an important reason for these equipment standards to be regulated is because the safety and efficiency benefits only exist, or are maximised when all the affected aircraft are fitted with the equipment.

Overall the total discounted cost is likely to be $81.7m (2012 value), with most of this cost incurred by the requirements for satellite navigation and automated surveillance broadcast systems to be fitted to most aircraft carrying fare paying passengers.

The efficiency benefits include reduced expenditure on ground-based navigation aid equipment by Airservices Australia and improved air traffic movements by allowing aircraft to fly closer together, having greater route flexibility and more direct routes for efficiency. The preferred options are estimated to have a total benefit of at least $129.4m (2012 value) and an expected net benefit of $47.7m (2012 value).

The safety benefits include a reduced accident risk between aircraft, between aircraft and terrain and between aircraft and ground based vehicles at aerodromes resulting from greatly improved surveillance capacity over the whole of the continent.

The proposed changes have been through a comprehensive consultation program that has refined the proposed requirements. The elements of the first CASA plan that was developed in response to the White Paper that were not supported by the aviation industry are excluded from this current proposal resulting in the current proposal being fully supported by the affected elements of the aviation industry, that is the commercial passenger transport businesses, as well as the private Instrument Flight Rules sector of General Aviation (represented by the Aircraft Owners and Pilots Association).

Background

Australia is supporting the wider application and use of modern aviation navigation and surveillance technology in its future air traffic management system, including satellite based surveillance technologies such as Automatic Dependent Surveillance-Broadcast (ADS-B) and satellite navigation technology such as the Global Navigation Satellite System (GNSS) [Box 1].

Box 1: Aviation navigation and communication

Automatic Dependent Surveillance-Broadcast (ADS-B) is an advanced surveillance technology that enables equipped aircraft to continually broadcast their identification, current position, altitude, and velocity through an on-board transmitter that can be received by ADS-B ground stations or other ADS-B equipped aircraft. Aircraft equipped with ADS–B OUT equipment provide air traffic controllers with real-time position information that is more accurate than the information available with current radar-based systems. With more accurate information air traffic control will be able to position and separate aircraft with improved precision and timing. ADS-B IN equipped aircraft are capable of receiving transmissions from other ADS-B equipped aircraft. Airservices Australia has installed more than 30 ADS-B ground stations across the continent and in the territorial islands to receive the aircraft transmitted information on air traffic controllers' screens.

Global Navigation Satellite System (GNSS) is a satellite navigation system for aircraft, akin to GPS for automobiles, with the modern GNSS incorporating glass LCD displays with moving colour base-maps that are generally more pilot-friendly and accurate than navigation by reference to ground-based navigation aids. GNSS derived position accuracy remains precise and constant everywhere, unlike the accuracy of navigation by ground based navigation aids which decreases significantly with increasing distance from the aid.

Primary radar surveillance is a system based on ground equipment sending radio waves out that 'bounce' off aircraft with the equipment calibrated to detect aircraft position and track from the returning radio waves. More advanced radar systems termed Secondary Surveillance Radar (SSR) operate with the radio waves being sent between ground-based equipment and aircraft transponders, acting as datalinks. In isolation primary radar cannot identify a particular aircraft.

Mode S (Select) is an advanced SSR transponder in aircraft used to provide datalink communications with aircraft traffic control and other aircraft and represents the most advanced radar system. It is also the necessary datalink for aircraft collision avoidance systems that provide pilots with air traffic alerts and manoeuvres to avoid the collision by use of synthesised voice advisories in the cockpit.

Traffic Collision Avoidance System (TCAS) is equipment fitted to an aircraft that warns a pilot if the aircraft is at risk of a collision with another aircraft and the modern systems provide the resolution advisory necessary for the pilots to avoid a collision.

The navigation requirements for aircraft differ according to the rules that apply to the flight. Flights can be conducted under visual flight rules (VFR) when the pilot can rely on visual references, however, when flight with visual reference is not possible such as during bad weather or in the upper airspace (above 20 000 feet), flights can occur only under Instrument Flight Rules (IFR). IFR flight requires the pilot to rely on the aircraft's instruments for flight navigation. In general, all the major passenger carrying operations within Australia require IFR equipped aircraft and suitably trained pilots. IFR aircraft require navigation information from either ground based navigation aids or from satellites.

Australia is increasingly adopting modern technologies and procedures to ensure that the safety of its air traffic management system is enhanced. However, as is the case in other leading aviation countries, Australia will also maintain a robust ground-based surveillance capability, including radar, to protect against vulnerabilities from over-reliance on one system, such as satellite navigation.

Space based Global Navigation Satellite System (GNSS) navigation allows an aircraft to determine its position at any time and navigate along an arbitrary but pre-planned path. The precision of the continuous position and tracking guidance provided by GNSS area navigation increases safety and efficiency. The use of GNSS has also allowed the introduction of long range wind optimised flight paths and direct tracking which reduces fuel usage with environmental and financial benefits. Optimised departures, arrival and approach paths minimise noise and allow some flexibility in the placement and spread of residual noise. Use of GNSS is the primary navigation system for current and the next generation aircraft enabling them to fly more accurate flight paths (CASA 2010).

In response to growing air traffic movements at the major aerodromes, Airservices Australia, the Australian air traffic management provider, is also installing Advanced Surface Movement Guidance and Control Systems (A-SMGCS) at Sydney, Melbourne, Brisbane and Perth aerodromes. A-SMGCS is a multi-sensor air traffic surveillance system that enables aircraft and vehicles on the aerodrome runways and taxiways to be accurately tracked in all visibility conditions by Air Traffic Control. It is an important system for reducing the risk of a collision between aircraft and between aircraft and ground based vehicles. The technology relies primarily on aircraft Mode S transponder and ADS-B transmissions, however it can use less accurate primary radar information if the Mode S or ADS-B is unserviceable or not operational. Techniques such as A-SMGCS have been successfully used for aerodrome surface surveillance to mitigate the risk of runway incursions, particularly in Europe.

Problem

The current technology of the Air Traffic Management (ATM) system used for navigation and surveillance is based on out-dated radar and ground based navigation aids that require replacement and/or upgrading to be relied on in the absence of satellite systems. Airservices Australia estimates the cost to be $120m to replace and to continue to maintain the ground based navigation aids that would not need to be replaced and maintained if this proposal were implemented.

In addition to the cost of replacing equipment, the existing and replacement Mode S radar system does not cover all Australian airspace; large sections over the middle, north and west of Australia and other areas including the mining areas north of Perth lack radar coverage. The lack of radar coverage creates problems in terms of the efficiency of air traffic management which presently involves wide enroute separation distances of 50 nautical miles longitudinally between aircraft to ensure safe aircraft operations. This reduces to 5 nautical miles if radar or ADS-B surveillance is available to air traffic control.

The lack of radar coverage removes the ability of air traffic control to accurately observe the aircraft in these areas with air traffic control relying on routine position reports from pilots to identify the location of aircraft. The lack of radar coverage also reduces efficiency by requiring aircraft routes to be procedurally based with pre-planned paths that only permit limited flexibility. The lack of coverage and the low accuracy also requires increased aircraft separation that can result in aircraft being held by ATM to fly at altitudes and on routes that do not maximise fuel efficiency.

Whilst satellite based navigation and surveillance can improve aircraft safety and efficiency, these systems require all the affected aircraft to have the necessary equipment installed to provide for inter-operation with the air traffic management system to obtain the safety and efficiency benefits. An element of this network externality problem also exists with the collision avoidance systems fitted to aircraft. In order for the collision avoidance systems of two aircraft to operate it requires the collision avoidance and transponder systems to be in both aircraft in order to provide full protection.

With increasing air traffic movements at Australia's major aerodromes there is a risk of a collision between aircraft and ground based vehicles, such as a tow tugs, fire-fighting vehicles, aerodrome inspection vehicles and aerodrome technician vehicles that operate on the manoeuvring areas.

Whilst there have been no runway incursion accidents in Australia over the last 2.5 years, there have been approximately 1000 safety incidents, with 32 reported as a major incident in which separation on runway/manoeuvring area decreased and there was significant potential for collision, which may have resulted in a time-critical corrective/evasive response to avoid a collision. There was one very serious incident in which a collision was narrowly avoided (AsA 2012). It is likely that this risk will increase in coming years with increased aircraft movements. Over the past 10 years at Australia's major aerodromes (Sydney, Brisbane, Melbourne and Perth), regular public transport aircraft movements have increased 21% (BITRE 2012).

Objective

The objective set out in the Aviation White Paper (Infrastructure 2009) seeks to create a safer and more efficient aviation system. The options considered in relation to communication, navigation and surveillance systems aim to improve the air traffic control and management systems to improve safety and efficiency.

Options

Navigation

Status Quo

Under the status quo Australia would continue to rely on ground based navigation equipment for the navigation of instrument flight rules equipped aircraft. Retention of the existing ground based system as presently provided will require Airservices Australia to invest in replacement and upgraded equipment in order to meet Australia's requirement for navigation of instrument flight rules aircraft.

There are approximately 415 terrestrial navigation aids located across Australia of which approximately 200 (mostly non-directional beacons and VHF Omni Range equipment installations) are mostly at end-of-life, do not have spare parts support by manufacturers and are difficult and expensive to maintain. Airservices Australia has estimated that it would cost approximately $120m to replace or upgrade the 200 navigation aids to support the current level of navigation services required for Instrument Flights Rules aircraft. The progressive rollout of the replacement navigation aids would need to be carried out in the next 2-3 years as the existing equipment is old and cannot be maintained beyond 2016.

Global Navigation Satellite System option

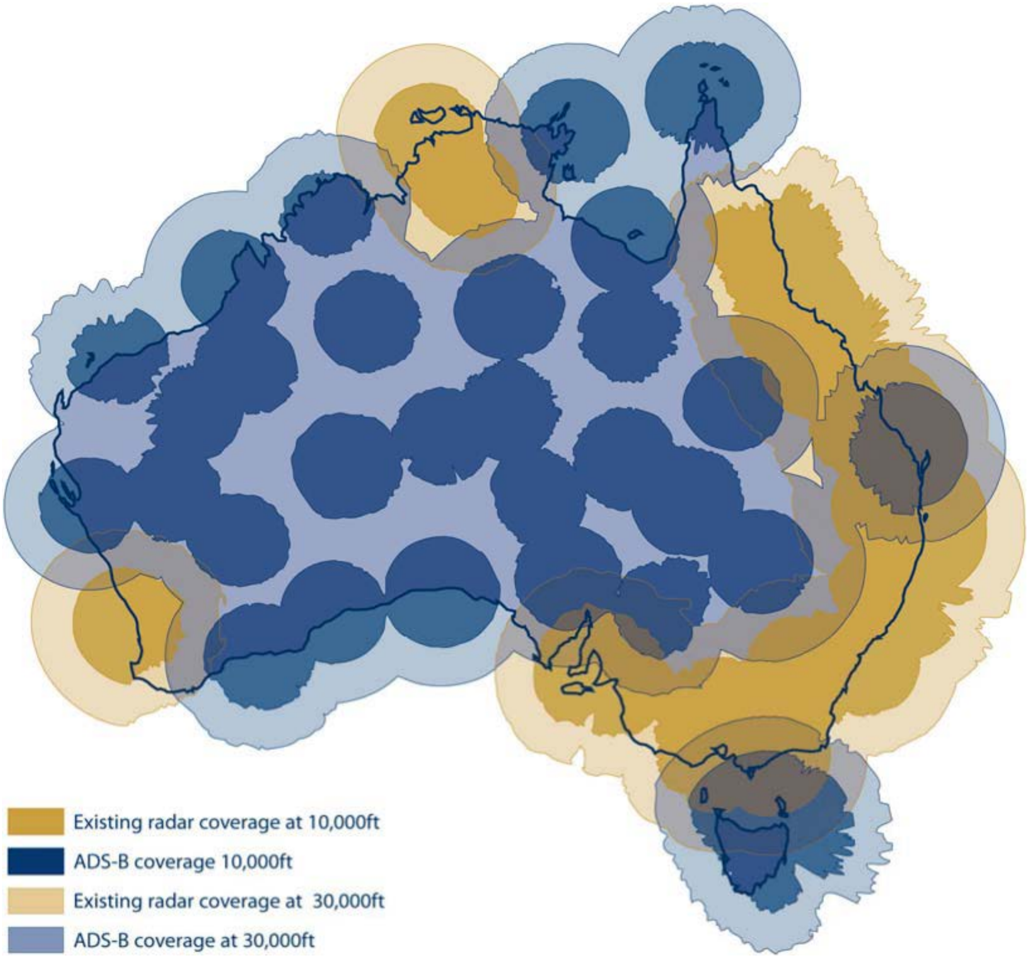
An alternative navigation system to ground based navigation aids is the satellite based Global Navigation Satellite System (GNSS) that requires aircraft to be fitted with GNSS receiver equipment. In response to the Aviation White Paper CASA proposed that all Instrument Flight Rule (IFR) aircraft be fitted with GNSS. Requiring GNSS equipment fitment to all new IFR aircraft and existing IFR aircraft will assist in meeting the White Paper objective of moving to a satellite based system for air traffic management. It is important to note that most new IFR aircraft are already fitted with GNSS.

Air Traffic Management/ Surveillance

Status Quo

Radar surveillance and communication forms the basis of Australia's air traffic control system and this would continue under the status quo option. For air traffic control the radar system provides coverage over the majority of the populated areas but does not cover areas over the middle of Australia or north of Perth (Figure 1).

Figure 1: Radar and ADS-B Coverage



For the large areas outside radar coverage procedural air traffic control applies with a 50 nautical mile procedural separation standard. The 50 mile separation standard limits traffic in the airspace in WA to the north of Perth. As traffic levels have dramatically increased with the mining activity, this capacity limitation can result in aircraft being unable to enter or depart the Perth area controlled airspace at the time of request. Complexity in managing traffic when weather conditions deteriorate can also lead to in-flight diversions or offset tracking. Airservices Australia has identified the following air traffic management issues under the status quo:

- the lack of safety nets & situational awareness without surveillance;
- delays to/from Perth;
- sequencing issues; and
- inability to issue timely clearances, which increases conflict risk to aircraft awaiting clearance.

In addition to radar, Australia has Automatic Dependent Surveillance Broadcast (ADS-B) that provides air traffic control with ‘radar-like’ surveillance without the cost or the technical limitations of radar. Enroute surveillance using ADS-B was introduced by Airservices

Australia commencing in 2006. In December 2009, Airservices Australia commissioned its Upper Airspace Program (UAP) providing ADS-B coverage across the continent at and above 29 000ft in areas not covered by radar and also into very significant areas of oceanic airspace. A network of 29 duplicated ADS-B ground stations on the mainland, 14 ground stations in Tasmania and one on Lord Howe Island provide continuous surveillance coverage above 29 000ft. A further 6 ground stations are planned for airspace in Western Australia in the short term. The ADS-B stations provide cooperative surveillance, that is they can only detect signals from ADS-B OUT equipped aircraft.

ADS-B provides the opportunity for significantly improved efficiency and safety wherever it is deployed for electronic surveillance by air traffic control. Air traffic control will be able to provide some efficiency improving systems for ADS-B equipped aircraft, such as reduced separation distances, however this is limited to when it is known that all affected aircraft in a particular airspace are equipped with ADS-B.

ADS-B option

With the current expansion of the ADS-B ground station network by Airservices Australia there is now complete coverage for airspace above 30 000ft and significant coverage at 10 000ft (figure 1). However, for Air Traffic Control to utilise ADS-B for Air Traffic Management and Surveillance requires the aircraft operating in this airspace to be fitted with ADS-B equipment.

To utilise the ADS-B in those airspaces one option is:

- Mandate ADS-B OUT equipment for new Instrument Flight Rules aircraft from February 2014 and from 2017 for existing aircraft operating under Instrument Flight Rules; and
- Mandate ADS-B OUT equipment for any Instrument Flight Rules aircraft operating in controlled airspace within 500NM north to east of Perth aerodrome from February 2016.

For the ADS-B equipment to operate effectively also requires the aircraft to be fitted with GNSS. The ADS-B equipment consists of a Mode S transponder with ADS-B OUT capability incorporated and a connection to a compatible GNSS receiver to input the aircraft position source data (latitude and longitude of aircraft position, position accuracy and integrity parameters).

Collision avoidance

Status Quo

To address the risk of a mid-air collision between large aircraft, new aircraft that are turbine powered aircraft are required to be fitted with a Traffic Collision Avoidance System (TCAS) and the current industry practice is to fit TCAS II Version 7.1. This system alerts pilots to an imminent collision and also provides the pilots of both aircraft with recommended coordinated actions to avoid the collision.

Whilst there is no regulatory mandate to fit TCAS II Version 7.1 it is likely that new aircraft will continue to be fitted with this system.

To address the risk of collisions between aircraft and ground based vehicles at aerodromes, Advanced Surface Movement Guidance and Control Systems (A-SMGCS) will operate at the four major aerodromes (Sydney, Brisbane, Melbourne and Perth). However, up to 10% of the aircraft using the aerodromes will not be fitted with Mode S transponders which will compromise the effectiveness of the system.

Traffic Collision Avoidance System option

One option is to mandate the fitment of TCAS II Version 7.1. This would only apply to new aircraft manufactured from 2014 required to fit a Traffic Collision Avoidance System. It would not affect existing aircraft.

Mode S option

To reduce the risk of a collision between aircraft and ground based vehicles within aerodromes one option is to mandate the fitment of Mode S transponders;

- For new aircraft operating in controlled airspace[1]; and
- For all aircraft operating at Melbourne, Sydney, Brisbane and Perth aerodromes. This will ensure the effective operation of the Advanced Surface Movement Guidance and Control Systems installed at Australia's four major aerodromes.

Separate or simultaneous implementation of options

Whilst the options under consideration can be implemented separately, there are advantages to implementing some simultaneously due to the degree of connection between the options, in particular for the ADS-B option. The main synergies between the options are:

- The ADS-B equipment does not function effectively without GNSS equipment
- If the GNSS and ADS-B options are implemented this would achieve the Mode S option at no additional cost for those aircraft.
- If an aircraft is fitted with TCAS version 7.1 then this will satisfy the Mode S requirement as the TCAS version 7.1 requires Mode S equipment to operate.

Impact

Global Navigation Satellite System equipment for instrument flight rules aircraft

Businesses and individuals impacted

This option will impact primarily on the owner/operators of all instrument flight rule aircraft that will be required to fit a Global Navigation Satellite System. The pilots of instrument

[1] Classes A, B, C and E and above 10000 feet in Class G

flight rules aircraft and related air traffic controllers will also be impacted by the improved level of service provided by satellite navigation and although both will be required to be trained to operate the equipment, the existing training already covers the GNSS requirements. Airservices Australia will also be impacted because if the aircraft are fitted with GNSS and rely on satellite navigation, Airservices Australia will not have to maintain the same level of ground based navigation aids.

Costs

CASA has consulted affected aircraft operators along with the relevant key industry organisations and associations and analysed administrative information held on the numbers of aircraft registered in Australia to estimate the number of aircraft affected by the proposed requirements to fit GNSS and ADS-B equipment. A significant number of instrument flight rule aircraft affected by this option are already fitted with GNSS equipment. CASA estimates that approximately 58% of instrument flight rule aircraft are fitted with GNSS equipment.

There are approximately 4634 IFR capable aircraft in Australia with 922 being large aircraft with a maximum take-off weight (MTOW) above 5700kg and 3712 being smaller aircraft with a MTOW below 5700kg (see Table 1 below). Of the IFR aircraft it is conservatively estimated that 90% of the large aircraft and 50% of the smaller aircraft already have GNSS navigation equipment installed.

The cost of purchase and installation of a modern GNSS navigator unit for small aircraft ranges from $10,000 to $20,000 depending on the features and extent of automation in the equipment selected. It is typical for the large aircraft to fit more advanced systems that cost approximately $100 000. It is of interest to compare this typical cost to the value of the aircraft affected. The minimum cost of an aircraft capable of operating under instrument flight rules would be approximately $200 000, however most of the aircraft affected by this option would have a value in excess of $1m. Airline aircraft may cost in excess of $100m.

The impact analysis assumes that all the affected aircraft will fit the equipment to comply with the proposed regulations. It is possible that some aircraft operators/owners may choose not to fit the equipment to avoid the cost, however, this will restrict the operation of the aircraft and no operator/owner reported their intention to take this approach during the consultation period.

In terms of ongoing costs, the equipment will be required to be inspected at periodic maintenance services with routine operational checks for transponders once every 2 years. Affected aircraft operators contacted by CASA did not foresee any significant ongoing maintenance costs for the GNSS equipment. The expectation is that the equipment will last for the typical working life of the aircraft.

On the estimate that 92 large aircraft would need to fit GNSS equipment at up to $100,000 per installation, the cost for the large aircraft category would be $9.2m (Table 1). For small IFR aeroplanes it is estimated that there are 1133 single engine and 586 multi-engine aeroplanes that would be required to fit GNSS receivers, based on a $20,000 cost per installation, the cost would be $22.7m for single engine and $11.7m for multi-engine aeroplanes (Table 1). The total cost for all IFR aircraft is estimated to be $46.3m (Table 1).

Under this option, Australia will continue to maintain ground based navigation aids as a back-up system with Airservices Australia continuing to maintain approximately 215 ground based navigation aids. Airservices Australia has estimated the ongoing maintenance cost for these 215 navigation aids at $2m per year.

Table 1: Instrument Flight Rules Aircraft[1]

	Aircraft	Single engine aeroplane	Multi-engine aeroplane	Helicopter	Amateur Built	Total
Weight (MTOW)	*> 5,700 kg*	*< 5,700 kg*	*< 5,700 kg*	*< 5,700 kg*	*All*	
Number registered	922	7554	1466	1761	1324	13027
% of IFR capable aircraft	100	30	80	8	10	
Number of IFR aircraft	922	2266	1173	141	132	4634
% of IFR aircraft without GNSS	10	50	50	50	50	
Number without GNSS	92	1133	586	70	66	1948
Cost to fit GNSS per aircraft	$100000	$20000	$20000	$20000	$20000	
Base Cost	$9.2m	$22.7m	$11.7m	$1.4m	$1.3m	$46.3m
Cost with 5% more aircraft	$9.7m	$23.8m	$12.3m	$1.5m	$1.4m	$48.7m
Cost with 15% more aircraft	$10.6m	$26.1m	$13.5m	$1.6m	$1.5m	$53.3m

1 Source: CASA administrative information (excludes gliders and balloons that are not affected by this option)

Benefits

A major benefit of the Global Navigation Satellite System is as an enabling technology, which when combined with ADS-B will permit aircraft to take advantage of:

- Flexi-route; a system by which the aircraft route can be optimised according to the latest weather and the location of other aircraft.
- Reduced separation distances; permitting aircraft to fly closer together, which is an important way of improving fuel efficiency, reducing flight time and reducing congestion at busy aerodromes whilst still being maintaining safety.
- More efficient approaches to aerodromes with air traffic control being able to manage the approaches of multiple aircraft so as to reduce the probability of aircraft being put into inefficient holding patterns whilst the aircraft waits for a landing clearance.

An important benefit of mandating Global Navigation Satellite Systems and the February 2016 compliance date is that it removes the need for Airservices Australia to replace approximately 200 ground-based radio communications equipment that is rapidly approaching or is already at end-of-life. Airservices Australia estimates the capital replacement cost at between $120m, and depending on the assumptions made, could be as high as $150m, however decommissioning costs needed to be considered.

Airservices Australia will be subject to an additional cost with the decommissioning of the 200 navigation aids that will not be replaced under this option. The decommissioning cost includes: updating charts and Aeronautical Information Package (AIP) publications and air traffic control procedures; complete safety work; undertake consultation with users and decommission and make good 170 sites. Airservices Australia estimates this cost at $30m, which when subtracted from replacement cost results in an estimated capital cost saving of between $90m and $120m.

In addition to the avoided replacement costs, Airservices Australia will not have to maintain the 200 navigation aids that would have been required under the status quo. Airservices Australia estimates that the maintenance cost for these navigation aids would be approximately $2m per annum, or approximately $20m over 10 years.

The savings to Airservices Australia from avoiding the replacement and annual maintenance of the navigation aids will be passed on to the aviation industry. If this option was not to be implemented Airservices Australia would pass on the replacement and annual maintenance costs to the aviation industry through higher terminal and en-route charges, however, if this option was implemented these increased charges will be avoided.

Mode S radar transponders

Businesses and individuals impacted

Similar to the GNSS satellite navigation option the Mode S option will impact on the owner/operators of instrument flight rule aircraft who are required to fit Mode S transponders. Pilots and passengers will benefit from the improved collision avoidance systems that require Mode S transponders to function. As the equipment does not require pilot input to operate there is no significant pilot training required. Airservices Australia already has systems in place to deal with the existing Mode S fitted aircraft and therefore will not be required to alter their procedures or staff training.

Costs

New aircraft and replacement transponders

The requirement to fit Mode S to new aircraft or when replacing a technically outdated transponder system is likely to occur without regulatory mandate because Mode S transponders are the industry standard for new aircraft and generally for replacements because of their superior user benefits. However, because of the need to maximise the number of aircraft with Mode S for the accident avoidance systems to work effectively, CASA is proposing to mandate the fitment to new aircraft and for transponder replacements in existing aircraft.

For small aircraft replacements the additional cost of a Mode S transponder is minimal with the additional cost being $2000 to $3000. The cost of a Mode S transponder suitable for a small IFR aircraft is within the range of $5,000 to $6,000 whereas the alternative Mode A/C transponder of similar application is within the range of $3,000 to $4,000.

Four major aerodromes

CASA is proposing to mandate Mode S fitment to aircraft operating at Melbourne, Sydney, Brisbane and Perth aerodromes from February 2016. The cost impact of the option will be minor in overall terms with a high proportion of aircraft operating at those aerodromes already fitted with Mode S transponders. A 2007 analysis by Airservices Australia found that the mode S fitment rate at 3 of the 4 aerodromes affected was at least 90% (Table 2). The high proportion of Mode S fitment can partly be explained by the fact that the traffic collision avoidance system presently installed on most air transport category aircraft operating at those aerodromes requires a Mode S transponder for its operation.

Table 2: Mode S fitment by aerodrome

	Proportion of aircraft with Mode S	Aircraft without Mode S
Sydney	92%	104
Brisbane	90%	124
Melbourne	94%	29

1: Source: AsA (2007)

Based on the assumption that 90 aircraft using Perth aerodrome operate without a Mode S transponder, a total of approximately 350 aircraft that use the four aerodromes will need to replace their Mode A/C transponders with a Mode S transponder. The cost of fitting Mode S transponders is estimated at $40,000 per aircraft, with 350 aircraft affected the total cost would be $14m.

Benefits

Mode S transponders have many technical advantages: improved resolution; less garbling; less erroneous data; less clutter and provide an increased number of aircraft parameters on air traffic control screens. The Mode S transponders reduce the risk of human error in the air traffic control system by automating a number of processes and reducing the workload of air traffic controllers.

Mode S transponders are an important enabling technology for the Traffic Collision Avoidance Systems that reduce the risk of a mid-air collision.

An important benefit and the reason for the regulation applying to the four major aerodromes is that in combination with other equipment they reduce the risk of a runway incursion accident, that is a collision between an aircraft and a ground based vehicle at an aerodrome such as a tow tug, fire-fighting vehicle, aerodrome inspection vehicle or aerodrome technician vehicle that operate on the manoeuvring areas.

Automatic Dependent Surveillance-Broadcast (ADS-B)

Businesses and individuals impacted

Similar to both the satellite navigation and Mode S options, the ADS-B option will impact on the owners of IFR aircraft that are required to fit ADS-B. The operators of aircraft and passengers will benefit from the improved efficiency of aircraft traffic management in terms of reduced flight time, less risk of a flight delay/cancellation and fuel burn. As the equipment does not require pilot input to operate there is no significant pilot training required. Airservices Australia already has systems in place to deal with the existing ADS-B fitted aircraft and therefore will not be required to alter their procedures or staff training.

Fitment in an aircraft of Global Navigation Satellite System equipment and Mode S transponder equipment (with ADS-B capability) will also result in compliance with the requirements for ADS-B at no significant additional cost. This is because Mode S transponders can be purchased with ADS-B OUT capability without significant additional cost.

Under the ADS-B requirements in this option, it is estimated that approximately 300 large aircraft and 3800 small aircraft will be required to fit an ADS-B transponder.[2] The cost is estimated at approximately $40,000 per installation for large aircraft and $10,000 including installation for small aircraft; a total cost of about $50m (Table 3).

Table 3: ADS-B out fitment cost estimates

Aircraft type	Proportion of aircraft types affected	Number of aircraft affected[1]	Cost per aircraft	Cost	Cost with 5% more aircraft	Cost with 15% more aircraft
Large >5700kg	0.1	300	$40,000	$12m	$13m	$14m
Small <5700kg	0.3	3800	$10,000	$38m	$40m	$44m
Total				$50m	$53m	$58m

1 Source: CASA administrative information

Benefit

A major benefit of ADS-B for Australia is that it provides complete airspace coverage allowing air traffic control to accurately view and track the locations of aircraft across Australia. This increased airspace coverage will reduce the likelihood of a mid-air collision in the areas that the current radar system does not cover. It is also more accurate than radar.

[2] 4,100 IFR capable existing aircraft will be required to fit ADS-B. However, it is estimated that about 400 large aircraft will already have ADS-B fitted by 12 December 2013 in compliance with an existing mandate for flight at/above Flight Level 290 that was promulgated by CASA in 2009. There are also 350 aircraft subject to the Mode S fitment at the four (4) major aerodromes that will comply as a result of the GNSS and Mode S requirements. The remaining IFR capable aircraft, estimated at about 300 large aircraft and about 3,800 small aircraft, will have to fit an ADS-B capable transponder.

In combination with GNSS, ADS-B improves the efficiency of aircraft traffic movements with reduced separation standards, user preferred routes, and less holding at non-preferred altitudes. Situational awareness and thus safety is also enhanced when air traffic control has electronic surveillance available for aircraft separation. Search and Rescue in the event of forced landing or accident is also improved by air traffic control having an accurate knowledge of the last known position.

The businesses operating with ADS-B reported that the benefits were permitting:

- Flexi-route; a system by which the aircraft route can be optimised according to the latest weather and other aircraft location
- Reduced separation distances; permitting aircraft to fly closer together, which is an important way of improving fuel efficiency and reducing congestion at busy aerodromes
- More efficient approaches to aerodromes, with air traffic control being able to manage the approaches of multiple aircraft so as to reduce the probability of aircraft being put in an inefficient a holding pattern whilst the aircraft waits for a landing clearance.

Whilst the businesses reported that the exact financial benefit will vary according to specific flight and weather conditions, there is some indicative quantitative evidence on the size of this efficiency benefit:

- For Australia one airline estimates the improvement in fuel efficiency to be within the range of 5% to 10%
- For Australia one airline estimates the improvement in time efficiency to be between 6 and 15 minutes for flights across Australia, which represents an approximate time reduction of between 3% and 9%.
- Worldwide the International Air Transport Association (representing airlines) estimates that the air traffic management changes could reduce fuel use by up to 12%
- Within Canada expanded ADS-B coverage is estimated to save airlines approximately $91m in fuel costs between 2012 and 2020.

CASA has estimated the benefits within a range of feasible values for efficiency improvement based on the estimate of one Australian airline and to be conservative has selected the 5% rate to estimate the expected benefits. In part the conservatism is based on the difficultly of aircraft operators separately identifying the ADS-B benefits from this proposal and the ADS-B in the upper airspace (already mandated for introduction in December 2013) and advancements in performance based navigation. The ITAA estimate of 12% fuel efficiency is based heavily on the operations in Europe and the US with more air traffic congestion than Australia and therefore is likely to be an overestimate for Australian conditions.

To be conservative CASA has estimated the benefit based on the proportion of aircraft required to fit the equipment by this option, however, one airline argued that the benefits would apply to all IFR aircraft (including those already fitted with ADS-B) as Airservices

Australia can only fully apply the efficiency procedures once all aircraft operating above 30 000ft are fitted with ADS-B.

Estimating the fuel efficiency benefit

The total fuel use for the affected aircraft is not known and requires estimation. The annual hours flown for Australian aircraft operations is published, however, not annual fuel use. The fuel use for aircraft operations affected by this option could be estimated using two methods:

- One approach is to estimate total fuel use by deriving the per hour fuel use for the affected aircraft and multiplying this by the published hours flown for the relevant aircraft.
- An alternative approach for the airline category is to utilise the published annual fuel costs for Australia's major airlines that are known to have an entire fleet of aircraft that would be affected by this option.

Fuel use per kilometre

Whilst Australian fuel use per hour for aircraft types is unavailable, the US FAA has undertaken an analysis to determine the average for particular aircraft categories. The FAA estimates that the average fuel cost for airline aircraft is $722 per hour and $114 for general aviation aircraft (FAA 2004). These 2004 estimates were based on a fuel price of US $2.51 per gallon however, the fuel price in 2012 is approximately US $3.28 (ITAA 2012). As a result the fuel use per hour estimates used for this analysis have being adjusted to reflect the 2012 fuel price and converted to Australian dollars based on exchange rate parity (Table 4).

The affected aircraft operators have reported that utilising the American per hour fuel use would be a reasonable assumption given that there is little variation between fuel use for the same aircraft operating in different countries, although it could underestimate fuel use as the American average is weighted by smaller aircraft types that are not as prevalent in Australia.

A 10% improvement in annual fuel efficiency for the affected aircraft is estimated to be approximately $20.9m, or $10.4m if the improvement was 5% (Table 4).

Table 4: Annualised ADS-B benefit

	hours flown per year	Proportion of aircraft affected	fuel cost per hour	total fuel cost $m per year	value of 2.5% fuel efficiency	value of 5% fuel efficiency	value of 10% fuel efficiency
Airline	1338100	0.1	943.49	126.25	$3.16m	$6.31m	$12.62m
General Aviation	1847700	0.3	148.97	82.58	$2.06m	$4.13m	$8.26m
Total					$5.22m	$10.44m	$20.88m

1: BITRE (2010) Table 1 page 13. 2: Table 3. 3: Fuel use per hour determined from Table 4.4 and 4.10 from FAA (2004), updated with fuel prices from ITAA (2012).

Annual fuel costs for airlines

During the 2010-2011 financial year Australia's major airlines[3] purchased $4762.8m of aviation fuel (Table 5). If there was to be a 5% fuel improvement affecting 10% of their fleet this would equate to an annual saving of $23.8m.

Table 5: Airline fuel cost (2010/2011)

Airline	*Annual fuel cost; year 2010/2011*
Qantas Group	$3627m
Virgin	$906m
Tiger	$229.8m
Total	$4762.8

Source: Qantas (2011), Virgin (2011), Tiger (2011)

Traffic Collision Avoidance System (TCAS) II Version 7.1

The Traffic Collision Avoidance System (TCAS) II Version 7.1 is the current industry standard for fitment to new turbine powered aeroplanes exceeding 5700kg maximum certified take-off weight or having a maximum authorised passenger capacity exceeding 19.

Businesses and individuals impacted

The TCAS II Version 7.1 fitment mandate as proposed applies only to turbine powered aeroplanes used in public transport services that are first registered in Australia on/after 1 January 2014. The mandate does not affect existing aircraft.

The existing training of pilots and air traffic controllers already covers the operation of the Traffic Collision Avoidance System.

Cost and Benefits

There will be minimal cost impact as existing aircraft are not affected and new aircraft subject to the option already fit the equipment. The only cost is the reduced flexibility to enable manufacturers to fit lower cost equipment as standard, although this is considered highly unlikely.

The major benefit of the option is ensuring that new aircraft are fitted with a version of TCAS that will be compatible with the accident avoidance systems operating in Australia and in other countries.

Total net benefit and sensitivity analysis

Given the differences in the timing of the expected costs and benefits it is necessary to discount future costs and benefits to a common value. The Office of Best Practice Regulation recommends using a 7% discount rate (OBPR 2008).

[3] BITRE (2011) estimates that these airlines undertake 88.4% of the domestic market.

Over the time period from 2012 until 2026 the upgraded navigation and communication equipment proposal set out in the Aviation White Paper is likely to cost $81.7m with benefits estimated to be at least $129.4m expressed in 2012 values discounted with a 7% discount rate (Appendix B: Table 5). There are likely to be further benefits in terms of improved safety, reduced delays and congestion that are not quantified financially.

Sensitivity Analysis

The important parameters that affect the size of the estimated costs and benefits that are subject to uncertainty are:

- The number of aircraft required to fit GNSS and ADS-B
- The fuel efficiency improvement rate from ADS-B
- Jet fuel prices
- The number of new aircraft
- Timing of compliance

Number of aircraft required to fit GNSS and ADS-B

CASA has consulted affected aircraft operators and the Aircraft Owners and Pilots Association of Australia (AOPA) to estimate the number of aircraft affected by the proposed requirements to fit GNSS and ADS-B equipment. The estimated number of aircraft affected derived from this informal consultation is consistent with the registration information held by CASA for the affected aircraft. In addition to the informal consultation with the affected businesses and aircraft operators, CASA has published the estimates in a Notice of Proposed Rule Making for formal public consultation (CASA 2012). As a result of the process for developing the estimates, CASA is confident that the proportion of aircraft affected is accurate to within a few percentage points. However, to be conservative a sensitivity analysis was undertaken to model the impact of changes to the number of aircraft affected.

If the aircraft affected by the GNSS and ADS-B options was 5% higher, this would increase the total cost of the GNSS option by $2.4m (Table 1) and ADS-B by $3m (Table 3). If the number of aircraft was 15% higher, than the cost of the GNSS option would increase by $8m (Table 1) and the ADS-B option by $8m (Table 3). Even when the cost estimates are based on a 5% or 15% increase in the number of aircraft affected the benefits still exceed the costs.

Fuel efficiency improvement rate from ADS-B

The size of the estimated benefit for ADS-B from improved efficiency is sensitive to the fuel efficiency improvement rate, the cost of jet fuel and the fuel efficiency of new aircraft.

The expected fuel efficiency benefit from ADS-B has been estimated at a fuel efficiency improvement rate of 5% and 10% reflecting the range of estimates supplied by affected businesses or industry associations (Table 4). To be conservative CASA has estimated the expected benefits at the lowest end of the industry estimates with a 5% improvement rate. CASA has also undertaken a worst case scenario under which the improvement rate was half the value of the lowest estimate supplied by industry at 2.5% (Table 4). With the 2.5%

improvement rate the option has estimated benefits at $27.8m that would be slightly below the estimated costs of $35.6m.

Fuel price

The expected fuel efficiency saving is based on a 2012 jet fuel price, however, jet fuel has increased by approximately 5.5% each year over the last 25 years in real terms (ABS 2012). If fuel prices were to continue to increase by 5.5% each year then the estimated benefit of ADS-B would increase by 5.5% each year. The total discounted benefit for ADS-B over the analysis time period would increase from $55.9m based on a 2012 real fuel price to $91.4m if it is assumed that real fuel prices increase by 5.5% each year (Appendix B: Table 5).

Whilst it is possible that fuel prices could continue to increase in real terms, if this was to occur there could be other developments that could mitigate the effect, in particular improvements in the fuel efficiency of new aircraft of the same size, moves to larger aircraft to carry more passengers for the same fuel burn and possible movements to alternative fuel sources.

Aircraft fleet size

The impact analysis is based on Australia's current aircraft fleet size being maintained into the future, however, the estimated net benefit of the options is likely to be insensitive to increases in the Australian aircraft fleet size.

Most new aircraft are already fitted with the equipment required by the options and therefore there is unlikely to be any significant change in the cost of the options relative to the status quo from increases in the fleet size. One affected aircraft operator argued that it is possible for the expected benefits of the options to be positively correlated to fleet size as the benefits of improved aircraft traffic management are larger when there is more aircraft traffic, both in terms of improved efficiency and improved safety.

Alternative timing of costs and benefits

The expected costs and benefits are based on compliance with the options occurring at the compliance date, however, it is likely that compliance would occur during the years before the compliance date. CASA has undertaken a sensitivity analysis to model an alternative timing of compliance under which one third of owner/operators and Airservices Australia comply with the regulations in the three years prior to the compliance date, which would also bring forward the benefits of the options. Under this sensitivity analysis the options still pass a cost benefit test (Appendix B: Table 5).

Consultation

The consultation process began with the publication of the Aviation White Paper in December 2009. In October 2010, CASA published a Discussion Paper (No. 1006AS) titled 'Proposed Strategy and Regulatory Plan in support of the Australian Government's White Paper' (CASA 2010) which set out the regulatory changes required to meet the goals set out in the White Paper, including requirements for ADS-B equipment for VFR aircraft operated in general aviation, sport aviation and recreational aviation sectors.

CASA received 35 formal responses to the 2010 Discussion Paper 18 from key industry organisations, 4 from airlines and 13 from individuals. In its review of those responses, CASA observed that there was strong support for most of the options from the airline and commercial sectors of the industry but not from the visual flight rules (VFR) general aviation (GA), sport aviation and recreational aviation sectors.

The main area of concern from the VFR GA, sport aviation and recreational aviation sectors was with the options for all aircraft to be equipped with a Mode S transponder having Automatic Dependent Surveillance (ADS-B OUT) capability in all classes of airspace over the period up to year 2020. The options applying to VFR aircraft operating in general, sport and recreational aviation were removed from the proposal presented in a subsequent Notice of Proposed Rule Making and the options considered in this Regulation Impact Statement. In addition, CASA is not proposing ADS-B equipment that has 'ADS-B IN' capability that industry did not support due to the increased cost of that equipment.

In response to the support from the airlines and commercial sectors of the industry, which included a request to bring forward the compliance dates for the ADS-B and GNSS options, CASA has responded and brought forward the implementation dates.

This formal consultation process was complemented by the formation of an industry and government working group to assist in the development of the options. The working group process involved and continues to involve consultation with the Australian Strategic Air Traffic Management Group (ASTRA) the peak industry body representing businesses involved in or affected by air traffic management. ASTRA includes members from Airservices Australia, the major airlines, associations representing smaller aircraft operators such as the Aircraft Owners and Operators Association and the pilot representative association.

Overall the options are supported by industry and the full comments by industry and other individuals to these options and CASA's response to those comments will be published in a Notice of Final Rule Making.

Implementation and Review

The preferred options will be implemented by amending Civil Aviation Order 20.18 and Division 5 of Part 14 of the *Civil Aviation Regulations* 1988.

The compliance dates for the proposed equipment requirements have been established in consultation with industry to ensure that businesses can meet these timelines. Compliance will be assisted by the fact that a number of the options are industry standards already and the relatively long compliance dates for those changes affecting existing aircraft that are not currently the industry standard.

The changes will be monitored by CASA taking account of operational outcomes and any industry issues to ensure the regulations are implemented and complied with as intended. It is likely that a review of all the changes to navigation and surveillance systems will be undertaken after they are implemented to ensure that they are meeting the objectives set out in the White Paper.

Conclusion

The regulatory options considered as part of CASA's regulatory plan in response to the Aviation White Paper plan for navigation and surveillance systems have undergone extensive consultation with industry to refine the requirements and gain industry support.

The two options in relation to Mode S and Traffic Collision Avoidance System II Version 7.1 that require the fitment of equipment are likely to occur without regulatory mandate. The major reason to implement these options is to address the potential network externality problems that exist if some aircraft do not have the equipment.

The Global Navigation Satellite Systems option will avoid Airservices Australia investing in the replacement and maintenance of approximately 50% of the existing ground based navigation aid system that has limitations in terms of safety and efficiency. In addition to these savings, the satellite navigation equipment required under this option is necessary for the operation of ADS-B surveillance equipment that will result in significant efficiency benefits from improved air traffic management.

The requirement to fit Automatic Dependent Surveillance-Broadcast equipment will have a cost impact to industry. However, the equipment will result in more precise management of air traffic allowing for reduced separation distances and other fuel saving efficiencies and improved safety.

Overall the estimated cost of the upgraded navigation and communication system options is $81.7m, with the quantifiable benefits estimated at $129.4m resulting in an estimated net benefit of $47.7m (measured in 2012 values discounted using a 7% discount rate). Moreover, this benefit does not quantify the major safety benefits and the benefits from the avoidance of delay and congestion at aerodromes. The options have been through extensive consultation with a Government Aviation White Paper, two CASA Discussion Papers and a Notice of Proposed Rule Making that have refined the requirements and gained the support of affected businesses.

References

ABS (Australian Bureau of Statistics) 2012: *International Trade Price Indexes, Australia*, catalogue number 6457.0, ABS, Canberra.

AsA (2007), *Unpublished data: Use of Mode S at Sydney, Brisbane and Melbourne aerodromes*, Airservices Australia, Canberra

AsA (2012), *Unpublished data*: *Total Runway Incursion Incidents*, Airservices Australia, Canberra

BITRE (2010), *General Aviation Activity*, Bureau of Infrastructure, Transport and Regional Economics, Canberra

BITRE (2012), *Airport Traffic Data May 2012*, Bureau of Infrastructure, Transport and Regional Economics, Canberra

BITRE (2011), *Avline 2010/11*, Bureau of Infrastructure, Transport and Regional Economics, Canberra

CASA (2010), Discussion Paper: '*Proposed Strategy and Regulatory Plan in support of the Australian Government's White Paper'*, Canberra

CASA (2012) *Notice of Proposed Rule Making: Aircraft avionics equipage mandates for satellite-based IFR navigation, Mode S/ADS-B transponders and forward fitment of TCAS II version 7.1*, Canberra

FAA (2004), *Economic Values For FAA Investment And Regulatory Decisions, A Guide* U.S. Federal Aviation Administration, Washington

Infrastructure (2009), *National Aviation Policy White Paper*, Department of Infrastructure, Transport, Regional Development and Local Government, Canberra

ITAA (2012) Fuel Price Monitor

OBPR (2010), *Best Practice Regulation Handbook*, Canberra

Qantas (2011), *Annual Report 2011*, Sydney

Tiger (2011), *Annual Report 2011 (financial year ended 31 March 2011)*, Singapore

Virgin (2011), *Annual Report 2011*, Brisbane

Appendix A: Background on the Aviation White Paper

On 16 December 2009 the Australian Government released the National Aviation Policy White Paper. This was stated to represent the first ever comprehensive aviation policy statement issued by an Australian government, bringing together all strands of aviation policy into a single, forward-looking document providing planning, regulatory and investment certainty for the aviation industry out to 2020 and beyond. The White Paper sets out the Government's commitment to a continuation of Australia's excellent aviation safety record and to strengthen aviation security systems, while providing a policy framework for the development of the aviation industry at all levels—international, domestic, regional and general aviation—including through skills and productivity improvements. It sets out initiatives to ensure better planning and integrated development on and around airports and to lessen the adverse effects of aviation activity on the environment and communities. The specific section of the White Paper that deals with Air Traffic Management is Chapter 7.

In Chapter 7 of the White Paper, the initiatives and timeframes for technology implementation were set out. The following is an extract from Chapter 7:

By 2020 Australia will have moved to a national ground and satellite-based network of air traffic management providing a level of communications, navigation and surveillance coverage unprecedented in Australia's aviation history. This will be achieved by the implementation of a number of key short, medium and long-term initiatives such as investment in surveillance infrastructure and the increasing use of performance based navigation and approach with vertical (APV) guidance procedures around Australia.

The Government's primary objective in pursuing this course of action is enhanced safety through the use of better, more advanced technology and through providing services to parts of Australia that have, until now, had little to no air traffic services and facilities or surveillance coverage.

In summary, Australia, consistent with the ICAO goals, and to harmonise with developments in other leading aviation nations, has identified a number of key ATM initiatives which CASA and Airservices, in their respective regulatory and service provision roles, will seek to pursue:

Short Term (five years to 2014)

- *Current investment in national infrastructure (including ground and satellite based technology) to address safety, efficiency, capacity and environmental needs.*
- *Closer alignment with ICAO based airspace classifications, adoption of proven international airspace systems and use of sound risk management processes for airspace management and administration.*
- *Completing the reviews of Australian airspace at airports to implement the Government's key AAPS reform directions – particularly alignment with ICAO and international best practice in airspace management and enhanced regional air traffic management services.*

- *Introduction of Class D airspace arrangements at GAAP aerodromes in 2010.*
- *Introduction of more controlled airspace with, as required, enhanced ATC services and infrastructure as determined by CASA, in the enroute environment in WA, as well as at growing regional aerodromes in WA and in eastern Australia.*
- *ADS-B OUT upper airspace mandate from December 2013.*

Medium Term (2014–2019)

- *Wider regulatory requirements for mandated communication, navigation and surveillance capability (e.g. uptake of Mode S and ADS-B OUT capable transponders) and use by aircraft set by CASA.*
- *APV procedures available for 100% of instrument runways used by APV-capable aircraft.*
- *Potential adoption of satellite based augmentation systems (SBAS) to assist in making APV widely available.*

Long Term (2020–2025)

- *The wider application of satellite technology, monitoring consistency with international timetables, including the provision of required back up ground based facilities.*
- *Performance based navigation capability appropriate to the operation will be used by all instrument flight rules aircraft.*
- *Electronic surveillance of traffic by either aircraft or air navigation service providers will be assured for operations in controlled airspace generally and from the surface within specified volumes of airspace at aerodromes with traffic densities exceeding a risk-based threshold.*
- *APV guidance for all Australian instrument runways.*

These safety priorities are best introduced through synchronised implementation of aircraft and ground systems, and informed decisions on future investments.

CASA will make the final decisions on regulatory scope and timing following appropriate regulatory development processes and in close consultation with the Aviation Policy Group.

In implementing these initiatives our government agencies will have regard to:

- *the use of sound risk management processes;*
- *the potential impacts on all operations and different industry sectors, including particularly airline and airport operators in those sectors;*
- *the cost recovery and resource implications for Government agencies; and*
- *how Australia's directions align with those of ICAO and other leading aviation nations including the US and those in the immediate Asia-Pacific region.*

Appendix B:

Table 5: Benefits and Costs over time $m

Costs	**Discounted totals**[1]	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
GNSS	$35.3					$46.3										
Mode S	$10.7					$14										
ADS-B	$35.6						$50									
Total	$81.7															
Benefits																
GNSS	$73.5						$90.0	$2	$2	$2	$2	$2	$2	$2	$2	$2
ADS-B	$55.9						$10.4	$10.4	$10.4	$10.4	$10.4	$10.4	$10.4	$10.4	$10.4	$10.4
Total	$129.4															
Net benefit	$47.7m															
Sensitivity Analysis																
ADS-B (5.5% higher fuel prices)	$91.4						$13.7	$14.4	$15.2	$16.0	$16.9	$17.8	$18.8	$19.9	$20.9	$22.1
Alternative timing																
GNSS	$40.5		$15.4	$15.4	$15.4											
Mode S	$12.2		$4.7	$4.7	$4.7											
ADS-B	$43.7		$16.7	$16.7	$16.7											
Total	$96.5															
Benefits																
GNSS	$91		$30	$30	$30	$2	$2	$2	$2	$2	$2	$2	$2	$2	$2	$2
ADS-B	$63.9					$10.4	$10.4	$10.4	$10.4	$10.4	$10.4	$10.4	$10.4	$10.4	$10.4	$10.4
Total	$154.9															

1: Discounted with a 7% discount rate