Cost Benefit Analysis of ADS-B Implementation for Below FL-245

22 September 2017

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The CAA commissioned this analysis to identify and assess policy options to facilitate the transition to ADS-B for operators below FL-245. It has been conducted in accordance with our contract and engagement agreement dated 7 March 2017 including the General Terms and Conditions ("**the Engagement Agreement**").

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Acronyms and Abbreviations

ACAS	Aircraft Collision Avoidance System
ADOC	Aircraft Direct Operating Cost
ADS-B	Automatic Dependant Surveillance Broadcast
ATC	Air Traffic Control
ATS	Air Traffic Services
BCR	Benefit Cost Ratio
CAA	Civil Aviation Authority
CBA	Cost Benefit Analysis
FAA	Federal Aviation Administration
FL-245	Flight Level 245 (24,500 feet / approximately: 7,468 metres)
FSIWG	Future Surveillance Implementation Working Group
GA	General Aviation
GNSS	Global Navigation satellite System
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
MC(D)A	Multi Criteria (Decision) Analysis
NM	Nautical Mile (approximately 1.15 standard miles or 1.85km)
PBN	Performance Based Navigation
PV	Present Value
SAR	Search and Rescue
SBAS	Satellite Based Augmentation System
TS	Tracking System (for example a Satellite Based Tracking System)
VFR	Visual Flight Rules

1. Executive Summary

1.1 Purpose and Scope of Analysis

CAA has engaged EY to conduct a cost benefit analysis (CBA) on the proposal to mandate the use of ADS-B Out for aircraft operating in controlled airspace below FL-245.

The purpose of this report is to identify the costs and benefits of implementing the ADS-B mandate below FL-245, and to help the CAA identify the policy options that could ease the transition to ADS-B.

This report provides an economic analysis of the proposed ADS-B mandate below FL-245. It explicitly excludes the benefits to aircraft that operate above FL-245, even though they may receive some benefits from implementation of the below FL-245 system.

This report focusses only on an ADS-B Out mandate, but it acknowledges that there are likely to be a significant number of aircraft owners and operators that choose to also install ADS-B In either because they acquire it vicariously with the ADS-B Out upgrade (it comes with the kit), or because they perceive benefits in having the greater situational awareness that ADS-B In can provide. The Multi-Criteria Analysis (Section 5) considers the possibility of some level of ADS-B In adoption.

The methodology employed for this analysis was a national Cost Benefit Analysis (CBA). The purpose of a national CBA is to quantify, so far as possible, the costs and benefits to society as a whole of a policy or project, rather than the costs and benefits to any individual or group. If benefits exceed costs, the project is considered to be an efficient use of resources, increasing the overall economic welfare of the country.

This CBA quantifies costs and benefits to aircraft owners, system operators, the avionics profession, and flight schools where possible, and describes costs and benefits qualitatively where necessary. This report also considers the *incidence* of costs and benefits (i.e., who bears what proportion of the costs and receives what proportion of the benefits) across different parties. The cost-benefit analysis is undertaken over a 20-year timeframe using the current public sector discount rate of 6%.[1]

The cost benefit analysis compares a future case to the base case scenario – a 'do nothing' or 'status quo' option, representing what would happen if we did not mandate for ADS-B below FL-245.

1.2 ADS-B

The purpose of surveillance is to accurately determine an aircraft's location and altitude so that air traffic control (ATC) can work to maintain aircraft separation, manage potential conflicts and reduce the risk of collisions. Surveillance services (i.e. separation of aircraft) takes place in controlled airspace only, however surveillance coverage extends beyond controlled airspace. In contrast to the existing radar systems, ADS-B utilises a system of satellites, on-board transponders, and ground receivers to achieve enhanced coverage of airspace (a greater volume of airspace with greater accuracy). ADS-B is:

- **A**utomatic – Transmissions are sent automatically, and they require no pilot input or external interrogation.
- **D**ependent – Depends on accurate position and velocity data from the aircraft's navigation system (e.g. GNSS).
- **S**urveillance – Provides aircraft position, altitude, velocity, and other surveillance data to facilities that require the information.

[1] A discount rate reflects the 'time value' of money, meaning that costs incurred today – or benefits received – are more valuable than those in the future. This reflects the opportunity cost of capital. The public sector discount rate is the discount rate used by the New Zealand Treasury to assess investments made for or on behalf of the government in New Zealand.

- ► Broadcast – Information is continually broadcast for monitoring by appropriately equipped ground stations (or aircraft).

The proposed mandate is for ADS-B Out only, but through engagement with FSWIG, EY has come to understand that some users may voluntarily choose to install ADS-B In to enhance their situational awareness, particularly given that the marginal cost of ADS-B In installation relative to the ADS-B Out system is minor.

1.3 Base and Alternative Cases

A cost benefit analysis compares a set of future options to a base case scenario so that the efficiency of a proposed investment or policy setting can be assessed. In many cases, the base case scenario is a 'do nothing' or 'status-quo' option, representing what would happen if we did nothing. That is the approach taken here.

Scenario Tested

The scenario we consider most likely is a scenario in which ADS-B below FL-245 will be mandated in 2021, and the ADS-B system will cover a greater volume of airspace than the current secondary radar system. If there was no ADS-B mandate, it is assumed that radar would continue to cover only the current volume of airspace.

The base case used in our analysis is as follows:

- ► There is no mandate for ADS-B below FL-245.
- ► Secondary radar is maintained at a level that provides the same volume of coverage for below FL-245 as is in place today.

The alternative case is as follows:

- ► ADS-B is mandated for all aircraft in controlled airspace, and the ADS-B network provides a greater volume of coverage relative to today's systems. The system provides for better positional accuracy and more efficient, higher accuracy air traffic management as GNSS based ADS-B transponders are required over the entire volume of controlled airspace.
- ► ATC has better visibility of aircraft within the surveillance coverage area while outside controlled airspace, ADS-B provides potential safety benefits in the event of an aircraft emergency, loss of situational awareness, etc.
- ► The current radar systems are retired in 2021.
- ► A cooperative contingency system remains in place for the main trunk.

1.4 Summary of Results

The benefits and costs are presented in Net Present Value (NPV) terms, which present costs and benefits overtime as a single number, using a discount rate of 6%.

We find that the total benefits from the ADS-B mandate below FL-245 are between $27.8M - $41.0M. These benefits accrue primarily from:

- ► Technological change leading to avoided capital investment in SSR radar and upgrades to obsolete aircraft equipment (Mode C transponders)

- ► There are also potentially large – but uncertain – safety benefits resulting from better positional accuracy leading to lower risk of loss-of-separation incidents and accidents.

The costs of implementation of the ADS-B mandate are $49.7m, which are primarily driven by:

- ► The costs of upgrading aircraft avionics and

- The costs to airways of installing the ADS-B system (although the costs are far lower than replacing the existing SSR system).

The net cost of this mandate is between $8.7M and $21.9M resulting in a Benefit-Cost Ratio of 0.56-0.82. Given the extended airspace coverage between the old and new systems, we anticipate it is likely that the BCR would be toward the upper end of this range: between 0.7-0.8.

BCRs involving regulation are frequently low, reflecting the relative ease of quantifying reasonably certain costs and the relative difficulty of quantifying relatively uncertain benefits, but also due to the mandate underlying regulatory changes. Therefore, while BCRs at this level would not normally be sufficient to justify investment, there is a reasonable chance that *total* benefits (as opposed to total quantifiable benefits) exceed costs, as there are some benefits that could not be calculated and some that are outside the scope of this analysis that may have significant impacts on flights above *and* below FL-245. In addition, sensitivity testing of the BCR shows that as the period of analysis is extended the BCR modestly rises reflecting that benefits outweigh costs in out-years.

The multi-criteria analysis (MCA) conducted is also strongly suggestive of additional benefits, with users suggesting that there is a strong likelihood of performance benefits from moving to surveillance based control. In addition, the MCA results also revealed that users felt strongly that greater situational awareness in *uncontrolled* airspace was the most likely and most beneficial outcome to all users, given the potential for voluntary ADS-B In.

1.4.1 Summary of Costs

A summary of the costs associated with the implementation of ASD-B over the base case, and their incidence, is provided in the table below. The greatest costs are borne by aircraft owners and operators, who bear $34.5M in total equipment upgrade costs, as well as a level of regulatory burden.

Costs Summary (20Y)		
Costs	**Incidence**	**Main Scenario**
Airways Capital and Operating Costs (ADS-B)	Airways	$9.8M
Aircraft Upgrade Costs	Aircraft owners	$34.5M
Mode A/C Early Obsolescence	Aircraft owners	$0.7M
Certification (60-Day Policy) Costs	Aircraft owners	$0.9M
Regulatory Impost (Capital Value Decrease)	Aircraft owners	$3.4M
Avionics Test Set Costs	Avionics	$0.5M
Total Costs		**$49.8m**

*Benefits / Costs may not sum due to rounding

The incidence of upgrade costs falls most heavily on older and/or lower cost aircraft for which equipment with an STC applicable to those aircraft is less likely to exist, and disproportionately affects the Microlight aircraft sector who suffer from a lack of equipment with an applicable STC, high upgrade costs (due to power requirements) and operate in controlled airspace relatively infrequently.

1.4.2 Benefits

The PV and incidence of benefits of implementation of ASD-B over the base case are summarised in the following table:

Benefits Summary (20Y)		
Benefits	**Incidence**	**Main Scenario**
Airways Capital and Operating Costs Avoided	Airways	$18.1M
Mode C Transponder Renewal Avoided	Aircraft operators	$6.1M
Safety Benefits	Aircraft operators, owners, passengers.	$0.8M - $13.9M
Avoided Tracking Costs	Training schools (quantitative), aircraft owners, operators, and passengers (qualitative).	$2.9M
Total Benefits		**$27.9m-$41.0m**

*Benefits / Costs may not sum due to rounding

- Benefits are driven almost exclusively by the reduction in capital costs to Airways who avoid $18.1M in capital upgrade costs and also incur lower operational costs.

- There are potentially large – but highly uncertain – safety benefits accruing from better, more accurate, and more frequent positioning information potentially leading to a reduction in accidents and incidents caused by loss of separation.

1.5 Multi Criteria Analysis

A Multi Criteria Analysis (MCA) was also undertaken to understand the qualitative benefits of the ADS-B mandate below FL-245, and particularly to understand whether the unquantified benefits were anticipated to be significant in this assessment.

MCA is a qualitative framework for assessing options across a set of evaluation criteria. It provides a mechanism by which qualitative factors (or quantitative factors that cannot be assessed) can be evaluated by extracting the intrinsic knowledge of groups.

EY undertook the MCA in order to use a standardised process to evaluate qualitative metrics that were unable to be easily assessed using a standard CBA. The MCA was undertaken in a workshop facilitated by EY on 25 May 2017 with members of the Future Surveillance Implementation Working Group (FSIWG). The participants were asked to score the likelihood that different aircraft users would experience these benefits relative to operations today.

In summary:

- The **results of the MCA were broadly consistent with the results of the CBA.** The members considered there to be significant benefits to ADS-B but had significant concerns with the cost and creation of perverse safety incentives.

- The group felt smaller **Sport Aircraft operators – particularly microlights – would be the most affected by the regulation**, both positively and negatively, with commercial operators the least affected.

- The results suggest that **increased safety within uncontrolled airspace is the most likely and most beneficial outcome** to all users with the potential for voluntary ADS-B In creating strong potential benefits, although these benefits could be offset by an ‘overreliance’ on the ADS-B system for situational awareness.

- The greatest risks were perceived to be in changes to flight patterns and pilots choosing to turn off their transponders to avoid detection in controlled airspace.

2. Purpose, Context and Scope

Implementation of enhanced and modernised surveillance is one of the key elements of the National Airspace and Air Navigation Plan (NAANP) being implemented under the New Southern Sky (NSS) programme. Moving from radar-based to Automatic Dependent Surveillance – Broadcast (ADS-B) surveillance is a key part of NSS.

NSS proposes a two stage approach for transitioning to ADS-B in New Zealand:

- Phase 1: ADS-B Out is mandatory for all aircraft in controlled airspace above FL-245 after 31 December 2018; and

- Phase 2: ADS-B Out is mandatory for all aircraft in controlled airspace below FL-245 after 31 December 2021.

CAA has engaged EY to conduct a cost benefit analysis (CBA) on the proposal to expand the implementation of (ADS-B) to aircraft operating below FL-245.

2.1 Purpose of Report

The purpose of this report is to identify the costs and benefits of implementing the ADS-B mandate below FL-245, and to help the CAA identify the policy options that could help ease the transition to ADS-B. CAA may commission further research to see how effective those types of policy options might be at maintaining safety while reducing the costs and maximising the benefits identified in this report.

This report also contains the results of a multi-criteria analysis (MCA) conducted to assess the benefits and costs that were not quantifiable. The participants contributing to the MCA were members of the Future Surveillance Implementation Working Group (FSIWG).

2.2 What is ADS-B?

The purpose of surveillance is to accurately determine an aircraft's location and altitude so that air traffic control (ATC) can work to maintain aircraft separation, manage potential conflicts and reduce the risk of collisions. Surveillance services (i.e. separation of aircraft) takes place in controlled airspace only, however surveillance coverage extends beyond controlled airspace.

The existing surveillance system utilises a network of primary and secondary radar stations across the country to determine aircraft position for ATC.

Secondary Radar systems (SSR) are dependent on active transponders on board the aircraft, which transmit information such as an aircraft's identification and altitude, in response to interrogation by the radar system. SSR is a co-operative system: it requires the aircraft and the ground system to work together to provide the information. SSR enables ATC to determine the aircraft's position, ensure separation, and manage the airspace efficiently and safely. There are six SSR systems in New Zealand with a maximum range of 256NM.[2]

Airways introduced SSR to New Zealand in the early 1990s. At that time, CAA made it mandatory for all aircraft entering controlled or transponder mandatory airspace to carry operable Mode A and Mode C transponders.

Primary Radar systems are conventional radar systems that utilise active transmission of radio-waves (pings) and the reception of 'backscatter' from a target to determine an aircraft's location. These systems allow ATC to detect incursions into controlled airspace by aircraft without transponders, and to manage aircraft without transponders or with equipment failure. They are not

[2] http://www.aip.net.nz/pdf/ENR_1.6.pdf

required for an ATC surveillance service and were introduced by Airways to meet customer requirements. There are three such radar systems in New Zealand covering the busiest airspace (Auckland, Christchurch, and Wellington) to a range of 80NM. They are non-cooperative – that is, they do not depend on transponders.[3]

In practice, ADS-B will replace SSR as the main source of information for an ATC surveillance service. Because ADS-B is dependent on the global navigation satellite system (GNSS) and this system will become a single point of failure for primary means of navigation and surveillance, the CAA System Safety Criteria requires Airways to retain a limited contingency system of non-GNSS dependent cooperative surveillance in case the GNSS system fails, and to manage aircraft with on-board equipment problems. That system, as proposed, would cover the main trunk which CAA defines as running between Auckland, Wellington, and Christchurch airports.

In contrast to the existing radar systems, ADS-B utilises a system of satellites, on-board transponders, and ground receivers to achieve enhanced coverage of airspace (a greater volume of airspace with greater accuracy. ADS-B is:

- **A**utomatic – Transmissions are sent automatically, and they require no pilot input or external interrogation.
- **D**ependent – Depends on accurate position and velocity data from the aircraft's navigation system (eg. GNSS).
- **S**urveillance – Provides aircraft position, altitude, velocity, and other surveillance data to facilities that require the information.
- **B**roadcast – Information is continually broadcast for monitoring by appropriately equipped ground stations (or aircraft). [4]

ADS-B systems also have two variations: ADS-B Out and ADS-B In.

- ADS-B Out transmits positional data from the aircraft that can be picked up by the air traffic management system, and by other aircraft.
- ADS-B In is a receiver that enables aircraft to receive information from other aircraft about aircraft position.

The proposed mandate is for ADS-B Out only, but through engagement with FSWIG, EY has come to understand that some users may voluntarily choose to install ADS-B In to enhance their situational awareness, particularly given that the marginal cost of ADS-B In installation relative to the ADS-B Out system is minor.

Figure 1, below, shows how ADS-B works compared with a radar system:

[3] Ibid.
[4] http://www.airservicesaustralia.com/projects/ads-b/how-ads-b-works/

Figure 1: How ADS-B Works

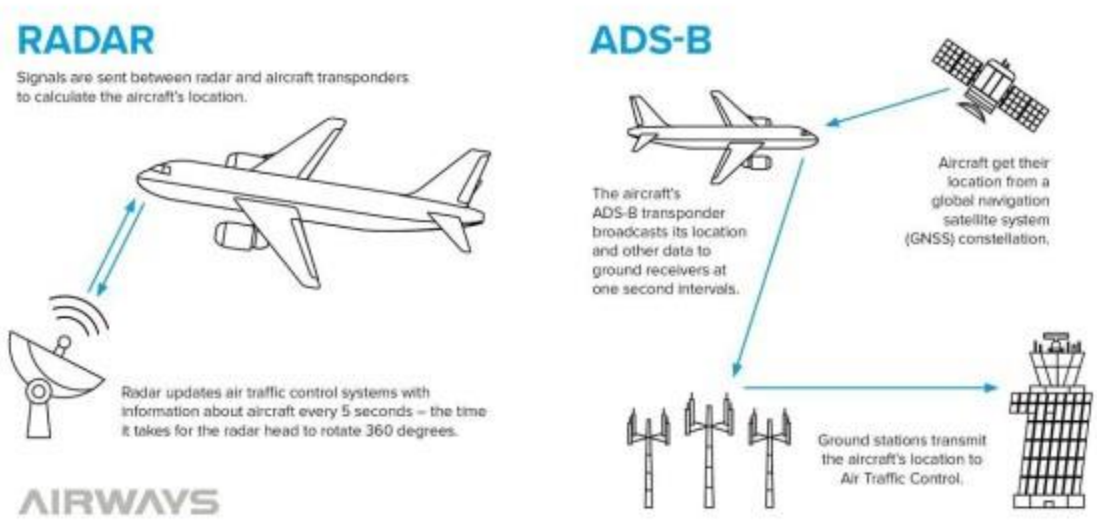


Image Credit: Airways NZ

2.3 Scope

ADS-B Out Mandate Below FL-245 Only

This report provides an economic analysis of the proposed ADS-B mandate below FL-245. It explicitly excludes the benefits to aircraft that operate above FL-245, even though they may receive some benefits from implementation of the below FL-245 system.

This report focusses only on an ADS-B Out mandate, but it acknowledges that there are likely to be a significant number of aircraft owners and operators that choose to also install ADS-B In either because they acquire it vicariously with the ADS-B Out upgrade (it comes with the kit), or because they perceive benefits in having the greater situational awareness that ADS-B In can provide. The Multi-Criteria Analysis (Section 5) considers the possibility of some level of ADS-B In adoption.

Coverage and Timeframe of the CBA

This CBA quantifies costs and benefits to aircraft owners, system operators, the avionics profession, and flight schools where possible, and describes costs and benefits qualitatively where necessary. This report also considers the *incidence* of costs and benefits (i.e., who bears what proportion of the costs and receives what proportion of the benefits) across different parties. The cost-benefit analysis is undertaken over a 20-year timeframe using the current public sector discount rate of 6%.[5]

The 20-year analysis timeframe is conservative, in that it may underrepresent the benefits of ADS-B in the long term, but it is considered reasonable as it reflects the minimum replacement period of ADS-B infrastructure after which new capital investment may be required.

Exclusion of Medium-Long Term Technological Change

We also note that there may be new and enhanced positioning systems (Satellite Based Augmentation System (SBAS)), new aviation challenges (e.g. UAVs) and airspace management

[5] A discount rate reflects the 'time value' of money, meaning that costs incurred today – or benefits received – are more valuable than those in the future. This reflects the opportunity cost of capital. The public sector discount rate is the discount rate used by the New Zealand Treasury to assess investments made for or on behalf of the government in New Zealand.

protocols that emerge over the 20-year analysis timeframe that could change the costs and benefits of the ADS-B Out system. In particular, we note that the emergence of drones / UAVs as a major factor in airspace management could increase the benefits of a system like ADS-B that provides for more accurate positioning information, and can serve to reduce airspace incidents.

As both the timeframe, magnitude, and certainty of these impacts are highly uncertain, this has been excluded from the CBA, but as a general principal the busier controlled airspace below FL-245 becomes, the greater the benefits of ADS-B in terms of safety and airspace management.

Aircraft Included

This report focusses primarily on aeroplanes, microlights, helicopters, gyrocopters, and gliders that have an operative ceiling of less than 24,500 ft.

This report excludes aircraft such as balloons, jetpacks, parachutes, paragliders / hang-gliders, which are few in number, do not often operate in controlled airspace (or operate within designated zones), and/or for which reliable information is unavailable.

It also excludes aircraft that have an operational ceiling above FL-245, but that often operate below that flight level (e.g. Air New Zealand ATR-72s). This simplifying assumption is justified by the fact that the primary operators of these types of aircraft have already committed to an upgrade programme to include ADS-B on their aircraft.

Exclusion of Alternative Policy Options

This report does not consider alternative policy options, for example it does not consider possible policy responses or recommendations, including (but not limited to):

- Making ADS-B upgrades a permitted modification to aircraft with no applicable STC in cases where power utilisation does not change and where there is no airframe modification.
- Allowing uncertified ADS-B units that are designed to the relevant operational standards, but do not have an applicable TSO.
- Allowing uncertified GNSS inputs, even if those units are designed to the relevant operational standards, but do not have an applicable TSO.

3. Stakeholder Engagement and Methodology

This section briefly outlines the stakeholder engagement undertaken, particularly the role of FSIWG in calibrating and verifying assumptions used for the CBA.

This section also provides a high-level summary of the CBA methodology, but greater detail about the approach taken to calculating each benefit or cost is included in Table 2 and Table 3 in Section 3.

3.1 Stakeholder Engagement

EY engaged extensively with the Future Surveillance Implementation Working Group (FSIWG) members to inform the cost-benefit analysis.

FSIWG is a stakeholder and reference group established by the CAA, with representatives from the commercial, sport, and amateur aviation sectors; avionics profession; and flight training schools. This group was instrumental in informing the assumptions underlying the CBA. A full list of members is provided in Appendix C.

Formal Engagement

EY conducted two formal workshops with FSIWG as part of developing this report, but not all members were in attendance at either meeting. The following elements of the CBA were tested with CAA, Airways, and FSIWG members:

- The categories of costs and benefits calculated
- The reasonableness of underlying assumptions about equipage, use of controlled airspace, existing use of uncertified systems to enhance situational awareness
- The initial results of the CBA analysis covered by this report.

In addition, EY also conducted a multi-criteria analysis with FSIWG members to qualitatively assess the impacts and incidence of those costs and benefits that could not be quantified (e.g. fuel savings / flight paths) due to insufficient data or where the benefit or cost did not lend itself to monetisation due to the speculative or inherently qualitative nature of the impact being assessed (e.g. pilot behaviour to avoid ADS-B use or controlled airspace fees).

Informal Engagement / Datapoints

In many cases, FSIWG members were able to provide estimates for key data points that were unavailable through primary or secondary sources, for example:

- the proportion of different aircraft that would at least occasionally enter controlled airspace,
- the proclivity of aviation enthusiasts to upgrade equipment without a mandate, and
- the compliance cost magnitude that would remove certain aircraft from operation.

Where possible, these estimates have been tested; where they could not be independently verified, this report uses the figures provided by stakeholders, with the understanding that they could be subject to estimation biases.

3.2 Methodology & Base Case

The methodology employed for this analysis was a national Cost Benefit Analysis (CBA), in a manner consistent with the Treasury's Guide to Social Cost Benefit Analysis. The purpose of a national CBA is to quantify, so far as possible, the costs and benefits to society as a whole of a policy or project, rather than the costs and benefits to any individual or group. If benefits exceed costs, the project is considered to be an efficient use of resources, increasing the overall economic welfare of the country.

A cost benefit analysis compares a set of future options to a base case scenario so that the efficiency of a proposed investment or policy setting can be assessed. In many cases, the base case scenario is a 'do nothing' or 'status-quo' option.

Developing a status-quo scenario is complicated by the fact that the existing radar system will reach the end of its useful life in 2021, and that regardless of the decision to implement ADS-B below FL-245, we assume that the proposed ADS-B mandate for *above* FL-245 will continue.

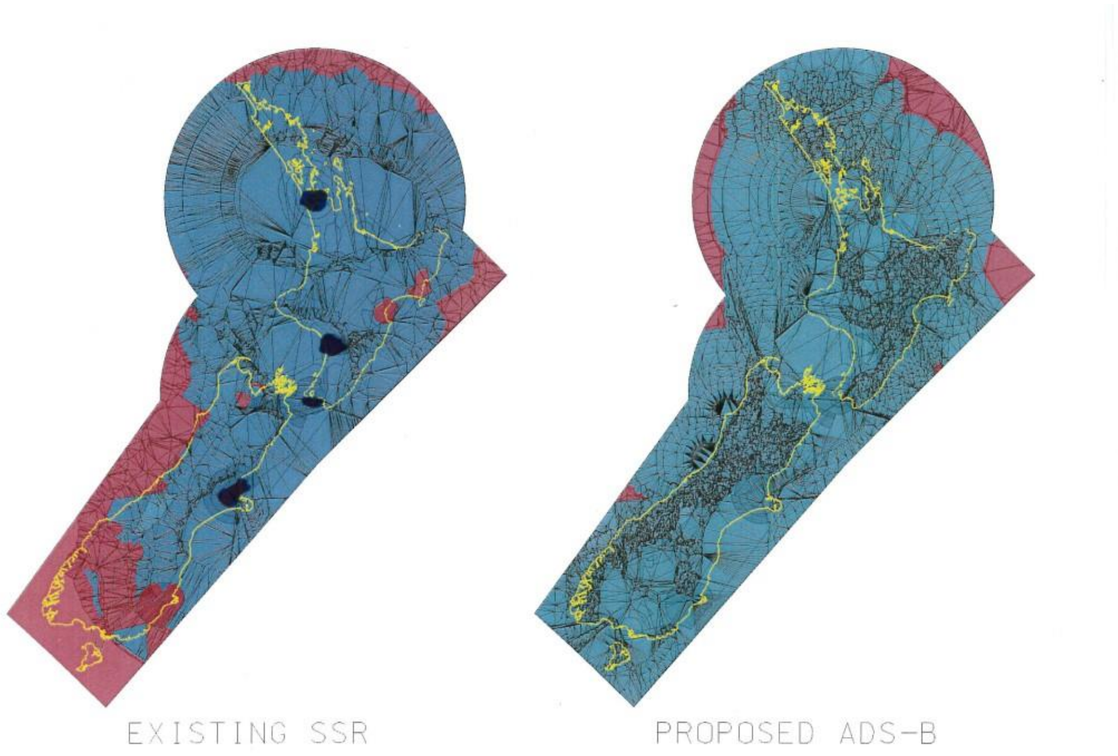
In preparing this report we considered three scenarios, with different base cases and alternative futures. The most realistic and most likely scenario is presented in the body of the report, but Appendix B covers the other scenarios considered.

Main Scenario: Comparative Scenario

The scenario we consider most likely is a scenario in which ADS-B below FL-245 will be mandated in 2021, and the ADS-B system will cover a greater volume of airspace than the current secondary radar system. If there was no ADS-B mandate, it is assumed that radar would continue to cover only the current volume of airspace. Figure 2 shows the level of coverage with ADS-B versus that with the existing radar system.

This scenario is deemed to be the most probable future, and represents the current policy settings and assumptions with respect to ADS-B coverage and radar coverage.

Figure 2 Comparison of Airspace Coverage



This means that this scenario has the following base case and comparative case.

Base Case

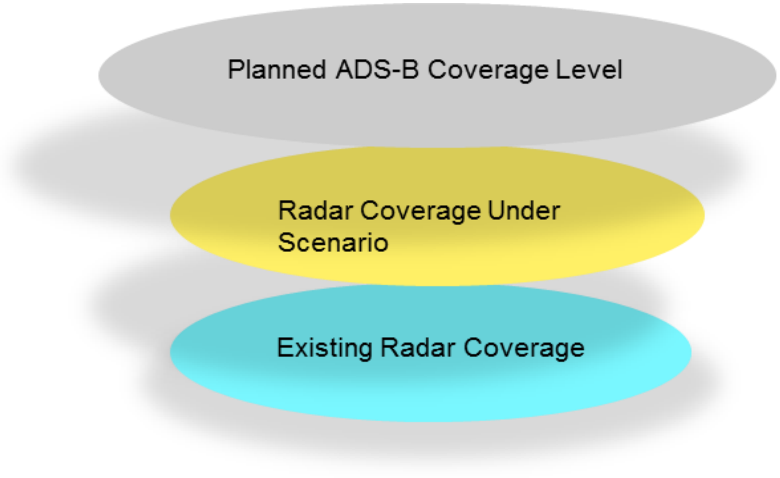
- There is no mandate for ADS-B below FL-245.
- Secondary radar is maintained at a level that provides the same volume of coverage for below FL-245 as is in place today.

Alternative Case

- ADS-B is mandated for all aircraft in controlled airspace; and the ADS-B network provides a greater volume of coverage relative to today's systems. The system provides for better positional accuracy and more efficient, higher accuracy air traffic management as GNSS based ADS-B transponders are required over the entire volume of controlled airspace.
- ATC has better visibility of aircraft within the surveillance coverage area, while outside controlled airspace ADS-B provides potential safety benefits in the event of an aircraft emergency, loss of situational awareness, etc.
- The current radar systems are retired in 2021.
- A cooperative contingency system remains in place for the main trunk.

Graphically, this scenario can be thought of as representing different volumes of airspace that are 'covered' by the systems, as shown in Figure 3, with the size of the ovals indicating the coverage expected by the ADS-B system, relative to a comparative replacement radar system under FL-245.

Figure 3: Airspace Coverage of Planned ADS-B Coverage versus Existing Radar



3.3 Approach taken to Costs and Benefits

In performing this analysis, we have generally focussed on those quantifiable costs and benefits that will make the most significant impact to the analysis. In general, a conservative approach to benefits quantification has been adopted, notably around potential safety benefits.

The conservative approach taken, and the fact that some benefits could not be quantified – like the (limited) potential fuel and time savings from more efficient approaches due to enhanced air traffic management – means that the benefit-cost ratio is likely to be moderately higher than reported.

Different Emphasis on Benefits for Below FL-245

Compared with other assessments of ADS-B that have been undertaken, this assessment focusses more heavily on the costs incurred (and avoided) by Airways (which is reflected in charges to aviation customers) and the equipage costs for different aircraft, rather than on fuel or time savings.

This is for three main reasons:

- ► The scope of this report was limited to understanding the benefits of ADS-B Out, but most fuel and time savings come from PBN enhancements.
- ► Most of the benefits operational benefits of ADS-B accrue to flights above FL-245, with only limited time and fuel savings impacts for most of the smaller aircraft that make up with fleet below FL-245. Quantification of the time and fuel benefits from ADS-B for this fleet was not possible given the limited information about the routes flown, the frequency of flights, and detail about the way in which private operators (who make up the majority of the below FL-245 fleet) will respond to the enhanced PBN benefits that ADS-B can enable.
- ► The equity impact of the regulatory impost is likely to be higher on smaller aircraft users.

Material Costs and Benefits

This report focusses on capital and operational costs and benefits for Airways and aircraft operators; it also considers the cost of regulation on aircraft owners, particularly as it relates to reduced aircraft value, increased compliance cost, or reduced utility.

The monetised costs and benefits are listed below in Table 1, and further detail about the methodology used to calculate these benefits is included in Table 2 and Table 3.

Table 1 **Quantified Costs and Benefits of Proposed ADS-B <FL-245 mandate**

Quantified Costs	Description
Aircraft Upgrade Costs for ADS-B	**Equipment costs.** This includes the cost of purchasing ADS-B equipment that is TSO certified. Depending on the aircraft's existing equipment this would include: a GNSS unit and/or an ADS-B transponder. **Installation costs.** The cost of installing the ADS-B transponder and GNSS (if required) plus any electrical or airframe modifications required. **Certification costs.** Some aircraft will require certification / approval for modifications where no applicable STC exists.
Maintenance Costs	The cost of yearly maintaining and testing ADS-B units in aircraft, over and above existing costs of maintaining any current equipment.
Installation and Maintenance of on Ground Infrastructure	The costs of installing and maintaining Airways' ADS-B receivers on the ground.
Regulatory Impact on Aircraft Value	Some aircraft will be uneconomic to upgrade, which will render the aircraft unusable in controlled airspace, reducing their value. This reduction in value is due to regulatory change.
Certification Costs (60-day stand-down policy)	In cases where an existing transponder fails on inspection and an owner chooses to upgrade their aircraft to ADS-B, but there is no equipment where the STC applies to the aircraft a design modification / certification may be required which can take 60+ days, during which time – for all practical purposes – the aircraft cannot be flown.
Test Set Costs	The cost imposed on the avionics industry of upgrading or acquiring test sets to certify and test new ADS-B transponders.
Opportunity Costs of Existing Mode A/C units	The proposed regulation would have the effect of prematurely retiring these units in New Zealand, but most Mode A/C transponders have only 10% of their useful life left (on average). These transponders became mandatory in the early-2000s, and are now reaching the end of their useful life.
Option Value Lost	Currently, aircraft operators with Mode A/C transponders have the option to enter controlled airspace, even if they do not regularly do so. Without upgrading, this option value will be lost.
Costs to CAA for increased processing of application for modification.	CAA may be required to process a greater number of modification applications, placing a burden on CAA staff.
Costs to CAA for communications, information, and training relating to ADS-B roll out.	CAA will need to engage in an information and education campaign for ADS-B.

Quantified Benefits	Description
Capital and Operational Costs Avoided (Airways systems)	According to data from Airways, the capital and operating costs of the ADS-B system are lower than that of replacing the existing radar and much lower than implementing a radar system with equivalent levels of coverage. The current radar system comes to the end of its useful life in 2021, and the replacement or upgrade costs of that system are taken as a benefit, as are the operational costs avoided. These cost savings (benefits) are partially offset by the cost of the new ADS-B system (see: costs).
Capital Cost of Mode C Replacement Avoided	Mode A/C transponders will no longer need to be replaced when they arrive at the end of their useful life. These cost savings (benefits) are offset by the cost of installing new ADS-B equipment where required.
Increased Safety	Better situational awareness and better airspace management due to enhanced information and accuracy may reduce airspace incidents, such as loss of separation and 'near miss' events. Avoided incidents have a value calculated using the statistical value of life. The value of an avoided incident is the statistical value of life multiplied by the probability of a given incident resulting in a fatality.
Tracking and Search and Rescue (SAR)	Flight training schools who may retire their tracking systems if ADS-B can provide much of the same information; these schools currently pay for tracking systems.

4. Costs and Benefits: Description and Methodology

4.1 Costs

The costs of implementing the new ADS-B surveillance regime fall on:

- Airways for new ground equipment
- Aircraft owners and operators for new GNSS receiver and ADS-B transponder equipment, installation costs, and design and certification costs where necessary
- Aircraft owners who cannot or choose not to upgrade and have reduced value in their aircraft due to an inability to access controlled airspace
- Avionics installers who must purchase a greater number of ADS-B compliant test-kits.

The extent of equipment upgrades for the under FL-245 fleet is extensive, as most aircraft are not currently fitted with ADS-B or Mode-ES transponders, some which can be upgraded to provide ADS-B functions.

A list of costs of this proposed mandate and the methodology for quantifying those costs are described in Table 2 below. The costs and benefits have been tested with representatives from CAA and the below FL-245 operator community through two separate workshops with FSIWG on 12 April 2017 and 25 May 2017.

Table 2 Costs of Proposed ADS-B <FL-245 mandate

Costs	Description	Quantification	Data Sources, Assumptions, Qualifications
Total Required Costs to Upgrade to ADS-B ► Includes GNSS, Mode ES upgrade, and ADS-B transponder purchase costs as required. ► Includes installation and certification where required.	**Equipment costs.** This includes the cost of purchasing ADS-B equipment that is TSO certified. Depending on the aircraft's existing equipment this would include: a GNSS unit and/or an ADS-B transponder. **Installation costs.** The cost of installing the ADS-B transponder and GNSS (if required) plus any electrical or airframe modifications required. **Certification costs.** Some aircraft will require certification / approval for modifications where no applicable STC exists.	**Quantified: Yes** **Incidence: Aircraft owners** Estimate of ADS-B installation costs[6]: Based on data from Massey University, CAA, Airways, and reasonable assumptions we calculated that: ► 4504 aircraft operate mostly or exclusively below FL-245 ► In total, 3924 aircraft do not have a Mode ES or ADS-B transponder: ○ 2360 aircraft do not have a Mode ES or ADS-B transponder and there is no equipment available with an STC applicable to those aircraft. ○ 1614 aircraft do not have a Mode ES or ADS-B transponder, but equipment with an STC applicable to that aircraft is available. ► 580 (c. 13%) of aircraft have a Mode-ES or ADS-B transponder ○ 241 have a Mode-ES transponder that can be upgraded to ADS-B where the equipment has an STC applicable to that aircraft. ○ 233 have a Mode-ES transponder that can be upgraded to ADS-B, but where no STC is available for that aircraft. ○ The remainder (106) have ADS-B installed **Upgrade Costs** Aircraft owners will face different upgrade costs depending on the status of their existing transponders as well as whether an aircraft has an approved STC for a relevant transponder. $5,500 in an aircraft with an existing Mode-ES transponder that can be upgraded to ADS-B with STC applicable to the relevant aircraft $9,000 in an aircraft where the equipment has a relevant STC for the aircraft, but where the aircraft does not have a Mode-ES transponder ► $500 - $1500 Installation $11,000 in an aircraft with an existing Mode-ES transponder, but no STC $13,000 (avg) in an aircraft with no Mode-ES transponder and no equipment with an STC applicable to that aircraft (this could break down into: ► $7000-8000 for lightweight unit suitable for installation in aircraft without an STC ► $1000-2000 for installation ► $3000-5000 for certification	To determine the current fit-out of existing aircraft the following data were interrogated: ► The ADS-B STC Project aircraft register, which provided an indication of where equipment with an STC applicable to those aircraft is available. Where the existing ADS-B STC Project register did not record an STC status, the following assumptions were made as to the availability of equipment with an STC relevant to an aircraft: ○ Microlights were assumed to not have equipment with a relevant STC, based on our discussions with SAANZ and Avionics providers ○ Helicopters that were not gyrocopters and had commercial uses were assumed to have an STC available. ► NZ ADS-B Data provided by airways that provided information about the type of transponder installed in the aircraft, as recorded by Airways. This data was only available for aircraft that entered controlled airspace, which means that this likely **underestimates** the true number of aircraft with transponders, as not all aircraft enter controlled airspace. **Sensitivity testing shows that changes of +/- 100 ADS-B equipped aircraft do not have a material impact on the BCRs, changing the BCR by +/- 0.02.** ► EY research and flight information from airways to determine which aircraft are likely to operate exclusively below FL-245 Based on our engagement with FSIWG members, we assumed that for the below FL-245 fleet: ► approximately 80% of non-glider aircraft without Mode-S transponders, and ► approximately 70% of gliders without Mode-S transponders Will at least occasionally enter controlled airspace. 100% of aircraft with Mode-S transponders are expected to enter controlled airspace. These aircraft will all require upgrades.[7] The costs of equipage were provided by avionics professionals in FSIWG and tested with CAA. These costs were verified by online searches for certified ADS-B equipment.
Maintenance Costs	The cost of yearly maintenance / testing of ADS-B units.	**Quantified: Yes*** **Incidence: N/A (see below)** $500 per aircraft per year. This cost is excluded from the analysis as this cost is currently incurred by aircraft owners with any transponder (e.g. a Mode A/C) so it does not reflect an added cost.	Consultation with avionics members of FSIWG suggest that the cost of yearly testing of ADS-B units will be approximately $500, but that testing of existing transponders is also $500.
Installation and Maintenance of on Ground Infrastructure	The costs of installing and maintaining ADS-B receivers.	**Quantified: Yes** **Incidence: Airways** **Capital Costs** The costs of installation will depend on the level of coverage required. We have examined two scenarios: 1) ADS-B to 'existing' level of coverage: $2.4M 2) ADS-B to planned (extended) coverage levels: $7.6M[8] **Operating / Maintenance Costs** Maintenance and operating costs were calculated on a pro-rata basis relative to the capital costs of retaining a system for below FL-245 coverage. This resulted in estimates of:	We received calculations from Airways regarding: ► Coverage volumes ► ADS-B installation costs for a 'BaU' and 'Extended / planned' system ► The installation costs of MSSR radar. We also received estimates from Airways as to their ongoing operating and maintenance costs.

[6] The price of all in one GNSS & ADS-B units have fallen quickly, which is why the maximum reported cost in this report, including certification, is lower than the costs reported in the 2014 Castalia report for an average installation. Equipment costs are not anticipated to fall further, with manufacturers adding additional features, rather than reducing price.

[7] Discussions with AOPA, NZSPA, CAA, and FSIWG.

[8] Model of NAANP CBA performed by Airways, email correspondence with Airways

		► Approximately $125,000p.a. for the existing level of coverage, using an ADS-B system. ► Anticipated to be $325,000p.a if ADS-B goes ahead as planned. Pro-rata from total system maintenance of: $532,000 p.a.[9]	
Regulatory Impact on Aircraft Value	It will become uneconomic to upgrade some (almost exclusively microlight) aircraft. This means that their value will be decreased to that of an aircraft without a transponder, as it cannot be used in controlled airspace.	**Quantified: Yes** **Incidence: Aircraft owners (microlight)** We understand through our engagement with Sport Aviation Association of New Zealand, that 50% of with aircraft having a value below $40,000 would not upgrade to ADS-B as they would deem it 'uneconomic' to do so. This means that approximately 200 aircraft would face a reduced value due to the lack of upgrade. It is assumed that the residual value of those aircraft would be similar to those aircraft without a transponder today.	Based on the last 3 months of TradeMe data, approximately: ► 40% of microlight aircraft with Mode A/C transponders have a value of $30,000 - $40,000 (average value of *circa*. $35,000). There are approximately 400 aircraft in this category.[10] ► The value of a microlight aircraft without a transponder is approximately $15,000
Certification Costs (60-day stand down policy)	In cases where an existing transponder fails on inspection, and an owner chooses to upgrade their aircraft to ADS-B, but no STC is available, a design modification / certification may be required. In these cases, CAA needs to process an application which can take 60 days during which time the aircraft cannot be flown.	**Quantified: Yes** **Incidence: Aircraft owners** The inability to use an aircraft during the certification process has a real (traded) or shadow (intrinsic) cost to the aircraft owner. In cases where a market value cannot be derived through transactions, economists use market value data to estimate the costs imposed on individuals and businesses. In this case, the cost refers to the lack of use of the aircraft; and conceptually represents the cost that would have to be incurred (if such a service existed) to 'lease' an aircraft during the period of embargo. For this reason, it is considered that this approach provides a reasonable approach to calculating a shadow cost for the certification process that in some cases makes aircraft temporarily unusable.[11]	Based on TradeMe data the average value of a: ► GA aircraft: $146,000 ► Helicopter: $573,000 ► Microlight Aircraft: $47,000 ► Glider: $80,000 Aircraft value (time): based on aircraft lease returns, it is estimated that an aircraft returns 6% of its capital value each year as an investment, which is used as the estimate of the value of an aircraft to its owner. According to representatives from the avionics field, 40% of Mode C transponders are liable to fail when tested.
Test Set Costs	The cost imposed on the avionics industry of upgrading or acquiring test sets to certify and test new ADS-B transponders.	**Quantified: To complete** **Incidence: Avionics** We understand from avionics experts in FSIWG that a new test set that has ADS-B testing capability costs approximately $35,000. This is approximately $5,000 more than a standard, non-ADS-B equipped test kit. There are 137 avionics operators with licenses permitting them to test ADS-B. EY estimates that 45-65 of these operators exist. 60% of all **flights** (to make a distinction from aircraft) use ADS-B currently, and 90%+ use Mode-S. These proportions are used to assume that: ► 27-39 avionics operators have ADS-B test sets today ► 41-59 have Mode-S test sets, which we assume can be upgraded. ► 4 – 6 operators do not have these test sets. That means that the total cost of upgrade is estimated at: ► $430,000 - $730,000 These values are highly uncertain and based on significant assumptions. For the purposes of the report we have used $500,000 for the cost to avionics operators, but this is subject to wide error bounds.	Data on test set kit values was provided by FSIWG and was separately verified through online research. CAA notes that there are 137 LAME licenses with Radio Group 3 avionics ratings (based on a database running back to the 1960s). Some of these may have retired, died, or otherwise stopped testing. Based on a simple business creation and lifetime model, EY estimates that 45 – 65 of these operators still exist. It is assumed that a Mode-S capable test set can be upgraded to an ADS-B test set for $5,000. It is assumed that each avionics practice in this category has on average 3 test sets.
Opportunity Costs of Existing Mode A/C units	Mode A/C transponders have approximately 10% of their useful life left (on average). The proposed regulation would have the effect of prematurely retiring these units	**Quantified: Yes** **Incidence: Aircraft owners** The value of a new Mode C transponder is approximately $2,600, with 10% of residual value left, this means that the remaining value of one transponder is approximately $260. There are approximately 2830 aircraft that operate below FL-245 with Mode A/C transponders only that are likely to upgrade to ADS-B. There is some use of Mode A/C in Australia as ADS-B is only mandated for IFR flight. As most existing units are heavily depreciated, and there appears to be a limited market for Mode A/C	No primary data was available on the condition or age of Mode C transponders. FSIWG members stated that Mode C transponders were heavily depreciated, and on average they had approximately 10% of their useful life left and that over the next 10 years all Mode C transponders would be likely to require replacement or significant repair. The number of aircraft with Mode A/C transponders only was calculated on an exceptions basis (e.g. they were not recorded as having Mode-S / ADS-B transponders but 80% enter controlled airspace).

[9] Pro-rata calculations performed by EY on the data from Fn 5.
[10] TradeMe data of national sales of microlight aircraft, sorted by price, accessed 20 May 2017.
[11] https://www.kgal-group.com/fileadmin/kgal/documents/pdf_WhitePaper/KGAL_WhitePaper_Aircraft-Leasing.pdf

		transponders in Australia, it is assumed that the resale value of these transponders in practice is minimal / zero.	
Option Value Lost	There is an option value to aircraft operators with Mode A/C transponders who currently have the choice to enter controlled airspace even if they do not regularly do so.	**Quantified: Yes** **Incidence: Already captured (aircraft owners, regulatory impost)** This is largely captured in the regulatory impost costs of reduced aircraft value and by the cost of upgrading. Those who choose not to upgrade will be left with aircraft with lower values, reflecting the loss of option value in entering controlled airspace. Some people who choose not to upgrade may only make this choice because it is slightly more than they are willing to pay for access to controlled airspace (choice on the margin) while others may see very little value in access to controlled airspace and lose very little option value. This report, therefore, assumes that approximately ½ of the value of the regulatory impost can be assumed to be the (consumer surplus) of those who have not upgraded and is lost due to the regulation. Those who upgrade will have borne the cost of the regulation through the ADS-B installation costs. There is an overall reduction in consumer surplus, but one that is substantively captured by the cost of the upgrades.	
Costs to CAA for increased processing of application for modification.	CAA may be required to process a greater number of modification applications, placing a burden on CAA staff.	**Quantified: No** **Incidence: CAA** These marginal costs are recovered through fees charged to applicants.	
Costs to CAA for communications, information, and training relating to ADS-B roll out.	CAA will need to engage in an information and education campaign for ADS-B.	**Quantified: No** **Incidence: CAA** These costs would be covered by CAA's normal operating budget, and do not represent a marginal economic cost of this initiative.	
International Compliance	The use of Radar based systems is no longer consistent with international best practice.	**Quantified: No** **Incidence: Aircraft operators, pilots.** Increasingly there will be costs to airline operators and pilots in countries that do not adopt ADS-B. ADS-B is rapidly becoming the new standard. This generates economic costs in two ways: 1) There is a reputational cost to New Zealand in not aligning with international best practice as described by ICAO. If ADS-B were not adopted this this could result in New Zealand airspace being deemed less safe and could even result in some aircraft being unable to enter New Zealand airspace due to the lack of legacy technology. 2) Airlines that do not adopt ADS-B technology they will increasingly find themselves unable to enter controlled airspace internationally. This has a limited impact on flights below FL-245.	

4.2 Benefits

As is often the case in regulatory CBAs, costs are relatively straightforward to calculate, but benefits are less certain. This is particularly true where benefits depend on predicting the behaviour of regulated parties. In these instances, two methods can be used to assess benefits:

1) Quantifying benefits where possible
2) Using Multi-Criteria Analysis to determine the relative importance of particular benefits, their incidence, and likelihood using expert stakeholder input.

We have used both methods to determine the benefits of the proposed ADS-B below FL-245 mandate.

Quantifiable benefits accrue largely to Airways, as the cost of installing the ADS-B system is significantly less expensive than replacing and maintaining the current radar system. There are also benefits in reduced incidents through greater coverage and better situational awareness that accrue to aircraft owners.

The list of benefits and quantification methodology (where applicable) of the ADS-B mandate are described in Table 3 below.

Table 3 Benefits of ADS-B <FL-245 Mandate

Benefits	Description	Quantification and Methodology	
Capital and Operational Costs Avoided (Airways systems)	The costs avoided between the ADS-B system and an equivalent radar system.	**Quantified: Yes** **Incidence: Airways** The existing radar system is coming to the end of its useful life. If ADS-B is not adopted, some level of secondary radar will need to remain in place to provide for safe operation of aircraft in controlled airspace. If ADS-B is adopted, the avoided costs of this radar system is a benefit.	The avoided radar costs will depend on the level of coverage required. We have undertaken two scenarios: 1) Radar replaced to 'existing' level of coverage: $18M (nominal) 2) Radar replaced to mimic coverage of planned (extended) ADS-B coverage levels: $96M (nominal).[12] Maintenance and operating costs: 1) Existing system: $382,000 p.a. 2) Extended system: $2.4M p.a.
Capital Cost of Mode C Replacement Avoided	Mode C transponders will no longer need to be replaced when they arrive at the end of their useful life.	**Quantified: Yes** **Incidence: Aircraft owners** This is an offsetting benefit to the cost of upgrading to ADS-B systems. Most transponders are at the end of their useful life, it is assumed that over the next 10 years 100% of transponders would need to be replaced.	► There are approximately 3,100 aircraft with existing Mode A/C transponders. ► The replacement cost is assumed to be $2,600 per unit based on advice from avionics experts and online searches. ► It is assumed that 100% of these users would replace their Mode A/C transponder when it failed / required replacement, but only 80% would upgrade to ADS-B.
Increased Safety	Better situational awareness and better airspace management due to enhanced information and accuracy may reduce airspace incidents, such as loss of separation and 'near miss' events. This can be attributed to: ► Enhanced real-time information (as opposed to radar to which provides data every 6 to 12 seconds) ► Increased situational awareness allowing ATC to have greater accuracy over relative location of aircraft.	**Quantified: Yes, also assessed qualitatively** **Incidence: Aircraft owners, operators, passengers** Calculating safety benefits is highly uncertain, particularly where there are few fatalities and small sample sizes. As a result, this report presents a wide range of safety benefits. There have been 166 near collision and loss of separation incidents recorded in controlled airspace in the last 5 years, and 3580 airspace incidents recorded, excluding large aircraft which operate almost exclusively above FL-245 and are outside the scope of this analysis. The Capstone project in Alaska – one of the few studies to closely examine the benefits of ADS-B on accidents – showed a 40% reduction in incidents after the introduction of ADS-B.[13] To estimate the reduction in incidents attributable to ADS-B we have taken ¼ of the benefits achieved in the Capstone project. The ¼ reduction is arbitrary, but is based on what was viewed by CAA and Airways as an appropriate scaling factor given the differences in terrain, enhanced coverage (in the Alaskan example), greater adoption of ADS-B in, and different cultural and behavioural factors between New Zealand and Alaskan aviation participants. This reduction in accident rates is applied over time, scaled by air traffic growth, and multiplied by the VoSL. This calculation provides a wide-range of results, depending on whether only near collisions and loss of separation events are counted, or whether all airspace incidents are included. The range is: $0.5M - $9.9M NPV equating to approximately 0.25 – 4 lives saved over the 20 year analysis period.	**Valuing Incidents** A well-known relationship between incidents, accidents and fatalities was established in *Industrial Accident Prevention: A Scientific Approach.* For every ► 300 incidents there are ► 29 accidents and ► 1 fatality (0.33%).[14] This relationship has been tested in multiple industries over the last 70 years and appears to hold with surprising regularity. It also comports with the CAA data on incidents, with the CAA recording approximately 0.32% the number of fatalities relative to incidents.[15] **Value of Statistical Life (VoSL)** We have taken the standard statistical value of life to be $4.22M based on the *NZTA Economic Evaluation Manual for the Value of Statistical Life (VOSL).*[16] Air traffic growth is taken to be 1.7% per annum[17], and incidents and accidents are assumed to increase proportionally with air traffic growth.
Potential for Increased Airspace Capacity	There may be benefits to increased capacity at some airports, particularly as airports take the opportunity provided by ADS-B to move from procedural to surveillance control.	**Quantified: No, see MCA.** **Incidence: Aircraft operators, owners, passengers.**	
Time Savings	There may be some secondary time savings accruing to newly enabled ADS-B aircraft that currently avoid controlled airspace.	**Quantified: No, see MCA.** **Incidence: Aircraft operators, owners, passengers.** This benefit is anticipated to be minor, as it would be partially offset by those aircraft owners who no longer can access controlled airspace and take more circuitous routes. It also assumes that operators without existing transponders would upgrade to ADS-B.	
Fuel Savings	As above	As above	

[12] Airways modelling provided to EY.
[13] http://www.planeandpilotmag.com/proficiency/pilot-skills/the-faas-capstone-project.html?tmpl=component&print=1
[14] Heinrich, H.W., Industrial Accident Prevention; A Scientific Approach. 1950, McGraw-Hill, NY.
[15] https://www.caa.govt.nz/assets/legacy/Safety_Reports/2016-q4-Safe-Sum-Rep.pdf
[16] *NZTA Economic Evaluation Manual.* 2016, NZTA. ISBN: 978-0-748-40782-2.
[17] Airways assumptions.

Table 3 Benefits of ADS-B <FL-245 Mandate			
Benefits	**Description**	**Quantification and Methodology**	
Tracking and Search and Rescue (SAR)	It is anticipated that there may be some moderate benefits to SAR due to: ► Greater airspace coverage and better data to lower levels. This benefit was not expected to be particularly significant, as the most significant challenge with SAR in New Zealand is the nature the terrain – both in terms of rescue and signal acquisition after an aircraft has gone down, not a lack of information about an aircraft's last known position prior to uncontrolled or controlled flight into terrain. There may be some benefits in the greater coverage provided by ADS-B relative to the existing radar system, given its ability to identify an aircraft in distress over 45% more area. There will also be some quantitative benefits, particularly to flight training schools who retire their tracking systems.	**Quantified: Yes / No** **Incidence: Training schools (quantitative), aircraft owners, operators, and passengers (qualitative).** Training schools may use ADS-B signals to track and find lost aircraft, although ADS-B is not being designed for this purpose. Currently, training aircraft are equipped with tracking systems to enable flight schools to monitor and find any lost aircraft. The cost of these systems can be up to $1700 per aircraft per annum. The MCA has also qualitatively assessed the likelihood of SAR benefits.	
International Compliance	ADS-B is becoming the international standard. Adopting ADS-B avoids the risk that NZs systems and training is inconsistent with international standards which could reduce the value pilot training received in NZ.	**Quantified: No** **Incidence: Aircraft operators, pilots, training schools**	

5. Cost Benefit Analysis Results

5.1 Summary of Results

This section presents the summary of the quantified costs and benefits of the proposed implementation of ADS-B below FL-245.

The benefits and costs are presented in Net Present Value (NPV) terms which present costs and benefits over time as a single number: a present value, based on the public sector discount rate of 6%. A discount rate represents the value of time and the opportunity cost of capital – essentially the alternative return that could be made if the investment did not proceed. At its most basic an NPV reflects that costs and benefits incurred 'now' are valued more highly than those in the future.

The results of each option are presented as benefit cost ratios (BCRs) which are the total additional net present benefits of a proposed intervention divided by their total additional net present costs, relative to a business as usual solution.

We have considered three scenarios in our analysis, but only one is presented in the body of the document, which compares the ADS-B mandate to the existing radar system. The other two scenarios are included in the Appendix for reference.

In all scenarios, safety benefits accrue under the ADS-B regimes because ADS-B provides benefits to airspace management that cannot be achieved with standard SSR radar. Safety benefits are presented as a range, but given that ADS-B as proposed covers a greater volume of airspace relative to the existing radar system, it would be reasonable to assume that the safety benefits in the main scenario are toward the upper end of the range.

Main Scenario: Comparative Case (Old Radar System to New ADS-B System)

- Generates greater safety benefits relative to the BaU like-for-like coverage model, so it is assumed that total benefits would be: $27.8M - $41.0M
- Costs: $49.7M
- Providing a net benefit / (cost) of: ($21.9) – ($8.7) M resulting in a BCR of 0.56 – 0.82.

Given the extended coverage between the old and new systems, we anticipate it is likely that the BCRs would be toward the top end of this range: between 0.7-0.8.

Based on these results, it is our judgement that the most reasonable BCR for this project is likely to be between 0.7-0.8 over 20 years, based on quantifiable benefits alone.

The summary costs and benefits are summarised in Table 4 below.

Table 4 Costs and Benefits Summary (20Y)

Costs and Benefits	Main Scenario
Benefits	
Airways Capital and Operating Costs Avoided	$18.1M
Mode C Transponder Renewal Avoided	$6.1M
Safety Benefits	$0.8M - $13.9M
Avoided Tracking Costs	$2.9M
Costs	

Table 4 Costs and Benefits Summary (20Y)	
Costs and Benefits	**Main Scenario**
Airways Capital and Operating Costs (ADS-B)	$9.8M
Aircraft Upgrade Costs	$34.5M
Mode A/C Early Obsolescence	$0.7M
Certification (60-Day Policy) Costs	$0.9M
Regulatory Impost (Capital Value Decrease)	$3.4M
Avionics Test Set Costs	$0.5M
Net Benefits (Costs)*	**($21.9M) – ($8.7M)**

*Benefits / Costs may not sum due to rounding

There is at least a reasonable chance that benefits exceed costs, as there are some benefits that could not be calculated and some that are outside the scope of this analysis that may have significant impacts on flights above *and* below FL-245. For example:

- ► There are likely to be some performance benefits as airports take advantage of ADS-B to transition from procedural to surveillance based control, enhancing aerodrome access and increasingly theoretical capacity.
- ► Flights that primarily operate above FL-245 may benefit from enhanced PBN during landing and take-off, and these systems are enhanced if there is ADS-B below FL-245.

Sensitivity Testing

Sensitivity testing of the BCR shows that as the period of analysis is extended the BCR modestly rises reflecting that benefits outweigh costs in out-years. For example, with a 40 year analysis period, the Main Scenario has a BCR range of 0.60 – 0.96. This BCR **does not** include the potential requirement for ADS-B system renewal, which may be required over this period.

5.1.1 Incidence Summary

Cost Benefit Analyses do not consider the equity impacts of investments or interventions – that is, it does not provide a way to make a judgement on whether a policy is 'fair'. To consider the fairness and equity of a policy, it can be useful to consider the incidence of costs and benefits. In the following sections, the benefits and costs will be examined in more detail, and the way in which those benefits and costs accrue to Airways, aircraft operators / owners will be explained.

In summary:

- ► Benefits are driven almost exclusively by the reduction in capital costs to Airways who avoid $18.1M in capital upgrade costs and also incur lower operational costs, and these cost reductions may be reflected in lower fees charged by Airways.
- ► The incidence of upgrade costs falls most heavily on older and/or lower cost aircraft that are less likely to have approved STCs, and disproportionately affects the Microlight aircraft sector that have few STCs, high upgrade costs (due to power requirements) and operate in controlled airspace relatively infrequently.
- ► Safety benefits accrue to those aircraft with the highest flying times, which are not – in general – the same aircraft that bear the highest upgrade costs as a proportion of the aircraft's value.

5.2 Airways capital and operating expenditure costs & benefits

The primary beneficiary of the proposal in quantitative terms is Airways, who avoids significant costs as a result of the shift from radar to ADS-B. ADS-B is a 'passive' system; it requires low power, no transmitter, and as a solid state system requires little maintenance.

We received data from Airways New Zealand on their planned capital investments and operating expenditure and used the implementation phasing assumptions for systems above FL-245 to apportion costs of the below FL-245 system, assuming that the system would be in place by 2020 – a year before the proposed mandate comes into force.

We have input all planned costs as costs, and taken avoided costs (e.g. the radar replacement and avoided maintenance costs) as benefits. This is consistent with the approach outlined in the NZ Treasury's CBA manual.

The costs and 'avoided costs' (benefits) are outlined below in Table 5.

Table 5 Airways Costs and Benefits

Scenario	Costs (NPV)	Benefits (NPV)	Net Benefits
Main Scenario: BaU Coverage Levels	Capital: $2.1M Operating: $0.94M	Capital: $14.7M Operating: $3.4M	**$15.1M**

5.3 Aircraft operator / owners capital costs & benefits

Aircraft owners and operators bear most of the costs of the proposed ADS-B below FL-245 mandate, and they bear the same costs under all scenarios (as all alternative scenarios under test assume an ADS-B regime).

The exact number of aircraft with existing Mode-S or ADS-B transponders was not available from CAA, so instead a list of aircraft that had been 'pinged' by radar in the last year was provided. This list was used to calculate the number of aircraft overall that would require upgrades.

Aircraft that normally operate above FL-245 have been excluded from this analysis.

As noted in Section 2, the costs of upgrade vary significantly depending on many factors, most notably whether the aircraft has an existing STC. Using previous work undertaken by Massey University, we were also able to apportion costs by whether aircraft had an STC or not.

Table 6 below reflects the aircraft subject to this analysis by category.

Table 6 Aircraft Numbers by Category and Equipage

Type	Mode S Only	ADS-B Equipped	Neither ADS-B NOR Mode S
Aeroplane (with applicable STC)	156	39	1032
Helicopter (with applicable STC)	85	12	582
Aeroplane (without STC)	55	16	691
Amateur Built Aeroplane	13	15	269
Amateur Built Glider	0	0	3
Amateur Built Helicopter	0	0	23

Table 6 Aircraft Numbers by Category and Equipage			
Type	**Mode S Only**	**ADS-B Equipped**	**Neither ADS-B NOR Mode S**
Glider	24	0	262
Gyroplane	25	1	46
Helicopter	45	4	115
Microlight (Class 1)	3	1	202
Microlight (Class 2)	58	18	804
Powerglider	10	0	41

We assume that 100% of Mode-S equipped aircraft will enter controlled airspace, and that 80% of all other aircraft will enter controlled airspace and require a transponder, with the exception of gliders where we assume that 70% will enter controlled airspace.

Aircraft operators also receive a small benefit in avoiding the cost of Mode C renewal, which they would otherwise be required to undertake, but which is partially offset by the early retirement (obsolescence) of Mode C transponders.

These costs also exclude the upgrade of aircraft that will not be upgraded as they are sold or are used only in 'uncontrolled airspace' (see Section 3.3).

This results in the following costs (in net present value terms):

Table 7 Costs & Benefits of Aircraft Equipage ($NPV)	
Type	**ADS-B Upgrade Costs**
Aeroplane	$14.2M
Amateur Built Aeroplane	$2.6M
Amateur Built Glider	$0.0M
Amateur Built Helicopter	$0.2M
Glider	$2.7M
Gyroplane	$0.7M
Helicopter	$5.6M
Microlight (Class 1)	$1.5M
Microlight (Class 2)	$6.5M
Powerglider	$0.4M
Retirement of Mode C Transponders (all aircraft)	$0.7M
Avoided Mode C Replacement Cost (all aircraft)	$6.0M
Net Costs*	**$29.2M**

*Totals may not sum due to rounding

5.4 Regulatory Impost Costs

There are costs imposed by the implementation of ADS-B that go beyond the simple equipage costs of the aircraft. For some users, the cost of equipping an aircraft will be judged by them to be too high relative to the value of the aircraft, or it will be viewed as 'uneconomic' given the amount of time they use controlled airspace.

These users suffer a regulatory impost, made up of real asset value reduction, a reduction in their enjoyment of their aircraft, and a reduction in option value – their ability to freely enter controlled airspace. As a proxy for these costs, a one off asset value reduction method is used, where those individuals who choose not to upgrade and are left with an aircraft that cannot enter controlled airspace.

Based on stakeholder feedback, the level at which it would become likely that a user would not upgrade would be $40,000; stakeholders estimate that 50% of those users would not upgrade. Approximately 40% of microlight aircraft have values under $40,000 based on TradeMe data, and the average value of those aircraft is approximately $35,000.

The value of an aircraft without a transponder is $15,000 based on FSIWG feedback and (limited) TradeMe data.

This equates to a nominal impact of $4.0M on 201 aircraft experienced in 2020 (**$3.4M NPV**). These costs fall almost exclusively on Microlight users, given the relatively low cost of their aircraft relative to the upgrade.

5.5 Costs of Delays to Certification '60 Day Stand Down Policy'

In instances where aircraft require certification for an upgrade, this can take significant time. If a current Mode A/C or More S transponder fails inspection, the owner chooses to upgrade to ADS-B, and there is no STC available, then a design approval and certification is required from CAA. There is an option for aircraft owners to seek approval from a Part 146 organisation, and the 60-day stand down policy is designed to encourage that behaviour, but some aircraft owners still seek to use the CAA for upgrade certification.

This can take 60 days to process, during which time an aircraft cannot, in practice, be flown. This can have significant cost on users.

This time-cost disproportionately affects helicopter users, as they have the highest capital value, although the most likely aircraft to face a delay are Microlights, due to the tendency for those aircraft to have older and less heavily used equipment.

Table 8 Delay Costs

Type	ADS-B Certification / 60-Day Policy Costs
Aeroplane	$0.29M
Amateur Built Aeroplane	$0.11M
Amateur Built Glider	$0.0+M
Amateur Built Helicopter	$0.03M
Glider	$0.06M
Gyroplane	$0.07M
Helicopter	$0.17M
Microlight (Class 1)	$0.02M

Table 8 Delay Costs	
Type	ADS-B Certification / 60-Day Policy Costs
Microlight (Class 2)	$0.09M
Powerglider	$0.0+
Total Costs	**$0.85M**

*Totals may not sum due to rounding

5.6 Safety Costs and Benefits

The willingness to pay (WTP) methodology used by NZTA has been employed to calculate the benefits of increased safety. In 2017, the value of a statistical life on a WTP basis is $4.22M.

This analysis assumes that enhanced situational awareness and better ATC information could result in the avoidance of between 0.5 – 4 fatalities over the 20 year period of analysis, based on an accepted relationship between incidents and fatalities. The range derives from which type of airspace incidents are reduced: if all airspace incidents are reduced (as per the Capstone / Alaska study) than the higher end of the range is appropriate, but if only those that are caused by loss of separation or near collision are reduced than the lower end of the range is more accurate. The values are also strongly dependent on the degree to which incidents are reduced (we have assumed 15%).

In addition, while the benefit of a greater *volume* of coverage cannot be directly calculated, it would not be unreasonable to assume that there are a greater number of incidents, accidents, and fatalities avoided where a larger volume of airspace is covered, and so we would anticipate the benefits to fall at the upper end of this range where ADS-B is implemented as anticipated.

These benefits have been allocated on an incident basis (1/300th of a life-value) to different aircraft types based on the historical number of incidents in which each aircraft class has been involved. These statistics are based primarily on incidents in controlled airspace, so the numbers may be higher. In addition, the aircraft most likely to experience a benefit from reduced incidents are those with the greatest flying time: the commercial aircraft and GA.

Table 9 Safety Benefits from ADS-B	
Type	VOSL Benefits (Accidents / Incidents Avoided)
Aeroplane	$0.60M - $10.92M
Helicopters	$0.11M - $1.55M
Sports Aircraft	
Aeroplane	$0.00+M - $0.29M
Amateur Built Aeroplane	$0.00+M - $0.27M
Amateur Built Glider	$0.00M - $0.00M
Amateur Built Helicopter	$0.00+M - $0.00+M
Glider & Powerglider	$0.01M - $0.20M
Helicopter	$0.00M+ - $0.00+M
Microlights (Class 1 & 2)	$0.03M - $0.70M
Total Benefits	**$0.78M - $13.95M**

5.7 Tracking Costs Avoided (Benefits)

Many flight schools currently use tracking systems to provide an extra layer of safety and security to their trainee pilots, and to ensure that they know the whereabouts of their aircraft at all times. Aircraft training schools currently spend approximately $1,700 per annum per aircraft on tracking systems and their operation. It is estimated that there are approximately 188 training aircraft in New Zealand.

With the advent of ADS-B, it may be possible to replace these systems with data from ground tracking systems that receive ADS-B. This could result in significant cost savings to aircraft training organisations, equating to a benefit of approximately $2.9M PV over 20 years.

6. Multi Criteria Analysis

A MCA is a qualitative framework for assessing options across a set of evaluation criteria. It provides a mechanism by which qualitative factors (or quantitative factors that cannot be assessed) can be robustly evaluated by extracting the intrinsic knowledge of groups. The MCA provides an efficient and consistent way to represent the view of experts on additional benefits and provide another data point about how the ADS-B mandate is likely to affect the operator and owner environment.

The MCA was undertaken in a workshop facilitated by EY on 25 May 2017. The purpose of this MCA was to use a standardised process to evaluate qualitative metrics that are difficult, expensive, and time-consuming to assess using a standard CBA.

Categories and criteria

The ADS-B mandate scenario was tested against a set of criteria that were organised into categories, weighted and agreed by the participants at the MCA workshop. The weightings were reported via email and derived by an exercise using pairwise comparison. Table 10 describes the relevant criteria and weights.

The FSIWG group generally felt that indirect compliance costs were of the most importance to operations and decision making, with no appreciable difference between the other three categories. Sensitivity testing was conducted on outlier scoring (i.e. changing individual scores that fell well outside the mean), but it did not change the relative ranking of the criteria.

6.1 Categories and Criteria

Table 10 MCA Categories, Criteria, and Weights

MCA Categories	MCA Criteria	Description	Weights
Safety and Search and Rescue	**How does the planned ADS-B system impact the ability of S&R to locate and rescue aircraft?**	Will increased positional accuracy increase the ability for search and rescue to successfully locate aircraft that have had experienced an accident?	22%
	How does ADS-B affect pilots' ability to remain safe within *controlled* airspace?	Will increased accuracy, coverage and better situational awareness (for example with ADS-IN) lead to increased safety in controlled and uncontrolled airspace?	
	How does ADS-B affect pilot's ability to remain safe within *uncontrolled* airspace? (Assuming ADS-B In Adoption)		
	How does ADS-B affect pilot's ability to remain safe within *uncontrolled* airspace? (Assuming no / limited voluntary ADS-B In Adoption)		
Operational Efficiency	**Changes to flight patterns decrease fuel consumption?**	There are instances where flights fly 'around' controlled airspace. Does the ADS-B regulation make this more likely or less likely?	24%
	Changes to flight patterns / airport operations reduce flight time / improve queuing time?	Can ADS-B enable better air traffic management and reduce flight time by reducing crowding / queuing or by allowing for PBN to be applied below FL-245?	
Airspace Use	**ADS-B increases capacity at airports currently operating under procedural control.**	Will increased capacity, particularly at those airports operating currently under procedural control (if transitioned) provide operational benefits?	23%

	Longer term, the ease of accessing controlled airspace will increase.	Accessing controlled airspace may become easier as procedurally controlled airspace is replaced by surveillance.	
Indirect Compliance Costs	Certification causes significant (3+ week) delays during which an aircraft is unusable?	How often will upgrades need to occur when a transponder has failed, especially prior to the mandate, where certification delays would lead to a loss of aircraft use for a significant period?	31%
	Pilots turn off their transponders to avoid detection in controlled airspace.	How likely is it that ADS-B incentivizes pilots to 'turn off' transponders when using controlled airspace to avoid costs?	

6.2 Summary of Results

The participants were asked to score the likelihood that different aircraft users would experience these benefits relative to operations today. They could say that each item was:

- Much More Likely
- More Likely
- Somewhat More Likely
- No Change
- Somewhat Less Likely
- Less Likely
- Much Less Likely

to occur under an ADS-B mandate than under today's scenario.

In summary:

- The results are broadly consistent with the results of the CBA, with FSIWG members considering that there are significant benefits to ADS-B but with significant concerns being expressed in terms of cost and the creation of perverse safety incentives.

- The group felt smaller Sport Aircraft operators – particularly microlights – would be the most affected by the regulation, both positively and negatively, with commercial operators the least affected.

- The results suggest that increased safety within uncontrolled airspace is the most likely and most beneficial outcome to all users with the potential for voluntary ADS-B In creating strong potential benefits, although these benefits could be offset by an 'overreliance' on the ADS-B system for situational awareness.

- The greatest risks were perceived to be in changes to flight patterns and pilots choosing to turn off their transponders to avoid detection in controlled airspace. There was significant concern that – particularly non-commercial operators – would be significant and adversely affected by the cost of upgrading their fleet, and may choose to operate 'outside' of controlled airspace, even if this required longer travel times / more circuitous routes. This may also encourage some users to turn off their transponders (if they have them) within controlled airspace to avoid detection and take the preferred route, particularly if their transiting of controlled airspace is infrequent. A view was also expressed that some operators may turn off their transponders to avoid Airways fees.

- A risk was also perceived that Sports Aircraft operators would be disproportionately affected by upgrade delays, given the lack of STCs for their aircraft.

Table 11 below shows the results of the MCA scoring. The vertical results axis shows the scores for each category, and the horizontal results axis shows the most affected users overall by rank. Higher scores mean that the impact of ADS-B was seen as more positive, while negative score meant that it would have a negative impact.

Table 11 MCA Results

Category	Criteria	Base Case	ADS-B Impact on Commercial Operators	ADS-B Impact on Individual Aircraft Operators (NOI)	ADS-B Impact on Sports Aircraft	ADS-B Impact on Flight Training	Score (Criteria)
Safety and Search and Rescue	How does the planned ADS-B system impact the ability of S&R to locate and rescue aircraft?	No Change	Somewhat More Likely	More Likely	More Likely	No Change	36
	How does ADS-B affect pilots' ability to remain safe within *controlled* airspace?	No Change	No Change	Somewhat More Likely	Somewhat More Likely	Somewhat More Likely	22
	How does ADS-B affect pilots' ability to remain safe within *uncontrolled* airspace? (Assuming ADS-B In Adoption)	No Change	Much More Likely	Much More Likely	Much More Likely	Much More Likely	88
	How does ADS-B affect pilots' ability to remain safe within *uncontrolled* airspace? (Assuming no / limited voluntary ADS-B In Adoption)	No Change	No Change	No Change	No Change	No Change	0
Operational Efficiency (Time and Fuel)	Changes to flight patterns decrease fuel consumption?	No Change	No Change	No Change	Somewhat Less Likely	No Change	-11
	Changes to flight patterns / airport operations reduce flight time / improve queuing time?	No Change	Somewhat More Likely	Somewhat More Likely	Somewhat More Likely	Somewhat More Likely	47
Airspace Use	ADS-B increases capacity at airports currently operating under procedural control.	No Change	Somewhat More Likely	Somewhat More Likely	Somewhat More Likely	More Likely	58
	Longer term, the ease of accessing controlled airspace will increase.	No Change	Somewhat More Likely	Somewhat More Likely	Somewhat More Likely	Somewhat More Likely	58
Indirect Compliance Costs (not direct costs)	Certification causes significant (>3week) delays during which the aircraft is unusable.	No Change	Somewhat More Likely	More Likely	Much More Likely	More Likely	68
	Pilots turn off their transponders to avoid detection in controlled airspace.	No Change	No Change	Somewhat More Likely	Somewhat More Likely	Somewhat More Likely	-34
Score (Aircraft) (RANK)			4	2	1	3	

6.3 Rationale

The rationale for the scoring of each category is described below:

How does the planned ADS-B system impact the ability of SAR to locate and rescue aircraft?
The group considered that there was a somewhat improved likelihood that ADS-B would positively impact the ability of SAR to locate commercial aircraft, but that this benefit would be relatively minor as many commercial operators already have emergency transponders, and fly predominantly in controlled airspace.

It was considered more likely that ADS-B would provide benefits for private recreational and Part 91 aircraft users as increased coverage to 500m / ground level will provide for greater positional accuracy and will cover a larger overall volume of airspace.

Flight training schools were not expected to obtain significant benefits from additional coverage, apart from the already quantified ability to retire existing tracking systems (TS).

How does ADS-B affect pilots' ability to remain safe within *controlled* airspace?
It was not anticipated that there would be any (significant) safety benefit to commercial operators as ATC already manages flight conflicts, and many commercial operators already utilise aircraft conflict avoidance systems (ACAS) or .

It was considered that it was **somewhat likely** that ADS-B could provide a level of enhanced safety for the remainder of the GA fleet as there will be greater overall coverage and the potential for enhanced situational awareness through voluntary acquisition of ADS-B IN. The benefits to flight training were viewed as similar to other GA aircraft, but they may achieve greater benefits in practice, as they are more likely to acquire ADS-B In as part of the planned upgrades.

How does ADS-B affect pilots' ability to remain safe within *uncontrolled* airspace?
Two scenarios were considered for uncontrolled airspace:

- **Scenario 1:** If there is limited / no voluntary acquisition of ADS-B IN, then there would be no change to safety in *uncontrolled* airspace, as ADS-B OUT only transmits information and there is no active ATC separation applied in uncontrolled airspace.

- **Scenario 2:** If aircraft operators voluntarily acquire ADS-B IN as part of their upgrades, then there could be significant benefits due to increased situational awareness: extending 'see and avoid' to 'see, be seen, and avoid'. It was noted, however, that high reliance on ADS-B IN, especially for VFR operators could have a perverse and partially offsetting impact on safety, substituting visual awareness for an overreliance on equipment.

Changes to flight patterns leading to a decrease in fuel consumption?

No change was anticipated for most aircraft as flight routes would not change solely as a result of ADS-B implementation.

The portion of the fleet that is most likely to have the highest upgrade costs as a proportion of the value of the aircraft -- Sport Aircraft operators – are the most likely to avoid the cost of upgrade and therefore may be more strongly incentivised to choose more circuitous or less efficient flight paths to avoid controlled airspace and the cost of upgrades.

Changes to flight patterns / airport operations reduce flight time / improved queuing time?
There may be some benefits resulting from ADS-B providing more frequent and more accurate data to air traffic control, which would enable enhanced management of controlled airspace relative to current operations driving better airspace management in areas of high aircraft density.

It is also possible that the shift to surveillance control enabled by ADS-B could relieve current issues of controllers being unwilling and unable to permit some flights entry to controlled airspace due to the volume of traffic present.

ADS-B increases capacity at airports currently operating under procedural control.
It is somewhat likely that aircraft receive benefits as airports transition procedural to surveillance control. This is particularly true for flight training instructors who would be able to take advantage of surveillance control for IFR training and redistribute flights from other, busier airports.

The capacity of these airports are not currently constrained by demand, however, and the on-ground infrastructure (e.g. aprons and taxi ways) may be unable to cope with additional aircraft demand, meaning that the theoretical increase in capacity might not support additional aircraft movements.

Longer term, the ease of accessing controlled airspace will increase.

It was considered that longer term it is somewhat likely that access to controlled airspace could improve for ADS-B equipped aircraft. The shift to surveillance control enabled by ADS-B could relieve the current issues experienced by controllers being unwilling to permit some flights entry to controlled airspace due to the volume of traffic present. This was viewed as only somewhat likely to affect aircraft across all operational groups, however, as many of the aircraft affected by these potential changes operate at airports without current demand constraints.

Certification causes significant (>3week) delays during which the aircraft is unusable due to the time required to receive certification for modifications (the 60-day stand down policy).
It was considered only somewhat likely that commercial operators would be affected by delays due to upgrades. Most commercial aircraft will have applicable STCs and therefore will not be subject to certification delays, even if their existing transponders are found to have failed.

It was more likely that the delays associated with a failed transponder, the decision to upgrade, and the need to seek and receive certification for a modification would affect individual aircraft operators and training aircraft, but a large proportion of these aircraft also have applicable STCs.

It is highly likely that sports aircraft would be affected. The nature and type of these aircraft means that they are unlikely to have an applicable STC and their existing transponders are more likely to be older and/or used less frequently, meaning there is a greater chance that they may have failed without the knowledge of the aircraft operator or owner leading to unexpected delays should they decide to proceed with an upgrade to ADS-B.

Pilots turn off their transponders to avoid detection in controlled airspace.

All aircraft users, except for commercial aircraft operators, were viewed as somewhat more likely to avoid transponder usage due to the high costs of upgrade and the ability to Airways to automatically identify (and charge) aircraft using Mode-S transponders in controlled airspace.

There are also strong incentives on GA operators to avoid the cost of upgrade to ADS-B but transit small areas of controlled airspace regardless, in order to reduce flight time / cost, particularly if the use of controlled airspace is incidental or infrequent.

Commercial aircraft operators were viewed as having a strong incentives to comply with regulations given the high economic costs of penalties, including loss of licences to operate, so there was no change expected from the base case as a result of the ADS-B mandate.

Appendix A – Example Cost / Benefit Calculation Detail

Summary Sheet: Extended ADS-B System versus BaU Radar System	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Costs																					
Capital Costs (Airways)	$ 2,533,333	$ 2,533,333	$ 2,533,333	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Upgrade Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Aeroplane	$ 3,250,380	$ 4,875,570	$ 8,125,950	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Amateur Built Aeroplane	$ 600,500	$ 900,750	$ 1,501,250	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Amateur Built Glider	$ 5,320	$ 7,980	$ 13,300	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Amateur Built Helicopter	$ 47,880	$ 71,820	$ 119,700	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Glider	$ 611,400	$ 917,100	$ 1,528,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Gyroplane	$ 153,420	$ 230,130	$ 383,550	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Helicopter	$ 1,275,300	$ 1,912,950	$ 3,188,250	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Microlight Class 1	$ 352,400	$ 528,600	$ 881,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Microlight Class 2	$ 1,494,840	$ 2,242,260	$ 3,737,100	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Power Glider	$ 99,140	$ 148,710	$ 247,850	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Regulatory Impost (Value Decrease Not Otherwise Captured)	$ -	$ -	$ 4,020,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Mode A/C Early Termination	$ -	$ -	$ 794,196	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Operational / Maintenance	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Airways (Based on Proportion)	$ -	$ -	$ -	$ 328,715	$ 328,715	$ 328,715	$ 328,715	$ 328,715	$ 328,715	$ 328,715	$ 328,715	$ 328,715	$ 328,715	$ 328,715	$ 328,715	$ 328,715	$ 328,715	$ 328,715	$ 328,715	$ 328,715	$ 328,715
Test Set Kit Upgrades	$ 160,000	$ 200,000	$ 205,000																		
Total (Nominal)	$ 10,583,913	$ 14,569,203	$ 27,278,979	$ 328,715	$ 328,715	$ 328,715	$ 328,715	$ 328,715	$ 328,715	$ 328,715	$ 328,715	$ 328,715	$ 328,715	$ 328,715	$ 328,715	$ 328,715	$ 328,715	$ 328,715	$ 328,715	$ 328,715	$ 328,715
Total NPV	$ 10,168,432	$ 13,226,362	$ 23,312,484	$ 260,373	$ 245,635	$ 231,731	$ 218,615	$ 206,240	$ 194,566	$ 183,553	$ 173,163	$ 163,362	$ 154,115	$ 145,391	$ 137,161	$ 129,398	$ 122,073	$ 115,163	$ 108,645	$ 102,495	$ 96,693
Benefits																					
Capital Costs Avoided																					
MSSR System Coverage	$ -	$ -	$ 9,000,000	$ 9,000,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Renewal of Mode C Transponders	$ 816,192	$ 816,192	$ 816,192	$ 816,192	$ 816,192	$ 816,192	$ 816,192	$ 816,192	$ 816,192	$ 816,192	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Operational Costs Avoided	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
MSSR System Maintenance	$ -	$ -	$ -	$ 382,500	$ 382,500	$ 382,500	$ 382,500	$ 382,500	$ 382,500	$ 382,500	$ 382,500	$ 382,500	$ 382,500	$ 382,500	$ 382,500	$ 382,500	$ 382,500	$ 382,500	$ 382,500	$ 382,500	$ 382,500
Safety Benefit	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Incidents Excluding Agricultural Aircraft	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Helicopters	$ -	$ -	$ -	$ 161,951	$ 162,501	$ 163,054	$ 163,608	$ 164,165	$ 164,723	$ 165,283	$ 165,845	$ 166,409	$ 166,974	$ 167,542	$ 168,112	$ 168,683	$ 169,257	$ 169,832	$ 170,410	$ 170,989	$ 171,570
	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Medium Aeroplanes	$ -	$ -	$ -	$ 163,193	$ 163,748	$ 164,305	$ 164,864	$ 165,424	$ 165,987	$ 166,551	$ 167,117	$ 167,685	$ 168,255	$ 168,828	$ 169,402	$ 169,978	$ 170,555	$ 171,135	$ 171,717	$ 172,301	$ 172,887
Small Aeroplanes	$ -	$ -	$ -	$ 996,556	$ 999,944	$ 1,003,344	$ 1,006,756	$ 1,010,179	$ 1,013,613	$ 1,017,059	$ 1,020,517	$ 1,023,987	$ 1,027,469	$ 1,030,962	$ 1,034,467	$ 1,037,985	$ 1,041,514	$ 1,045,055	$ 1,048,608	$ 1,052,173	$ 1,055,751
Sport Aircraft	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Aeroplane	$ -	$ -	$ -	$ 31,479	$ 31,586	$ 31,693	$ 31,801	$ 31,909	$ 32,018	$ 32,127	$ 32,236	$ 32,345	$ 32,455	$ 32,566	$ 32,676	$ 32,788	$ 32,899	$ 33,011	$ 33,123	$ 33,236	$ 33,349
Amateur Built Aeroplane	$ -	$ -	$ -	$ 29,408	$ 29,508	$ 29,608	$ 29,709	$ 29,810	$ 29,911	$ 30,013	$ 30,115	$ 30,217	$ 30,320	$ 30,423	$ 30,527	$ 30,630	$ 30,735	$ 30,839	$ 30,944	$ 31,049	$ 31,155
Amateur Built Glider	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Amateur Built Helicopter	$ -	$ -	$ -	$ 828	$ 831	$ 834	$ 837	$ 840	$ 843	$ 845	$ 848	$ 851	$ 854	$ 857	$ 860	$ 863	$ 866	$ 869	$ 872	$ 875	$ 878
Glider	$ -	$ -	$ -	$ 13,668	$ 13,715	$ 13,762	$ 13,808	$ 13,855	$ 13,902	$ 13,950	$ 13,997	$ 14,045	$ 14,092	$ 14,140	$ 14,188	$ 14,237	$ 14,285	$ 14,334	$ 14,382	$ 14,431	$ 14,480
Helicopter	$ -	$ -	$ -	$ 414	$ 416	$ 417	$ 418	$ 420	$ 421	$ 423	$ 424	$ 426	$ 427	$ 428	$ 430	$ 431	$ 433	$ 434	$ 436	$ 437	$ 439
Microlight Class 1	$ -	$ -	$ -	$ 5,385	$ 5,403	$ 5,421	$ 5,440	$ 5,458	$ 5,477	$ 5,495	$ 5,514	$ 5,533	$ 5,552	$ 5,570	$ 5,589	$ 5,608	$ 5,627	$ 5,647	$ 5,666	$ 5,685	$ 5,704
Microlight Class 2	$ -	$ -	$ -	$ 70,413	$ 70,653	$ 70,893	$ 71,134	$ 71,376	$ 71,619	$ 71,862	$ 72,106	$ 72,352	$ 72,598	$ 72,844	$ 73,092	$ 73,341	$ 73,590	$ 73,840	$ 74,091	$ 74,343	$ 74,596
Power Glider	$ -	$ -	$ -	$ 7,870	$ 7,896	$ 7,923	$ 7,950	$ 7,977	$ 8,004	$ 8,032	$ 8,059	$ 8,086	$ 8,114	$ 8,141	$ 8,169	$ 8,197	$ 8,225	$ 8,253	$ 8,281	$ 8,309	$ 8,337
Accident, Excluding Agricultural Aircraft	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Helicopter	$ -	$ -	$ -	$ 4,285	$ 4,299	$ 4,314	$ 4,329	$ 4,343	$ 4,358	$ 4,373	$ 4,388	$ 4,403	$ 4,418	$ 4,433	$ 4,448	$ 4,463	$ 4,478	$ 4,493	$ 4,509	$ 4,524	$ 4,539
Small Aeroplane	$ -	$ -	$ -	$ 12,854	$ 12,898	$ 12,942	$ 12,986	$ 13,030	$ 13,074	$ 13,119	$ 13,163	$ 13,208	$ 13,253	$ 13,298	$ 13,343	$ 13,389	$ 13,434	$ 13,480	$ 13,526	$ 13,572	$ 13,618
	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Potential Tracking Benefits (Training) - Cost Savings	$ -	$ -	$ -	$ 322,232	$ 322,232	$ 322,232	$ 322,232	$ 322,232	$ 322,232	$ 322,232	$ 322,232	$ 322,232	$ 322,232	$ 322,232	$ 322,232	$ 322,232	$ 322,232	$ 322,232	$ 322,232	$ 322,232	$ 322,232
Total Benefits (Nominal)	$ 816,192	$ 816,192	$ 9,816,192	$ 12,019,229	$ 3,024,323	$ 3,029,435	$ 3,034,564	$ 3,039,710	$ 3,044,874	$ 3,050,055	$ 2,239,062	$ 2,244,279	$ 2,249,514	$ 2,254,766	$ 2,260,036	$ 2,265,324	$ 2,270,630	$ 2,275,954	$ 2,281,296	$ 2,286,656	$ 2,292,035
Total Benefits (NPV @ 6%)	$ 769,992	$ 726,408	$ 8,241,864	$ 9,520,355	$ 2,259,950	$ 2,135,632	$ 2,018,158	$ 1,907,152	$ 1,802,256	$ 1,703,135	$ 1,179,510	$ 1,115,338	$ 1,054,660	$ 997,285	$ 943,034	$ 891,736	$ 843,231	$ 797,366	$ 753,998	$ 712,990	$ 674,214
Net Benefits	-$ 9,398,440	-$ 12,499,954	-$ 15,070,619	$ 9,259,982	$ 2,014,315	$ 1,903,900	$ 1,799,544	$ 1,700,912	$ 1,607,690	$ 1,519,582	$ 1,006,347	$ 951,976	$ 900,545	$ 851,894	$ 805,873	$ 762,339	$ 721,158	$ 682,203	$ 645,353	$ 610,495	$ 577,521
Net Benefits 30Y NPV	**-$ 8,647,385**																				

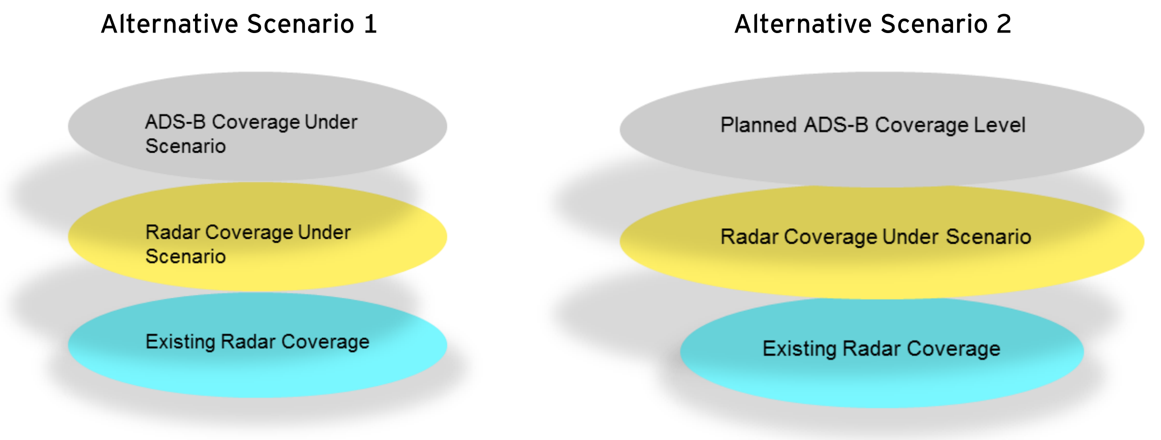
Appendix B – Alternative Scenarios

We have also worked to understand the potential impacts of different scenarios on the cost-benefit analysis results. In particular, we were interested in investigating what would happen if different directives were provided by decision-makers regarding the extent of ADS-B or radar.

- **Alternative Scenario** 1 tests what would happen if a decision was taken to reduce the coverage of ADS-B to a level that matches the existing radar coverage – which reduces the cost of the ADS-B system.

- **Alternative Scenario 2** tests what would happen if a question were asked about the costs of extending radar coverage to 'match' the volume of coverage provided by ADS-B.

These scenarios represent potential futures, but they are 'synthetic' in that they suppose the imposition of external settings or realities that have not occurred. This means that the BCRs can be deceiving. For example, Scenario 2 appears to generate large 'benefits' and a high BCR – and it does – but it assumes that the base case would be a scenario where radar would need to be extended to cover the same volume of airspace as ADS-B. In this case, the costs avoided by not having to invest in radar at this level are very high and are taken as a benefit. It does not mean that this scenario performs 'better' than the other scenarios in this document – it simply demonstrates that under certain policy settings there are large cost savings to moving to ADS-B relative to using radar.



The balance of this section describes the alternative scenarios and summarises the results. The methodology used is the same as for the Main Scenario.

Alternative Scenario 1: Maintaining current coverage using radar

Base Case

- There is no mandate for ADS-B below FL-245.
- Secondary radar is maintained at a level that provides the same coverage for below FL-245 as is in place today.

Alternative Case

- ADS-B is mandated for all aircraft in controlled airspace; the ADS-B network provides the *same volume* of coverage as the existing radar system, although the quality of coverage could increase (e.g. accuracy).
- The current radar systems are retired in 2021.
- A cooperative contingency system remains in place for the main trunk.

Alternative Scenario 2: Enhanced Coverage

Base Case

- There is no mandate for ADS-B below FL-245.
- A policy decision is made to extend coverage to 'match' what would have been covered with ADS-B. If this base case was being considered, then the rationale for this policy decision would need to be subject to a separate CBA.
- Radar is extended to provide the same volume of extended coverage that is planned for the ADS-B roll out, but positional accuracy would not be enhanced to the same degree as with ADS-B as ADS-B would not be mandated below FL-245 (i.e. there would be no GNSS information provided, although some operators – particularly larger commercial operators – may voluntarily choose to adopt the system).

Alternative Case

- ADS-B is mandated for all aircraft in controlled airspace; and the ADS-B network provides a greater volume of coverage relative to today's systems. The system provides for better positional accuracy and more efficient, higher accuracy air traffic management as GNSS based ADS-B transponders are required over the entire volume of controlled airspace.
- ATC has better visibility of aircraft within surveillance coverage while outside controlled airspace, providing potential safety benefits in the event of an aircraft emergency, loss of situational awareness, etc.
- The current radar systems are retired in 2021.
- A cooperative contingency system remains in place for the main trunk.

The results of each option are presented as benefit cost ratios (BCRs) which are the total additional net present benefits of a proposed intervention divided by their total additional net present costs, relative to a business as usual solution.

As previously noted, in all scenarios, safety benefits accrue under the ADS-B regimes because ADS-B provides benefits to airspace management that cannot be achieved with standard SSR radar. Safety benefits are presented as a range, but given that these two scenarios assume a like-for-like coverage volume (whether BaU or extended), the difference between the base case and the alternative case is likely to be lower than in the Main Scenario. We therefore anticipate that the safety benefits for Additional Scenario 1 will be toward the lower end of the range presented, and the benefits for Additional Scenario 2 only slightly higher.

Alternative Scenario 1 (BaU: Identical Coverage Level):

- Generates $27.6M – $36.4M in benefits
- Costs $43.0M
- Providing a net present benefit / (cost) of: ($15.4) – ($6.6) M resulting in a BCR of 0.64 - 0.85 of quantifiable benefits. It is anticipated that the benefits would be toward the bottom of this range, meaning that the true BCR is likely to be closer to 0.65 – 0.7 in this scenario.

Alternative Scenario 2 (Extended Coverage Levels):

- Generates $108.9M - $117.7M in benefits, primarily from avoided upgrade costs to airways.
- Costs: $49.7M
- Providing a net benefit / (cost) of: $59.2M - $68.0M and a BCR of 2.19 - 2.37.

Table 12 Costs and Benefits Summary (20Y)			
Costs and Benefits	**Scenario 1**	**Scenario 2**	**Scenario 3**
Benefits			
Airways Capital and Operating Costs Avoided	$18.1M	$99.4M	$18.1M
Mode C Transponder Renewal Avoided	$6.1M	$6.1M	$6.1M
Safety Benefits	$0.5M - $9.3M	$0.5M - $9.328M	$0.8M - $13.9M
Avoided Tracking Costs	$2.9M	$2.9M	$2.9M
Costs			
Airways Capital and Operating Costs (ADS-B)	$3.1M	$9.8M	$9.8M
Aircraft Upgrade Costs	$34.5M	$34.5M	$34.5M
Mode A/C Early Obsolescence	$0.7M	$0.7M	$0.7M
Certification (60-Day Policy) Costs	$0.9M	$0.9M	$0.9M
Regulatory Impost (Capital Value Decrease)	$3.4M	$3.4M	$3.4M
Avionics Test Set Costs	$0.5M	$0.5M	$0.5M
Net Benefits (Costs)*	**($15.4M) – ($6.6M)**	**$59.2M - $68.0M**	**($21.9M) – ($8.7M)**

*Benefits / Costs may not sum due to rounding

Table 13 Airways Costs and Benefits			
Scenario	**Costs (NPV)**	**Benefits (NPV)**	**Net Benefits**
Scenario 1: BaU Coverage Levels	Capital: $2.1M Operating: $0.94M	Capital: $14.7M Operating: $3.4M	**$15.1M**
Scenario 2: Extended Coverage Levels	Capital: $6.7M Operating: $3.0M	Capital: $77.5M Operating: $21.9M	**$89.7M**
Scenario 3: BaU Radar Coverage relative to ADS-B Extended Coverage (Comparative Scenario)	Capital: $6.7M Operating: $3.0M	Capital: $14.7M Operating: $3.4M	**$8.4M**

Appendix C – FSIWG Membership

The Future Surveillance Implementation Working Group (FSIWG) is comprised of representatives from CAA, Airways, and the commercial, recreational, sport aviation communities as well as the avionics profession and training institutes. The membership is detailed below:

Name	Group
Brigid Borlase	Policy, CAA (Convener)
Katie Gunatunga/Jessica Henderson	Policy, CAA
Rod Buchanan/Ryan Nicholl	Flight Operations, CAA
Clayton Hughes	Aircraft Certification, CAA
Carlton Campbell	Aviation Safety Advisor, CAA
Grant Twaddle	Helicopter Flight Operations, CAA
Peter White	Aeronautical Services, CAA
Stu MacKenzie	Royal New Zealand Air Force (RNZAF)
Wayne Blythe	Airways Corporation of New Zealand
Ian Andrews	Aircraft Owners and Pilots Association (AOPA)/ Aviation Federation
Qwilton Biel Mike Groome	Aviation Community Advisory Group
Max Stevens	Gliding New Zealand
Phil Hickman	Air New Zealand Group
Steve Scott (Air Nelson)	Air New Zealand Regional Airlines
Richard Rayward (Air Safari) Alex McHardy (Skyline Aviation) Mark Cook (HNZ) Hank Sproull (Air Milford)	Rule Part 125, 135 Operator(s) – small air transport operations
Peter Armstrong	Sport Aircraft Association NZ (SAANZ)
Robert Feasey Danni Higgins	Aviation Engineering Association of New Zealand
Adam Seumanutafa Philip Hutchings	Avionics Engineers
Ashok Poduval Paul Kearney Malcolm Fraser	Training Organizations (Massey University School of Aviation)
Peter Turnball (Northland Emergency Services Trust)	Emergency services
Dave Brown	Warbirds

Not all members attended all sessions, and – in general – at the instruction of the CAA, outputs from the sessions were only the documents were circulated only to those members who attended sessions.