Partial Regulatory Impact Assessment

PROPOSAL TO AMEND THE AIR NAVIGATION ORDER 2005 FOR THE PURPOSE OF IMPROVING THE TECHNICAL INTEROPERABILITY OF ALL AIRCRAFT IN UK AIRSPACE

Issue 1.2

Code of Practice on Consultation

The code of practice applies to all UK public consultations by government departments and agencies, including consultations on EU directives.

Though the code does not have legal force, and cannot prevail over statutory or other mandatory external requirements (e.g. under European Community Law), it should otherwise generally be regarded as binding unless Ministers conclude that exceptional circumstances require a departure.

The code contains six criteria. They should be reproduced in all consultation documents. There should be an explanation of any departure from the criteria and confirmation that they have otherwise been followed.

Consultation criteria

1. Consult widely throughout the process, allowing a minimum of 12 weeks for written consultation at least once during the development of the policy.
2. Be clear about what your proposals are, who may be affected, what questions are being asked and the time-scale for responses.
3. Ensure that your consultation is clear, concise and widely accessible.
4. Give feedback regarding the responses received and how the consultation process influenced the policy.
5. Monitor your department's effectiveness at consultation, including through the use of a designated consultation co-ordinator.
6. Ensure your consultation follows better regulation best practice, including carrying out a Regulatory Impact Assessment if appropriate.

A full version of the code of practice is available on the Cabinet Office web-site at:
http://www.cabinet-office.gov.uk/regulation/consultation/code.asp

If you consider that this consultation does not comply with the criteria or have comments about the **consultation process** please contact:

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1 Title of Proposal

"Proposal to Amend the Air Navigation Order 2005 for the Purpose of Improving the Technical Interoperability of all Aircraft[1] in UK Airspace[2]."

2 Purpose and Intended Effect

2.1 Objective

2.1.1 The objective of this proposal is to make a significant contribution towards ensuring that the number of mid-air collisions and serious risk-bearing 'near-miss' incidents in UK airspace does not increase and, preferably, decreases as the level of air traffic grows. This will be achieved by requiring the fitment and operation of suitable avionics to all aircraft in order to substantially improve their technical interoperability with each other throughout all classes of UK airspace.

2.1.2 Assuming that other conditions remain unchanged, the probability of aircraft colliding rises proportionally faster than the increase in the number of flights. As safety is the highest priority in aviation, any safety improvements will, therefore, need to be put in place before air traffic levels can be allowed to increase. This growth in aviation is fundamental to the success of the UK economy but the safe separation of all aircraft is essential for the maintenance of public confidence in aviation. Current forecasts indicate that air traffic levels in European airspace could nearly double by 2022 compared with those for 2002[3]. This increase will mean that, if current accident rates stay the same, the actual number of accidents will increase. Therefore, in order to maintain a publicly acceptable risk in a scenario where demand is expected to increase by a factor of two, the accident rate has to be at least halved (i.e. become twice as stringent). This required safety improvement will be very challenging to achieve and it will need the implementation of many and varied measures throughout the whole of the aviation industry over the coming years.

2.1.3 This specific proposal by the UK Civil Aviation Authority (CAA) takes a significant step towards improving overall safety levels by substantially improving interoperability between all classes of aircraft in all parts of UK airspace, but especially in unregulated airspace. It recommends a large increase in the number of aircraft that must be equipped with Secondary Surveillance Radar (SSR) transponders that provide altitude and identity information electronically to Air Traffic Control (ATC) radars and Airborne Collision Avoidance Systems (ACAS)[4]. The safety benefits from the carriage and operation of SSR transponders are regularly acknowledged and referred to by the UK Airprox[5] Board (UKAB)[6] in its reports[7]. For example, in Airprox Report 092/05, the UKAB members agreed that the lack of SSR-derived altitude data on one of the aircraft involved had actually "contributed to the Airprox" because, had it

[1] ICAO Annex 6 defines an aircraft as: 'any machine that can derive support in the atmosphere from the reactions of the air other than the reactions of the air against the earth's surface.'
[2] This includes airspace outside the UK for which the UK has in pursuance of international arrangements undertaken to provide air navigation services.
[3] EUROCONTROL Air Traffic Management Strategy for the years 2000+, Volume 2 – 2003 Edition.
[4] A description of ACAS is given at Annex A.
[5] A situation in which, in the opinion of a pilot or a controller, the distance between aircraft as well as their relative position and speed was such that the safety of the aircraft involved was or may have been compromised.
[6] The UKAB is the independent organisation that investigates reports of perceived risks of collisions between aircraft in the UK and it promotes improved safety standards.
[7] Annex B summarises data from recent Airprox Reports where the UKAB considered that the use of SSR transponders helped to resolve a hazardous situation or would have helped had they been available or in operation.

been switched on, "early action to resolve the situation" could have been taken. This particular incident occurred in UK airspace where the carriage and operation of an SSR transponder is not currently required.

2.1.4 An analysis of 299 UK Airprox reports from the period January 2004 to June 2005 indicates that the number of risk-bearing[8] incidents could have potentially been reduced by as much as 36% had SSR transponders been able to interact successfully with collision avoidance and/or ATC systems. For example, there is considered to be a four-fold to ten-fold reduction in the risk of mid-air collision in circumstances where SSR transponders fitted to aircraft interact successfully with airborne electronic collision warning systems, and this is one of many aspects that the CAA wishes to maximise through this proposal. Therefore, through this policy proposal the CAA seeks to make a significant contribution towards increasing safety levels and, thereby, enable the future benefits of air traffic growth in UK airspace.

2.2 Background Issues and Risks

2.2.1 There are a number of background issues that the CAA believes must be addressed within the next 2 to 5 years to help maintain or improve current levels of safety in UK airspace as air traffic levels grow. Many of these specific issues are interrelated and interdependent, and they are explained in Paragraphs 2.2.5 to 2.2.12 below. However, the underlying concern is the current lack of technical interoperability between aircraft from all sectors of the aviation community, and the inherent risks that this brings when they operate in proximity to each other; particularly, in terms of their interaction with each other to minimise the risk of mid-air collisions, the general surveillance of aircraft in all UK airspace, and the efficiency with which UK airspace can be shared by all users.

2.2.2 If this technical interoperability is not put in place, the alternatives are to either segregate non-compatible users through restrictive airspace measures or to restrict traffic growth. The CAA considers that both these alternatives are untenable and are contrary to its remit to ensure that a joint and integrated approach to UK airspace is maintained. The CAA, therefore, believes that doing nothing is not a viable option. The CAA consistently strives to ensure that all users are afforded maximum flexibility and freedom to operate as permitted by safety constraints, and it believes that greater technical interoperability between aircraft will improve access to airspace for all operators while helping to increase overall safety levels.

2.2.3 This proposal comprises the second phase of the wider CAA initiative to improve safety levels by updating the technology that is used for the surveillance of UK airspace in support of ATC. The first phase comprised a limited introduction of the new SSR Mode Select (Mode S) technology from 31 March 2005 for flights operating under Instrument Flight Rules (IFR) in the major terminal and en route airspace. This was subject to a formal consultation process between 2001 and 2004 and mainly affected the Commercial Air Transport (CAT) sector. During the consultation for the first phase, the CAA also highlighted its intentions to propose this second phase, at a later date, to update the SSR technology used in the wider UK airspace. The intention is also to implement any new equipage requirements in a manner that will minimise the future impact and burden on Stakeholders of the further introduction of emerging technology for the surveillance of air traffic up to 2020 and beyond.

2.2.4 SSR transponders are electronic devices that report the position, altitude (known as SSR Mode C) and information used to asses the identity of the host aircraft. As an analogy, in the electronic environment these transponders provide similar safety

[8] Risk-bearing incidents are defined by the UKAB as either Risk A, where an actual risk of collision existed, or Risk B, where the safety of aircraft was compromised.

benefits to those provided by bicycle lights in the visual environment; they make the host aircraft much more conspicuous to other airspace users, such as those aircraft equipped with electronic collision warning systems and air traffic controllers observing radar displays. Hence, the risk of collision is reduced in much the same way that a bicycle light will reduce the risk of a motorist colliding with a cyclist in the dark. Under current regulations, not all aircraft operating in the UK are required to equip with and operate SSR transponders.

2.2.5 **Issue 1: Replacement of 'Classical'[9] SSR**. There has been increasing reliance on SSR over the last 3 decades for the provision of safe and efficient Air Traffic Management (ATM) in Europe. However, traffic growth has stretched the capabilities of the current 'classical' SSR Mode 3A/C technology to its limits. For the following reasons, 'classical' SSR must be replaced by a more modern variant or there is a risk that safety levels will not be able to be increased and traffic growth may have to be restricted:

a. There are now severe shortages of SSR Mode 3A identity codes for the discrete identification of air traffic in Europe. There is a risk that this could result in regular delays of commercial flights within the next few years unless the Mode 3A technology is replaced with a new method of identifying individual flights.

b. Ageing 'classical' SSR interrogators have track capacity limitations that could constrain traffic growth. Some modern replacement SSR systems have greater track capacity but, within Europe, 'classical' SSR systems are typically being replaced by SSR Mode Select (Mode S)[10] technology, which offers other benefits in addition to the increased track capacity. National Air Traffic Services (NATS) has committed to a programme replacing all its 'classical' SSR systems throughout the UK with Mode S systems and it also has a future upgrade programme for its Flight Data Processing Systems to be able to process Mode S data. The Ministry of Defence (MoD) is considering a similar programme of SSR Mode S replacements at its operating bases. There is a risk that the safety and enabling economic benefits of the investment being made in SSR Mode S interrogators will not be maximised unless 'classical' SSR transponders currently fitted to aircraft are also updated to Mode S standards.

c. Increased traffic growth is leading to a higher density of aircraft, particularly within controlled airspace in the terminal manoeuvring areas around airports. Where 'classical' SSR responses overlap, then the Mode 3A/C data may become corrupted; a phenomenon known as 'garbling'. This is especially prevalent at the holding points and in the 'stacks' for the major airports, where traffic often has to be handled procedurally[11]. SSR Mode S responses are far less susceptible to garbling, and NATS has taken advantage of the increased robustness of the SSR Mode S responses to develop an on screen representation of the 'stacks' used at the major airports, which will increase both the safety[12] and the efficiency of 'stack management'. 'Classical' SSR

[9] 'Classical' SSR Mode 3A/C technology has its roots in the military Identification Friend or Foe system developed during World War II. It uses coded pulses on the 1030 MHz and 1090 MHz radio frequencies to interrogate and ascertain the four-digit Mode 3A 'identity code' setting and Mode C altitude of aircraft.

[10] A description of SSR Mode S is provided at Annex C.

[11] Under procedural control, air traffic controllers do not rely on the images on the radar screen to separate aircraft.

[12] Use of the "Selected Vertical Intention" parameter that can be downlinked from Mode S transponders is now being used to detect and prevent 'Level Busts' in the London Terminal Manoeuvring Area.

transponders on all aircraft need to be replaced with SSR Mode S if the safety benefits of SSR Mode S ground equipage are to be realised in the wider UK airspace.

d. There is a need to protect and preserve the integrity of the SSR Radio Frequencies (RF) from becoming overloaded in order to maintain and improve safety levels. Also, the ageing 'classical' SSR technology needs to be phased out to overcome detection and interference issues in busy airspace. Modelling has shown that if SSR Mode S was not implemented, the forecast increases in interference would be significant and this could have an adverse effect on the effectiveness of collision avoidance systems.

2.2.6 **Issue 2: A Need to Improve Collision Avoidance Measures**. The risk of collision between CAT, General Aviation (GA) and military aircraft needs to be further minimised, particularly in the face of the forecast growth in air traffic up to the year 2020 and beyond. If this is not achieved, there is a risk that an increased segregation of aircraft activity may have to be reconsidered or traffic growth will have to be restricted, in order to maintain current levels of safety. During 2003 and 2004, approximately two thirds of all Airprox encounters experienced by pilots occurred in the unregulated Class G UK airspace[13], with the vast majority of these occurring below 3000 feet. It is also believed that not all Airprox incidents are reported and so the number of 'near misses' occurring could be greater. Approximately 60% of all Airprox encounters in UK airspace during 2003/2004 involved GA aircraft, many of which are not currently required to carry and operate an SSR transponder:

a. There are continuing concerns over the effectiveness of 'see and avoid' in certain situations in unregulated Class G airspace and on the efficacy of this primary method of separation in unregulated UK airspace in helping to avoid collisions between CAT, GA and military aircraft. Very light aircraft, such as gliders, can be particularly difficult to 'spot', especially at high rates of closure. Overall, sighting issues and the breakdown of 'see and avoid' represent the single largest cause of Airprox reports in unregulated UK airspace. Table 1 below shows the analysis of the proportion of common causal factors assigned to Airprox incidents between January 2003 and June 2005 that were related to sighting issues. The CAA and the UKAB believe that a greater use of the interaction between collision warning systems and SSR transponders is required to supplement 'see and avoid' and reduce these incidents; this is examined further in Annex B. Indeed, in the Analysis of Airprox in UK Airspace Report Number 11, the Director of UKAB stated that: "One final point that merits attention is the very positive influence that Collision Warning Systems (CWS) bring to bear. Aircraft fitted with CWS equipment enjoy a significantly lower 'risk rate' of collision than those without it. The magnitude in improvement is in the order of four to ten times better." Alternatively, there is a risk that the use of more restrictive airspace measures may need to be reconsidered to segregate aircraft in order to reduce the number of Airprox occurrences and improve safety levels.

[13] Analysis of Airprox in UK Airspace, Report Numbers 10 to 13. Figures for the whole of 2005 are not yet available but Report Number 14, which covers the period Jan to Jul 05 indicates broadly similar trends in Airprox occurrences.

	Proportion of the Most Common Airprox Causal Factors that were Related to Sighting Issues		
User Category	**2003**	**2004**	**2005 (Jan-Jun)**
CAT	10%	14%	17%
GA	54%	55%	67%
Military	61%	47%	61%

Table 1: Analysis of Common Causal Factors in Airprox Reports

b. On average, some 350 airspace infringements are reported formally each year, and it is accepted that a significant number of others are resolved informally and never reported[14]:

(i) Statistics show that about 75% of all airspace infringements are attributable to GA aircraft and, consequently, there is a clear cyclical pattern where peaks of occurrences are reached in summer months when there are the most GA movements.

(ii) Approximately half of all airspace infringements take place in the controlled airspace serving airports, especially in the South East of England where traffic levels are higher and the airspace structures more complex. For example, five out of the six most infringed Control Zones/Areas serve London airports. However, regional airports such as Birmingham, Glasgow and Newcastle also feature highly in the available statistics.

(iii) Since 1996, about 5% of airspace infringements have resulted in a loss of minimum separation between aircraft. During 2003 and 2004, CAT pilots experienced 22 Airprox encounters where the causal factor was airspace infringement. For military pilots, this figure was 13 and for GA pilots it was 25 over the two-year period.

(iv) The current lack of SSR data, especially altitude information (SSR Mode C), on many GA sporting and recreational aircraft presents considerable difficulties for ATC units in their efforts to detect and prevent airspace infringements, or to safely manage them when they occur. Moreover, NATS is now keen to develop a suitable infringement warning system, which would rely on SSR data. This system would be designed to provide mitigation for airspace infringements by giving prior warnings of potential occurrences. The warnings would then permit immediate actions to be taken by ATC to maximise safety for all aircraft involved while also minimising disruption to the flow of air traffic operating legitimately within the controlled airspace. In order to achieve these aims, SSR Mode C altitude data on all aircraft involved will be a crucial element of the required information. Without this, there is risk that the effectiveness of these warning systems will not be maximised.

c. There are increasing levels of CAT movements, especially at regional airports, which is leading to pressure for more controlled airspace both around the airports and connecting these airports to the en route airways structure. Table 2 below highlights growth in air transport movements at regional

[14] Detailed infringement statistics have been taken from The General Aviation Airspace Infringements Website at http://www.flyontrack.co.uk/detinfr.asp.

airports between 2002 and 2004[15]. It is also noteworthy that in 2003, approximately one third of the Airprox encounters experienced by CAT pilots occurred in unregulated airspace. If the traffic growth trends highlighted below continue, it is considered likely that CAT will interact more frequently with military and GA aircraft in the future, either through infringements of any new controlled airspace that is created for these airports or through greater use of unregulated airspace by CAT aircraft approaching and departing these airports. If GA aircraft do not carry and operate SSR transponders, the collision warning systems fitted to CAT aircraft will not be able to detect the GA aircraft and help to resolve potential mid-air collisions when 'see and avoid' breaks down.

Airport	2002	2004	% Increase
Blackpool	7,768	10,173	31%
Bournemouth	7,600	9,616	26.5%
Bristol	45,829	54,793	19.5%
Cardiff	18,736	21,993	17%
Durham Tees Valley	9,322	10,434	12%
Exeter	5,283	8,251	56%
Inverness	9,632	14,783	53.5%
Leeds/Bradford	28,566	31,493	10%
Liverpool	32,764	39,736	21%
Newcastle	44,080	49,921	13%
Norwich	13,962	14,886	6.5%
Nottingham East Midlands	48,627	55,904	15%
Southampton	27,662	37,199	34.5%

Table 2: Air Transport Growth at UK Regional Airports

d. The performance capability of some GA aircraft has increased markedly over the last 3 decades, particularly in gliders, and this has increased their potential interaction with other airspace users. For example, modern gliders can operate over very large distances, increased altitudes and for longer durations than older versions. Their head-on profiles are extremely small and closure rates with CAT and military aircraft can be very high. In some circumstances, there can be little warning of potential collisions when 'see and avoid' is used as the primary method of separation. Furthermore, due to their small size and the use of modern composite construction materials, the detection of gliders using primary radars can be less than ideal. Therefore, the conspicuity of gliders on ATC displays can be significantly improved if an SSR transponder is operated.

e. Traffic Proximity Alert Systems (TPAS) for use in light aircraft are becoming more accessible. The majority of these systems rely on the availability of unsolicited SSR responses from conflicting aircraft that have been interrogated by ground radars or Airborne Collision Avoidance Systems (ACAS). Therefore, in order to generate suitable alerts for light aircraft

[15] Data has been taken from: 'UK Airports – Annual Statements of Movements, Passengers and Cargo' for the years 2002 to 2004, which is prepared by the Civil Aviation Authority with the co-operation of the UK airport operators. The reports are available at http://www.caa.co.uk.

operating with TPAS in unregulated Class G airspace, all aircraft operating within that airspace would have to carry and operate an SSR transponder.

f. MoD Collision Warning System (CWS) and Traffic Alert and Collision Avoidance System I (TCAS I)[16] fitment programmes to some of its combat and training aircraft will rely on increased carriage of SSR transponders in UK airspace to maximise their benefits; these systems will be electronically 'blind' to all conflicting aircraft that are not equipped with SSR transponders. The equipage of military aircraft with these electronic warning systems is being actively encouraged by the UKAB as an essential step for reducing the risk of collisions when 'see and avoid' breaks down. However, if this procurement programme is not coupled with all aircraft being required to carry and operate an SSR transponder, safety benefits will not be maximised and there is a risk that safety levels will not be improved.

2.2.7 **Issue 3: International Obligations and Co-operation**. Aviation regulations, obligations and co-operation are layered and complex. At the global level, the UK is a contracting signatory to the Convention on International Civil Aviation (Chicago, 1944). The Standards and Recommended Practices (SARPs) for this Convention are managed and published by the International Civil Aviation Organisation (ICAO). It is UK policy that ICAO SARPs are always adopted into UK legislation unless to do so would compromise safety or would be contrary to the national interests associated with operating a joint and integrated approach to national airspace arrangements. Where the UK files a 'difference' with SARPs, it is generally associated with an undertaking to comply as soon as practicable. At the European level, States have historically co-operated and co-ordinated their activities for mutual benefit and enacted appropriate legislation through national processes. This continues today but there is also now an overarching EU legislative framework in the form of the recent Single European Sky (SES) initiative and associated regulations[17], which require interoperability and harmonisation across European Community States. The final layer comprises national aviation regulations and procedures, enacted to ensure safe and efficient operations within the airspace of sovereign States. This proposal has the following associated with international obligations and co-operation:

a. Current ICAO Annex 6 SARPs specify pressure-altitude reporting SSR transponder carriage requirements[18] for all aeroplanes[19] and helicopters, irrespective of the airspace in which they operate. The aim of these SARPs is to overcome that lack of interoperability between SSR and non-SSR equipped aircraft, with the resultant inefficiency and safety issues that this causes for ATC and ACAS. ACAS equipage is increasing through recent regulation and voluntary equipage, and the effectiveness of ACAS is evolving. For example, under current requirements, all aircraft with a maximum take-off mass in excess of 5,700 kg must carry and operate ACAS II. Many Police Air Support Units and Pipeline Inspection helicopters also now carry and operate TCAS I. Voluntary equipage of TCAS I by private operators and businesses has also increased in the last decade, as the cost of the equipment has decreased. ACAS II is designed to work at its optimum performance in an SSR Mode S

[16] ACAS refers only to the concept of collision avoidance, whereas TCAS is associated with commercially available technology that satisfies ICAO standards for ACAS. This is explained further in Annex A.
[17] Regulation (EC) No 549/2004 (the framework Regulation) and Regulation (EC) 552/2004 (the interoperability Regulation) of the European Parliament and of the Council of 10 March 2004.
[18] A full description of the ICAO Annex 6 requirements is at Annex D.
[19] ICAO Annex 6 defines an aeroplane as: 'A power-driven heavier-than-air aircraft, deriving its lift in flight chiefly from aerodynamic reactions on surfaces which remain fixed under given conditions of flight.'

environment. However, the CAA has currently filed a 'difference' with these SARPs because it would increase the carriage of SSR transponders in UK airspace and, if these were based on 'classical' SSR technology, there is a risk that the integrity of the SSR radio frequency used by the transponders could be intolerably degraded. Modelling has shown that where SSR Mode S transponders are implemented to meet the ICAO requirements, the probability of detection remains high and the levels of mutual interference are fully sustainable. The CAA fully supports the rationale behind these international obligations and, therefore, intends to enact the Annex 6 SARPs into UK legislation as part of this proposal by employing the new SSR Mode S technology.

b. Other European States have implemented an SSR Mode S Enhanced Surveillance (EHS)[20] and Elementary Surveillance (ELS)[21] programme for IFR flights under co-operative and co-ordinated arrangements. The next step of this European SSR Mode S programme is to extend the applicability of Mode S ELS to aircraft operating under Visual Flight Rules (VFR) with effect from 31 March 2008. The States comprise the UK, France, Germany, Belgium, The Netherlands, Luxembourg and Switzerland. As described above, the UK has currently only introduced SSR Mode S into major terminal and en route airspace for IFR flights; this currently comprises the London TMA but it will be extended in the near future.[22] The full benefits of an SSR Mode S implementation in Europe can only be maximised when there is contiguous Mode S radar coverage and notified Mode S airspace across the States with the highest traffic levels. These benefits are, therefore, at risk if the UK does not continue to support this European Mode S programme.

c. Under the SES initiative, mandates are being issued to EUROCONTROL by the European Commission to develop interoperability implementing rules on SSR Mode S Interrogator Code Allocation for radars and on Surveillance Performance requirements. However, these will not legislate for the carriage and operation of SSR transponders on aircraft, and appropriate mandates in this regard are not currently being muted. The SES initiative is still somewhat embryonic and the work programme has to be prioritised within available resources. Indeed, the initial SES rules are likely to just support existing programmes and projects. The UK policy proposal contained within this Regulatory Impact Assessment (RIA) is, therefore, complementary to foreseen future SES requirements for SSR transponder carriage. In any case, mandating the carriage and operation of SSR Mode S in UK airspace from 31 March 2008, ahead of any potential European legislation, is essential because of national concerns. These concerns are elaborated throughout this RIA but centre on the need to introduce measures that sustain or improve levels of safety in a joint and integrated UK airspace, while managing the increasing complexity of this airspace and the increasing density of air traffic using it.

2.2.8 **Issue 4: Support for Future Surveillance Technology**. Global and European ATM surveillance strategy[23] is to introduce Automatic Dependent Surveillance - Broadcast (ADS-B)[24] technology in stages up to the year 2020 and beyond. Initial applications of ADS-B will use the Mode S 1090 MHz 'Extended Squitter' data link to provide this functionality. A common technological baseline among all airspace users needs to be created in order to set the foundations for the future ADS-B airborne environment.

[20] An explanation of SSR Mode S Enhanced Surveillance is at Annex C.
[21] An explanation of SSR Mode S Elementary Surveillance is at Annex C.
[22] Further information can be found in AIC 49/2005 (Yellow 171) dated 23 Jun 05.
[23] The Surveillance Strategy for ECAC, Edition 2.0, dated 18 November 2005.
[24] A description of ADS-B is at Annex E.

Where possible, therefore, the CAA aims to 'future-proof' the equipage requirements of this particular proposal for any potential future introduction of ADS-B in UK airspace. Otherwise, there is a risk that Stakeholders may have to undertake a further burden in a few years when ADS-B needs to be introduced. This is seen by the CAA as a significant Simplification Measure[25] for Stakeholders.

2.2.9 **Issue 5: Efficiency of the Use of Airspace in the UK FIR**. There is currently a lack of a common technology baseline among all airspace users with which to facilitate measures to employ flexible use of airspace efficiently and safely in the UK FIR. For example, these measures could include turning on or off airspace for temporary military activity, GA events or even volumes of temporary controlled airspace around airports during peak periods of activity. The current lack of interoperability of all airspace users precludes the ability to provide adequate surveillance of the airspace and, in particular, the capability to detect the height of all aircraft, to provide suitable warnings of potential infringements of reserved and controlled airspace, and to manage these infringements when they occur. However, it must be stressed that this technology baseline would not need to include the carriage of radios on all aircraft and these policy proposals do not seek to require radio equipage. If this ability to use airspace flexibly is not available as air traffic levels grow, there is a risk that growth would either have to be restricted or more restrictive airspace measures reconsidered, such as permanent segregation, would have to be introduced to maintain the required levels of safety.

2.2.10 **Issue 6: Integration of UAV Operations**. Any proposed future integration of flights by Unmanned Aerial Vehicles (UAVs) into all UK airspace will require them to have a common technology baseline with all other airspace users in order for them to be interoperable. In particular, this would be necessary for facilitating effective 'sense and avoid' measures to be introduced on UAVs for flights in unregulated airspace. Furthermore, it is envisaged that any 'sense and avoid' technology suite on UAVs would incorporate an SSR-based collision avoidance system that would rely on the detection of SSR transponder signals from other aircraft and UAVs. Therefore, if all aircraft do not carry and operate an SSR transponder, there is a risk that UAVs may not be able to be integrated with other airspace users in unregulated airspace.

2.2.11 **Issue 7: Impact of Wind Turbines on Aviation**. Mitigation for the effects of wind turbine developments on aviation equipment needs to be found in order for planning objections to be reduced. This will help to ensure that Government targets for renewable energy can be met. In particular, the problems caused by the 'clutter' that these developments cause to primary radar pictures, by masking genuine radar returns from aircraft, needs to be overcome. It is considered that the carriage and operation of SSR transponders on all aircraft could provide a substantial element of this mitigation.

2.2.12 **Issue 8: Spectrum Availability for Primary Radar**. Continued pressure on the availability of radio spectrum in the bands used by primary radar from the mobile communications industry may create further reliance on co-operative[26] airspace surveillance technology, such as SSR Mode S and ADS-B.

[Views and comments on the aforementioned background issues and risks are sought under "RESPONSE 1" in the attached RIA Consultation Response Document.]

[25] Simplification looks at removing regulations, merging regulations into a more manageable form and resolving overlap or inconsistency within or between regulations.

[26] Co-operative surveillance systems require aircraft to be equipped with and operate appropriate technology with which to communicate the required information to ground systems. Non co-operative surveillance systems, such as primary radar, can detect aircraft without a requirement for any particular airborne systems or avionics to have to be fitted or operated.

2.3 Guiding Policy Principles

2.3.1 In order to achieve the overall policy objective and attempt to address as many of the aforementioned background issues as possible, the CAA has applied the following guiding policy principles when considering possible non-regulatory and regulatory options:

a. **Principle 1: Maximise Effectiveness of Collision Avoidance Technology**. Provide a suitable airborne environment with which to maximise the effectiveness of ACAS in all UK airspace.

b. **Principle 2: 'Future-Proof' the Introduction of New Airspace Surveillance Technology**. Create an airborne environment in which all aircraft operating in UK airspace are equipped with a common technology that will ease the introduction of new airspace surveillance systems and ATC tools for the years up to 2020 and beyond. This is considered to be a major Simplification Measure for all sectors of the aviation community.

c. **Principle 3: Facilitate Measures to Enhance 'See and Avoid' Techniques**. Provide an airborne environment with which to facilitate technology-based measures that could enhance the 'see and avoid' techniques used by pilots to prevent mid-air collisions in unregulated Class G UK airspace. Similarly, by facilitating the use of suitable 'sense and avoid' technology, this airborne environment must also support the future integration of UAV operations into UK airspace in a safe and interoperable manner.

d. **Principle 4: Facilitate Improved ATC Efficiency in the UK FIR**. Provide a suitable airborne environment with which to facilitate efficiency improvements in the provision of Air Traffic Services (ATS) in the UK FIR.

e. **Principle 5: Meet International Obligations**. Implement the ICAO Chicago Convention Annex 6 requirements for the carriage and operation of pressure-altitude reporting transponders on all aeroplanes and helicopters. Furthermore, continue to support the European Mode S programme.

f. **Principle 6: Protect the SSR Frequencies**. Preserve and protect the integrity of the radio frequencies on which SSR operates, and hence the safe use of ACAS, SSR and ATM systems, in the face of the forecast growth in air traffic movements.

g. **Principle 7: Update Existing SSR Transponders on Aircraft**. Update those SSR transponders that are currently fitted to aircraft, and which operate in 'classical' SSR Mode 3A/C, with new SSR Mode S technology.

h. **Principle 8: Maximise the Use of New SSR Mode S Technology**. Maximise the carriage and operation of SSR Mode S transponders on all flights in UK airspace operating under IFR and VFR.

i. **Principle 9: Facilitate Measures for Flexible Use of Airspace in the UK FIR**. Provide an environment where all aircraft operating in the UK FIR are interoperable so that measures to use airspace flexibly can be enhanced.

j. **Principle 10: Provide Potential Mitigation for Impact of Wind Turbines on Aviation**. Provide a suitable airborne environment with which to facilitate measures to provide potential mitigation for the effects of wind turbine developments on aviation operations; and, in particular, mitigation for the impact of wind turbine structures on the performance of primary radar.

2.3.2 **Simplification.** Table 3 below provides an overall summary of how the guiding policy principles contribute towards overcoming the aforementioned background issues. It details the significant and complex interdependency that exists between the principles themselves and with the issues that need to be addressed. It also highlights how this proposal draws together many diverse issues into a single regulation and, hence, is consistent with the Government's current Simplification requirements.

Guiding Principles / **Background Issues**		Maximise Effectiveness of Collision Avoidance Technology	'Future-Proof' the Introduction of New Airspace Surveillance Technology.	Facilitate Measures to Enhance 'See and Avoid' Techniques	Facilitate Improved ATC Efficiency in the UK FIR	Meet International Obligations	Protect the Secondary Surveillance Radar Frequencies	Update 'Out-of-Date' SSR Transponders on Aircraft	Maximise the Use of New SSR Mode Select Technology	Facilitate Measures for Flexible Use of Airspace in the UK FIR	Provide Potential Mitigation for Impact of Wind Turbines on Aviation
		1	2	3	4	5	6	7	8	9	10
Replacement of 'Classical' SSR.	1	✓	✓		✓	✓	✓	✓	✓	✓	✓
A Need to Improve Collision Avoidance Measures.	2	✓		✓		✓	✓	✓	✓	✓	✓
International Obligations and Co-operation.	3	✓	✓		✓	✓	✓	✓	✓		
Support for Future Surveillance Technology.	4		✓	✓	✓	✓	✓	✓	✓		✓
Efficiency of the Use of Airspace in the UK FIR.	5				✓				✓	✓	✓
Integration of UAV Operations	6	✓	✓	✓	✓				✓	✓	✓
Impact of Wind Turbines on Aviation	7				✓				✓	✓	✓
Spectrum Availability for Primary Radar	8		✓			✓	✓		✓		

Table 3: Relationships Between the Guiding Policy Principles and the Issues

2.4 Rationale for Government Intervention

The policy objective is vital for the future of ATM in the UK to accommodate the forecast increases in levels of air traffic while maintaining or improving levels of safety and efficiency of airspace use. It is considered that a non-regulatory approach could not be applied to resolve the aforementioned issues for the following reasons:

a. The achievement of the overall objective must not be left to chance, and voluntary equipage or an incentives-based scheme would not guarantee carriage of the required avionics by all aircraft.

b. A non-regulatory approach would not ensure that the UK meets its international obligations to ensure that all aeroplanes and helicopters are equipped with pressure-altitude reporting transponders, and/or in a way that is sustainable for the SSR frequency environment.

c. A common technology baseline to maximise the safety benefits of ACAS and provide a migratory path to future technologies cannot be assured through voluntary equipage. If left to market forces or voluntary equipage, different sectors of the industry might chose alternative technologies that are not interoperable.

d. There is a compelling need to provide a coherent approach for the introduction of future ATM surveillance technology through the application of a single regulatory measure rather than introduce piecemeal and iterative equipage of the different aviation industry sectors over time.

e. It is difficult to quantify, in monetary terms, the value of the safety and operational benefits for individual aviation industry sectors from the adoption of new technology in light aircraft. The monetary cost of equipage of aircraft can be estimated and this is likely to be perceived as unacceptably high by private recreational operators and small firms. It may, therefore, not be possible to encourage wide scale voluntary equipage using a cost-benefit approach.

3 Consultation

3.1 Within Government

The CAA has been liaising with the following departments over the last few years to discuss and provide advance information about these policy proposals:

a. Department for Transport (DfT).

b. UK Spectrum Strategy Committee (UK SSC).

c. Department of Trade and Industry (DTI).

d. Cabinet Office Better Regulation Executive.

e. MoD.

3.2 Public Consultation

3.2.1 The CAA has been providing pre-notification of these proposals to the UK aviation industry since 1989. Publications that have been issued include the following:

a. Aeronautical information Circular (AIC) 121/89 (Yellow 156) published in 1989.

b. AIC 100/1997 (Yellow 268) published in 1997.

c. CAA Directorate of Airspace Policy (DAP) consultation paper entitled “Information on the Future Employment of Secondary Surveillance Radar (SSR) in the UK and the Associated Regulatory Impact”, dated 31 January 2000.

d. AIC 88/2001 (Yellow 65) published in 2001.

e. Formal public consultation with the UK aviation industry between 2001 and 2004 as part of the previous RIA process for the implementation of SSR Mode S in major en route and terminal airspace. The RIAs produced as part of this process also provided advance information about the policy proposals contained within this particular Partial RIA.

f. AIC 105/2004 (Yellow 155), ‘Secondary Surveillance Radar (SSR) – Mode S’, published in November 2004.

g. AIC 49/2005 (Yellow 171), ‘SSR Mode S – Transition Arrangements’, published in June 2005.

3.2.2 The following consultation has also been undertaken within the last five years:

a. Informal consultation with CAA and aviation industry consultation groups:

(i) National Air Traffic Management Advisory Committee (NATMAC).

(ii) Spectrum and Surveillance Working Group (SASWG).

(iii) General Aviation Working Group (GAWG).

(iv) General Aviation Consultative Committee (GACC).

(v) National IFF/SSR Committee (NISC).

b. Briefings and presentations to airspace user groups and their representatives:

(i) PPL/IR Europe.

(ii) Aircraft Owners and Pilots Association (AOPA).

(iii) CAA Safety Evening at the Fairoaks Airport Flight Centre to GA pilots.

c. Individual briefings for aviation journalists.

3.2.3 The feedback from the informal consultation that was conducted during the development of the Initial RIA for these proposals has revealed the following issues:

a. The GA community is understandably concerned about the initial cost outlay for the proposed new equipage requirements. For this reason, the CAA has been briefing these proposals to representatives from GA user groups for several years and the AICs listed at Paragraph 3.2.1 above have been issued. Furthermore, the use of suitable transition periods will be considered for any actual implementation. The CAA is investigating ways and means of reducing the initial cost burden and has taken a leading role in the research and development for suitable, cost effective technology for very light aircraft. It is also believed that the cost of existing 'classical' SSR transponder equipment and SSR Mode S is now broadly similar and that this cost will continue to decrease with market forces.

b. There is belief in the GA community that this initial cost should be subsidised by the Government or the commercial aviation sector because the main beneficiaries of the proposals will be CAT and ATC providers. The CAA would dispute this contention, as the safety benefits of greater technical interoperability with ATC and ACAS accrue to all airspace users. Furthermore, the attainment of a baseline technical interoperability between all airspace users should reduce the need for restrictive airspace measures to be put in place in the future to improve safety. For example, these airspace measures could comprise an increase in the amount of controlled airspace to segregate non-interoperable aircraft.

c. The GA community has stressed that any new equipage requirements should be 'future-proofed' to ensure that further upgrades or additional equipment does not need to be mandated for GA aircraft in the short to medium term. The CAA agrees with this view and some of the proposed policy options have been identified to address this requirement. Any implementation will also aim to reflect and recognise European and global ATM policy.

d. Some sectors of the GA community have questioned the rationale and benefits for proposals to equip very light, un-powered aircraft, such as Hang Gliders, with avionics that could cost more than the value of the aircraft. The intention of the CAA is to apply equipage requirements for technical interoperability for non-motorised aircraft only where there would be a beneficial impact on safety and efficiency through the interaction that the activity would have with other airspace users. For example, well promulgated competition events involving large numbers, or 'clusters', of aircraft within a small volume of airspace should not normally require equipage; other airspace users will have sufficient knowledge of these events to avoid the airspace in use, or be aware that the required airborne technology may not be in use on the participating aircraft. Some limited flying training activity, such as winch-launched glider circuits contained within notified areas, will be considered for exemption from the need to carry and operate the required technology. As the equipment for very light aircraft would almost certainly need to be highly portable, it may also be possible for equipment to be leased temporarily when required, rather than purchased. An exemptions policy is also envisaged and some generic principles that could be applied are at Annex F for further information.

e. The GA community has raised concerns that widespread equipage of SSR transponders on aircraft that routinely operate in large ‘clusters’ could saturate radars, ATC systems and ACAS. The CAA has investigated this issue and conducted modelling for the period up to 2012, which indicates that there should be no significant problems in this regard. Further modelling will be conducted. However, SSR Mode S radars have almost double the track capacity of ‘classical’ SSR systems and SSR Mode S uses a selective interrogation system to reduce the number of responses that are made by Mode S transponders. Special arrangements could be put in place and promulgated for those occasions where large groups of aircraft are expected to operate in a small volume of airspace. ATC units can filter out tracks that are not operating within their area of operational interest; this filtering does not switch off the transponders and so aircraft will still be visible to other ATC units and collision avoidance systems. Also, a Mode S capable Low-Power SSR Transponder (LPST) operating at 20-30W is being developed for very light aircraft; this unit will be smaller than a typical SSR transponder, be portable and battery-powered.

f. Some members of the GA community are reluctant to fit modern avionics to historic and vintage aircraft. The CAA believes that many of these aircraft would be able to use a portable LPST without affecting the aesthetics of the airframes. However, the CAA recognises that this type of unit would not necessarily be suitable for high performance vintage aircraft due to the fact that the low power may limit the range at which ACAS and ground surveillance systems will detect the aircraft.

4 Options

4.1 Option 1 – Do Nothing

4.1.1 Option 1 would be to do nothing. It assumes that none of the issues set out in this RIA require any regulatory intervention to overcome them, or that the issues are not severe enough to warrant any action. Option 1 is also the ‘baseline’ option from which the impact of the other proposed options can be measured.

4.1.2 Under Option 1, the UK SSR transponder carriage requirements would continue to just be linked to airspace rather than aircraft type or operating activity. Currently, aircraft operating at and above Flight Level 100, or operating under IFR in controlled airspace below this level, or operating for the purposes of public transport, must be equipped with an SSR transponder that provides Mode A and Mode C as a minimum. Gliders are currently exempt these carriage requirements in all airspace.

4.1.3 A view could also be taken that Option 1 is the means by which a delay to national action is agreed until any wider proposed European legislation on this issue may be enacted through SES interoperability implementing rules. However, as yet there are no firm indications or dates for when any similar European legislation could come into force.

4.2 Option 2 – Require SSR Transponder Carriage on All Aeroplanes and Helicopters

4.2.1 Option 2 would adopt the ICAO Annex 6 transponder carriage requirements in UK airspace in a manner that would protect the integrity of the SSR RF environment. Under Option 2, the Air Navigation Order (ANO) 2005 would be amended to mandate the carriage and operation of ICAO Annex 10 compliant SSR Mode S transponders on all aeroplanes and helicopters conducting IFR and VFR flights within all UK airspace, with effect from 31 March 2008. In accordance with current regulations for notified Mode S en route and terminal airspace, some IFR flights[27] would require SSR Mode S EHS functionality. All other IFR and VFR flights would require SSR Mode S ELS functionality as a minimum.

4.2.2 In addition, where other aircraft must carry and operate an SSR transponder in accordance with the current regulations (described under Option 1 above), a minimum of SSR Mode S ELS functionality would also now need to be provided in these transponders instead of 'classical' SSR Mode 3A/C.

4.2.3 The main effect of Option 2 would be to phase out the existing SSR Mode 3A/C transponders currently fitted to aircraft and replace them with SSR Mode S technology. It would also extend the current SSR transponder carriage requirements, as all motorised aircraft would now be required to carry and operate an SSR Mode S transponder, irrespective of the airspace in which they were operating. Moreover, Option 2 is similar to the implementation of SSR Mode S ELS transponders for VFR flights in neighbouring European States with effect from 31 March 2008. Table 4 below illustrates how this would affect various categories of aircraft in different parts of UK airspace.

	IFR GAT in notified en route and terminal airspace[27]	**Special Flight Notification and Rule 21 exempted flights in notified en route and terminal airspace[27]**	**IFR flights in controlled airspace below Flight Level 100**	**IFR and VFR flights at and above Flight Level 100**	**IFR and VFR flights in all other UK airspace**
Aeroplanes	Mode S EHS or ELS	Mode S ELS	Mode S ELS	Mode S ELS	Mode S ELS
Helicopters	Mode S ELS	Mode S ELS	Mode S ELS	Mode S ELS	Mode S ELS
Gliders[28]	No effect	No effect	No effect	No effect	No effect
All Other Aircraft	No effect	Mode S ELS	Mode S ELS	Mode S ELS	No effect

Table 4: SSR Transponder Functionality Requirements for Option 2

[27] Aeroplanes operating under IFR as General Air Traffic in the notified airspace, and which have a maximum take-off weight of more than 5,700 kg or a maximum cruising true airspeed capability of more than 250 knots. Mode S airspace is defined and promulgated in accordance with Aeronautical Information Circular 49/2005 (Yellow 171), dated 23 June, and the UK Aeronautical Information Publication.

[28] In accordance with ANO 2005 (Article 155), the classification of 'glider' now includes self-sustaining gliders and self-propelled hang gliders.

4.3 Option 2(a) – Require SSR Transponders with an ADS-B 'Out' Capability on Aeroplanes and Helicopters

4.3.1 Option 2(a) would include all of the requirements of Option 2. However, in order to 'future-proof' the equipage requirements for the eventual introduction of ADS-B into UK airspace, Option 2(a) further extends the equipage requirements by mandating that a 1090 MHz 'Extended Squitter' (1090ES) capability also be included as a requirement for all SSR Mode S transponders fitted to aircraft under Option 2. This functionality is sometimes referred to as ADS-B 'Out'.

4.3.2 Notwithstanding, it is not proposed under Option 2(a), at this stage, to require that the ADS-B 'Out' capability be enabled to a full functionality by also mandating equipage with an approved Global Positioning System (GPS) source to support 1090ES position reporting. This functionality would remain voluntary until such time as ADS-B applications need to be introduced in the UK. Nevertheless, by ensuring that the SSR transponders fitted under this proposal have the capability to support 1090ES, additional transponder equipage requirements would not then be needed at a later date to meet any potential future ADS-B mandate.

4.4 Option 3 – Require SSR Transponders on All Aircraft

4.4.1 Under Option 3, the ANO 2005 would be amended with effect from 31 March 2008 to mandate the equipage of SSR Mode S transponders on all aircraft operating in the UK FIR to the maximum extent possible as permitted by available technology. In this case, both motorised and non-motorised aircraft would be expected to equip where suitable SSR transponder products were available. The aim of this option would be to maximise the carriage and operation of SSR as far as was technically feasible.

4.4.2 However, under this option, it is envisaged that applicability to aircraft could also be linked to the type of activity being conducted by aircraft, such that the carriage and operation of an SSR transponder would only be required for operations that brought an aircraft into interaction with collision avoidance systems and the provision of ATC. For example, it is not envisaged that glider training, with short duration flights contained within the vicinity of a promulgated glider site, would need to equip. Similarly, hang gliding activity with short duration flights contained within promulgated sites would not apply. Moreover, para gliders would not need to equip with an SSR transponder due to the lack of a rigid structure on which to locate the equipment. Exemptions would also apply for those promulgated events involving large numbers, or 'clusters', of aircraft operating within a relatively small volume of airspace, such as competitions.

4.5 Option 3(a) - Require SSR Transponders with an ADS-B 'Out' Capability on All Aircraft

In a similar way to Option 2(a), this option would 'future-proof' the SSR transponder equipage requirements of Option 3 by also requiring that the SSR Mode S transponders fitted under Option 3 be capable of providing 1090ES as well. However, once again it is not proposed to require that the capability be enabled to a full functionality with approved GPS units until ADS-B applications need to be introduced in the future.

4.6 Summary of Options

4.6.1 Table 5 below summarises the overall applicability of the options:

	SSR Mode 3A/C	SSR Mode S	SSR Mode S and ADS-B 'Out' Capability
Aeroplanes	Option 1	Options 2 and 3	Options 2(a) and 3(a)
Helicopters	Option 1	Options 2 and 3	Options 2(a) and 3(a)
Public Transport Aircraft	Option 1	Options 2 and 3	Options 2(a) and 3(a)
All aircraft at and above FL100, or IFR flights inside controlled airspace below FL100	Option 1	Options 2 and 3	Options 2(a) and 3(a)
All aircraft below FL100 and outside controlled airspace	Not Applicable	Option 3	Option 3(a)

Table 5: Summary Matrix for Overall Applicability of the Options

4.6.2 Table 6 below highlights the extent to which the guiding policy principles listed in Paragraph 2.1 above would be applied by the options. Option 3(a) is currently the CAA's preferred solution, as it incorporates all of the guiding principles and, hence, would maximise the efforts to overcome all of the issues highlighted within this RIA.

Guiding Policy Principles	Options				
	1	**2**	**2(a)**	**3**	**3(a)**
1. Maximise Effectiveness of Collision Avoidance Technology.	✗	✓*	✓*	✓	✓
2. 'Future-Proof' the Introduction of New Airspace Surveillance Technology.	✗	✗	✓*	✗	✓
3. Facilitate Measures to Enhance 'See and Avoid' Techniques.	✗	✗	✓*	✗	✓
4. Facilitate Improved ATC Efficiency in the UK FIR.	✗	✓*	✓*	✓	✓
5. Meet International Obligations.	✗	✓	✓	✓	✓
6. Protect the Secondary Surveillance Radar Frequencies.	✗	✓	✓	✓	✓
7. Update 'Out-of-Date' SSR Transponders on Aircraft.	✗	✓	✓	✓	✓
8. Maximise the Use of New SSR Mode Select Technology.	✗	✓	✓	✓	✓
9. Facilitate Measures for Flexible Use of Airspace in the UK FIR	✗	✓*	✓*	✓	✓
10. Provide Potential Mitigation for Impact of Wind Turbines on Aviation	✗	✗	✗	✓	✓

** Denotes that the particular policy principle would only be partially achieved by the option.*

Table 6: Relationship of the Options with the Guiding Policy Principles

4.6.3 It has been recognised that there may be technical limitations or other reasons why it would be impractical for certain aircraft to carry the equipment defined in the aforementioned proposed policy options. Therefore, Annex F provides information on the exemption principles that could be applied to cater for these circumstances.

4.7 Other Options Discounted After the Initial RIA Development Stage

4.7.1 The carriage and operation of suitable non-SSR based technology, such as FLARM[29] or ADS-B using the Very High Frequency Data Link (VDL) Mode 4 or Universal Access Transceiver (UAT) data links, was considered by the CAA during the Initial RIA phase. However, none of this technology would be interoperable with SSR-based collision avoidance systems or the provision of ATS using SSR-derived position and height information. Therefore, safety benefits would only accrue within those groups or sectors that equipped with a particular technology and some important interoperability aims of this policy proposal would not be achieved. Furthermore, if differing data link technologies for ADS-B were adopted by different groups, any future introduction of ADS-B applications and services in the ATC ground environment would be more expensive and technically complicated because of the need to integrate data from separate data link sources. Therefore, only ADS-B functionality via the 1090ES data link has been carried forward to the Partial RIA.

4.7.2 The introduction of airspace segregation measures was also considered as a separate and distinct option in the Initial RIA phase. This approach would provide an alternative method of providing safety benefits between aircraft equipped with collision avoidance systems and all those aircraft not equipped with SSR transponders. It would also provide practical restrictions on recreational pilots who choose not to equip. This approach would ensure that all aircraft that came into proximity with collision avoidance systems could be detected and that the provision of ATS could always take place in airspace where the position and height of all traffic was known.

4.7.3 Notwithstanding the above, there would be unquantifiable economic costs with airspace segregation, which would be accrued over future years from ATM inefficiency and lack of access to airspace; this is contrary to the CAA's remit to ensure an efficient use of UK airspace in a joint and integrated manner as far as practicable. There would be social costs for those private pilots that would be denied access to certain airspace that they currently use, and there would also be costs associated with designing, publicising, monitoring and enforcing the segregated airspace. Furthermore, it is highly likely that the number of airspace infringements would increase above current levels if more UK airspace was converted into controlled or restricted access airspace. In addition, the amount of airspace available to aircraft that were not technically interoperable with SSR or ACAS would also reduce. This would force these aircraft to operate together in smaller volumes of airspace and, therefore, increase safety risks. Moreover, instances of aircraft having to fly closer together could increase environmental and noise pollution in those locations. Greater use of airspace segregation was, therefore, discounted as being a viable option and not carried forward to the Partial RIA.

[Views and comments on the policy options and the potential need for regulation are sought under "RESPONSE 2" and "RESPONSE 3" in the attached RIA Consultation Response Document. In particular, opinions would be welcomed on whether or not the 1090ES (ADS-B 'Out') capability on SSR transponders fitted under Options 2(a) and 3(a) should be enabled to provide the full ADS-B 'Out' functionality from 31 March 2008 rather than at a later date.]

[29] A brief explanation of FLARM is at Annex G.

5 Costs and Benefits

5.1 Sectors and Groups Affected

It is envisaged that the following groups and sectors would be positively or negatively affected by the proposed policy options:

a. CAT operators not already equipped with SSR Mode S. However, the impact on this sector is expected to be minimal due to the introduction of SSR Mode S into major en route and terminal airspace on 31 March 2005. This sector includes the following:
   (i) Regional airlines.
   (ii) Freight carriers.

b. Small aviation businesses as follows:
   (i) Aerial work companies.
   (ii) Flying clubs.
   (iii) Flying training schools.
   (iv) Air taxi and air ambulance companies.

c. Private individuals as follows:
   (i) Aircraft owners.
   (ii) Recreational and sporting pilots.

d. Aircraft and avionics manufacturers and suppliers.

e. Aircraft maintenance organisations.

f. Airworthiness certification authorities and organisations.

g. MoD and other operators of State aircraft, from both EU and non-EU member States.

h. Search and Rescue (SAR) agencies and the emergency services.

i. Air Navigation Service Providers (ANSPs), especially NATS.

j. CAA.

k. Government Departments.

[Views and comments on the sectors and groups affected are sought under "RESPONSE 4" in the attached RIA Consultation Response Document.]

5.2 Benefits

5.2.1 Option 1

No investment outlay would be required by the industry for new equipment until a later implementation was approved for future technology. There would also be no new regulatory impact on small businesses.

5.2.2 Option 2

5.2.2.1 Option 2 would bring a variety of actual and potential safety and economic benefits to some or all of the sectors and groups identified in Section 5.1 above. Many of these are extremely difficult to quantify in monetary terms. This is because there is a multi-dimensional relationship between the benefits themselves, the airspace in which the aircraft operate, the times that aircraft operate and the impact of other aviation initiatives and technology implementation, both in the UK and the rest of Europe. The qualitative benefits of Option 2 for the different groups and sectors have been set out in Table 7 below.

5.2.2.2 Nevertheless, for this proposal it is the safety benefits that are the key drivers. In these terms, the Value of Statistical Life (VOSL) could be used to provide a comparative and quantitative measure against monetary costs. Currently, the ‘DfT Highways economic note No.1: 2004’ quantifies VOSL as being approximately £1.4M for valuing acute risks. In 1999, four lives were lost when an RAF Tornado and a Cessna aircraft collided in unregulated airspace. The subsequent accident report stated that the operation of an SSR transponder on the Cessna and an SSR-based collision warning system on the Tornado could have prevented the accident. If, due the implementation of Option 2, a similar accident can be prevented in the future, the quantitative benefits in terms of VOSL for this one accident alone would be £5.6M. This figure would increase significantly when taking account of any material damage to property, Search and Rescue operations and administration. It is considered that the implementation of Option 2 could help to prevent several collisions over the lifetime of the technology.

5.2.2.3 Notwithstanding the significant safety benefits to all airspace users that should result from an increased carriage of SSR transponders, economic benefits should also be derived from the potential to increase overall efficiency, and hence cost effectiveness, in the provision of ATC and in the usage of the airspace in the UK FIR. This would come from a combination of factors that could include: less disruption to the flow of air traffic resulting from ‘conflicts’ with unknown aircraft; the potential to use airspace more flexibly; potential controller workload offsets that would permit the handling of more traffic; and more direct routing for all aircraft resulting in fuel efficiency savings and reduced delays. The ability to integrate UAV operations in all airspace should also bring long-term benefits to the economy in terms of the reduced ‘through-life’ operating and environmental costs of UAV operations compared to piloted aircraft. A reduced level of planning objections from the aviation industry to wind turbine developments would also be economically and environmentally beneficial. Private pilots should be able to share in these economic benefits through continued or improved access to airspace and ATC services as the levels of CAT grow.

5.2.2.4 Many of these economic benefits are dependent on other issues and initiatives outside of the influence of these policy proposals, and it is, therefore, not possible to directly attribute quantitative monetary figures to the impact of Option 2 in these areas. In particular, it is not possible to attribute the proportion of the economic benefits that could be derived by individual groups or sectors. Nevertheless, all sectors and groups would benefit from improved safety as traffic levels and airspace complexity continue to rise.

5.2.2.5 The introduction of SSR Mode S technology to replace existing SSR Mode 3A/C transponders would be an essential step in improving the efficiency of the SSR 1090 MHz ‘Reply’ frequency, and hence safety. Implementation of SSR Mode S would be the only way to permit the UK to increase the carriage of SSR transponders on aeroplanes and helicopters above current levels and meet the ICAO Annex 6 pressure-altitude reporting requirements. The withdrawal of SSR Mode 3A/C technology would also ensure that the full benefits of the recent investment made by operators in collision avoidance systems, SSR Mode S radars and the future ATC ground environment can be realised.

5.2.3 Option 3

Option 3 would further increase the magnitude of all the safety and economic benefits of Option 2, by providing additional equipage of SSR Mode S transponders on a wider variety of aircraft in all of UK airspace. SSR transponder equipage would be maximised to the greatest extent possible under this option and, therefore, the potential benefits set out in Table 6 below would also be maximised. The implementation of Option 3 would help to overcome most of the background issues associated with this proposal in a single regulatory step. This provides a significant Simplification Measure for Stakeholders.

5.2.4 Options 2(a) and 3(a)

The implementation of Options 2(a) and 3(a) would provide a key link to the adoption of the European future ATM surveillance strategy into UK airspace. In particular, it would provide an airborne environment with which to facilitate the evolutionary introduction of a new ADS-B infrastructure to support ATC and airborne aircraft spacing and separation applications. By 'future-proofing' the capability of SSR Mode S transponders fitted under this policy proposal, Stakeholders would not then need to replace the transponders at a later date to support any subsequent implementation of ADS-B. Consequently, future ADS-B implementation costs would be minimised and the steps required to create a suitable ADS-B airborne environment would be eased considerably. The implementation of Option 3(a) would also ensure that all the guiding policy principles could be applied in a single regulatory step and help to overcome all of the background issues. The aim of this is to provide a significant Simplification Measure for Stakeholders.

5.2.5 Summary of the Qualitative Benefits of the Options

5.2.5.1 Table 7 below identifies the potential qualitative benefits of Options 2 and 3 for each sector and group affected by the proposals. As explained earlier, the potential magnitude of the benefits would be greater under Option 3 but it is not possible to quantify this in a meaningful way. It is also recognised that in some of the categories of user, all the benefits might not apply to all individuals and organisations within the category. For example, only those private pilots that use ATC would have their recreational flying directly helped by any economic benefits from more efficient ATS. However, they would benefit from ATC efficiency as members of the public when undertaking flights with commercial operators for business or pleasure.

		CAT	Private Pilots	Small Aviation Business	ANSPs	MoD	Aircraft and Avionics Suppliers	Maintenance Organisations	SAR	Government
Safety	Improved effectiveness of collision avoidance systems	✓	✓	✓	✓	✓			✓	✓
	Improved safety in ATM and provision of ATS	✓	✓	✓	✓	✓			✓	✓
	Improvements to ATC safety nets	✓	✓	✓	✓	✓			✓	✓
	Potential to improve emergency response by ATC	✓	✓	✓	✓	✓			✓	✓
	Improved SSR RF environment	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Potential to improve detection and management of airspace infringements	✓	✓	✓	✓	✓				✓
	Improved data for Search and Rescue	✓	✓	✓	✓	✓			✓	✓
Economic	Improved efficiency in provision of ATS	✓	✓	✓	✓	✓				✓
	Improved management of ATS workload	✓	✓	✓	✓	✓				✓
	Potential for more efficient and flexible use of airspace	✓	✓	✓	✓	✓				✓
	Potential for reduced operational delays	✓	✓	✓	✓	✓				✓
	Continued or improved access to airspace		✓	✓		✓				
	Potential for improved commercial passenger services	✓		✓	✓					✓
	Growth in avionics supply and installation market	✓	✓	✓	✓	✓	✓	✓		✓
	Potential to provide mitigation for the effects on wind farms	✓	✓	✓	✓	✓				✓
	Potential for reduced insurance premiums	✓	✓	✓	✓	✓				✓
	Improved implementation of future technology	✓	✓	✓	✓	✓	✓	✓		✓
	Improved aircraft surveillance for defence and security	✓	✓	✓	✓	✓			✓	✓
	Meet international obligations									✓

Table 7: Qualitative Benefits of Options 2 and 3

5.2.5.2 Table 8 below summarizes the potential of the proposed policy options to have a beneficial impact on the efforts to try and overcome the background issues described in Paragraph 2.2 above. Option 3(a) is currently the CAA's preferred option as it would maximise efforts to overcome all of the background issues.

Background Issues	Options				
	1	**2**	**2(a)**	**3**	**3(a)**
1. Replacement of 'Classical' SSR.	✗	✓	✓	✓	✓
2. A Need to Improve Collision Avoidance Measures.	✗	✓*	✓*	✓	✓
3. International Obligations and Co-operation.	✗	✓	✓	✓	✓
4. Support for Future Surveillance Technology.	✗	✗	✓*	✗	✓
5. Efficiency of the Use of Airspace in the UK FIR.	✗	✓*	✓*	✓	✓
6. Integration of UAV Operations	✗	✓*	✓*	✓	✓
7. Impact of Wind Turbines on Aviation	✗	✓*	✓*	✓	✓
8. Spectrum Availability for Primary Radar	✗	✓*	✓*	✓	✓

** Denotes that the option would only provide partial benefits for helping to overcome the background issue.*

Table 8: Potential Benefits of the Options in Overcoming the Background Issues

[Views and comments on the potential benefits of the proposed policy options are sought under "RESPONSE 5" in the attached RIA Consultation Response Document.]

5.3 Costs

5.3.1 General Cost Assumptions

5.3.1.1 Table 9 below sets out the estimated costs (excluding VAT) for the initial purchase of the required equipment for individual aircraft. Fitment of the equipment is likely to be classed as a minor modification to the aircraft and all costs include estimates for integration and certification. Market research indicates that SSR transponders with the Mode S 1090 MHz 'Extended Squitter' capability are unlikely to be significantly more expensive than ones without the capability. Indeed, many vendors are now including the capability as standard. The prices quoted below do not include the cost of also providing a suitable GPS unit with which to provide positional data to the transponder, as this is proposed to remain voluntary under Options 2(a) and 3(a) at this stage.

Description	Power	Estimated Cost
SSR Mode S ELS Level 2 IFR Certified Transponder	200W	£2,600 to £3,100
Panel Mounted SSR Mode S ELS LAST[30]	125W	£1,800
	70W	£1,700
Portable SSR Mode S ELS LAST or LPST[31]	70W	£1,000
	20-30W	£500 to £1,000
Balloon Station for SSR Mode S ELS LAST		£440
Mobile Housing for SSR Mode S ELS LAST		£340

Table 9: Initial Purchase Equipment Costs

5.3.1.2 Table 10 below sets out the estimated additional annual costs of operating SSR transponders on aircraft that are not currently required to carry the equipment. In the case of the Wireless Telegraphy Act (WTA) licences, the CAA hopes move from an annual renewal system to one that is in line with the renewal of the Certificate of Airworthiness (C of A) of an aircraft. With this Simplification Measure, it is envisaged that the WTA licence would then only have to be renewed every three years.

[30] Mode S capable Light Aviation SSR Transponder (LAST) products currently available with an ICAO-compliant power output of 70W, which are certified for operations below 15,000 feet and 175 knots True Air Speed. It is envisaged that a low-power (20W to 30W) portable SSR transponder would need to be developed before equipage of most very light aircraft (less than 750 kg) could be achieved.

[31] A Mode S capable Low-Power SSR Transponder (LPST) is envisaged as a self-contained, highly portable unit operating at 20 to 30 W power output. The LPST product is not yet available on the market but a technology demonstrator has been successfully flight trialled and further development work is ongoing in the UK.

Description	Estimated Cost
Annual Check of SSR Equipment	£80 to £140
Biennial Check in accordance with AAD 02-12-99 R2 and Airworthiness Notice 12 Appendix 67	£45 to £67.50
Annual Wireless Telegraphy Act Licence Fee (required for an SSR transponder even where a radio is not fitted)	Transportable LPST = £15
	<3,700 kg (Fixed) = £20
	>3,700 kg (Fixed) = £150

Table 10: Annual Costs for SSR Transponders

5.3.1.3 In the following sections, only aircraft that are registered in the UK have been counted, as there are no accurate figures available on aircraft that are registered in another State but which are based and operated in the UK. For aircraft that are not included on the CAA Aircraft Register, such as gliders and hang gliders, numbers of aircraft have been obtained from consultation with the appropriate user organisations. Cost figures have been estimated for aircraft with a current valid C of A and also for aircraft with an invalid C of A, on the assumption that they may all be eventually equipped. However, the costs for the latter scenario are considered to be worst case.

5.3.1.4 In the case of very light aircraft, costs may have also been overestimated. This is because a conservative assumption has been made about the numbers of aircraft that would operate with a portable, and less expensive, SSR transponder. Under the current European Minimum Operation Performance Specification for a LAST, owners of aircraft with a maximum take-off mass below 1,200 kg and a maximum cruising True Air Speed of 175 knots could elect to equip with one of these units rather than a more expensive fixed transponder. Moreover, rather than purchase a portable unit for every aircraft, it may be possible for some owners to share or to lease these transportable units from clubs, associations or businesses when required for applicable flights.

5.3.1.5 Under all the options, it is also envisaged that the CAA would have to fund a temporary Exemption Co-ordination Cell (ECC) to manage the processing of exemption applications; particularly during any transition periods. This ECC is expected to be required for a period of at least two years from the regulation coming into force and could cost up to an estimated £40,000 per year.

5.3.2 Option 1

5.3.2.1 Under this ‘Do Nothing’ option, there would be no new additional equipage costs for businesses or private individuals operating aircraft in airspace where an SSR transponder is not currently required (when compared to the estimated equipage costs required by Options 2 and 3, which are set out later in this document).

5.3.2.2 However, there would be longer term costs for aviation businesses, and the UK economy as a whole, which would be accrued over future years from the ATM inefficiency and the increased risk of mid-air collisions that may occur through the continued lack of interoperability between some groups and sectors. Furthermore, there could be economic, social and environmental costs from a future need to segregate non-interoperable aircraft in the recreational and sporting flying communities from commercial or military air traffic; particularly, where this air traffic is equipped with collision avoidance systems or receiving a service from an ATC unit. Ultimately, as safety is the highest priority in aviation, the growth of air traffic in the

UK may have to be restricted and this would have significant adverse consequences for the UK economy.

5.3.2.3 Specifically, the CAA considers that the adverse impact of Option 1 would be as follows:

a. The potential would be lost to contribute towards improved safety levels by reducing the occurrence or severity of risk-bearing ‘near miss’ incidents in unregulated UK airspace by as much as 36%.

b. The potential safety improvements and economic benefits from the significant investment in SSR Mode S and collision avoidance technology that has been made by NATS, MoD and CAT operators would not be maximised. In particular, the potential four to ten-fold reduction in the risk of mid-air collision that is provided by collision warning systems would not be realised throughout UK airspace.

c. The potential improvements aimed at reducing the adverse safety and economic impacts of some 350 annual infringements of regulated UK airspace would not be realised.

d. In order to maintain safety levels, growth of air traffic movements at regional airports may have to be restricted or increased amounts of regulated airspace put in place to help reduce the risk of collision between flights using those airports and any non-interoperable aircraft flying in the vicinity. Any restriction of air traffic growth would have significant adverse consequences for the UK economy and an increase in regulated airspace would have a major impact on small businesses operating non-interoperable light aircraft.

e. Small aviation businesses that choose to continue to operate light aircraft without an SSR transponder under Option 1 may find it increasingly difficult to gain optimum routings or ATC services through regulated airspace. The costs accruing from the additional fuel needed to route around the regulated airspace would then increase, particularly if the price of oil continues to rise in line with recent trends.

f. The future implementation of aircraft surveillance based on ADS-B technology may be made more difficult and have a greater impact on operators if the opportunity to create a common baseline of interoperability between all aircraft is lost at this stage. In particular, if outdated ‘classical’ SSR transponders are not phased out, there may be insufficient integrity and capacity in the radio frequency chosen for initial ADS-B applications to support an implementation of this new technology.

g. The UK would be unable to meet its international obligations as a contracting signatory to the Chicago Convention on International Civil Aviation for ensuring that all aeroplanes and helicopters were equipped with pressure-altitude reporting transponders. Moreover, the CAA would not be able to guarantee that aircraft conducting international flights to mainland Europe outside of the en route airways structure would be correctly equipped with the SSR Mode S Elementary Surveillance transponder functionality required by other European States with effect from 31 March 2008.

h. Due to a potential suitable mitigation for the impact of wind turbine developments on aviation surveillance systems being discarded under Option 1, the UK may not be able to meet Government targets for the use of renewable energy sources. This is because the aviation industry will continue to need to place objections to planned wind turbine developments where they are likely to ‘mask’ the safe detection of aircraft on primary radars.

i. The potential economic and environmental benefits of the integration of UAV operations throughout UK airspace may be severely reduced. This is because under Option 1, there would continue to be a lack of a crucial element of technical interoperability with which to avoid mid-air collisions between manned aircraft and UAVs in unregulated airspace. Consequently, it may never be possible to achieve this integration, with the resultant significant cost to this emerging industry sector.

5.3.3 Options 2 and 2(a)

5.3.3.1 The estimated costs for equipage of light aircraft under Options 2 and 2(a) are set out in detail at Annex H. For these calculations, it has been assumed that all aircraft of less than 5,700 kg except the non-motorised gliders, hang gliders and balloons would need to equip with suitable SSR transponders.

5.3.3.2 Overall, under Options 2 and 2(a) the estimated total cost of equipping light aircraft that are owned by, and used in the activity of, aviation businesses is summarised in Table 11 below. The majority of these businesses are expected to be small firms. However, little is currently known about the actual numbers of light aircraft operated by small firms, as the CAA does not have a remit to oversee the economic regulation of this sector. Therefore, the margin for error in the estimates may be significant. It is hoped that the inputs from consultation will help to refine these estimates, which are currently considered to be conservative.

Equipage Costs for Business Under Options 2 and 2(a)	Estimated Lower Cost	Estimated Higher Cost
Business Aircraft <5,700 kg (Valid C of A)	£3M	£5.6M
Business Aircraft <5,700 kg (All C of A)	£3.4M	£6.4M

Table 11: Estimated Business Equipage Costs for Options 2 and 2(a)

5.3.3.3 The overall total cost of equipping all light aircraft in the UK (owned by both business and private individuals) is estimated to be between £11M and £32.6M for Options 2 and 2(a). Therefore, it can be seen that a significant proportion of the overall costs is expected to fall on private aircraft operators rather than on businesses. The highest cost figure assumes that those aircraft that do not currently have a valid C of A would eventually need to equip, and this is considered to be a very conservative assumption. The estimates do not take account of the possibility that some of the aircraft with an existing SSR Mode S functionality may need to obtain a software upgrade or new SSR Mode S transponders to provide the 'Extended Squitter' capability required by Option 2(a). Notwithstanding this, it is considered that the overall cost would still fall with the range of estimates.

5.3.3.4 It is envisaged that current annual and biennial costs incurred for checking SSR transponders might increase slightly with the introduction of SSR Mode S. Some aircraft may also require an upgraded WTA radio licence or a radio licence for the first time. This is because a WTA licence is required for an SSR transponder, even if a communications radio is not also required to be fitted to an aircraft. It should be stressed that a communications radio would not be a requirement of these policy proposals. The additional costs to the aviation community from any new WTA licensing needs for Option 2 are estimated to be between £30,000 and £120,000 depending on whether an LPST or a fixed SSR transponder is fitted.

5.3.4 Options 3 and 3(a)

5.3.4.1 The estimated costs for equipage of light aircraft under Options 3 and 3(a) are set out in detail at Annex I and are based on mandatory fitment of transponders to all aircraft with a maximum take-off mass of less than 5,700kg. A wide variation in the figures has resulted from the need to make assumptions about the type of SSR transponders that would be fitted to the various aircraft and the number of aircraft operated by small firms. For example the costs for portable LPSTs for very light and/or non-motorised aircraft are not known. Also, pilots and owners of very light non-motorised aircraft may choose to lease equipment when required for applicable flights rather than purchase it.

5.3.4.2 Overall, the estimated equipage costs for businesses for implementing Options 3 and 3(a) are summarised in Table 12 below. It is hoped that these can be refined following conclusion of the consultation process and, in particular, those costs associated with small firms.

Equipage Costs for Business Under Options 3 and 3(a)	Estimated Lower Cost	Estimated Higher Cost
Business Aircraft <5,700 kg (Valid C of A)	£3.5M	£6.8M
Business Aircraft <5,700 kg (All C of A)	£4.8M	£9.5M

Table 12: Estimated Business Equipage Costs for Options 3 and 3(a)

5.3.4.3 The overall total cost of equipping all aircraft in the UK (owned by both business and private individuals) is estimated to be between £13.6M and £45.7M for Options 3 and 3(a). Therefore, it can be seen that a significant proportion of the overall costs is expected to fall on private aircraft operators rather than on businesses. The highest cost figure assumes that all aircraft that do not currently have a valid C of A would eventually need to equip, and this is considered to be very conservative assumption.

5.3.4.4 Under Option 3, it is estimated that between 6,700 and 13,200 additional aircraft would require annual and/or biennial checks on SSR transponders for the first time. Therefore, there could be an additional total annual cost to private individuals and businesses of between £685,000 and £2.3M. Of this, the total costs directly attributable to businesses are estimated as being between £108,000 and £456,000 per year. The upper figures are, once again, considered to be a worst case scenario because they account for aircraft that do not currently have a valid C of A.

5.3.4.5 A proportion of aircraft carrying and operating an SSR transponder would also now be required to hold a WTA Licence for the first time. Some owners may just have to upgrade an existing licence. The overall additional cost for this requirement to private individuals and businesses is estimated to be between £100,000 and £275,000, depending on what SSR transponder is fitted.

[Views and inputs on the potential costs of the proposed policy options and the means by which they should be financed are sought under "RESPONSE 6" and "RESPONSE 7" in the attached RIA Consultation Response Document.]

6 Small Firms Impact Test

6.1 Stage 1 of the Small Firms Impact Test (SFIT) has been conducted by liaising with small GA businesses and user groups. Only a few responses were received from small business owners but these enquiries have indicated that there could be a significant and disproportionate financial impact on small aviation businesses under Options 2 and 3 resulting from the costs of equipping aircraft with the appropriate equipment in time to meet any regulatory mandate. The initial financial outlay required for the new equipage is the main issue involved. In some cases, the estimated cost of equipping with an SSR Mode S transponder represented 20% of the value of an individual aircraft.

6.2 For example, one business involved in the leasing of aircraft, where 8 aircraft below 1,350 kg are owned and 20 people are employed, indicated that it might have to sell one of the aircraft to meet the potential £23,500 required for equipment outlay. This would impact the revenue earning capability of the business. Alternatively, the increased costs would have to be passed on the customers with the potential resultant loss of business. In particular, profit margins were cited as already being extremely low in the flying training market. Therefore, a potential unintended consequence on small flying schools could be that any costs passed on to customers may potentially make the price of obtaining a Private Pilot's Licence in the UK more expensive than travelling abroad for 3 to 4 weeks to obtain the training.

6.3 One small business also cited the cumulative burden of this proposal and other regulatory initiatives, such as CAA charge increases and a proposed reclassification of airspace so that instrument flying outside of controlled airspace would not be permitted, as having a significant impact on its revenue. However, the impact is not considered to be complex and it is not considered that the formal conduct of Stage 2 of the SFIT would reveal any additional major impacts. Notwithstanding, potential Simplification Measures for small firms will be further investigated during the workshops that will be held during the public consultation.

6.4 **Potential Simplification Measures**. In mitigation of the potential financial impact on the industry, the CAA considers that the following Simplification Measures are relevant to these policy proposals:

a. The proposals would improve the interoperability and conspicuity of light aircraft with ATC radars and collision avoidance systems, and this should, in turn, make it easier for small business aircraft to gain easier access to airspace, more direct routings and ATC services. As a minimum, this improved interoperability should result in less pressure to implement restrictive airspace regimes in the future to segregate light aircraft from commercial and military air traffic that is equipped with collision avoidance systems or receiving a service from an ATC unit. The fuel cost savings for businesses resulting from these potential future benefits could make a significant contribution towards off-setting the initial equipage costs.

b. The current requirement to renew a WTA licence annually will be reviewed. The aim will be to try and tie this process in with the C of A renewal such that, in most cases, the WTA licence may only have to be renewed every three years. This will simplify the process and save on administration costs. Notwithstanding this, the CAA has already recently simplified the WTA licence application process to remove the need for applicants to have to list all the relevant equipment (including serial numbers) carried on an aircraft, and only one short application form is now required for both the WTA radio licence and the certificate of installation of equipment. Moreover, where a radio licence is currently held, the process for updating the licence for the addition of an SSR transponder will be automatic and no further administrative input from Stakeholders will be required.

c. It is envisaged that a minimum of a two-year transition period would be provided from the new requirement coming into force, during which small firms will be able to manage and spread their equipage programmes. Exemptions will be granted during this transition period without operating restrictions or penalties being applied. The exemption application process would be kept simple in order to minimise any administrative burden.

d. Options 2(a) and 3(a) are designed specifically to provide 'future-proofing' and simplification for the eventual introduction of ADS-B applications in the UK ATM system. Therefore, any airborne equipage for these options would ensure that expensive avionics upgrades should not be required in the short to medium term in order to provide a suitable airborne environment for ADS-B based ATC applications.

e. This proposal will simplify the UK SSR transponder carriage requirements in the ANO 2005 considerably. This is consistent with one of the overall aims of the DfT's draft Simplification Plan.

f. Equipage with SSR Mode S transponders ensures that small firms would meet the minimum carriage requirements in the airspace of other European States. Therefore, this proposal resolves some overlap and potential inconsistency with similar legislation in other European States. Consequently, should any related Single European Sky legislation follow in the future, there would be minimum impact on UK Stakeholders.

g. The specification for the LPST includes a requirement for a self-test function. This will minimise the requirement for formal periodic checking of the units and, hence, the through-life cost of ownership will be kept as low as possible.

h. Research with some avionics suppliers has indicated that they should be able to offer discounts of at least 15% on the prices set out in Table 6 above for the purchase of ten or more new SSR Mode S transponders with which to equip fleets of aircraft.

6.5 Option 3(a) would result in the highest costs of all the options, with an estimated worst-case scenario of £9.5M attributable to businesses. The majority of these costs are expected to fall on small businesses, as these are believed to be the major operators of aircraft with a maximum take-off mass of less than 5,700 kg. The CAA intends to continue to analyse small business issues in more detail. In particular, it plans to organise a specific presentation/workshop for interested user groups and small businesses as part of the formal consultation process for the Partial RIA. Through this consultation, it is hoped that the costs to business can be further refined and, in particular, those that would have to be met by small firms.

6.6 The Cabinet Office Better Regulation Executive has scrutinised this Partial RIA document. It has been agreed that, as the worst-case estimated costs to business are expected to be significantly less than £20M, the proposals do not need to be cleared by the Prime Minister's Panel for Regulatory Accountability prior to consultation. However, this issue will be reviewed following consultation when the cost estimates have been refined.

[Information, views and comments on the impact that the proposed policy options would have on small businesses are sought under "RESPONSE 8"and "RESPONSE 9" in the attached RIA Consultation Response Document.]

7 Competition Assessment

7.1 These policy proposals would affect only those businesses that did not need to equip aircraft in response to the introduction of SSR Mode S into major terminal and en route airspace with effect from 31 March 2005. Furthermore, it is not felt that there are any markets where companies affected by Options 2 and 2(a) will compete against those that would only be affected by Options 3 and 3(a).Therefore, in terms of competition issues, the following two cases need to be considered:

a. Markets where some business aircraft are currently mandated to be equipped with SSR Mode S and some are not.

b. Markets where no aircraft are currently mandated to be equipped with SSR Mode S.

7.2 In the former case, these are the markets where some but not all users were affected by the earlier regulation. These new policy proposals are, in effect, the reverse of the earlier requirements; those companies that were obliged to equip with SSR Mode S transponders from 31 March 2005 would not need to do so now, and those companies that did not need to equip by 2005 would now need to do so with effect from 31 March 2008. The effects on competition can, therefore, be assumed to be the reverse of those experienced in response to the earlier regulation. The markets affected by the earlier regulation were documented in the published RIA consultation documents as: air taxi and air ambulance operations, pilot training schools, corporate aircraft services and aerial work services. The CAA sought representations from these sectors as to the likely effect of the earlier SSR Mode S regulation on competition issues but none were received. Nevertheless, a number of responses were received commenting on the burden of the initial equipage costs.

[Information, views and comments from businesses on the likely impact of the proposed policy options on competition within the affected markets are sought under "RESPONSE 8" and "RESPONSE 9" in the attached RIA Consultation Response Document.]

7.3 In the second instance highlighted in Paragraph 7.1(b) above, the proposed policy options would affect all airspace users. Therefore, it is not considered that any adverse competition issues would arise from these proposals and no barriers to entry into the relevant aviation markets would be created. There may, however, be some initial adjustments in some of the markets where costs are passed on to customers. In these cases, it is considered likely that some of the larger businesses may be able to absorb the initial equipage costs more easily than small firms, which would place them at a competitive advantage for pricing their services during the early years of any implementation. A small proportion of customers may also look to overseas companies for cheaper services.

7.4 Options 3 and 3(a) would affect an additional group of users that were not impacted by the earlier SSR Mode S requirements and which would not be affected by Options 2 and 2(a); namely those businesses that involve aircraft other than aeroplanes and helicopters. Since all such users would be affected by the proposed regulation, it is not considered that any adverse competition issues would arise from these proposals. Again, larger businesses may be better placed to absorb the initial costs than smaller ones in the initial years of the implementation. However, since suitable equipment is not yet available for many of these airspace users to comply with the proposed regulation, there is an additional uncertainty in the costs of implementation. This could result in a temporary disincentive for new entrants into the market and a subsequent lessening of competition.

8 Enforcement, Sanctions and Monitoring

8.1 Through its responsibility to issue permits under ANO 2005 Article 138, the DfT could enforce the requirement for operators of foreign registered public transport aircraft to equip with SSR Mode S, before being allowed to fly in UK airspace. Similarly, permits for foreign registered aircraft conducting aerial work could be issued under ANO 2005 Article 140.

8.2 The issue and renewal of Cs of A to aircraft operators in the UK and the conduct of 'ramp' inspections of aircraft to confirm equipage would supplement this process.

Staff from the CAA Safety Regulation Group would conduct both of these functions under existing arrangements. The WTA Licensing process, which is managed by the CAA, would also be used to monitor and enforce equipage. It is considered that these mechanisms will be sufficient for monitoring the effectiveness of this regulation.

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Annex A. Airborne Collision Avoidance Systems

1 ACAS Overview

1.1 Airborne Collision Avoidance Systems (ACAS) have been developed to provide a 'last resort' measure to reduce the risk of mid-air collisions between aircraft. ACAS uses Secondary Surveillance Radar (SSR) technology to detect other aircraft and provide suitable warnings to flight crew but is totally independent of ground-based ATC systems.

1.2 ACAS is often referred to as the Traffic Alert and Collision Avoidance System (TCAS) and the terms used interchangeably. However, in its strictest sense, ACAS refers only to the concept of collision avoidance, whereas TCAS is associated with commercially available technology that satisfies ICAO standards. For example, TCAS II is the only commercially available implementation of ACAS II.

1.3 Safety studies have shown that there is a significant safety benefit from the widespread carriage of ACAS. Specifically, the risk of mid-air collision can be reduced by at least a factor of three.

2 Principles of ACAS Operation

2.1 Aircraft equipped with ACAS are able to detect and monitor other aircraft that are equipped with and operating SSR transponders; non-transponding aircraft cannot be detected by ACAS. ACAS operates by interrogating the SSR transponders of nearby aircraft on the 1030 MHz SSR 'challenge' frequency in Modes A/C and Mode Select (Mode S). Replies are then monitored on the 1090 MHz SSR 'reply' frequency. In addition, the unsolicited 'squitters' of information from Mode S transponders on 1090 MHz can be detected.

2.2 Each reply from a transponder that is received from an ACAS interrogation contains information to calculate an opposing aircraft's range, bearing and, if suitably equipped, its altitude. By using a series of replies, the closure rate between the 'host' aircraft equipped with ACAS and other aircraft can be calculated, together with the vertical speed of the opposing aircraft. Where SSR Mode S transponders are available on opposing aircraft, ACAS will employ 'selective' addressing based on the ICAO 24-bit Aircraft Address (AA); these AAs are described more fully in Annex C.

2.3 Where ACAS detects a potential risk from nearby aircraft, a Traffic Advisory (TA) is provided to the flight crew on a visual display and via an audible warning. Where a risk of collision is detected, some forms of ACAS can generate a Resolution Advisory (RA), which will recommend avoidance manoeuvres in the vertical plane. When both aircraft involved are equipped with ACAS II (see paragraph 3 below), co-ordination of the manoeuvres is achieved by an exchange of data between the Mode S transponders. However, RAs are only generated where aircraft are transmitting an altitude report, otherwise only a TA will be generated.

3 Levels of ACAS Functionality

3.1 **ACAS I/TCAS I**. This functionality only provides TAs, which will help flight crew to visually search for conflicting traffic. TCAS I is currently used by some small aircraft and helicopters, particularly by pipeline inspection helicopters and police air support units. The MoD is also equipping some of its training aircraft with TCAS I and some private pilots have voluntarily equipped with TCAS I in the UK.

3.2 **ACAS II/TCAS II**. This functionality provides RAs in the vertical plane in addition to TAs. TCAS II Version 7.0 is the only equipment that complies fully with ICAO standards and, in Europe, must be carried by all aircraft with a maximum take-off mass in excess of 5,700 kg or a passenger seating configuration in excess of 19. In order to maximise the effectiveness of ACAS II equipage, ICAO standards require the carriage and use of altitude reporting transponders on aeroplanes and helicopters, irrespective of the airspace or class of flight involved. This differs from the current UK regulations where transponders are only required above FL 100 and in controlled airspace. The UK CAA has currently filed a difference with this ICAO requirement and this is described more fully at Annex B.

3.3 **ACAS III**. This functionality provides TAs and RAs in both the vertical and horizontal planes. However, ACAS III has not so far been progressed operationally.

4 Other Electronic Collision Warning Systems

4.1 **Traffic Proximity Alert System**. Traffic Proximity Alert Systems (TPAS) passively detect replies from SSR transponders on 1090 MHz within the vicinity of the host aircraft and can display the estimated distance, altitude and Mode 3A identity code of these aircraft. They can also evaluate whether or not 'threat' aircraft are manoeuvring in the vertical plane. Visual and audible alerts can be provided and units are independent of any SSR equipment carried on board the host aircraft; some are also self-contained and require no external power to operate. Scanning range is typically about 5 nm. Some TPAS products are very light, small and relatively cheap compared to other avionics. However, like ACAS, they are only able to detect aircraft that are equipped with and are operating SSR transponders. Furthermore, TPAS needs those transponders to be interrogated by external sources in order for replies to be available for detection.

Annex B. Analysis of Airprox Reports

1 Introduction and Overview of Results

1.1 The CAA has analysed 299 individual Airprox reports published by the UK Airprox Board (UKAB), which cover the 18-month period from January 2004 to June 2005 inclusive. Each report was examined to determine whether or not Secondary Surveillance Radar (SSR) was a relevant factor in helping to reduce the risk of collision in the incidents or, if it had been available, could have been of benefit. The results of this analysis support the CAA proposals to widen the carriage and operation of SSR transponders on all aircraft in order to increase safety levels in the UK Flight Information Region.

1.2 Overall, it was found that just under half of the 299 Airprox reports examined had some relevance to the issues contained in this proposal surrounding the interaction of SSR transponders with collision warning systems and/or Air Traffic Control (ATC) systems. Table 13 below sets out a summary of the results:

	Number of Airprox	Airprox in Class G Airspace	Risk Bearing Airprox
All Airprox.	**299**	**176**	**107**
Airprox where SSR and/or ACAS was of benefit.	**74**	**34**	**5** *(3 Class G)*
Airprox where SSR and/or ACAS could have been of benefit if fitted and operated.	**59**	**53**	**39** *(All Class G)*
Other Airprox where UKAB commented on SSR.	**11**	**11**	**2**

Table 13: Summary of SSR Related Airprox Reports

1.3 There are a number of important observations that arise from this analysis. Firstly, it is often argued that collision warning systems are mainly relevant to safety in the domain of controlled airspace in the en route airspace system. However, nearly half of all Airprox reports where the use of SSR and/or ACAS was of benefit in reducing the risk of collision occurred in the unregulated Class G airspace. Secondly, in those 74 Airprox incidents where SSR and ACAS was deemed to be of benefit, only 5 were assessed by the UKAB as being of Risk A (an actual risk of collision existed) or Risk B (the safety of aircraft was compromised). This highlights the safety benefits of the interaction of SSR transponders with collision warning systems and ATC systems, even in unregulated Class G airspace.

1.4 The 59 Airprox incidents where the interaction of SSR with collision warning or ATC systems could have been of benefit, if they had been available, also highlight some important issues. Firstly, almost two thirds of these incidents were assessed by the UKAB as being of Risk A or B risk bearing incidents, which is in direct contrast to the few risk bearing incidents that occurred where those systems were present and deemed beneficial. Furthermore, nearly all of these 59 incidents occurred in the unregulated Class G airspace and, more significantly, all of the risk bearing incidents were in Class G airspace. Moreover, in two reports, the UKAB assessed that the lack of SSR data was actually a contributory cause of the Airprox.

1.5 On the basis of the analysis of these Airprox reports, the CAA estimates that the wider carriage and operation of SSR transponders on aircraft in the unregulated

Class G airspace, and their subsequent availability for interaction with collision avoidance and ATC systems, may have potentially been able to help contribute towards reducing the overall number of risk bearing Airprox incidents by up to 36% between January 2004 and June 2005.

1.6 The UKAB published 298 out of the 299 Airprox reports in three volumes over the 18-month period. Each volume covered a 6-month period and they are all publicly available on the UKAB website. However, for further information, the results of the assessment of each of the volumes are summarised below.

2 Report Number 14 – January to June 2005

A total of 92 reports on Airprox incidents are available for the period January to June 2005. An analysis of these reports indicated that the issues surrounding the interaction of SSR transponders with collision warning and ATC systems are relevant in at least 37 (40%) Airprox incidents for the following reasons:

a. Of the 37 relevant Airprox reports, there are 15 incidents where the successful interaction of ACAS, Short Term Conflict Alert tools (STCA) or ATC radars with SSR transponders actually or potentially assisted in reducing the risk of collision between aircraft. This represents about 16% of all the Airprox incidents that occurred during this period. About half of these 15 incidents occurred in unregulated Class G airspace. Furthermore, only 3 of these 15 incidents were then assessed as Risk A or Risk B. The UKAB assessed the other 12 Airprox incidents as Risk C (no risk of collision existed). In many cases, ACAS interaction with SSR transponders was clearly responsible for reducing the risk of collision.

b. Of the 37 relevant Airprox reports, there are 16 incidents where it is believed that the interaction of ACAS or ATC radars with SSR transponders, if they had been fitted and/or operated, could have helped to reduce the risk of collision between aircraft. It is particularly noteworthy that 12 of these 16 incidents were assessed by the UKAB as Risk A or B and all occurred in unregulated Class G airspace. Furthermore, in Airprox 092/05, the UKAB made an assessment that the lack of SSR Mode C altitude data on one of the aircraft involved was a contributory factor in the cause of the Airprox.

c. In the remaining 6 relevant Airprox reports, the UKAB felt the need to refer to the benefits of equipping with and/or operating SSR transponders to provide ACAS and ATC with important safety information. In particular, it recommended that GA pilots should use SSR transponders to the maximum extent feasible in order to make their aircraft more conspicuous.

3 Report Number 13 – July to December 2004

A total of 98 reports on Airprox incidents are available for the period July to December 2004. An analysis of these reports indicated that the issues surrounding the interaction of SSR transponders with collision warning and ATC systems are relevant in at least 50 (51%) Airprox incidents for the following reasons:

a. Of the 50 relevant Airprox reports, there are 27 incidents where the successful interaction of ACAS, STCA or ATC radars with SSR transponders actually or potentially assisted in reducing the risk of collision between aircraft. This represents about 27.5% of all the Airprox incidents that occurred during this period. Some 11 of these 27 incidents occurred in unregulated Class G airspace. Furthermore, none of these 27 incidents were assessed as Risk A or B. In many cases, ACAS interaction with SSR transponders was clearly responsible for reducing the risk of collision.

b. Of the 50 relevant Airprox reports, there are 20 incidents where it is judged that the interaction of ACAS or ATC radars with SSR transponders, if they had been fitted and/or operated, could have helped to reduce the risk of collision between aircraft. It is particularly noteworthy that 12 of these 20 incidents were assessed by the UKAB as Risk A or B and the vast majority occurred in unregulated Class G airspace.

c. In the remaining 3 relevant Airprox reports, the UKAB felt the need to refer to the benefits of equipping with and/or operating SSR transponders to provide ACAS and ATC with important safety information.

4 Report Number 12 – January to June 2004

A total of 109 reports on Airprox incidents are available for the period January to June 2004. An analysis of these reports indicated that the issues surrounding the interaction of SSR transponders with collision warning and ATC systems are relevant in at least 57 (52%) Airprox incidents for the following reasons:

a. Of the 57 relevant Airprox reports, there are 32 incidents where the successful interaction of ACAS, STCA or ATC radars with SSR transponders actually or potentially assisted in reducing the risk of collision between aircraft. This represents about 29% of all the Airprox incidents that occurred during this period. Some 12 of these incidents occurred in unregulated Class G airspace. Furthermore, only 2 of these 32 incidents were then assessed as Risk A or Risk B. In many cases, ACAS interaction with SSR transponders was clearly responsible for reducing the risk of collision.

b. Of the 57 relevant Airprox reports, there are 23 incidents where it is believed that the interaction of ACAS or ATC radars with SSR transponders, if they had been fitted and/or operated, could have helped to reduce the risk of collision between aircraft. It is particularly noteworthy that 15 of these 23 incidents were assessed by the UKAB as Risk A or B and all occurred in unregulated Class G airspace. Furthermore, in Airprox 110/04, the UKAB made an assessment that the lack of SSR data on one of the aircraft involved was a contributory factor in the cause of the Airprox.

c. In the remaining 2 relevant Airprox reports, the UKAB felt the need to refer to the benefits of equipping with and/or operating SSR transponders to provide ACAS and ATC with important safety information. There was also some discussion in several reports about the benefits of gliders being equipped with SSR transponders in order to make their aircraft more conspicuous.

5 UKAB Analysis of Recent Airprox Incidents

The UKAB has analysed 119 currently unpublished Airprox incidents covering the 6-month period September 2005 to February 2006. Of these reports, a total of 16 (13.5%) involved situations where one aircraft was receiving a radar service from an ATC unit and the other aircraft was not operating an SSR transponder. The UKAB believes that these 16 incidents could have either been prevented, or the risk of collision reduced, had SSR transponders been operated by all the aircraft involved. This is because the ATC units would have been able to provide improved traffic information on the conflicting traffic to those pilots receiving a service.

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Annex C. SSR Mode Select

1 Mode S Overview

1.1 Secondary Surveillance Radar (SSR) Mode Select (Mode S) is a co-operative surveillance and communication system for Air Traffic Control (ATC) purposes. It employs ground-based interrogators and airborne transponders. Furthermore, ground-air-ground data link communications can be accommodated integrally with surveillance interrogations and replies. Mode S has been designed as an evolutionary improvement to the existing ‘classical’ SSR system operating in Modes 3A and C, and it provides the necessary improved surveillance, communication capability and capacity required to handle the forecast increased levels in air traffic. Both ground and airborne Mode S installations are backwards compatible in that Mode S interrogators will provide surveillance of aircraft equipped with Mode S and Mode 3A/C transponders and Mode S transponders will reply to existing SSR Mode 3A/C and Mode S interrogations. Mode S and Mode 3A/C interrogations are all made on 1030 MHz and all replies are made on 1090 MHz.

1.2 The ‘monopulse’ technique used in Mode S surveillance affords excellent position determination of SSR targets and selective interrogation techniques used by Mode S radars reduce the number of required replies by transponders. This reduction of replies is extremely beneficial to the SSR Radio Frequency (RF) environment. This means that full safety and effective airspace management benefits can be realized in a sustainable environment.

2 Principles of Mode S Operation

2.1 **Aircraft Addressing**. A principal feature of Mode S is that each aircraft is assigned an individual and unique identification number. This is known as an ICAO 24-bit Aircraft Address (AA), which is preset and cannot be changed from the cockpit. Although bound to the individual airframe identity, it has no direct relationship to the operational aircraft identification (i.e. callsign used in flight), other than during a specific flight. For the same reason that aircraft identification, and not the airframe identity, is used as the primary Air Traffic Management (ATM) reference, except in specific circumstances where the two are the same, the ICAO 24-bit AA will not be exposed to, or used by, operational ATC staff. Using this unique address, interrogations can be directed selectively to a particular aircraft and replies identified unambiguously. Channel interference is minimized because a radar can limit its interrogations to targets of interest. In addition, by proper timing of interrogations, replies from closely spaced aircraft can be received without mutual interference. The unique address in each interrogation and reply also permits the inclusion of data link messages to or from particular aircraft. There are nearly 17 million AAs available for use worldwide and the first few digits of each address identify the country of registration or origin. This is more than sufficient to accommodate the envisaged traffic growth in the ATC environment. In the UK, ICAO 24-bit AAs are assigned to civil aircraft by the CAA Safety Regulation Group.

2.2 **Interrogator Codes**. Another key feature of Mode S is the use of Interrogator Codes (ICs) to uniquely identify Mode S radars. The ICs comprise 15 Interrogator Identifier (II) and 63 Surveillance Identifier (SI) codes. The purpose of the ICs is to allow for unambiguous data exchange between radars and aircraft transponders. Unlike ‘classical’ SSR sensors, a Mode S radar has two methods of interrogating aircraft transponders: a general ‘All Call’ and a selective ‘Roll Call’. An ‘All-Call’ request is used by a Mode S radar to acquire Mode S equipped aircraft entering its area of radar coverage, which will reply with their unique ICAO 24-bit AAs. After acquisition of an aircraft’s ICAO 24-bit AA has been achieved, ‘lock-out’ protocols can then be used (based on the IC that the radar is using) to suppress further replies from the aircraft to any ‘All-Call’ requests by the same interrogator. The aircraft transponder will, however, continue to reply to ‘All Call’ requests from other Mode S radars using different ICs until they also apply ‘lock out’; they will also continue to reply to ‘classical’ SSR interrogations. In effect, the ICs identify the Mode S radars to which the transponders should reply or ignore. Following an ‘All-Call lock-out’ by a particular Mode S radar, that radar will then selectively address an aircraft transponder using a ‘Roll-Call’ interrogation. Only the specifically addressed aircraft will reply and this is commonly referred to as the ‘Mode S period’. The use of ICs also allows radars to discard replies that are not intended for them. It is this implementation of the ‘All-Call lock-out protocols’ and the ‘Roll-Call’ interrogations that reduces RF pollution and the problems associated with an interference phenomenon known as FRUIT (False Replies Unsynchronized In Time) and the general levels of over interrogation.

3 Mode S Surveillance Functionality

3.1 **Elementary Surveillance**. Mode S Elementary Surveillance (ELS) is the minimum surveillance functionality foreseen for aircraft equipped with any type of Mode S transponder. For Mode S ELS, the following information is provided by a transponder:

a. **Range and Azimuth**. Range and azimuth measurement is made from a single reply to a selective addressed interrogation. Position information will be of a similar accuracy to monopulse ‘classical’ SSR but it will not suffer from the same plot resolution problems when aircraft are very close together.

b. **Mode A and Mode C Decodes**. The routine selective addressed interrogation that is made each scan will request pressure-altitude information from an aircraft transponder. The same information is available as with the present Mode C but with a capability to decode altitudes to 25 ft precision. Selective addressed interrogations are also used to obtain Mode A ‘identity’ codes. Mode A information need not be requested on every scan as there is a ‘bit set’ in the ‘Roll-Call’ reply from the aircraft to highlight when its Mode A code has changed. Therefore, the Mode A code will only be requested when the aircraft is first acquired, re-acquired or when the Mode A code value is changed. This differs from existing systems when the Mode A code is requested from all aircraft within coverage on every scan.

c. **ICAO 24-bit AA**. Mode S ELS provides the ICAO 24-bit AA to enable discrete identification of the aircraft by the interrogating radar system.

d. **Aircraft Identification**. In addition to the Mode A code, an aircraft identification is provided in the form of a Downlinked Aircraft Parameter (DAP). This is an alpha-numeric string set that the flight crew are required to set on the transponder for transmission to correspond with the aircraft identification specified in Item 7 of the ICAO Flight Plan. If no Flight Plan has been filed, the transponder is required to report the aircraft registration. This information will be displayed to air traffic controllers and will form the primary means of identifying flights on controller workstations at suitably equipped units. The information will also be used by operational systems as a suitable aircraft identifier and will eventually replace the current usage of the 4096 Mode A Codes for this purpose. Requirements for the data contained in the Mode S aircraft identification feature are detailed in Appendix 2 to ICAO Annex 10, which have recently been reinforced by the CAA in AIC 4/2006 (Yellow 187) dated 5 January.

e. **Transponder Capability**. The Transponder Capability Report is, in effect, a ‘Data Link Capability Report’. Its purpose is to indicate to the radar the ability of the aircraft transponder to handle additional Mode S data link functionality.

It is extracted when the aircraft is first acquired and is transmitted in the form of a DAP.

f. **Flight Status**. The Flight Status functionality will indicate whether the aircraft is airborne or on the ground and could also be used to notify emergency conditions. The Flight Status report includes the 'Squawk Ident' function and takes the form of a DAP.

3.2 **Enhanced Surveillance**. Mode S Enhanced Surveillance (EHS) provides all the functionality of ELS but, in addition, it provides data link functionality and access to additional DAPs. In order to achieve this, the aircraft must have an interface between the transponder and its avionics system. It is, therefore, generally only supported by aircraft with modern 'digital' avionics and is most useful to the ATC community in the busy terminal and en route environments. The additional DAPs available are divided into the following 2 categories:

a. **Aircraft Current State Vector Information**. The aircraft current state vector information indicates the current state of motion of the aircraft. The information available can include:

(i) Ground Speed.

(ii) Track Angle.

(iii) Turn Rate.

(iv) Roll Angle.

(v) Climb Rate.

(vi) Magnetic Heading.

(vii) Indicated Air Speed.

(viii) Mach No.

b. **Aircraft Intention Information**. Aircraft intention information may be available from the avionics to indicate the future path of the aircraft. This information may be displayed to controllers and used to enhance safety net systems such as 'Short Term Conflict Alert (STCA)'. The information available includes Selected Altitude and the Barometric Pressure Setting on which this is based; this is useful for helping controllers to notice and prevent potential 'level busts' by aircraft.

3.3 **Differing Levels of Transponder Capability**. In accordance with ICAO Annex 10, Volume IV, to the Chicago Convention, all SSR Mode S-capable transponders must conform to one of the following five levels:

a. **Level 1**. This permits radar surveillance of aircraft based on pressure-altitude reporting and the Mode A identity code using the selective addressing. Level 1 Mode S transponders are no longer valid in UK and other European airspace.

b. **Level 2**. This has the same capability requirements as Level 1 but also permits aircraft identification reporting and other standard length data link communications to be conducted. Level 2 is the minimum standard required for SSR Mode S transponders in UK and other European airspace.

c. **Level 3**. This has the same capability requirements as Level 2 but also permits extended length ground to air data link communications.

d. **Level 4**. This has the same capability requirements as Level 3 but also permits extended length air to ground data link communications.

e. **Level 5**. This has the same capability requirements as Level 4 but also permits extended length link communications with multiple interrogators without requiring the use of multi-site reservations.

f. **Suffixes**. SSR Mode S transponders that are capable of 1090 MHz ‘Extended Squitter’, which is explained below, are annotated with the suffix “e”. For example, a Level 2 transponder with ‘Extended Squitter’ capability would be designated ‘Level 2e’. Additionally, SSR Mode S transponders with the ability to process SI codes, which is explained above, are annotated with the suffix “s”. Hence, a Level 2 transponder capable of ‘Extended Squitter’ and of processing SI codes would be designated ‘Level 2es’. Under Options 2 and 3 set out in this policy proposal, SSR Mode S transponders would have to be a minimum of ‘Level 2s’ to be operated in the UK. Under Options 2(a) and 3(a), the transponders would have to have a minimum capability of ‘Level 2es’.

4 Additional Mode S Functionality

4.1 **Controller Access Parameters (CAPs)**. CAPs are those DAPs that are available for display to air traffic controllers. These CAPs will typically include magnetic heading, indicated airspeed and selected altitude.

4.2 **System Access Parameters (SAPs)**. SAPs are those DAPs that are available to ATC systems and tools. These SAPs will typically include selected altitude, ground speed, true track angle, roll angle, vertical rate and track angle rate.

4.3 **‘Squitter’ Transmissions**. A Mode S transponder will periodically emit an unsolicited transmission of position and other parameters. This transmission is commonly referred to as a ‘Squitter’. The functionality can be used to support the passive acquisition of a Mode S target by either ground or airborne users. The ‘Squitter’ transmission is issued on the Mode S reply frequency 1090 MHz and its functionality includes the following:

a. **Acquisition Squitter**. Acquisition Squitter is used primarily by Airborne Collision Avoidance Systems (ACAS) and by ground-based ‘multilateration’ systems, particularly to support surface movement surveillance techniques. The Acquisition Squitter contains the unique ICAO 24-bit AA.

b. **Extended Squitter**. Mode S 1090 MHz ‘Extended Squitter’ is a means by which Mode S can provide Automatic Dependant Surveillance - Broadcast (ADS-B), which is a surveillance system based on unsolicited broadcasts of information from aircraft. The ‘Extended Squitter’ messages are transmitted every half second and contain additional information to the Acquisition Squitter, including position reports, altitude, aircraft identity and other Aircraft Derived Data (ADD) parameters. It is one of the three recognised ADS-B data links and is sometimes referred to as 1090ES. ADS-B and 1090ES are described further in Annex D.

Annex D. ICAO Annex 6 SSR Transponder Carriage Requirements

1 ICAO Annex 6 – Operation of Aircraft

In order to improve the effectiveness of Air Traffic Services (ATS) as well as airborne collision avoidance systems, ICAO Annex 6 to the Chicago Convention (Operation of Aircraft), sets out standards and recommended practices (SARPs) for the equipage of aeroplanes and helicopters with SSR transponders. These SARPs are described below.

1.1 Part I – International Commercial Air Transport - Aeroplanes

ICAO Annex 6, Part I, Chapter 6, Paragraph 6.19, states that *"all aeroplanes shall be equipped with a pressure-altitude reporting transponder which operates in accordance with the relevant provisions of Annex 10, Volume IV."*

1.2 Part II – General Aviation

1.2.1 ICAO Annex 6, Part II, Chapter 6, Paragraph 6.13, states that from 1 January 2003, *"unless otherwise exempted by the appropriate authorities, all aeroplanes shall be equipped with a pressure-altitude reporting transponder which operates in accordance with the relevant provisions of Annex 10, Volume IV."*

1.2.2 The note that accompanies this standard explains that the *"intent is also for aircraft not equipped with pressure-altitude reporting transponders to be operated so as not to share airspace used by aircraft with airborne collision avoidance systems. To this end, exemptions from the carriage requirement for pressure-altitude reporting transponders could be given by designating airspace where such carriage is not required."*

1.3 Part III - Helicopters

ICAO Annex 6, Part III, Chapter 4, Paragraph 4.15, states that *"all helicopters shall be equipped with a pressure-altitude reporting transponder which operates in accordance with the relevant provisions of Annex 10, Volume IV."*

2 Current UK Position

2.1 The UK CAA has currently chosen not to implement these ICAO standards. It is concerned that significantly increasing the equipage of aeroplanes and helicopters with pressure-altitude reporting transponders that are based on 'classical' SSR Mode C, over and above present levels, could have a detrimental effect of the efficacy of the 1090 MHz SSR 'reply' frequency. 'Classical' SSR interrogations and replies are indiscriminate in that all aircraft within the coverage of a particular radar will reply to all interrogations made by that radar during every rotation. Increasing the number of transponders in UK airspace that operate in this way could, therefore, increase the loading on 1090 MHz such that interference became intolerable and the probability of replies from transponders reduced considerably.

2.2 However, the UK CAA intends to conform with the ICAO transponder carriage standards, as soon as is practicable, through the implementation of new SSR Mode Select (Mode S) technology. This technology is explained at Annex C but allows for selective interrogation of transponders, thereby reducing the number of replies that are made on 1090 MHz.

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Annex E. Automatic Dependent Surveillance - Broadcast

1 ADS-B Overview

1.1 Automatic Dependent Surveillance – Broadcast (ADS-B) is a co-operative surveillance system that is dependent on aircraft automatically transmitting unsolicited 'radar-like data' at regular intervals. This 'broadcast' of information is conveyed by a suitable data link over a radio frequency; no input is required from pilots and no prior interrogations from radars are needed. The information from the host aircraft can then be passively received by other suitably equipped aircraft and ground systems and the position of aircraft displayed to pilots and controllers.

1.2 Globally, it is recognised that ADS-B applications will play a major role in Air Traffic Management of the future and several States, such as Australia and the USA, have begun to integrate ADS-B as an operational surveillance system alongside Secondary Surveillance Radar (SSR) and Primary Radar. Within Europe, the current Surveillance Strategy[32] foresees an evolutionary approach from the current SSR-based infrastructure to one combining ADS-B with SSR Mode Select (Mode S), Primary Radar and Wide Area Multilateration from today to the year 2020 and beyond. In particular, an increasing use of Aircraft Derived Data (ADD), such as that provided by ADS-B messages, is envisaged for Air Traffic Control (ATC) applications and to support Air Traffic Situational Awareness and, in the longer term, a move towards increasing delegation of responsibility for separation of aircraft to flight crew.

2 ADS-B Functionality

2.1 ADS-B technology enables the automatic broadcast of Global Navigation Satellite System (GNSS)-derived present position data, altitude, aircraft identity (including the unique ICAO 24-bit Aircraft Address and aircraft identification) and other parameters derived from the aircraft avionics. Suitable on-board GNSS receivers, such as GPS, and pressure-altitude encoders are required to provide the position and altitude data. Transmissions are made at half-second intervals on a suitable 'line-of-sight' data link and this functionality is commonly referred to as ADS-B 'Out'. ICAO provisions for ADS-B 'Out' include the potential to use it for the broadcast of position data from airport vehicles, temporary obstacles and parachutists. There are several choices of data link for ADS-B and these are described in Paragraph 3 below.

2.2 The ADS-B transmissions from aircraft can be passively received by suitably equipped ground stations and the ADD used to provide a 'radar-like' surveillance display for air traffic controllers. Additionally, other aircraft equipped with an ADS-B 'In' functionality can receive the position reports from ADS-B 'Out' transmissions and display the aircraft 'tracks' to flight crew on a Cockpit Display of Traffic Information (CDTI); this can be associated with a 'moving map' facility. As the ADS-B 'In' functionality operates independently of ground systems, CDTI-based surveillance for flight crew will function even if the host aircraft is outside of ATC radar surveillance coverage. Although CDTI can provide more information than ACAS displays, ADS-B is not designed for reactive collision avoidance. However, in Class G airspace, it could provide a very useful supplement to 'see and avoid' for pilots and, also, an invaluable part of a 'sense and avoid' suite for UAVs.

2.3 Typical ranges for ADS-B are in excess of 100 nm and positional accuracy can be better than that provided by SSR interrogators. Furthermore, the rate of update of this positional information is much greater than with an SSR interrogator. However, the suitability for the use of ADS-B in congested European airspace is still currently unproven.

[32] The Surveillance Strategy for ECAC, Edition 2.0, dated 18 November 2005.

3 ADS-B Data Links

3.1 There are three different data links currently available to support ADS-B. Although ground systems could be introduced to accept more than one of these data links, this is not generally considered to be feasible on grounds of cost and ease of implementation. Consequently, a single data link will need to be selected to support interoperability of ADS-B in the UK. Furthermore, from an airborne viewpoint, the data links are not interoperable with each other and they are not currently interoperable with ACAS. However, some work is currently ongoing under the auspices of ICAO to assess the feasibility of using 1090 MHz 'Extended Squitter' position information in ACAS tracking algorithms so that 'non-threat' aircraft could be tracked without requiring active ACAS interrogations; this is known as ACAS Hybrid Surveillance.

3.2 **Mode S 1090 MHz 'Extended Squitter'**. This data link medium requires aircraft to use an SSR Mode S transponder, or a standalone transmitter, to send the required ADS-B 'Out' information via an 'Extended Squitter' message on the SSR 'reply' frequency of 1090 MHz. This data link is sometimes referred to as 1090ES for short. SSR Mode S transponders can be purchased with the 'Extended Squitter' capability and many commercial aircraft operating in European airspace now use this data link because of the recent SSR Mode S Enhanced Surveillance mandates in the UK, Germany and France. Globally, the 11th ICAO Air Navigation Conference concluded that 1090ES should be used for initial ADS-B applications. The Civil Aviation Safety Authority of Australia has adopted 1090ES for its initial implementation of ADS-B, as has the Federal Aviation Administration in the USA for commercial air traffic.

3.3 **Universal Access Transceiver**. The Universal Access Transceiver (UAT) system employs a 1 MHz channel in the 900 MHz frequency range and has been specifically designed to transmit ADS-B messages. It also supports uplink broadcasts from ground stations. In the USA, UAT has been adopted for the use of ADS-B for the General Aviation community.

3.4 **Very High Frequency Data Link Mode 4**. The Very High Frequency Data Link Mode 4 (VDL-4) system uses one or more of the existing 25 kHz frequencies in the aeronautical VHF spectrum to transmit ADS-B messages. No ground stations are required for VDL-4, as it is self-organising, and it can be used for broadcast and point-to-point air-to-air and air-to-ground communications. It is ideal for short message transmissions from a large number of users and VDL-4 can also provide greater range than 1090ES or UAT. However, VDL-4 is likely to be the most expensive of the data link choices and there is currently little global support for its use in initial ADS-B applications.

4 Required GPS Standards

In order to provide the requisite integrity and accuracy of ADS-B position reporting from aircraft, the navigational performance of GPS receivers used on light aircraft to provide the information for transmission over any of the three data links will need to be of a minimum suitable standard. In this case, it is likely that GPS/WAAS units for light aircraft would have to be approved under Technical Standard Order (TSO) 129, C145a/C146a, or European TSO (ETSO) C145a/C146a, which set out the minimum certification standards for airborne navigation GPS/WAAS sensors. It will, therefore, not be possible to just use any available commercial 'off the shelf' GPS unit to support ADS-B functionality. This could add considerable cost to any future ADS-B equipage requirement for light aircraft.

5 Future of ADS-B in Europe

5.1 Within Europe, there are plans to improve ground-based surveillance of air traffic using ADS-B. EUROCONTROL has set up the CASCADE Programme to plan and co-ordinate the implementation of the first set of ADS-B applications and these are expected to provide or enhance surveillance in specific airspace and at specific airports. There is also a European Convergence and Implementation Plan (ECIP) objective that addresses the implementation of ADS-B using 1090ES data link technology in accordance with the implementation period considered in the CASCADE Programme (i.e. 2006-2010).

5.2 The recent update to the Surveillance Strategy[32] produced by EUROCONTROL also features an initial migration to ADS-B via the 1090ES data link. While this document has no regulatory standing, and will be influenced by major programmes such as the Single European Sky ATM Requirements (SESAR), it does, nonetheless, represent the desires of the EUROCONTROL Surveillance domain and the supporting States to migrate to ADS-B. SESAR is still in its early stages but it will produce a 'European ATM Master Plan'; it is considered highly likely that this Plan will be based on the EUROCONTROL ATM 2000+ Strategy, of which the EUROCONTROL Surveillance Strategy and the CASCADE Programme are features. There is, therefore, a high probability of ADS-B also appearing in this SESAR European ATM Master Plan.

5.3 Consequently, it is necessary to take into account the foreseen introduction of ADS-B in the UK or the rest of Europe by considering whether or not any related new equipage requirements for aircraft need to be 'future-proofed' to be able to provide ADS-B data at a later date and with minimum upgrade costs.

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Annex F. Generic Applicability and Exemption Principles

1 Introduction

1.1 This annex sets out the possible exemption principles that could be applied to IFR and VFR flights conducted in airspace where the operation of a Mode S capable SSR transponder and/or ADS-B 'Out' functionality may be required from 31 March 2008. However, these principles would not apply to the carriage of SSR Mode S transponders in existing notified Mode S Enhanced Surveillance airspace in the major en route and terminal environment, which is covered by separate exemption co-ordination arrangements managed by EUROCONTROL.

1.2 These principles are provided only for guidance on the exemption issues that the CAA is considering. The final detail of any exemptions will be developed once a recommended option has been determined from the public consultation process. Prior to any new regulation coming into force, an appropriate Exemptions Policy will be produced and promulgated accordingly.

2 Overall Objectives

The exemption principles will aim to achieve the following objectives:

a. The principles should encourage equipage of aircraft as soon as possible after 31 March 2008 while being realistic about timescales and any associated deployment of ground systems.

b. The principles should balance the 'out-of-service' dates for military and civil aircraft with any associated deployment of ground systems.

c. The principles should balance the requirement for limited access to applicable airspace with cost of equipage and the effect that non-compliance would have on the realization of any safety or economic benefits.

d. Where appropriate, the principles should be applied to civil and military aircraft operators alike.

e. Suitable transition periods after the implementation milestone should be applied. A transition period is the period during which the exemption principles are applied fully to facilitate the transition to full equipage. At the end of the period, the exemption principles would be reviewed and redefined as necessary.

f. Exemptions should be made on a case-by-case basis. However, where appropriate a particular case could refer to a whole class of aircraft or operation as well as to individual aircraft operators.

g. The principles should aim to realize the benefits of implementation in the UK as early as possible.

h. Where appropriate, the principles should be co-ordinated and harmonized with the relevant exemption policies of the other European partner States. This is consistent with the provisions of ICAO Doc 7030.

3 Applicability Criteria

Any new regulation would specify applicability criteria with which to identify the situations when aircraft would be expected to carry and operate the required equipment. These criteria could comprise aspects such as aircraft weight and/or performance, airspace, class of aircraft, class of flight or types of activity. Only those aircraft that fall within the applicability criteria, but which are not yet equipped, would need to apply for an exemption from any carriage requirements.

4 General Exemption Principles

4.1 The assessment of applications for exemptions for reasons of technical infeasibility could take into account the estimated annual flying hours of individual aircraft in the relevant airspace. In this case, the impact that non-compliance would have on the overall realisation of the safety and economic benefits of the equipage requirements would need to be taken into account.

4.2 During any transition periods, and in all but exceptional cases, the exemptions should be temporary in nature. Furthermore, operators could be required to provide evidence that plans have been made to equip aircraft with the relevant functionality as soon as possible.

4.3 The decision on whether aircraft will be eligible to carry a portable, self contained Low-Power SSR Transponder (LPST), rather than fit standard integrated avionics, could be based on the weight and/or performance of the aircraft, and/or the technical feasibility to equip an aircraft. If suitable equipment cannot be successfully developed, applicability and exemptions from the requirements could also be based on these criteria.

5 Assumptions for Certain Activity

5.1 At this stage, it is envisaged that certain types of recreational, sporting or unusual activity will either fall outside of the applicability criteria, or will be specifically exempted from any equipage requirements. For example, it is assumed that this proposal would not apply to the following circumstances:

a. Activity that would not have a significant impact on other airspace users or ATC. For example, this could include the following:

    (1) Winch-launched gliding activity of short duration that remains within the bounds of known and suitably promulgated sites. These sites could be promulgated laterally and vertically.

    (2) Foot-launched gliding activity of short duration that similarly remains within the bounds of known and suitably promulgated sites.

b. Pre-planned and suitably promulgated competitions and other known gatherings involving large numbers of aircraft operating within a small volume of airspace.

c. Para Gliding and parachuting activity where the lack of a suitable rigid structure would prevent the suitable installation of the required equipment.

d. Special flights for which the activity, routes and operating areas will be suitably promulgated or which will operate in dedicated airspace.

5.2 When assessing the applicability for exemption of the type of aforementioned activity, the test of whether or not there would be a significant impact on other airspace users would be applied. In particular, the safety and economic benefits that the equipage requirements are designed to realise would be considered carefully.

6 Specific Exemption Criteria

It is envisaged that the following specific exemption criteria could be applied to the following scenarios:

a. An aircraft has a confirmed out-of service date that is within 2 years of any regulation coming into force.

b. An aircraft has a confirmed out-of-service date that is within 2 years of the end of any applicable transition periods.

c. An operator has experienced delays in equipage of an aircraft due to circumstances that are beyond their control. In this case, aircraft operators would have to undertake to equip the aircraft as soon as practicable and could be expected to provide documentary evidence that equipment orders and fitment plans have been put in place.

d. An aircraft cannot be equipped on the grounds that it would be technically infeasible to do so with currently available equipment or technology. For example, this may apply if an SSR Mode S transponder is required but it would be only feasible to equip with a portable LPST that was not yet commercially available.

e. Flights conducted for the purpose of flight testing, delivery and for transit to and from maintenance bases.

7 Exemption Application Process

It is envisaged that the exemption application process currently used for SSR transponders, and which is in accordance with the requirements of Aeronautical Information Publication General 1.5.3, would continue to be employed for a new regulation. Short-notice ‘tactical’ exemptions would be sought from any relevant ATC authorities and all other requests would need to be submitted to the CAA Airspace Utilisation Section.

8 Example Decision Making Process

An example exemption decision making process is at Figure 1 below:

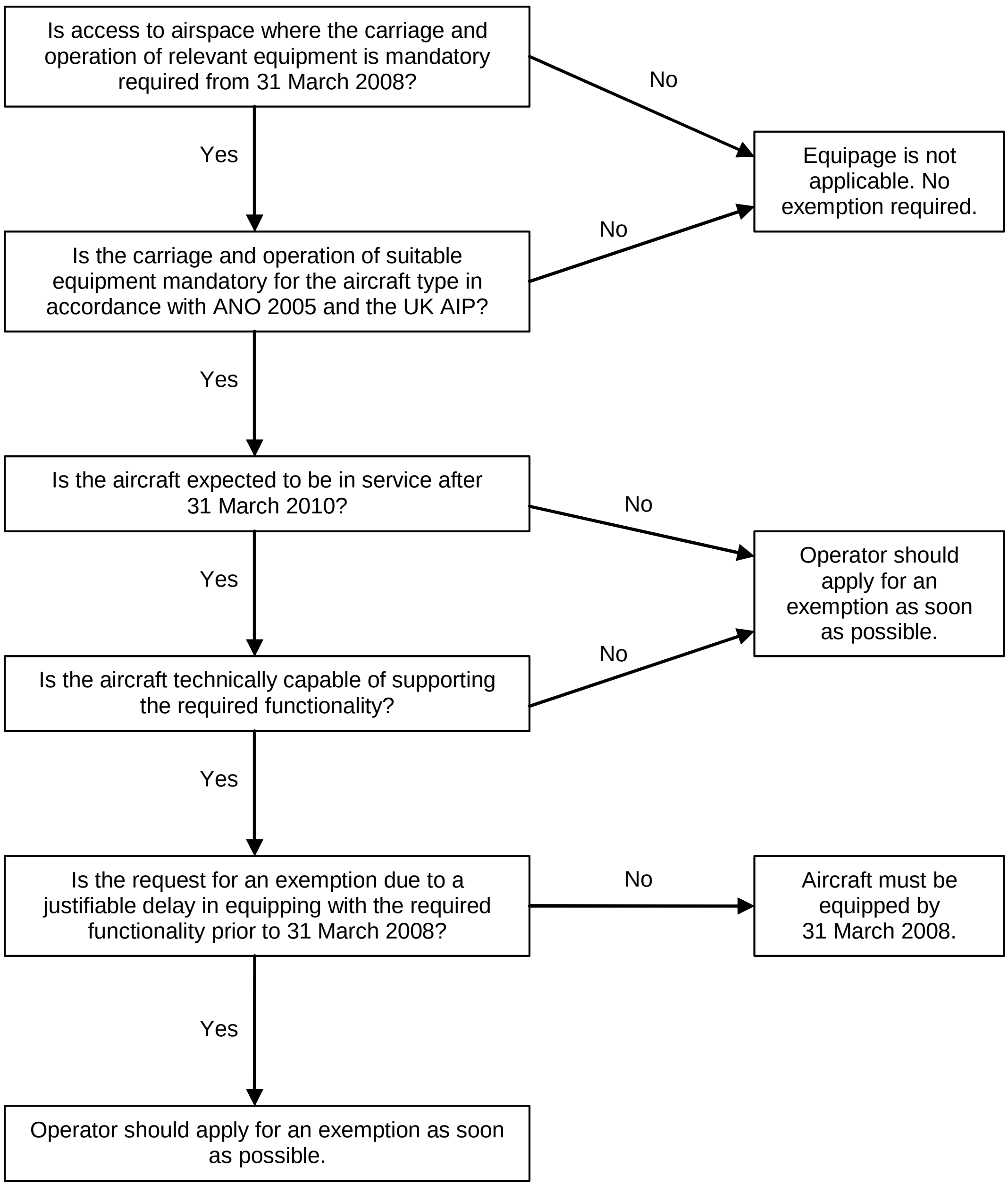

Figure 1: Example Exemption Decision Making Process

Annex G. FLARM

1 FLARM Overview

1.1 FLARM is a product developed in Switzerland that is based on the concept of disseminating Global Positioning System (GPS) derived information using a digital radio broadcast. This information is exchanged between suitably equipped aircraft and is primarily aimed at the Alpine gliding community to enhance 'see and avoid' in Visual Flight Rules (VFR) operations. As such, FLARM units are small, light and low-powered.

1.2 However, it should be noted that FLARM does not yet have approval for use in the UK and is not interoperable with Secondary Surveillance Radar (SSR) or the Airborne Collision Avoidance System (ACAS). In particular, FLARM operates on an unregulated radio frequency. Furthermore, FLARM is only useful for providing warning of collisions between mutually equipped aircraft.

2 Functionality of FLARM

2.1 FLARM uses position and movement information obtained from an integrated Wide Area Augmentation System (WAAS) 16-channel GPS unit and an embedded barometric sensor; however, it is not known whether this GPS unit is approved under a relevant Technical Standard Order (TSO). FLARM predicts the flight path of the host aircraft and transmits the data over a low-power, short range radio once per second. Messages are received by other compatible units within range and the flight paths compared with their own predicted flight path. Furthermore, flight paths are also compared with the position of fixed obstacles stored within the system.

2.2 When a potential collision threat is calculated, FLARM warns the pilot using an audible and visual alarm. A set of LEDs provide directional information and calculated 'time to impact' to help the pilot locate the conflict visually. The first alarm is usually issued 18 seconds prior to the predicted impact. Typical range is advertised as being 2-3 km and FLARM units have a capacity to handle in excess of 50 aircraft within this range. Pilots can adjust the intensity of the audible alarms, suppress alarms or display traffic in addition to 'threats'. FLARM also includes a flight recorder.

2.3 FLARM must not be used in Instrument Meteorological Conditions (IMC) or during aerobatics. However, FLARM units are able to distinguish between different flight modes, such as cruising as opposed to circling. During glider flights in thermals, specific algorithms are employed to handle clusters of gliders in the same lift scenario so that unnecessary alarms are not issued that would constantly distract the pilot.

2.4 It is believed that several manufacturers of glider avionics and PDA software now offer integral FLARM functionality.

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Annex H. Options 2 and 2(a) Equipage Cost Estimates

Costs for Business Aircraft Only

Equipage with 20-30W LPST or 70W LAST with 'Extended Squitter' Facility

CofA	No of Aircraft		Lower Cost		Higher Cost	
<750kg	Low (Valid CofA)	High (All CofA)	Valid CofA	All CofA	Valid CofA	All CofA
Airship	0	6	£0	£3,000	£0	£10,200
Amphibian	0	0	£0	£0	£0	£0
Fixed Wing	167	207	£83,500	£103,500	£283,900	£351,900
SLMG	1	2	£500	£1,000	£1,700	£3,400
Gyroplane	0	0	£0	£0	£0	£0
Helicopter	130	151	£65,000	£75,500	£221,000	£256,700
Microlight	0	0	£0	£0	£0	£0
	298	**366**	**£149,000**	**£183,000**	**£506,600**	**£622,200**

Individual Cost	
Low	**High**
£500	**£1,700**

Equipage with 70W LAST or IFR 200W Transponder with 'Extended Squitter' Facility

CofA	No of Aircraft		Lower Cost		Higher Cost	
>750<5700kg	Low (Valid CofA)	High (All CofA)	Valid CofA	All CofA	Valid CofA	All CofA
Airship	1	11	£1,700	£18,700	£3,100	£34,100
Amphibian	0	0	£0	£0	£0	£0
Fixed Wing	1649	1879	£2,803,300	£3,194,300	£5,111,900	£5,824,900
SLMG	0	0	£0	£0	£0	£0
Seaplane	1	2	£1,700	£3,400	£3,100	£6,200
Gyroplane	0	0	£0	£0	£0	£0
Helicopter	412	443	£700,400	£753,100	£1,277,200	£1,373,300
	2063	**2335**	**£3,507,100**	**£3,969,500**	**£6,395,300**	**£7,238,500**

Individual Cost	
Low	**High**
£1,700	**£3,100**

TOTALS	No of Aircraft		Lower Cost		Higher Cost	
<5700kg	Low (Valid CofA)	High (All CofA)	Valid CofA	All CofA	Valid CofA	All CofA
	2361	**2701**	**£3,656,100**	**£4,152,500**	**£6,901,900**	**£7,860,700**

Less:		
Mode S already equipped	**101**	**101**

REVISED TOTALS	No of Aircraft		Lower Cost		Higher Cost	
<5700kg	Low (Valid CofA)	High (All CofA)	Valid CofA	All CofA	Valid CofA	All CofA
	2260	**2600**	£3,484,400	£3,980,800	£6,588,800	£7,547,600
Less Expected Discount of 15%			**£2,961,740**	**£3,383,680**	**£5,600,480**	**£6,415,460**

Assumptions:
1. Aircraft numbers are taken from the aircraft register on 31/10/05 for those conducting aerial work, public transport and cargo.
2. Assumes 422 aircraft <5,700kg are already Mode S equipped.
3. Aircraft register on 31/10/05 shows business aircraft make up 24% of aircraft <5,700kg.
4. Therefore, assume that 24% of 422 = 101 business aircraft are already equipped with a Mode S transponder.
5. Businesses could expect to obtain a discount of around 15% on the estimated costs of purchasing and installing transponders.

Total Overall Costs for Aircraft Owned Privately and by Businesses

Equipage with 20-30W LPST or 70W LAST with 'Extended Squitter' Facility

CofA	No of Aircraft		Lower Cost		Higher Cost	
<750kg	**Low (Valid CofA)**	**High (All CofA)**	**Valid CofA**	**All CofA**	**Valid CofA**	**All CofA**
Airship	1	7	£500	£3,500	£1,700	£11,900
Amphibian	1	7	£500	£3,500	£1,700	£11,900
Fixed Wing	1809	3029	£904,500	£1,514,500	£3,075,300	£5,149,300
SLMG	2	4	£1,000	£2,000	£3,400	£6,800
Gyroplane	75	247	£37,500	£123,500	£127,500	£419,900
Helicopter	228	291	£114,000	£145,500	£387,600	£494,700
Microlight	2258	4081	£1,129,000	£2,040,500	£3,838,600	£6,937,700
	4374	**7666**	**£2,187,000**	**£3,833,000**	**£7,435,800**	**£13,032,200**

Individual Cost	
Low	**High**
£500	**£1,700**

Equipage with 70W LAST or IFR 200W Transponder with 'Extended Squitter' Facility

CofA	No of Aircraft		Lower Cost		Higher Cost	
>750<5700kg	**Low (Valid CofA)**	**High (All CofA)**	**Valid CofA**	**All CofA**	**Valid CofA**	**All CofA**
Airship	4	17	£6,800	£28,900	£12,400	£52,700
Amphibian	5	7	£8,500	£11,900	£15,500	£21,700
Fixed Wing	4709	5705	£8,005,300	£9,698,500	£14,597,900	£17,685,500
SLMG	66	72	£112,200	£122,400	£204,600	£223,200
Seaplane	2	4	£3,400	£6,800	£6,200	£12,400
Gyroplane	0	1	£0	£1,700	£0	£3,100
Helicopter	830	938	£1,411,000	£1,594,600	£2,573,000	£2,907,800
	5616	**6744**	**£9,547,200**	**£11,464,800**	**£17,409,600**	**£20,906,400**

Individual Cost	
Low	**High**
£1,700	**£3,100**

TOTALS	No of Aircraft		Lower Cost		Higher Cost	
<5700kg	**Low (Valid CofA)**	**High (All CofA)**	**Valid CofA**	**All CofA**	**Valid CofA**	**All CofA**
	9990	**14410**	**£11,734,200**	**£15,297,800**	**£24,845,400**	**£33,938,600**

Less:		
Mode S already equipped	**422**	**422**

REVISED TOTALS	No of Aircraft		Lower Cost		Higher Cost	
<5700kg	**Low (Valid CofA)**	**High (All CofA)**	**Valid CofA**	**All CofA**	**Valid CofA**	**All CofA**
	9568	**13988**	**£11,016,800**	**£14,580,400**	**£23,537,200**	**£32,630,400**

Assumptons:

1. Aircraft numbers have been taken from the aircraft register on 31/10/05 and based on aircraft covered by Option 2.
2. Equipment costs are the minimum and maximum expected for each aircraft type.
3. Aircraft register on 11/11/05 shows 1599 aircraft assigned with Mode S transponder adddress.
4. Aircraft register on 31/10/05 shows 1117 valid Cof A aircraft 5,700kg and above.
5. Assumes all aircraft of 5,700kg and above have Mode S transponder from Phase 1 requirement.
6. Therefore, estimate that 422 aircraft <5,700kg also already have a Mode S transponder.

Annex I. Options 3 and 3(a) Equipage Cost Estimates

Costs for Business Aircraft Only

Equipage with 20-30W LPST + Extended Squitter Facility

	No of Aircraft		Lower Cost		Higher Cost	
	Low	**High**	**Low**	**High**	**Low**	**High**
Hang Gliders	**300**	**630**	**£150,000**	**£315,000**	**£300,000**	**£630,000**

Individual Cost	
Low	**High**
£500	**£1,000**

Equipage with 20-30W LPST or 70W LAST + Extended Squitter Facility

	No of Aircraft		Lower Cost		Higher Cost	
	Low (Valid CofA)	**High (All CofA)**	**Valid CofA**	**All CofA**	**Valid CofA**	**All CofA**
Gliders (BGA)	**110**	**220**	**£55,000**	**£110,000**	**£187,000**	**£374,000**

Individual Cost	
Low	**High**
£500	**£1,700**

Equipage with 20-30W LPST, 70W Portable LAST, or 70W LAST with Balloon Station, + Extended Squitter Facility

	No of Aircraft		Lower Cost		Higher Cost	
	Low (Valid CofA)	**High (All CofA)**	**Valid CofA**	**All CofA**	**Valid CofA**	**All CofA**
Balloons <750kg	198	633	£99,000	£316,500	£198,000	£633,000
Balloons >750<5700kg	359	906	£359,000	£906,000	£768,260	£1,938,840
	557	**1539**	**£458,000**	**£1,222,500**	**£966,260**	**£2,571,840**

Individual Cost		
	Low	**High**
<750kg	**£500**	**£1,000**
>750<5700kg	**£1,000**	**£2,140**

Equipage with 20-30W LPST or 70W LAST + Extended Squitter Facility

CofA	No of Aircraft		Lower Cost		Higher Cost	
<750kg	**Low (Valid CofA)**	**High (All CofA)**	**Valid CofA**	**All CofA**	**Valid CofA**	**All CofA**
Airship	0	6	£0	£3,000	£0	£10,200
Amphibian	0	0	£0	£0	£0	£0
Fixed Wing	167	207	£83,500	£103,500	£283,900	£351,900
SLMG	1	2	£500	£1,000	£1,700	£3,400
Gyroplane	0	0	£0	£0	£0	£0
Helicopter	130	151	£65,000	£75,500	£221,000	£256,700
Microlight	0	0	£0	£0	£0	£0
	298	**366**	**£149,000**	**£183,000**	**£506,600**	**£622,200**

Individual Cost	
Low	**High**
£500	**£1,700**

Equipage with 70W LAST or IFR 200W Transponder + Extended Squitter Facility

CofA	No of Aircraft		Lower Cost		Higher Cost	
>750<5700kg	**Low (Valid CofA)**	**High (All CofA)**	**Valid CofA**	**All CofA**	**Valid CofA**	**All CofA**
Airship	1	11	£1,700	£18,700	£3,100	£34,100
Amphibian	0	0	£0	£0	£0	£0
Fixed Wing	1649	1879	£2,803,300	£3,194,300	£5,111,900	£5,824,900
SLMG	0	0	£0	£0	£0	£0
Seaplane	1	2	£1,700	£3,400	£3,100	£6,200
Gyroplane	0	0	£0	£0	£0	£0
Helicopter	412	443	£700,400	£753,100	£1,277,200	£1,373,300
	2063	**2335**	**£3,507,100**	**£3,969,500**	**£6,395,300**	**£7,238,500**

Individual Cost	
Low	**High**
£1,700	**£3,100**

TOTALS	No of Aircraft		Lower Cost		Higher Cost	
<5700kg	**Low (Valid CofA)**	**High (All CofA)**	**Valid CofA**	**All CofA**	**Valid CofA**	**All CofA**
	3328	**5090**	**£4,319,100**	**£5,800,000**	**£8,355,160**	**£11,436,540**

Less:		
Mode S already equipped	**101**	**101**

REVISED TOTALS	No of Aircraft		Lower Cost		Higher Cost	
<5700kg	**Low (Valid CofA)**	**High (All CofA)**	**Valid CofA**	**All CofA**	**Valid CofA**	**All CofA**
	3227	**4989**	£4,147,400	£5,628,300	£8,042,060	£11,123,440
Less Expected Discount of 15%			**£3,525,290**	**£4,784,055**	**£6,835,751**	**£9,454,924**

Assumptions:
1. Assume that 10% of all gliders and hang gliders are used in business.
2. All other aircraft numbers are taken from the aircraft register on 31/10/05 for those conducting aerial work, public transport and cargo.
3. Assumes 422 aircraft <5,700kg are already Mode S equipped.
4. Aircraft register on 31/10/05 shows business aircraft make up 27% of aircraft <5,700kg.
5. Therefore, assume that 24% of 422 = 101 business aircraft are already equipped with a Mode S transponder.
6. Businesses could expect to obtain a discount of around 15% on the estimated costs of purchasing and installing transponders.

Total Overall Costs for Aircraft Owned Privately and by Businesses

Equipage with 20-30W LPST + Extended Squitter Facility

	No of Aircraft		Lower Cost		Higher Cost	
	Low	**High**	**Low**	**High**	**Low**	**High**
Hang Gliders	**3000**	**6300**	**£1,500,000**	**£3,150,000**	**£3,000,000**	**£6,300,000**

Individual Cost	
Low	**High**
£500	**£1,000**

Equipage with 20-30W LPST or 70W LAST + Extended Squitter Facility

	No of Aircraft		Lower Cost		Higher Cost	
	Low	**High**	**Low**	**High**	**Low**	**High**
Gliders (BGA)	**1100**	**2200**	**£550,000**	**£1,100,000**	**£1,870,000**	**£3,740,000**

Individual Cost	
Low	**High**
£500	**£1,700**

Equipage with 20-30W LPST, 70W Portable LAST, or 70W LAST with Balloon Station, + Extended Squitter Facility

	No of Aircraft		Lower Cost		Higher Cost	
	Low (Valid CofA)	**High (All CofA)**	**Valid CofA**	**All CofA**	**Valid CofA**	**All CofA**
Balloons <750kg	226	753	£113,000	£376,500	£226,000	£753,000
Balloons >750<5700kg	449	1051	£449,000	£1,051,000	£960,860	£2,249,140
	675	**1804**	**£562,000**	**£1,427,500**	**£1,186,860**	**£3,002,140**

Individual Cost		
	Low	**High**
<750kg	**£500**	**£1,000**
>750<5700kg	**£1,000**	**£2,140**

Equipage with 20-30W LPST or 70W LAST + Extended Squitter Facility

CofA	No of Aircraft		Lower Cost		Higher Cost	
<750kg	**Low (Valid CofA)**	**High (All CofA)**	**Valid CofA**	**All CofA**	**Valid CofA**	**All CofA**
Airship	1	7	£500	£3,500	£1,700	£11,900
Amphibian	1	7	£500	£3,500	£1,700	£11,900
Fixed Wing	1809	3029	£904,500	£1,514,500	£3,075,300	£5,149,300
SLMG	2	4	£1,000	£2,000	£3,400	£6,800
Gyroplane	75	247	£37,500	£123,500	£127,500	£419,900
Helicopter	228	291	£114,000	£145,500	£387,600	£494,700
Microlight	2258	4081	£1,129,000	£2,040,500	£3,838,600	£6,937,700
	4374	**7666**	**£2,187,000**	**£3,833,000**	**£7,435,800**	**£13,032,200**

Individual Cost	
Low	**High**
£500	**£1,700**

Equipage with 70W LAST or IFR 200W Transponder + Extended Squitter Facility

CofA	No of Aircraft		Lower Cost		Higher Cost	
>750<5700kg	**Low (Valid CofA)**	**High (All CofA)**	**Valid CofA**	**All CofA**	**Valid CofA**	**All CofA**
Airship	4	17	£6,800	£28,900	£12,400	£52,700
Amphibian	5	7	£8,500	£11,900	£15,500	£21,700
Fixed Wing	4709	5705	£8,005,300	£9,698,500	£14,597,900	£17,685,500
SLMG	66	72	£112,200	£122,400	£204,600	£223,200
Seaplane	2	4	£3,400	£6,800	£6,200	£12,400
Gyroplane	0	1	£0	£1,700	£0	£3,100
Helicopter	830	938	£1,411,000	£1,594,600	£2,573,000	£2,907,800
	5616	**6744**	**£9,547,200**	**£11,464,800**	**£17,409,600**	**£20,906,400**

Individual Cost	
Low	**High**
£1,700	**£3,100**

TOTALS	No of Aircraft		Lower Cost		Higher Cost	
<5700kg	**Low (Valid CofA)**	**High (All CofA)**	**Valid CofA**	**All CofA**	**Valid CofA**	**All CofA**
	14765	**24714**	**£14,346,200**	**£20,975,300**	**£30,902,260**	**£46,980,740**

Less:		
Mode S already equipped	**422**	**422**

REVISED TOTALS	No of Aircraft		Lower Cost		Higher Cost	
<5700kg	**Low (Valid CofA)**	**High (All CofA)**	**Valid CofA**	**All CofA**	**Valid CofA**	**All CofA**
	14343	**24292**	**£13,628,800**	**£20,257,900**	**£29,594,060**	**£45,672,540**

Assumptons:

1. Maximum Hang Glider numbers provided by BHPA and Glider numbers by BGA.
2. Low Hang Glider and Glider numbers assume that not all aircraft would need a permanent installation.
3. Other aircraft numbers have been taken from the aircraft register on 31/10/05.
4. Equipment costs are the estimated minimum and maximum expected for each aircraft type.
5. Aircraft register on 11/11/05 shows 1599 aircraft assigned with Mode S transponder adddress.
6. Aircraft register on 31/10/05 shows 1117 valid Cof A aircraft 5,700kg and above.
7. Assumes all aircraft of 5,700kg and above have Mode S transponder from Phase 1 requirement.
8. Therefore, estimate that 422 aircraft <5,700kg also already have a Mode S transponder.

Annex J. Glossary of Terms

AA	ICAO 24-bit Aircraft Address
AAD	Additional Airworthiness Directive
ACAS	Airborne Collision Avoidance System
ADD	Aircraft Derived Data
ADS-B	Automatic Dependent Surveillance - Broadcast
AIC	Aeronautical Information Circular
AIP	Aeronautical Information Publication
ANO	Air Navigation Order
ANSP	Air Navigation Service Provider
AOPA	Aircraft Owners and Pilots Association
ATC	Air Traffic Control
ATM	Air Traffic Management
ATS	Air Traffic Service
CAA	Civil Aviation Authority
CAP	SSR Mode S Controller Access Parameter
CAT	Commercial Air Transport
CDTI	Cockpit Display of Traffic Information
C of A	Certificate of Airworthiness
DAP	CAA Directorate of Airspace Policy SSR Mode S Downlink Aircraft Parameter
DfT	Department for Transport
DTI	Department of Trade and Industry
ECIP	European Convergence and Implementation Plan
EHS	SSR Mode S Enhanced Surveillance
ELS	SSR Mode S Elementary Surveillance
ES	Mode S 1090 MHz Extended Squitter
ETSO	European Technical Standard Order
EU	European Union
EUROCONTROL	European Organisation for the Safety of Air Navigation
FIR	Flight Information Region
FL	Flight Level
FLARM	Collision Warning Technology for Gliders
FRUIT	False Replies Unsynchronised In Time
GA	General Aviation
GACC	General Aviation Consultative Committee
GAWG	General Aviation Working Group
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
IC	SSR Mode S Interrogator Code
ICAO	International Civil Aviation Organisation
IFF	Identification Friend or Foe
IFR	Instrument Flight Rules
II	SSR Mode S Interrogator Identifier Code
IMC	Instrument Meteorological Conditions
LAST	Light Aviation SSR Transponder (Mode S)
LED	Light Emitting Diode
LPST	Low-Power SSR Transponder (Mode S)
MHz	Megahertz
MoD	Ministry of Defence
MODE S	SSR Mode Select
MTOM	Maximum Take-Off Mass
NATMAC	National Air Traffic Management Advisory Committee
NATS	National Air Traffic Services (En Route) plc
NISC	National IFF/SSR Committee
PDA	Personal Digital Assistant
RA	ACAS Resolution Advisory

RF	Radio Frequency
RIA	Regulatory Impact Assessment
SAP	SSR Mode S System Access Parameter
SAR	Search and Rescue
SARPs	ICAO Standards and Recommended Practices
SASWG	Spectrum and Surveillance Working Group
SES	Single European Sky
SESAR	Single European Sky ATM Requirements
SI	SSR Mode S Surveillance Identifier Code
SRG	CAA Safety Regulation Group
SSR	Secondary Surveillance Radar
STCA	Short Term Conflict Alert System
TA	ACAS Traffic Alert
TCAS	Traffic Alert and Collision Avoidance System
TPAS	Traffic Proximity Alert System
TSO	Technical Standard Order
UAT	Universal Access Transceiver
UAV	Unmanned Aerial Vehicle
UK SSC	Cabinet Office Spectrum Strategy Committee
VAT	Value Added Tax
VDL	Very High Frequency Data Link
VFR	Visual Flight Rules
VOSL	Value of Statistical Life
WAAS	Wide Area Augmentation System
WTA	Wireless Telegraphy Act

Intentionally Blank