CONSULTATION DOCUMENT - ANNEXES

PROPOSAL FOR AN INCREMENTAL EXPANSION OF THE USE OF SECONDARY SURVEILLANCE RADAR MODE SELECT TRANSPONDERS IN UK AIRSPACE

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Annex A: UK Air Transport Movement Statistics and Forecasts

Airport Movement Statistics[1]

London Area Airports	1996	2006	Change	%
	(000s of Movements)			
GATWICK	209	254	45	22%
HEATHROW	427	471	44	10%
LONDON CITY	25	66	41	164%
LUTON	28	79	51	182%
STANSTED	75	190	115	153%
Total London Area Airports	**765**	**1061**	**296**	**39%**
Other UK Airports	**1996**	**2006**	**Change**	**%**
	(000s of Movements)			
ABERDEEN	78	98	20	26%
BELFAST CITY	35	37	2	6%
BELFAST INTERNATIONAL	33	48	15	45%
BIRMINGHAM	77	109	32	42%
BLACKPOOL	7	13	6	86%
BOURNEMOUTH	4	12	8	200%
BRISTOL	26	66	40	154%
CARDIFF WALES	16	22	6	38%
COVENTRY	5	8	3	60%
DONCASTER SHEFFIELD	-	7	-	-
DURHAM TEES VALLEY	10	12	2	20%
EDINBURGH	66	116	50	76%
EXETER	6	15	9	150%
GLASGOW	75	97	22	29%
HUMBERSIDE	8	13	5	63%
INVERNESS	6	17	11	183%
ISLE OF MAN	19	32	13	68%
KIRKWALL	8	10	2	25%
LANDS END (ST JUST)	-	4	-	-
LEEDS BRADFORD	24	37	13	54%
LIVERPOOL	23	48	25	109%
MANCHESTER	141	213	72	51%
NEWCASTLE	39	58	19	49%
NEWQUAY	-	10	-	-
NORWICH	12	21	9	75%
NOTTINGHAM EAST MIDLANDS	35	56	21	60%
PLYMOUTH	6	5	-1	-17%
PRESTWICK	9	19	10	111%
SCATSTA	4	11	7	175%
SOUTHAMPTON	24	46	22	92%
STORNOWAY	3	7	4	133%
SUMBURGH	20	7	-13	-65%
WICK	4	3	-1	-25%
Total Other UK Airports	**863**	**1315**	**452**	**52%**
Total All Reporting UK Airports	**1630**	**2376**	**746**	**46%**

Figure 1: Actual Commercial Air Transport Movements UK Airports – 1996 to 2006 (Thousands)

[1] Source: http://www.caa.co.uk/default.aspx?categoryid=80&pagetype=88&pageid=3&sglid=3

London Area Airports	2002	2006	Change	%
	(000s of Movements)			
GATWICK	234	254	20	9%
HEATHROW	460	471	11	2%
LONDON CITY	53	66	13	25%
LUTON	55	79	24	44%
STANSTED	152	190	38	25%
Total London Area Airports	**955**	**1061**	**106**	**11%**

Other UK Airports	2002	2006	Change	%
	(000s of Movements)			
ABERDEEN	80	98	19	23%
BELFAST CITY	37	37	0	0%
BELFAST INTERNATIONAL	39	48	10	25%
BIRMINGHAM	112	109	-3	-3%
BLACKPOOL	8	13	5	67%
BOURNEMOUTH	8	12	4	58%
BRISTOL	46	66	20	44%
CARDIFF WALES	19	22	3	18%
COVENTRY	4	8	4	116%
DONCASTER SHEFFIELD	-	7	-	-
DURHAM TEES VALLEY	9	12	3	29%
EDINBURGH	105	116	11	11%
EXETER	5	15	10	183%
GLASGOW	87	97	10	11%
HUMBERSIDE	15	13	-2	-12%
INVERNESS	10	17	7	77%
ISLE OF MAN	25	32	7	30%
KIRKWALL	8	10	2	25%
LANDS END (ST JUST)	-	4	-	-
LEEDS BRADFORD	29	37	8	29%
LIVERPOOL	33	48	15	46%
MANCHESTER	178	213	36	20%
NEWCASTLE	44	58	14	32%
NEWQUAY	-	10	-	-
NORWICH	14	21	7	50%
NOTTINGHAM EAST MIDLANDS	49	56	7	15%
PLYMOUTH	5	5	0	6%
PRESTWICK	15	19	4	25%
SCATSTA	10	11	1	7%
SOUTHAMPTON	28	46	18	66%
STORNOWAY	4	7	3	59%
SUMBURGH	6	7	2	27%
WICK	2	3	1	25%
Total Other UK Airports	**1069**	**1315**	**247**	**23%**
Total All Reporting UK Airports	**2023**	**2376**	**353**	**17%**

Figure 2: Actual Commercial Air Transport Movements UK Airports – 2002 to 2006 (Thousands)

Medium-Term Forecast for UK Air Traffic Movements[2]

Forecast Scenario	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
	IFR Movements (000s)									
High				2,480	2,567	2,670	2,769	2,864	2,957	3,043
Base	2,155	2,265	2,384	2,460	2,535	2,603	2,674	2,763	2,845	2,928
Low				2,441	2,499	2,550	2,606	2,663	2,716	2,771

Forecast Scenario	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average Annual Growth 2005 - 2012
	Growth Rates										
High				4.0%	3.5%	4.0%	3.7%	3.4%	3.2%	2.9%	3.5%
Base		5.1%	5.3%	3.2%	3.0%	2.7%	2.7%	3.3%	3.0%	2.9%	3.0%
Low				2.4%	2.4%	2.1%	2.2%	2.2%	2.0%	2.0%	2.2%

Figure 3: EUROCONTROL Growth Forecasts for UK Airspace 2003-2012 (Thousands)

Long-Term Forecast for UK Air Traffic Movements[3]

Forecast Scenario	2003	2004	2005	2012	2015	2020	2025	Average Annual Growth 2005 - 2025	Traffic Multiple 2005 - 2025
	IFR Movements (000s)								
A				3,183	3,428	4,010	4,566	3.3%	1.9
B				3,027	3,192	3,676	4,151	2.8%	1.7
C	2,156	2,265	2,385	3,027	3,114	3,558	3,959	2.6%	1.7
D				2,885	2,988	3,298	3,627	2.1%	1.5

Figure 4: EUROCONTROL Growth Forecasts for UK Airspace 2003-2025 (Thousands)

[2] Source: EUROCONTROL Medium-Term Forecast: IFR Flight Movements 2006-2012 Volume 2.
[3] Source: EUROCONTROL Long-Term Forecast: IFR Flight Movements 2006-2025.

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Annex B: The Need to Replace Existing Mode A/C Technology

1. The technological principles behind the current Mode A/C SSR systems used on many aircraft are based on the same principles as the World War II Identification Friend or Foe (IFF) technology. The systems are dependent on transponders fitted to aircraft receiving 'interrogations' from radars on one radio frequency. The transponders then send corresponding 'replies' back on another frequency. Information provided by aircraft equipped with conventional SSR technology normally contains a four-digit identity code (known as Mode A) and pressure-altitude reports (known as Mode C). Replies are used to display the position, altitude and identity of aircraft on controllers' radar displays.

2. At each sweep of the radar head, a general request for SSR responses is sent out on one frequency and the replies received on another. However, like hundreds of radio stations seeking to transmit on a frequency band designed for only fifty, a serious problem is developing. As the number of radars installed in the UK and Europe has increased, and air traffic levels grown, the system is running out of available capacity.

3. The four key problems with conventional SSR are as follows:

   - **Garbling**. Replies from aircraft at similar distances often overlap in time when they arrive at the radar. It is difficult for conventional SSR radars to unravel these replies; this effect is known as 'garbling'.
   - **Mutual Interference**. All SSRs operate on common transmit and receive frequencies. Consequently they are likely to be receiving unwanted signals from aircraft replying to other radars. This mutual interference, known as 'False Replies Unsynchronised In Time (FRUIT)', can significantly affect the efficiency of the radar.
   - **Radio Reflections**. Signals reflecting off various obstacles, such as buildings, can cause misinterpretation of aircraft position.
   - **Lack of SSR Codes**. The current SSR system was designed to support only 4096 individual Mode A identity codes. With the predicted growth in traffic levels, ATC units are likely to run out of codes and, at peak periods, commercial aircraft may have to be held on the ground until spare codes become available. Reports of code shortages are now starting to appear throughout Europe.

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Annex C: Technical Principles of Mode S

1. Every aircraft equipped with Mode S is assigned a unique 'address' allowing Mode S radars to interrogate them selectively and receive individual replies. This means unambiguous identification of aircraft, improved tracking and a significant reduction in interference and loading on the SSR reply frequency. Another key feature of Mode S is the use of Interrogator Codes (ICs) to individually identify Mode S radars. Their purpose is to allow unambiguous data exchange between radars and aircraft transponders. Unlike conventional SSR, 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 range, which will reply with their unique aircraft address. After acquisition, further replies to 'All Call' requests from the same radar are ignored by the transponder, thereby reducing the amount of mutual interference. This is called 'Lock Out'. Following an 'All Call' 'Lock Out', that radar will then only selectively address the transponder using the 'Roll Call' interrogations. 'Roll Calls' are scheduled in time by the radar. This means that the timing of the receipt of replies at the radar can be controlled; thus eliminating 'garbling'. Conventional SSR only uses 'All Call' and there is no 'Lock Out' facility to constrain the number of replies.

2. There are two types of Mode S: Mode S Elementary Surveillance (ELS) and Mode S Enhanced Surveillance (EHS). Mode S ELS is suitable for smaller aircraft and compliant transponders can provide the following information:

   - **Range and Azimuth**. These measurements are made from a single reply to a selective interrogation. The responses will not suffer from the plot resolution problems of conventional SSR when aircraft are close together.
   - **Altitude**. Pressure-altitude information to an accuracy of down to 25 feet can be provided.
   - **ICAO 24-bit Aircraft Address**. Mode S provides the unique technical aircraft address, which enables the radar to uniquely identify the aircraft, thereby avoiding any ambiguity. It is not displayed to controllers on their workstations.
   - **Aircraft Identification**. 'Identity' codes, which are compatible with Mode A, are normally only requested when the aircraft is first acquired or when the pilot changes squawk. In addition, a specific aircraft identification feature is provided in the form of a Downlinked Aircraft Parameter (DAP). This alpha-numeric identification is set by the flight crew and is used to transmit either the callsign used in flight or the aircraft registration. This additional feature will allow future savings of Mode A codes and can be displayed directly on controller workstations. Use of this feature requires high levels of aircraft equipage with Mode S and so Aircraft Identification is not expected to be in widespread use on ATC workstations in the UK until around 2012.
   - **Transponder Capability**. This provides information to a radar on a transponder's capability to handle additional Mode S data link functionality. It is extracted when the aircraft is first acquired.
   - **Flight Status**. This provides an indication of whether the aircraft is airborne or on the ground and may also be used to notify an emergency. However, international standards require that if a means for automatically indicating the 'on-the-ground' status is not available, the flight status code transmitted must be set to indicate that the aircraft is airborne. This is typically the case for light aircraft.

3. Mode S EHS provides all of the features of ELS but, in addition, provides data link functionality and access to additional aircraft parameters. In order to achieve this, the aircraft must have an interface between the transponder and its avionics system. Generally, it is only supported by aircraft with modern 'digital' avionics and is particularly useful in busy terminal and en-route airspace. It is currently only required in specific airspace and on aircraft with a maximum take-off mass in excess of 5,700 kg or 250 knots maximum cruising true airspeed conducting Instrument Flight Rules (IFR) flights.

4. Mode S improves the effectiveness of ground-based conflict alert tools and airborne collision avoidance systems. For example, Traffic Alert and Collision Avoidance System II (TCAS II), which is fitted to all aircraft over 5,700 kg or with more than 19 seats, uses Mode S technology. Although TCAS II is backwards compatible with conventional SSR transponders, it was designed for a Mode S environment and works much more effectively with aircraft equipped with Mode S transponders.

5. Mode S is being introduced by France, Belgium, The Netherlands, Germany, Switzerland and Luxembourg for IFR and Visual Flight Rules (VFR) flights in designated airspace. Additionally, a growing number of other European States are also committing to implementing Mode S.

6. Carriage of Mode S is a key enabler for emerging surveillance technologies such as 'Wide Area Multilateration' and 'Automatic Dependent Surveillance – Broadcast', more commonly known as ADS-B. This is due to the Mode S 'Extended Squitter' function, used by most ADS-B systems, through which aircraft are able to transmit their position 'automatically' without being interrogated by a radar. Mode S transponders are also able to uniquely report the aircraft identification feature via this ADS-B 'Extended Squitter' data link. There are currently no firm plans for any widespread European implementation of ADS-B but it is included as a pillar in the European air traffic surveillance roadmap. However, as the TCAS conflict avoidance algorithms will not interact with aircraft that are only equipped with ADS-B technology, ADS-B alone does not provide a complete alternative to the use of SSR.

Annex D: Related Research and Studies

Computer Modelling of the SSR Radio Frequency Environment

1. In March 2006, the CAA engaged QinetiQ Ltd[4] to investigate the effect of growth in commercial air transport on pollution of the SSR radio frequency environment. Within this modelling, a tight cluster of gliders carrying a 20W low-power Mode S transponder was placed in the vicinity of Lasham. The cluster comprised 40 gliders distributed randomly within in a 1 nautical mile by 0.25 nautical miles by 1,000 foot volume of airspace between 3,000 feet and 4,000 feet, orientated at a 45-degree angle so that the Heathrow Airport radars, in particular, would see a large spread of aircraft. The modelling revealed that the presence of the gliders was detected by radars but gave no serious increase in the levels of radio frequency interference on any of the radars investigated.

2. The effect of the glider cluster on Traffic Alert and Collision Avoidance System (TCAS) 'interference limiting' was also studied. Interference limiting is a process whereby TCAS will reduce its interrogation power when there are large numbers of aircraft within its range. This allows TCAS to concentrate on the most threatening targets and reduce the number of targets under surveillance. A TCAS II aircraft was positioned approximately 5 nautical miles to the west of the cluster in the modelling scenario, heading directly towards the gliders at 3,500 feet (i.e. at the mid height of the glider volume). Results showed that the TCAS II aircraft operated at highest interrogation power when the glider cluster was not included in the scenario. The inclusion of the cluster within range of the TCAS II aircraft resulted in an increase in the number of aircraft under TCAS surveillance and a slight drop in power. In accordance with TCAS interference limiting, some of the least 'threatening' targets were dropped from surveillance.

3. An additional scenario then increased the glider transponder power from 20W to 70W, and this resulted in a further 12 gliders being within reply range of the TCAS II aircraft. This caused a further slight drop in interrogation power and additional lower 'threat' aircraft being dropped from surveillance.

4. Overall, the CAA is content that the results of this modelling were as expected and the effect on TCAS 'interference limiting' was tolerable.

5. Additional SSR environmental modelling was then conducted in September 2006[5]. This modelling put an unprecedented number of General Aviation aircraft into the baseline scenario and examined the effect on the radio frequency environment up to the year 2020 based on estimated growth figures for commercial air transport. The modelling scenario contained 1,200 General Aviation aircraft operating standard Mode S ELS transponders (70W) and 600 aircraft operating Mode S low power transponders (30W). Mode S radars were modelled using a scanning technique that combines Mode S and Mode A/C interrogations, which gives a worst-case result for interference levels.

6. The modelling results indicated that transponder 'availability' was high, averaging around 95%, and this did not degrade greatly from 2006 to 2020. However, 'round-trip probability' (which is the likelihood of a transponder reply being successfully received at the radar) was low, largely as a result of high levels of mutual interference. This interference is caused by transponders replying to interrogations from other systems, including TCAS and other SSRs, and is known as 'False Replies Unsynchronised In Time' (FRUIT). The modelling used the current mode of operation of Mode S radars

[4] Reference: QINETIQ/06/00383 dated March 2006.
[5] Reference: QINETIQ/06/01797/1.1 dated September 2006.

in the UK that employs a combination of traditional Mode A/C and Mode S interrogations that is known as 'Mixed Mode'. 'Mixed Mode' is not optimum for Mode S, but has been necessary as a mitigation for detection problems with faulty Mode S transponders. The modelling showed that overall radar plot detection was acceptable (this includes Mode A/C and Mode S 'Roll Call' replies) but Mode S 'All Call' plot detection fell as low as 81%. This shows that a mixed Mode A/C and Mode S environment will be difficult to sustain in the long-term; not least because 80-85% of the 'FRUIT' shown in the modelling results was triggered by Mode A/C interrogations. The CAA anticipates that the 'Mixed Mode' of operation, which contributes to the high 'FRUIT' levels, will no longer be necessary beyond 2012 due to the resolution of current Mode S transponder problems.

7. Most importantly, the results of this modelling also showed that, once a Mode S target had been acquired by the radar, the Mode S 'Roll Call' probability of detection was typically in excess of 99%.

TCAS Experiments and Flight Trials in France

8. Following a non-fatal collision in 1999 between a glider and a commercial airliner, the French regulatory authorities and Air Navigation Service Provider set up a working group and conducted a series of trials to study technical means of avoiding collisions between gliders and commercial air transport.

9. Initial flight trials in 2002 were conducted using an ATR aircraft equipped with TCAS II and a cluster of gliders equipped with Mode A/C transponders. The results showed that the radar and TCAS performance were greatly degraded due to 'garbling' of the Mode A/C replies.

10. Consequently, the trials were repeated using Mode S transponders in 2004. However, gliders were not used in these trials due to problems encountered with weather conditions in the earlier trial.

11. Using Mode A/C multi-radar tracking, 'garbling' existed and this led to incorrect trajectories and false altitude information being displayed. However, using Mode S radar, the aircraft were tracked perfectly but the overlap of the aircraft labels on the radar screen, together with the cluster appearing as a single point, caused some concern because the controller was unaware of how many aircraft were in the cluster.

12. With the exception of one transponder, which was not performing to specification, TCAS detection rate was 100% for 98% of the time when Mode S transponders were used. Bearing information error averaged at 10°, which is slightly higher than the accepted level and loss of bearing was rare, lasting only a few seconds and occurring only at high elevation angles. TCAS logic was acceptable for all scenarios except head on, where 3 aircraft separated vertically by 500 ft (+500ft, co-altitude, -500ft) faced the ATR. The TCAS display also had limitations, as it was designed specifically for collision avoidance rather than traffic situational awareness.

13. The working group concluded that the Mode S flight trials were successful and proved the worth of fitting Mode S transponders to light aircraft. However, it identified that the benefits to ATC would only be realised with full Mode S radar coverage. In addition, the report concluded that a Mode S transponder with reduced functionality and cost must be approved in order to make the technology available to General Aviation communities. The study group also advised that the issue of battery power consumption by SSR transponders should be investigated. The reports of these trials in France can be viewed in the 'Technical Reviews' section of the following website:

    http://www.dsna-dti.aviation-civile.gouv.fr

14. The view has been expressed by some UK General Aviation representative associations that, before substantial investment is committed by aircraft owners for

Mode S equipage, that the CAA should carry out further trails in the UK using a target assembly of motor gliders to ensure that an accurately controlled series of different representative flight scenarios are explored. However, the CAA would welcome information on how glider clusters could impact on the airspace affected by the specific options contained in this consultation document. Additionally the British Gliding Association has instituted flight trials of Mode S transponders in a small number of UK gliders to determine battery endurance in representative flight profiles.

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Annex E: Relevant AAIB and UKAB Reports and Recommendations

1. The following are examples of UKAB Airprox reports that contain discussion and comment on the use of SSR transponders:

   106/03; 152/03; 163/03; 090/04; 168/04; 028/05; 045/05; 050/05; 075/05; 077/05; 081/05; 123/05; 175/05; 186/05; 191/05; 074/06.

2. The UKAB has issued a safety recommendation concerning the carriage and operation of transponders in gliders **(UKAB Safety Recommendation 186/05-02)**.

3. The AAIB has made a recommendation to the CAA concerning the use of SSR transponders with altitude information **(AAIB Recommendation 99-34)**.

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Annex F: Estimated Equipage Cost Calculations and Assumptions

1. General One-off Equipage and Ongoing Costs

1.1 Through the 2006 interoperability consultation responses, impact assessment workshops with General Aviation representative associations, and liaison with avionics suppliers and maintenance organisations, Mode S transponder equipment and one-off installation costs have been estimated as shown in Table 1 below.

Upgrade of Mode A/C to Mode S Transponder	**Low Estimate**	**Medium Estimate**	**High Estimate**
Transponder	£1,410	£1,760	£2,940
Minor Parts	£20	£75	£150
Installation Fees	£250	£300	£500
Mod/EASA Paperwork	£0	£195	£435
Total (inc VAT)	**£1,680**	**£2,330**	**£4,025**
First Fit of a Mode S Transponder	**Low Estimate**	**Medium Estimate**	**High Estimate**
Transponder	£1,410	£1,760	£2,940
Minor Parts	£100	£230	£230
Installation Fees	£550	£1,000	£2,000
Mod/EASA Paperwork	£0	£435	£435
Total (inc VAT)	**£2,060**	**£3,425**	**£5,605**
First Fit of a Mode S Transponder to Gliders	**Low Estimate**	**Medium Estimate**	**High Estimate**
Transponder	£1,410	£1,760	£2,940
Minor Parts	£500	£1,400	£1,800
Installation Fees	£100	£100	£100
Mod/EASA Paperwork	£195	£195	£435
Total (inc VAT)	**£2,205**	**£3,455**	**£5,275**

Table 1: Estimated One-Off Equipage Costs for Mode S Transponder Equipage

1.2 There are also ongoing annual costs associated with operating an SSR transponder. Consultation with industry indicates that the cost of routine maintenance checks of Mode S transponders are equivalent to those for Mode A/C transponders. Those operators required to upgrade Mode A/C transponders to Mode S would, therefore, not incur any additional expense, as they already have to meet this ongoing cost. In addition, the use of an SSR transponder requires operators to hold a Wireless Telegraphy Act (WTA) licence for radio equipment. Once again, those operators required to upgrade Mode A/C transponders to Mode S would not be affected by this element, as they will already hold the required licence. For those operators equipping aircraft with a Mode S transponder for the first time, they could incur the estimated

ongoing annual costs per aircraft that are shown in Table 2 below as a result of the CAA's proposals. It should be noted that a WTA radio licence would only be required if one is not already held. Any existing WTA licences for other radio equipment would just be amended to include the new transponder equipment without any additional charge.

Description	Estimated Cost
Annual Check of Mode S Transponder	Nil additional cost for Mode A/C equipped aircraft
	£55 to £100 for new Mode S equipage
Annual WTA Radio Licence Fee (required for an SSR transponder even where a radio is not fitted)	<3,700 kg take-off mass = £20
	>3,700 kg take-off mass = £150

Table 2: Estimated Ongoing Annual Cost of Mode S Transponder Equipage

2. Equipage Costs for Option 1

2.1 **General**. Option 1 would require all aircraft (other than gliders[6]) flying within controlled airspace of classification A to E from 31 March 2009 to operate a Mode S compliant transponder unless otherwise authorised by an appropriate ATC unit. Those aircraft currently operating Mode A/C transponders would have until 31 March 2012 to be upgraded. Due to the other phases of Mode S implementation in the UK, it has been assumed that all aircraft with a take-off mass in excess of 5,700 kg will already be equipped with Mode S transponders. Where available, data on numbers of aircraft and current transponder equipage has been taken from the Aircraft Register as at 7 September 2007. Statistics and assumptions on other aircraft types, and on those aircraft used for non-private purposes, have been based on the "Strategic Review of General Aviation in the UK" and liaison with representative associations.

2.2 **One-off Costs**. The one-off equipage costs for different types of aircraft are set out in the following sub-paragraphs. The estimates and calculations assume that this equipage would be required to be completed between 31 March 2009 and 31 March 2012; and it further assumes that, on average, the total cost for each aircraft sector would be spread evenly across the three-year transition. Each section firstly shows a table that estimates the number of aircraft that the CAA believes may be affected by the proposals; and these should be read in conjunction with the related assumptions listed at the bottom of each figure. Below each of these equipage tables, a series of three 'One-off Equipage Cost Analysis' tables is then provided to show the break down of private, non-private and total one-off equipage cost estimates. The calculations in these tables combine the data on the estimated number of aircraft affected and the one-off equipage costs that are set out in Table 1 above. The 'Low Estimate' amounts assume a 'best-case' scenario where all aircraft could equip at the relevant low cost estimates in Table 1, and the 'High Estimate' amounts assume a 'worst-case' scenario where all aircraft in the sector would have to equip at the highest one-off equipage cost estimates in Table 1. It is recognised that there could be some specific individual equipage cases that may fall outside of these 'Low-High' ranges. At this stage, the CAA considers that the likely total cost per aircraft sector may be around the 'Medium Estimate' amounts. Government rules require the

[6] Within the Air Navigation Order 2005, gliders include Self-Sustaining Gliders and Self-Propelled Hang Gliders. Self-Propelled Hang Gliders include powered versions of Hang Gliders and Paragliders subject to certain criteria.

equipage costs over the three-year period to be discounted at 3.5%[7], and these calculations are also included in each of the three analysis tables for each sector.

a. **Gliders, Hang Gliders and Paragliders**. With the exception of Self-Launching Motor Gliders (SLMG) and Touring Motor Gliders (TMG), these types of aircraft are not currently included within the SSR transponder carriage regulations. Therefore, they would not need to equip with Mode S transponders under Option 1. The one-off equipage cost estimates for SLMG and TMG are set out separately in Paragraph 2.2(e) below.

b. **Airships and Balloons**. Between 2009 and 2012, it is estimated that the total one-off equipage costs for the airship and balloon sector to meet the requirements of Option 1 could be between £427,300 and £1,155,767 when discounted at 3.5%. Figure 5 below sets out the detailed calculations.

Policy Option 1 Equipage Estimates for Airships and Balloons	Private	Non-Private
Total Aircraft	1245	533
Number of Aircraft Currently Mode Mode A/C Equipped	6	7
Number of Aircraft Currently Mode Mode S Equipped	0	0
Number of Aircraft Currently Without an SSR Transponder	1239	526
Expected Number of Mode A/C Upgrades Due to Earlier Mandates	0	0
Estimated Number of Mode A/C Upgrade Due to Option 1	6	7
Estimated 1st Time Transponder Equipage Due to Option 1	99	105

One-Off Equipage Costs Analysis - Private Airships/Balloons	2009/2010	2010/2011	2011/2012	TOTAL
Average Cost Per Year at Current Prices (Low Estimate)	£71,340	£71,340	£71,340	**£214,020**
Present Value Cost Analysis @ 3.5% Discount Rate	£71,340	£68,929	£66,596	**£206,865**
Average Cost Per Year at Current Prices (Medium Estimate)	£117,685	£117,685	£117,685	**£353,055**
Present Value Cost Analysis @ 3.5% Discount Rate	£117,685	£113,707	£109,859	**£341,251**
Average Cost Per Year at Current Prices (High Estimate)	£193,015	£193,015	£193,015	**£579,045**
Present Value Cost Analysis @ 3.5% Discount Rate	£193,015	£186,491	£180,180	**£559,686**

One-Off Equipage Costs Analysis - Non-Private Airships/Balloons	2009/2010	2010/2011	2011/2012	TOTAL
Average Cost Per Year at Current Prices (Low Estimate)	£76,020	£76,020	£76,020	**£228,060**
Present Value Cost Analysis @ 3.5% Discount Rate	£76,020	£73,451	£70,965	**£220,435**
Average Cost Per Year at Current Prices (Medium Estimate)	£125,312	£125,312	£125,312	**£375,935**
Present Value Cost Analysis @ 3.5% Discount Rate	£125,312	£121,076	£116,978	**£363,366**
Average Cost Per Year at Current Prices (High Estimate)	£205,567	£205,567	£205,567	**£616,700**
Present Value Cost Analysis @ 3.5% Discount Rate	£205,567	£198,619	£191,896	**£596,082**

One-Off Equipage Costs Analysis - All Airships/Balloons	2009/2010	2010/2011	2011/2012	TOTAL
Average Cost Per Year at Current Prices (Low Estimate)	£147,360	£147,360	£147,360	**£442,080**
Present Value Cost Analysis @ 3.5% Discount Rate	£147,360	£142,379	£137,561	**£427,300**
Average Cost Per Year at Current Prices (Medium Estimate)	£242,997	£242,997	£242,997	**£728,990**
Present Value Cost Analysis @ 3.5% Discount Rate	£242,997	£234,783	£226,837	**£704,617**
Average Cost Per Year at Current Prices (High Estimate)	£398,582	£398,582	£398,582	**£1,195,745**
Present Value Cost Analysis @ 3.5% Discount Rate	£398,582	£385,110	£372,076	**£1,155,767**

Assumptions for Airships and Balloons:
30% of airships and balloons are operated by non-private organisations
100% of Mode A/C equipped airships and balloons would upgrade to Mode S
8% of private airships and balloons would install Mode S
20% of non-private airships and balloons would install Mode S

Figure 5: Option 1 Equipage Cost Calculations for Airships and Balloons

[7] For further information on this requirement, the 'Treasury Green Book' should be consulted.

c. **Microlights**. Between 2009 and 2012, it is estimated that the total one-off equipage costs for the microlight sector to meet the requirements of Option 1 could be between £2,258,944 and £6,136,274 when discounted at 3.5%. Figure 6 below sets out the detailed calculations.

Policy Option 1 Equipage Estimates for Microlights	Private	Non-Private
Total Aircraft	4151	173
Number of Aircraft Currently Mode Mode A/C Equipped	19	0
Number of Aircraft Currently Mode Mode S Equipped	4	0
Number of Aircraft Currently Without an SSR Transponder	4128	173
Expected Number of Mode A/C Upgrades Due to Earlier Mandates	0	0
Estimated Number of Mode A/C Upgrade Due to Option 1	19	0
Estimated 1st Time Transponder Equipage Due to Option 1	1032	87

One-Off Equipage Costs Analysis - Private Microlights	2009/2010	2010/2011	2011/2012	TOTAL
Average Cost Per Year at Current Prices (Low Estimate)	£719,287	£719,287	£719,287	**£2,157,861**
Present Value Cost Analysis @ 3.5% Discount Rate	£719,287	£694,975	£671,454	**£2,085,716**
Average Cost Per Year at Current Prices (Medium Estimate)	£1,192,968	£1,192,968	£1,192,968	**£3,578,904**
Present Value Cost Analysis @ 3.5% Discount Rate	£1,192,968	£1,152,646	£1,113,636	**£3,459,250**
Average Cost Per Year at Current Prices (High Estimate)	£1,953,630	£1,953,630	£1,953,630	**£5,860,891**
Present Value Cost Analysis @ 3.5% Discount Rate	£1,953,630	£1,887,598	£1,823,714	**£5,664,942**

One-Off Equipage Costs Analysis - Non-Private Microlights	2009/2010	2010/2011	2011/2012	TOTAL
Average Cost Per Year at Current Prices (Low Estimate)	£59,740	£59,740	£59,740	**£179,220**
Present Value Cost Analysis @ 3.5% Discount Rate	£59,740	£57,721	£55,767	**£173,228**
Average Cost Per Year at Current Prices (Medium Estimate)	£99,325	£99,325	£99,325	**£297,975**
Present Value Cost Analysis @ 3.5% Discount Rate	£99,325	£95,968	£92,720	**£288,013**
Average Cost Per Year at Current Prices (High Estimate)	£162,545	£162,545	£162,545	**£487,635**
Present Value Cost Analysis @ 3.5% Discount Rate	£162,545	£157,051	£151,736	**£471,332**

One-Off Equipage Costs Analysis - All Microlights	2009/2010	2010/2011	2011/2012	TOTAL
Average Cost Per Year at Current Prices (Low Estimate)	£779,027	£779,027	£779,027	**£2,337,081**
Present Value Cost Analysis @ 3.5% Discount Rate	£779,027	£752,696	£727,222	**£2,258,944**
Average Cost Per Year at Current Prices (Medium Estimate)	£1,292,293	£1,292,293	£1,292,293	**£3,876,879**
Present Value Cost Analysis @ 3.5% Discount Rate	£1,292,293	£1,248,614	£1,206,356	**£3,747,262**
Average Cost Per Year at Current Prices (High Estimate)	£2,116,175	£2,116,175	£2,116,175	**£6,348,526**
Present Value Cost Analysis @ 3.5% Discount Rate	£2,116,175	£2,044,649	£1,975,450	**£6,136,274**

Assumptions for Microlights:
4% of microlights are operated by non-private organisations
100% of Mode A/C equipped microlights would upgrade to Mode S
25% of private microlights would install Mode S
50% of non-private microlights would install Mode S

Figure 6: Option 1 Equipage Cost Calculations for Microlights

d. **Gyroplanes**. Between 2009 and 2012, it is estimated that the total one-off equipage costs for the gyroplane sector to meet the requirements of Option 1 could be between £123,083 and £334,364 when discounted at 3.5%. Figure 7 below sets out the detailed calculations.

Policy Option 1 Equipage Estimates for Gyroplanes	Private	Non-Private
Total Aircraft	236	29
Number of Aircraft Currently Mode Mode A/C Equipped	1	0
Number of Aircraft Currently Mode Mode S Equipped	4	0
Number of Aircraft Currently Without an SSR Transponder	231	29
Expected Number of Mode A/C Upgrades Due to Earlier Mandates	0	0
Estimated Number of Mode A/C Upgrade Due to Option 1	1	0
Estimated 1st Time Transponder Equipage Due to Option 1	46	15

One-Off Equipage Costs Analysis - Private Gyroplanes	2009/2010	2010/2011	2011/2012	TOTAL
Average Cost Per Year at Current Prices (Low Estimate)	£32,147	£32,147	£32,147	**£96,440**
Present Value Cost Analysis @ 3.5% Discount Rate	£32,147	£31,060	£30,009	**£93,216**
Average Cost Per Year at Current Prices (Medium Estimate)	£53,293	£53,293	£53,293	**£159,880**
Present Value Cost Analysis @ 3.5% Discount Rate	£53,293	£51,492	£49,749	**£154,535**
Average Cost Per Year at Current Prices (High Estimate)	£87,285	£87,285	£87,285	**£261,855**
Present Value Cost Analysis @ 3.5% Discount Rate	£87,285	£84,335	£81,481	**£253,100**

One-Off Equipage Costs Analysis - Non-Private Gyroplanes	2009/2010	2010/2011	2011/2012	TOTAL
Average Cost Per Year at Current Prices (Low Estimate)	£10,300	£10,300	£10,300	**£30,900**
Present Value Cost Analysis @ 3.5% Discount Rate	£10,300	£9,952	£9,615	**£29,867**
Average Cost Per Year at Current Prices (Medium Estimate)	£17,125	£17,125	£17,125	**£51,375**
Present Value Cost Analysis @ 3.5% Discount Rate	£17,125	£16,546	£15,986	**£49,657**
Average Cost Per Year at Current Prices (High Estimate)	£28,025	£28,025	£28,025	**£84,075**
Present Value Cost Analysis @ 3.5% Discount Rate	£28,025	£27,078	£26,161	**£81,264**

One-Off Equipage Costs Analysis - All Gyroplanes	2009/2010	2010/2011	2011/2012	TOTAL
Average Cost Per Year at Current Prices (Low Estimate)	£42,447	£42,447	£42,447	**£127,340**
Present Value Cost Analysis @ 3.5% Discount Rate	£42,447	£41,012	£39,624	**£123,083**
Average Cost Per Year at Current Prices (Medium Estimate)	£70,418	£70,418	£70,418	**£211,255**
Present Value Cost Analysis @ 3.5% Discount Rate	£70,418	£68,038	£65,736	**£204,192**
Average Cost Per Year at Current Prices (High Estimate)	£115,310	£115,310	£115,310	**£345,930**
Present Value Cost Analysis @ 3.5% Discount Rate	£115,310	£111,413	£107,642	**£334,364**

Assumptions for Gyroplanes:
11% of gyroplanes are operated by non-private organisations
100% of Mode A/C equipped gyroplanes would upgrade to Mode S
20% of private gyroplanes would install Mode S
50% of non-private gyroplanes would install Mode S

Figure 7: Option 1 Equipage Cost Calculations for Gyroplanes

e. **Self-Launching and Touring Motor Gliders**. Between 2009 and 2012, it is estimated that the total one-off equipage costs for the SLMG and TMG sector to meet the requirements of Option 1 could be between £561,034 and £1,342,513 when discounted at 3.5%. Figure 8 below sets out the detailed calculations.

Policy Option 1 Equipage Estimates for SLMG & TMG	Private	Non-Private
Total Aircraft	199	81
Number of Aircraft Currently Mode Mode A/C Equipped	51	11
Number of Aircraft Currently Mode Mode S Equipped	2	0
Number of Aircraft Currently Without an SSR Transponder	146	70
Expected Number of Mode A/C Upgrades Due to Earlier Mandates	0	0
Estimated Number of Mode A/C Upgrade Due to Option 1	51	11
Estimated 1st Time Transponder Equipage Due to Option 1	146	70

One-Off Equipage Costs Analysis - Private SLMG & TMG	2009/2010	2010/2011	2011/2012	TOTAL
Average Cost Per Year at Current Prices (Low Estimate)	£135,870	£135,870	£135,870	**£407,610**
Present Value Cost Analysis @ 3.5% Discount Rate	£135,870	£131,278	£126,835	**£393,982**
Average Cost Per Year at Current Prices (Medium Estimate)	£207,753	£207,753	£207,753	**£623,260**
Present Value Cost Analysis @ 3.5% Discount Rate	£207,753	£200,731	£193,938	**£602,422**
Average Cost Per Year at Current Prices (High Estimate)	£325,142	£325,142	£325,142	**£975,425**
Present Value Cost Analysis @ 3.5% Discount Rate	£325,142	£314,152	£303,520	**£942,813**

One-Off Equipage Costs Analysis - Non-Private SLMG & TMG	2009/2010	2010/2011	2011/2012	TOTAL
Average Cost Per Year at Current Prices (Low Estimate)	£57,610	£57,610	£57,610	**£172,830**
Present Value Cost Analysis @ 3.5% Discount Rate	£57,610	£55,663	£53,779	**£167,052**
Average Cost Per Year at Current Prices (Medium Estimate)	£89,160	£89,160	£89,160	**£267,480**
Present Value Cost Analysis @ 3.5% Discount Rate	£89,160	£86,146	£83,231	**£258,537**
Average Cost Per Year at Current Prices (High Estimate)	£137,842	£137,842	£137,842	**£413,525**
Present Value Cost Analysis @ 3.5% Discount Rate	£137,842	£133,183	£128,675	**£399,699**

One-Off Equipage Costs Analysis - All SLMG & TMG	2009/2010	2010/2011	2011/2012	TOTAL
Average Cost Per Year at Current Prices (Low Estimate)	£193,480	£193,480	£193,480	**£580,440**
Present Value Cost Analysis @ 3.5% Discount Rate	£193,480	£186,940	£180,614	**£561,034**
Average Cost Per Year at Current Prices (Medium Estimate)	£296,913	£296,913	£296,913	**£890,740**
Present Value Cost Analysis @ 3.5% Discount Rate	£296,913	£286,878	£277,169	**£860,960**
Average Cost Per Year at Current Prices (High Estimate)	£462,983	£462,983	£462,983	**£1,388,950**
Present Value Cost Analysis @ 3.5% Discount Rate	£462,983	£447,334	£432,195	**£1,342,513**

Assumptions for SLMG and TMG:
29% of SLMG & TMG are operated by non-private organisations
100% of Mode A/C equipped SLMG & TMG would upgrade to Mode S
100% of private SLMG & TMG would install Mode S
100% of non-private SLMG & TMG would install Mode S
If SLMG were treated as SSG and exempted, the estimates may be reduced by between £155K and £370K

Figure 8: Option 1 Equipage Cost Calculations for Fixed-Wing TMG and SLMG

f. **Fixed-Wing Aeroplanes (less than 5,700 kg take-off mass)**. Between 2009 and 2012, it is estimated that the total one-off equipage costs for the fixed-wing aeroplane sector to meet the requirements of Option 1 could be between £7,913,309 and £20,204,080 when discounted at 3.5%. Figure 9 below sets out the detailed calculations.

Policy Option 1 Equipage Estimates for Fixed-Wing Aeroplanes (<5,700 kg)	Private	Non-Private
Total Aircraft	6254	2567
Number of Aircraft Currently Mode Mode A/C Equipped	2884	2013
Number of Aircraft Currently Mode Mode S Equipped	158	236
Number of Aircraft Currently Without an SSR Transponder	3212	318
Expected Number of Mode A/C Upgrades Due to Earlier Mandates	536	673
Estimated Number of Mode A/C Upgrade Due to Option 1	1174	1340
Estimated 1st Time Transponder Equipage Due to Option 1	1606	318

One-Off Equipage Costs Analysis - Private Aeroplanes	2009/2010	2010/2011	2011/2012	TOTAL
Average Cost Per Year at Current Prices (Low Estimate)	£1,760,232	£1,760,232	£1,760,232	**£5,280,695**
Present Value Cost Analysis @ 3.5% Discount Rate	£1,760,232	£1,700,736	£1,643,176	**£5,104,144**
Average Cost Per Year at Current Prices (Medium Estimate)	£2,745,359	£2,745,359	£2,745,359	**£8,236,076**
Present Value Cost Analysis @ 3.5% Discount Rate	£2,745,359	£2,652,566	£2,562,792	**£7,960,717**
Average Cost Per Year at Current Prices (High Estimate)	£4,575,705	£4,575,705	£4,575,705	**£13,727,116**
Present Value Cost Analysis @ 3.5% Discount Rate	£4,575,705	£4,421,047	£4,271,421	**£13,268,173**

One-Off Equipage Costs Analysis - Non-Private Aeroplanes	2009/2010	2010/2011	2011/2012	TOTAL
Average Cost Per Year at Current Prices (Low Estimate)	£968,778	£968,778	£968,778	**£2,906,334**
Present Value Cost Analysis @ 3.5% Discount Rate	£968,778	£936,033	£904,354	**£2,809,166**
Average Cost Per Year at Current Prices (Medium Estimate)	£1,403,752	£1,403,752	£1,403,752	**£4,211,255**
Present Value Cost Analysis @ 3.5% Discount Rate	£1,403,752	£1,356,305	£1,310,402	**£4,070,458**
Average Cost Per Year at Current Prices (High Estimate)	£2,391,940	£2,391,940	£2,391,940	**£7,175,819**
Present Value Cost Analysis @ 3.5% Discount Rate	£2,391,940	£2,311,092	£2,232,876	**£6,935,907**

One-Off Equipage Costs Analysis - All Aeroplanes	2009/2010	2010/2011	2011/2012	TOTAL
Average Cost Per Year at Current Prices (Low Estimate)	£2,729,010	£2,729,010	£2,729,010	**£8,187,029**
Present Value Cost Analysis @ 3.5% Discount Rate	£2,729,010	£2,636,769	£2,547,531	**£7,913,309**
Average Cost Per Year at Current Prices (Medium Estimate)	£4,149,110	£4,149,110	£4,149,110	**£12,447,331**
Present Value Cost Analysis @ 3.5% Discount Rate	£4,149,110	£4,008,870	£3,873,194	**£12,031,175**
Average Cost Per Year at Current Prices (High Estimate)	£6,967,645	£6,967,645	£6,967,645	**£20,902,935**
Present Value Cost Analysis @ 3.5% Discount Rate	£6,967,645	£6,732,139	£6,504,297	**£20,204,080**

Assumptions for Fixed-Wing Aeroplanes:
50% of Mode A/C equipped private aeroplanes would upgrade to Mode S
100% of Mode A/C equipped non-private aeroplanes would upgrade to Mode S
50% of private aeroplanes would install Mode S
100% of non-private aeroplanes would install Mode S

Figure 9: Option 1 Equipage Cost Calculations for Fixed-Wing Aeroplanes <5,700 kg

g. **Helicopters (less than 5,700 kg take-off mass)**. Between 2009 and 2012, it is estimated that the total one-off equipage costs for the helicopter sector to meet the requirements of Option 1 could be between £1,048,916 and £2,554,449 when discounted at 3.5%. Figure 10 below sets out the detailed calculations.

Policy Option 1 Equipage Estimates for Helicopters (<5,700 kg)	Private	Non-Private
Total Aircraft	421	967
Number of Aircraft Currently Mode Mode A/C Equipped	308	719
Number of Aircraft Currently Mode Mode S Equipped	51	215
Number of Aircraft Currently Without an SSR Transponder	62	33
Expected Number of Mode A/C Upgrades Due to Earlier Mandates	60	275
Estimated Number of Mode A/C Upgrade Due to Option 1	124	444
Estimated 1st Time Transponder Equipage Due to Option 1	31	33

One-Off Equipage Costs Analysis - Private Helicopters	2009/2010	2010/2011	2011/2012	TOTAL
Average Cost Per Year at Current Prices (Low Estimate)	£90,601	£90,601	£90,601	**£271,802**
Present Value Cost Analysis @ 3.5% Discount Rate	£90,601	£87,538	£84,576	**£262,715**
Average Cost Per Year at Current Prices (Medium Estimate)	£131,524	£131,524	£131,524	**£394,571**
Present Value Cost Analysis @ 3.5% Discount Rate	£131,524	£127,078	£122,777	**£381,379**
Average Cost Per Year at Current Prices (High Estimate)	£223,983	£223,983	£223,983	**£671,949**
Present Value Cost Analysis @ 3.5% Discount Rate	£223,983	£216,412	£209,088	**£649,484**

One-Off Equipage Costs Analysis - Non-Private Helicopters	2009/2010	2010/2011	2011/2012	TOTAL
Average Cost Per Year at Current Prices (Low Estimate)	£271,132	£271,132	£271,132	**£813,396**
Present Value Cost Analysis @ 3.5% Discount Rate	£271,132	£261,968	£253,102	**£786,201**
Average Cost Per Year at Current Prices (Medium Estimate)	£382,282	£382,282	£382,282	**£1,146,846**
Present Value Cost Analysis @ 3.5% Discount Rate	£382,282	£369,361	£356,860	**£1,108,503**
Average Cost Per Year at Current Prices (High Estimate)	£656,953	£656,953	£656,953	**£1,970,858**
Present Value Cost Analysis @ 3.5% Discount Rate	£656,953	£634,748	£613,265	**£1,904,965**

One-Off Equipage Costs Analysis - All Helicopters	2009/2010	2010/2011	2011/2012	TOTAL
Average Cost Per Year at Current Prices (Low Estimate)	£361,733	£361,733	£361,733	**£1,085,198**
Present Value Cost Analysis @ 3.5% Discount Rate	£361,733	£349,506	£337,677	**£1,048,916**
Average Cost Per Year at Current Prices (Medium Estimate)	£513,806	£513,806	£513,806	**£1,541,417**
Present Value Cost Analysis @ 3.5% Discount Rate	£513,806	£496,439	£479,638	**£1,489,882**
Average Cost Per Year at Current Prices (High Estimate)	£880,936	£880,936	£880,936	**£2,642,807**
Present Value Cost Analysis @ 3.5% Discount Rate	£880,936	£851,160	£822,353	**£2,554,449**

Assumptions for Helicopters:
50% of Mode A/C equipped private helicopters would upgrade to Mode S
100% of Mode A/C equipped non-private helicopters would upgrade to Mode S
50% of private helicopters would install Mode S
100% of non-private helicopters would install Mode S

Figure 10: Option 1 Equipage Cost Calculations for Helicopters <5,700 kg

h. **Overall Summary of One-Off Costs for Option 1**. Between 2009 and 2012, it is estimated that the total one-off equipage costs for all aircraft below a 5,700 kg take-off mass to meet the requirements of Option 1 could be between £12,332,585 and £31,727,447 when discounted at 3.5%. Figure 11 below sets out the detailed calculations.

Policy Option 1 Equipage Estimates for All Aircraft	Private	Non-Private
Total Aircraft (Not including Gliders, Hang Gliders or Paragliders)	12506	4350
Number of Aircraft Currently Mode Mode A/C Equipped	3269	2750
Number of Aircraft Currently Mode Mode S Equipped	219	451
Number of Aircraft Currently Without an SSR Transponder	9018	1149
Expected Number of Mode A/C Upgrades Due to Earlier Mandates	597	948
Estimated Number of Mode A/C Upgrade Due to Option 1	1375	1802
Estimated 1st Time Transponder Equipage Due to Option 1	2960	628

One-Off Equipage Costs Analysis - Private	2009/2010	2010/2011	2011/2012	TOTAL
Average Cost Per Year at Current Prices (Low Estimate)	£2,809,476	£2,809,476	£2,809,476	**£8,428,428**
Present Value Cost Analysis @ 3.5% Discount Rate	£2,809,476	£2,714,516	£2,622,646	**£8,146,637**
Average Cost Per Year at Current Prices (Medium Estimate)	£4,448,582	£4,448,582	£4,448,582	**£13,345,746**
Present Value Cost Analysis @ 3.5% Discount Rate	£4,448,582	£4,298,220	£4,152,751	**£12,899,553**
Average Cost Per Year at Current Prices (High Estimate)	£7,358,761	£7,358,761	£7,358,761	**£22,076,282**
Present Value Cost Analysis @ 3.5% Discount Rate	£7,358,761	£7,110,034	£6,869,403	**£21,338,198**

One-Off Equipage Costs Analysis - Non-Private	2009/2010	2010/2011	2011/2012	TOTAL
Average Cost Per Year at Current Prices (Low Estimate)	£1,443,580	£1,443,580	£1,443,580	**£4,330,740**
Present Value Cost Analysis @ 3.5% Discount Rate	£1,443,580	£1,394,787	£1,347,582	**£4,185,949**
Average Cost Per Year at Current Prices (Medium Estimate)	£2,116,955	£2,116,955	£2,116,955	**£6,350,866**
Present Value Cost Analysis @ 3.5% Discount Rate	£2,116,955	£2,045,402	£1,976,178	**£6,138,535**
Average Cost Per Year at Current Prices (High Estimate)	£3,582,870	£3,582,870	£3,582,870	**£10,748,611**
Present Value Cost Analysis @ 3.5% Discount Rate	£3,582,870	£3,461,769	£3,344,609	**£10,389,249**

One-Off Equipage Costs Analysis - All Aircraft	2009/2010	2010/2011	2011/2012	TOTAL
Average Cost Per Year at Current Prices (Low Estimate)	£4,253,056	£4,253,056	£4,253,056	**£12,759,168**
Present Value Cost Analysis @ 3.5% Discount Rate	£4,253,056	£4,109,303	£3,970,228	**£12,332,586**
Average Cost Per Year at Current Prices (Medium Estimate)	£6,565,537	£6,565,537	£6,565,537	**£19,696,612**
Present Value Cost Analysis @ 3.5% Discount Rate	£6,565,537	£6,343,622	£6,128,929	**£19,038,088**
Average Cost Per Year at Current Prices (High Estimate)	£10,941,631	£10,941,631	£10,941,631	**£32,824,893**
Present Value Cost Analysis @ 3.5% Discount Rate	£10,941,631	£10,571,804	£10,214,012	**£31,727,447**

Figure 11: Summary of Overall Equipage Costs for Option 1

2.2 **Estimated Ongoing Annual Costs**. Estimated annual ongoing costs have been calculated over the period 2009 to 2025, as this is considered to be the minimum time period over which the Mode S transponders will be required to be used. A summary of the total ongoing cost calculations for Option 1 is as follows:

a. From Figure 11 above, it can be seen that an estimated 2,960 private aircraft and 628 non-private aircraft may need to equip with a Mode S transponder for the first time under the Option 1 proposals. Combining this with the cost estimates for annual checks, which are set out in Table 2 above, the estimated annual total cost of this requirement in every year between 2009 and 2025 could, therefore, be between £197,000 and £359,000. The total Present Value of this ongoing cost by 2025 is estimated to be £2.6M to £4.7M at a discount rate of 3.5%. For simplicity, it has been assumed that annual checks for all these aircraft would take place from 2009 onwards and so the total amounts will be slightly over estimated.

b. Of the total 3,588 aircraft that may be expected to equip with a Mode S transponder for the first time due to the Option 1 proposals, the CAA estimates that around 86% of them (3,085 aircraft) may not currently need to hold a WTA radio licence. The new requirement to hold a licence under the Option 1 proposals could, therefore, result in an additional total Present Value

cost by 2025 of around £808,000 at a discount rate of 3.5%. This will result from the owners of these 3,085 aircraft incurring a £20 annual fee. For simplicity, it has been assumed that all these additional licences would be required from 2009 onwards and so the total amounts will be slightly over estimated.

c. Mindful of the aforementioned elements for ongoing costs, the total additional Present Value costs of Option 1 for annual maintenance checks and WTA licences are, therefore, estimated to be between £3.4M and £5.5M by 2025.

2.3 **Total Estimated Costs for Option 1**. A summary of the overall estimated costs for Option 1 is set out in Table 3 below. Although the total costs are based on the period 2009 to 2025, it should be noted that the main portion of the cost element relates to initial one-off equipage of aircraft and this will be need to be incurred by 31 March 2012.

Cost Element	Period	Low	High
Average One-Off Equipage Costs During Each Year of the Transition Period	3 Years (2009 to 2012)	£4.2M pa	£11M pa
Average Ongoing Annual Cost	17 years (2009 to 2025)	£259,000 pa	£420,500 pa
Total PV Cost @ 3.5% Discount Rate	By 2025	£15.7M	£37.2M

Table 3: Summary of Overall Estimated Costs for Option 1

3. Equipage Costs for Option 3

3.1 **General**. Option 3 would require all gliders intending to fly in airspace where transponder carriage was mandatory to be equipped with Mode S transponders from 31 March 2009, unless otherwise authorised by an appropriate ATC unit. Under the proposed transition arrangements, any glider currently operating a Mode A/C transponder would need to be upgraded by 31 March 2012. Statistics on gliders have been gained from the “Strategic Review of General Aviation in the UK” and liaison with the British Gliding Association. The equipage costs are set out in the following paragraphs.

3.2 **One-Off Equipage Costs**. The methodology and presentational aspects of the following one-off equipage cost estimates for Option 3 are the same as was set out for Option 1 above:

a. **Hang Gliders and Paragliders**. There are currently no available Mode S transponder products that are suitable for installation and operation on hang gliders and paragliders. These aircraft would, therefore, not be able to equip to meet the requirements of Option 3 and would need authorisation from appropriate ATC units to operate within mandatory transponder carriage airspace after 31 March 2009.

b. **Gliders**. Between 2009 and 2012, it is estimated that the total one-off equipage costs for the glider sector to meet the requirements of Option 3 could be between £2,237,843 and £5,353,571 when discounted at 3.5%. Figure 12 below sets out the detailed calculations.

Policy Option 3 Equipage Estimates for Gliders	Private	Non-Private
Total Aircraft (Not including Hang Gliders and Paragliders)	2373	50
Number of Aircraft Currently Mode Mode A/C Equipped	0	0
Number of Aircraft Currently Mode Mode S Equipped	10	0
Number of Aircraft Currently Without an SSR Transponder	2363	50
Expected Number of Mode A/C Upgrades Due to Earlier Mandates	0	0
Estimated Number of Mode A/C Upgrade Due to Option 3	0	0
Estimated 1st Time Transponder Equipage Due to Option 3	1000	50

One-Off Equipage Costs Analysis - Private Gliders	2009/2010	2010/2011	2011/2012	TOTAL
Average Cost Per Year at Current Prices (Low Estimate)	£735,000	£735,000	£735,000	**£2,205,000**
Present Value Cost Analysis @ 3.5% Discount Rate	£735,000	£710,157	£686,123	**£2,131,280**
Average Cost Per Year at Current Prices (Medium Estimate)	£1,151,667	£1,151,667	£1,151,667	**£3,455,000**
Present Value Cost Analysis @ 3.5% Discount Rate	£1,151,667	£1,112,740	£1,075,081	**£3,339,488**
Average Cost Per Year at Current Prices (High Estimate)	£1,758,333	£1,758,333	£1,758,333	**£5,275,000**
Present Value Cost Analysis @ 3.5% Discount Rate	£1,758,333	£1,698,902	£1,641,404	**£5,098,639**

One-Off Equipage Costs Analysis - Non-Private Gliders	2009/2010	2010/2011	2011/2012	TOTAL
Average Cost Per Year at Current Prices (Low Estimate)	£36,750	£36,750	£36,750	**£110,250**
Present Value Cost Analysis @ 3.5% Discount Rate	£36,750	£35,508	£34,306	**£106,564**
Average Cost Per Year at Current Prices (Medium Estimate)	£57,583	£57,583	£57,583	**£172,750**
Present Value Cost Analysis @ 3.5% Discount Rate	£57,583	£55,637	£53,754	**£166,974**
Average Cost Per Year at Current Prices (High Estimate)	£87,917	£87,917	£87,917	**£263,750**
Present Value Cost Analysis @ 3.5% Discount Rate	£87,917	£84,945	£82,070	**£254,932**

One-Off Equipage Costs Analysis - All Gliders	2009/2010	2010/2011	2011/2012	TOTAL
Average Cost Per Year at Current Prices (Low Estimate)	£771,750	£771,750	£771,750	**£2,315,250**
Present Value Cost Analysis @ 3.5% Discount Rate	£771,750	£745,665	£720,429	**£2,237,843**
Average Cost Per Year at Current Prices (Medium Estimate)	£1,209,250	£1,209,250	£1,209,250	**£3,627,750**
Present Value Cost Analysis @ 3.5% Discount Rate	£1,209,250	£1,168,377	£1,128,835	**£3,506,462**
Average Cost Per Year at Current Prices (High Estimate)	£1,846,250	£1,846,250	£1,846,250	**£5,538,750**
Present Value Cost Analysis @ 3.5% Discount Rate	£1,846,250	£1,783,847	£1,723,474	**£5,353,571**

Assumptions for Gliders:
28% of gliders are operated by non-private organisations
Assumes no areas of 'Non-Transponder Airspace' above FL 100 for gliders
Estimates of potential equipage levels provided by the BGA
Areas of non-transponder carriage airspace for gliders above FL 100 may reduce estimated costs by £1M to £2.5M
Some owners may incur additional costs of £100 to £200 if the glider needs to be re-weighed after equipage

Figure 12: Option 3 Equipage Cost Calculations for Gliders

3.3 **Estimated Ongoing Annual Costs**. Owners of gliders that are not currently equipped with an SSR transponder would incur annual ongoing costs for maintenance checks of any Mode S transponders installed as a result of the Option 3 proposals. Many owners may also need a WTA radio licence for the first time to accompany the transponders. A summary of the total ongoing cost calculations for Option 3 is as follows:

a. From Figure 12 above, it can be seen that an estimated 1,000 private gliders and 50 non-private gliders may need to equip with a Mode S transponder for the first time under the Option 3 proposals. Combining this with the cost estimates for annual checks, which are set out in Table 2 above, the estimated annual total cost of this requirement in every year between 2009 and 2025 could, therefore, be between £57,750 and £105,000. The total Present Value of this ongoing cost by 2025 is estimated to be £756,000 to £1.4M at a discount rate of 3.5%. For simplicity, it has been assumed that

annual checks for all these aircraft would take place from 2009 onwards and so the total amounts will be slightly over estimated.

b. Of the total 1,050 gliders that may be expected to equip with a Mode S transponder for the first time due to the Option 3 proposals, the CAA estimates that around 86% of them (903 gliders) may not currently need to hold a WTA radio licence. The new requirement to hold a licence under the Option 3 proposals could, therefore, result in an additional total Present Value cost by 2025 of around ££236,500 at a discount rate of 3.5%. This will result from the owners of these 1,050 gliders incurring a £20 annual fee. For simplicity, it has been assumed that all these additional licences would be required from 2009 onwards and so the total amounts will be slightly over estimated.

c. Mindful of the aforementioned elements for ongoing costs, the total additional Present Value costs of Option 3 for annual maintenance checks and WTA licences are, therefore, estimated to be between £1M and £1.6M by 2025.

3.4 **Total Estimated Costs for Option 3**: Assuming that there would be no promulgated airspace between FL 100 and FL 195 in which gliders could operate without transponders, a summary of the overall estimated costs for Option 3 is shown in Table 4 below.

Cost Element	Period	Low	High
Average One-Off Equipage Costs During Each Year of the Transition Period	3 Years (2009 to 2012)	£771,750 pa	£1.85M pa
Average Ongoing Annual Cost	17 years (2009 to 2025)	£75,800 pa	£123,000 pa
Total PV Cost @ 3.5% Discount Rate	By 2025	£3.2M	£7M

Table 4: Summary of Overall Estimated Costs for Option 3

4 Consolidated Cost Estimates for Options 1 to 4

4.1 It is not possible to estimate meaningful total costs of implementing a process to support applications for Transponder Mandatory Zones (TMZs), as set out in Option 2, because it will be highly dependent on the numbers and complexity of the applications that are received. The CAA costs for setting up the process will be minimal if they are merely a subset of the current Airspace Change Process. One General Aviation representative association has estimated that each application for a TMZ would cost the organisation around £300 in order to participate in any required consultation. Similarly, it has not been possible to accurately estimate the cost impact of requiring all powered aircraft to be equipped with Mode S transponders if they are flown internationally, as set out in Option 4. However, it is considered likely that the aircraft being operated on international flights would be mainly that ones that would also need to be equipped under Option 1. Consequently, it has been assumed that the one-off and ongoing costs of compliance with Option 4 would be contained within the estimates calculated for Option 1.

4.2 Therefore, the consolidated costs of implementing Options 1 to 4 are currently estimated to be as shown in Table 5 below.

Cost Element	Period	Low	High
Average One-Off Equipage Costs During Each Year of the Transition Period	3 Years (2009 to 2012)	£5M pa	£12.8M pa
Average Ongoing Annual Cost	17 years (2009 to 2025)	£335,000 pa	£543,600 pa
Total PV Cost @ 3.5% Discount Rate	By 2025	£19M	£44.2M

Table 5: Consolidated Cost Estimates for Options 1 to 4

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Annex G: Transponder Mandatory Zones

1. Regulatory Aspects

1.1 Schedule 5 Article 20(2) of the Air Navigation Order 2005 sets out the existing regulatory powers to require the carriage of SSR transponders within specific, notified airspace[8]. Any airspace that is notified for this purpose is promulgated in the Aeronautical Information Publication in the General Section at Paragraph 1.5.3. In effect, this existing provision allows the CAA to create 'Transponder Mandatory Zones' (TMZs) in any airspace volume but, to date, this has been only applied on a limited basis.

1.2 The only airspace that is currently notified in accordance with this regulatory provision is within the Scottish TMA between 6000 feet altitude and Flight Level 100. Until recently, the Sumburgh Control Zone was also temporarily notified to provide mitigation for pre-planned radar outages. This work has now been completed and the notified airspace at Sumburgh withdrawn.

1.3 The current minimum capability for transponders operated within airspace notified under this regulation is Mode A/C. However, under Phase 1 of the proposed expansion of Mode S in UK airspace, the Government has now approved a CAA recommendation to change the minimum requirement to Mode S capability with effect from 31 March 2008.

1.4 Greater use of TMZs may be required to address specific safety and airspace efficiency issues as commercial traffic levels continue to rise. Although the regulation to set up TMZs is already in force, the CAA is consulting with stakeholders to seek views on what process should be used to determine and adopt TMZs. It is envisaged that TMZs could be initiated by the CAA or as a result of requests from stakeholders, such as NATS.

2. Reasons Why TMZs May Need to be Established

Stakeholders and the CAA may wish to establish TMZs to provide mitigation for specific risks and requirements. Examples of reasons why applications for TMZs may be submitted are as follows:

- To support efforts to improve detection and early warning of airspace infringements. Infringements are a major element currently under consideration by the Airspace and Safety Initiative (ASI)[9];
- To support efforts to improve the safe and efficient management of airspace infringements once they have occurred to minimise the adverse safety, economic and environmental consequences;
- To provide volumes of airspace in which all air traffic can be detected by airborne and ground-based collision avoidance systems operating in the vicinity;
- To provide volumes of airspace in which all air traffic can be detected on radar with accurate height and identity to improve the safety and efficiency of Air Traffic Services;

[8] Air Navigation Order 2005, sub-paragraph (3)(b) in the table at paragraph 2 of Schedule 5 Article 20(2).

[9] The ASI is joint CAA, NATS, AOA, GA and MOD effort to investigate and tackle the major safety risks in UK airspace. More information on the ASI can be obtained at http://www.airspacesafety.com.

- To address identified safety risks in airspace shared by large numbers of IFR and VFR traffic, or with diverse levels of speed and performance in aircraft operating in close proximity;
- To provide mitigations for limitations in Primary Surveillance Radar coverage;
- To provide volumes of airspace in which all air traffic can be detected on radar with height and identity for national security reasons.

3. Foreseen Elements of the Process for Establishment of TMZs

3.1 As the establishment of a TMZ could result in a change to the use of airspace by stakeholders, the CAA currently considers that the processing of TMZ applications should fall within the existing Airspace Change Process (ACP) as set out in the Airspace Charter[10] and in CAP 725. However, it is considered that the elements of the ACP relevant to TMZ establishment could be scaleable; for example, a full environmental assessment may not be appropriate for TMZ establishment but any indirect environmental effects of proposed changes to airspace use, such as the 'channelling' of non-compliant aircraft trying to avoid the TMZ, may need to be assessed. The extant timescales and consultation requirements of the ACP could also be applicable to TMZ applications, and air traffic surveillance system performance within the TMZs would need to be considered. Moreover, the CAA considers that applications for some TMZs from ATC providers may need to be supported with a commitment to make some level of Air Traffic Service available to aircraft operating within a TMZ. This would need to be assessed on a case-by-case basis. Applicants may also be expected to provide results of risk assessments as part of any evidence base used to support applications.

3.2 The charting and promulgation requirements for TMZs will need to be considered carefully, as will awareness and publicity considerations. The CAA's 'Maps and Charts Working Group' is examining the issues but mechanisms could include the following:

- Airspace charts;
- Aeronautical Information Publication Amendments or Supplements;
- Aeronautical Information Circulars;
- Notices to Airmen (NOTAMs).

3.3 Notification periods for TMZs would be in accordance with the current amendment cycles applicable to aeronautical publications.

3.4 It is also considered that applicants for TMZs would need to consider potential mitigations for aircraft that are technically not capable of being equipped with available SSR transponders. Consideration of these issues would form part of the consultation process within the ACP. The handling of any unserviceability of SSR equipment on aircraft within TMZs would also need to be addressed.

3.5 In order to reduce the burden on stakeholders, the CAA will seek to ensure that consultation meetings concerning multiple simultaneous TMZ proposals from a single applicant are consolidated to the greatest extent possible.

[10] CAP 724, Appendix F.

4. Supporting Evidence for TMZ Applications

4.1 Criteria and supporting evidence to trigger requests for the establishment of TMZs could include the following:

- Airspace infringement statistics, including analysis of categories of aircraft;
- Aircraft movement statistics, such as passenger movements, freight movements, air traffic movements, military and General Aviation activity levels;
- Relevant accident reports, recommendations and statistics;
- Relevant Airprox[11] reports, recommendations and statistics.

4.2 Moreover, the use of TMZs could become a required consideration in ACP applications concerning the establishment or amendment of controlled airspace volumes. The aim would be for applicants to consider the use of TMZs instead of, or to reduce, the required dimensions of any proposed controlled airspace.

[11] An Airprox is a situation in which, in the opinion of a pilot or a controller, the distance between aircraft as well as their relative positions and speed have been such that the safety of the aircraft involved was or may have been compromised. Only a pilot or air traffic controller can report an Airprox. Details of the procedures are given in UK Aeronautical Information Publication (AIP) En Route (ENR) Section 1.14 and UK AIP (MIL) ENR 1.14.

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Annex H: UK Airspace Infringement Statistics

1. One of the most significant current safety risks to UK aviation is the inadvertent or unauthorised penetration of controlled and reserved airspace, and it is a major issue currently being considered by the Airspace and Safety Initiative (ASI)[12]. This operational hazard, commonly called an airspace infringement, may result in serious harm either from an actual mid-air collision or from the need for a rapid avoidance manoeuvre. Most, but not all, reported infringements are of controlled airspace and, primarily, the control zones serving airports but also control areas and airways. In addition to safety risks, infringements of controlled airspace also result in increased economic and environmental costs through delayed departures, 'go-arounds', unnecessary airborne holding patterns and extended routings for commercial aircraft. Those infringements that occur outside controlled airspace tend to involve Danger Areas and Air Traffic Zones (ATZ) at regional airports. Infringements of temporary restricted airspace associated with air shows or Red Arrows displays also feature in the statistics. The infringement of Red Arrows airspace in 2005 and 2006, and the subsequent cancellation of certain displays, left many fee paying spectators particularly disgruntled.

2. Over the last 10 years, the average annual number of reported airspace infringements has been around 400, although a recent publicity campaign and a more robust reporting mechanism by NATS has resulted in a marked increase in the number of reported infringements over the last few years. The true number is likely to be significantly greater as, for many reasons, not every infringement is formally reported or can be detected. Infringements occur throughout the year, but there is a clear cyclical pattern to when they occur. Peaks are traditionally reached during the summer months where good VFR conditions encourage more General Aviation activity, and sheer numbers alone increase the probability of infringement. Consequently, the majority of airspace infringements are committed by General Aviation aircraft, particularly by powered light aircraft.

3. Where an airspace infringement is committed by an aircraft not reporting SSR-based height information, the resultant consequences of the infringement are much more difficult to manage because aircraft cannot be separated efficiently by air traffic controllers, and anti-collision safety systems, such as Traffic Alert and Collision Avoidance System II (TCAS II) and Short-Term Conflict Alert (STCA), cannot be activated when separation is degraded. Moreover, without altitude data, it is not always possible to determine when aircraft are actually committing an airspace infringement, as the aircraft may be 'deemed' by controllers to be above or below the volume of controlled or reserved airspace. The implementation of infringement early warning systems is also adversely affected by the lack of altitude data from all aircraft operating in the vicinity of the controlled or reserved airspace.

4. Mindful of the above, the proportion of actual infringements by non-transponding aircraft, and/or aircraft equipped with transponders that do not report height information, is difficult to accurately quantify. Nevertheless, a recent investigation by NATS has shown that there were at least 34 infringements of the very high density controlled airspace around the major London airports in 2006 by aircraft that were not operating an SSR transponder; nine of these incidents resulted in a breakdown of the minimum separation standards between aircraft. In these infringements, the safety layers provided by ground-based safety systems and airborne collision avoidance systems cannot come into play; ATC procedures and visual sighting are the only methods of maintaining safety where non-transponder equipped aircraft are involved.

[12] The ASI is joint CAA, NATS, AOA, GA and MOD effort to investigate and tackle the major safety risks in UK airspace. More information on the ASI can be obtained at http://www.airspacesafety.com.

5. The need to minimise the adverse consequences of airspace infringements is a major issue for the CAA and NATS in the efforts to ensure that the aims of the 2003 Government White Paper on "The Future of Air Transport" can be realised. Safety must be maintained or improved as traffic levels continue to grow, and efficient use of airspace is paramount. Measures to minimise the adverse economic and environmental effects of airspace infringements must be implemented, and maximum opportunities must be afforded for safety systems to be effective when infringements occur. In order to achieve this, the CAA considers that all aircraft operating within controlled airspace, whether IFR or VFR, should be required to carry and operate transponders. Moreover, a formal mechanism for creating 'buffer zones' around airspace with high incidences of infringements should also be put in place within which Mode S transponders must be carried and operated.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Mean
January	6	8	24	12	15	13	**4**	28	14	15	**31**	21	16
February	18	11	16	19	21	20	**10**	18	18	15	23	**34**	19
March	16	33	19	31	26	**12**	29	19	30	35	44	**62**	25
April	**14**	34	18	24	18	22	17	23	39	33	61	**99**	34
May	**27**	39	42	55	35	36	33	32	46	**69**	51	66	44
June	41	36	36	54	46	37	39	43	**27**	56	**106**	83	50
July	49	96	**40**	63	47	**40**	59	46	43	74	**112**	91	63
August	42	40	37	38	54	**34**	41	54	38	**55**	49		44
September	49	27	**23**	40	32	33	50	48	34	**56**	51		36
October	36	32	26	29	30	34	25	31	**19**	48	**51**		33
November	16	13	27	23	**10**	19	12	22	21	38	**40**		22
December	9	12	**6**	**25**	10	14	7	12	12	23	11		12
Total	323	381	**314**	413	344	**314**	326	376	341	**517**	630	456	**396**
Mean total	**413**	**413**	**413**	**413**	**413**	**413**	**413**	**413**	**413**	**413**	**413**	**413**	

high
low

Figure 13: Monthly Infringement Reports – 1996 to 2007

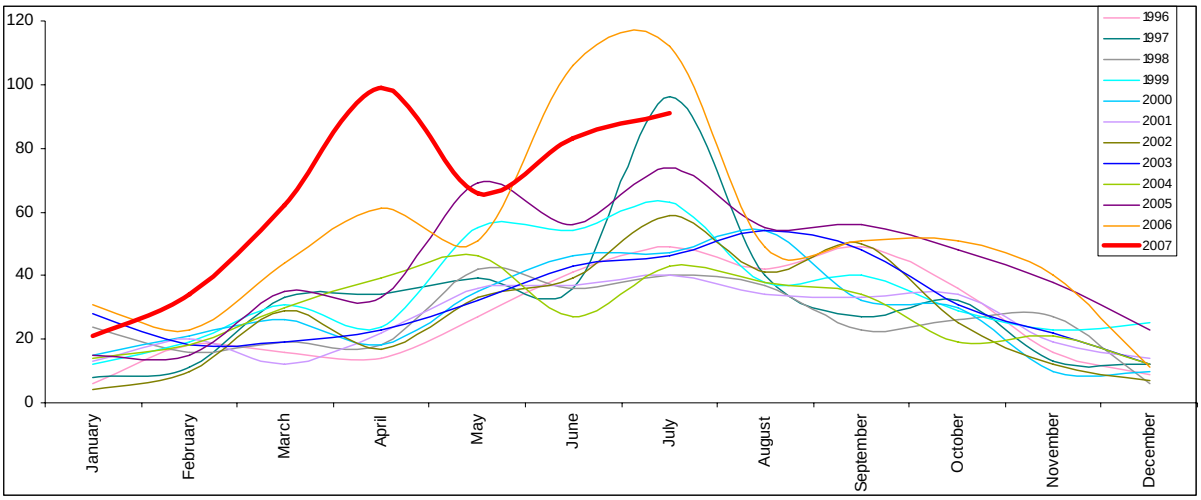

Figure 14: Monthly Infringement Report Trends

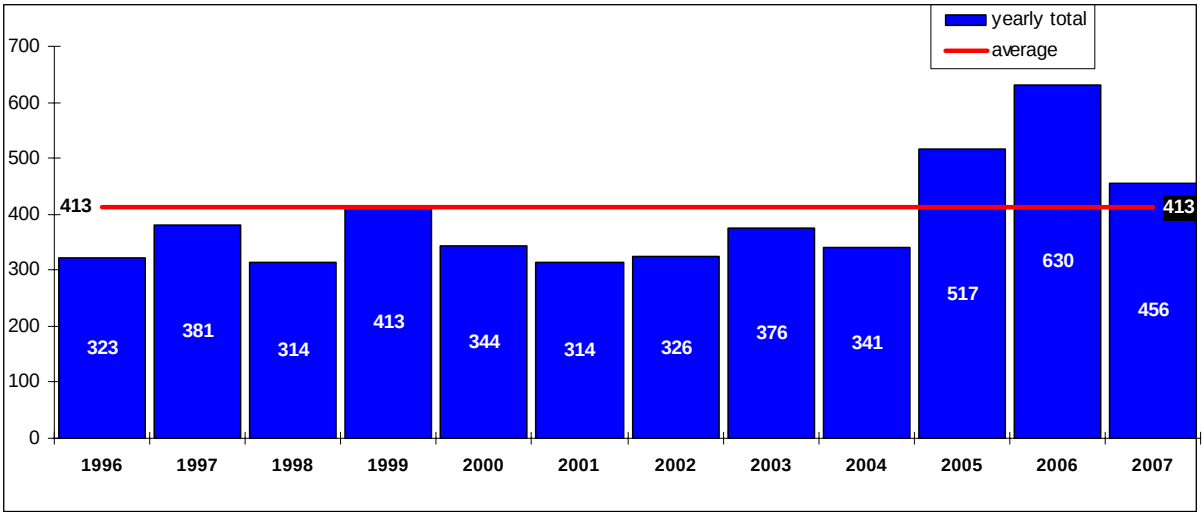

Figure 15: Annual Infringement Report Trends

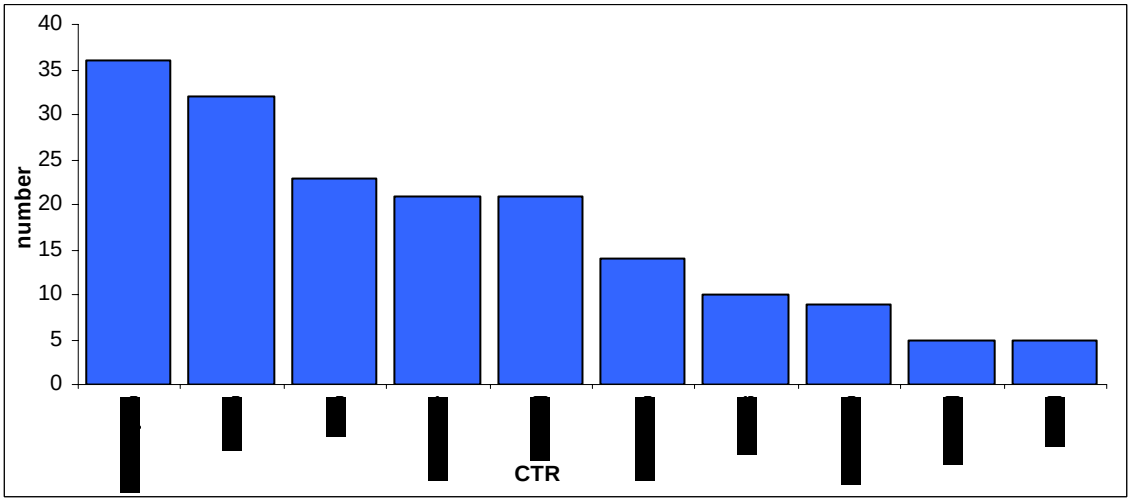

Figure 16: Ten Most Infringed Control Zones – Jan to Jul 2007

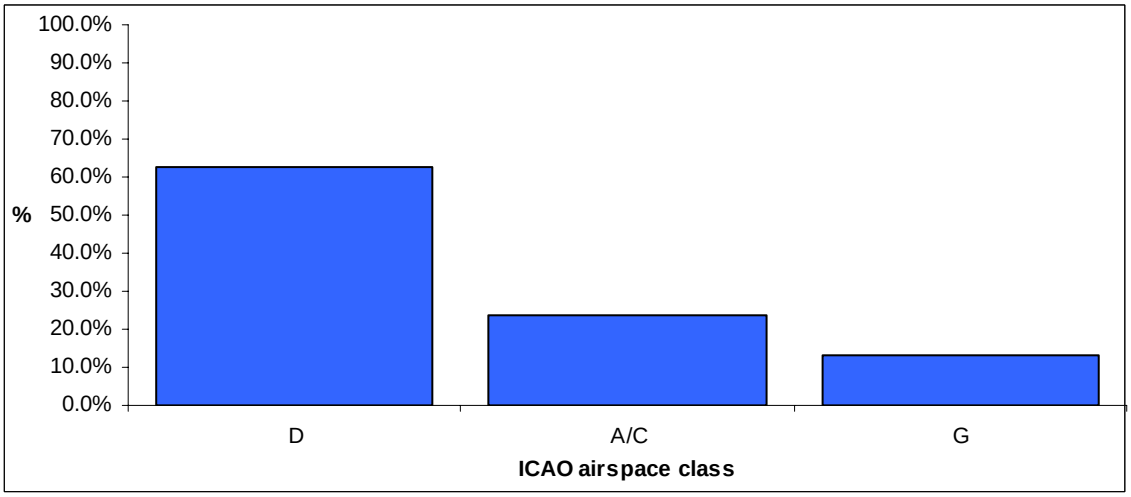

Figure 17: Most Infringed Airspace Classification – Jan to Jul 2007

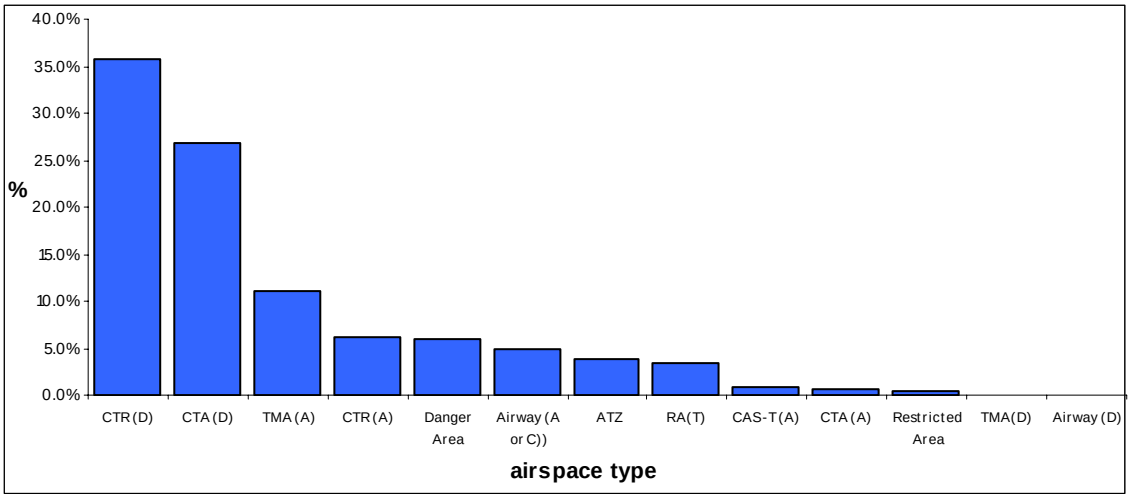

Figure 18: Most Infringed Airspace Types – Jan to Jul 2007

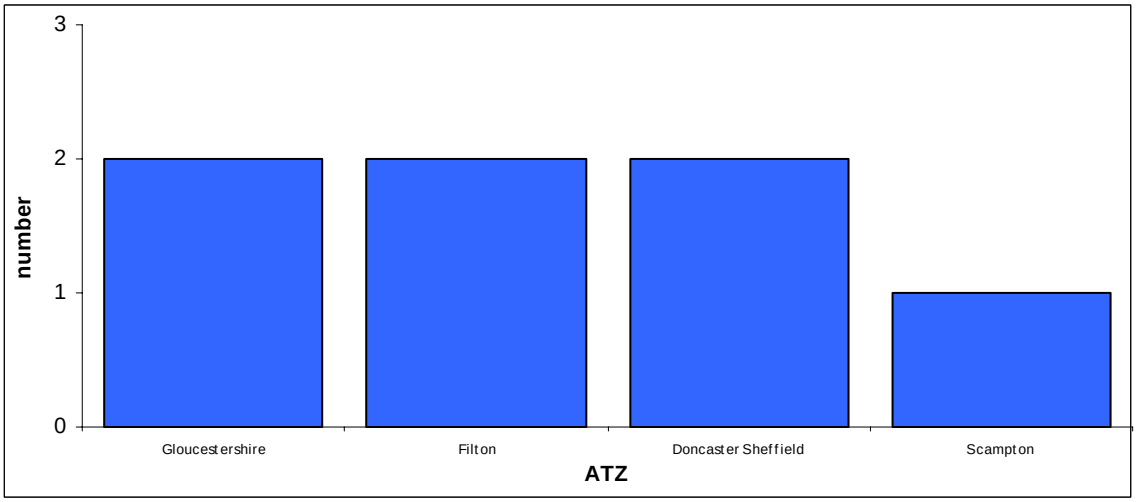

Figure 19: Most Infringed Aerodrome Traffic Zones – Jan to Jul 2007

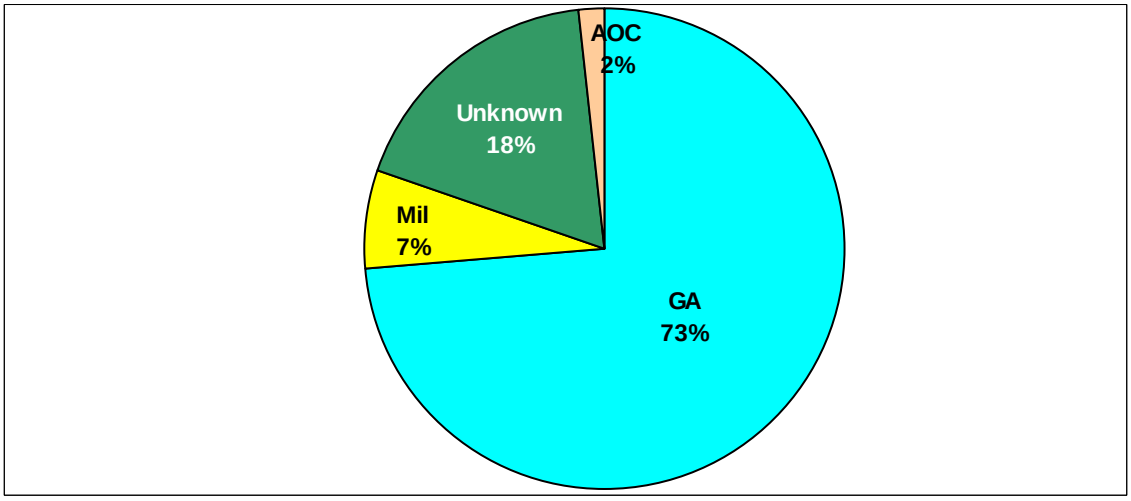

Figure 20: Infringements by Airspace User Group – Jan to Jul 2007

Annex I: Sectors and Groups Affected

The following groups and sectors would be affected by some or all of the proposed options:

a. **Commercial Air Transport**. Commercial air transport operators not already equipped with Mode S to meet the existing requirements would be affected. However, any adverse impact on this sector is expected to be minimal due to the introduction of Mode S into major en-route and terminal airspace on 31 March 2005, which will have already required many operators to equip their aircraft to continue to access the Mode S airspace in the UK and rest of Europe. This sector would be adversely impacted under Option 1 if the current conventional SSR system became a limiting factor for continued traffic growth in UK airspace. This sector includes the following:

   (1) Airlines;

   (2) Freight carriers.

b. **Small Aviation Businesses**. Small businesses that use aircraft, but which are not commercial air transport operators, are hard to define. However, small businesses including the following could be affected:

   (1) Aerial work companies;

   (2) Flying clubs, including gliding clubs;

   (3) Flying training schools;

   (4) Air taxi and air ambulance companies;

   (5) Air sport associations.

c. **Private Pilots**. Private pilots and aircraft owners, particularly those from the sporting and recreational sector, form the main group that would be affected by these proposals from the need to upgrade existing equipment or install an SSR transponder for the first time. Those who choose not to equip to meet the requirements of the proposals may encounter a reduced ability to access airspace or routes of their choice.

d. **General Aviation User Groups**. There are many individual user groups and representative associations in the General Aviation community, some of which are currently responsible for regulating particular activities on behalf of the CAA. These user groups could include:. Aircraft Owners and Pilots Association; British Balloon and Airship Club; British Gliding Association; British Hang Gliding and Paragliding Association; British Microlight Aircraft Association; British Parachuting Association; and Light Aircraft AssociationThe proposed options could affect user groups, particularly if increased equipage costs mean that their memberships decrease significantly.

e. **Aircraft and Avionics Manufacturers and Suppliers**. Aircraft manufacturers and suppliers would need to ensure that new aircraft are suitably equipped and avionics companies would need to ensure an adequate supply of compliant Mode S transponders is available to meet demand.

f. **Aircraft Maintenance Organisations**. These organisations would be responsible for installing Mode S transponders into aircraft and for the periodic maintenance checking of transponders in accordance with certification requirements. In particular, European Aviation Safety Agency (EASA) Part 145 Maintenance Organisations.

g. **Airworthiness Certification Authorities and Organisations**. EASA and the CAA's Safety Regulation Group would be affected in terms of establishing, approving, monitoring and enforcing the certification of Mode S transponder installations in the affected aircraft. Furthermore, EASA Part 21 Design Organisations would need to approve design data for 'minor' modifications for some transponder installations.

h. **Aviation Goods and Equipment Suppliers**. There is a considerable supporting industry to the General Aviation community in terms of goods and equipment for aircraft, pilots and enthusiasts. If the number of pilots in the General Aviation community decreased significantly as a result of the costs of any of the options, this sector would be adversely affected. However, the options also provide an opportunity to supply additional equipment required by the proposed regulation.

i. **State Aircraft Operators**. The Ministry of Defence and other operators of 'State Aircraft', from European Union (EU) and non-EU member States, would need to ensure that their aircraft are suitably equipped with Mode S.

j. **Search and Rescue (SAR)**. SAR agencies and the emergency services would need to ensure that their aircraft are suitably equipped with Mode S for access to any new mandatory transponder carriage airspace.

k. **Air Navigation Service Providers (ANSPs)**. Air traffic agencies, such as NATS and military ATC authorities, would need to ensure that their systems had adequate capabilities and facilities to use the Mode S data provided by transponder equipped aircraft. Furthermore, controllers would need to be adequately trained and associated procedures created. Under Option 1, those ANSPs that are equipped with Mode S systems would continue to be adversely affected by the lack of available Mode S data from some aircraft transponders.

l. **Aerodrome Operators**. Airport and independent airfield operators could be adversely affected if the amount of General Aviation activity was to reduce significantly as a result of increased costs. Private landowners, including farmers, also derive income from General Aviation activity; therefore, they could also be adversely affected by the proposals.

m. **Civil Aviation Authority**. The CAA would be responsible for implementing, monitoring and enforcing any new regulations. It would also have to ensure that any exemption arrangements were adequately resourced.

o. **Government Departments**. The Department for Transport would be affected by these proposals, as it has a remit to enforce the requirement for operators of foreign registered public transport aircraft to be suitably equipped before being allowed to fly in UK airspace. It also has a remit to issue permits for foreign registered aircraft conducting aerial work under ANO 2005 Article 140.

p. **Vintage Aircraft Restorers**. Restorers of vintage aircraft would be affected by the need to incorporate Mode S transponders into some vintage aircraft. Moreover, a downturn in business opportunities for restorers may occur if the requirements were to reduce the number of vintage aircraft being operated.

q. **Visiting Aircraft Operators**. Overseas pilots would need to ensure that their aircraft were suitably Mode S equipped to operate in the UK airspace where transponders are required. Pilots from France, Germany, The Netherlands, Belgium, Luxembourg and Switzerland are likely to be unaffected, as these States are introducing similar proposals in their own national airspace.

r. **Charities**. Feedback from consultation indicated that there are charities supported by, and operating within, the General Aviation community that provide flying experiences for disabled and disadvantaged groups. Any new costs of compliance could affect the viability of these charities.

s. **Tourism Industry**. The tourist industry would be affected by continued access to affordable commercial air transport and all options could impact on this sector. Moreover, General Aviation activity provides support and an income stream for the tourism sector, which would be adversely affected if General Aviation activity was reduced significantly.

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Annex J: Proposed Transition and Exemption Arrangements

1. Circumstances where SSR transponders are <u>mandatory</u> after 31 March 2009:

- **Aircraft equipped with a Mode A/C transponder prior to 31 March 2009**. Mode A/C transponders fitted prior to 31 March 2009 to aircraft affected by these proposals would need to be upgraded to Mode S compliant transponders by 31 March 2012 to operate in circumstances where transponders are mandatory. However, an exemption to continue to use a Mode A/C transponder between 31 March 2009 and 31 March 2012 would need to be obtained from the CAA using the promulgated registration process. This process would be free of charge and could be completed quickly via the CAA website.
- **Aircraft registered after 31 March 2009**. Transponders fitted to aircraft registered after 31 March 2009 that would be affected by these proposals would need to be Mode S compliant to operate in circumstances where transponders are mandatory. No exemptions to this requirement would be granted except as follows:
  - Operators of 'self-build' aircraft that would operate under a 'Permit to Fly' may apply for an exemption to operate a Mode A/C transponder until 31 March 2012 if the construction of the aircraft commenced, and the transponder equipment was purchased, prior to 31 March 2009. The CAA would consider requests on a case-by-case basis and applications would need to be supported by appropriate documentary evidence. There would be no charge for this type of exemption.
- **Any exemptions granted will <u>only</u> be valid until 31 March 2012**.
- **Exempted aircraft**. Mode A/C transponder equipped aircraft that have been granted an exemption may continue to use Mode A/C transponders until 31 March 2012, even if the transponders are temporarily replaced during this period. However, continued use of Mode A/C after 31 March 2012 would **<u>not</u>** be permitted.
- **Airspace access for non-transponder equipped aircraft**. The rules for gaining access to airspace where transponders are mandatory by aircraft that are not equipped with any form of transponder would remain the same as applied today. The rules and procedures are set out in Aeronautical Information Publication (AIP) General Section (GEN) 1.5.3. Exemptions from transponder carriage would not normally be issued, but applications for exceptional circumstances may be submitted to the CAA for consideration. Short notice permission for entry to applicable airspace may also be requested from appropriate ATC units, but entry cannot be guaranteed and it is likely that access will become increasingly more difficult for non-equipped aircraft as commercial traffic levels rise. Appropriate Letters of Agreement with responsible ATC units can also be negotiated by organisations, associations and operators to accommodate routine non-transponder equipped operations in applicable airspace. These are generally valid for finite time periods to allow for a regular review of the agreements to take account of any changing circumstances.

2. Circumstances where transponders are <u>not mandatory</u> after 31 March 2009:

- Operators may still continue to choose whether to install Mode S, Mode A/C or no transponder at all on aircraft that would **<u>not</u>** operate in circumstances where transponders are mandatory after 31 March 2009.

- No exemptions would need to be requested from the CAA if access to mandatory transponder carriage airspace was not required.
- However, the CAA strongly recommends that Mode S transponders are installed and that any voluntary carriage of Mode A/C is upgraded as early as possible.
- **It should be noted that the CAA may, at any time, review the situation regarding the continued use of Mode A/C transponders after 31 March 2012**. Permission for continued use of Mode A/C transponders may have to be withdrawn to ensure that interference levels in the SSR spectrum are tolerable and that the continued voluntary use of Mode A/C transponders is not compromising overall SSR performance levels in UK airspace and the performance of safety systems.

Annex K: Draft Air Navigation Order Amendments for Proposed Options 1, 3 and 4

SCHEDULE 5 **Article 20(2)**

Radio communication and radio navigation equipment to be carried in aircraft

1 Subject to paragraph 3, every aircraft shall be provided, when flying in the circumstances specified in the first column of the Table in paragraph 2 of this Schedule, with the scales of equipment respectively indicated in the second column of that Table; provided that, if the aircraft is flying in a combination of such circumstances the scales of equipment shall not on that account be required to be duplicated.

2 Table

	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**J**
(1) All aircraft (other than gliders) within the United Kingdom:									
(a) when flying under Instrument Flight Rules within controlled airspace	A					F			
(b) when flying within controlled airspace	A				E2				
(c) when making an approach to landing at an aerodrome notified for the purpose of this sub-paragraph							G		
(1A) All aircraft (other than gliders and balloons) within the United Kingdom when flying for the purpose of public transport					E2				
(2) All aircraft (other than gliders) within the United Kingdom:									
(a) when flying at or above flight level 195	A								
(b) when flying within airspace notified for the purposes of this sub-paragraph	A								
(2A) All gliders unless otherwise authorised or flying within airspace notified as TRA(G):									
(a) when flying at or above flight level 100					E2				

	A	B	C	D	E	F	G	H	J
(b) when flying below flight level 100 in controlled airspace					E2				
(c) when flying within airspace notified for the purposes of this sub-paragraph					E2				
(3) All aircraft (other than gliders) within the United Kingdom:									
(a) when flying at or above flight level 245					E2	F			
(b) when flying within airspace notified for the purposes of this sub-paragraph					E2				
(c) when flying at or above flight level 100					E2				
(4) When flying under Instrument Flight Rules within airspace notified for the purposes of this paragraph:									
(a) all aeroplanes having a maximum take-off weight authorised not exceeding 5700kg and a maximum cruising true airspeed capability not exceeding 250 knots					E2				
(b) all rotorcraft					E2				
(c) All aeroplanes having either a maximum take-off weight authorised of more than 5700kg or a maximum cruising true airspeed capability of more than 250 knots					E3				
(4A) All aircraft required to carry scale E2 or E3					EE				
(5) All aircraft registered in the United Kingdom, wherever they may be:									
(a) when flying for the purpose of public transport									

	A	B	C	D	E	F	G	H	J
under Instrument Flight Rules:									
(i) while making an approach to landing	A		C	D				H	
(ii) on all other occasions	A		C					H	
(c) multi-engined aircraft when flying for the purpose of public transport under Visual Flight Rules	A							H	
(d) single-engined aircraft when flying for the purpose of public transport under Visual Flight Rules:									
(i) over a route on which navigation is effected solely by visual reference to landmarks	A								
(ii) on all other occasions	A	B							
(e) when flying under Instrument Flight Rules within controlled airspace and not required to comply with paragraph (5)(a) above	A								
(5A) All aircraft (except gliders and balloons) registered in the United Kingdom, wherever they may be when flying for the purpose of public transport					E2				
(6) All aeroplanes registered in the United Kingdom, wherever they may be, and all aeroplanes wherever registered when flying in the United Kingdom, powered by one or more turbine jets or turbine propeller engines and either having a maximum take-off weight exceeding 15,000 kg or with a maximum approved passenger seating configuration of more than 30									J
(7) All aeroplanes powered by one or more turbine jets or turbine propeller engines and either having a maximum take-off weight exceeding									

	A	B	C	D	E	F	G	H	J
5700kg or a maximum approved passenger seating configuration of more than 19, and:									
(a) registered in the United Kingdom and flying for the purposes of public transport;									J
(b) registered in the United Kingdom and flying within the airspace of member states of the European Civil Aviation Conference; or									J
(c) flying in the United Kingdom									J
(7A) Any aeroplane or helicopter on a flight which is international air navigation[13]					E2				

3 (1) In the case of sub-paragraphs (1), (2), (3), (4)(a), (4)(c) and (5)(e) of paragraph 2, the specified equipment need not be carried if:

(a) the appropriate air traffic control unit otherwise permits in relation to the particular flight and the aircraft complies with any instructions which the air traffic control unit may give in the particular case; or

(b) the aircraft flies in accordance with a general permission given by the appropriate air traffic control unit and the aircraft complies with any instructions which the air traffic control unit may give in relation to the particular flight.

(2) An aircraft which is not a public transport aircraft and which is flying in Class D or Class E airspace shall not be required to be provided with distance measuring equipment in accordance with paragraph (b) of Scale F when flying in the circumstances specified in sub-paragraph (1)(a) of paragraph 2.

4 The scales of radio and radio navigation equipment indicated in the foregoing Table shall be as follows:

Scale E2

Secondary surveillance radar equipment which includes a pressure altitude reporting transponder capable of operating in Mode A and Mode C and has the capability and functionality prescribed for Mode S Elementary Surveillance and is capable of being operated in accordance with such instructions as may be given to the aircraft by the air traffic control unit.[14]

Scale E3

Secondary surveillance radar equipment which includes a pressure altitude reporting transponder capable of operating in Mode A and Mode C and has the capability and functionality prescribed for Mode S Enhanced Surveillance and is capable of being operated in accordance with such instructions as may be given to the aircraft by the air traffic control unit.

[13] Defined at Schedule 10 of the ANO

[14] This does not require that aircraft are also equipped with a radio outside of the relevant radio carriage requirements that are listed elsewhere in Schedule 5.

Scale EE

The aircraft shall, in the circumstances specified in paragraph 2.1.5.3 of Volume IV (Third Edition July 2002) of Annex 10 to the Chicago Convention, comply with the requirements for antenna diversity set out in that paragraph.

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Annex L: Code of Practice on Consultation

1. The Government has adopted a 'code of practice' on consultations. The code of practice applies to all UK public consultations by Government departments and agencies, including consultations on EU directives. Although 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.

2. 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. In this instance as a Non Departmental Public Body, the CAA has not appointed an overall consultation coordinator (Criterion 5).

3. A full version of the code of practice is available on the Cabinet Office web-site at:

   http://www.cabinetoffice.gov.uk/regulation/documents/consultation/pdf/code.pdf

4. **Criterion 1: Consult widely throughout the process, allowing a minimum of 12 weeks for written consultation at least once during the development of the policy**.

   In 2006, the CAA conducted a 12-week written public consultation on its interoperability proposals, which resulted in over 3,100 responses being received from interested parties. Throughout 2007, personnel from the CAA's Directorate of Airspace Policy (DAP) held a series of meetings and Impact Assessment (IA) workshops with the main General Aviation representative associations, ATC providers and the Ministry of Defence. These meetings discussed the overall regulatory approach and the specific proposals contained within this consultation document and associated IAs. This consultation document and the IAs have been produced to support a further 16-week written public consultation to elicit information and comments on four specific policy options. Relevant publicity material has been posted on the CAA's website throughout 2007 and regional presentations to stakeholders during the public consultation will be conducted, on request, subject to resource availability.

5. **Criterion 2: Be clear about what your proposals are, who may be affected, what questions are being asked and the timescale for responses**.

   Four policy options are being proposed for comment in the public written consultation and these are set out in Section 14 of the main body of this consultation document. The stakeholders that the CAA believes may be affected by the proposals are set out in Annex I to the consultation document. Specific questions are being asked and these are listed at the end of each proposed option in Section 14 and then repeated in the 'Evidence Base' of the associated IA for each of the options. For ease of reference, the consolidated list of questions is set out below. ***Responses to the proposals must be submitted to the CAA by 1700 hours on 31 May 2008.***

   Q1: What other advantages and disadvantages could there be under Option 1 if all aircraft operating within controlled airspace used SSR?

   Q2: Has the cost impact of Option 1 been accurately estimated? [When considering your response, please provide supporting data where available.]

Q3: What would be the impact of Option 1 on small businesses? [When considering your response, please provide supporting data where available.]

Q4: What other issues should be taken into account within a mechanism to process and consider applications for TMZs?

Q5: What could be the cost to businesses and General Aviation representative associations of participating in a process for considering the establishment of a TMZ? [When considering your response, please provide supporting data where available.]

Q6: What other advantages and disadvantages could arise if gliders were brought within the SSR transponder carriage regulations?

Q7: Has the cost impact of Option 3 been accurately estimated? [When considering your response, please provide supporting data where available.]

Q8: What would be the impact of Option 3 on small businesses? [When considering your response, please provide supporting data where available.]

Q9: Would the cost impact of Option 4 fall within the estimates for Option 1?

Q10: Has the number of UK aircraft affected by Option 4 been accurately estimated? [When considering your response, please provide supporting data where available.]

Q11: What other issues should be taken into account by the CAA when considering whether or not to continue to notify a 'Difference' with the ICAO Annex 6 international obligations?

Q12: What would be the impact of maintaining the current status quo on your main activity?

6. **Criterion 3: Ensure that your consultation is clear, concise and widely accessible**.

The CAA recognises that the subject matter and rationale for these proposals is technically complex and involved. As far as practicable, the consultation material has been kept as short as possible and uses a minimum of jargon and abbreviations. Prior to the public written consultation, the consultation document and associated annexes were submitted to representatives of the main General Stakeholder associations for feedback on clarity and readability. Wherever possible, any relevant comments received from representatives of these associations have been incorporated into the material. Also, the consultation pack provides a point of contact by which consultees can seek further clarification of specific issues. The consultation document and IAs will be published on the CAA website and issued to all members of the main DAP consultation mechanism: the National Air Traffic Management Advisory Committee (NATMAC). A press release will also be issued to promulgate the consultation.

7. **Criterion 4: Give feedback regarding the responses received and how the consultation process influenced the policy**.

Following the 2006 consultation, 'Summary of Responses' and 'Response to Consultees' documents were published. A summary of the consultation and how it influenced the proposed policy was set out in a Full Regulatory Impact Assessment that supported the resultant recommendations to Government. This was published in 2007. Sections 2 and 13 in the main body of this consultation document also set out how the 2006 consultation influenced the overall policy and helped shape the four

specific options now being proposed. At the end of the 16-week written public consultation, another 'Summary of Responses' document will be published and further meetings with the main stakeholder groups are envisaged to discuss the issued raised.

8. **Criterion 5: Monitor your department's effectiveness at consultation, including through the use of a designated consultation co-ordinator**.

CAA DAP consultations are conducted and monitored through the aforementioned NATMAC processes. DAP staff drafting IAs also maintain close liaison with the Department for Transport Better Regulation Unit. The NATMAC Secretary is the overall focal point for DAP consultations but if you consider that this consultation does not comply with the criteria or have comments about the consultation process please contact:

Mr Andy Knill
Head of Surveillance & Spectrum Management
Directorate of Airspace Policy
CAA House K6 G6
45-59 Kingsway
London
WC2B 6TE

9. **Criterion 6: Ensure your consultation follows better regulation best practice, including carrying out a Regulatory Impact Assessment if appropriate**.

The CAA, as a Non-Departmental Public Body (NDPB), regulates in compliance with a statutory responsibility. NDPBs are encouraged by the Government to complete IAs that are adapted to the circumstances, as appropriate, using professional judgement. As CAA proposed regulations are mainly safety driven, there are limits to the extent that generalised cost benefit analysis can be applied when constructing IAs. However, an IA has been drafted for each of the proposed policy options contained in this consultation document; and these have been attached to form part of the consultation material. Estimated costs of compliance with the proposals have been monetised as far as practicable and the spirit of the IA process has been followed.