International Civil Aviation Organization

Automatic Dependent Surveillance – Broadcast (ADS-B)
Study and Implementation Task Force

Brisbane, Australia, 24-26 March 2003

Agenda Item 3: Evaluate information available on the selection of link technology as the preferred technology for Asia/Pacific Region

AVAILABILITY OF MODE S BASED ADS-B AVIONICS

SUMMARY

This paper catalogues available Mode S extended squitter avionics products from a number of vendors

(Presented by Australia)

1 Introduction

1.1 Airservices Australia contracted Andrew Rose from Llanbury Consulting (UK) to catalogue the avionics that are available from each avionics vendor. Andrew now works part-time for the British Airways Air Safety department and part time runs Llanbury Consulting, which specialises in all areas of transportation surveillance and communications. Whilst full time in the Standards Department Andrew held UK CAA delegated Design Authority for the approval of aircraft modifications and for a number of years chaired the Airlines Electronic Engineering Committee Airborne Separation Assurance Systems Subcommittee which developed equipment characteristics for ACAS and Enhanced Mode S Transponders. He also represented the Airline at a wide range of technical and policy forums both within Europe and the USA and was responsible for a number of major studies and investigations for both the Airline and other organisations. The report produced by Llandbury Consulting is made available to the ADS-B Task Force and is attached to this paper.

2 Report conclusion

2.1 The report concludes that

"*Honeywell, ACSS, Rockwell Collins and UPS Aviation Technology have certified Extended Squitter capable Mode S transponders. By early 2003 there should be at least seven different transponder product lines that are capable of Extended Squitter transmission. Many existing Mode S transponders can be upgraded by Service Bulletin to include Extended Squitter and in the case of the ACSS product this can be done via a software load on the aircraft (note that the addition of wiring of data sources to the transponder is also required to activate Extended Squitter).*"

Recommendations

3.1 The meeting note the availability of ADS-B avionics using Mode S 1090 Mhz.

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1090MHz ADS-B Avionics and Avionics Manufacturers' plans

Produced by Andrew Rose, Llanbury Consulting
under contract to Airservices Australia

March 2003 Issue 3 (draft A)

1 Executive Summary

Airservices Australia is undertaking an operational trial of ADS-B in Queensland, based on 1090MHz Extended Squitter. Part of this programme involves equipping a number of aircraft with 1090MHz Extended Squitter transmitters to allow them to participate in the trial.
The objective of this study is to catalogue available ADS-B avionics and outline the avionics manufacturers plans in this area. This will enable Airservices Australia to encourage more aircraft to participate in the trials and also to assess the impact of wider implementation.
The most likely means for the broadcast of Extended Squitter is via a Mode S transponder and therefore all the transponder manufacturers have been contacted to give an input into this study. All of the major manufacturers have already certified Extended Squitter capable transponders for the Air Transport and/or GA/Business market. By the end of 2002 there were five different transponder products certified which include extended squitter and by mid 2003 there will likely be eight products from various manufacturers. In addition to new transponders, most of the manufacturers are developing modification paths for existing transponders that are in wide use today.

The major airframe manufacturers are developing certified modifications to meet the European Mode S requirements and as part of this effort are including ADS-B out (Extended Squitter) functionality. New build Airbus aircraft with extended squitter will be available, subject to customer request, by mid 2003 and service bulletins for aircraft retrofit modifications should follow in the third quarter of 2003. Boeing aircraft follow a similar schedule but about three months behind.

For the purposes of airborne 1090MHz reception, the main activities underway today by the manufacturers involve the use of existing Airborne Collision Avoidance System (ACAS) equipment to receive the squitters. One manufacturer already has products certified that allow Extended Squitter reception for the purposes of passive ACAS surveillance and another has products under development.
At present there is little availability of dedicated 1090MHz Extended Squitter receivers or the means with which to display ADS-B information for air-to-air applications, but there is keen interest within the GA/Business avionics manufacturers to develop products to support situational awareness.

2 Introduction

2.1 Background

Airservices Australia is undertaking an operational trial of ADS-B for ATC surveillance in Queensland. Initially the trial will comprise of a single 1090MHz ground station, connected to the operational air traffic management system, and a number of aircraft equipped with Extended Squitter broadcast capability.
To encourage more aircraft to participate in the trial and to consider the effects of wider implementation, Airservices Australia have commissioned this study to evaluate the availability of 1090MHz Extended Squitter capable avionics.

2.2 Purpose of this document

The purpose of this document is to catalogue available 1090MHz Extended Squitter Avionics both available now and under development by avionics manufacturers, including existing equipment that can be upgraded. It is also intended to bring together the best industry knowledge on the intentions and future plans of the Avionics manufacturers regards ADS-B avionics. The third issue of this document was expanded to include the availability of certified installations of Extended Squitter by the airframe manufacturers.
This document will then enable Airservices Australia and their customers to assess the availability of avionics to meet their operational objects and support the trial and also to help guide the future airborne implementation of ADS-B in Australia.

2.3 Scope of study

To gather together the information contained in this document, the following avionic equipment manufacturers were contacted: Rockwell Collins, Honeywell, ACSS, UPS Aviation Technologies, Garmin, Marconi Mobile, Becker Avionics, BF Goodrich Avionics, Walter Dittel, Ryan International and Thales Tracs.
For the update of the paper to issue 2 in March 2003, all the manufacturers who provided input to the first issue were contacted again. Responses were received from Honeywell, ACSS, UPS Aviation Technologies, Garmin, Becker Avionics and Goodrich Avionics.
For issue 3 of the document the following airframe manufacturers were approached for an input on their progress to Extended Squitter aircraft certification and Service Bulletin availability. Airframe manufacturers contacted were: Airbus, Boeing, ATR, Embraer, BAe Systems, Saab, Bombardier and Fokker (Stork Services).

3 Required components for airborne implementation of 1090MHz ADS-B

For the full airborne implementation, including air-to-air applications, of an ADS-B system there are four pieces of hardware required in the aircraft. For an aircraft to participate in an air to ground scenario, or to be tracked by another fully equipped aircraft, the minimum required is the ability to be able to squitter position information. To enable an aircraft to perform air to air type ADS-B activities the aircraft must also be equipped with the necessary avionics to receive and process the squitter information from other aircraft and also potentially equipment to display the information to the crew.

3.1 Squitter data sources

For an aircraft to be able to provide an ADS-B squitter it initially requires the necessary avionics to generate the data that is required in the squitter. As a minimum this would involve having a position data source on the aircraft that can be interfaced with the transmitting, and potentially the receiving, device. It is feasible that such a data source would be an existing navigation system on the aircraft or could be a self contained unit packaged with the ADS-B avionics.
This paper will focus on the means to transmit the ADS-B squitter rather than the data sources, but it will touch on the availability of integrated ADS-B data sources and the requirements surrounding other existing data sources on the aircraft.

3.2 ADS-B Squitter transmitter

Assuming a suitable data source is available on the aircraft, the minimum avionics required to participate in any sort of ADS-B activities is a device, connected to those sources, to squitter the ADS-B messages. In the case of the 1090MHz implementation of ADS-B, that device will most commonly be the ATC transponder that will likely already be fitted to the aircraft. All existing

Mode S transponders provide a short squitter and a modification to them to provide the Extended Squitter messages will allow the aircraft to be ADS-B capable.
The major transponder manufacturers have been working towards the implementation of Extended Squitter in their transponders, both existing and new production, and some units are already provided with such functionality.
An alternative implementation would be to provide a dedicated Extended Squitter device, which may be an option for an aircraft not already required to be equipped with an ATC transponder.
The availability and status of available transponders to meet the Extended Squitter requirements is given in appendix A.
Before a transponder manufacturer can develop and certify a unit capable of Extended Squitter a number of design and certification documents are useful to guide their development and enable certification of the units. The three key items required are:

3.2.1 Minimum Functional Standards

The minimum functional requirements that are necessary for certification and approval are needed by the manufacturers to ensure their equipment complies with the basic requirements and will be certifiable for aircraft use. These standards are developed by Eurocae and RTCA by way of MOPS (Minimum Operational Performance Standards):

EUROCAE Minimum Operational Performance Specification for Secondary Surveillance Radar Mode S Transponders, ED-73A, amendment 1, published March 1999.

RTCA Minimum Operational Performance Specification for Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment, RTCA DO-181C, published June 2001.

Both of these MOPS include Extended Squitter functionality and therefore provide guidance for the manufacturers to design and certify transponders including this functionality.

3.2.2 Equipment characteristics

Equipment characteristics determine the form and fit of the unit for its application in aircraft. Such characteristics also define the functionality of the unit in relation to its installation in the aircraft, where as the MOPS define its required functional characteristics beyond the aircraft. The AEEC (Airlines Electronic Engineering Committee) forms sub committees to generate these specifications, which are known as 'ARINC Characteristics'.

These characteristics are primarily used in the Air Transport market where airlines and airframe manufacturers seek to use standardised and interchangeable equipment on their aircraft. In the regional, business and general aviation community there is less emphasis on standardisation of form and fit for equipment and in these cases different standards may be used for each manufacturer and aircraft type.

ARINC Characteristic 718A Mark 4 Air Traffic Control Transponder (ATCRBS/Mode S), adopted by AEEC in December 2001. This characteristic includes the interfaces required for Mode S Elementary Surveillance, Enhanced Surveillance and Extended Squitter.

This characteristic provides design guidance to the transponder manufacturers to design transponders with the required interfaces and to an interchangeable standard. These are primarily of benefit to the air transport transponder manufacturers, but will also be of value to GA/Business transponder manufacturers.

3.2.3 Equipment Approval

The JAA have published JTSO C112a, Minimum Operational Performance Specification for SSR Mode S Transponders, which adopts ED-73A. This provides a JTSO standard against which Mode S transponders can be certified to comply fully with the European Elementary Surveillance requirements.

Before equipment is allowed to be manufactured for fit on an aircraft it is required to be certified to a TSO and for the TSO marking to go on every unit. This European JTSO is based on ED-73A which includes Extended Squitter, so allows a manufacturer to certify a unit containing Extended Squitter functionality.

The FAA TSO for Mode S transponders TSO C112A was published in 1986 and is based on RTCA DO-181 MOPS, therefore does not include Extended Squitter functionality.

3.3 ADS-B Squitter reception

To participate in air to air type ADS-B applications an aircraft needs to be capable of receiving and processing Extended Squitters transmitted by other aircraft, or vehicles. All Airborne Collision Avoidance System (ACAS)/Traffic Alert and Collision Avoidance System (TCAS) equipped aircraft have an existing 1090MHz receiver as part of that ACAS installation which could be used to receive the Extended Squitter broadcasts. Where ACAS is not available or a different solution is preferred, then a dedicated 1090MHz receiver could be used.
A number of ACAS manufacturers have worked on the ability of the ACAS to receive Extended Squitters and some units are, or will shortly be, available with such functionality included. In initial implementations the ACAS only tracks the Extended Squitter equipped aircraft and then treats the track generated as an ACAS track so that it can be displayed on an existing ACAS traffic display. This provides increased situational awareness, primarily in range, to the crew, but doesn't as yet allow identification or use of any other ADS-B information that may be available. The primary limitation on further use of the ADS-B data is the availability of a system to accept it from the ACAS or a system with which to display it.
The availability of dedicated devices to receive Extended Squitter broadcasts is more limited than the ACAS case. Some equipment has been developed for trials activities and further work is on-going at the manufacturers. There is however significant interest in the business/GA sector where manufacturers of existing traffic situational awareness systems are looking to further develop these systems to include the passive reception of extended squitter.
The availability of Extended Squitter receivers is outlined in appendix B.
Similarly to the transponder case the manufacturers need a number of documents to enable then to develop and certify Extended Squitter receivers. At the present time only design and certification guidance documents for ACAS units that include Extended Squitter reception are available as follows:

3.3.1 Minimum Functional Standards

RTCA Minimum Operational Performance Standards for Traffic Alert and Collision Avoidance System (TCAS) Airborne Element, RTCA DO-185A.

These MOPS include the ability of the TCAS to receive Extended Squitter and to process the Extended Squitter tracks as passively tracked TCAS intruders, this is commonly known as hybrid surveillance. Other than passive surveillance these MOPS do not cover any other ADS-B applications and additional ADS-B MOPS are being developed by RTCA.

3.3.2 Equipment characteristics

ARINC Characteristic 735A Mark 2 Traffic Alert and Collision Avoidance System (TCAS), adopted by AEEC in December 1997. This characteristic includes the interfaces required for Extended Squitter reception and also contains protocols for the transmission of ADS-B information to a suitable display system.

3.3.3 Equipment Approval

The FAA TSO for TCAS TSO C119b is based on RTCA DO-185A MOPS. Therefore this standard includes the ability of the TCAS to receive Extended Squitter information.

3.4 ADS-B Display equipment

The final piece of equipment to consider in an air-to-air ADS-B type environment is a display to provide the ADS-B information from other aircraft to the flight crew, as a minimum, for situational awareness. This is the area where probably least activity has been undertaken by the industry, particularly in the air transport area where only some equipment development has been done to support trials activities with limited certified equipment. In the business and GA sector there has been a greater level of interest by existing manufacturers of traffic situational awareness tools and the planned development of these is detailed in appendix C.
In the case where ACAS is used as the Extended Squitter receiver, the ADS-B information could be passed on to the existing ACAS display if it had been designed or modified to accept and display it. Alternatively, and where a dedicated Extended Squitter receiver is used, a dedicated ADS-B type traffic display could be used and apart from display of the information, it could also contain functions to allow air-to-air ADS-B applications to be performed. These functions may be specific display requirements regarding certain tracks, or the ability of the crew to interact with the display and select certain aircraft with which to carry out a specific ADS-B application. Aircraft display equipment is usually an aircraft type certificated component and therefore the normal regulatory guidelines and approvals are not generally developed. Where dedicated equipment is used, some standards may be developed but little work has been undertaken in this area yet. One of the key areas that needs to be addressed is the need of the ADS-B traffic display to be in the pilots direct field of vision or whether, for most applications, a remotely mounted or side display is satisfactory.

4 Equipment availability timescales

Section 3 outlines the key components needed for an ADS-B system and its associated appendices address the availability and manufacturer plans for such equipment. To determine the fuller timescales for equipment availability consideration needs to be given to the other constraints that apply to both the design and implementation phases.

4.1 Additional Industry requirements

The requirements for Mode S Extended Squitter are not the only development and modifications being considered for Mode S transponders at the present time. For various regions of the world there are a number of additional transponder requirements that have to be addressed and will effect the initial and long term availability of Extended Squitter capable transponders.

4.1.1 Mode S Elementary Surveillance

In Europe there are published requirements for the implementation of Mode S Elementary Surveillance, of which the most significant part is the ability of the transponder and aircraft to down link the Flight Identity (ATC Call sign) of the flight. The published mandatory end dates for these requirements are the 31st March 2003, but it is widely acknowledged that a transition period will be required until the beginning of 2005 to allow aircraft to comply. These requirements will mean that almost all the Mode S transponders fitted to aircraft operating in Europe will require modification, either in the workshop or via an on-board software load.

From a transponder manufacturer design perspective the design work for these requirements is complete and existing transponders meet the requirements, therefore this should not impact the development of Extended Squitter capable transponders. However the modification requirements are such that vendor capacity to modify existing transponders will be limited up to 2005 and beyond.

The positive aspect of this programme is that some transponder manufacturers are trying to minimise the number of modifications developed for the Mode S transponder and are therefore trying to include functionality for Enhanced Surveillance and Extended Squitter in the baseline units developed for the Elementary Surveillance requirements. This will mean that many transponders modified for Elementary Surveillance will be Extended Squitter capable and that the required modifications and units will have been approved and certified, all be it not specifically referencing Extended Squitter.

4.1.2 Mode S Enhanced Surveillance

Additional requirements are being considered in Europe for the Mode S transponder to downlink some aircraft data to ATC. These requirements are not firm or fixed as yet but are being developed by a number of Air Traffic Service Providers in core Europe. This functionality will require the transponder to interface with a number of data sources on the aircraft and make specific data available on request from the ground. Those data sources will likely be the same or similar as those required to provide Extended Squitter.

As discussed in 1.4.1.1, the transponder manufacturers are trying to roll these changes into one and therefore transponders that include the Enhanced Surveillance functionality will likely include Extended Squitter either in their base line or via a software upgrade. Where such units have been installed on aircraft and wired for Enhanced Surveillance then the activation of a basic Extended Squitter would be a simple exercise. These requirements therefore likely help to accelerate the availability of Extended Squitter transmission on a wide range of aircraft operating through Europe.

4.1.3 Transponder Security functionality

Following the terrorist attacks in the United States in September 2001, the US authorities have introduced requirements for the ATC transponder to be secure such that it cannot be de-selected in the event of a hi-jack. The necessary changes to MOPS and equipment characteristics are being developed but are not, as yet, finalised. Until these requirements are fixed, this programme is likely to impact Extended Squitter transponder development and availability. A Notice of Proposed Rule Making has been issued for comment and at present only applies to US operators.

4.2 Production and Modification capacity

Once transponder designs are complete and new equipment and modifications available, the constraints on the availability of transponders is driven by the production capacity and modification capacity of the manufacturers and other overhaul workshops. Where equipment can be modified on the aircraft with an on-board software load the timescale is driven by the maintenance organisation. Where a unit has to be removed from the aircraft, there is a significant time overhead in the removal and routing to workshops as well as the limitations of capacity in the workshops to modify units.

5 Airframe modification certification

Once certified Extended Squitter capable transponders are available, they then need to be installed, connected to appropriate data sources and certified on different aircraft types. There are a number that this will be achieved:

5.1 Type certification for production aircraft

Where aircraft types are still in production and being delivered, the certification of an modification or additional function would usually be done by the airframe manufacturer on a new aircraft. The modification would be included into the build standard of the aircraft (either as standard or as a customer selected option) and the first aircraft off the line with it embodied would be certified. Such a certification leads to a type certificate for the modification and can be applied to future production aircraft and existing delivered aircraft. The type certification would, depending upon the modification, need to be repeated for each different vendors equipment and configuration.

In the case of Extended Squitter the modification would involve wiring from aircraft data sources to the transponder, which would be common for all transponder manufacturers, and then certification of each of the transponder types offered to the customer (For Airbus and Boeing aircraft that would usually be three types).

Once type certificated the modification and transponder could then be offered on all future aircraft deliveries.

5.2 Airframe manufacturer service bulletin

Once the modification and transponder has been type certificated the airframe manufacturer can then develop service bulletins for their retrofit on existing aircraft that have already been delivered. These service bulletins would include the required wiring modifications and installation of the appropriately modified transponders. The service bulletin would then be approved by the regulatory authority of the state of manufacture and that approval would then be accepted by the state of operation of the aircraft as acceptable certification. The transponder fitted may also need state approval before final certification.

Although once the type certificate has been obtained a service bulletin could be developed for all aircraft, the airframe manufacturer will not usually do so until requested by each individual aircraft operator. Once an order has been received the airframe manufacturer will raise the service bulletin to include that operators aircraft.

For the retrofit of existing aircraft that are still in production, the service bulletin path is becoming the preferred method for most operators. The reason for this is it maintains a globally recognised certification standard on the aircraft and it minimises the need for in-house design and certification effort. The drawbacks of the approach are usually cost and timescales.

5.3 Supplemental Type Certificates / locally approved modifications

Where a service bulletin is not available or the operator elects not to use that route, an alternative means is to use a locally approved modification to install the wiring and modified transponders. The airframe manufacturers often choose not to develop service bulletins for aircraft types that are out of production or where there is not a great demand for service bulletins. An operator may elect to use this route where the locally approved modification is offered as part of a deal with the transponder supplier or can be developed for significantly low costs than the service bulletin.
In this route the modification is developed by a locally approved design organisation, which may be the operators own design organisation or a third party, and that modification is then submitted for approval by the local regulatory authority. In the USA, and increasingly in Europe, that local approval is known as a Supplemental Type Certificate (STC). An STC from the USA will often be recognised in another country but is usually required to be submitted by a locally approved design organisation.
The availability of local designs and STCs is entirely demand driven. Like a service bulletin, even once it has been developed for an aircraft type, the modification has to be raised for each individual group of aircraft to take into account specific differences.

6 Conclusion

The modification of existing Mode S transponders is the simplest path to implementing Extended Squitter on most aircraft. Amongst the transponder manufacturers there is already significant activity in this area and a number of Extended Squitter capable transponders are already certified for use on aircraft.

Honeywell, ACSS, Rockwell Collins and UPS Aviation Technology have certified Extended Squitter capable Mode S transponders. By early 2003 there should be at least seven different transponder product lines that are capable of Extended Squitter transmission. Many existing Mode S transponders can be upgraded by Service Bulletin to include Extended Squitter and in the case of the ACSS product this can be done via a software load on the aircraft (note that the addition of wiring of data sources to the transponder is also required to activate Extended Squitter).

Within the smaller manufacturers there is also interest in developing Extended Squitter capable transponders and further details of these plans should be clearer over the coming months.
The major airframe manufacturers are developing certified modifications to meet the European Mode S requirements and as part of this effort are including ADS-B out (Extended Squitter) functionality. New build Airbus aircraft with extended squitter will be available, subject to customer request, by mid 2003 and service bulletins for aircraft retrofit modifications should follow in the third quarter of 2003. Boeing aircraft follow a similar schedule but about three months behind.

In the area of avionics capable of receiving Extended Squitters there is some activity, primarily for GA/Business aircraft, on the development of dedicated receivers or systems capable of processing and displaying the ADS-B information. The main activity in the air transport arena is in the modification of existing ACAS receivers to passively track aircraft that are broadcasting and Extended Squitter and to use this information to provide increased range ACAS displays for improved situational awareness. ACSS already has certified ACAS units that, via programme pin activation, allow the passive tracking of Extended Squitter targets. Honeywell are developing a new TCAS with the same functionality which should be available by the end of 2003.

Appendix A Extended Squitter transmitters

A1 Summary of Equipment Status

Equipment	Part Number	Capabilities	Availability	Notes
Honeywell				
Transponder TRA-67A	066-01127-1401	Extended Squitter & Enhanced Surveillance [Air Tran – Airbus]	NOW	Upgrade of existing TRA-67A
Transponder TRA-67A	066-01127-1402	Extended Squitter, Enhanced Surveillance & 718A compatible [Air Tran – Airbus]	NOW TSO'd in Dec'02	Upgrade of existing TRA-67A
Transponder TRA-67A	066-01127-1412	Extended Squitter, Enhanced Surveillance, 718A compatible & XPDR security [Air Tran – Airbus]	on hold	Upgrade of existing TRA-67A
Transponder TRA-67A	066-01127-1601	Extended Squitter & Enhanced Surveillance [Air Tran – Boeing]	NOW	Upgrade of existing TRA-67A
Transponder TRA-67A	066-01127-1602	Extended Squitter & Enhanced Surveillance & 718A compatible [Air Tran – Boeing]	TSO due Q3 '03	Upgrade of existing TRA-67A
Transponder TRA-67A	066-01127-1612	Extended Squitter, Enhanced Surveillance & 718A compatible [Air Tran – Boeing]	on hold	Upgrade of existing TRA-67A
Transponder KT-73	066-01164-____	Extended Squitter [GA/Business – panel mount]	TSO due Mar'03	
Rockwell Collins				
Transponder TPR-901	822-1338-021	Extended Squitter, Enhanced Surveillance & 718A compatible [Air Tran - Airbus]	TSO due March '03	Upgrade of existing TPR 901
Transponder TPR-901	822-1338-003	Extended Squitter, Enhanced Surveillance & 718A compatible [Air Tran - Boeing]	TSO expected December '03	Upgrade of existing TPR-901
Transponder TDR-94	622-9352-007	Extended Squitter & Enhanced Surveillance [GA/Business]	NOW TSO'd Sept '02	
Transponder TDR-94D	622-9210-007	Extended Squitter & Enhanced Surveillance (with diversity) [GA/Business]	NOW TSO'd Sept '02	

Equipment	Part Number	Description	Availability	Notes
ACSS				
Transponder XS-950	7517800-10003	Extended Squitter [Air Transport]	NOW	Software upgrade of existing XS-950
Transponder XS-950	7517800-10004	Extended Squitter & Enhanced Surveillance [Air Tran - Boeing]	NOW TSO'd & JTSO'd, certified on 737NG, 747, 757 & 777	Software upgrade of existing XS-950
Transponder XS-950	7517800-10005	Extended Squitter &Enhanced Surveillance [Air Tran - Airbus]	NOW TSO'd & JTSO'd, certification on Airbus expected Mar '03	Software upgrade of existing XS-950
Transponder XS-950	7517800-55003	Extended Squitter [Air Trans/Business - 28vdc]	NOW	Software upgrade of existing XS-950
Transponder XS-950	7517800-55004	Extended Squitter & Enhanced Surveillance [Air Trans/Business - 28vdc]	NOW	Software upgrade of existing XS-950
Transponder XS-950	7517800-55005	Extended Squitter, Enhanced Surveillance[Air Trans/Business - 28vdc]	NOW TSO'd & JTSO'd	Software upgrade of existing XS-950
Transponder RCZ-852	7510700-850	Extended Squitter & Enhanced Surveillance [GA/Business]	TSO due Q2'03	Upgrade of existing RCZ-852
UPS Aviation Tech				
Transponder AT7000	430-6091-100-010	Mode S transponder that will do Extended Squitter when connected to an LDPU (see App 2)	NOW	Certified to TSO C112

5.1. A2 Manufacturers detailed information

A2.1 Honeywell

Honeywell also have both an air transport model transponder (TRA-67A) and two GA/Business transponders (KT-73 & MST-67A).
The TRA-67A was certified in May 1999 against the FAA TSO, but includes 1090MHz Extended Squitter functionality (Part No. 066-01127- Airbus –1401, Boeing –1601). These units were developed prior to the adoption of ARINC specification 718A and are not in accordance with it, so they have not been type certified by either Boeing or Airbus. They developed a –1402 model for Airbus which complies with 718A and provides an ATSU interface and that was TSO'd in December 2002. The equivalent Boeing version (-1602) is scheduled to be TSO'd in the 3rd Qtr 2003.
Honeywell's implementation of transponder security is on hold at present in the absence of any firm requirements, however they will incorporate the security requirements into new transponders –1412/-1612 if and when required.
For the KT-73 Honeywell are developing a modification that incorporates Extended Squitter and that is scheduled for certification in March 2003. The older KT-70 transponder will not be upgraded to include Extended Squitter.
Honeywell are, at present, only developing modifications for the MST-67A to comply with Elementary Surveillance requirements in Europe and are not including Extended Squitter.
All existing TRA-67A units in the field are upgradeable via Service Bulletin to include Extended Squitter functionality. This modification requires a workshop visit.
The implementation of Extended Squitter in the TRA-67A supports the following Extended Squitter registers: 05, 06, 08 & 09. Honeywell use ARINC 429 label 247 (Horizontal Figure of Merit) or label 130 (Autonomous Horizontal integrity limit) to set the measurement precision category for the Extended Squitter messages. When label 247 or 130 is not received by the transponder the default values are 18 for airborne messages (greater than 10Nm) and 8 for surface messages (greater than 0.05Nm).
The KT-73 is designed to work with the Honeywell KLN 94 GNSS navigation system so the position and accuracy data is accepted by the transponder via an RS-232 bus.

A2.2 Rockwell Collins

Rockwell Collins have two main lines of transponders in new manufacture, the TPR-901, for the air transport market, and the TDR-94/94D for the GA/Business market.
For the TPR-901 (Part No. 822-1338-, Boeing -003 and Airbus -021), Rockwell Collins will incorporate Elementary/Enhanced Surveillance, Extended Squitter and full compliance with 718A.

Availability of modifications for the TDR-94/94D to take them to Enhanced Surveillance standard has been since September 2002.

Transponder changes to meet the transponder security requirements are at present on hold waiting for firm requirements to be determined.

With regards to upgrade of existing products, Rockwell Collins have recently decided not to provide an upgrade path for older transponders (TPR-720 & TPR-900) to include Extended Squitter. For these older units they plan to offer a swap out programme to the TPR-901.

A2.3 ACSS

ACSS also produces both air transport and GA/Business transponders. Present production is XS-950 for air transport and RCZ-852 for GA/Business.
The latest versions of the XS-950, Part no. 7517800-10004 (Boeing) and –10005 (Airbus) are already capable of Extended Squitter and have TSO/JTSOs. The Boeing unit is certified on the 737NG, 747, 757 and 777 but not with navigational data supplied to it to activate the extended squitter function.
Certification of the Airbus model is expected in March or April 2003 and that includes the provision of navigational data and extended squitter. The RCZ-852 is being upgraded to include ACAS II, Extended Squitter, Elementary and Enhanced Surveillance and is expected to be TSO'd in the second quarter 2003.
For all existing XS-950 and RCZ-852 transponders that upgrade is via a software change only which can be performed whilst the unit is still installed upon the aircraft. The ACSS transponders prior to the XS-950 will not be upgraded to include Extended Squitter.

The ACSS units support the following squitter registers: 05, 06, 08, 09 & 0A. In addition the units support registers 51 and 52 to allow the interrogated extraction of position information.
ACSS use ARINC 429 label 247 (Horizontal Figure of Merit) to set the measurement precision category for the Extended Squitter messages. When label 247 is not received by the transponder the default values are 18 for airborne messages (greater than 10Nm) and 8 for surface messages (greater than 0.05Nm).
ACSS have not yet included transponder security modifications in their transponders but will do if firm requirements are created. The upgrade for this (transponder only) is expected to be via an on-board software load only.

A2.4 UPS Aviation Technologies

UPS (United Parcel Service) has been involved in the development of ADS-B for a long period and have set up UPS Aviation Technologies to develop equipment to meet the emerging requirements.
UPS AT are developing an ADS-B system that incorporates several link technologies, including 1090MHz Extended Squitter. Their initial implementation, mainly for trials activities, requires a separate Link to Display Processing Unit (LDPU) to format the Extended Squitter data. It is likely that future products will be combined with the data processing managed in the transmitter.
Their transponder (AT7000), when connected to the LDPU, which includes a GPS unit, will transmit extended squitter registers 05, 06, 08, 09 & 0A. The LDPU uses it own internal GPS unit to set the position uncertainty bits using the Autonomous Horizontal Integrity Limit label.

A2.5 Becker Avionics

Becker Avionics are currently developing a General Aviation Mode S transponder that includes extended squitter, initially without antenna diversity. Development plans also include a model that includes dual antennas for diversity and also a light weight transponder for light aircraft.
No update was available for issue 2 of this document.

A2.5 Garmin

Garmin have certified a Mode S transponder, with and without diversity. The units meet the European Mode S Elementary Surveillance requirements and have been designed to receive Traffic Information Service (TIS) broadcasts. They are designed to be expandable to accommodate potential future services such as ADS-B but at the present time there are no firm plans for the inclusion of extended squitter.

A2.6 Marconi

Marconi are at present manufacturers of military transponders and are developing Mode S capable models. Although these initial products will be military versions, they will comply with civil specifications and will receive a JTSO. From these products they intend to develop both air transport and lightweight transponders, possibly including Extended Squitter.
No update was available for issue 2 of this document.

A2.6 Walter Dittel

Dittel have been playing an active role in the development of MOPS for a lightweight transponder. At the present time they cannot provide any definitive plans on the development of a transponder.
No update was available for issue 2 of this document.

Appendix B Extended Squitter receivers

B1 Summary of Equipment Status

Equipment	Part Number	Capabilities	Availability	Notes
Honeywell				
TCAS TPA-100A		Extended Squitter reception / Passive Surveillance [Air Transport]	End of 2003	
Rockwell Collins				
ACSS				
TCAS RT-950	7517900-10003 s/w A	Extended Squitter reception / Passive Surveillance [Air Transport]	NOW	Software upgrade of existing –10001/2 Activated by programme pin
TCAS RT-950	7517900-10004	Extended Squitter reception / Passive Surveillance [Air Transport]	NOW	Software upgrade of existing –10001/2/3 Activated by programme pin
TCAS RT-951		Extended Squitter reception / Passive Surveillance [28vdc – 4 mcu]	NOW	
UPS Aviation Tech				
LDPU AT9011	430-6079-100-001	Dual 1090 MHz receiver (and UAT 966 MHz ADS-B transceiver)	NOW	Includes GPS with WAAS (TSO C145a) and works with AT7000 to provide Extended Squitter
LDPU AT9051	430-6079-500-001	Dual 1090 MHz receiver	NOW	Includes GPS with WAAS (TSO C145a) and works with AT7000 to provide Extended Squitter

5.2. B2 Manufacturers detailed information

B2.1 Honeywell

Honeywell are developing a new TCAS product (TPA-100A), which will include Extended Squitter reception capabilities when it is certified towards the end of 2003.
The existing TCAS system (TPA-81A) has not been offered with an Extended Squitter reception capability but engineering test versions of software have tested such functionality for this unit.

B2.2 Rockwell Collins

Rockwell Collins do not at present offer a TCAS product that includes Extended Squitter reception. They do however have plans to do so in the future, but the details are not yet available.

No update was available for issue 2 of this document.

B2.3 ACSS

ACSS have included Extended Squitter reception capability in their TCAS 2000 product since mid 2000. This function is activated by programme pin and allows passive surveillance and display of long range targets equipped with Extended Squitter. The display of these passively acquired tracks is the same as active TCAS tracks and active interrogation is resumed once the intruder reaches close range or becomes a threat.
ACSS also produce a smaller TCAS product in a 4 MCU packages, as opposed to the 6 MCU usual TCAS size, which makes it on one third smaller. This unit can be powered by 115vac or 28vdc.

B2.4 UPS Aviation Technologies

UPS (United Parcel Service) has been involved in the development of ADS-B for a long period and have set up UPS Aviation Technologies to develop equipment to meet the emerging requirements.
UPS AT are developing an ADS-B system that incorporates several link technologies, including 1090MHz Extended Squitter. Their initial implementation, consists of a transponder that works with a separate Link to Display Processing Unit (LDPU) to format the Extended Squitter data. This LDPU also contains a TSO C145a GPS/WAAS to provide the squitter data and dual 1090 MHz receivers to provide extended squitter reception capability. The dual receivers allow it to provide coverage to receive squitters from top and bottom antennas and to forward the extended squitter data on to a separate display system. They have also incorporated a UAT transceiver in one model of the DLPU.

B2.5 Ryan International

Ryan International produces a number of TCAD products, primarily for General Aviation, that provide traffic situational awareness using 1090 MHz transponder signals. Although at present none of these products include Extended Squitter reception capability, they are ideally suited to it and the manufacturer has plans to include it once a reasonable level of demand has been established. Ryan participated in the USA Ohio Basin trails using a modified 9900B TCAS unit with experimental software. This software allowed the passive surveillance of Extended Squitter aircraft and the display of their tracks. This trial demonstrated the capability of the TCAD products to provide ADS-B functionality.

B2.6 Goodrich Avionic Systems

Goodrich Avionics produce a number of traffic situational awareness products for the business and GA markets, including a certified TCAS I system and a product called SkyWatch. At present all these systems use active interrogations of transponders to provide traffic displays, but Goodrich are positioned to develop the products to support passive surveillance using Extended Squitter.

B2.7 Becker Avionics

Becker Avionics are working on the development of a 1090MHz ADS-B receiver, the details of which are not yet available.
No update was available for issue 2 of this document.

B2.8 Marconi

Marconi are considering development of a 1090MHz ADS-B receiver, details are not yet available.
No update was available for issue 2 of this document.

Appendix C ADS-B Display equipment

C1 Summary of Equipment Status

Equipment	Part Number	Capabilities	Availability	Notes
AT2000 display	430-1500-201-011 430-1500-101-011 430-1500-301-011	CDTI display (of ADS-B data); NAV display weather radar display TCAS display	NOW	TSO C105 and C113

5.3. C2 Manufacturers detailed information

C2.1 UPS Aviation Technologies

UPS Aviation Technologies are develop equipment to receive 1090MHz Extended Squitter and as part of that are developing the necessary interfaces for ADS-B displays and applications. Their AT2000 display is certified to several TSOs, and they have STCs for B-727, and B-757 aircraft, with an STC for B-767 aircraft expected in March 2003. The STCs for the B-757 and B-767 aircraft include the use of the CDTI to display TCAS targets as well as ADS-B targets, with the LDPU being used to associate TCAS tracks with ADS-B tracks, so that a target seen on TCAS, that is also emitting ADS-B extended squitters, will be displayed as a single target rather than two targets. (In the absence of good ADS-B data, the CDTI reverts to functioning as a TCAS display using data received directly from TCAS.)

C2.2 Ryan International

The Ryan International TCAD product includes a traffic situational awareness display primarily for General Aviation aircraft. Although at present these products do not track and display ADS-B tracks, the manufacturer has development plans to do so once the market conditions are right.

C2.3 Goodrich Avionic Systems

Goodrich Avionics situation is similar to that of Ryan in that its SkyWatch display products will be updated to ADS-B display capability once the market conditions are right.

C2.4 ACSS

ACSS are developing a cockpit traffic display device (PVI-600) that could be capable of displaying ADS-B information gathered by a TCAS or other extended squitter receiver.

Appendix D Aircraft modification certification

D1 Summary of aircraft type / transponder combination status

Aircraft type	Transponder	Capabilities	Type Certificate (TC)	Service Bulletin / STC
Airbus				
Single Isle (A318/319/320/321)	ACSS (7517800-10005)	Extended Squitter & Enhanced Surveillance	March 2003	SB - 3 mths from TC
Single Isle (A318/319/320/321)	Honeywell (066-01127-1402)	Extended Squitter & Enhanced Surveillance	March/April 2003 (dependent on JTSO)	SB - 3 mths from TC
Single Isle (A318/319/320/321)	Rockwell Collins (822-1338-021)	Extended Squitter & Enhanced Surveillance	April 2003	SB - 3 mths from TC
Long Range (A330/A340)	ACSS (7517800-10005)	Extended Squitter & Enhanced Surveillance	March 2003	SB - 3 mths from TC
Long Range (A330/A340)	Honeywell (066-01127-1402)	Extended Squitter & Enhanced Surveillance	March/April 2003 (dependent on JTSO)	SB - 3 mths from TC
Long Range (A330/A340)	Rockwell Collins (822-1338-021)	Extended Squitter & Enhanced Surveillance	April 2003	SB - 3 mths from TC
Wide Bodied (A310/A300-600)	ACSS (7517800-10005)	Extended Squitter & Enhanced Surveillance	March 2003	no requests yet
Wide Bodied (A310/A300-600)	Honeywell (066-01127-1402)	Extended Squitter & Enhanced Surveillance	March/April 2003 (dependent on JTSO)	no requests yet
Wide Bodied (A310/A300-600)	Rockwell Collins (822-1338-021)	Extended Squitter & Enhanced Surveillance	April 2003	no requests yet
Wide Bodied (A300-B2/B4)				
Boeing	Awaiting issue of Airplane Change Bulletin			

5.4. D2 Airframe manufacturers detailed information

D2.1 Airbus

Airbus transponder certification schedule is being driven to meet the European requirements for elementary and enhanced surveillance. As part of that programme Airbus have opted to include extended squitter

broadcast as a standard function as it is provided by all the transponders. To achieve this the wiring modification for enhanced surveillance also includes connections to the GPS for the squitter position.
The Airbus approach to this certification is to certify each manufacturers transponder on all aircraft types concurrently so certification availability is transponder type dependent and not aircraft type dependent. Once Airbus have achieved type certification of each transponder, service bulletins will be available for each aircraft type, orders dependent, three months later.
Airbus are not adopting the modification and new transponders as basic aircraft standard, so will only be installed on new build aircraft when specifically requested by the customer.
To simplify retrofit implementation Airbus have opted to split the modification into two service bulletins: one to fit the modified transponder and the second to modify the wiring to provide data to the transponder. The implementation of both these service bulletins will activate enhanced surveillance and extended squitter. If only elementary surveillance is required it can be achieved by embodying only the transponder service bulletin.
Customer requests have been received for both the single aisle and long range fleets so service bulletins will be developed immediately for these types. Development of service bulletins for the wide bodied aircraft is dependent on a customer request and order being submitted.
Airbus are still analysing there approach to the A300-B2/B4 fleet of aircraft as these are analogue aircraft that are no longer in production. If they provide a service bulletin approach, the functionality of the enhanced surveillance and extended squitter will be limited by the equipment installed on the aircraft.
Regarding ADS-B reception and cockpit display of traffic information, Airbus are participating in a number of trials and research projects but have no firm plans for inclusion at present. Once requirements are more clearly defined it would be Airbus intention to include the traffic display on the existing navigational displays installed on the aircraft.

D2.2 Boeing

Boeing are in the process of developing a Airplane Change Bulletin (ACB) which will fully outline Boeing's plans regarding Mode S Enhanced Surveillance and Extended Squitter implementation and certification. Once issued that ACB should provide detail on individual aircraft types. Advance information suggests that production certification is expected to run from 3rd quarter 2003 to 1st quarter 2004.
Like Airbus Boeing are concentrating certification efforts on meeting the European Mode S programme and associated mandates. As part of that programme Boeing are developing Extended Squitter as an option with the Enhanced Surveillance modifications, but it is not yet clear whether that will be a separate option in included as one upgrade.
Boeing will develop service bulletins for elementary and enhanced surveillance wiring for all models, but service bulletins for installation of modified transponders will be dependent on production aircraft certification. It is likely that like Airbus Boeing will split the service bulletins between wiring provisions and transponder installation/activation. Service bulletins will only be developed once customer requests are received and it is anticipated that they will take 25 weeks to prepare from the customer order. Activation service bulletins should be available 4 weeks after production certification.
Boeing are negotiation with the three main transponder manufacturers to enter into freedom of choice agreements where an operator can select any transponder on any airframe type. To achieve this Boeing will certify all three transponders across the full range of existing production aircraft.
Regarding ADS-B reception and traffic display, Boeing have no definite plans yet.

D2.3 Embraer

The Embraer CNS/ATM team has developed short (2003-2004) and medium term (2005-2007) plans for CNS/ATM implementation to evaluate the requirement, the applicability and the affected equipment. ADS-B implementation appears in the medium term plan for all the aircraft programs, but will be offered as an optional item since an immediate mandated is not yet proposed.
Embraer expects to have, dependent upon avionics supplier status, an ADS-B option on its aircraft during 2005. This would be on customer request for both forward fit and retrofit aircraft.

D2.4 ATR

ATR are beginning an experimental programme to install Extended Squitter on an Air Calédonie ATR aircraft. That modification will require an upgrade to the Mode S transponder and the Flight Management System and ATR are in discussion with French Authorities regarding certification.
ATR do not expect to have any service bulletins available for the installation of extended squitter before 2004.

D2.5 BAe Systems

Awaiting response.

D2.6 Bombardier

Awaiting response.

D2.7 Saab

Saab is monitoring future requirements such as the extended squitter function. So far, it seems that the Australian extended squitter requirements are in line with the elementary/enhanced surveillance programme in Europe. The Saab intention is to have SB's available well in advance of applicable compliance date.