

## White Paper Mode S and the European Mandates

### The Elementary Surveillance Mandate

For several years, the International Civil Aviation Organization (ICAO) has been working on a recommendation for its members in the European Region to adopt a mandate for certain aircraft to replace existing Mode A/C transponders with the new Mode S transponder (see side bar). Eurocontrol, in cooperation with its member states, is managing the implementation of this program. The US has

no similar requirements at this time. Per the Specimen Aeronautical Information Circular (AIC) version 1.0, 28/07/2000 from the Eurocontrol Web site ([http://www.eurocontrol.int/mode\\_s/](http://www.eurocontrol.int/mode_s/)), the Elementary Surveillance (then called Basic Functionality) mandate specifics are:

*“...the carriage and operation of Mode S transponders with **Basic Functionality**, is mandatory in [applicable country’s] airspace ... as follows:*

- a). for IFR flights as General Air Traffic (GAT); a level 2 transponder, as a minimum, compliant with ICAO Annex 10 Standards and Recommended Practices (SARPs) with effect from 31 March 2003, and,*
- b). for VFR flights; conducted in airspace where the carriage and operation of SSR transponders is mandatory, a level 2 transponder, as a minimum, compliant with ICAO Annex 10 SARPs with effect from 31 March 2005.”*

The AIC further provides for alleviation and exemptions under certain conditions. Refer to the AIC for specifics. The following States are known to have mandates in place for Elementary Surveillance: Belgium, France, Germany, Switzerland, Netherlands, UK. Note that Germany, France, and UK are also mandating Enhanced Surveillance (see below) and as a result are planning on modifying or eliminating their Elementary Surveillance requirements.

### New Elementary Surveillance Transition Program

In late 2001, the Eurocontrol Mode S Program Steering Group (PSG) was notified that

#### What is Mode S?

Mode S transponders perform the same basic function as a traditional Mode A/C transponder and provides all the same data (and much more) to the ground (and TCAS), however, the method by which these transponders are “interrogated” is much different. All so-called A/C transponders reply when interrogated – this happens when the beam of the interrogator dwells on the transponder. There is no selectivity between transponders – they all reply. This can lead to saturation or garble when too many transponders attempt to reply to the same interrogation simultaneously. So a means of selectively interrogating specific transponders was needed. Mode S accomplishes just that. In fact, the ‘S’ in Mode S stands for “Select”. Interrogators may now “address” their interrogations to specific transponders in their vicinity and no other transponder will reply. How does the Mode S Ground Station or TCAS know which address to interrogate for? All Mode S transponders “squitter” their unique, 24 bit, ICAO Mode S ID – this address is assigned to each aircraft operating a Mode S transponder by the governing regulatory agency. A squitter is simply a transmission (unsolicited reply) from the transponder that TCAS systems listen for. When TCAS hears a squitter, it will add the address in the squitter to its “roll call” list and will discretely interrogate that transponder for its altitude and Mode A code along with other pieces of information. Mode S ground stations do not use these squitters the way TCAS does. They perform what is called a Mode S All Call interrogation and all Mode S transponders in the interrogation beam will respond with a reply that contains their Mode S address. The ground station then adds any new addresses to its roll call interrogation list.

<b>Datalink Levels</b>	
Level 1 (Comm A)	No Datalink Capability - Receive 56 Bit Messages
Level 2 (Comm B)	Level 1 + Receive/Transmit 112 Bit Messages
Level 3 (Comm C)	Level 2 + Receive 16 Linked 112 Bit Extended Length Messages (ELM) Segments
Level 4 (Comm D)	Level 3 + Rx/Tx 16 Linked 112 Bit ELM Segments

the ability of users, particularly airlines, to equip prior to the March 2003 deadline was a high risk item. As a result, the PSG, proposed a transition period for equipage which would require all new aircraft to be equipped by March 2004 (12 month transition period) and all aircraft (including retrofits) completed by March 2005 (24 month transition period). A Specimen AIC dated September 2002 has been published and can also be found on the Eurocontrol Web site.

As with all European programs, the official requirements are those published by the individual European States. In general, States are expected to update their Mode S requirements, either via AIC or other mechanism, to match the Eurocontrol PSG recommendation following the Provisional Council approval.

<b>Elementary Surveillance</b>	
24-bit aircraft address	ICAO Mode S Address unique to each aircraft as assigned by appropriate state authorities
Automatic reporting of aircraft identity	ICAO Flight ID: Flight Plan call sign or aircraft registration marking
Capability Report	Reports the available data and means by which the transponder can report.
Pressure Altitude	In 25 ft increments if available, otherwise in 100 ft increments
Flight Status	Airborne / on-ground

### **Mode S Transponder Background**

Mode S has several advantages over the current ATCRBS (Mode A/C) transponder standard. First it offers much more efficient utilization of the existing SSR spectrum. As airspace densities continue to climb, the ability for ground stations (and TCAS) to accomplish their required surveillance of the airspace is being threatened due to saturation of the SSR (Secondary Surveillance Radar) spectrum. Since Mode S transponders can be selectively interrogated (see side bar), surveillance can now be accomplished on a one-to-one basis. This eliminates many extraneous replies and allows for much better use of the limited available spectrum. Mode S also offers the capability to communicate far more information than the current ATCRBS system (Mode A code and pressure altitude). A subset of this additional information forms the basis of the new European requirements.

The primary rationale for the adoption of Elementary Surveillance in Europe is to alleviate the Mode A code shortage by the use of Flight ID as an additional discriminator when identifying air traffic

The specifications in ICAO Annex 10 SARPS to which the mandate language refers are as follows (see sidebars for explanations):

- Level 2 datalink
- Antenna diversity (two antenna's: one top mounted, the other bottom mounted) if:
  1. Aircraft's max cruise speed is greater than 250 kts, OR

### SI Codes

Surveillance Identifier Codes. These codes provide for additional space in which to encode the address of the ground interrogator. If a transponder is being interrogated by more than one ground station, each requesting different information, it must reply to each interrogation with the proper data, addressed to the proper interrogating ground station. The number of codes assigned to these ground station addresses in the original specification of Mode S was found to be insufficient, so additional codes needed to be added. The SI Codes provide space for this.

2. *Aircraft's max take off mass is 5,700 Kg (12,500 lbs.).*

- Basic Functionality (also known as Elementary Surveillance)
- SI Codes
- TCAS II Change 7 (also known as ACAS II) compliance

### TCAS II Change 7 (ACAS II) Compliance

There are some minor protocol changes required to make TCAS compatible transponders fully compliant with the Change 7 spec.

- TCAS Crosslink – Change 7
- XGD/TGD protocol - Change 7
- RA report capability for ACAS II - Change 7

### Aircraft Interfaces for Flight ID

The requirement to report Flight ID results in a new operational requirement for flight crews to enter their call sign in some manner that allows the transponder to capture and report it. There are several possible methods for entry of Flight ID including: FMS CDU, dedicated control head, or various RMU's.

Existing Honeywell Business Jet FMS products currently do not provide a Flight ID output. Honeywell is reviewing customer requirements for this feature and will provide plans as they become available.

Honeywell is producing a new line of controllers to accompany the new Primus II Select line of radios. The PS-550 TCAS / Mode S Controller includes flight ID and is also a single-unit, direct replacement for the Collins CTL-92/92T combination. The PS-550 will also replace the Honeywell CD-671C Series III controller. The PS-578 is a drop-in replacement for the KFS-578A controllers and also includes flight ID.

The Honeywell Radio Management Units (RMU) that are TCAS compatible have flight ID on the TCAS page. This includes both RMU models, RM-850 and RM-855. No further upgrade is needed.

### The Enhanced Surveillance Mandate

A second type of transponder capability referred to as Enhanced Surveillance is also being mandated by UK, Germany, and France.

Enhanced Surveillance is intended to provide additional information about an aircraft's state and intent for use by air traffic controllers. It includes the elements of information (called Downlink Aircraft Parameters – DAPs) referred to in the sidebar at left about the aircraft stored in the transponder and downlinked on command from the ground:

Details of the Enhanced Surveillance mandate can be found on the Eurocontrol website at [http://www.eurocontrol.int/mode\\_s/](http://www.eurocontrol.int/mode_s/) under Enhanced Surveillance including

### Enhanced Surveillance Data Downlink Aircraft Parameters

- Magnetic heading
- Indicated airspeed / Mach No
- Vertical Rate (barometric rate of climb/descent or, preferably, baro-inertial)
- Roll Angle
- Track Angle Rate
- True Track Angle
- Ground Speed
- Selected Altitude

individual states AIC's and the Eurocontrol 3-State Master Plan for Enhanced Surveillance.

The primary rationale for the adoption of Enhanced Surveillance is to maintain or improve safety and capacity levels while airspace densities continue to climb. Providing controllers with additional data allow better flow planning and deconfliction with other traffic.

Enhanced Surveillance is mandated as follows:

*“The carriage and operation of Mode S Enhanced Surveillance functionality shall be mandatory for aircraft with a maximum take-off mass in excess of 5,700 kg or a maximum cruising true airspeed in excess of 250 kts conducting IFR flights as General Air Traffic (GAT), with effect from **31st March 2005**. A transition period of 2 years shall be applied until 30th March 2007, during which a coordinated exemptions policy shall be applied...”*

Installation of Enhanced Surveillance compliant transponders will almost always require wiring changes to the aircraft to create an interface between avionics containing the required data (such as Flight Management Computers) to the transponder. The scope of the wiring is dependent on the type of equipment currently installed on the aircraft. Newer aircraft may have systems where all required information is available from the FMS and a single A429 connection may be all that is required. Older aircraft may have to interface to more than one sensor to get the information necessary.

Eurocontrol and the States do offer some guidance for aircraft without the necessary equipment to generate all the information required for Enhanced Surveillance. It appears that temporary exemptions may be given. Please contact Eurocontrol or your regulatory agency for more specific guidance.

The last page of this White Paper shows a graphic representation of the Elementary Surveillance mandate as well as the Enhanced Surveillance mandate. The ACAS II mandate is also shown for reference.

## **Future Developments in Mode S**

### **ADS-B**

Automatic Dependent Surveillance – Broadcast is an emerging surveillance technique whereby an aircraft will transmit some or all of its location, state data, and intent as a broadcast for other aircraft and the ground to use for tracking, surveillance, and traffic management purposes. ADS-B technology is still developing and several technologies are being studied as possible candidates for the ADS-B communication datalink. Mode S is one of the datalinks being evaluated for ADS-B implementation. The Honeywell Mode S transponders in the following section are upgradeable to provide the ‘extended squitter’ message incorporating ADS-B information.

### **Honeywell Mode S Transponders**

Honeywell produces several Mode S transponders and plans to have mandate compliant versions available by mid year of 2002.

### **KT 73**

The KT 73 is a new Panel Mount Mode S transponder designed for light aircraft.

- Capability
  - Datalink Level 2
  - Non-diversity antenna
  - Elementary Surveillance

- SI Codes
- No TCAS compatibility
- Traffic Information Service (TIS)
- ADS-B Extended Squitter
- Availability: Now

## MST 67A

The MST 67A Remote Mode S Transponder will have two new part numbers that will supercede all existing part numbers.

- New Part numbers (2101 diversity, 2001 non-diversity)
- Capability
  - Datalink Level 3
  - Antenna Diversity (-2101 flavor)
  - Elementary and Enhanced Surveillance
  - SI Codes
  - TCAS Change 7
- Availability: Q1, 2004.
- Upgrades: Upgrades will be available by part number as listed in the table (for complete upgrade information, please see the corresponding service bulletins). Pricing TBA.

### Part Numbers and Upgrade Information for MST 67A

Current	New	Service Bulletin
• -0201	-2001	SB MST 67A-M2
• -0020	-2001	SB MST 67A-M2
• -0011	-2101	SB MST 67A-M1
• -0601	-2101	SB MST 67A-M1
• -1301	-2101	SB MST 67A-M1
• -1602	-2101	SB MST 67A-M1

**Important Note about Flight ID:** The MST 67A has a feature that allows it to automatically determine the aircraft Registration Number (Tail Number) of US registered (N numbered) aircraft. If the aircraft is US Registered and operated where the tail number is used as the call sign (Flight ID), then the operator does not have to manually enter the Flight ID – therefore a new Flight ID control head is not required. The transponder automatically reads the Mode S address assigned to the aircraft. If it falls within the range of addresses assigned to the US by ICAO, it will automatically convert that Mode S address to the tail number of the aircraft and place it in the Flight ID register for compliance with Elementary Surveillance. If the aircraft is operated where the Flight ID is not the tail number or the aircraft is not US registered, then a Flight ID control head is required to allow for manual entry of Flight ID.

## XS-852

The XS-852 is part of the Primus II Radio system. It's an integrated module inside the Primus II Communications Unit (RCZ-8xx, P/N 7510700-xxx). To implement the Elementary Surveillance Mandate, the RCZ will have to be upgraded and have the part number changed per the table below. The Field Service Bulletins necessary to perform the Elementary Surveillance upgrades are listed in below.

Unit	Field Service Bulletin
Integrated Communication Unit	A24-3851-004, Rev 00
Transponder Module	A24-3854-001, Rev 00 – For Reference Only

- New Dash Numbers (Comm Unit): See table
- Capability:
  - Datalink Level 3
  - Antenna Diversity
  - Elementary Surveillance
  - SI Codes
  - TCAS Change 7
- Availability: Now
- Upgrades
  - Software only

<b>Part Numbers for Primus Comm Unit (7510700- xxx)</b>	
<b>Current</b>	<b>New</b>
- 802	- 813
- 806	- 815
- 826	- 825
- 862	- 863
- 866	- 875
- 726	- 725
- 762	- 763
- 766	- 765

### **XS-857A**

Two new Diversity, Mode S Transponders (P/N 7517400), compatible with the EPIC radio system, are now available. These new dash numbers have Elementary Surveillance capability.

- New Dash Numbers (-876 and -896)
- Capability:
  - Datalink Level 3
  - Antenna Diversity
  - Elementary Surveillance
  - SI Codes
  - TCAS Change 7
- Availability (TSO): Now
- Upgrade available from 7517400-855 to 7517400-876
  - Service Bulletin #: A24-3834-018
  - Software only

#### ***(For Enhanced Surveillance Mandate Only):***

As with Elementary Surveillance, the upgrade to Enhanced Surveillance will require an update to the XS-852 and will be rolled into the Communication Unit (RCZ) with a part number change. The availability of the Enhanced Surveillance for the XS-852 will be 4Q 2004.

Upgrades to Enhanced Surveillance will also be available for the Primus EPIC transponders (XS-857A) in 4Q 2004.

Updates to this white paper will be released to communicate more defined schedules and changes to part numbers, as they become available.

# ACAS II and Mode S European Mandate

