RTCA Special Committee 209
ATCRBS / Mode S Transponder
Meeting #4
Honeywell, Olathe, Kansas
18 – 19 October 2006

Transponder operating when the 24- bit Address Announced is invalid

Prepared and Presented by Wm. A. Thedford, AACAS LL

SUMMARY:
This WP presents the position of EUROCAE WG 49 that the transponder shall not be operated as a Mode S transponder when the AA is all ZEROs or ONEs..

The attached two papers accepted by the EUROCAE WG49 Meeting 8.

EUROCAE WG49N8 Action (A6/15)	Working Paper WG49N8-20a AGENDA Item 6.2.3

EUROCAE/WG-49
Meeting #8 – Cologne
October 2006

EUROCAE WG-49

TITLE: Topic for Consideration-differences in handling invalid Address Announced (AA) and a proposed WG49 position

Prepared and presented by Wm. A. (Bill) Thedford (AACAS LLC)

SUMMARY

This is a brief discussion of the potential differences in ED 73C and DO 181D with respect to the processing of invalid Mode S addresses and the WG49 position.
(WAT – 10/5/06)

Background:

In Meeting 7 of WG 49 (July 4-6, 2006 in Paris at EUROCAE) Mikaël Ponnau presented WG49N7-11a and it was accepted with modifications by Roland Malllwitz. However, it was not accepted as an ED 73 standard. In the subsequent RTCA SC 209 meeting (FAA Technical Center, Atlantic City Airport, NJ) the paper was presented by Bill Thedford. The approach for handling an invalid AA was not accepted.

Discussion:

The paper WG49N8-24 provided to WG49 is a modification of WG49N7-11a to establish a proposed Minimal Operational Performance Standard.

State military aircraft Mode S transponders commonly provide a pure Mode A/C operational mode. Dieter Kunze observed that some general aviation transponders have this same feature. Additionally, some military and GA Mode S transponders provide a convenient means of changing the Mode S address. For military aircraft, this allows an aircraft to be reassigned from civilian to military operation and State operation to NATO operation without delay or major maintenance action.

During the SC 209 meeting it was observed that some TSOd civil transponders do operate in Mode S with an invalid AA. At the SC 209 meeting there was little interest in accepting the text developed for ED 73C as provided in WG40N7-11a. It was mentioned that maintenance should ensure that a correct address has been installed and that the transponder should not be expected to solve every issue that may come up.

Recommendation:

1. Modify the ED 73 text according to WG49N8-24. This will establish the proposed Minimum Operational Performance Standard for operation under the condition that the Mode S 24-bit address is invalid (all ZEROs or ONEs).
2. Observe that a Mode S transponder operating with an invalid address will not be visible to other ACAS aircraft and its ACAS should be inoperative. Thus, the safety margin in Air-Air operation provided by ACAS is reduced or lost. The Mode S sensors and the associated automation systems are not uniform in handling Mode S plots with invalid addresses. There in an increased possibility of multiple aircraft in a radar coverage area with the same invalid address. The efficiency of management of the airspace is reduced with a corresponding reduction in the safety margin. The EUROCONTROL Airborne Monitoring Program has observed instances of Mode S aircraft operating in European airspace with invalid addresses.
3. Forward this proposed standard to SC 209 for their attention. If this is ultimately a difference in the ED 73 and DO 181 documents that it should be suitably noted.

The position of WG 49 is:

> The EUROCAE WG 49 has determined that Mode S operation with an invalid Address Announced (AA) is such a serious degradation of air–air and air-ground safety margin that it must be prevented. It is the position of this working group that a procedural solution is not possible since neither the flight crew nor the air traffic controller have cognizance of the Mode S address or the ability of correct an invalid address (with the exception of some military and GA transponders). The standard accepted and proposed by WG 49 in WG49N8-29 is an appropriate solution.

The following text is proposed. The text highlighted in yellow was accepted during the WG-49 in Toulouse in March 2006. The new text for this meeting in Paris in July 2007 is highlighted in green and completes action A6/07. That in blue is simply a comment that no change has been made. The text highlighted in Red completes action A7/05 for Roland Mallwitz. The text highlighted in Blue completes the action for Wm. Thedford.

1.5.2 Definitions

Power Off Condition – The condition in which the transponder electrical power is not applied to the receiver, transmitter or related components.

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Standby State – The condition in which transponder electrical power may be applied to the receiver, transmitter and related components but the transponder is disabled from transmitting. In this state the transponder does not reply to interrogations and does not squitter any information in any Mode A/C/S format.

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3.14.3 Failure Indication

a. An indication shall be provided of the validity/non-validity of the equipment.
b. Any failure detected by the self-test, squitter monitor or other monitoring function shall cause the indication to assume the invalid state.
c. Momentary power interruptions shall not cause indication of the invalid state.
d. The status of the equipment shall be indicated to the flight crew.
e. Failures related to the 24 bit discrete address shall generate a diagnostic error message in order to alert maintenance personnel (if a change in the 24 bit discrete address is detected or if a 24 bit discrete address consisting of all ONEs or all ZEROs is read during the power-on initialisation process).

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3.17.1 Direct Data

a. Fixed Direct Data

(1) 24 Bit Aircraft Address. During the power-on initialisation process, the transponder shall read and store its 24-bit discrete address. Thereafter, the address used by the transponder shall not change from the value stored at power-up. The transponder should continue to monitor the 24-bit discrete address after the initial read and store at power-up. If a change in the 24-bit discrete address is detected after the initial read and store, the transponder shall continue to use only the 24-bit discrete address stored at power-up and shall generate a diagnostic error message in order to alert maintenance personnel to the occurrence of intermittent discrete address bit input data. If the transponder 24-bit discrete address is set to all ONEs or all ZEROs at startup then this error condition shall be indicated to the pilot and the transponder shall either transition to Standby State, Power Off Condition, or operate as a pure Mode A/C transponder.

Note 1: This last requirement is imposed to specifically disallow Mode S transponders from operating with invalid addresses. This condition has been observed in airspace operations and it poses a number of unsafe conditions.

Note 2: If there is no other Mode S transponder active (not in Standby or a Failed condition), then ACAS will declare a "ACAS System Fail" or enter the "Standby" condition." (3.23.4 ACAS-Compatible Transponder Automatic Performance Monitoring).

Note 3: If this condition occurs at startup then the transponder should be deactivated until the condition is corrected or only be able to operate in pure Mode A/C only. Pure Mode A/C transponders reply to all P1-P3 and P1-P3-P4 interrogations with a Mode A/C reply and do not transmit any squitter.

Note 4: Accommodation should be made for those military transponders that have the capability to change the 24-bit address (e.g., so the aircraft can operate as a State aircraft with a corresponding address or as a NATO aircraft with a NATO address). However, under no conditions may such a transponder operate as a Mode S transponder if the address is invalid.

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1.1.1 5.4.9.3 Failure Indication (Paragraph 3.14.3)

The manufacturer shall demonstrate that failures are properly detected by the self test or monitors and cause the indication to assume the "invalid" state. The generation of diagnostic error messages related to illegal 24 bit discrete addresses is tested in section 5.4.12.1.2.

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1.1.1.1 5.4.12.1 Fixed Direct Data

(Paragraph 3.17.1 a.)

1.1.1.1.1 *5.4.12.1.2 Test Procedure*

With the transponder RF port connected to the RF port of the Transponder Test Set, (Figure 5.3) perform the following test sequences:

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e. Step 5 – Invalid AA

Put the transponder in the Power Off Condition and set the AA to all ZEROs. Turn on the transponder and verify that a transponder error condition is set.

Note : the transponder will normally either go into Standby State, revert to a pure Mode A/C transponder or return to the Power Off Condition.

Repeat this test with the AA set to all ONEs.

Put the transponder in the Power On Condition with an AA set to ONE for the first bit and ZEROs for all other bits. Verify that the transponder functions normally as indicated in steps 1 and 2.

Without putting the transponder in Power Off Condition change the AA to all ZEROs. Verify that the transponder generates a diagnostic error message for maintenance and that it keeps operating using the initial AA read during the power-on initialisation process (first bit set to ONE and all other bits set to ZEROs).

Repeat this test with the AA set to all ONEs.

Repeat with the remaining twenty-three different transponder addresses each consisting of 23 ZEROs and a single ONE.

1.1.2 3.23.4 ACAS-Compatible Transponder Automatic Performance Monitoring

The transponder shall be capable of detecting malfunctions in the Mode S transponder system that would degrade ACAS functioning, and upon detection shall make this information available to ACAS. In particular, loss of complete Mode S functionality shall trigger an ACAS II system failure.