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ATCRBS / Mode S Transponder MOPS Maintenance

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NATS and Eurocontrol position on expected behaviour of Register 08_{16} when data input is lost / faulted

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SUMMARY

RTCA / EUROCAE and ICAO ASP working papers have been issued on the subject of the expected behaviour of Register 08_{16} when data input is lost / corrupted. This paper presents the NATS and EUROCONTROL position on what the expected behaviour should be for consistency of reporting Flight ID and the need for indication of failure to be presented to user applications.

WP for WG-49 / SC-209 Joint meeting 15th – 19th November

1. Introduction

A working paper was raised (WP/ASP09-24) at the 9th ICAO ASP WG meeting held in Brussels 4-8th October 2010, highlighting a difference in the reporting of Flight ID information delivered via Extended Squitter (BDS 0,8) and Mode S (BDS 2,0). The working paper requested guidance from operationally experienced personnel or airborne application owners to advise whether:

> The continued squittering of the last known valid flight ID data is acceptable when the data becomes invalid or is not available at the transponder interface.
>
> OR
>
> That the Register should be zeroed when the data becomes invalid or is not available at the transponder interface, and so let the application decide how best to continue.

This Working Paper is presented by NATS and EUROCONTROL to WG-49 / SC-209 to:

- inform changes to MOPS, as it is pertinent to the ED-73 and DO-181 MOPS documentation currently open for review and improvement via the current working group activity.
- provide a response to that question for consideration and recommendation to the ICAO ASP.

2. System behaviour of Flight ID on failure (taken from WP/ASP09-24)

The following high level description of expected behaviour has been taken from ICAO ASP working paper WP/ASP09-24:

In the event that the chosen Flight ID source becomes unavailable or invalid during a flight:

Mode S - Register 20_{16}

Register 20_{16} is loaded with all zeroes. Change is announced to the ground system and the ground system extracts the zeroed register.

Once the Flight ID data becomes available, the transponder will load the new value into Register 20_{16} and announces the change to the ground for extraction. The ground will then extract Register 20_{16}.

Therefore the ground applications are aware that data is invalid or no longer available and can therefore take the appropriate action in line with the requirements of the application that is being used.

Extended Squitter – Register 08_{16}

Register 08_{16} is not reset or zeroed but continues to hold the last known valid data. The last known valid Fight ID is then squittered.

Once valid Flight ID data becomes available, the transponder will load the valid data into Register 08_{16} and valid Flight ID is squittered.

3. Review of documented expected behaviour

ICAO Doc 9871 Appendix C Table C-1-4 entry for BDS 0,8 data requirements points to notes 13 & 14 and defines the expected behaviour for the population of the Flight ID into Register 08_{16}. Note 13 part c is explicit in stating that:

"If flight identification data have been entered into transponder Registers 08_{16} and $20_{16,}$ and then become NOT available, then the character subfields of the transponder registers should be set to all ZEROs."

This clearly determines that 08_{16} and 20_{16} should not be treated any differently in respect to faults, and the action is to populate the fields in such a way as to indicate to a user application (ground or airborne) that the Flight ID is invalid so that it may determine the appropriate application response to the invalid data.

However, ICAO Doc 9871 also states in section A.2.4.2 (“Register Time-out”) that Register 08_{16} is not cleared. ED-73C section 3.28.4 Note 3 agrees with the ICAO Doc 9871 requirement which states that Register 08_{16} is not to be cleared if there has not been an update for 2 seconds. This behaviour is unlike most other registers and was based upon the reasoning that the Flight ID is highly unlikely to change in flight and the opportunity for incorrect data to be transmitted is minimal.

ED-73C procedure 5.5.8.6.2.2 “Extended Squitter Protocol Verification” contains tests to confirm the transponder behaviour when the transponder data input stops. The test here expects that the last known good Flight ID continues to be output even if the data provided to fill Register 08_{16} has stopped.

DO-260B Appendix A section A.1.5.2.d also states “*The ADS-B Transmitting Subsystem will not clear the aircraft identification message*” which likely can be traceable to the Doc 9871 requirement in A.2.4.2.

With regards to ED102A/DO260B, the related test procedures specify that Register 08_{16} is to be zeroed. At the same time, the descriptive Main Body sometimes specify the opposite behaviour (refer to Section 2.2.3.3.2.11 “ADS-B Message Time-out”).

ICAO Annex 10 volume IV section 3.1.2.9 contains requirements related to aircraft identification reporting. Delivery of this information using Register 08_{16} is not considered, only delivery via Register 20_{16} and related Comm-B protocol. Section 5.1.1 contains requirements related to ADS-B OUT, but points to Doc 9871 for data formats and protocols.

Therefore there is clearly inconsistency between, and even within, ICAO documentation and MOPS documentation sets which is likely to lead to inconsistent implementation of future platforms and applications.

4. Analysis of impact to future applications.

ADS-B IN applications under development (i.e., ASAS) will require knowledge of the identity of detected ADS-B squittering aircraft. Register 08_{16} is the only means of delivering this information, without the need for an airborne Mode S interrogator. The criticality of this information is as yet undetermined for advanced ASAS applications, but the availability and correctness of the Flight ID of aircraft undertaking ADS-B IN applications can be expected to be a fundamental data item.

If there is a failure of the data entry to the transponder to populate Register 08_{16}, by continuing to relay the last known data value the airborne applications on ADS-B IN equipped aircraft will receive no indication that the Flight ID is invalid and will continue to assume that the data is good. This may indeed be an acceptable course of action. However, at this stage of ADS-B IN application development it seems prudent for the airborne applications to be informed of the fact that the Flight ID content of Register 08_{16} is invalid by the setting of the register to all ZEROs. The application can then decide what action should be taken (if any) with this information. It may decide to continue to use the last received Register 08_{16} content before receipt of the all ZEROs content, or it may decide to discontinue use of any Register 08_{16} data if it is considered unreliable. The key point here is that the decision on what to do with the data should be taken by the recipient application, not the source of the data (i.e., the transponder). Furthermore, this retains consistency with what is performed under similar conditions for Register 20_{16}.

The same point can be made for ground applications that may have access to multiple sources of Flight ID data from an aircraft, with Register 20_{16} Flight ID data being provided by conventional Mode S interrogators or Wide Area Multilateration (WAM) systems deployed within the ATM environment. Register 08_{16} delivered Flight ID data could again be provided by WAM systems and/or ADS-B receiver stations within the ATM environment.

In all cases, a solution whereby the conflicting information was to be detected and filtered by the automation system would add unnecessary system complexity. Given that there is currently potential for Register 08_{16} to be delivered when known to be faulted, such a solution would also bear the risk that Mode S Flight ID information from Register 20_{16} could be considered to be superior to that provided by ADS-B. Both aspects would be highly undesirable as both delivery mechanisms should be treated exactly the same.

It is noted that the European and US ADS-B Out implementation rulemakings demand that the same sources are to be used to encode the SSR and ADS-B data formats, this in response to hazards associated with data discrepancies in a multi-sensor environment including ADS-B (refer to ED161/DO318). It is therefore important that the information derived from these sources is delivered consistently from the airborne transponder platform and that failure indications are also treated consistently.

For any application making use of Mode S data (air or ground), the principle should be that the application should be the entity that makes the decision what do with particular information with Mode S being the delivery system providing relevant indications of data quality to make that decision.

5. Mode A Code

It is noted that there is an apparent lack of EUROCAE/RTCA and ICAO specifications on the handling of stale Mode A Codes. In effect, SC209-WP12-03 states that in case of a control head failure, in today's transponders, the Mode A code is retained and the transponder continues to reply with the last known valid Mode A code. This should be reviewed in light of the discussions on the transmission of stale Flight ID information.

6. Recommendations

Mode S was developed to provide a datalink mechanism with inherent high integrity and reliability, making better use of technology, to deliver reliable, accurate data to applications and to allow the ATM environment to move away from conventional unreliable conventional SSR / ATCRBS techniques. The development of protocols and inherent data checking and correction mechanisms of Mode S are there to provide user applications a high confidence that data supplied is good unless flagged within the data as otherwise.

To deliberately present data that is known to be invalid (as its source has been lost or corrupted) without indication of this to the user applications appears to be against the above principles.

It is the recommendation of NATS and Eurocontrol:

- Recommendation 1: To make the implementation of Register 08_{16} common to that of Register 20_{16} in the event of data input loss event. This will provide a consistent, identifiable status to current and future applications (both ground and air) and let the application take the appropriate action as required by the user, rather than the decision being taken at the data source to continue to send data without an indication of the status of that data even when known to be faulted.

- Recommendation 2: That ED-73 / DO-181 requirements and tests related to the deliver of extended squitters containing Register 08_{16} data are consistent with Recommendation 1 and that all current conflicting requirements are removed from Extended Squitter and Transponder MOPS documentation. It is believed that changes to MOPS are required and can be implemented in the current update cycle and ICAO Doc 9871 can also be made consistent through the next release currently underway.

- Recommendation 3: WG-49 / SC-209 to make a recommendation to ICAO ASP to remove ambiguity within Annex 10 volume 4 and Doc 9871 with regard to requirements for Flight ID reporting mechanisms.

- Recommendation 4: WG51 / SC186 to capture inconsistencies regarding the handling of stale Flight ID information in ED102A/DO260B.

- Recommendation 5: WG-49 / SC-209, WG51 / SC186 and ICAO ASP to review the current provisions regarding the handling of stale Mode A Codes.