

RTCA SC-209 and EUROCAE WG-49

ATCRBS / Mode S Transponder MOPS Maintenance

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Extended Squitter Version 2: Maximum Squitter Rates

**Prepared by: Chris Tourigny, FAA Spectrum Engineering Services,
ATO Technical Operations**

SUMMARY

A change to the International Civil Aviation Organization (ICAO) Standards and Recommended Practices (SARPs) Annex 10 Volume IV was presented during the Aeronautical Surveillance Panel (ASP) Working Group (WG) meeting the week of October 4 – 8 in Brussels, Belgium. The proposed change made the SARPs consistent with RTCA and EUROCAE documents as a result of the publishing of the 1090 MHz Extended Squitter (1090ES) Version 2 Minimum Operating Performance Standards (MOPS) by RTCA, Inc. (RTCA) as DO-260B and EUROCAE as ED-102A. The average maximum squitter rate in DO-181D and ED-73C was also changed to harmonize international standards. During the ASP WG review, it was discovered that the proposed maximum squitter rate did not accommodate for all DO-260B changes and the possibility exists that the maximum rates could be exceeded under certain conditions. This working paper proposes changes to DO-181D/ED-73C that better characterize the maximum 1090ES rates DO-260B/ED-102A standardized.

1. Introduction

The International Civil Aviation Organization (ICAO) Aeronautical Surveillance Panel (ASP) Working Group (WG) met October 4 through 8 in Brussels, Belgium and reviewed proposed changes to the Annex 10 Volume IV Standards and Recommended Practices (SARPs). One proposed change was to make the SARPs consistent with RTCA and EUROCAE documents as a result of the publishing of the 1090 MHz Extended Squitter (1090ES) Version 2 Minimum Operating Performance Standards (MOPS) by RTCA, Inc. (RTCA) as DO-260B and by EUROCAE as ED-102A. The maximum squitter rate in DO-181D and ED-73C was also changed to harmonize international transponder standards. During the ASP WG review, it was discovered that the proposed average maximum squitter rate did not accommodate for all DO-260B changes and the possibility exists that the maximum rate could be exceeded under certain conditions. The WG decided to send this change back to RTCA/EUROCAE to propose a change that includes all possible scenarios and assign each a rate limit. This working paper proposes changes to DO-181D/ED-73C that better characterize the maximum 1090ES rates that DO-260B/ED-102A standardized.

2. Discussion

The adoption of DO-260B and ED-102A changed the event-driven message protocol such that a new protocol, the Periodic Status Message, was defined as a stand alone protocol that is still subject to the 6.2 messages per second rate limit under nominal aircraft operation. This change was necessary because it was recognized by RTCA and EUROCAE that the event-driven squitter maximum transmission rate would prevent adequate updates of critical safety messages under rare conditions of an emergency and/or a TCAS RA. Also, since the amount of time the messages are averaged over was still being defined, a sufficient time average could allow this change while respecting the ICAO accepted rate limit under nominal aircraft conditions. RTCA/DO-181D Change 1 removes the Target State and Status and Aircraft Operational Status from the event-driven message and defines the messages as periodic status messages.

DO-181D §2.2.23.1.2

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e. Target State and Status. The Target State and Status Extended Squitter shall use format DF=17 with the contents of GICB Register 6,2₁₆ inserted in the ME field.

Note: A GICB request (see §2.2.19.1.12.3) containing RR=22 (16 HEX), DI=7 and RRS=2 will cause the resulting reply to contain the Target State and Status report in its MB field.

f. Aircraft Operational Status. The Aircraft Operational Status Extended Squitter shall use format DF=17 with the contents of GICB Register 6,5₁₆ inserted in the ME field.

Note: A GICB request (see §2.2.19.1.12.3) containing RR=22 (16 HEX), DI=7 and RRS=5 will cause the resulting reply to contain the Aircraft Operational Status report in its MB field.

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The transmission rates have been proposed in RTCA/DO-181D Change 1 as:

DO-181D Change 1 §2.2.23.1.3

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f. Target State and Status Squitter Rate. The Target State and Status squitter shall be initiated only when the aircraft is airborne and when target state information is available and valid as a minimum. The Target State and Status squitter shall be transmitted at random intervals that are uniformly distributed over the range of 1.2 to 1.3 seconds relative to the previous Target State and Status squitter for as long as valid data is available, with the exceptions as specified in subparagraph “i.”

g. Aircraft Operational Status Squitter Rate. The Aircraft Operational Status squitter shall be transmitted at the rates as specified in §2.2.3.3.1.4.2 of RTCA DO-260B/EUROCAE ED-102A, with the exceptions as specified in subparagraph “i.”

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The purpose of the Aircraft Operational Status message is to provide the capability class and current operational mode of air traffic control related applications and other operational information. The Target Stage and Status Information message provides aircraft state and status information such as target altitude and heading. As these messages directly support safety and regularity of flight, the transmission of these by the aircraft is compliant with the international spectrum allocation for 1090 MHz under the Aeronautical Mobile (Route) Service.

The 1090ES capacity is provided by (and limited by) the maximum message (squitter) rate. The previous limit of 6.2 squitters per second was accomplished by the limit on individual squitters. Before DO-260B, the 6.2 limit was imposed by the following:

<u>Squitter Type</u>	<u>Maximum Average Rate per Second</u>
Position	2
Airborne Velocity	2
Aircraft Identification and Category	0.2
Event Driven	2
Total	6.2

As a result of the adoption of RTCA/DO-260B, the following maximum rates apply:

<u>Squitter Type</u>	<u>Maximum Average Rate per Second</u>
Position	2
Velocity	2
Aircraft Identification and Category	0.2
Periodic Status	1.25
Event Driven	2
Total	7.45

This is not the actual message rate in all aircraft conditions and configurations, so to define the amount of time to average over such that the 6.2 messages per second nominal value is maintained, each condition must be examined. A peak rate must also be defined for completeness.

Condition 1

Nominal Squitter Rates for Aircraft Not Transmitting Target State and Status Message

<u>Squitter Type</u>	<u>Squitter Rate per Second</u>
Position	2
Velocity	2
Aircraft Identification and Category	0.2
Periodic Status	
Operational Status	0.4
Event Driven	0.2
Total	4.80

Condition 2

Nominal Squitter Rates for Aircraft Transmitting Target State and Status Message

<u>Squitter Type</u>	<u>Squitter Rate per Second</u>
Position	2
Velocity	2
Aircraft Identification and Category	0.2
Periodic Status	
Operational Status	0.4
Target State and Status	0.8
Event Driven	0.2
Total	5.60

As shown above, normally the transmit rate is either 4.8 or 5.6 depending upon the aircraft installation.

Condition 3

Squitter Rates for Aircraft Not Transmitting Target State and Status Message and a Change in NAC, NIC Supplement or SIL Parameters

<u>Squitter Type</u>	<u>Squitter Rate per Second</u>
Position	2
Velocity	2
Aircraft Identification and Category	0.2
Periodic Status	
Operational Status	1.25
Event Driven	0.2
Total	5.65

This total occurs for 24 seconds and then the aircraft transmits 4.8 messages per second for 36 seconds, which averages to 5.14 messages per second over a 60 second period.

Condition 4

Squitter Rates for Aircraft Not Transmitting Target State and Status Message when a Mode A Code Change Occurs

<u>Squitter Type</u>	<u>Squitter Rate per Second</u>
Position	2
Velocity	2
Aircraft Identification and Category	0.2
Periodic Status	
Operational Status	0.4
Event Driven	1.25
Total	5.85

This occurs for 24 seconds and then the aircraft transmits 4.8 messages per second for 36 seconds, which averages to 5.22 messages per second over a 60 second period.

Condition 5

Squitter Rates for Aircraft Transmitting Target State and Status Message When a Mode A Code Change Occurs

<u>Squitter Type</u>	<u>Squitter Rate per Second</u>
Position	2
Velocity	2
Aircraft Identification and Category	0.2
Periodic Status	
Operational Status	0.4
Target State and Status	0.8
Event Driven	1.25
Total	6.65

This occurs for 24 seconds and then the aircraft transmits 5.6 messages per second for 36 seconds, which averages to 6.02 messages per second over a 60 second period.

As shown in Conditions 4 and 5, when a Mode A code change occurs, the transmit rate averages 5.22 or 6.02 messages per second depending upon the aircraft installation.

Condition 6

Squitter Rates for Aircraft Not Transmitting Target State and Status Message and an Emergency occurs or TCAS Resolution Advisory (RA) is Active

<u>Squitter Type</u>	<u>Squitter Rate per Second</u>
Position	2
Velocity	2
Aircraft Identification and Category	0.2
Periodic Status	
Operational Status	0.4
Event Driven	1.25
Total	5.85

The emergency duration is unknown, so worst case is 5.85 messages per second averaged over 60 seconds.

Condition 7

Squitter Rates for Aircraft Transmitting Target State and Status Message and an Emergency occurs or TCAS RA is Active

<u>Squitter Type</u>	<u>Squitter Rate per Second</u>
Position	2
Velocity	2
Aircraft Identification and Category	0.2
Periodic Status	
Operational Status	0.4
Target State and Status	0.8
Event Driven	1.25
Total	6.65

The emergency duration is unknown, so worst case is 6.65 messages per second averaged over 60 seconds.

As shown in Conditions 6 and 7, when an emergency or TCAS RA is active, the transmit rate averages 5.85 or 6.65 messages per second depending upon the aircraft installation. These conditions are rare and limited to aircraft engaged in an emergency or TCAS RA.

Condition 8

Squitter Rates for Aircraft Not Transmitting Target State and Status Message, a NIC Supplement, NAC or SIL Change occurs, experiencing an Emergency, and a TCAS RA is Active

<u>Squitter Type</u>	<u>Squitter Rate per Second</u>
Position	2
Velocity	2
Aircraft Identification and Category	0.2
Periodic Status	
Operational Status	1.25
Event Driven	2
Total	7.45

This occurs for 24 seconds and then the aircraft transmits 6.6 messages per second for 36 seconds, which averages to 6.94 messages per second over 60 seconds.

Condition 9

Squitter Rates for Aircraft Transmitting Target State and Status Message, experiencing an Emergency, and TCAS RA is Active

<u>Squitter Type</u>	<u>Squitter Rate per Second</u>
Position	2
Velocity	2
Aircraft Identification and Category	0.2
Periodic Status	
Operational Status	0.4
Target State and Status	0.8
Event Driven	2
Total	7.4

The duration of the emergency is unknown, so the worst case is 7.4 messages per second over a 60 second period.

Conditions 8 and 9 represent the highest possible transmission rate RTCA/DO260B would allow. They are worst case scenarios and the occurrence would be very rare as an aircraft would be engaged in both an emergency and have an active TCAS RA. When an emergency and TCAS RA is active, the transmit rate averages 6.94 or 7.4 messages per second depending upon the aircraft installation.

Condition 10

Peak Message Rate per Second for Aircraft Not Transmitting Target State and Status Message

<u>Squitter Type</u>	<u>Squitter Rate per Second</u>
Position	3
Velocity	3
Aircraft Identification and Category	1
Periodic Status	
Operational Status	2
Event Driven	2
Total	11

Condition 11

Peak Message Rate per Second for Aircraft Transmitting Target State and Status Message

<u>Squitter Type</u>	<u>Squitter Rate per Second</u>
Position	3
Velocity	3
Aircraft Identification and Category	1
Periodic Status	
Operational Status	1
Target State and Status	1
Event Driven	2
Total	11

The totals in Conditions 10 and 11 represent the worst case peak message rate that a DO-260B transponder could transmit in one second. This provides a good peak value to go along with the average message rate over 60 seconds.

3. Proposed DO-181D and ED-73C Change

To comply with the ICAO 6.2 maximum squitter rate requirement, as the analysis for system performance modeling was based on this assumption, and recognizing that the ability to exceed 6.2 per second on rare occasions is now possible due to the DO-260B changes, the proposal to the ICAO WG in October 2010 was to modify the 6.2 messages per second requirement to "6.2 messages per second averaged over any 60 second interval." This change was recommended by the ASP through FLIMSY ASP06-01 and accepted by RTCA and EUROCAE.

In RTCA/DO-181D Change 1 §2.2.23.4, the proposal was to amend the maximum transmission rate as follows:

“The maximum total number of Extended Squitters (DF=17, 18 or 19) emitted by any Extended Squitter installation shall not exceed 6.2 per second **averaged over any 60 second interval.**”

Since the 6.2 messages per second over 60 seconds is exceeded only when an emergency or TCAS RA with unknown duration, an all encompassing requirement would need to allow for these rare conditions. The ASP WG reviewed this language and decided the exceptions need to be included for clarity and completeness.

This working paper proposes the following changes be made in DO-181D and ED-73C:

The maximum total number of full power Extended Squitters (DF=17, 18 and 19) emitted by any Extended Squitter installation shall not exceed:

- (1) 6.2 messages per second averaged over 60 seconds for nominal aircraft operation with no emergency and no TCAS RA activity; or
- (2) 7.4 messages per second averaged over 60 seconds under an emergency and/or TCAS RA condition; and
- (3) 11 messages transmitted in any one second period.

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