242A-WP-11-04
Version 4.1, Jan. 23, 2002

RTCA SC-186
Work Group 3

Proposed Approach for 1090 MHz Extended Squitter to Accommodate New Requirements for Intent Information

Prepared by Ron Jones, FAA, ASD-140

Summary

The proposed changes to the ADS-B MASPS for the broadcast of intent information will need to be finalized for the ballot version of DO-242A in March 2002. Two key areas for which the requirements need further investigation is the rate at which the receiving application requires updates of TSRs, TCR and TCR+1 reports. The other is what is the minimum set of parameters required for each report type. This paper includes proposals for how 1090 MHz Extended Squitter avionics could support the revised requirements for intent reporting. Also attached is a copy of a draft working paper for Working Group 6 that makes proposals for the update rate requirements for reports of intent information and recommends an approach for specifying the minimum set of data parameters.

Reference: RTCA Paper #377-01/SC-186-184, Proposed ADS-B MASPS Revisions: Intent Information Broadcast, Version 3.0, December 2001

Attachment: Draft working paper for SC-186/WG6

1. Background

The referenced paper that was produced by WG6 and presented to SC-186 plenary in December 2001, included in section 10, under "Minimum Intent Report Requirements" a section on "Transmission Update Requirements." While for a given ADS-B link, the associated MOPS will need to define the transmission rates for each of the various ADS-B reports, the ADS-B MASPS must remain independent of the ADS-B link technologies. Therefore, the MASPS requirement must be expressed in terms of the effective update rate requirement as viewed by the receiving system. Since the application that is using the intent information to support an operational capability is on the aircraft that is receiving the ADS-B reports, this is consistent with the MASPS stating the requirements in terms of the effective received update rate. This is the approach that was taken with the update rate requirements in the current DO-242.

The following material proposes changes for DO-260A that are aligned with the most recent proposal being offered to WG6 for the MASPS requirements associated with intent report update rates.

2. Discussion

A proposal has been forthcoming to WG6 to require TSR reception at an air-to-air range of 40 nmi. with 50 nmi. desired for Class A2 avionics. The update rate requirements that have been proposed are a nominal rate of 12 seconds at 95% probability at an air-to-air range of 20 nmi. and at ranges beyond 20 nmi. the nominal update rate would be no faster than 12 seconds but would decrease to 18 seconds at 40 nmi. according to the formula 0.45 x Range. In effect requiring a 12 second update rate out to 27 nmi. then linearly decreasing to 18 sec. at 40 nmi. As a further condition the update rate following a significant change in the information being conveyed in a TSR would need to be received within 12 seconds even at the 40 nmi. air-to-air range. Requirements for TSR beyond 40 nmi. would only apply to Class A3 avionics and are being debated by WG6. The update rates for TCR and TCR+1 are still being debated by WG6 at the time this paper was being drafted. The revision A of the ADS-B MASPS may include a range of possible update rates and indicate that further validation is required to settle on an appropriate value for TCR. It not expected that the link MOPS will include the specific provisions for TCR or TCR+1 in the next update. However, TCR may be addressed in an appendix to the link MOPS (e.g., DO-260A).

The current DO-260 broadcast rate requirements for intent (i.e., TCP and TCP+1) information are shown below in Table 1:

TABLE 1

DO-260 TCP requirements	TCP rate	TCP+1 rate	**Total Rate (squitters/sec)**
broadcast interval	1.700	1.700	
broadcast squitters/sec.	0.588	0.588	**1.176**

The proposal in the referenced RTCA working paper #377-01/SC-186-184 included three types of intent reports (TSR, TCR and TCR+1). It appears that a TSR could be broadcast within a single squitter, but TCR and TCR+1 each probably require more data elements than could be accommodated in a single squitter. WG6 is still reviewing the minimum required elements for TCR and TCR+1 and it not yet possible to determine with any degree of certainty the number of bits required to encode these messages. A preliminary review of the proposed TCR report contents, from the referenced working paper and a review of the most recent proposal from Tony Warren to WG6 on the reporting rate requirements for TCR and TCR+1 could result in a requirement for 400% to 500% the amount of intent information that needs to be conveyed per unit of time as compared to the current DO-242 requirement for TCP plus TCP+1. This represents a substantial new requirement for the ADS-B links and could have a significant impact on the link MOPS and could perhaps delay the introduction of ADS-B in general. This can be expected to have an impact on the overall capacity of the system in terms of the maximum aircraft density supported and the effective air-to-air range of the system. However, the degree of this impact will depend on the percentage of aircraft that are actually transmitting TCR and TCR+1 at any give time.

One significant consideration of accommodating TSR, TCR and TCR+1 within 1090 MHz. Extended Squitter MOPS should be to either keep the total allowed peak squitter rate at approximately the same as currently defined (i.e., 6.2 squitters per second) or to seek approval from ICAO and RTCA for allowing a higher peak total squitter rate. If for the moment we consider just the near-term requirement to accommodate TSR in the 1090 extended squitter MOPS then no increase to the total authorized peak squitter rate are proposed. Since the specific provisions for TCR and TCR+1 are longer-term considerations, this will allow time to coordinate on the need for increasing the allowed peak squitter rate if necessary.

If TSR were broadcast using the squitters previously allocated for both TCP and TCP+1 this would provide TSR broadcasts at a nominal interval of 0.85 seconds (or 1.176 TSR squitters per second).

The consequence of applying the above TSR squitter transmission rate and of also satisfying the proposed MASPS requirements for received TSR update rates would be a need to achieve the individual squitter reception probabilities shown in Table 2 below.

TABLE 2

a-a range	Required per Squitter Reception Probability	
	TSR (nominal)	TSR (Peak)
20 nmi.	0.191	0.191
40 nmi.	0.132	0.191

The probabilities shown in Table 2 above are for 95% probability of reception a TSR squitters are based on the formula: $P_{squitter} = 1 - (0.05)^{1/N}$. Where $P_{squitter}$ is the probability of individual squitter reception and N is the number of squitter transmissions within the required update interval. The required reception probabilities under this above scenario would be similar at ranges up to 40 nmi. as compared to the reception probability necessary to satisfy the original TCP reception requirements of DO-242. However, the impact on the 1090ES system would be to require for TSR the full capacity previously specified for both TCP and TCP+1. This is consequence of requiring a 12 second update rate at 40 nmi. for TSR as compared to a 24 second update rate requirement for TCP at that same range.

The above approach for supporting TSR within 1090ES MOPS would leave no spare capacity to support TCR or TCR+1 without a change to the 1090ES design. The two alternatives available would be either to reduce the rate at which state vector information is transmitted (as least when TCR is present) or to seek approval to allow the use of a higher total peak rate for squitter transmission for those aircraft capable of reporting TCR and TCR+1. The first approach would require a change to the Mode S transponder MOPS and SARPs while the second approach would require approval from ICAO, RTCA and the FAA spectrum office. The timescale for the first approach would probably be shorter than the second. Once the requirements for TCR and TCR+1 are validated and we have a more mature operational concept of what aircraft are expected to be capable of broadcasting TCR and when, then a decision will need to be made as the preferred approach to accommodate these new requirements. Given that it is likely that no aircraft will be equipped with a FMS capable of providing the source data required for TCR for perhaps a decade, the urgency to adding specific provisions for TCR to the link MOPS is minimal.

3. Proposal

WG3 is invited to review and endorse the above proposal to accommodate TSR in DO-260A. Further it is proposed that TSR be defined for now and leave the definition of the requirements for TCR and TCR+1 for a longer-term update to the extended squitter MOPS. This would allow time for the validation of the MASPS provisions.

If this proposal is accepted by WG3, then WG3 is invited to undertake coordination with WG6 to confirm the provisions for intent reporting in DO-260A will be limited to TSR with a possible appendix on TCR describing the possible approaches for the future accommodation of TCR once the TCR requirements are mature and validated.