RTCA Special Committee 186, Working Group 3

ADS-B 1090 MOPS

Meeting 6

Proposal to Define 1090 MHz ADS-B Receiver Classes Requiring Enhanced Reception

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Summary

Analysis of the data collected by the FAA during evaluations of 1090 MHz Extended Squitters in Los Angles and Frankfurt, Germany clearly indicate that the effective range of the 1090 MHz ADS-B systems can be significantly reduced by the presence of very high levels of Mode A/C fruit. It is clear from both measurement results and from modeling of the 1090 MHz ADS-B system that enhanced reception methods, providing performance at least similar that that afforded by the enhanced decoding technique detailed in appendix I of DO-260A, will be necessary in order for the 1090 MHz ADS-B system to fully satisfy the DO-242 requirements. Therefore, it is proposed to amend the draft DO-260A to include a means of designating, for purposes of certification, those avionics that incorporate 1090 MHz receivers that employ suitable enhanced reception techniques. This change will facilitate the certification of 1090 MHz ADS-B avionics for supporting such application as Separation Assurance and Sequencing even in the highest traffic density and highest 1090 MHz Mode A/C fruit environments.

References:

SC-186/1090-WP-5-07, “A Comparison of Different Methods of Enhanced Reception”, John Van Dongen, July 10, 2001

DOT/FAA/ND-01/1, “Measurement of the 1090 MHz Extended Squitter Performance and the 1030/1090 MHz Environment in Frankfurt, Germany”, Joint FAA/DFS/Eurocontrol Report, May 4, 2001

1. Background

John Van Dongen reported to WG-3 in Working Paper 5-07 (reference 1) on the relative performance of 4 alternative enhanced methods of 1090 MHz Extended Squitter reception. For this comparison he used approximately 5 minutes of video waveform data recorded by the FAA during the evaluation of 1090 MHz Extended Squitter performance in Frankfurt, Germany. The time period associated with the selected data corresponds to the period of the poorest reception performance recorded during the evaluations in Frankfurt. Working Paper 5-07 clearly showed substantial variations in performance among the reception methods evaluated. In addition, reference 2 included an evaluation of the performance of a conventional 1090 MHz Mode S decoder, as typical of a classic TCAS receiver, as compared to the performance measured with the UPSAT LDPU 1090 MHz receiver and for the 'Gold Standard' enhanced reception method as described in the draft DO-260A. The same approximately 5 minute period from the Frankfurt data set was used for this comparison. Figure 4.7-1 and 4.7-3 from reference 2 are provided below.

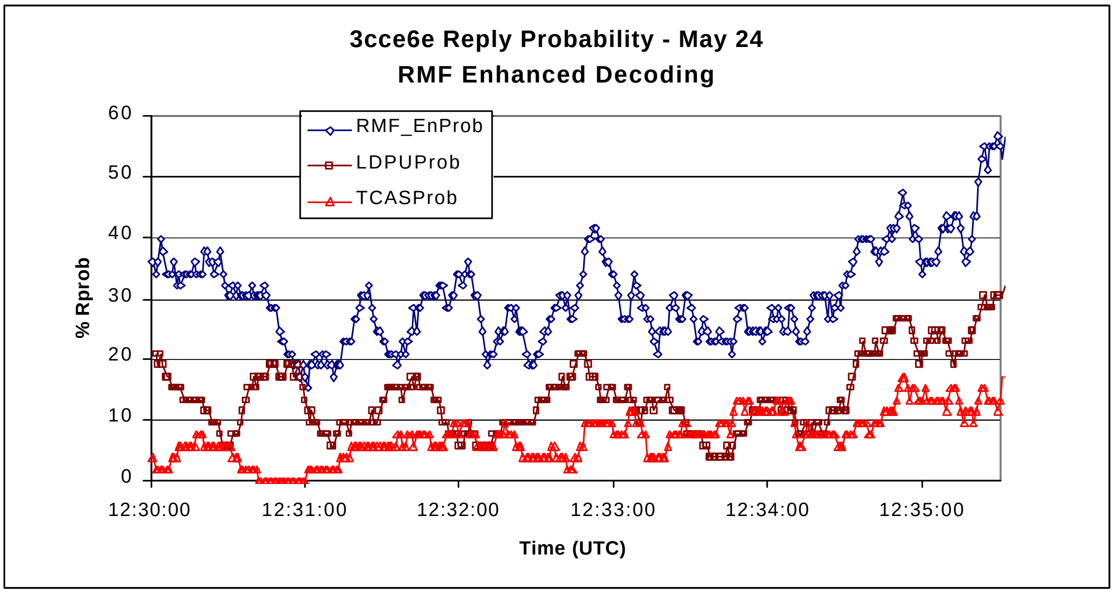

Figure 4.7-1. Comparison of LDPU against Enhanced Reception Techniques and TCAS Reception Techniques

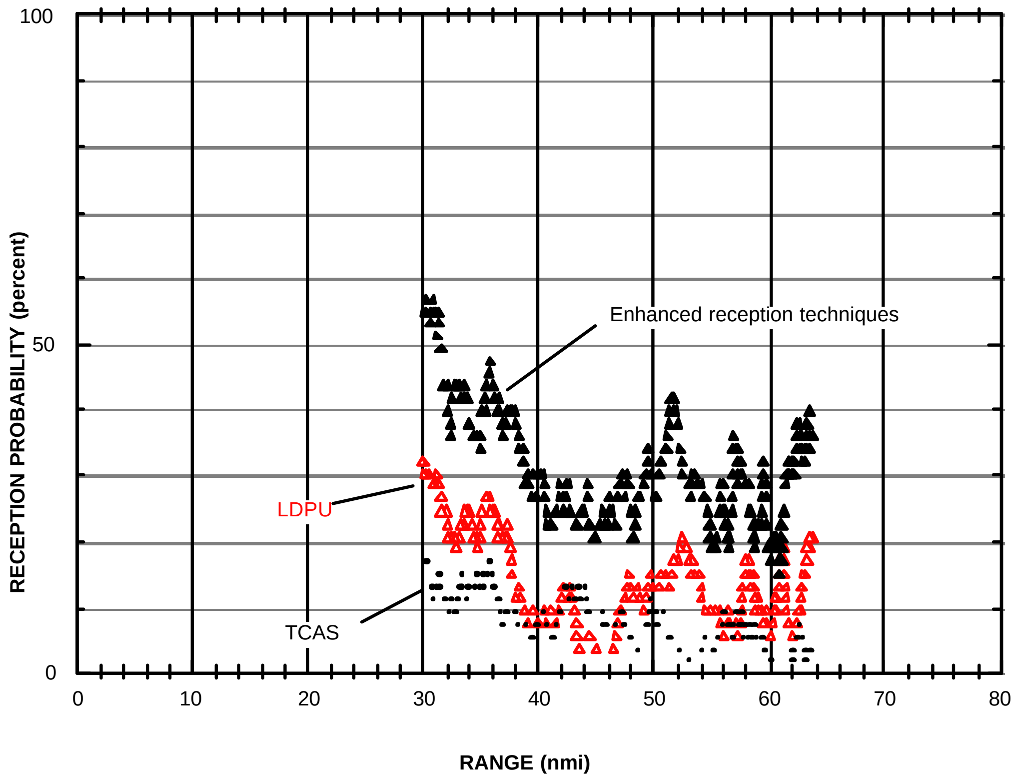

Figure 4.7-3. Enhanced Performance as a Function of Range, 24 May

2. Discussion

The most demanding application (in terms of air-to-air range) defined by DO-242 that is applicable to high-density airspace is for Separation Assurance and Sequencing. This application requires an air-to-air range of $\leq$ 40 NM. In addition to reception of the target aircraft state vectors, DO-242 also requires reception of the first TCP with an update rate of 24 seconds at 95% probability at the maximum range of 40 NM. As detailed in section 6.1.6.1 of reference 2, this requires a 19.2% probability of individual squitter reception. As shown in the second of the figures presented in section 1 above, for the worst case period observed during the Frankfurt evaluation, the classic TCAS reception technique could not have satisfied this requirement, even at 30 NM. (the lower range limit of this data set). The enhanced reception method used by the LDPU (probably using a center sample technique), could only satisfy the MASPS requirements at ranges of less than approximately 38 NM. However the use of the "Gold Standard" enhanced reception technique as described in DO-260Acould have satisfied the reception performance requirement at target ranges well beyond those required by the DO-242 (on the order of 60 NM) for Separation Assurance and Sequencing application.

The 1090 MHz Mode A/C fruit levels during this time interval were approximately 30,000 per second, which corresponds to a level of approximately 150% of what was observed by the FAA during the data collection in Los Angles in 1999. However, the actual worst-case fruit level in Los Angles today may be greater than what was observed during the limited data collection periods recorded in 1999.

Furthermore, as the traffic levels in southern California increase over the next decade or two, the 1090 MHz fruit levels may approach the levels already being experienced in Frankfurt, Germany.

It is clear from the measured results that in a high 1090 MHz fruit environment the air-to-air range is limited not so much by the receiver's MTL but to a large degree by the characteristics of decoding technique employed in the 1090 MHz receiver. In order for the FAA to be able to certify 1090 MHz ADS-B receivers as being compatible with specific ADS-B applications and specific ATC operations, there must be a means to distinguish those avionics that incorporate Extended Squitter receivers that are capable of providing the performance compatible with the application requirements from those that are not. Neither the current DO-260 nor the draft DO-260A offer this opportunity.

3. Proposal

It is proposed to modify Table 2-5 as shown below to define enhanced classes of 1090 MHz ADS-B receivers and to note the limitations of the receivers that do not incorporate the enhanced reception techniques.

Table 2-5 ADS-B Class A Receiver Equipment To Report Coverage

RECEIVER CLASS	MINIMUM TRIGGER THRESHOLD LEVEL (MTL)	RECEPTION TECHNIQUE	OPERATION	MASPS REQUIREMENT (RTCA/DO-242)	MINIMUM REPORT REQUIRED
A_0 (Basic VFR)	-72 dBm	Standard	♦ Aid to Visual Acquisition ♦ Airport Surface	SV	ADS-B State Vector Report (per Section 2.2.8.1)
A_1 (Basic IFR)	-74 dBm	Standard	♦ Aid to Visual Acquisition ♦ Conflict Avoidance ♦ Simultaneous Approaches ♦ Airport Surface	SV $MS\text{-}P_{IFR}$	ADS-B State Vector Report (per Section 2.2.8.1) AND ADS-B Mode Status Report (per Section 2.2.8.2)
A_2 (Enhanced IFR)	-79 dBm	Standard	♦ Aid to Visual Acquisition ♦ Conflict Avoidance ♦ Separation Assurance and Sequencing* ♦ Simultaneous Approaches ♦ Airport Surface * may be restricted to exclude use in or near certain very high traffic density terminal areas	SV MS	ADS-B State Vector Report (per Section 2.2.8.1) AND ADS-B Mode Status Report (per Section 2.2.8.2)
A_{2E} (Enhanced IFR with enhanced reception)	-79 dBm	Enhanced (per section tbd)	♦ Aid to Visual Acquisition ♦ Conflict Avoidance ♦ Separation Assurance and Sequencing ♦ Simultaneous Approaches ♦ Airport Surface	SV MS	ADS-B State Vector Report (per Section 2.2.8.1) AND ADS-B Mode Status Report (per Section 2.2.8.2)
A_3 (Extended Capability)	-84 dBm	Standard	♦ Aid to Visual Acquisition ♦ Conflict Avoidance ♦ Separation Assurance and Sequencing* ♦ Flight Path Deconfliction Planning* ♦ Simultaneous Approaches ♦ Airport Surface * may be restricted to exclude use in or near certain very high traffic density terminal areas	SV MS OC	ADS-B State Vector Report (per Section 2.2.8.1) AND ADS-B Mode Status Report (per Section 2.2.8.2) AND ADS-B TCP+1 Report (per Section 2.2.8.3)
A_{3E} (Extended Capability with enhanced reception)	-84 dBm	Enhanced (per section tbd)	♦ Aid to Visual Acquisition ♦ Conflict Avoidance ♦ Separation Assurance and Sequencing ♦ Flight Path Deconfliction Planning ♦ Simultaneous Approaches ♦ Airport Surface	SV MS OC	ADS-B State Vector Report (per Section 2.2.8.1) AND ADS-B Mode Status Report (per Section 2.2.8.2) AND ADS-B TCP+1 Report (per Section 2.2.8.3)