RTCA Special Committee 186, Working Group 3

ADS-B 1090 MOPS, Revision A

Meeting #14

Enhanced Surveillance Processing Test Procedures Performance Data Revision

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SUMMARY

This Working Paper contains revised Enhanced Reception Test Procedures performance data. The data contained in this paper replaces data previously presented as part of Working Paper 1090-WP-12-10. The data was processed with the revised Enhanced Decoder software that uses the techniques as they are now defined in the revised Appendix I. This Working Paper is intended to support establishing the success criteria for the Enhanced Reception Test Procedures.

This Working Paper contains the results from running the enhanced reception test procedures with the revised RMF enhanced reception software. The software algorithms were modified to work as they are defined in the revised Appendix I. It is critical that the text in Appendix I accurately reflects the established Enhanced Reception Techniques and that there are no key elements of the implemented techniques that are not included in Appendix I. The revisions can be grouped into three categories:

1. The Enhanced Preamble Detection process now includes the 1, 3.5, and 4.5 microsecond tests and the consistent power test.

2. Additional tests that terminate processing of the data block early under certain conditions have been eliminated. These conditions were a lack of pulses for a parameter number of consecutive bits, and/or exceeding a parameter number of low confidence bits. These tests actually impeded extended squitter reception.

3. The DF code Filter was eliminated. There was a test of the first 2 bits (MSB's) of the DF code that, of those that are declared with high confidence if a binary '10' can not be declared, processing was terminated. This test as applied did not provide significant benefit.

Enhanced Reception Test Procedure Data

The following tables are from the Enhanced Reception Test Procedures and are filled in to contain the revised measured results. Following the tables are a plot of the test data. The measured performance for A2 and A3 equipment class uses the Baseline enhanced bit and confidence decoding technique and the performance for A1 equipment uses the Center Sample bit and confidence decoding technique.

Note: Tables 2.4.4.4.5.1 and 2.4.4.4.5.1a in 1090-WP-12-10 erroneously contained reception probabilities from the data with the fruit at the same amplitudes instead of with the fruit at multiple amplitudes as is now defined in the test procedures. The data contained in the next 2 tables contains measured performance using the multi-level fruit as well as the revisions identified above.

Table 2.4.4.4.5.1: Success Criteria for Preamble and Data Block Tests with Mode A/C Fruit – A2 and A3 Equipment Class

Number of Fruit	**1**	**2**	**3**	**4**	**5**
	.97	.96	.95	.9	.89
Minimum Probability	*TBD*	*TBD*	*TBD*	*TBD*	*TBD*
Max Undetected Errors	1	1	1	1	1

Table 2.4.4.4.5.1a: Success Criteria for Preamble and Data Block Tests with Mode A/C Fruit – A1 Equipment Class

Number of Fruit	**1**	**2**	**3**
	.94	.67	.55
Minimum Probability	*TBD*	*TBD*	*TBD*
Max Undetected Errors	1	1	1

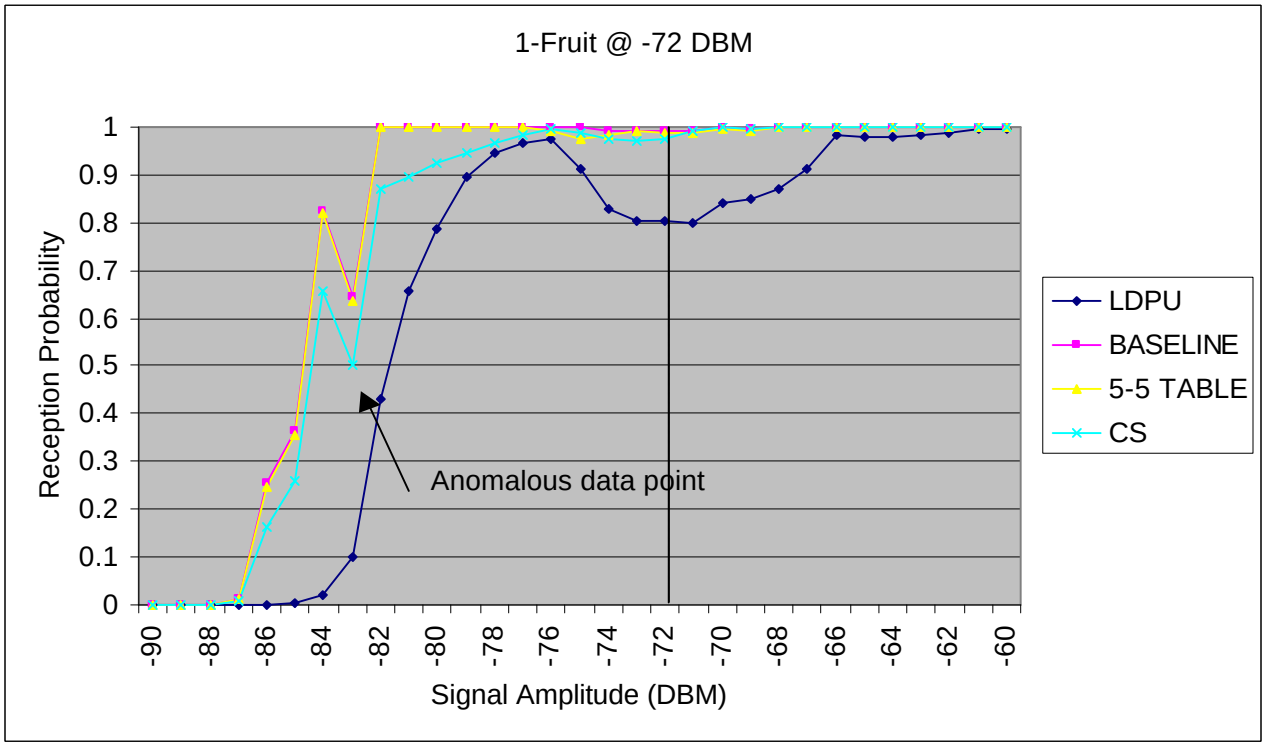

Figure 1. Preamble and Data Block Tests with 1 Mode A/C Fruit.

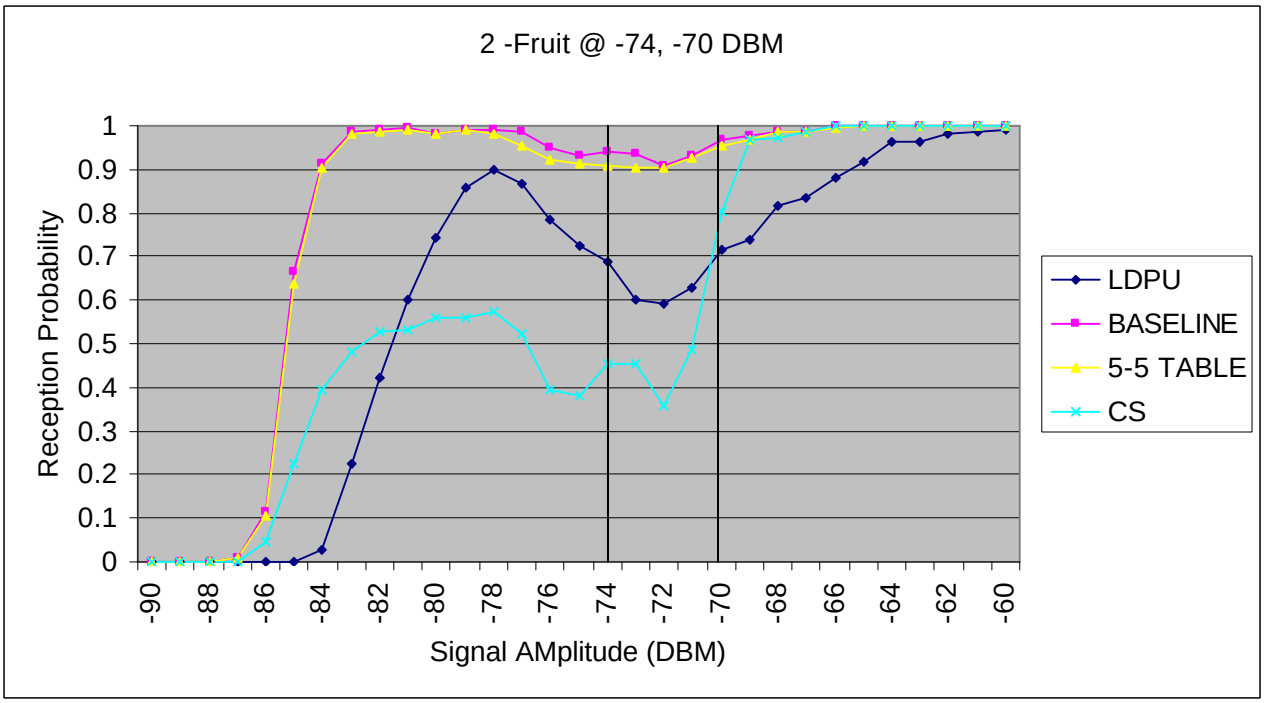

Figure 2. Preamble and Data Block Tests with 2 Mode A/C Fruit.

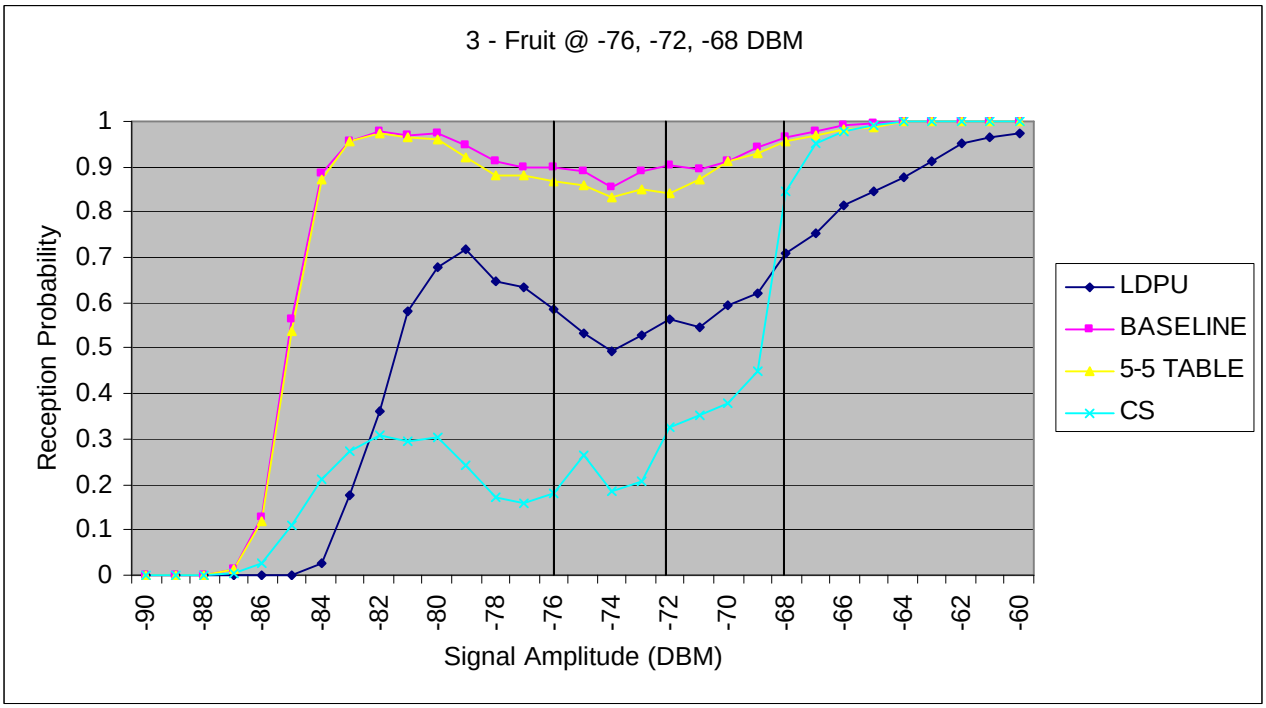

Figure 3. Preamble and Data Block Tests with 3 Mode A/C Fruit.

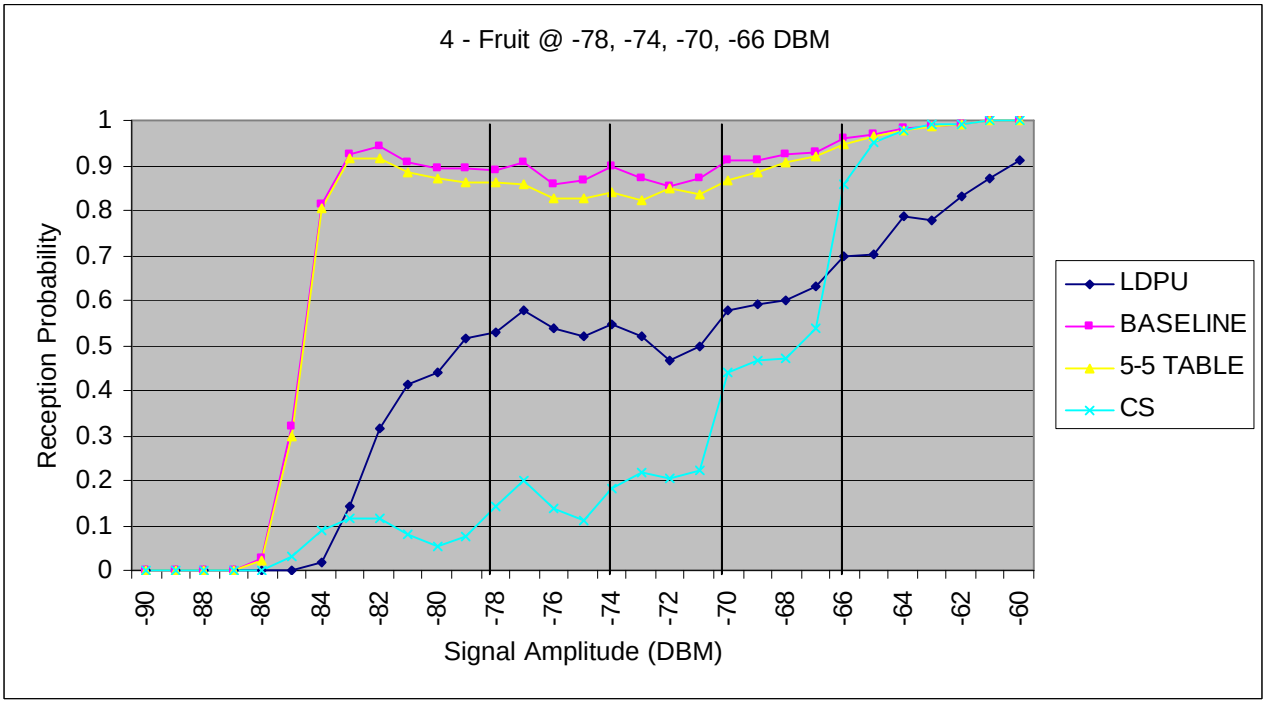

Figure 4. Preamble and Data Block Tests with 4 Mode A/C Fruit.

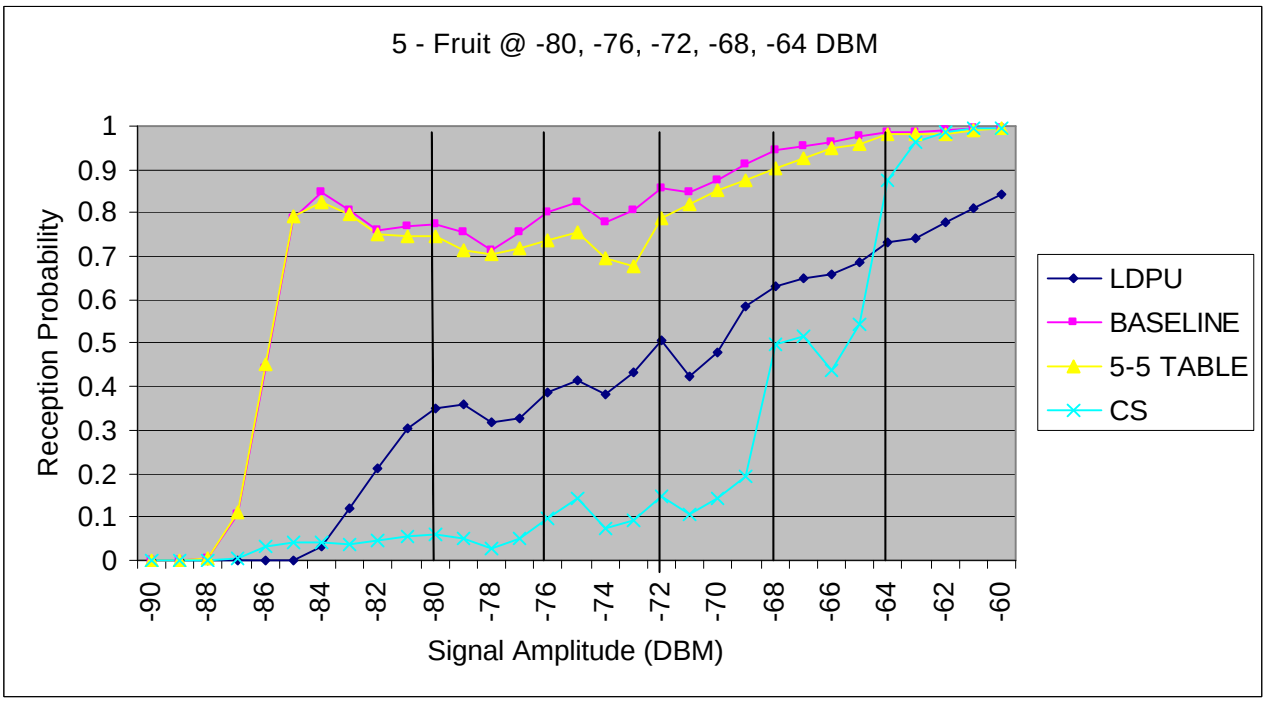

Figure 5. Preamble and Data Block Tests with 5 Mode A/C Fruit.

The revised data block tests with Mode S fruit show a surprising result. The center sample technique outperforms the multiple sample techniques. This is especially evident in the graph showing the data in 1 dB steps. This shift in performance was due to the removal of the low confidence bit filter. A large number of the now successfully decoded messages have a high occurrence of low confidence bits (as high as 86% low confidence). With previously presented data, most of these messages were suppressed by a filter allowing only messages with fewer than 13 low confidence bits to pass.

The center sample technique advantage only occurs when a message encounters only fruit that is lower in amplitude but within 3 dB of the signal. When all, or nearly all of the samples for a given bit are within the + or – 3 dB window because of fruit, the bit is declared low confidence and the bit value is declared depending on the demodulation technique being applied. In this case, the center sample technique declares the bit based on the chip with higher amplitude. With the data block tests with Mode S fruit, under these conditions the chip with the higher amplitude usually belongs to the transmitted signal. The baseline multiple sample technique defaults to a bit value of zero under these conditions. A potential improvement could be made to both the center sample and baseline techniques by setting the bit value based on the chip that most closely matches the reference level amplitude. It would be difficult to modify the table lookup method since the bit value is based on the contents of the table.

Table 2.4.4.4.6.1: Success Criteria for Data Block Tests with Mode S Fruit

Relative Power, (S/I) dB	**0**		**+4**		**+8**		**+12**	
	.01	0	.59	.52	.99	1	1	1
Equipment Class	A1	A2, A3	A1	A2, A3	A1	A2, A3	A1	A2, A3
Minimum Probability	*TBD*	*TBD*	*TBD*	*TBD*	*TBD*	*TBD*	*TBD*	*TBD*
Max Undetected Errors	1		1		1		1	

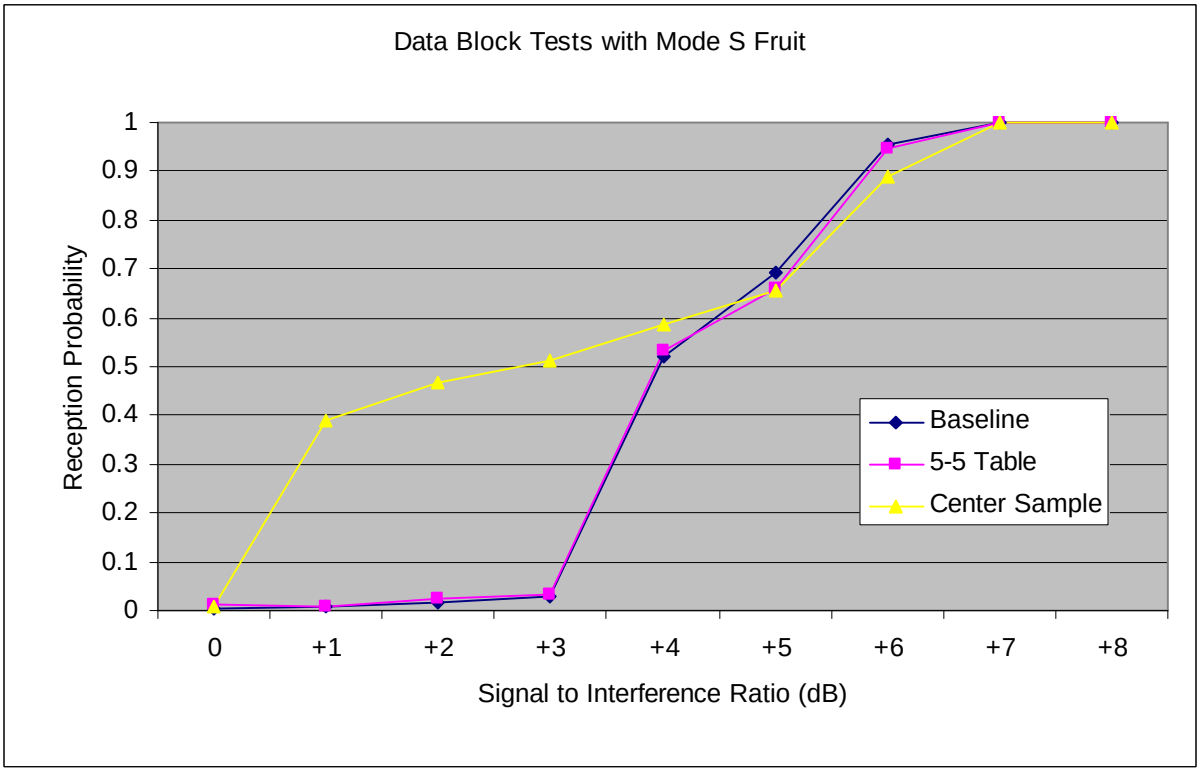

Figure 6. Data Block Tests with Mode S Fruit.

Table 2.4.4.4.7.1: Success Criteria for Re-triggering Test with Varying Position Mode S Fruit

Relative Power, (S/I) dB	**+4**		**+8**		**+12**	
	.13	.13	.74	.93	.96	.99
Equipment Class	A1	A2, A3	A1	A2, A3	A1	A2, A3
Minimum Probability	*TBD*	*TBD*	*TBD*	*TBD*	*TBD*	*TBD*
Max Undetected Errors	1		1		1	

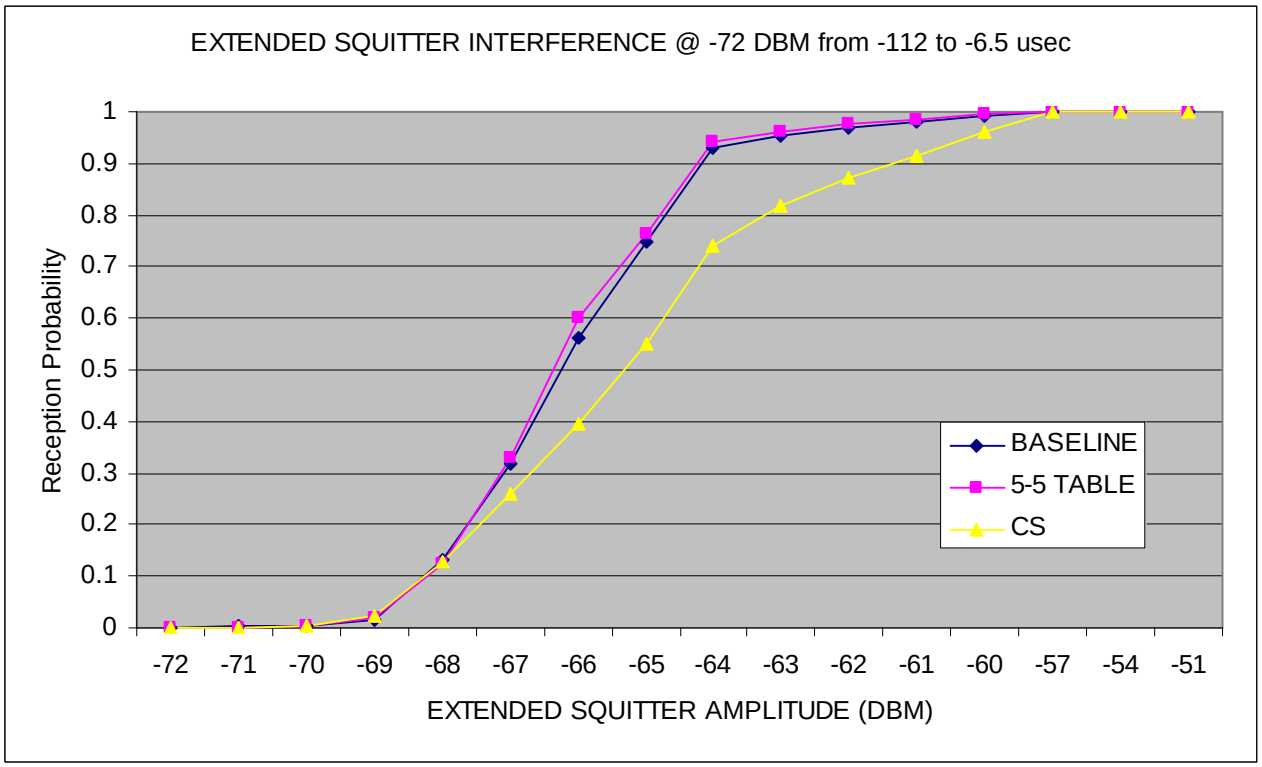

Figure 7. Re-triggering test with varying position Mode S Fruit.

Table 2.4.4.4.7.2: Success Criteria for Re-triggering Test with Fixed Position Mode S Fruit

Relative Power, (S/I) dB	**+4**		**+8**		**+12**	
	.02	.28	.52	.98	.92	.99
Equipment Class	A1	A2, A3	A1	A2, A3	A1	A2, A3
Minimum Probability	*TBD*	*TBD*	*TBD*	*TBD*	*TBD*	*TBD*
Max Undetected Errors	1		1		1	

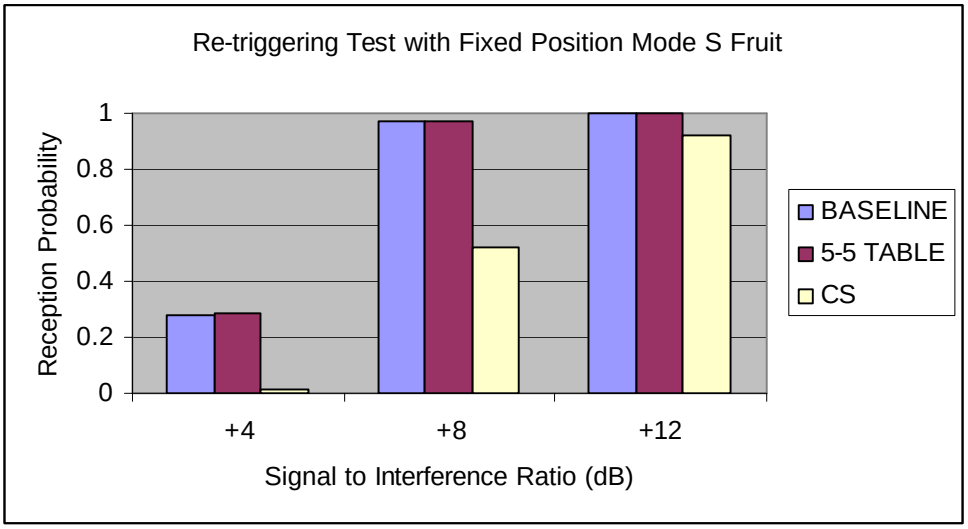

Figure 8. Re-triggering test with fixed position Mode S Fruit.