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ADS-B 1090 MOPS

Meeting #10

Test Results of an Investigation of Re-triggering Performance with the Enhanced Reception Techniques and LDPU

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SUMMARY

This paper contains the results of tests that were run to measure the reception performance of the Gold Standard Enhanced Reception technique and that of the LDPU under conditions that require the receiver to re-trigger. This paper also details a modification that was made to the Gold Standard to improve re-triggering performance. In addition, the Mode S data block tests were repeated and compared to the LDPU.

Retriggering Performance Investigation

Tests were conducted with the RMF Gold Standard and the LDPU to investigate the probability of reception of a 1090 MHz extended squitter signal in the presence of Mode S interference. The primary focus was with the interference preceding the extended squitter thus requiring the receiver to re-trigger to receive the extended squitter. In addition, the Data Block Tests with Mode S fruit were repeated to include the measured LDPU performance. The tests were conducted using the same test configuration that has been used for the enhanced surveillance test procedure data that has been presented to RTCA Special Committee 186, Working Group 3. The RMF Gold standard technique used for this data is the multi-sampling technique without look-up tables that was recently added to the draft 1090 MOPS rev. A. However, the Gold Standard technique includes a modification to the re-triggering logic that was made for these tests. The modification and the reason for it will be discussed later. Figure 1 shows the measured performance of the RMF Gold standard, RMF Center Sample, LDPU performance, and the APL model from the Johns Hopkins APL 1090 Receiver Performance Monitoring: LDPU MER Estimation Errors December 27, 2000.

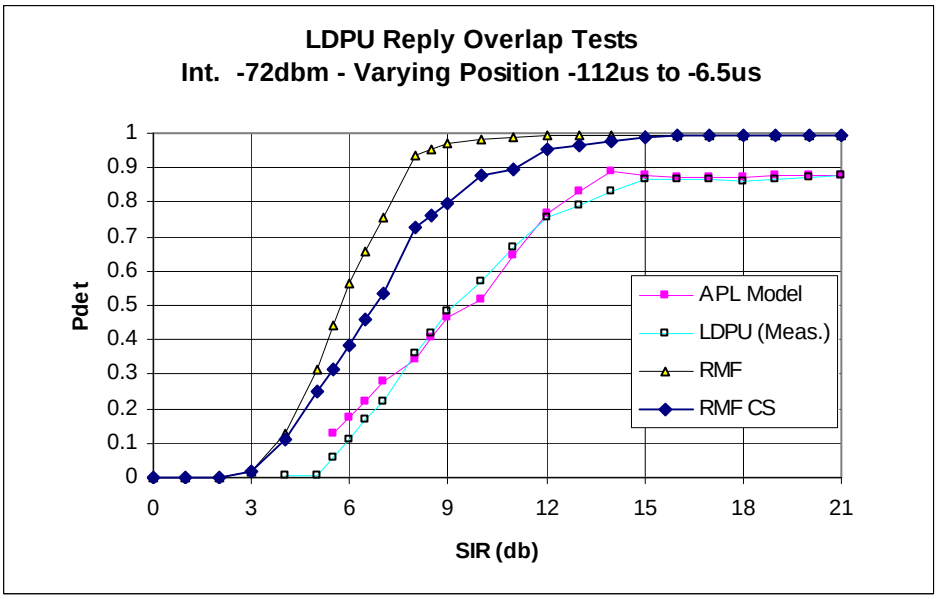

Figure 1 – Reception Performance in the Presence of Mode S Interference Preceding the Extended Squitter.

The data in Figure 1 shows the performance with a 112-bit Mode S fruit signal varying in position from –112 to –6.5 microseconds (P1 lead edge to P1 lead edge) with respect to the extended squitter. The signal to interference ratio was varied as indicated by the X-axis and there were 1000 messages sent per data point. This test measures the ability to re-trigger from a lower level message in progress. With all of the test data presented in this document, the interfering signal is a 112-bit Mode S signal that alternates between DF 20 and 21 with otherwise random content. The desired signal is an extended squitter alternating between DF 17 and 18 with a fixed ICAO address (to facilitate data analysis) and a valid fixed type code with all other subfields with random content.

Figure 2 shows the results of running the Data Block Tests with Mode S Fruit as defined in the draft Enhanced Surveillance Processing Test Procedures except that the test was expanded to run in 1 dB SIR steps. Here, the fruit was varied in position from +8 to +90 microseconds (P1 lead edge to P1 lead edge). In this case the re-triggering mechanism is not being tested but the ability to properly decode in the presence of low-level Mode S fruit.

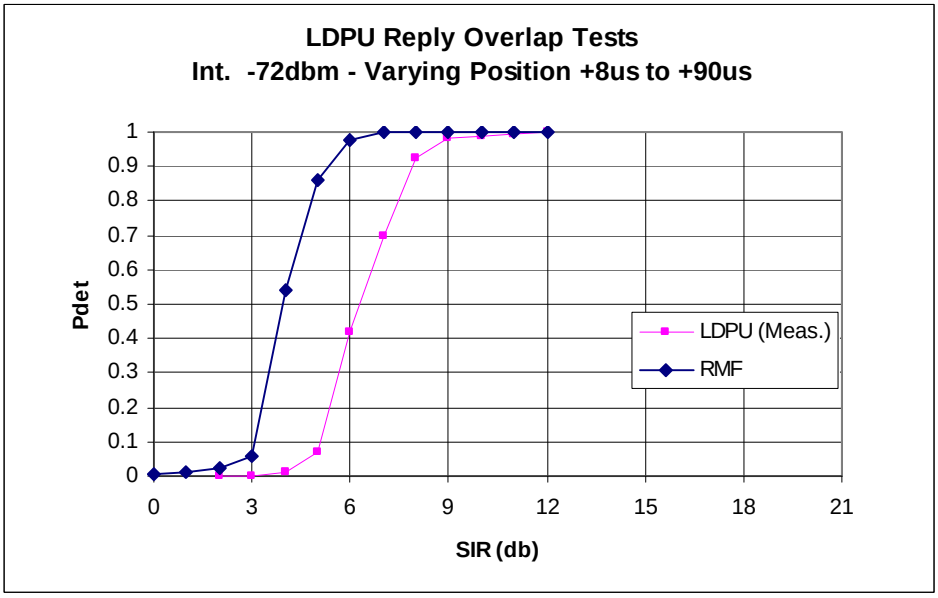

Figure 2 – Reception Performance with Data Block Tests with Mode S Fruit.

Figure 3 shows the results of another method of testing the ability of the decoder to re-trigger. Here the interference precedes the desired signal. With this series of tests, there were 13 test groups conducted, one with no interference and the remaining 12 with a 112-bit Mode S signal beginning at a fixed position indicated by the x-axis labels. The interference amplitude was fixed at –72 DBM for all test points while the desired signal amplitude was set as indicated by the legend. Figure 4 shows the equivalent plot for the LDPU data. An extra test point with SIR at 18 dB was added for the LDPU. Even with a SIR of 18 dB, the LDPU does not achieve a 90% reply rate. Also, with the LDPU loses the ability to re-trigger when the signal is somewhere less than 10 microseconds of a preceding trigger.

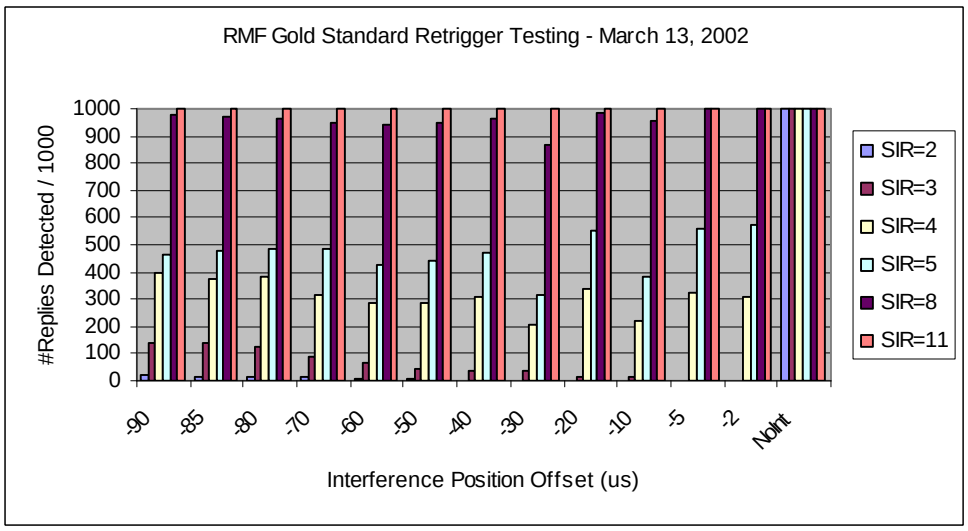

Figure 3 – RMF Gold Standard Enhanced Reception Performance in the Presence of Mode S Fruit Preceding the Desired Signal

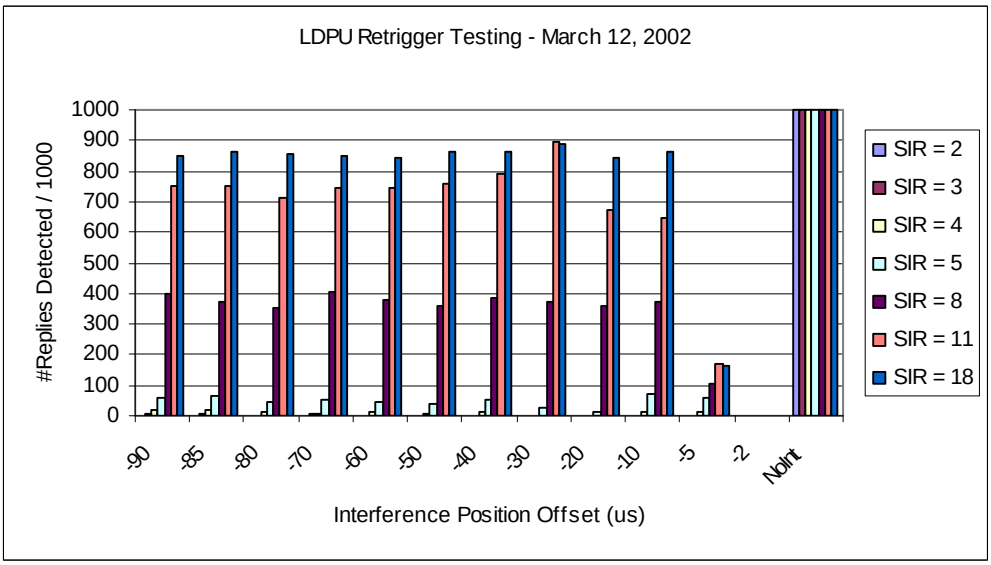

Figure 4 – LDPU Reception Performance in the Presence of Mode S Fruit Preceding the Desired Signal

Gold Standard Re-triggering Modification

During preliminary testing, it was discovered that the Gold Standard reception performance was not as expected with the re-triggering test series. Figure 5 shows these preliminary results.

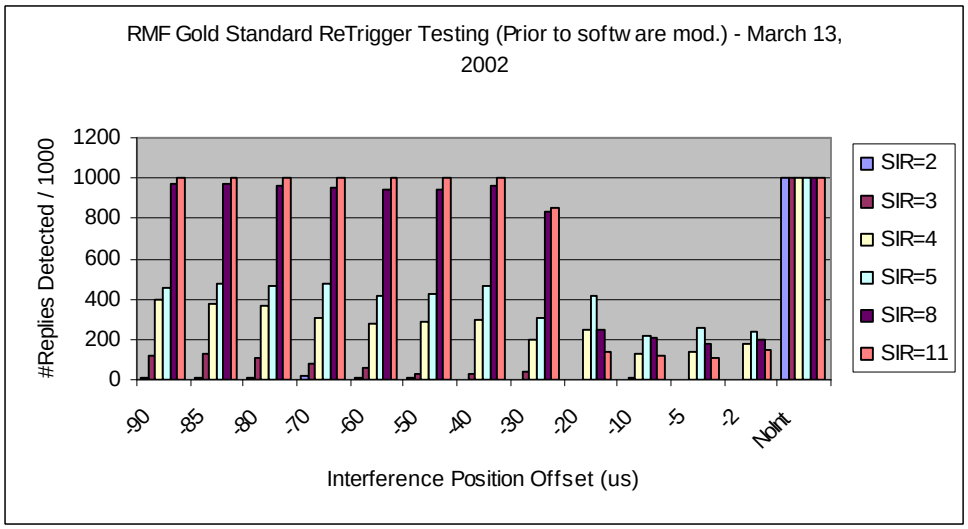

Figure 5 – RMF Gold Standard Enhanced Reception Performance in the Presence of Mode S Fruit Preceding the Desired Signal Prior to Re-triggering Software Modification

The data in Figure 5 shows an obvious degradation in performance when the interference is within 30 microseconds of the desired signal. This was caused by a flaw with the amplitude comparison in the re-trigger process. The Gold Standard establishes two amplitudes for each message that is processed, one of which is the reference level based on the preamble, and the other is a reference level based on the entire data block. The reference level based on the data block was originally added for environment analysis purposes because it is usually a more accurate determination of signal level. Prior to the modification, the re-triggering logic would compare the preamble reference level and the first five data bits of the new signal with the reference level from the data block of the signal in process. When a large part of the interfering signal is overlapped by the stronger extended squitter, the data block amplitude algorithm switches to the dominant amplitude resulting in the data block amplitude of the interference to equate to the amplitude of the extended squitter. When this occurs, re-triggering can not occur. The software was modified to use the preamble reference level for comparison. The modified version is also consistent with the recommended method in the MOPS Appendix I.

Noise Test

The performance in the presence of high level noise test was not conducted as yet due to equipment unavailability and lower priority. The relevance of this test to the subject of the data in this report is questionable and unless otherwise directed will be omitted.