RTCA Special Committee 186, Working Group 3

ADS-B 1090 MOPS, Revision A

Meeting #4

Use of DMTL in preamble detection
Action Item 3-9

Presented by William Harman

SUMMARY:

Analysis by John Van Dongen has led to a suggestion for use of DMTL during preamble validation. This would be a change from the design as currently given in MOPS Appendix I. At the last WG-3 meeting I was asked to discuss this proposal with Jeff Gertz, who was the originator of the enhanced reception techniques.

Jeff told me that he considered this issue previously, and that he concluded that reception would be better if DMTL were not used during the preamble validation step. Jeff noted that the avionics implementation would be more difficult using the proposed change.

On the other hand, Jeff recognizes the value in John's more recent work. Jeff's opinion, in summary, is that the original design is reasonable, and should be allowed by the MOPS, whereas the modified design may also be reasonable, and probably should also be allowed.

Use of DMTL in preamble detection

John Van Dongen has performed a substantial analysis of Extended Squitter reception, particularly using data recorded airborne in Frankfurt, Germany. In doing this work, John has implemented the specifics of the reception techniques, which are defined in MOPS Appendix I. John's work also included several variations in the reception techniques, exploring sensitivity to different design alternatives. These studies have led to a proposed design change in which Dynamic Minimum Triggering Level (DMTL) is used during Preamble Validation.

To understand the change John is proposing, note that Appendix I (ref. section I.4.1.2.2) describes preamble detection as a three-step process:

(1) Raw Preamble Detection
(2) Preamble Validation (using the first 5 data bits)
(3) Reference Level Generation (estimates received power level)

It is useful to estimate the received power level of the particular Extended Squitter currently being received, for use in demodulation of the data bits and confidence bits. Given the order of these three steps, the power level estimate is not available at the time of Preamble Validation. Therefore very weak receptions can have an effect of the Preamble Validation process.

John's proposal is to reverse the order of (2) and (3), and to use the estimated power level in the Preamble Validation step. The advantage would be that very weak interference pulses would be eliminated by DMTL from having an effect on Preamble Validation.

For consideration of these issues, it may be useful to refer to the accompanying figure, which shows the waveform of a Mode S preamble and the first 5 data bits. This figure also illustrates the possibility of an early detection by 1 microsecond and similarly a late detection by 1 microsecond. These two particular preamble detection errors are noteworthy because when the timing error is 1 microsecond, there is a substantial similarity between the detected signal and the actual signal, a similarity in both the preamble and in the data block. Looking at the case of early preamble detection, note that bit number 1 is a key indication that this is not a valid detection: provided that the 1 microsecond period of bit 1 is empty (having no detected power), then the validation will fail, which is correct. Not using DMTL during this time, as in the original design, leaves the receiver vulnerable to very weak interference that might be received during this time. Using DMTL here, as suggested by John, seems to be an obvious way to improve performance in these cases.

I presented this suggestion to Jeff Gertz, who was the originator of the enhanced reception techniques. Jeff responded that he previously considered this issue, and at that time came to the conclusion that the design is better in form currently given in the MOPS. He added that he thinks there isn't much difference between the two designs. He

pointed out that to perform Preamble Validation (step 2) before Reference Level Generation (step 3) is more readily implemente, because a large number of incorrect detections get eliminated prior to step (3).

Jeff also pointed out that in heavy interference, not only will there be cases when interference pulses fall in the 1 microsecond period before bit 1, but there will also be cases in which interference coincides with bit 1 and reduces its power level as received. When this happens, the use of DMTL can cause a correct preamble detection to fail the validation step. Therefore there is a tradeoff, in which an improvement will occur as a result of one mechanism and a degradation will occur as a result of another mechanism. Given that, and given that the differences are relatively small, Jeff concluded that it's best to carry out the steps in the order given in the MOPS.

As a final note, though, Jeff recognizes that John's recent work is quite thorough, and may be more extensive that Jeff's original work. Therefore John's suggestion should probably be allowed in the MOPS. Jeff still believes the original design is reasonable, and should also be allowed in the MOPS.