RTCA Special Committee 186, Working Group 5

ADS-B UAT MOPS

Meeting #9

Guidance on Range Measurement

Presented by T. Mosher, UPS AT

SUMMARY

This paper presents some guidance on using the UAT datalink ability to measure the range to a target by using the Time of Message Receipt (TOMR) value. If deemed appropriate by WG-5, this material may be expanded into a separate Appendix to the UAT MOPS.

Introduction:
This paper is in general response to the discussions at Meeting #8 (Naval Station Norfolk) regarding whether, or where, should a requirement for anti-spoofing of targets exist in the UAT documentation. It is not likely that approval of any proposed anti-spoofing method could be gained within the desired time frame of MOPS approval. The next best solution is to place some guidance in an Appendix to the MOPS, which could perhaps be incorporated into the body of the MOPS at some future date.

This paper does not attempt a detailed and fully developed presentation of anti-spoofing. The goal is to present the idea for placing guidance on range measurement in an Appendix, with sufficient background material to allow a general discussion to occur.

Time of Message Receipt (TOMR)
Section 2.2.8 of the draft MOPS details the requirements for accuracy and resolution of making the raw measurements on which a range calculation can occur. TOMR is relative to the start of the UTC second, and typically is measured in units of 100 nanoseconds.

The UAT receiver can directly calculate the raw range to the target by knowing how many whole and fractions of an MSO (250 usec) of time elapsed between transmission and receipt of the message. The fractional portion is directly calculated from each SV report received, which gives fine-scale resolution to about 30 meters (1e-7 seconds times 3.0e+8 m/sec). The integer portion provides resolution of about 40.47 nmi.

Acquisition of full TOMR Range
The full TOMR range (integer and fractional parts) can be determined once a Long message containing the Transmission Epoch report has been received (such as the Long Type 1 message). The Transmission Epoch field has sufficient span to unambiguously identify in which MSO the message was transmitted. The receiving UAT can then calculate the integer portion of the TOMR range.

Once the integer part of the TOMR range has been acquired, the fractional portion can be used to maintain a track of the range value during the interval between receipts of the Transmission Epoch.

TOMR Range Filtering
Due to plant noise and other physical effects, one can expect the raw TOMR range values will require some filtering prior to use. An alpha-beta recursive filter can be used to both smooth and predict range values, which allows for uneven time between message receptions (due to dropped messages, etc.).

Correlation of TOMR Range vs. SV-based Range.
The filtered range value includes the slant range effects, and will normally exceed the great-circle range calculated from the SV position of the target and the ownship SV position. The correlation of the target's range will require either some compensation of the great-circle range to include an estimate of the slant range, or a correlation window that has greater tolerance for increased slant range at high elevation angles. Since it is possible that some targets may not be reporting their altitude, provision must be made for cases where slant range compensation is not possible.

One other effect of the TOMR range calculation is that the range measured is based on the time of transmission, while the SV-based range calculation is based on the time of applicability. This can lead to some additional variation between the measured and calculated range, which would be particularly noticeable in head-on encounters at high velocity. For example, at a closing rate of 1200 kts, the range closes at about 620 meters per second. That represents a change in TOMR value of about 20 counts (at 100 nsec per count), if the last possible Tx MSO in a second was used. Some study would be required to determine whether this effect or the slant range issue represents the limiting case on range measurement.

Anti-Spoofing
It is a difficult question of what to do in the case that the target's TOMR range cannot be correlated with its great-circle range. Other than flagging the target to alert the host application (e.g. CDTI or ATC surveillance) that there is some question as to it's veracity, it is not obvious what the appropriate action would be. There is probably no expectation in the CDTI working groups that they would have to depict a "questionable" target, and dropping a potentially malicious target from the traffic file doesn't seem proper, either.

Summary
WG-5 can hopefully use this discussion material develop a recommendation on how to proceed with documentation of the range measurement capability.