RTCA Special Committee 186, Working Group 5

ADS-B UAT MOPS Maintenance

Meeting #26

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Proposed Changes to Appendix K In Response to Action Item 25-03 Revision 1

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Summary
This Working Paper addresses Action Item 25-03 to review UAT-WP25-09 and add more information as an introduction as to why the scenarios were used and specify where in Appendix K to add the information.

K.6 UAT A1S Performance Analysis

A new category of aircraft type has been defined for this version of the MOPS, the A1 single antenna (A1S). The A1S is required to have a medium transmit power as defined in Table 2-2, but it will use a single bottom-mounted antenna. An evaluation of this category of equipage has been performed in a highly stressful environment. The three challenging situations that were specified for this analysis were:

1. A stationary A1S aircraft on the surface of LAX attempting to receive ADS-R being broadcast by the ground infrastructure. A DME/TACAN antenna pattern at low power was used for the ground transmitting antenna. Scenario 1 will focus on surface transmissions from the ground infrastructure, and it is assumed that there is no interference from other ground station transmissions.
2. An A1 aircraft on approach attempting to receive ADS-B transmissions from an A1S aircraft on the surface of a GA airport. An A1 aircraft was chosen, because the alternating receive antenna is expected to provide the worst case. Scenario 2 will include a heavy load of ADS-R and TIS-B transmissions from nearby ground stations.
3. A bottom-mounted A1S banking away from a ground receiver at various bank angles, with various multipath losses. For this scenario, the aircraft is assumed to be moving in a circle with constant speed and bank angle; thus it is always facing away from the ground receive antenna. Scenario 3 will include a heavy load of ground transmissions as receiver blanking of the ground station.

The air traffic scenario used for this analysis is the LA2020 scenario developed for the TLAT. This scenario is based on the LA Basin 1999 maximum estimate. It is assumed that air traffic in this area would increase by a few percent each year until 2020, when it would be 50 % higher than in 1999. The distribution of aircraft in the scenario is based on approximations of measured altitude and range density distributions. For the purposes of this study, it is assumed that UAT comprises all airborne A0 (replaced by A1S for this analysis) and around 65% of airborne A1 aircraft in the scenario, for a total of 1232 aircraft below FL180 and within 400 NM of LAX. In addition, 113 aircraft are located on the ground at LAX and other airports in the region. For the LAX ground scenario, it is assumed that there are 10 ground vehicles equipped with 1090 ES that are being transmitted over UAT via ADS-R. The approach scenario also assumes that there are 3 ground vehicles transmitting directly over UAT.

For A1S equipage, the model simulates transmission and reception on a bottom antenna. When on the surface, aircraft with top antennas transmit from those antennas without switching. The simulation assumes a single multipath ground reflection.

Scenario 1: For this scenario, the ground transmit power was varied between 1 w and 1 kw, and the ranges examined were 1, 3, and 5 NM between ground transmitter and A1S receiver on the ground. It is assumed that there is a single multi-path ground reflection. The values used in the multi-path calculation were provided by Stan Jones of Mitre Corporation [1]. The metric used is the standard 95% update interval. Results are shown in the table below:

Table K-9: 95% Update Interval for Scenario 1 as a Function of Range and Transmit Power

	Ground Transmitter Power				
Range		**1 w**	**10 w**	**100 w**	**1000 w**
	1 NM	**2.0 s**	**1.2 s**	**X**	**X**
	3 NM	**X**	**3.0 s**	**2.0 s**	**X**
	5 NM	**X**	**X**	**6.9 s**	**2.1 s**

In the table above, "X" is used to indicate that this case was not evaluated. These results should be compared to a required 95% update interval of two seconds for the ASSA and FAROA applications (as described in RTCA DO-289). The table indicates that, for a surface separation of no more than one NM, a 1 watt transmitter would meet the two second update interval, while it is likely that a 10 watt transmitter would be needed if the distance were two NM.

Scenario 2: For this scenario (Scenario 2a), there is an A1S on a GA airport surface transmitting ADS-B to an A1 dual-antenna aircraft five miles away on approach to the airport. There is also a high power (100 w) ground transmitter 5 NM from the A1 receiver, which interferes with the reception of transmissions by the A1S on the ground. There is a variable single multipath ground reflection used by the model, since the model itself predicts no multipath effect at 5 NM. The metric used is the standard 95% update interval. Results are shown in the table below:

Table K-10: 95% Update Interval for Scenario 2a as a Function of Multipath Effect and Ground Transmissions

		Number of Ground Station Messages per Second	
		0	**400**
Multipath Effect	**0 dB**	**2.0 s**	**3.4 s**
	-10 dB	**2.1 s**	**4.0 s**
	-20 dB	**6.5 s**	**12.8 s**

These results should be compared to a required 95% update interval of two seconds for the ASSA and FAROA applications.

This scenario (Scenario 2b) was also run for the case of the aircraft on approach three NM away from the airport. The results are shown in the Table below.

Table K-11: 95% Update Interval for Scenario 2b as a Function of Multipath Effect and Ground Transmissions

		Number of Ground Station Messages per Second	
		0	**400**
Multipath Effect	**0 dB**	**2.1 s**	**3.9 s**
	-10 dB	**2.1 s**	**3.9 s**
	-20 dB	**3.0 s**	**5.9 s**

These results should be compared to a required 95% update interval of two seconds for the ASSA and FAROA applications.

Scenario 3: For this scenario, there is an A1S at FL 120 at variable range from a ground receiver. The A1S is banking at a variable angle away from the ground receive antenna. The ground uplink transmissions (0 or 100 uplinks/second) prevent simultaneous reception of the A1S ADS-B transmissions. The ranges examined were 10, 30, and 50 NM.

For all ranges, the A1S achieved a 95% update interval less than three seconds (3 seconds is required in the terminal domain) with no bank angle and no ground uplinks. Adding 100 ground uplinks resulted in an increase in the 95% update interval to around 5 seconds at 10 NM and around 6 seconds at 50 NM. Increasing the bank angle resulted in a gradual increase in update interval up to a critical angle, where the curve experiences a sharp rise (see figure below). The critical angle varies with the range from the receive antenna: a greater range corresponds to a smaller critical angle.

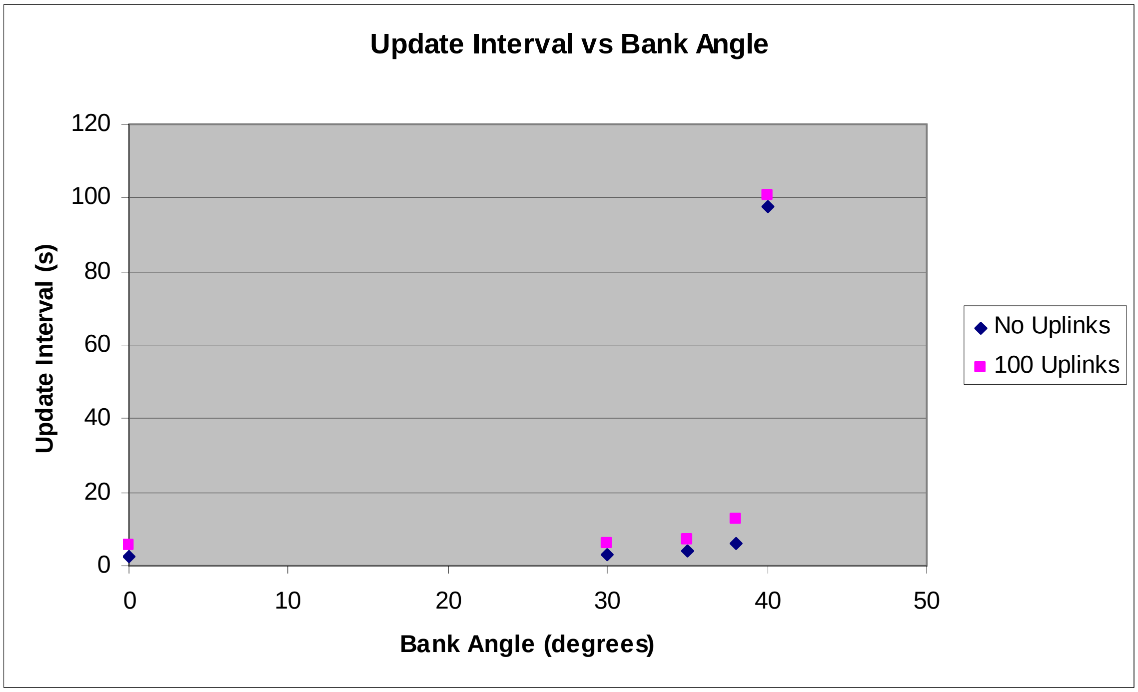

Figure K-131: Typical Result for Scenario 3 for Update Interval as a Function of Bank Angle

Note that the critical angle for the case in Figure K-131 is around 40 degrees. Also, the effect of the addition of 100 uplink transmissions is shown.