RTCA Special Committee 186, Working Group 5

ADS-B UAT MOPS

Meeting #7

Impact of UAT Interference to Currently Operating DME Equipment

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SUMMARY
This analysis is an attempt to use the data that we have available in measurements and simulations to make an initial determination of the impact of UAT interference to currently operating DME equipment. Though limited, the data contains some valuable information.

Introduction/Purpose:

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Procedure:

A number of bench tests have been conducted at the William J. Hughes Technical Center to provide the data necessary to assess the impact of UAT messages on DME operation. The test configuration utilized consisted of a victim DME interrogator connected to a DME ground station simulator and a UAT message source. The DME ground station simulator received interrogations from the DME units under test and transmitted replies as well as unsolicited pulse pairs to closely match the operation of an actual ground interrogator. Since the potential frequencies being considered for UAT will not reside in the interrogation frequency band, the testing was configured with a clear interrogation channel. The UAT frequency was tested co-channel with the DME reply frequency and also located on adjacent DME channels. On the reply channel, every reply was completely overlapped with the same level of UAT interference. This is much more severe than any real world interference environment, but is appropriate for the purposes of bench testing where performance under extreme conditions provides data required to model real world scenario performance. A data point consists of measuring both the interfering signal level that prohibits the DME to acquire a track (Acquire Stable Operating Point (ASOP)) and the level that causes the DME to lose a track that it has already acquired (Break Stable Operating Point—BSOP). In general, it was found that these two levels were separated by about 1dB.

One especially informative measurement was taken where ASOP and BSOP were determined as a function of the reply efficiency of the ground station. The simulator in the test configuration has the capability to randomly reply to 0-100% of the interrogations it receives. The measurements found that the DME interrogator can acquire and track in the presence of the same level of UAT interference as long as at least 30% of its interrogations elicit replies. Each DME model tested could tolerate relatively high amplitude UAT interference; although each unit tolerated a slightly different level of interference, the behavior out to 30% reply efficiency was consistent. This seems to indicate that as long as a DME is able to receive more than 30% of the replies from its interrogations with interference less than the ASOP/BSOP point particular to that DME unit, it should be able to operate.

At the JHU Applied Physics Laboratory, very reliable simulations of UAT and JTIDS environments have been generated. Future UAT interference in Core Europe, as agreed to by international consensus, was simulated and measured at the bottom antenna of a centrally located aircraft, including co-site transmissions, which would block the DME from receiving a pulse pair. JTIDS interference was also simulated and the power levels were adjusted to those seen by a DME. The idea of this analysis is to derive from these simulations and from the reply efficiency tests an idea as to where the DMEs will run into problems trying to operate in the simulated environment.

Results:

Figures 1 through 3 show the results of essentially calculating the distribution of power in time for the given simulated environments. The curves labeled "CDF" are the cumulative distribution function of power. The curves labeled with an equation are the CDF multiplied by 0.7, 70% being the typical reply efficiency of a DME ground beacon. Because the ground segment is different from the air segment, there are some unsavory statistical problems in

associating the scenarios, segmented in time, with the testing, which was continuous in time. There are three sets of curves. Figure 1 leaves the ground segment empty, Figure 2 extrapolates the ADS-B interference into the ground segment, and Figure 3 essentially fills the entire ground segment with interference greater than 60%. Figure 2 is the one that can be best related to the testing done since the interference is statistically homogenous in time.

A point (X, Y) on the red curve gives Y, the percentage of replies to interrogations that arrive at the DME antenna, with overlapping interference at or below X If the interference level at the 30% mark is low enough, that is a good indication that the DME will work ok. For the ADS-B-filled ground segment run, 30% of the DME's interrogations elicit replies overlapped with –104 dBm of interference or less. Even in the worst case, where the ground segment is occupied entirely by interference greater than –60 dBm, 30% of the replies have less than –97 dBm.

The next graphs show the expected performance of each individual DME in the simulated environment. More specifically, the graph tells what percentage of the reply pairs will return with a SIR better than that which was measured on the bench to be the critical level between successful and unsuccessful operation. The x-value corresponding to 30% is the lowest DME signal level we can expect to still allow DME operation. The y-value corresponding to the –83 dBm point is some measure of the margin left for DME to operate with the weakest signal guaranteed by the FAA to provide service. The following table summarizes this result.

	DME-890	KD-7000	KDM-706A	DME-900
30% Signal Level	-100 dBm	-98 dBm	-93 dBm	-102 dBm
-83 dBm %RE	~60%	~60%	~50%	~60%

Conclusions:

From this preliminary sketch drawn from the data we have available today, it seems as though DME should not suffer from any noticeable degradation in performance. For all boxes under test, at the minimum guaranteed FAA signal level, 50-60% of the pulse-pair replies should have acceptable interference levels. The weakest signals for which the DME might still operate are down around sensitivity. Though performance near sensitivity is unpredictable and this last result doesn't necessarily reflect reality, it shows that where DME operation would drop off in the given interference environment is in the noise.

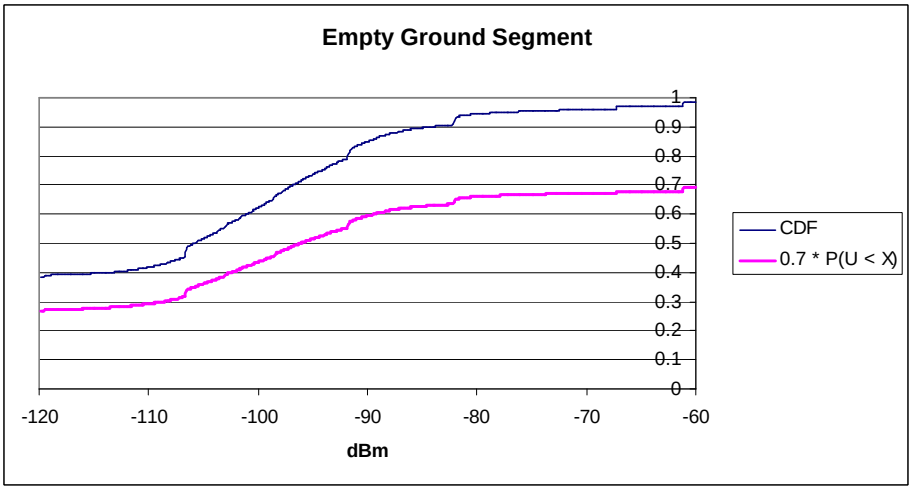

Figure 1.
Ground Segment is interference-free.
30% mark at –108 dBm

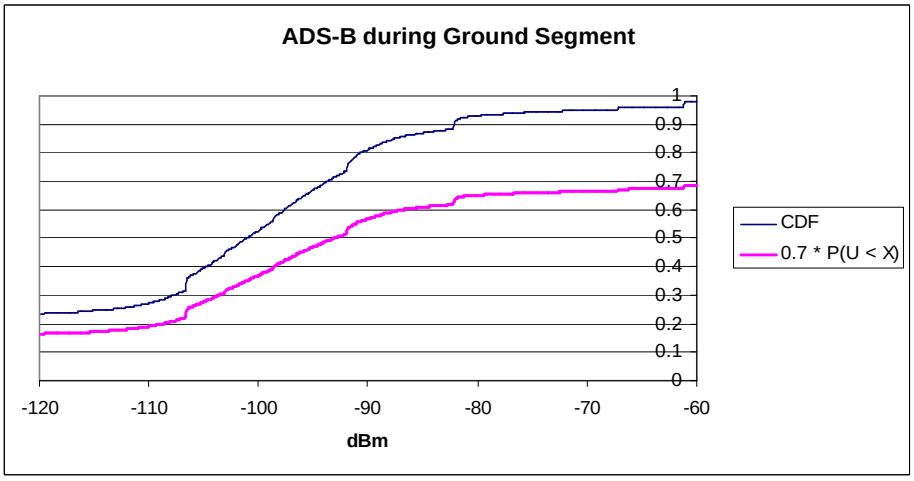

Figure 2
Ground segment interference is the same statistically as the ADS-B segment
30% mark around –104 dBm

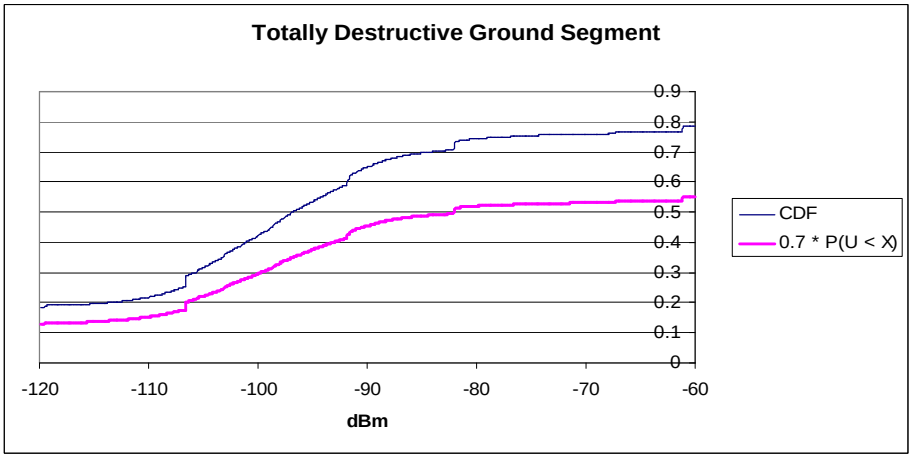

Figure 3
Interference during ground segment is greater than –60 dBm
30% mark around –100 dBm

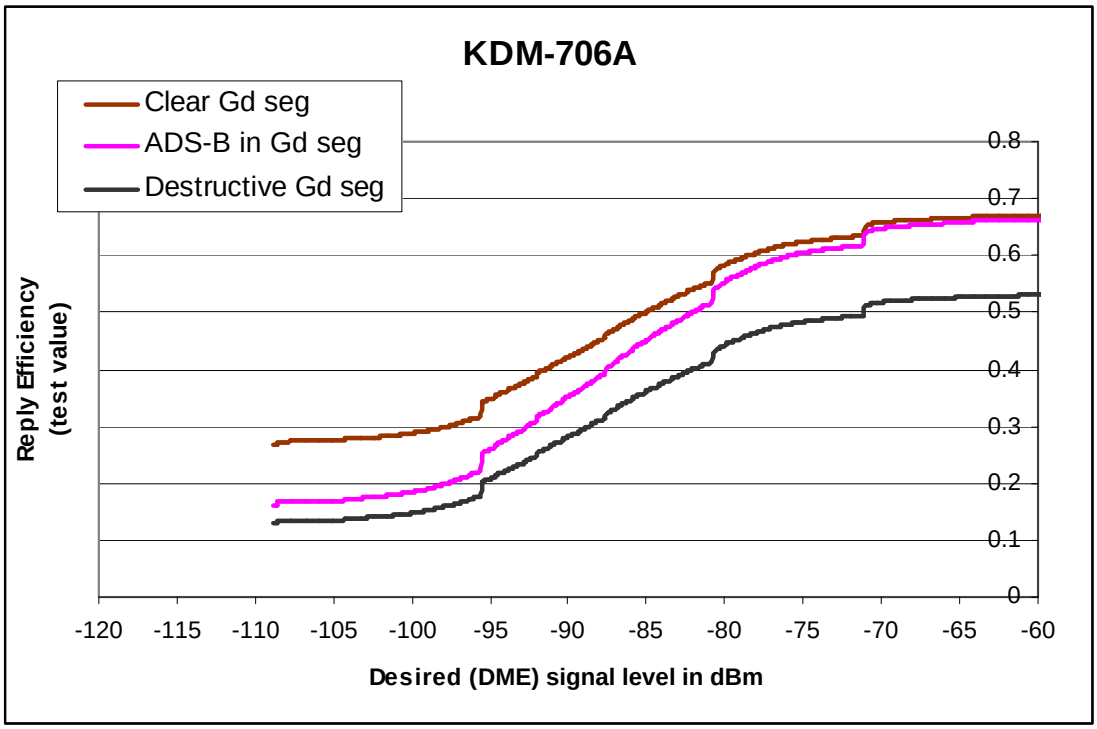

Table 4
-83 dBm point at around 50% for median curve, 40% for worst case

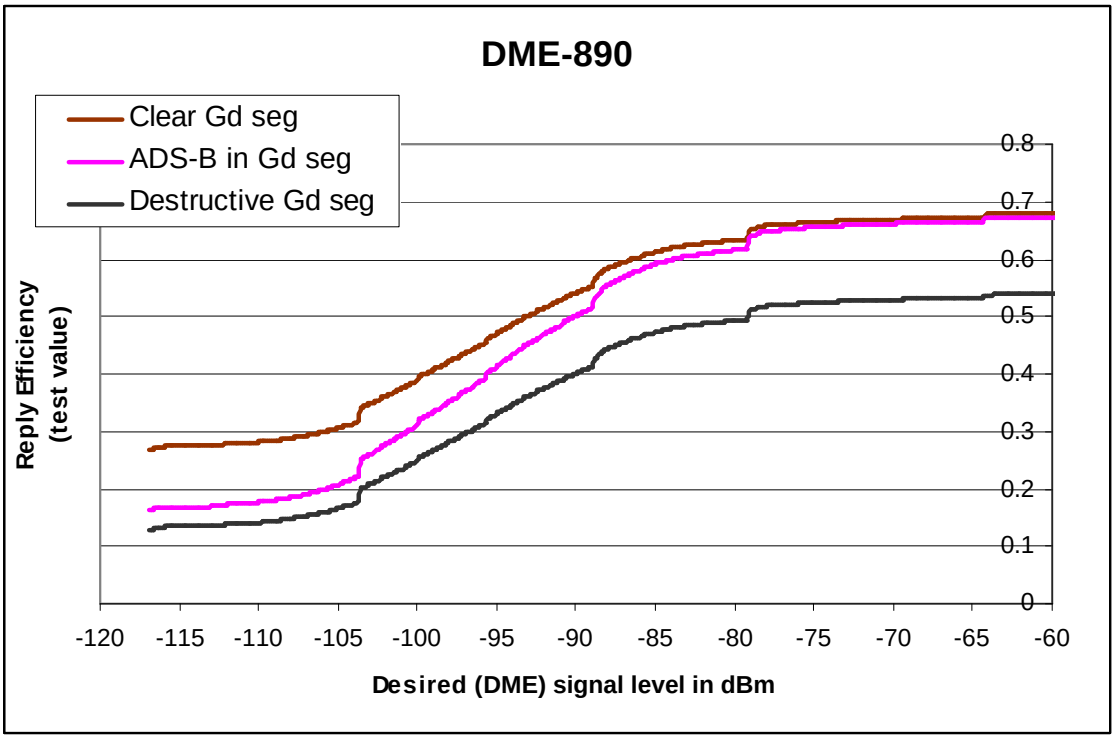

Table 5
-83 dBm point at around 60% for median, 50% for worst case

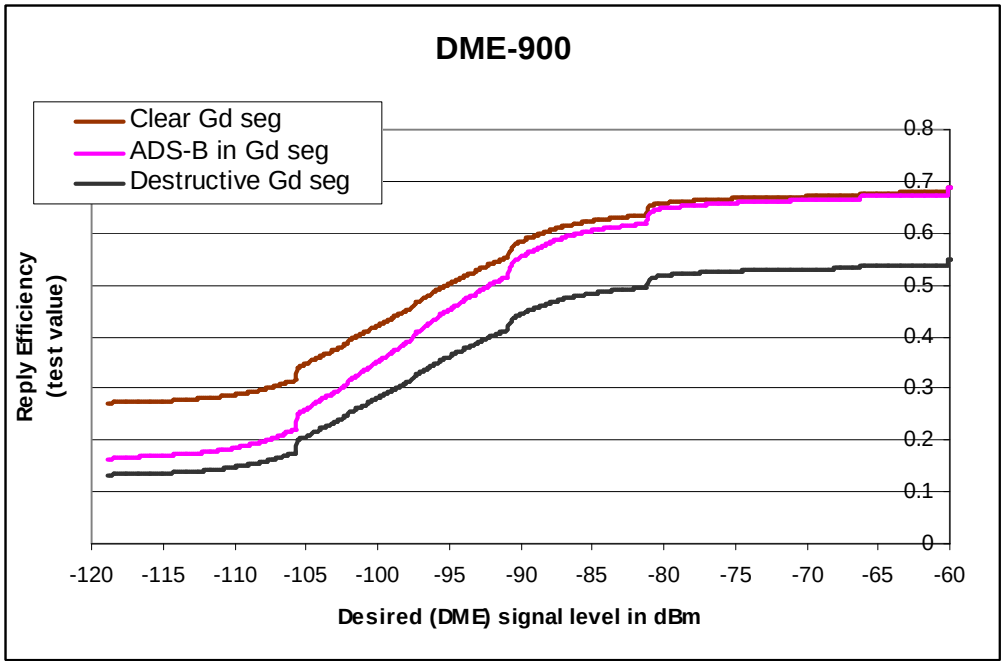

Table 6
-83 dBm point at around 60% median, 50% worst case

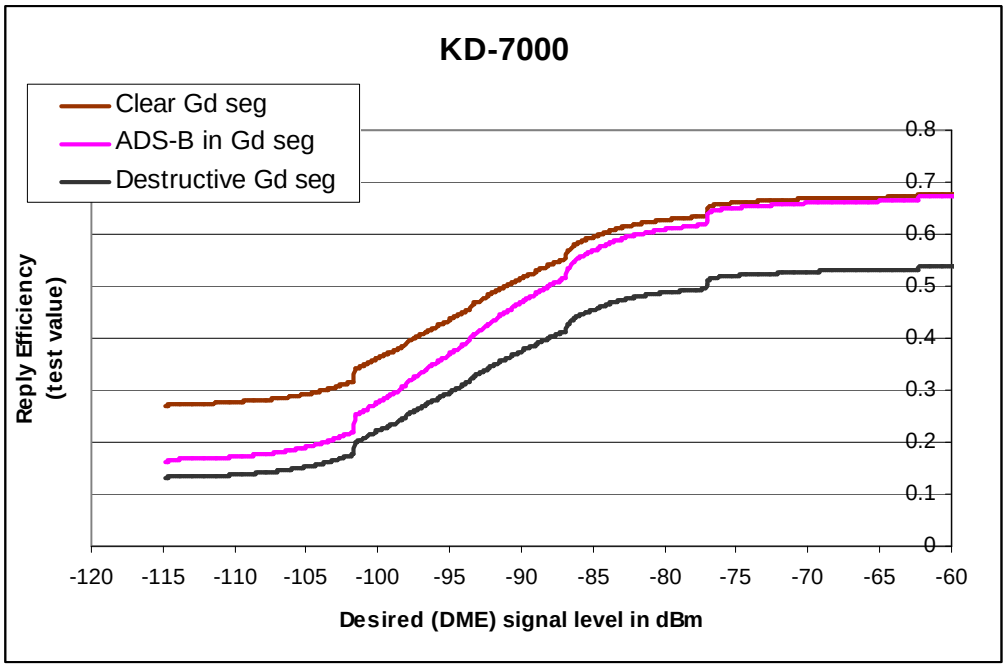

Table 7
-83 dBm point at around 60% median, 50% worst case