

RTCA Special Committee 186, Working Group 5

ADS-B UAT MOPS

Meeting #5

Impact of UAT on DME

Presented by Al Muaddi

SUMMARY



Impact of UAT on DME

Albert B. Muaddi

**The Johns Hopkins University
Applied Physics Laboratory
Laurel, Maryland**



Outline

- Approach
- Model Components
 - UAT Air Segment
 - UAT Ground Segment
 - DME Ground Transponder
 - DME Interrogator (Bendix King KDM-7000)
- Evaluation Scenario
 - LAX 2020
- Experimental Results



Approach

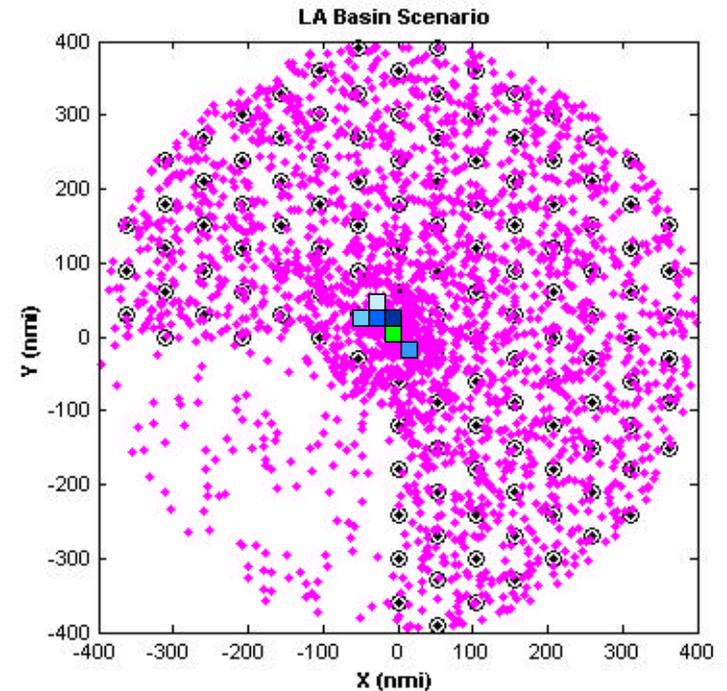
- For the LAX 2020 scenario, place a DME interrogator on an aircraft having a large number of UAT transmitters within sight.
- Simulate transmission of DME interrogations as well as replies to those interrogations from DME ground transponders in the Los Angeles area.
- Simulate UAT interference from UAT ground stations and other aircraft.
- Simulate co-site interference from on-board UAT, 1030, and 1090.
- Model DME interrogator:
 - State transition diagram (states are SEARCH and TRACK)
 - Use data obtained from FAA TC tests to detect pulse-pairs when subject to UAT interference
- Determine fraction of time during which the interrogator is in TRACK state.



LAX 2020 Scenario

- LAX, UAT Ground Stations, UAT Aircraft, and DME Ground Transponders

Location	Latitude/Longitude	(X,Y) [nmi]	Power
■ LAX	335548N, 118240W	0, 0	
■ DME (LA1)	335705N, 1182356W	0.06, 1.28	100 W
■ DME (LA2)	335650N, 1182622W	-1.97, 1.03	100 W
■ DME (Santa Ana)	334055N, 1175145W	26.88, -14.88	100 W
■ DME (Ventura)	340654N, 1190258W	-32.47, 11.10	1 kW
■ DME (Lake Hughes)	344059N, 1183437W	-8.85, 45.18	3.5 kW
⊙ UAT Ground Stations			



Shown above are all UAT ground stations, Aircraft, and DME ground transponders



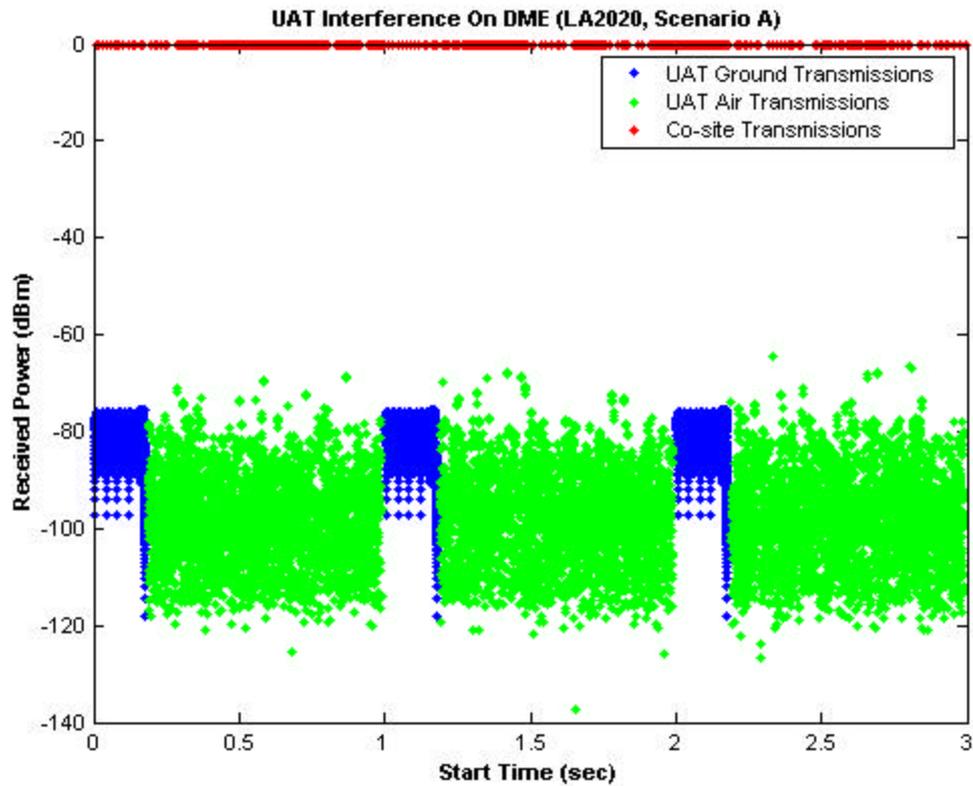
UAT Air and Ground Segments

- UAT Air Segment
 - Selected an aircraft with the greatest number of other aircraft within sight
 - (X,Y,Altitude) = (10.7 nmi, 55.4 nmi, Altitude = 40,000 ft)
 - UAT air transmissions were generated using network model
 - Co-site transmissions (UAT, 1090, 1030) were also generated using network model
- UAT Ground Segment
 - Continuous population of ground stations on a 60 nmi inter-site grid spacing
 - Two categories of slots
 - Long Range Coverage: 25 W, 8 dBi (peak) antenna
 - Local Coverage: 10 W, 0 dBi aircraft-style antenna
 - Ground antenna pattern is identical to DME ground antenna pattern



UAT Interference Timeline

- UAT and Co-site interference timeline





LA 2020 / Scenario A

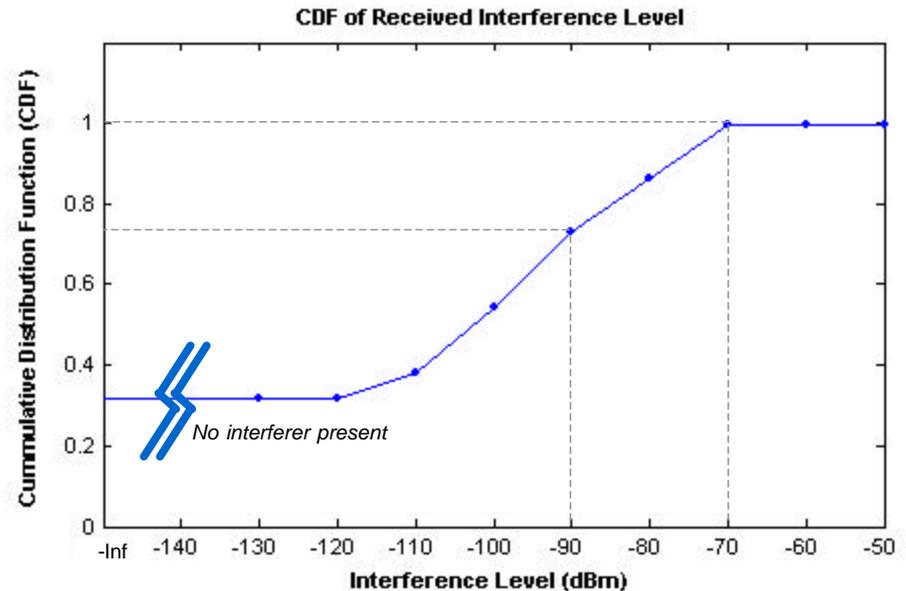
- DME Link Budget Analysis

<i>DME Location (City)</i>	<i>DME Ground Elevation Angle (deg)</i>	<i>DME Ground Antenna Gain (dB)</i>	<i>Range (nmi)</i>	<i>Propagation Loss (dB)</i>	<i>DME Air Elevation Angle (deg)</i>	<i>DME Air Antenna Gain (dB)</i>	<i>Received DME Signal Level (dBm)</i>
Los Angeles 1, CA	6.8	4.4	55.5	-132.5	-6.8	-1.7	-79.9
Los Angeles 2, CA	6.7	4.5	56.2	-132.6	-6.7	-1.8	-79.8
Santa Ana, CA	5.2	7.6	72.4	-134.8	-5.2	-2.0	-79.2
Ventura, CA	6.0	0	62.2	-133.5	-6.0	-1.9	-75.4
Lake Hughes, CA	16.7	0	23.0	-124.8	-16.7	-0.3	-59.7



Distribution of Received UAT Interference Level

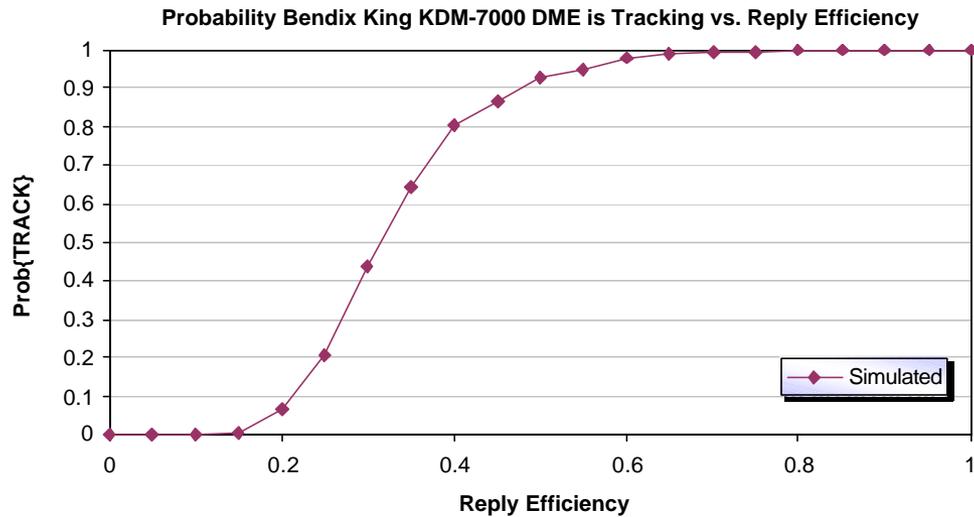
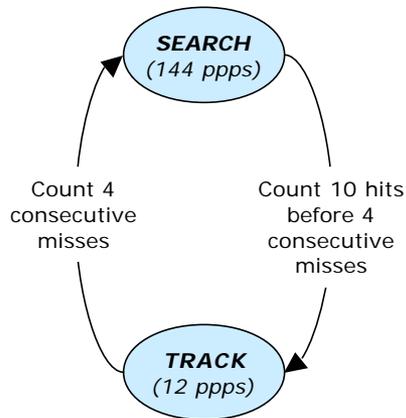
- What fraction of time is channel clear?
- Obtained answer via simulation
 - There are 3200 MSOs
 - 2200 aircraft randomly select a MSO and transmit messages
 - 30% transmit short messages
 - 70% transmit long messages
 - Ignore propagation delays
- Channel is clear **31%** of the time, which is in agreement with CDF of received UAT interference level





Operation of Bendix King KMD-7000 DME Interrogator

- Pulse Repetition Frequency (PRF)
 - Search: 144 ppps
 - Track: 12 ppps (achieved with divide-by-12 counter)
- State Transition Diagram

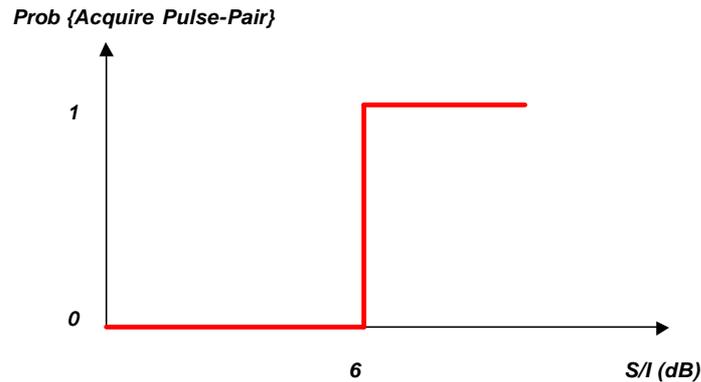


High SNR, High SIR



Bendix-King KD-7000

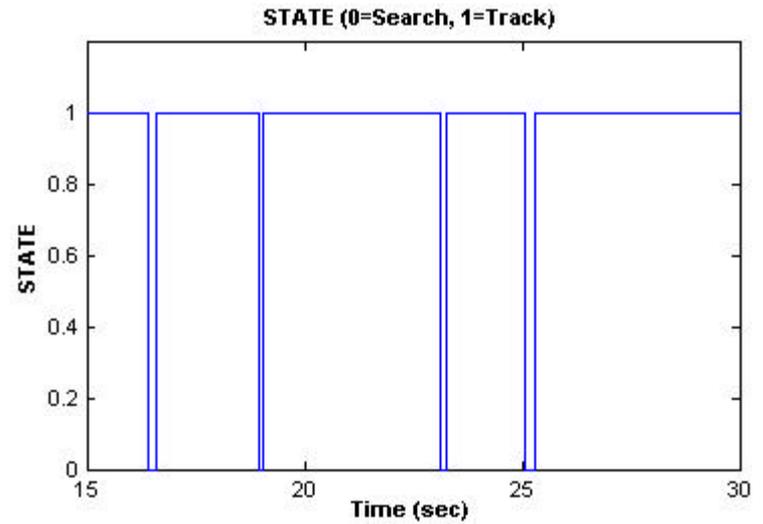
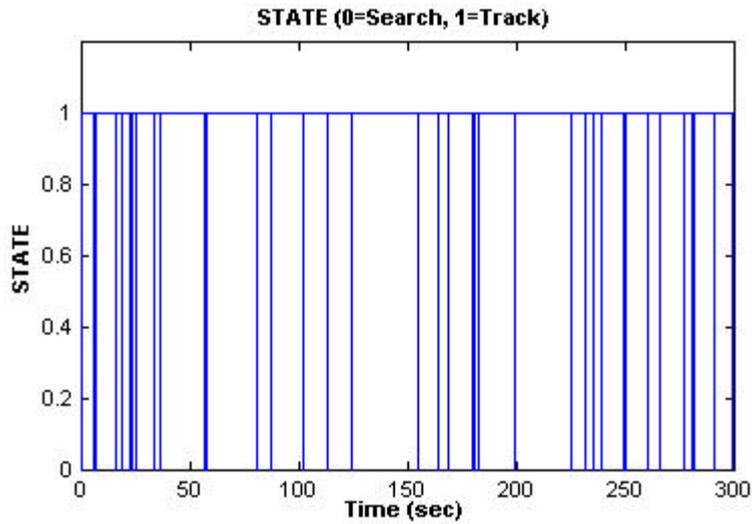
- For a 70% reply efficiency (used in the simulation)
 - ASOP point measured at 5.5 dB S/I
 - BSOP point measured at 4.5 dB S/I
- Approximated probability of pulse-pair acquisition versus S/I curve as a step function where the step occurs at S/I = 6 dB.





Example

- DME is LA1





Fraction of Time During Which State is Track

- LA Scenario
 - Bendix King 7000/Los Angeles 1, CA 98.8 %
 - Bendix King 7000/Los Angeles 2, CA, 98.8 %
 - Bendix King 7000/Santa Ana, CA, 98.7 %
 - Bendix King 7000/Ventura, CA, 98.8 %
 - Bendix King 7000/Lake Hughes, CA 99.2 %

- Subtracted 6 dB from received DME signal level to effectively double range (*)
 - Bendix King 7000/Los Angeles 1, CA 98.5 %
 - Bendix King 7000/Los Angeles 2, CA, 98.7 %
 - Bendix King 7000/Santa Ana, CA, 98.7 %
 - Bendix King 7000/Ventura, CA, 98.7 %
 - Bendix King 7000/Lake Hughes, CA 99.2 %

** Assumed antenna gains are unchanged*



Conclusions

- For this particular scenario, the interrogator remains in the TRACK state for more than 98% of the time.
 - When it does revert to SEARCH mode, it remains in that mode for typically less than a few hundred milliseconds before acquiring a track and reentering the TRACK state.
- For this particular scenario, UAT is only on the air for 65-70% of the time leaving the channel clear for at least 30% of the time.
- Currently attempting to obtain theory of operation for Narco Avionics DME-890 interrogator to assess its performance when subject to UAT interference.
- Can run additional scenarios as needed.