

**RTCA Special Committee 186, Working Group 5**

**ADS-B UAT MOPS**

**Meeting #3**

**Looking at DME/UAT Interference**

**Presented by Albert Muaddi, JHU-APL**

<b>SUMMARY</b>

# DME/UAT Interference

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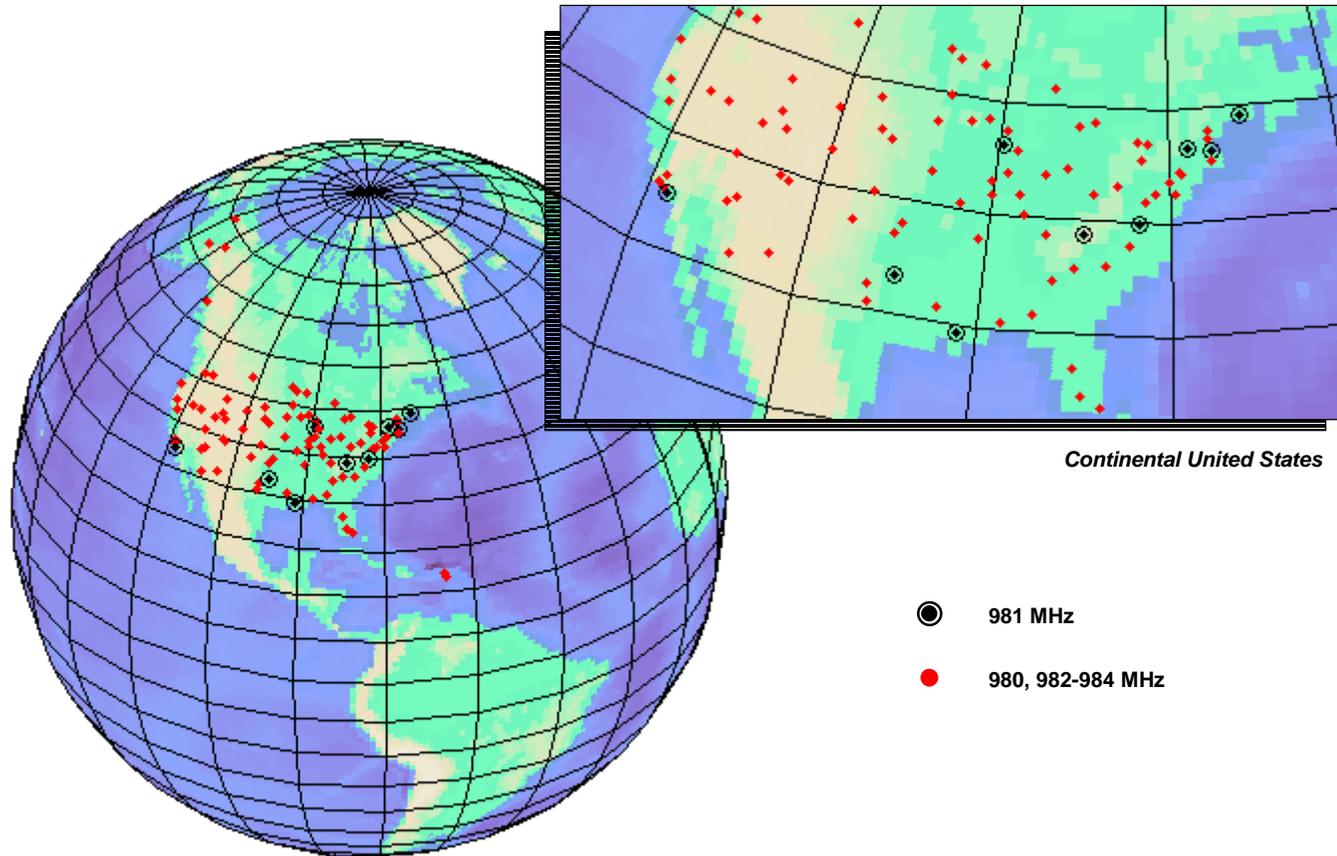


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2 APRIL 2001

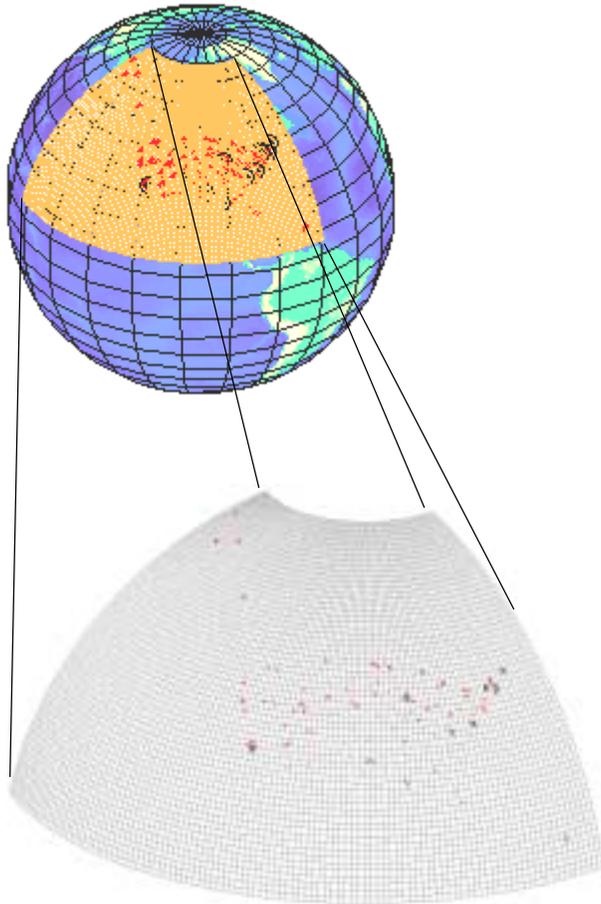


# UAT Performance Against DME Interference





# Number of Interfering DMEs



1/4-degree resolution in Latitude/Longitude

Channel assignment map for United States was used to determine maximum number of DMEs that could potentially interfere with a UAT transmission.

Maximum Number of DME Ground Transponders Within LOS Over All Locations							
Min. Look Angle	980	981	982	980/981	981/982	980/982	All
0°	4	3	4	4	6	6	8
5°	1	1	1	2	2	2	2

Aircraft Altitude is 30,000 ft

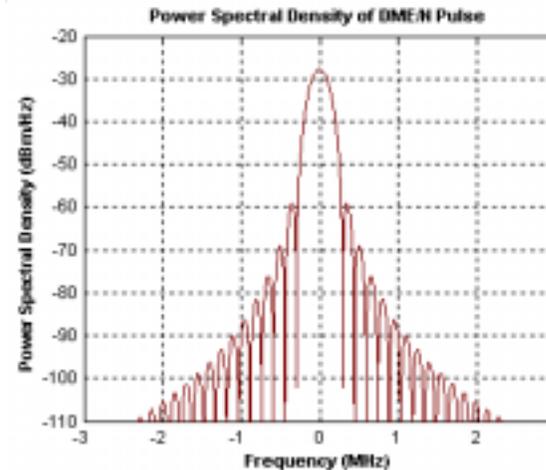
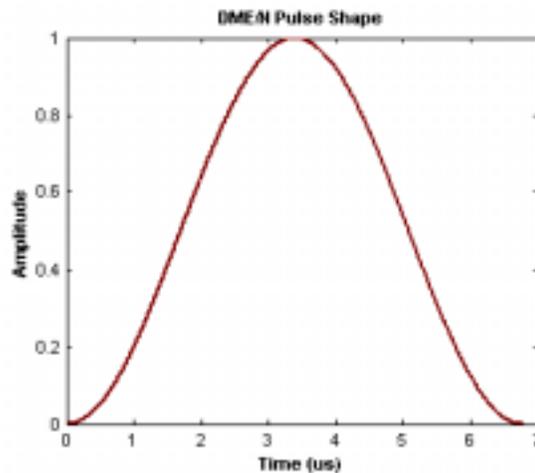
For this study, we assume that a UAT receiver has an LOS to 2 DME ground transponders that are operating at 2 different frequencies.



# Model Assumptions

- DME Ground Transponder

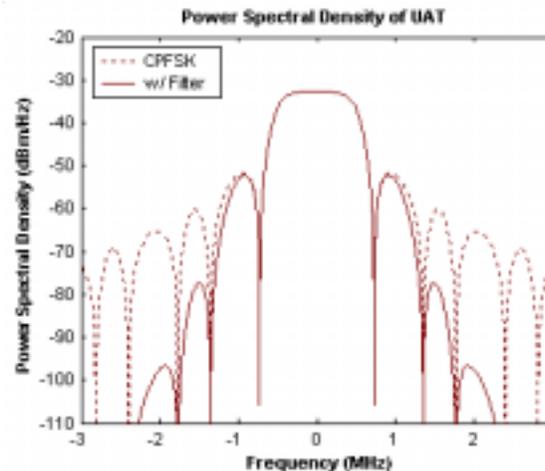
- Reply rate = 2,700 ppps
- ERP = 5000 W (omni-directional)
- Pulse shape assumed to be  $\sin^2(\alpha t)$ , where  $\alpha = \frac{\text{acos}(\sqrt{0.1}) - \text{acos}(\sqrt{0.9})}{\text{risetime}_{10\%-90\%}}$
- Pulse Risetime<sub>10%-90%</sub> = 2  $\mu\text{s}$
- Pulse Duration<sub>50%-50%</sub> = 3.4  $\mu\text{s}$





# Model Assumptions

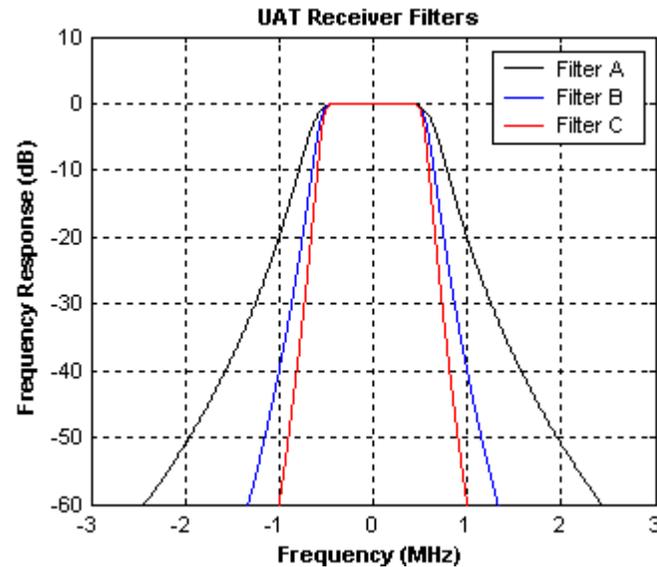
- UAT Air Transmitter
  - ERP = 25 W (omni-directional)
  - Reed-Solomon coding is (46, 34)
  - Transmit filter applied to theoretical CPFSK power spectral density to match transmit spectrum obtained from bench testing
  - Modeled only ADS-B Long Messages





# Model Assumptions

- UAT Receiver
  - Bandwidth = 1 MHz
  - Experimented with 3 Filters (Butterworth)
    - -1 dB at 0.5 MHz, -20 dB at 1 MHz
    - -1 dB at 0.5 MHz, -40 dB at 1 MHz
    - -1 dB at 0.5 MHz, -60 dB at 1 MHz



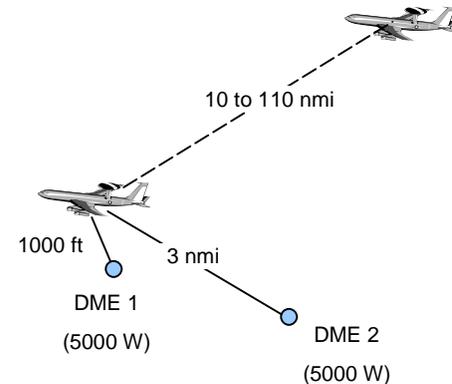


# Scenarios for DME Interference to UAT

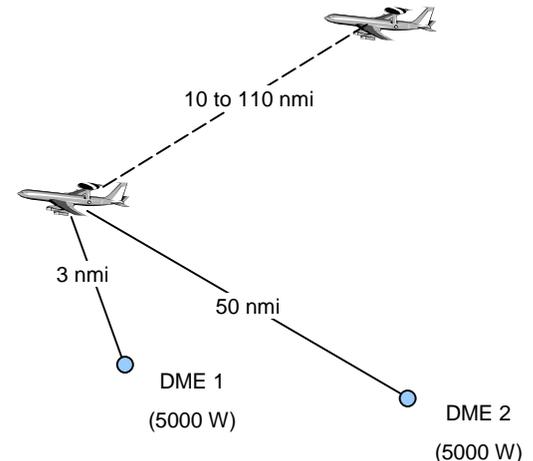
Evaluated performance of UAT when subject to DME interference under two scenarios: *Harsh* and *Mild*. In each scenario, the number of cleared DME channels was varied from 1 to 3, and UAT performance with the 3 different receive filters was analyzed.

No. Cleared DME Channels	UAT Freq.	DME 1 Freq.	DME 2 Freq.
1	981 MHz	980 MHz	982 MHz
2	981.5 MHz	980 MHz	983 MHz
3	981 MHz	979 MHz	983 MHz

## Harsh Scenario:

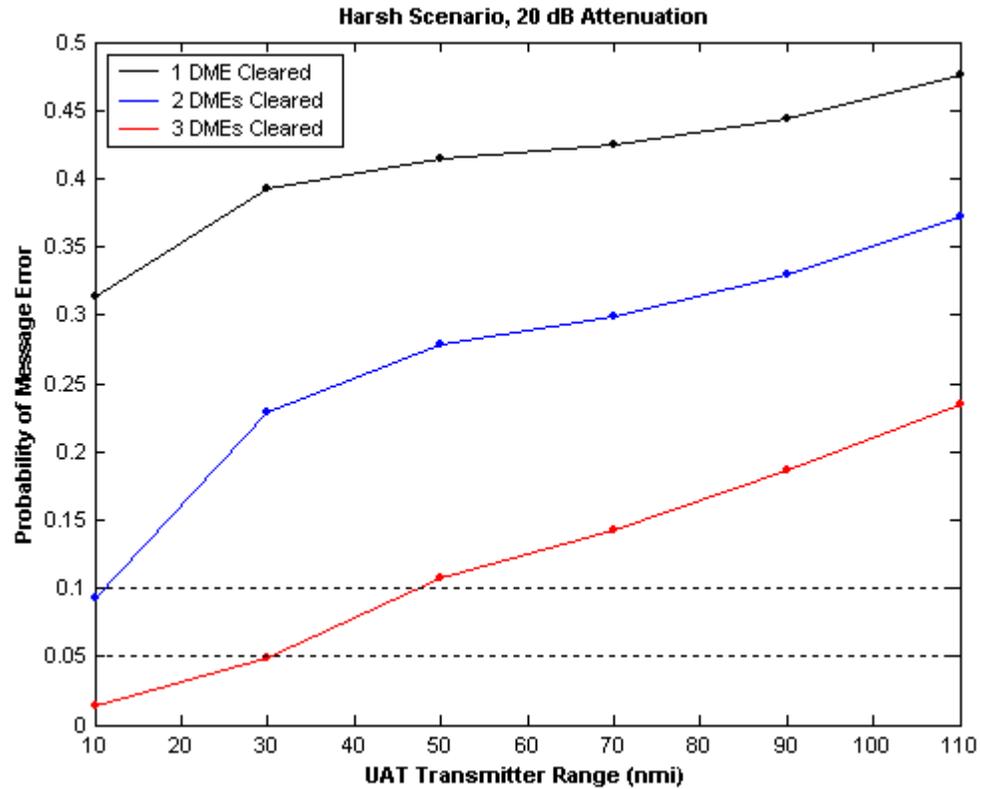


## Mild Scenario:



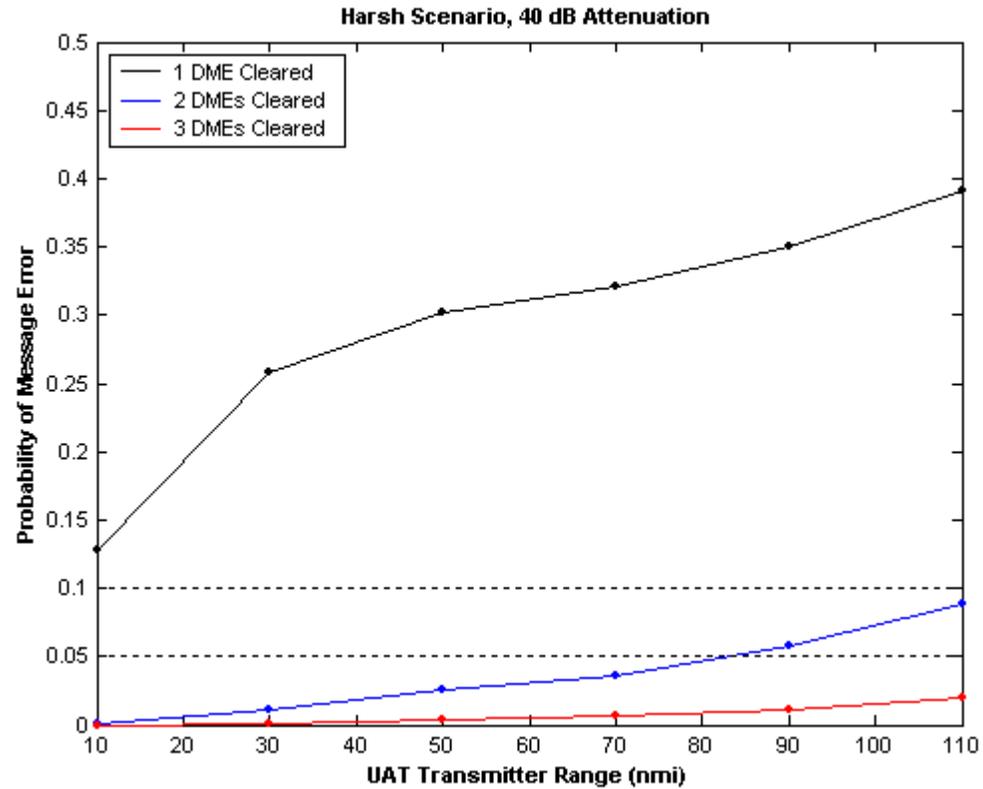


# Harsh Scenario, 20 dB



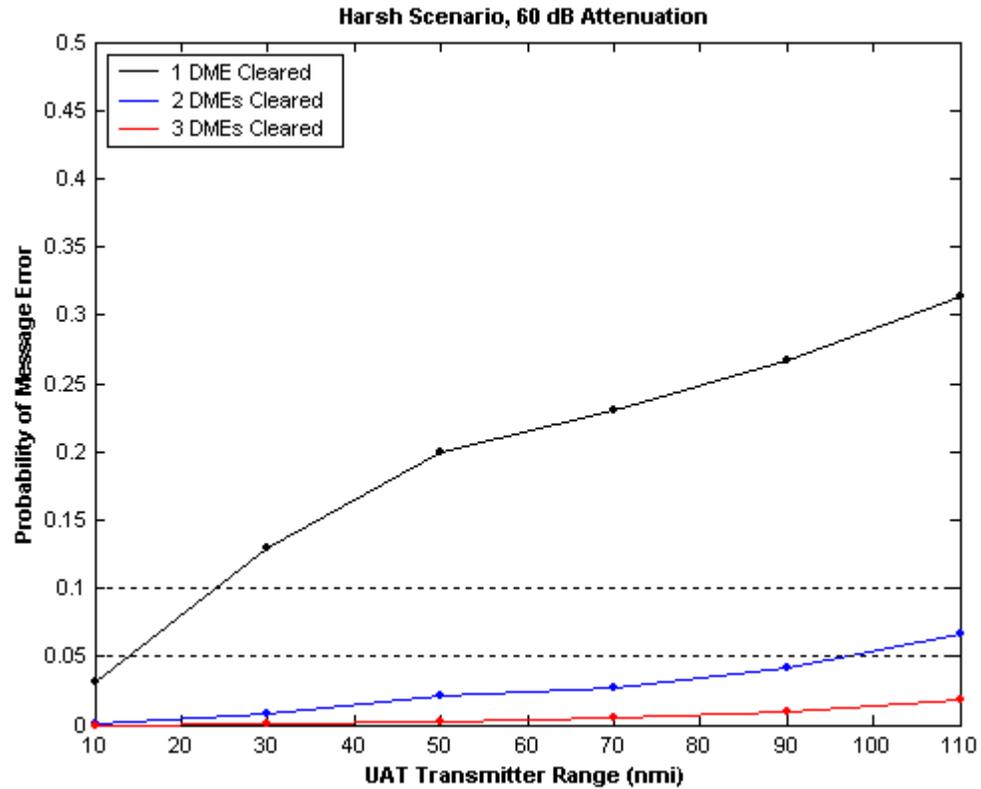


# Harsh Scenario, 40 dB



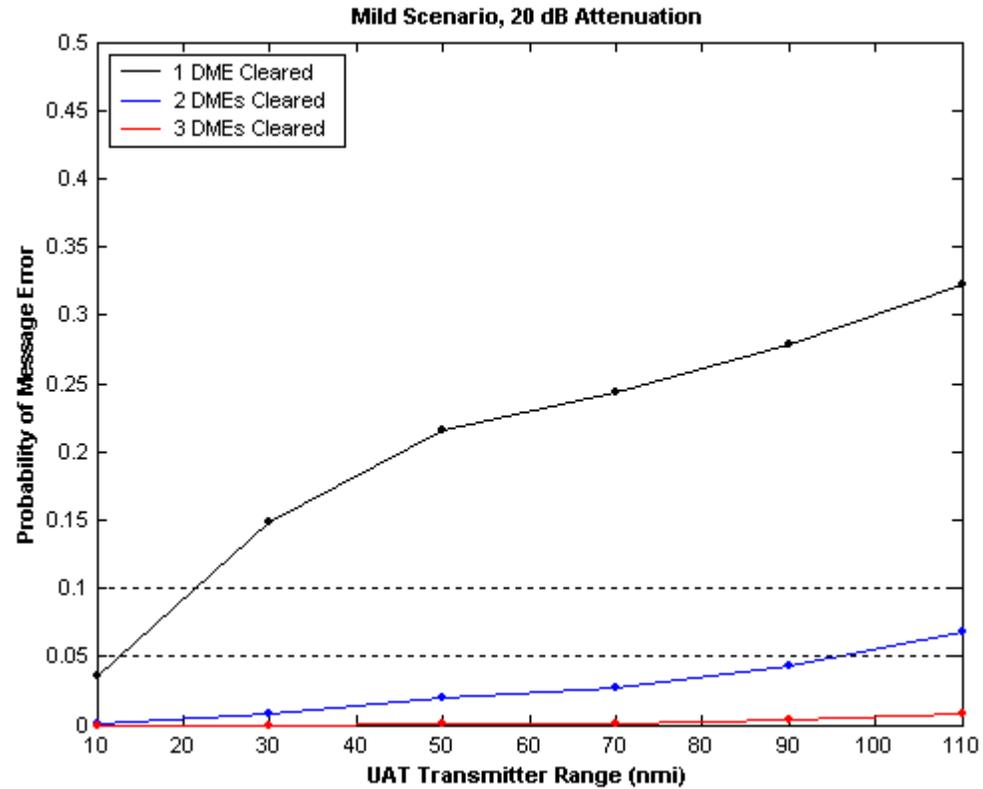


# Harsh Scenario, 60 dB



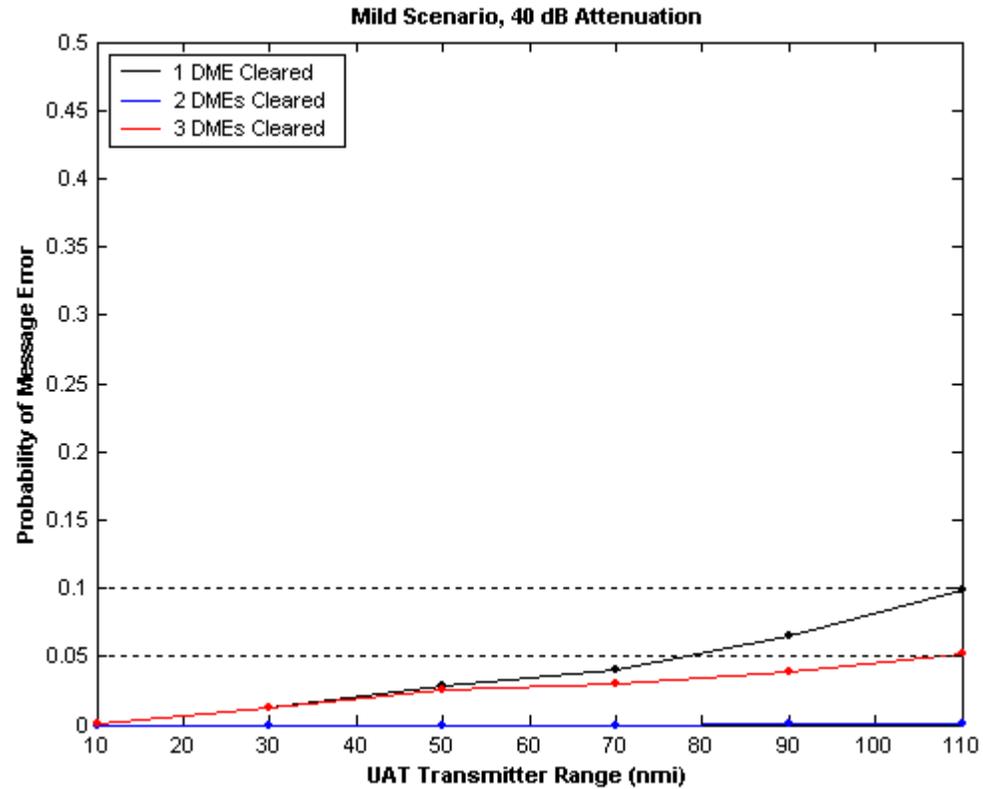


# Mild Scenario, 20 dB



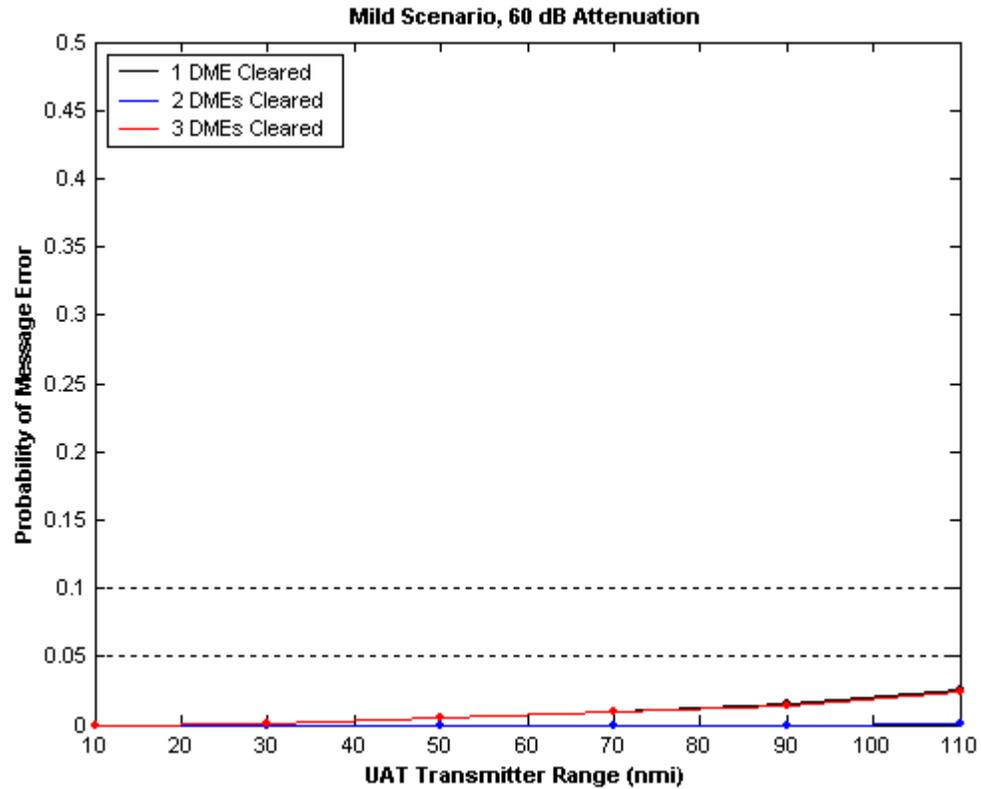


# Mild Scenario, 40 dB





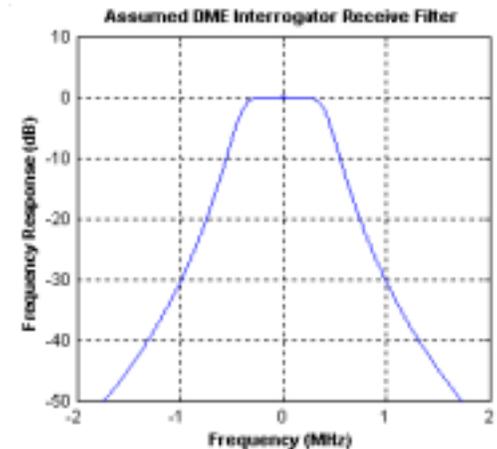
# Mild Scenario, 60 dB





# DME Performance Against UAT Interference

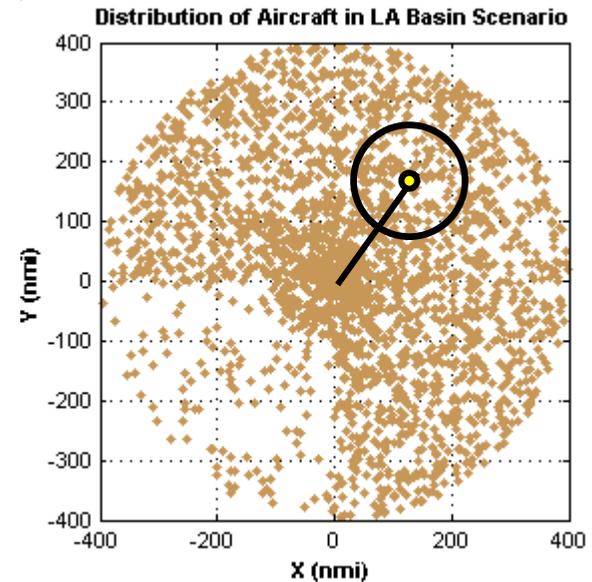
- UAT Assumptions
  - UAT Ground ERP = 125 W (omni-directional)
  - UAT Air ERP = 25 W (omni-directional)
  - UAT Airborne Transmitters transmit long messages
  - Number of UAT Ground Slots = 4
  - Power spectral density is same as in UAT performance analysis
- DME Assumptions
  - DME Ground ERP = 500 W (omni-directional)
  - DME Pulse Shape and Spectrum are same as in UAT performance analysis
  - Minimum Desired-to-Undesired (D/U) Ratio for DME Interrogators is 8 dB
  - Assumed filter is Butterworth
    - 1 dB at 330 kHz, 10 dB at 550 kHz





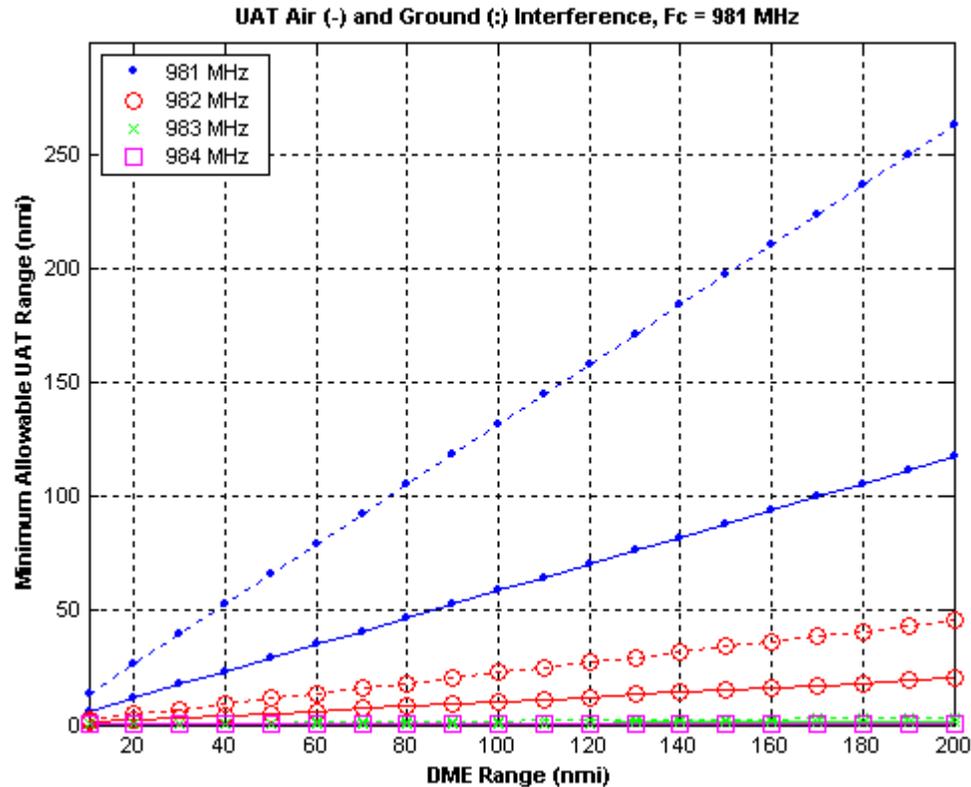
# Approach

- Determined minimum allowable range for a UAT transmitter to a DME interrogator such that D/U does not fall below 8 dB.
- Placed DME at center of LA Basin scenario and determined for each aircraft, the minimum allowable range.
- Determined number of aircraft which are within that range and estimated fraction of DME pulse-pairs which are not received due to UAT interference.



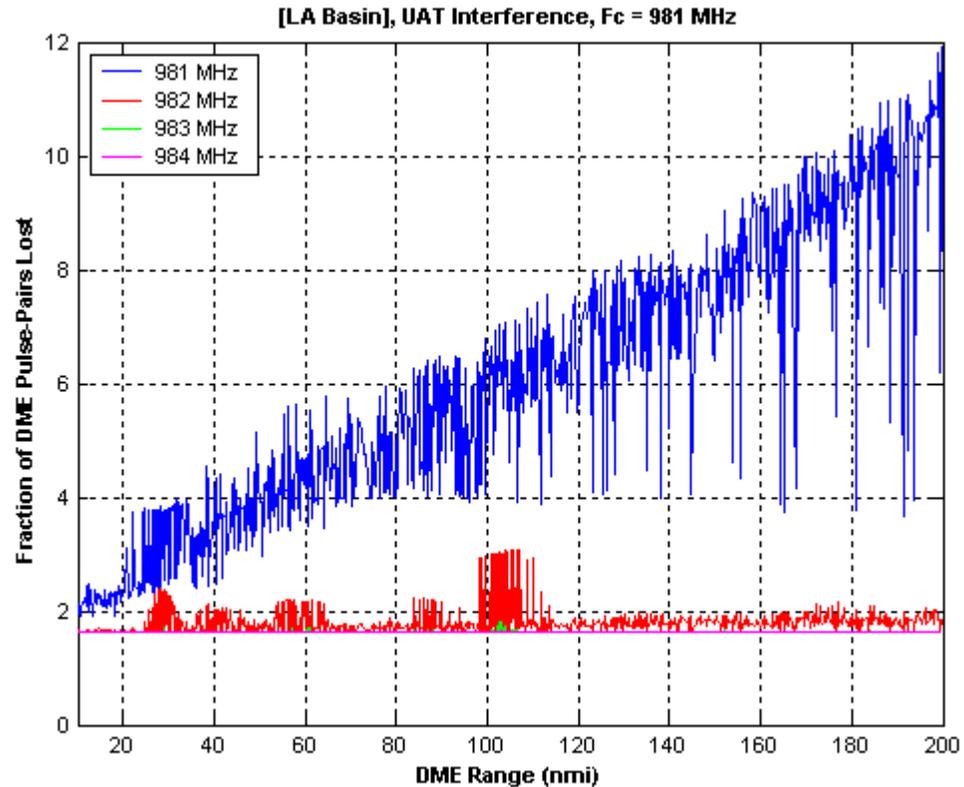


# UAT Frequency = 981 MHz



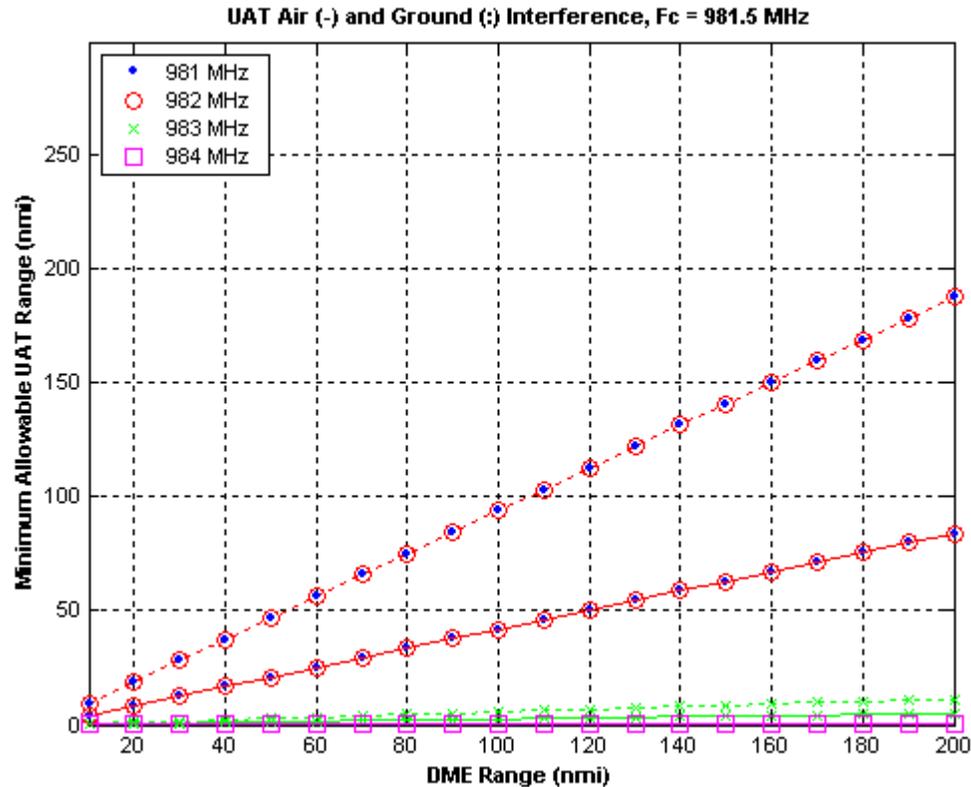


# UAT Frequency = 981 MHz



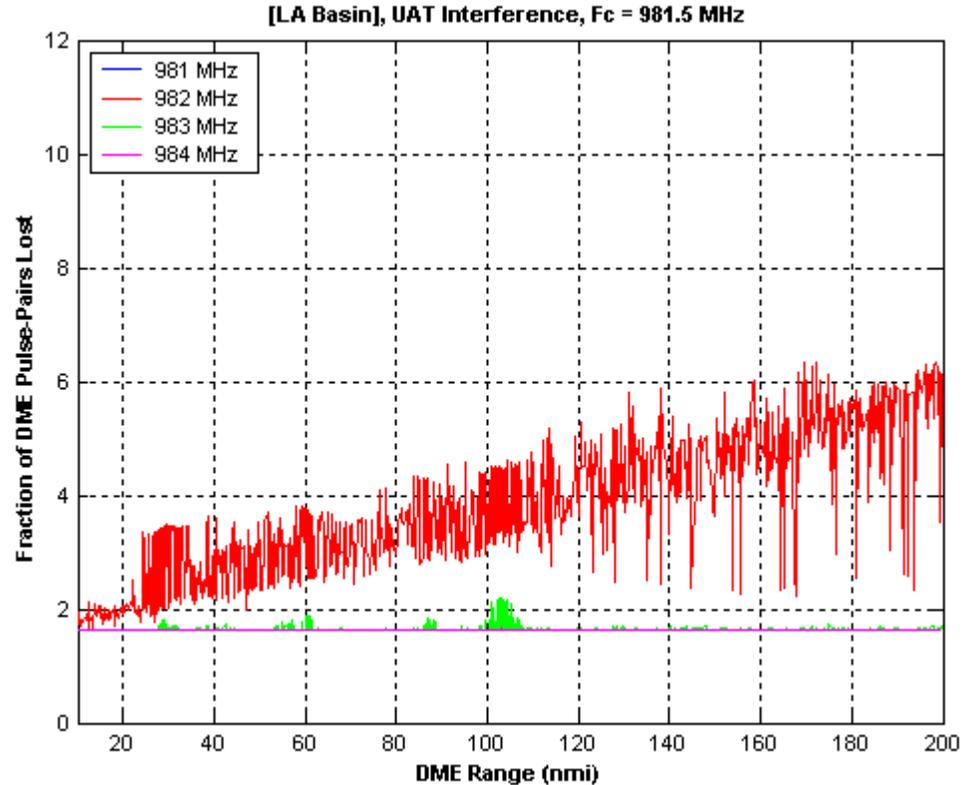


# UAT Frequency = 981.5 MHz





# UAT Frequency = 981.5 MHz





# Conclusions

- UAT Performance Against DME Interference
  - Mild Scenario:
    - For a probability of message error less than 10% out to 100 nmi, clear 1 DME channel and use a filter with at least 40 dB attenuation beyond 1 MHz.
  - Harsh Scenario:
    - For a probability of message error less than 10% out to 100 nmi, clear 2 DME channels and use a filter with at least 40 dB attenuation beyond 1 MHz.
- DME Performance Against UAT Interference
  - UAT at 981 MHz:
    - Fraction of pulse-pairs lost is less than 8% at 100 nmi and less than 12% at 200 nmi.
  - UAT at 981.5 MHz:
    - Fraction of pulse-pairs lost is less than 6% at 100 nmi and less than 8% at 200 nmi.