RTCA Special Committee 186, Working Group 5

ADS-B UAT MOPS

Meeting #5

Measurement of UAT Interference effects on DME Interrogators

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In Response to Action Items 3-1 and 3-3

SUMMARY
Testing has been completed on three DME Interrogators. Measurements of the three DMEs appear consistent with each other. DME operation does not appear to be overly sensitive to constant phase interference. We do not expect there to be much of a problem caused by near- or co-channel UAT operations.

Measurement of UAT interference effects on DME interrogators

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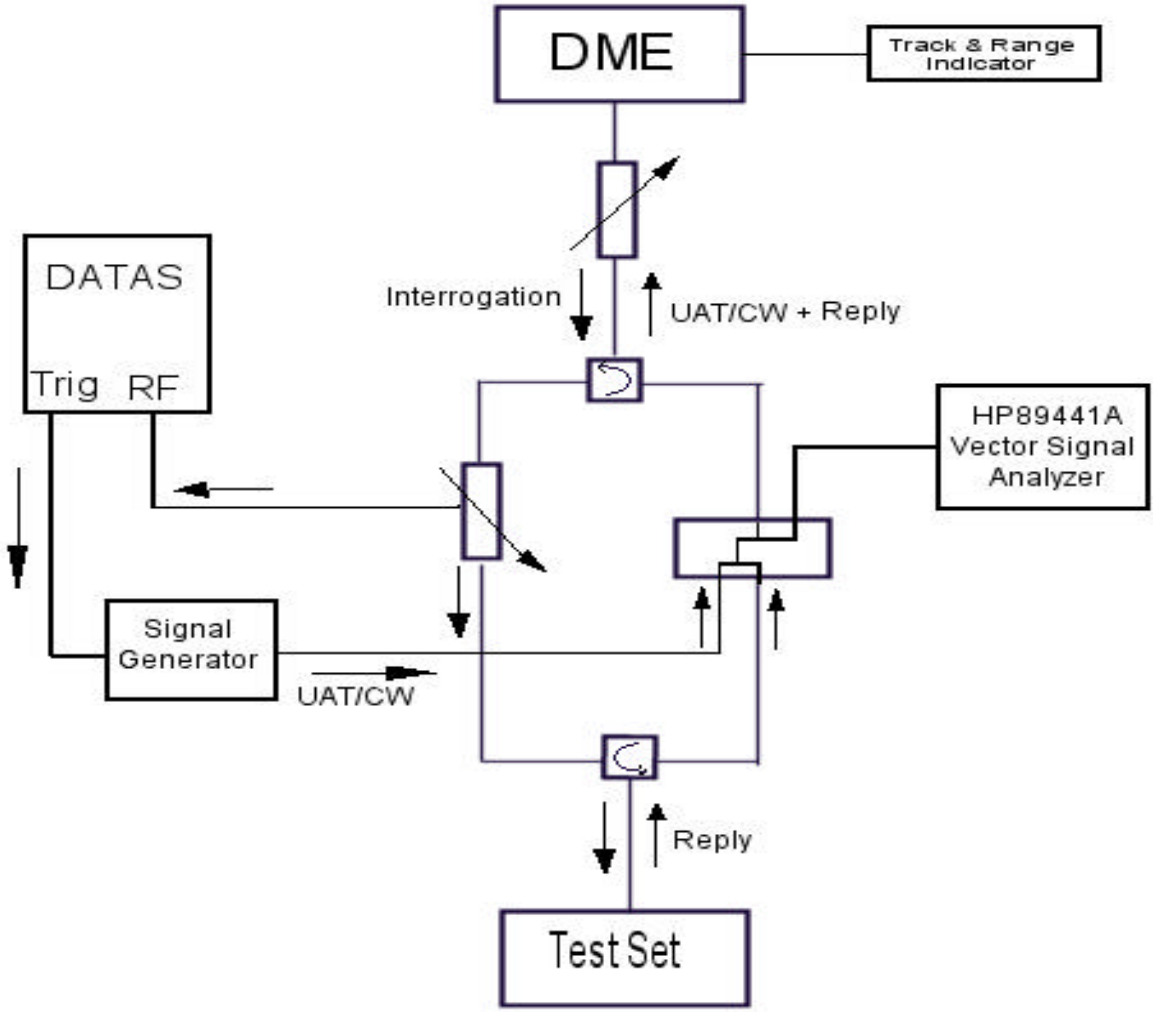
Summary of collected data

- Testing completed on three DME interrogators
  - Bendix King KD-7000, circa 1978
  - Narco DME-890, GA equipment, recently purchased
  - Honeywell KDM-706A (European)
- ASOP/BSOP measurements
  - ASOP is the UAT level that renders the DME able to acquire
  - BSOP is the UAT level that causes the DME to break lock
  - number reported was observed in 4 out of 5 measurements
  - as a function of frequency offset at 100% test-set reply efficiency
  - as a function of test-set reply efficiency at zero frequency offset
- Additional measurements
  - sensitivity measurements
  - DME performance against a constant phase signal (sanity check)
  - time domain captures of interference, overlapped pulses, etc.
  - spectrum captures of UAT and DME signals
  - some UAT duty-cycle measurements leftover from previous trials

Test-bed block diagram

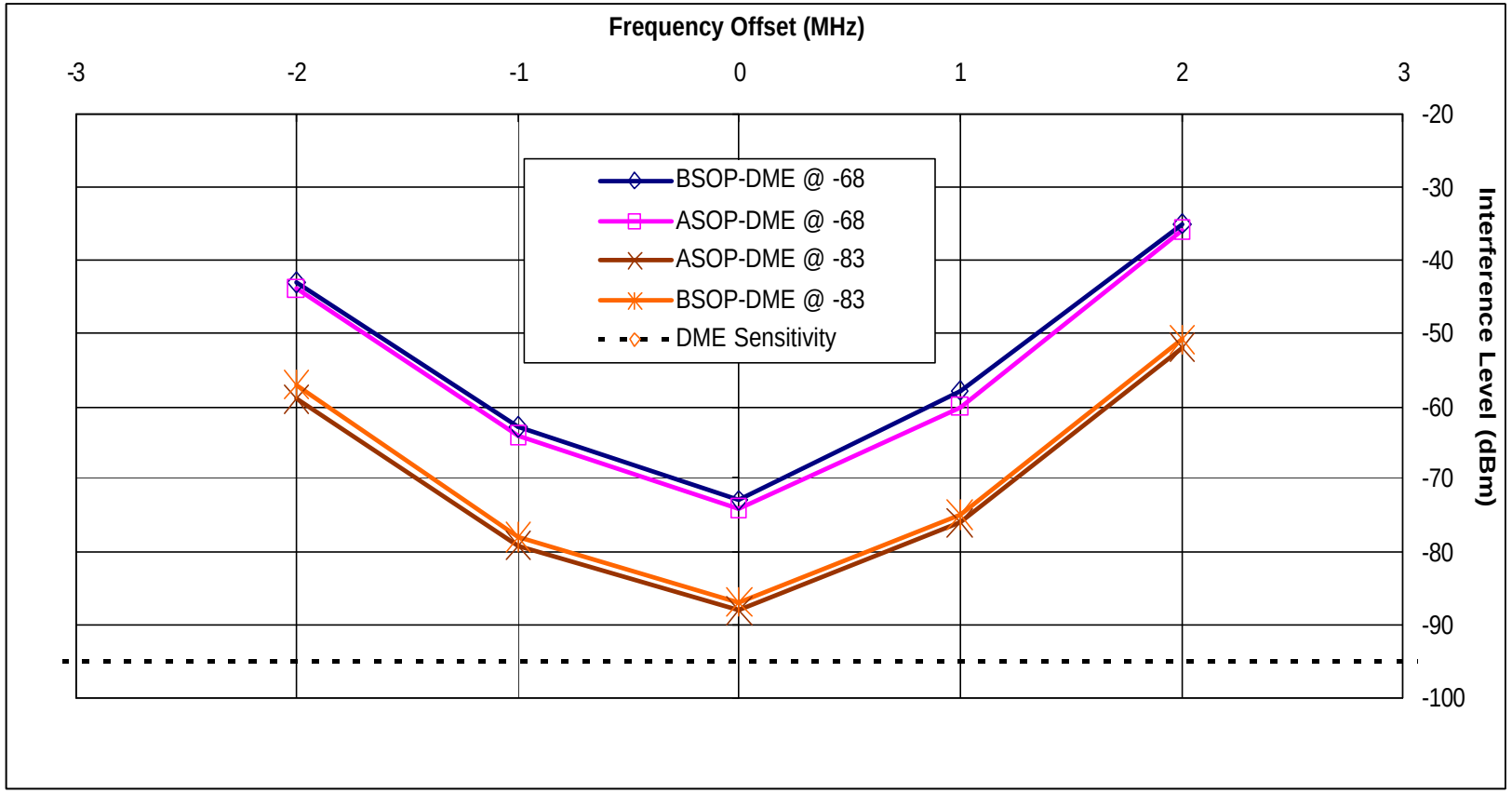


Data Notes

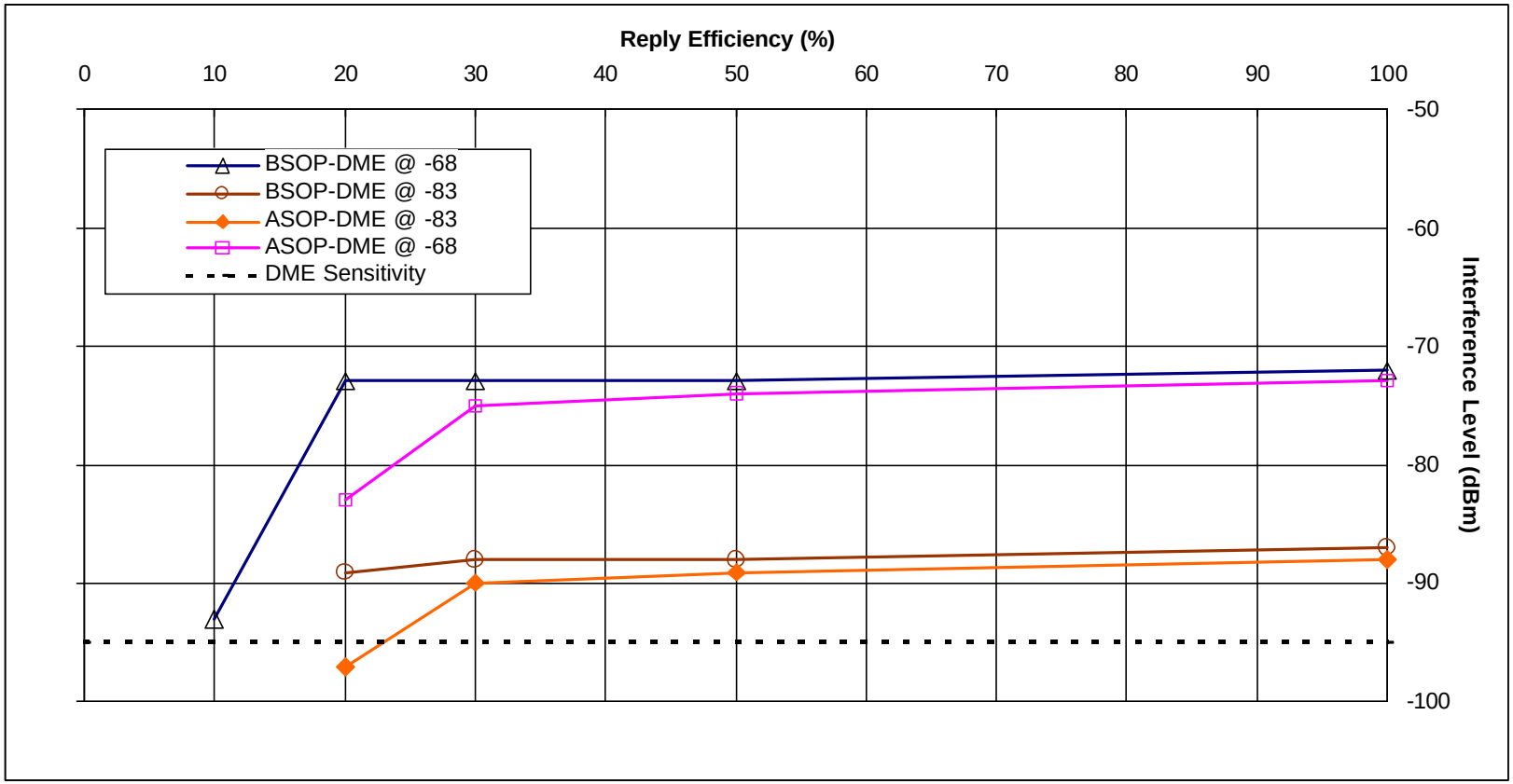
- Reply efficiency tests were measured at 10, 20, 30, 50, and 100%. If there is no data point, it means that the DME could not be made to operate at that reply efficiency.

- Effects seem to depend on SIR given that the signal is well enough above sensitivity. The SIR begins to degrade in the Narco w/ signal @ -75 dBm, only 5-6 dB above sensitivity

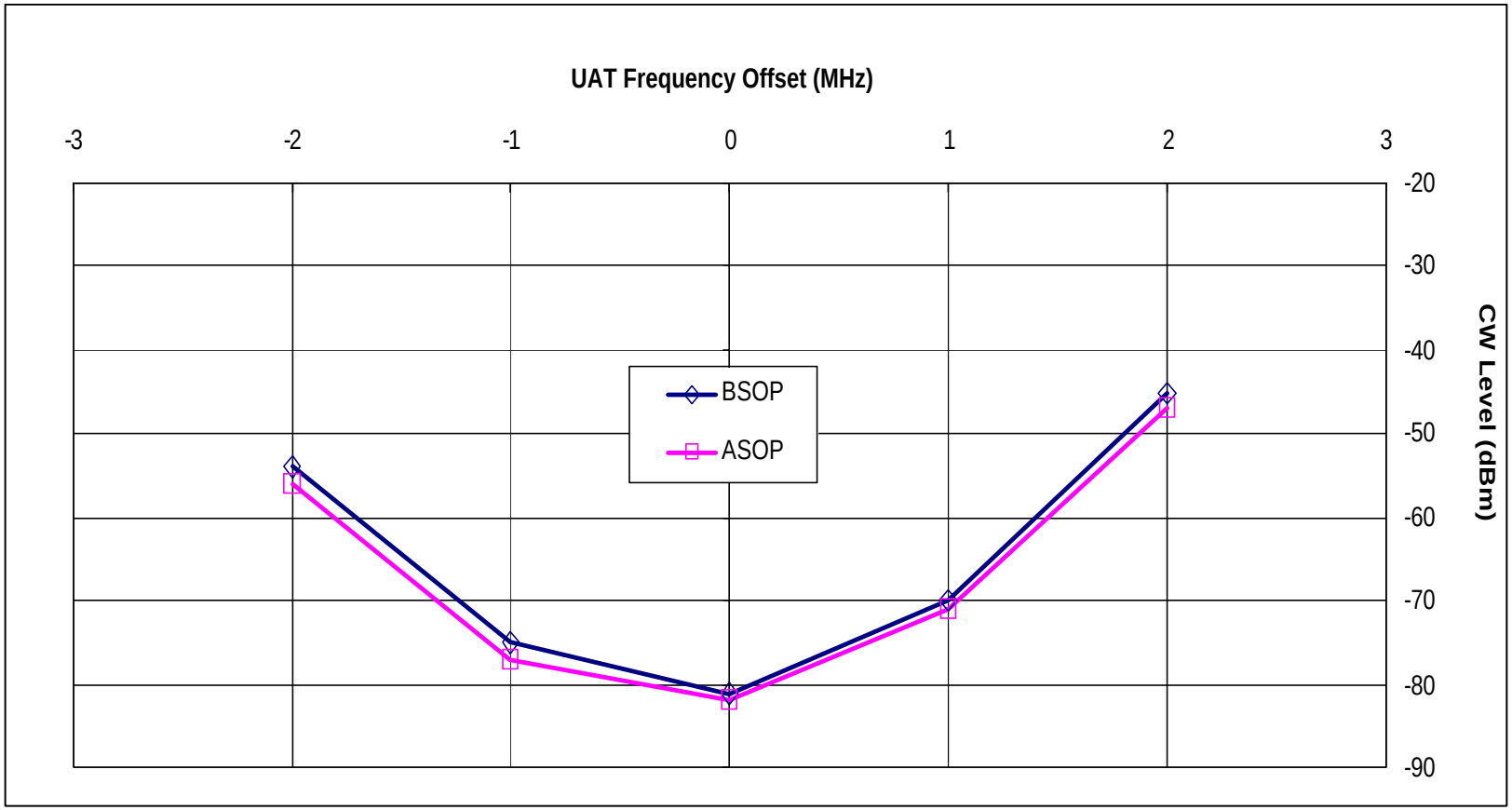
Bendix King KD-7000
Frequency Offset Test



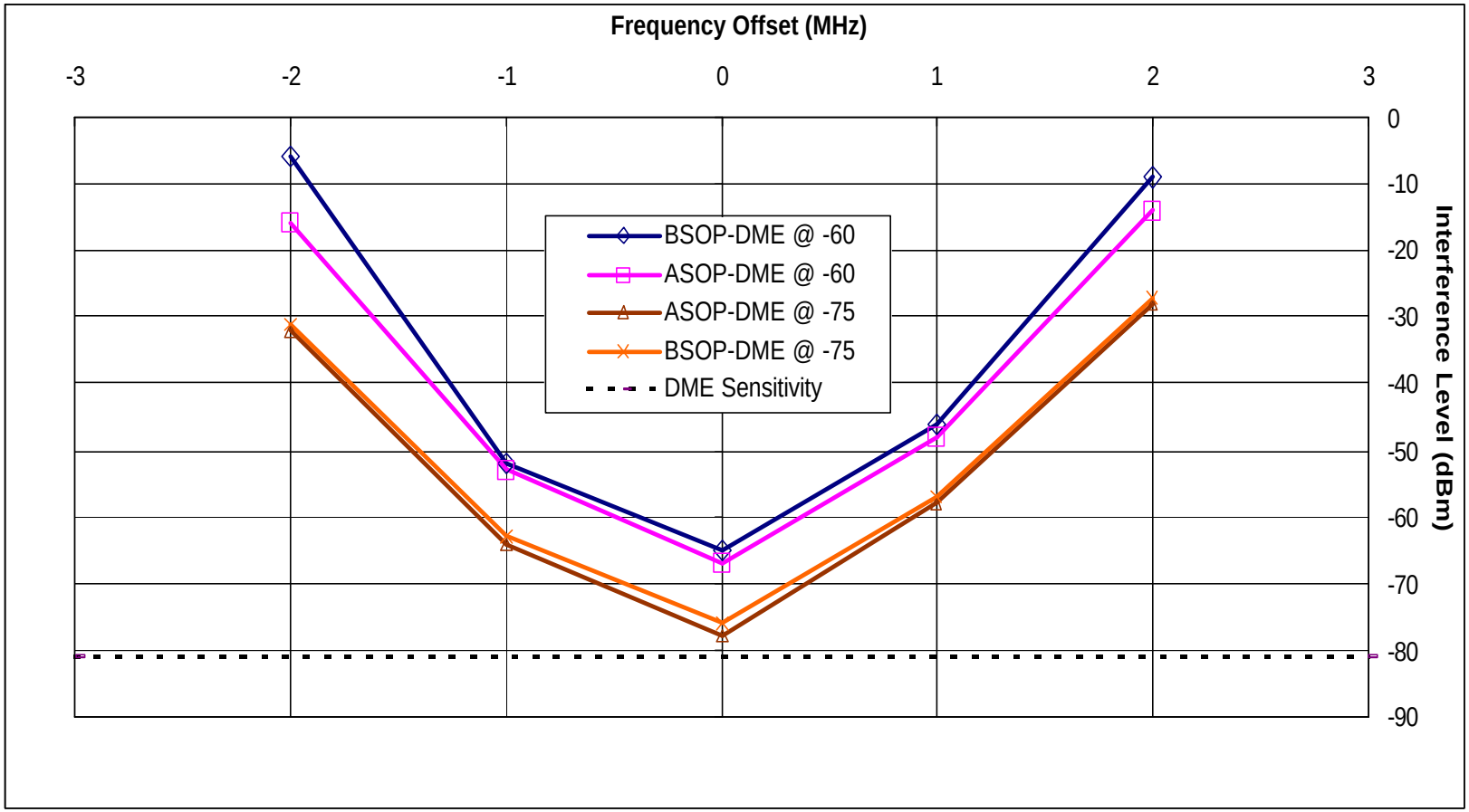
Bendix King KD-7000
Reply Efficiency Test



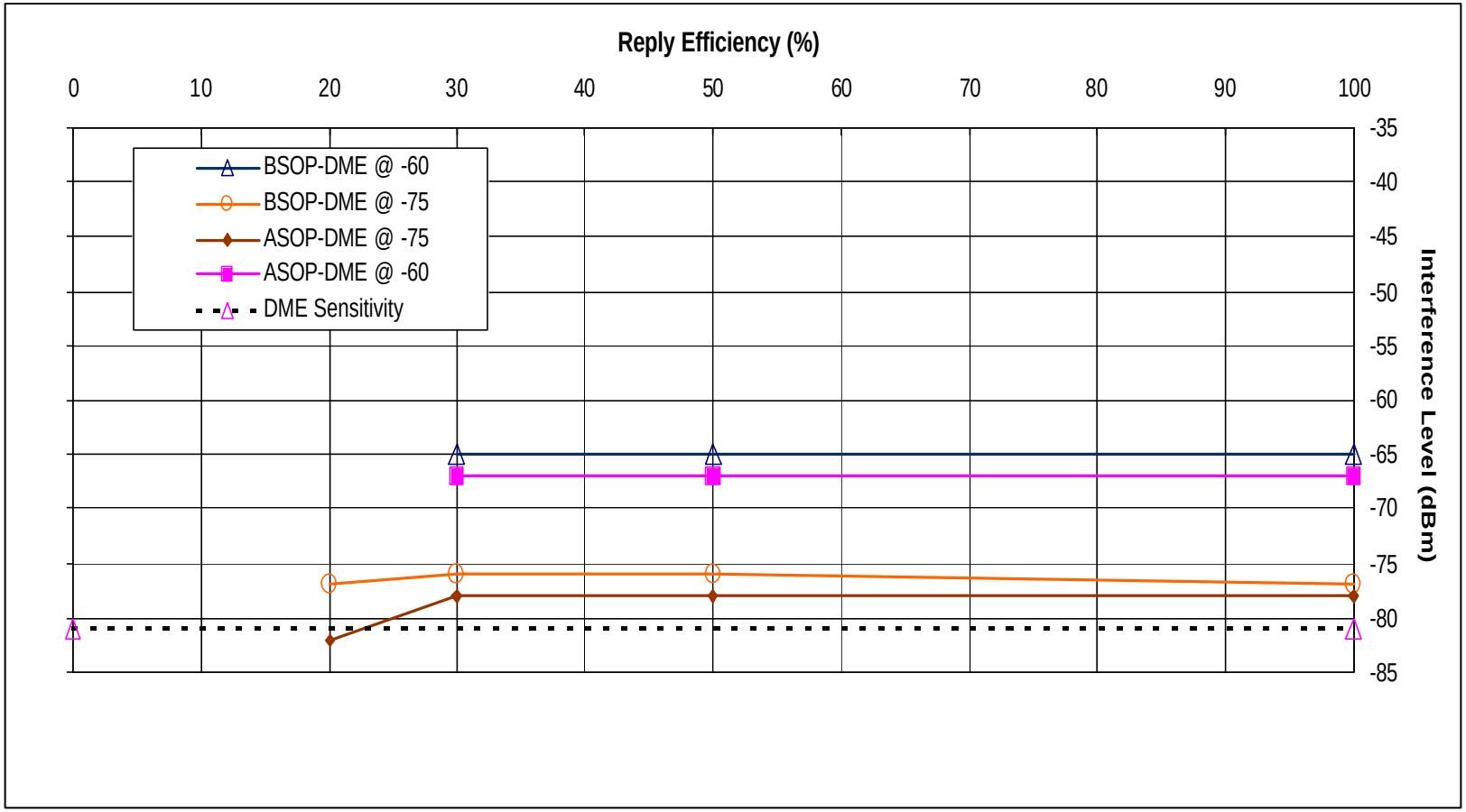
Bendix King KD-7000
CW testing: DME level -83 dBm



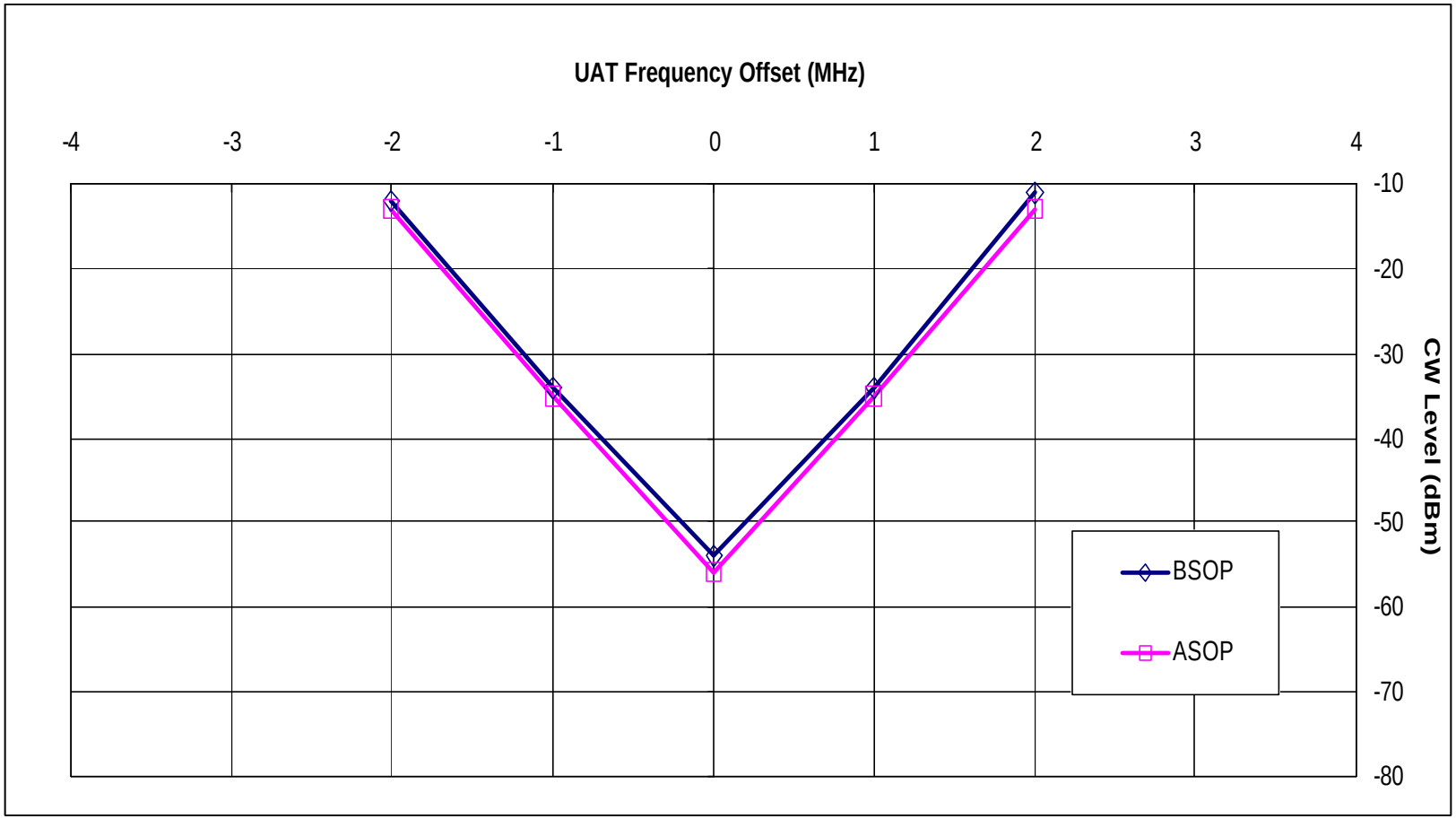
Narco DME-890
Frequency Offset Test



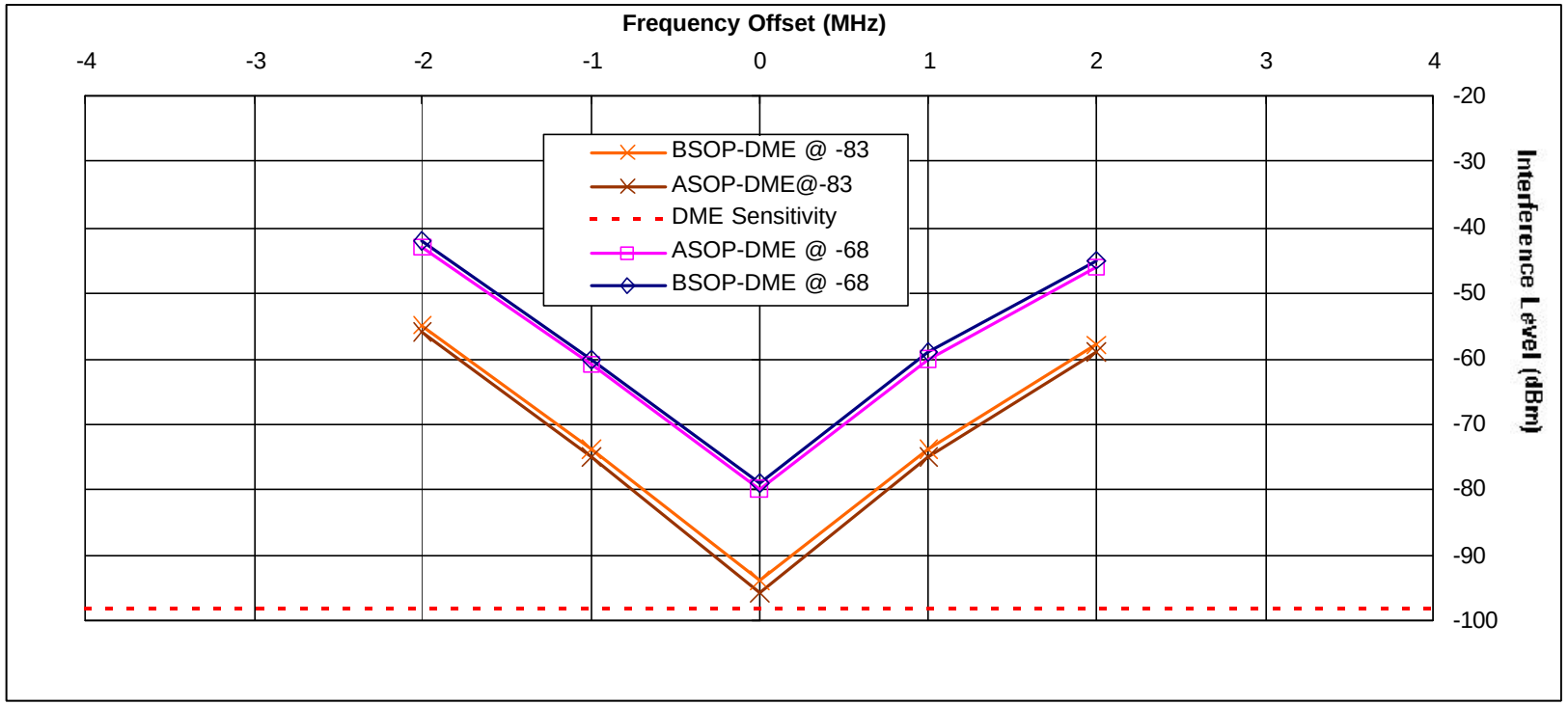
Narco DME-890
Reply Efficiency Test



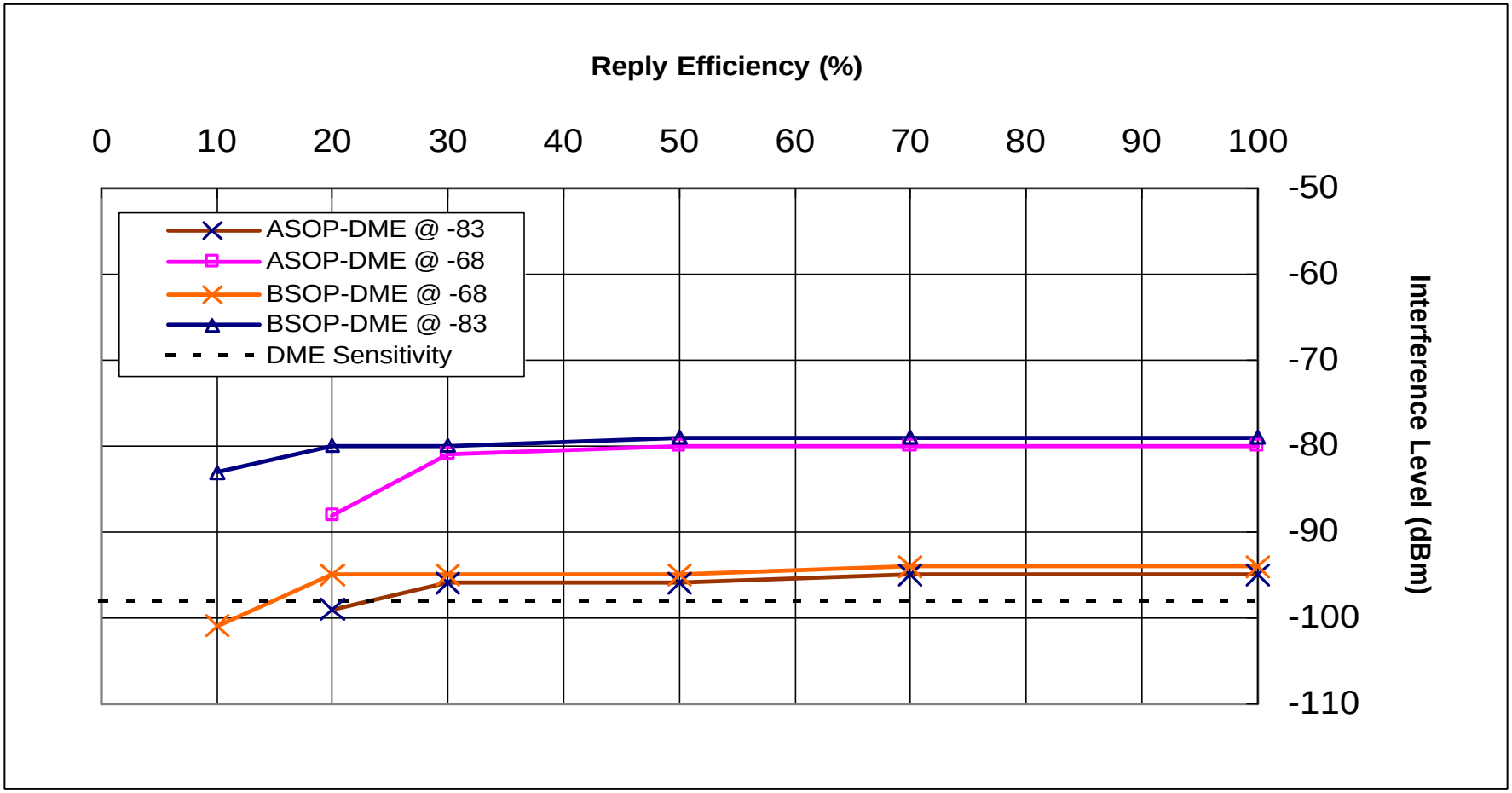
Narco DME-890
CW testing: DME level -75 dBm



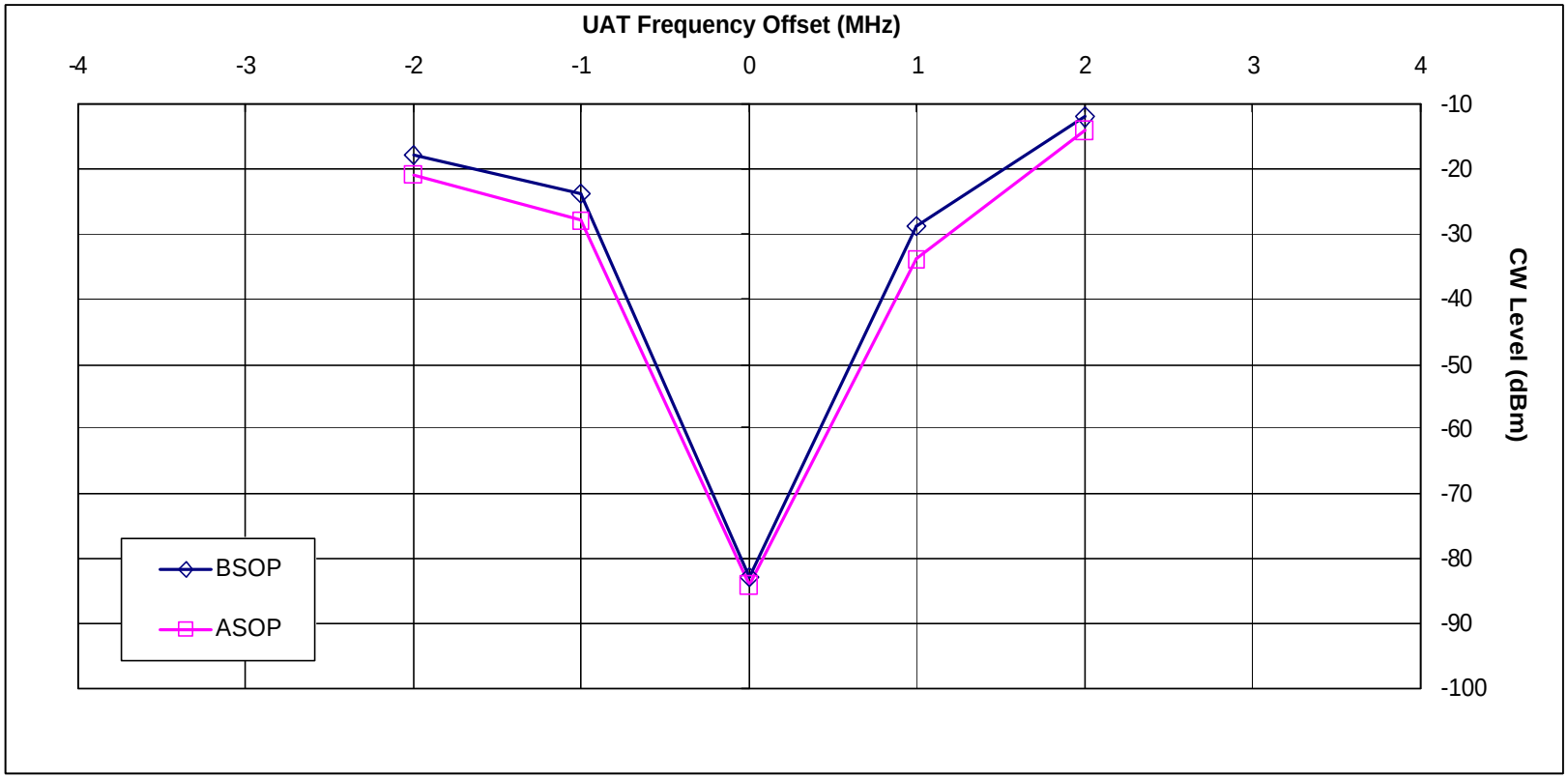
Honeywell KDM-706A
Frequency Offset Test



Honeywell KDM-706A
Reply Efficiency Test



Honeywell KDM-706A
CW testing: DME level -83 dBm



Conclusions

- Measurements of the three DMEs appear consistent with each other, i.e. no surprises.
- DME operation does not appear to be overly sensitive to constant phase interference. We do not expect there to be much of a problem caused by near- or co-channel UAT operations.

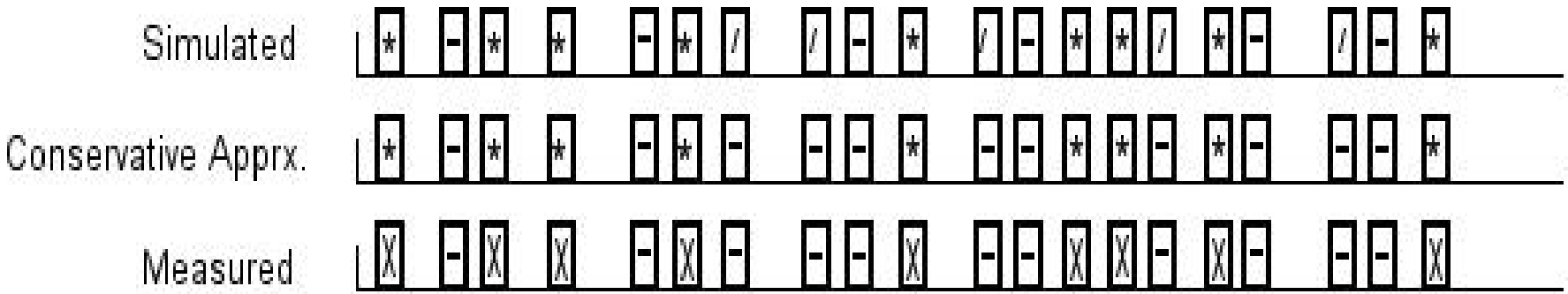
Alternative proposal to pulse-level simulation

In looking at the collected data, it has become apparent that there is another way to judge whether or not a DME will be able to operate in a given UAT environment, involving fewer assumptions and more directly applying measured data to the model. The results of the Reply Efficiency tests show that the DME operates when replies arrive at the receiver with a certain SIR 30% of the time or better, and only interference the rest of the time. The UAT traffic scenario can be conservatively reduced to this identical scenario, so that the measured and simulated data can be directly compared. This method does not assume anything about what happens at the pulse level nor does it require knowledge of the DME's Theory of Operation. All of this is inherent in the measured data.

Concept:

Each rectangle on the timelines below represents a window in which a DME reply is expected. The rectangle is marked with a - if there was no pulse pair present, with a / if there was a pulse pair but it has an SIR less than some value A, with an X if there was a pulse pair with an SIR equal to A, and with a * if there was a pulse pair with an SIR greater than A. The first timeline can be directly derived from the JHU/APL UAT interference scenarios. We can make a conservative approximation to that timeline by replacing all /'s with -'s, i.e. replacing heavily interfered replies with no reply at all. The resulting timeline can be further conservatively approximated by replacing the *'s with X's, i.e. increasing the interference level on all arriving replies. This final timeline (with appropriately chosen A, of course) is equivalent to what was measured on the bench in the Reply Efficiency curves. If the percentage of windows with an 'X' is greater than 30 (30% is above the critical value for all receivers measured to date), then we can safely assume that the DME will operate in the simulated environment.

(-) no reply present
(/) reply present, SIR < A
(X) reply present, SIR = A
(*) reply present, SIR > A



Procedure:

The procedure to use the data in this way is very simple. If the inequality

$$R_g \cdot P(SIR > X) > 0.3$$

holds true, where

$$P(SIR > X) = 1 - \left(\frac{N_{UAT>(DME-X)} \cdot L_{UAT}}{T} \right),$$

$$R_g = \text{Ground Station Reply Efficiency},$$

and $N_{UAT>(DME-X)}$ is the number of UAT messages stronger than the DME signal level (in dB) minus X, L_{UAT} is the length of the UAT messages (in seconds), and T is the total time, then the DME can be expected to operate in the simulated environment.

Model Assumptions

- DME Replies are uniformly distributed in time.
- The presence of UAT signal does not affect the DME receiver except when interfering with a pulse pair. This has been shown to be a fair assumption for the KD-7000.