RTCA Special Committee 186, Working Group 5

ADS-B UAT MOPS

Meeting #5

The Effect of Time Slot Permutation on UAT Ground Uplink Message Performance in the Presence of JTIDS/MIDS Interference

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SUMMARY

Pursuant to Action Item 4-12 this paper addresses the issue of the difference in UAT ground uplink performance in the presence of JTIDS/MIDS interference depending on whether or not the uplink time slots are permuted. It appears that permutation will be required in *all* proposed scenarios.

Introduction

This paper examines the effect of permuting the slots used for UAT ground uplink messages in the presence of various JTIDS/MIDS interference scenarios. The motivation for this effort is to see whether or not the effort necessary to permute the UAT uplink slots is justified. If the slots are fixed, it is possible that a particular nearby JTIDS/MIDS interferer will repeatedly jam a particular uplink time slot, even if the interferer has a low duty factor. This is possible because both JTIDS/MIDS and UAT have timing architectures including one-second intervals. If the slots are permuted, then the low duty factor of the nearby interferer will work against it, and its worst-case effect will be reduced.

In the paper the UAT system is assumed to be operating at 981 MHz. A change to a neighboring frequency (e.g., 978 MHz) would not materially change the results of this paper. The ground transmitter is assumed to have an effective radiated power of 125 watts. The format of the ground uplink message is assumed to include six interleaved Reed-Solomon (RS) (85,65) blocks. In a companion paper it is suggest that the RS(85,65) code be changed to RS(92,72). If implemented, this change would not alter the conclusions of this paper. The results presented here also assume that the "narrow" IF filter (approximate width = 800 kHz) is used in the receiver. A wider filter may change the results.

The JTIDS/MIDS interferer is modeled exactly as it was in previous working papers on the subject of JTIDS/MIDS interference (e.g., UAT-WP-2-03 and UAT-WP-4-05).

Scenarios

The interference scenarios that are addressed in this paper are those which were listed in UAT-WP-4-04 prepared by Michael Biggs and Richard Weathers. For convenience we list them again here.

Baseline
1A: TSDF=50% at –50 dBm, TSDF=50% at –60 dBm, TSDF=300% at –84.5 dBm
1B: TSDF=50% at –39 dBm, TSDF=50% at –60 dBm, TSDF=300% at –84.5 dBm
1C: TSDF=20% at –39 dBm, TSDF=30% at –50 dBm, TSDF=50% at –60 dBm, TSDF=300% at –84.5 dBm

Heavy
2A*: TSDF=50% at –39 dBm, TSDF=50% at –60 dBm, TSDF=300% at –78 dBm
2B*: TSDF=50% at –50 dBm, TSDF=50% at –60 dBm, TSDF=300% at –78 dBm
2C*: TSDF=100% at –60 dBm, TSDF=300% at –78 dBm

Light
3: TSDF=20% at –39 dBm, TSDF=80% at –60 dBm, TSDF=300% at –90 dBm

The "heavy" scenarios are listed with an asterisk because these scenarios are slightly changed from those in UAT-WP-4-04. In that paper the background consisted of TSDF=150% at –78 dBm and TSDF=150% at –82 dBm. In order to model this background in the context of the current simulation software, it was simpler to put the entire background at the same level. If the simulations had been run at the original levels, the UAT performance would have been very slightly better.

Simulation Results

Each of the scenarios was simulated with and without time slot permutation for the ground uplink messages. For the cases with permutation, the likelihood of an uplink message's being "hit" by a particular interferer was strictly proportional to the percentages listed above. Also, the timing relationship within a time slot between UAT and JTIDS was randomized. For the cases without permutation, it was assumed that the JTIDS/MIDS block assignments were such that the most powerful foreground interferer repeatedly hit the same UAT time slot. Additionally, it was assumed that the timing of this interfering signal was worst-case with respect to the timing of the desired signal (although, in the model, the random jittering of the JITDS/MIDS signal within a time slot ameliorated this effect to a large extent). The timing relationship between the background 300% TSDF interferer and UAT remained randomized.

The following graphs (figures 1 through 7) summarize the results. For each scenario the permuted and fixed cases are both included in a single figure.

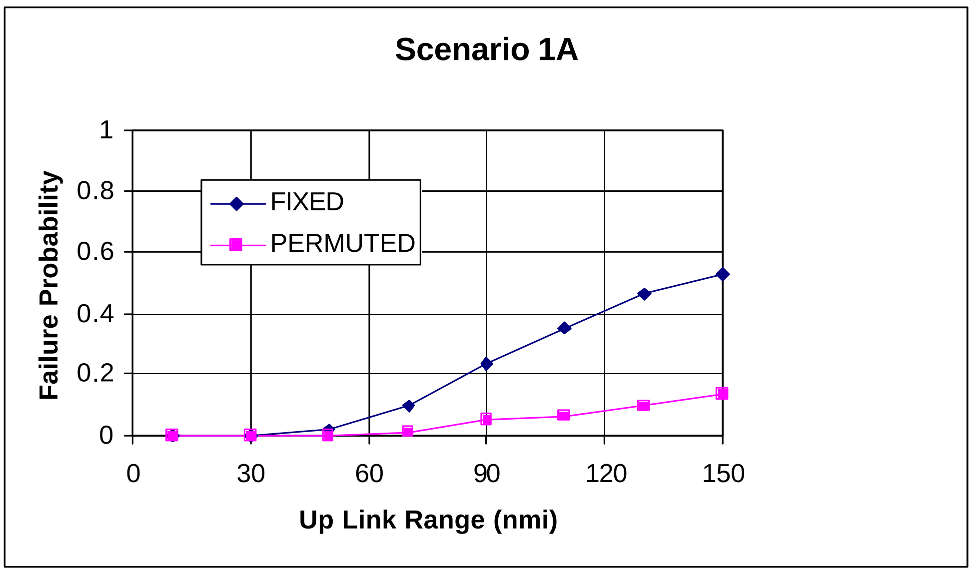

Figure 1. Scenario 1A

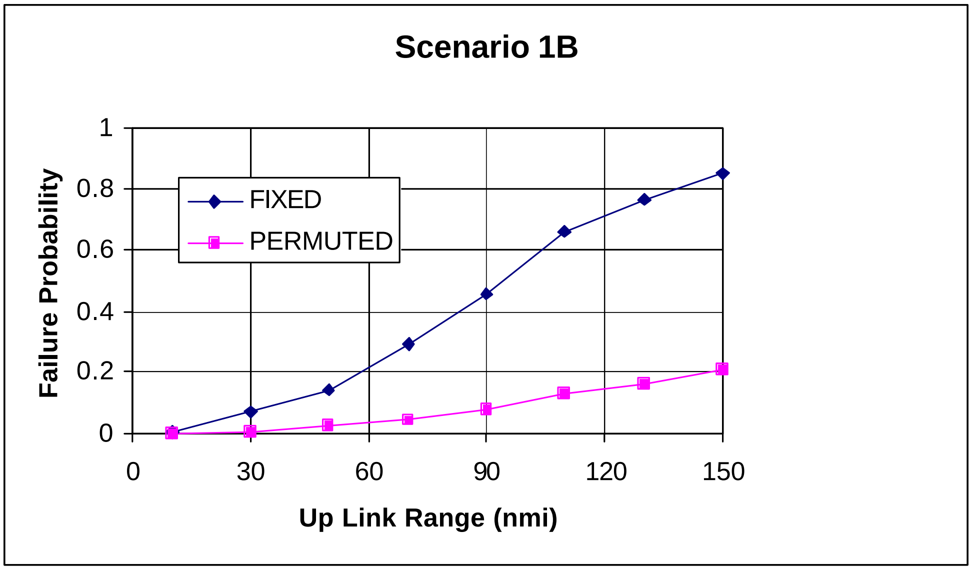

Figure 2. Scenario 1B

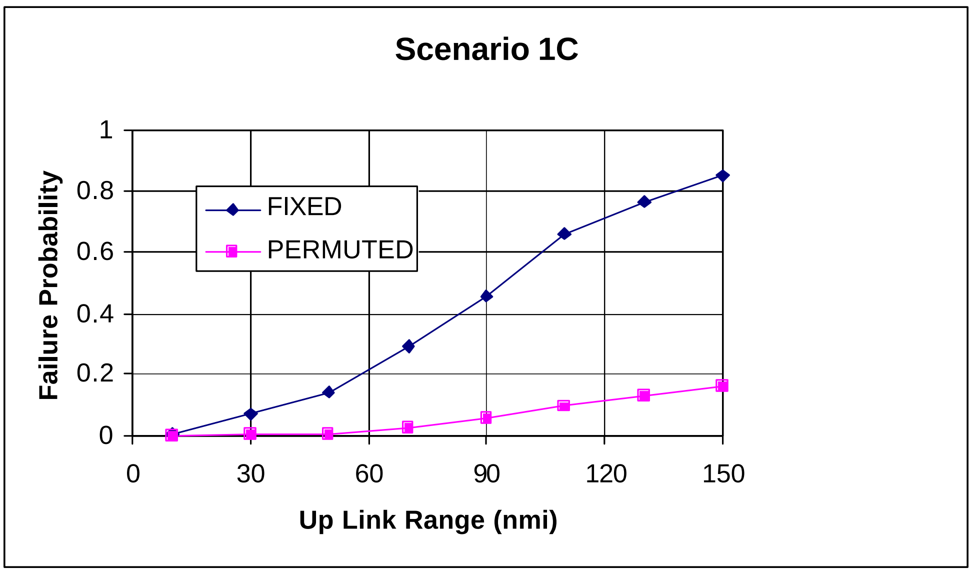

Figure 3. Scenario 1C

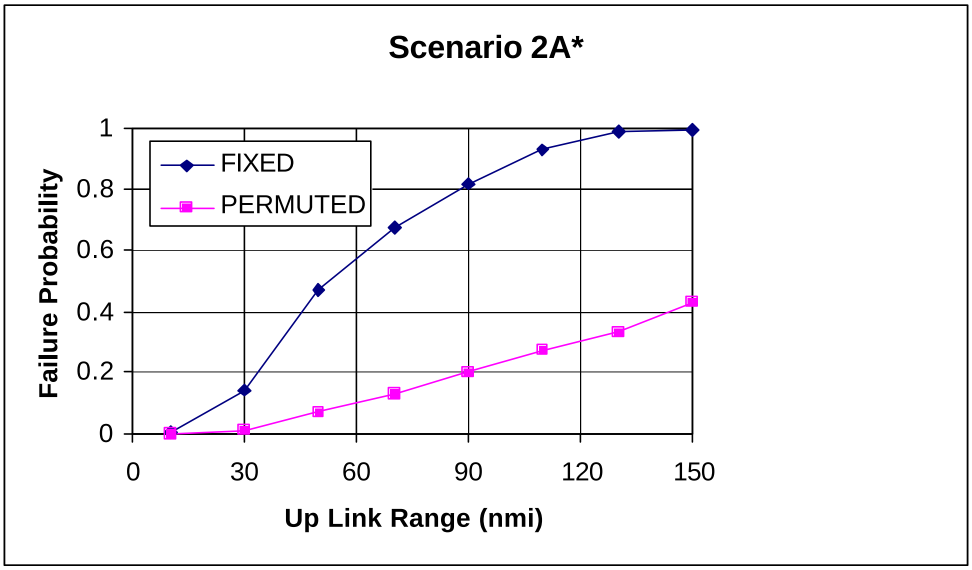

Figure 4. Scenario 2A*

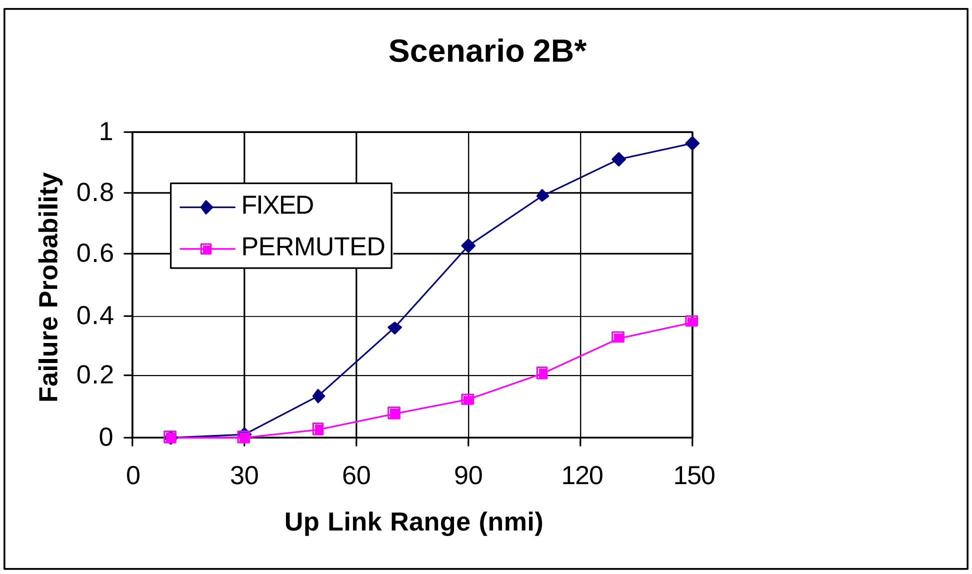

Figure 4. Scenario 2B*

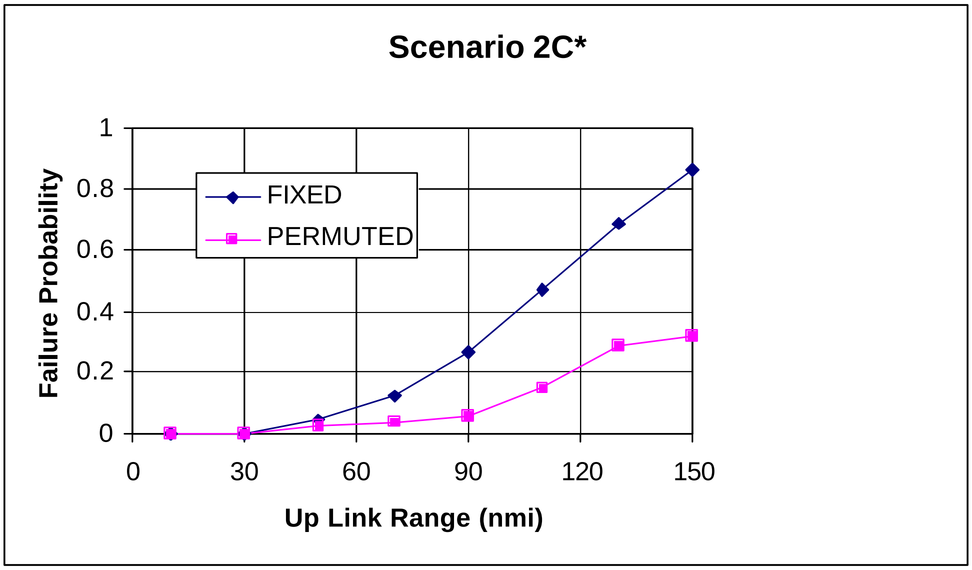

Figure 6. Scenario 2C*

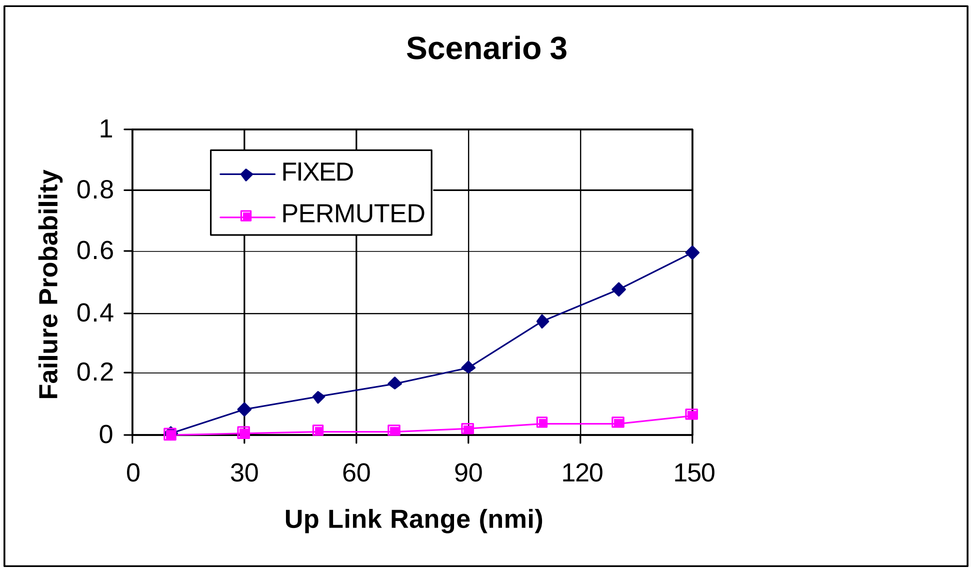

Figure 7. Scenario 3

Summary

The results of all the scenarios indicate that there is a significant difference in performance between the cases with and without permutation. If we take as a benchmark the desire to have an uplink burst failure probability of no more than 10% (see UAT-WP-3-16), then we can summarize the results in terms of the approximate effective uplink range. This is done in Table 1.

Scenario	Range with Permutation (nmi)	Range without Permutation (nmi)
1A	130	70
1B	100	40
1C	110	40
2A*	60	20
2B*	80	40
2C*	100	60
3	>150	40

Table 1. Effective Uplink Range (for 90% Burst Success Rate)

The performance in the cases *without* permutation is highly dependent on the strength of the strongest interferer. For cases 1B, 1C, 2A*, and 3 the strongest interferer is at a level of –39 dBm, and the ranges are all equal to or less than 40 nmi. A range of only 40 nmi would probably not be acceptable. In all cases the performance *with* permutation is significantly improved. In all cases except the "heavy" scenarios of 2A* and 2B*, the range is at least 100 nmi.

Conclusion

The results of this paper indicate that UAT time slot permutation will be necessary if JTIDS/MIDS transmitters are permitted to operate in *any* of the scenarios described in UAT-WP-4-04. This conclusion assumes that the uplink range requirement is approximately 100 nmi and that JTIDS/MIDS is allowed to hop on frequencies at and/or close to the UAT operational frequency. If either of these conditions changes, the conclusion might also change.

Note that the time-slot permutation algorithm need not be very complex. Simply incrementing all slot assignments by one each second would suffice. The main complication in the permutation operation would be in coordinating the ground transmitters so that they not only recognize one-second boundaries, but also have absolute time information.