RTCA Special Committee 186, Working Group 5

ADS-B UAT MOPS (DO-282), Revision A

Meeting 21

UAT ADS-B and TIS-B Performance in Surface and Low-Density Environments

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April 7, 2004

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Assumptions

- TIS-B uplinks are made in the ADS-B segment
- Performance is measured as 95/95 percentiles of update intervals
- Requirement for ADS-B aircraft-aircraft updates on airport surface
  - DO-282 considered requirement to be 1.5 seconds
  - Surface applications for ASA MASPS (ASSA, FAROA) have update requirements of 2 seconds
- Ground Station broadcasting TIS-B
  - Transmit power is 45 dBm at antenna input
  - Antenna gain pattern is omni-directional in azimuth, TACAN in elevation
  - Long format messages

ADS-B Aircraft-Aircraft Performance on Airport Surface

UAT-WP-21-02

Assumptions for Analysis of UAT on Airport Surface

- Performance metric is 95% ADS-B update intervals on surface in the presence of a TIS-B ground station
- TIS-B ground station assumptions for surface analysis:
  - Average uplink rate of 90 messages per second, based on previous LA 2020 analysis (see WP 20-02 to this WG)
  - Station located 0.25 NM away from victim receiver on surface
  - Station at 100 ft. altitude
    - Elevation angle of approx. 3.7 degrees down to receiver
    - Approximately -5 dB elevation gain at that angle (measured pattern)
- Transmitter range was 1 NM from receiver
  - Only range where UAT performance satisfied DO-282 requirements on surface

Results for A3 and A2 Receivers

- Multipath included - estimated worst-case path loss based on equipage
- 1 NM transmitter – receiver range

A3 Receiver

Transmit Class	95% Update Interval (sec)	
	DO-282	With Uplinks
A3	1.17	2.06
A2	1.96	2.08
A1H	1.99	2.08
A1L	2.04	2.11
A0	2.09	2.88

A2 Receiver

Transmit Class	95% Update Interval (sec)	
	DO-282	With Uplinks
A3	1.17	2.04
A2	1.89	2.08
A1H	1.91	2.06
A1L	2.01	2.09
A0	2.05	2.16

Results for A1 and A0 Receivers

- Multipath included - estimated worst-case path loss based on equipage
- 1 NM transmitter – receiver range

A1 Receiver

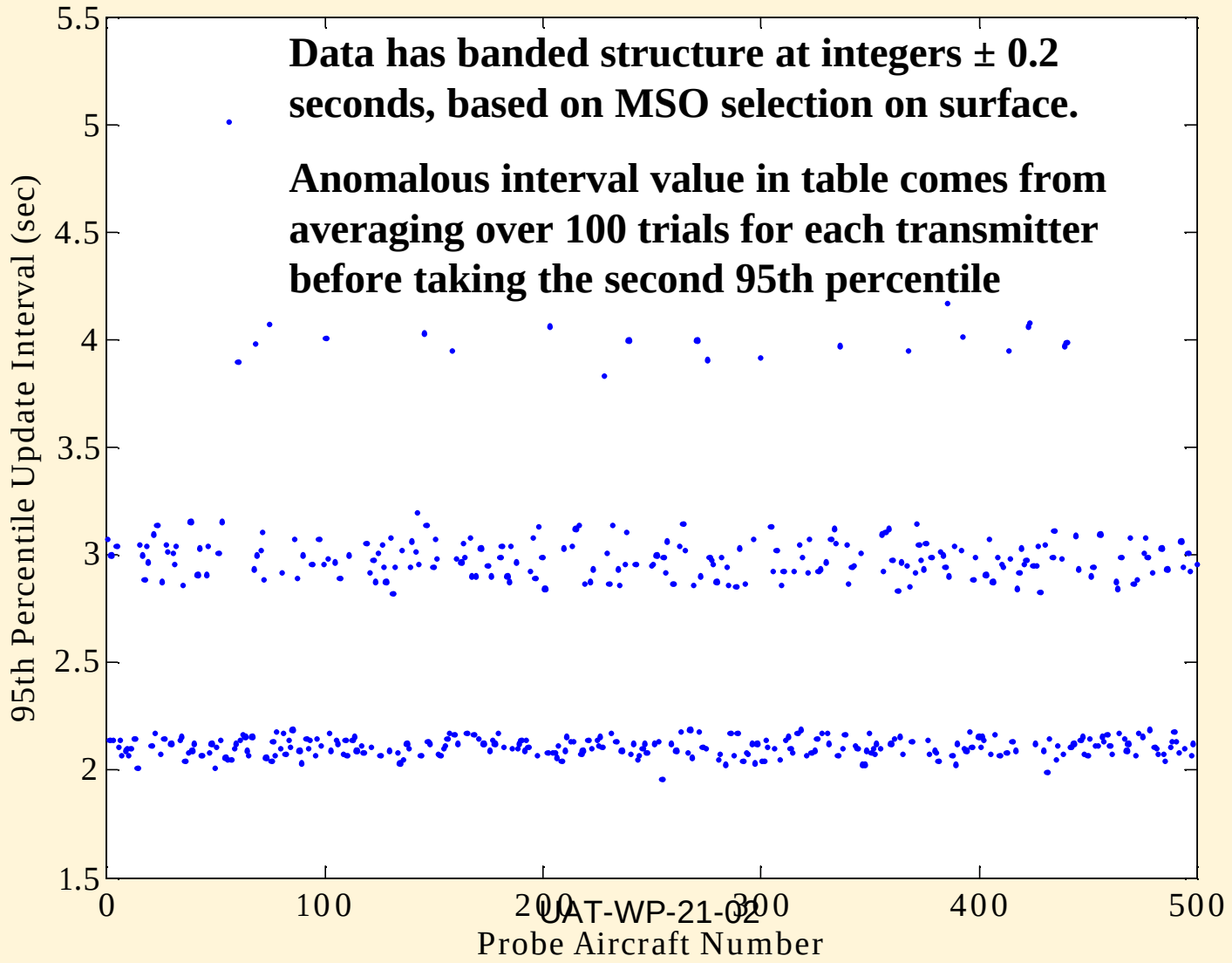
Transmit Class	95% Update Interval (sec)	
	DO-282	With Uplinks
A3	1.19	2.07
A2	2.01	2.1
A1H	2.05	2.1
A1L	2.12	2.88
A0	2.79	3.03

A0 Receiver

Transmit Class	95% Update Interval (sec)	
	DO-282	With Uplinks
A3	1.22	2.07
A2	2.01	2.1
A1H	2.07	2.15
A1L	2.97	3.03
A0	3.04	**3.35***

*** Seemingly impossible interval given configuration**

95% updates for 500 A0 Probe Transmitters for One Trial



Conclusions

- On the airport surface, in a stressing case for ground station placement and uplink rate at 1 NM range, within the modeling uncertainty, the ASSA/FAROA 2 second update interval requirement is
  - Met for A3 receivers for all transmitters other than A0
  - Met for A2 receivers for all transmitters
  - Met for A1 and A0 receivers for A1H, A2, and A3 transmitters

Low-Density Scenario with TIS-B Uplinks

Metrics

- TIS-B
  - Relevant metric is the 95% update interval for state data from TIS-B service
  - Successive 95th percentiles are taken over
    - Intervals between updates for messages broadcast about each individual target in traffic information volume
    - Set of 95th percentile intervals of all targets
- ADS-B
  - Standard 95% update intervals (in the presence of the TIS-B uplinks)

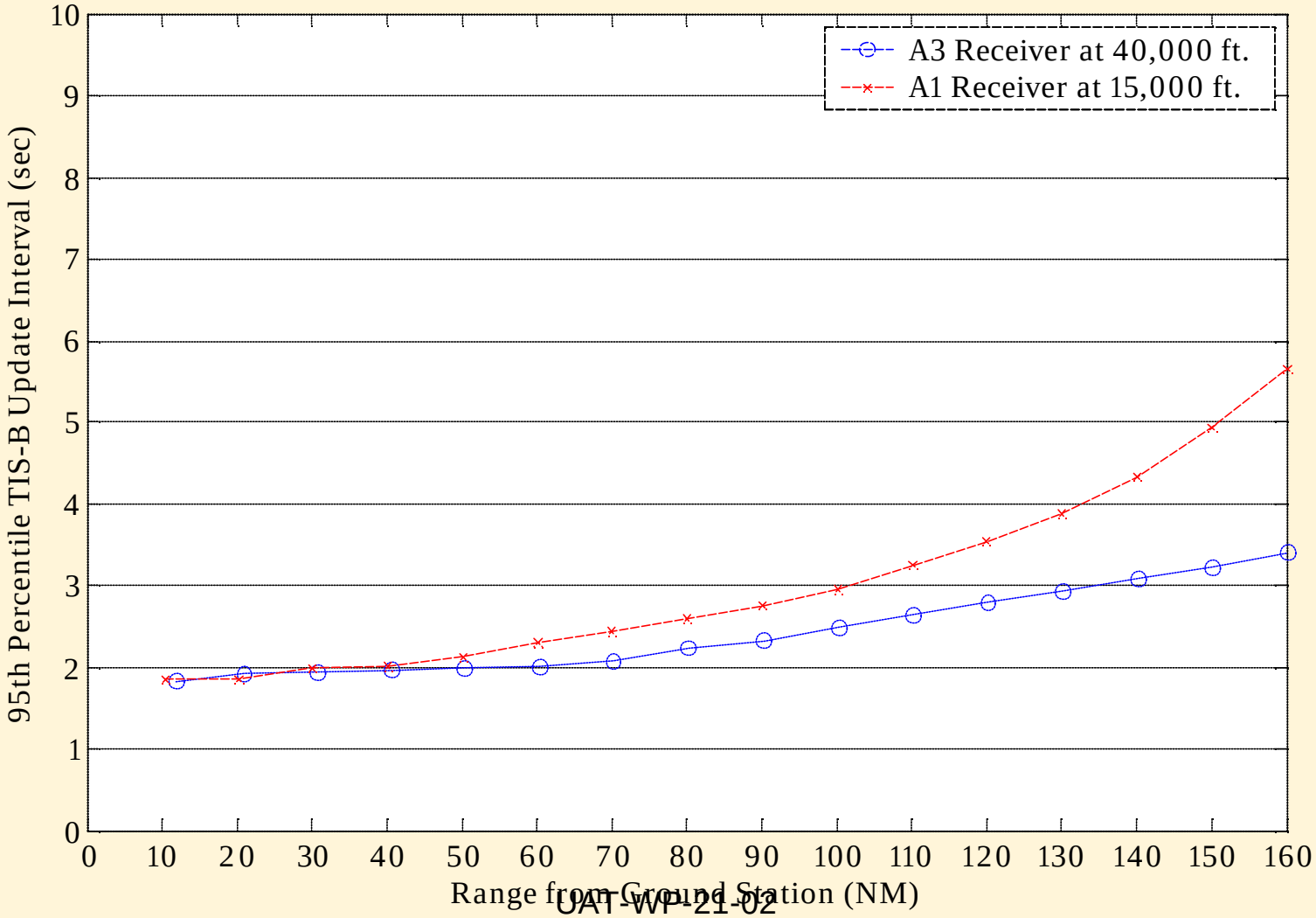
Modified Low-Density Scenario

- Standard Low density scenario:
  - 360 aircraft scattered uniformly within 400 NM radius
  - All A3 equipage
  - Altitudes between 25,000-40,000 ft.
- Near-term low-density would feature low UAT interference, due to low equipage and A3 aircraft indicated for 1090ES
- More interesting to assume a far-term, rebroadcast scenario
  - Assume 50% of aircraft equip with UAT, 50% with 1090ES
  - Assume a single ground station serving this large volume (overbounds uplinks)

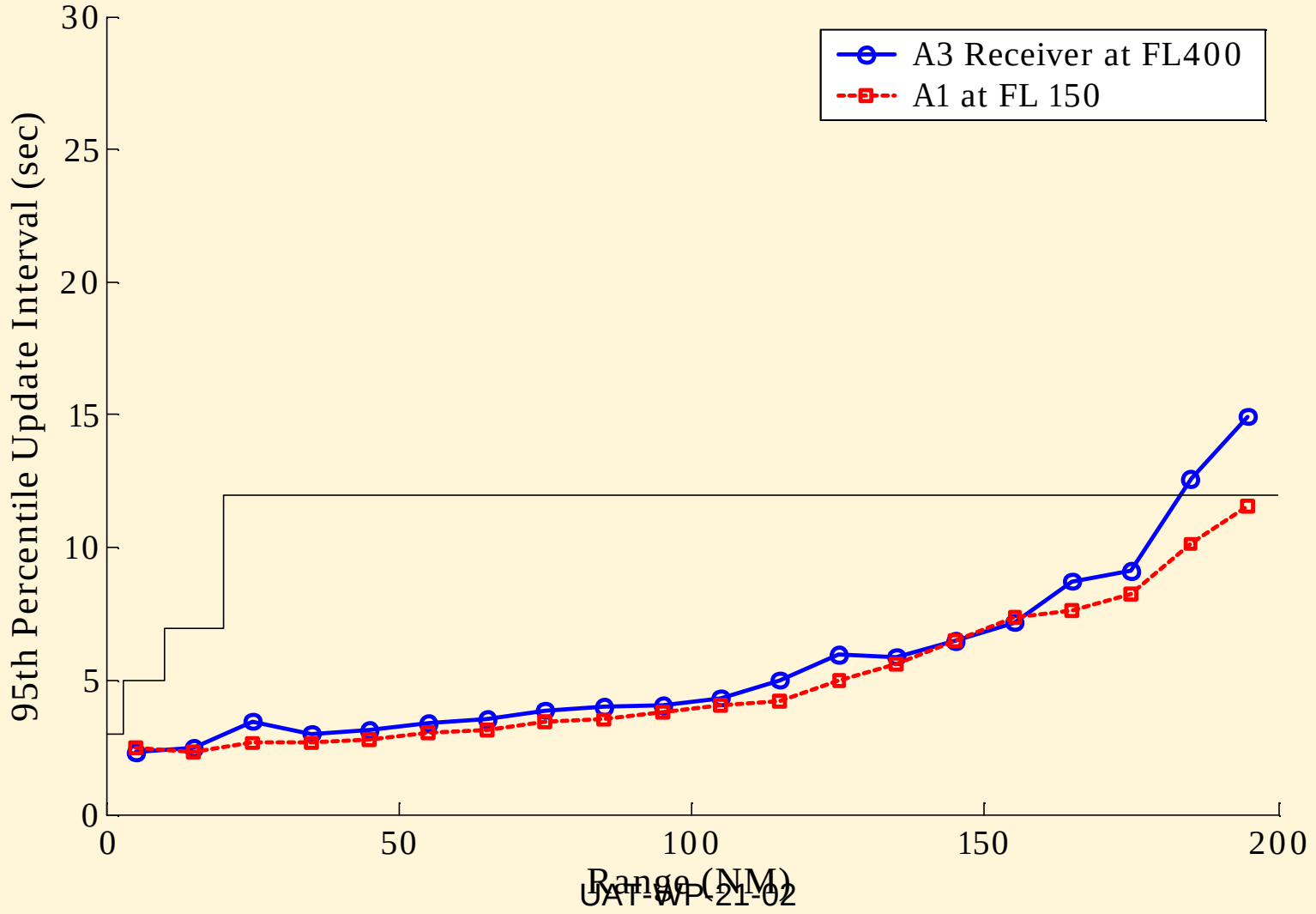
Assumptions

- TIS-B Uplinks:
  - Capstone method to schedule uplinks
  - 180 uplinks per second rebroadcasting 1090ES state data
- Two receivers simulated were:
  - A1 @ 15,000 ft.
  - A3 @ 40,000 ft.

TIS-B Update Interval vs. Range from Ground Station in Low-Density Scenario



ADS-B Update Interval vs. Range in Low-Density Scenario with TIS-B



Conclusions

- Good performance was observed for 95th percentile state data update intervals in a low-density scenario with a TIS-B broadcasts
  - UAT ground stations are expected to provide TIS-B update intervals at the 95% level in less than:
    - 6 seconds out to 160 NM range from the ground station (meets desired update interval req. for EVAcq.*
    - 3 seconds out to 100 NM range from ground station (meets desired update interval req. for CD + EVApp.*)
  - A3 ADS-B transmitters meet ADS-B requirements out to beyond 150 NM
    - Update intervals will support EVAcq., EVapp., & CD requirements for DO-289

* - recall update interval requirement is levied for aircraft-aircraft pairs