ADS-B Assessment Methodology

Presentation to ADS-B FAA/Industry Meeting

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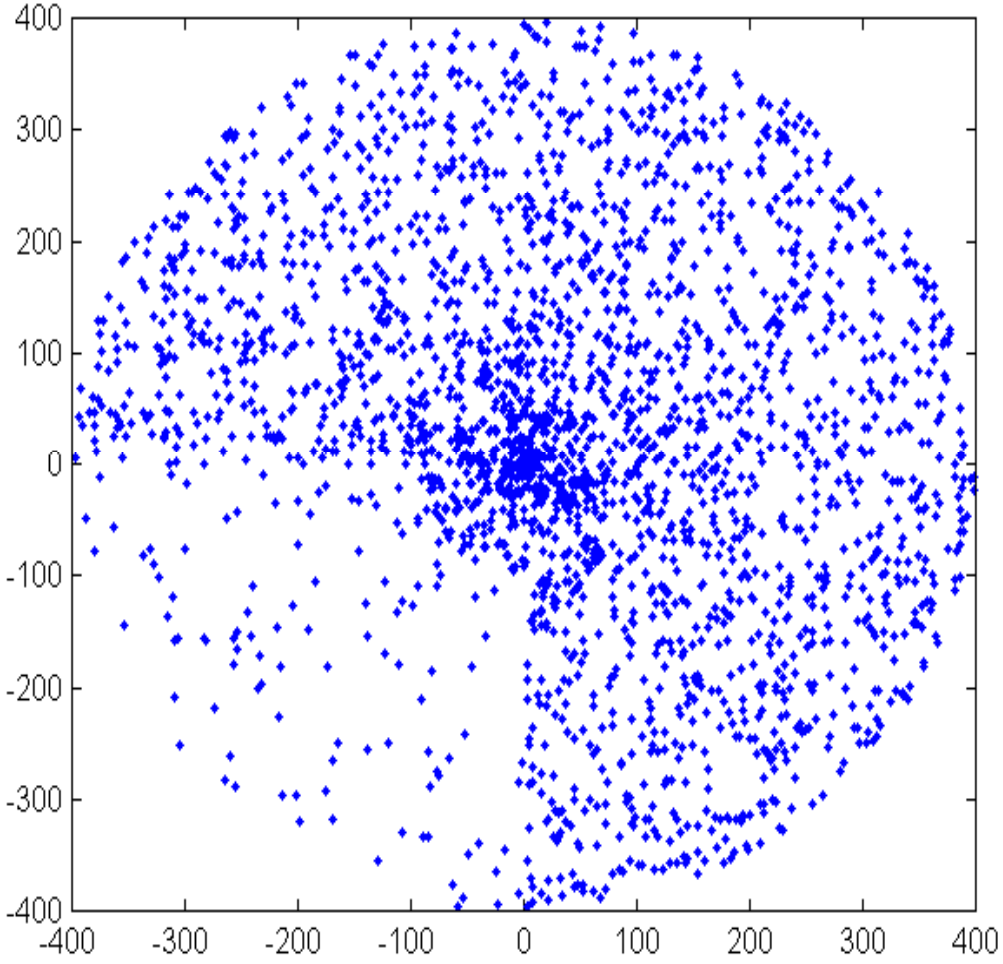
Link Assumptions

Air Traffic Scenarios

	LA BASIN	CORE EUROPE
Current	1796 AC	838 AC
Future	2694 AC	2091 AC
Low Density	360 AC	

Focus was on future and low density scenarios

LA Basin Scenario



Aircraft Equipage

	LA BASIN	CORE EUROPE	LOW DENSITY
A3	30%	30%	100%
A2	10%	30%	0%
A1	40%	30%	0%
A0	20%	10%	0%

A3 = Extended Capability
A2 = Enhanced IFR
A1 = Basic IFR
A0 = Basic VFR

All aircraft are equipped with ADS-B.

1090 Assumptions/Parameters

- Transmit characteristics
  - Transmission rates
    - Position squitters: 2 per second (even or odd)
    - Velocity squitters: 2 per second
    - Aircraft ID squitter: once every 5 seconds
    - Intent A: once every 1.7 seconds for A3 only
    - Intent B: once every 1.7 seconds for A3 only
    - Status: once every 1.7 seconds
  - Transmitter power at antenna
    - A1-A3: 51-57 dBm
    - A0: 48.5-57 dBm
  - Alternate transmissions from top and bottom antennas

1090 Assumptions/Parameters II

- Receive characteristics
  - MTL at antenna
    - A0: <= -72 dBm
    - A1: <= -74 dBm
    - A2: <= -79 dBm
    - A3: <= -84 dBm
  - Receiver diversity for A1-A3 (not A0)
  - Receiver blanked during co-site transmissions
- Future interrogators
  - LA Basin - two radars upgraded to Mode S
  - Core Europe - approved by Eurocontrol

1090 Assumptions/Parameters III

- Additional
  - Equipment mix (TCAS, decoder types)
    - TCAS future equipage rate same as current in LA Basin (40%), 100% for Core Europe
    - Evaluation focused on enhanced decoders
  - TCAS operation
    - Response rate will be modeled as ideal
    - Future LA Basin will remove terrafix
  - FIS-B implementation uses hexagonal ground network
  - Process has been developed which incorporates expected effects of motion in assessment

UAT Assumptions/Parameters

- Transmit characteristics
  - Transmit one extended message per second
  - Transmitter power at antenna
    - A2,A3: 50-54 dBm
    - A0,A1: 44-48 dBm
  - Alternate transmissions from top and bottom antennas
- Receive characteristics
  - MTL: -93 dBm at antenna
  - Receiver diversity

UAT Assumptions/Parameters II

- Co-site interference due to:
  - DME transmissions
  - Mode S interrogations and replies
  - Whisper-shout interrogations
  - ATCRBS replies

VDL4 Assumptions/Parameters

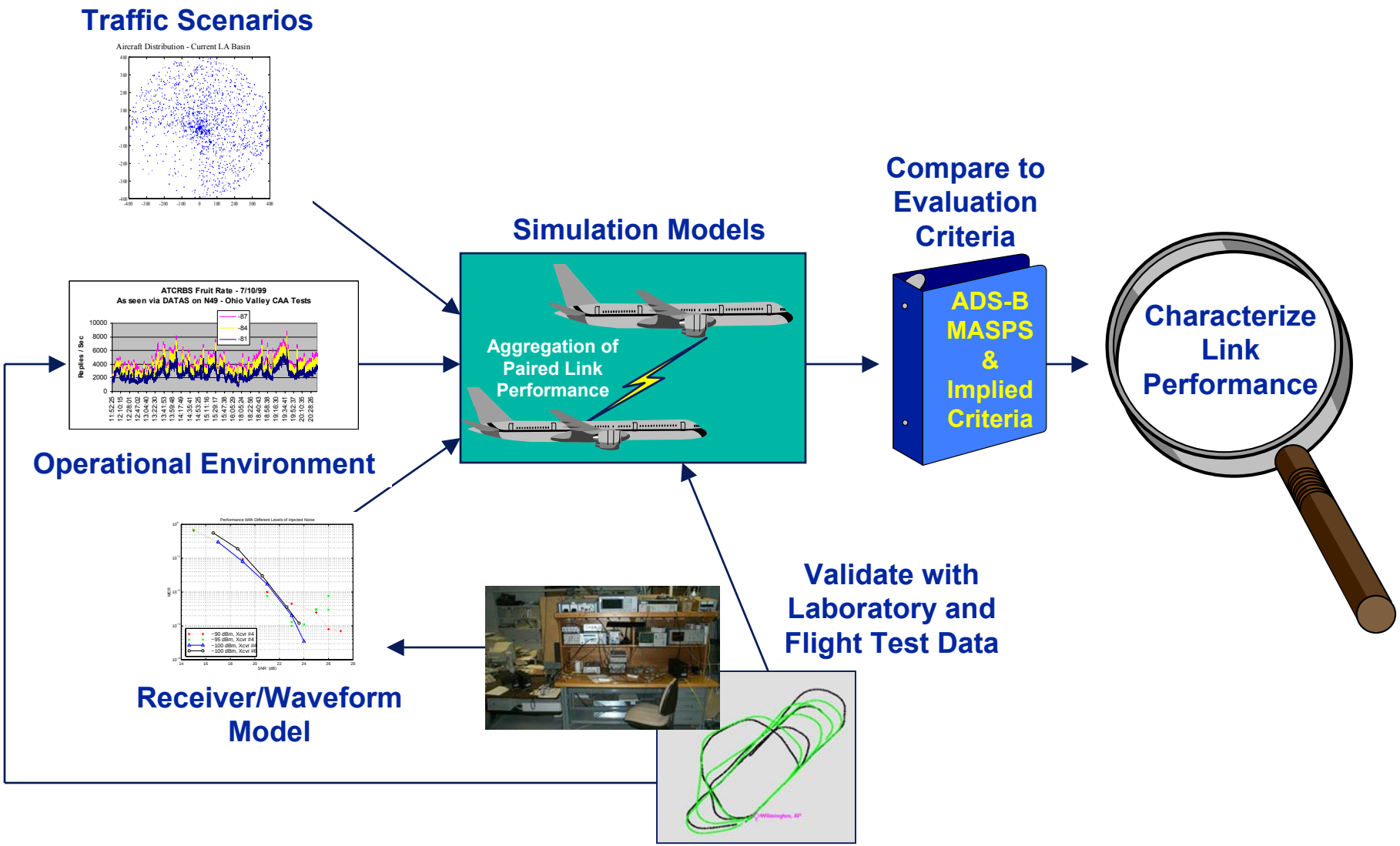
- Transmit characteristics
  - Channel transmission rate dependent on airspace and/or timeframe
    - TMA Region - 12/min
    - Outside TMA Region - 12/min (exception - 6/min for some)
  - Transmitter power at antenna:
    - A2, A3: 38.5-40 dBm
    - A0, A1: 36.5-38 dBm
  - Alternate transmissions from top and bottom antennas

VDL4 Assumptions/Parameters II

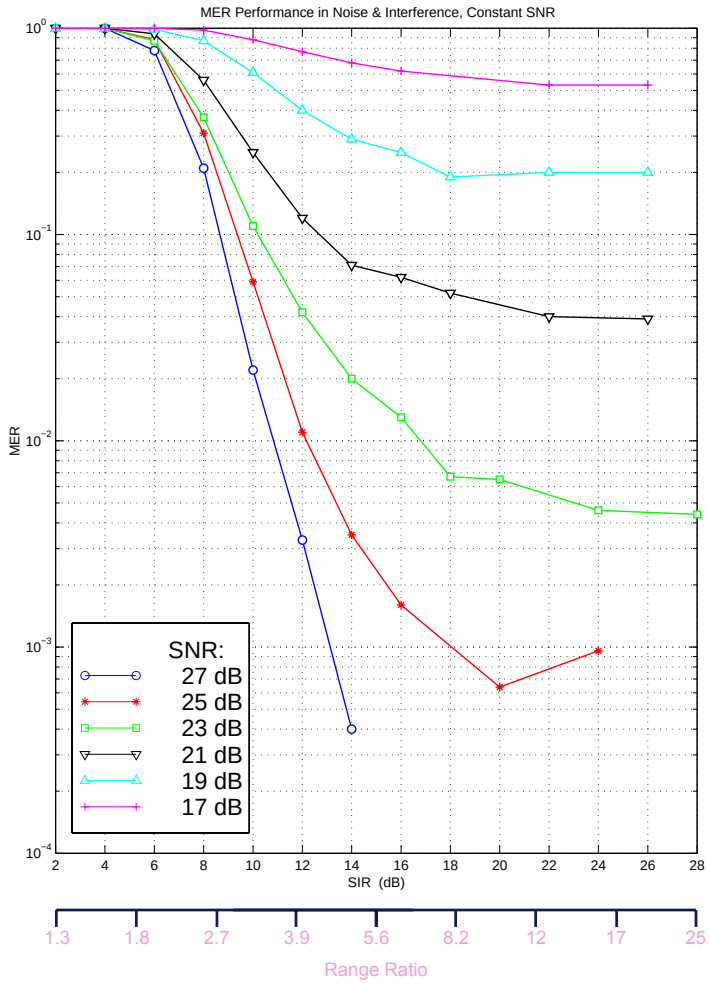
- Receive characteristics
  - MTL: -98 dBm
  - Receive antenna diversity
  - Receiver cannot receive only if transmitting on a VDL4 channel
    - Assumes frequency planning provides channel clear of co-site transmissions

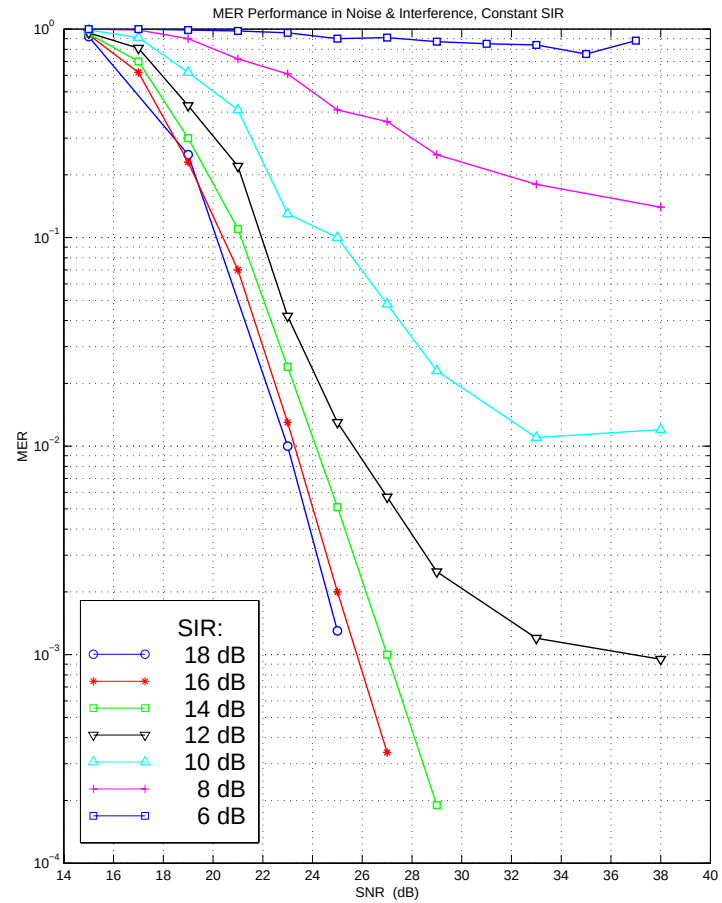
Modeling Methodology

Modeling Diagram

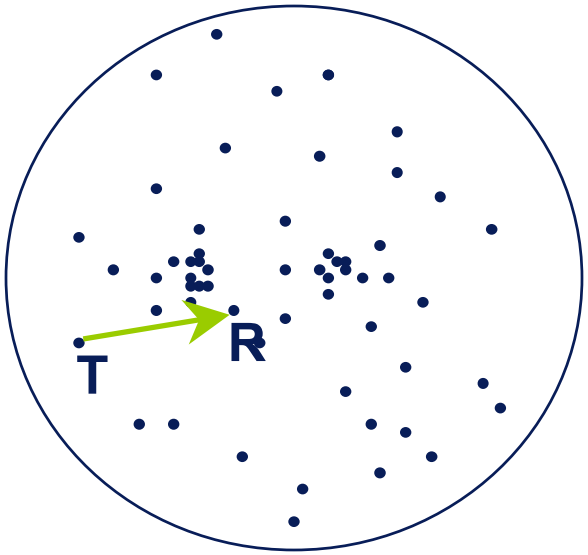


MER PERFORMANCE IN INTERFERENCE - RESULTS



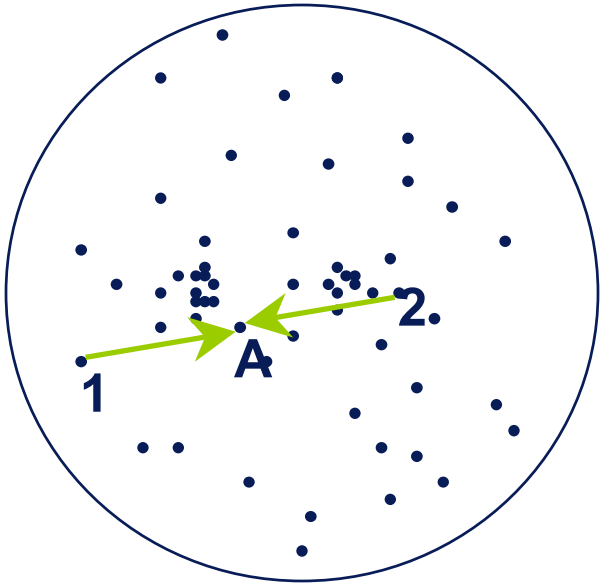


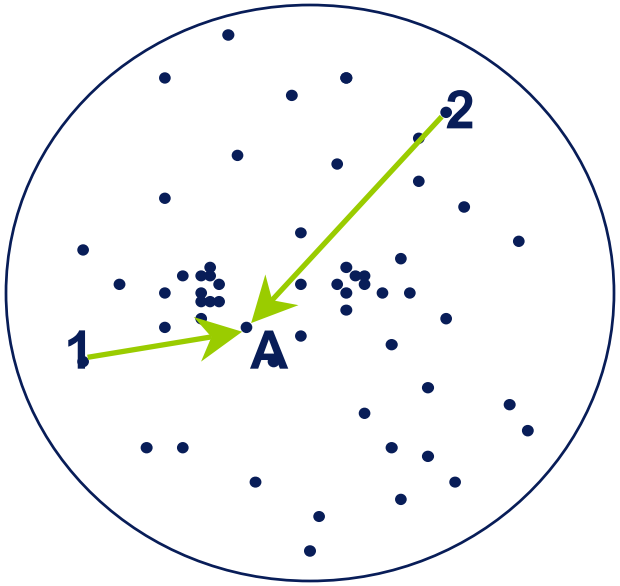
ADS-B Net Model



When an aircraft T transmits, the SNR at each aircraft (e.g., R) is determined, including effects such as antenna patterns.

Interference from other ADS-B transmitters will also be calculated. If aircraft 1 and 2 transmit at the same time, A may not receive either one.





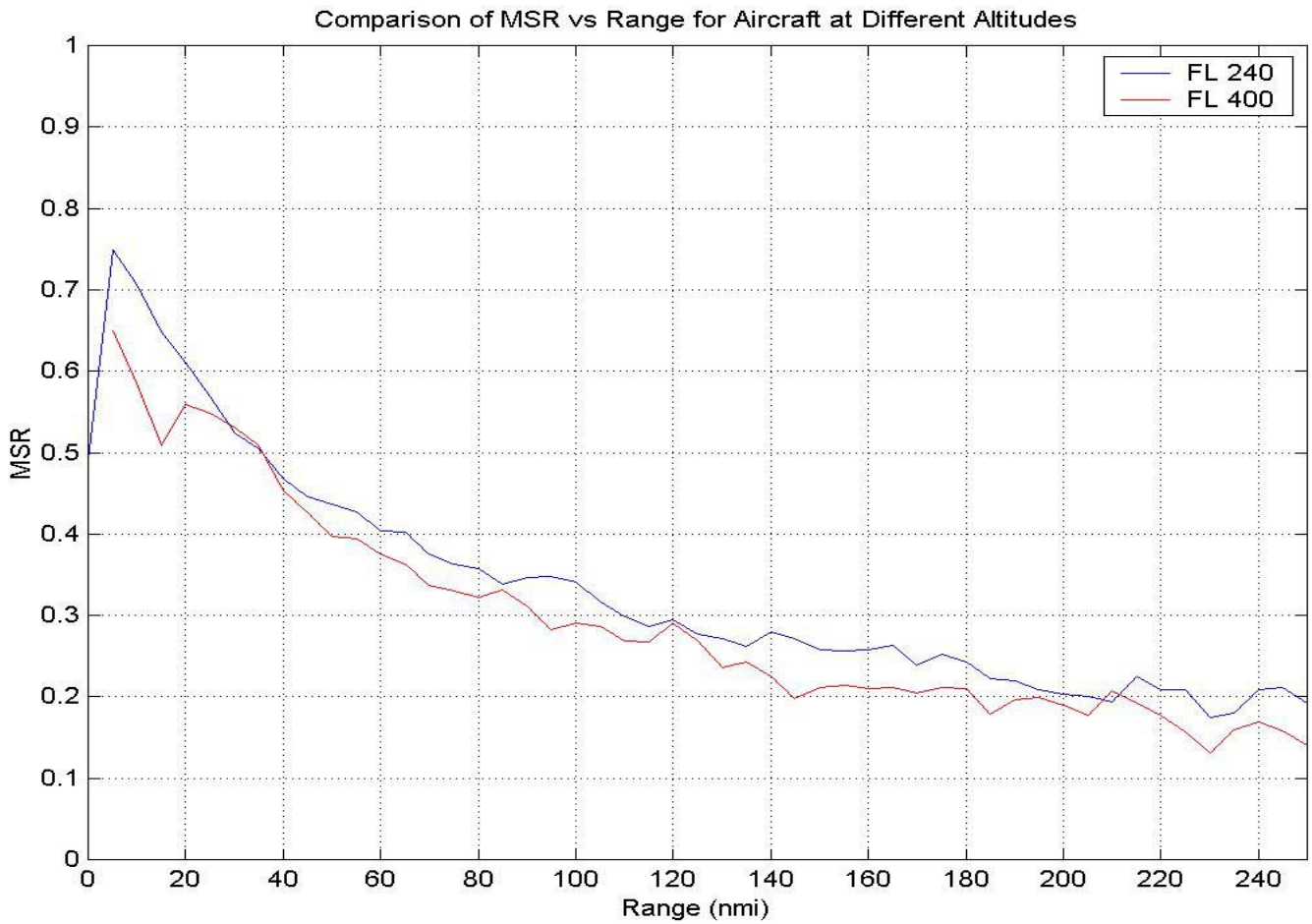
In this case, if aircraft 1 and 2 transmit at the same time, A may receive 1, while ignoring 2.

Evaluation Criteria

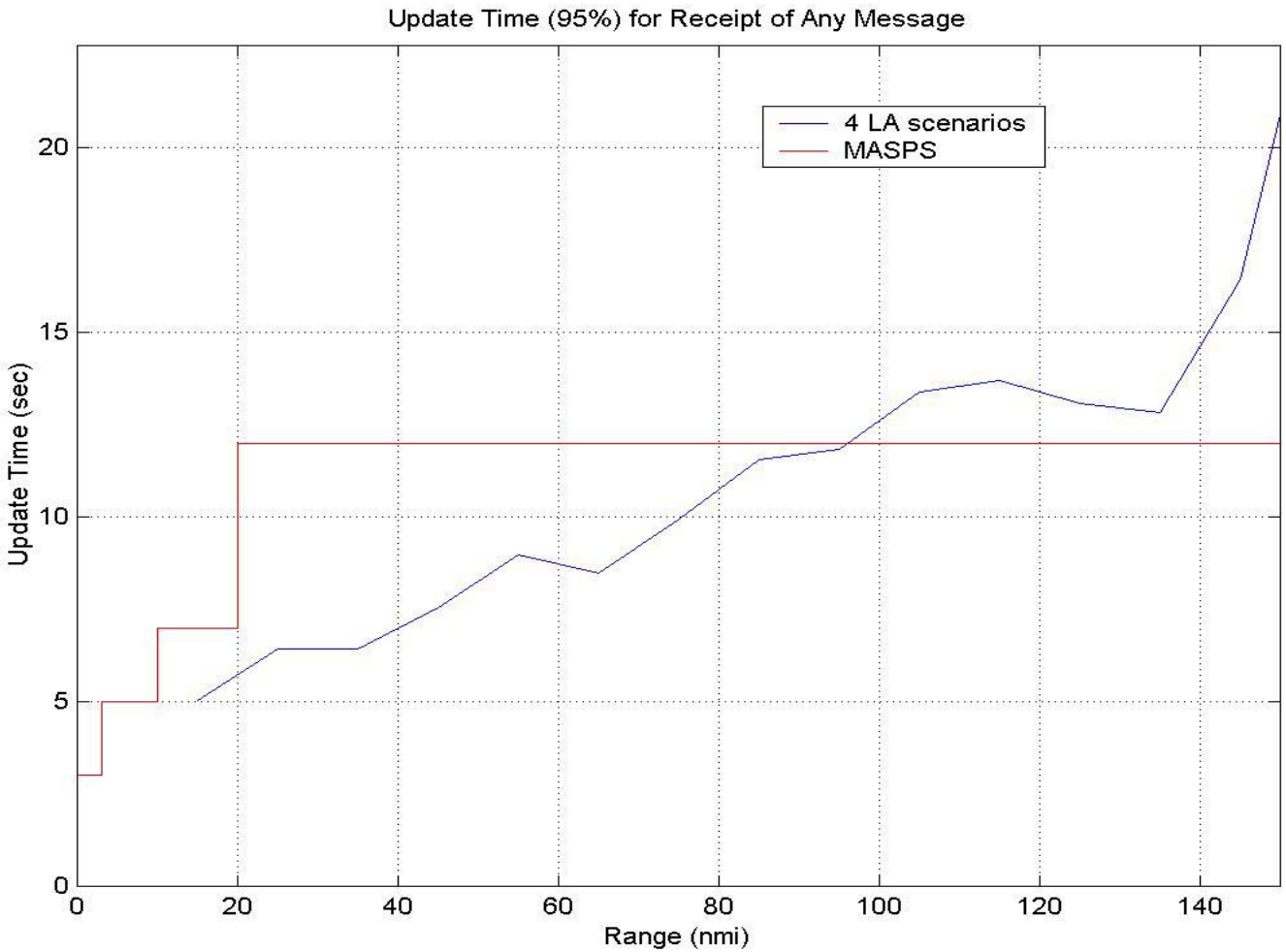
	Aid to Visual Acquisition	Conflict Avoidance and Collision Avoidance	Separation Assurance and Sequencing	Flight Path Deconfliction Planning	Simul-taneous Approach	Airport Surface (note 5)
State Vector Acquisition Range	10 nmi	20 nmi	40 nmi	90 nmi (note 3) (120 nmi desired)	10 nmi	*5 nmi*
Mode-status Acquisition Range (note 8)	10 nmi	20 nmi	40 nmi	90 nmi (note 3) (120 nmi desired)	10 nmi	*5 nmi*
On Condition Acquisition Range (note 8)	n/a	n/a	n/a	90 nmi (note 3) (120 nmi desired)	10 nmi	TBD
Nominal Update Period (95th percentile) (note 6) (note 7)	<=3s (3 nmi) <= 5 s (10 nmi)	<=3s (3 nmi) (1 s desired, note 2) <‘~ ~ (20 nmi)	<=7s (20 nmi) <= 12 ~ (40 nmi)	<=12s	*<=1.5s (1000 ft runway separation)* <=3s *(is desired) (2500 ft runway separation)*	*<=1.5s*
99th Percentile State Vector Report Received Update Period (Coast Interval) (Note 7, 8)	<=6s (3 nmi) <=lOs (10 nmi)	<=6s (3 nmi) <=14s (20 nmi)	<=14s (20 nmi) <=24s (40 nmi)	<=24s .	<=3s(lOOOft runway separation) (is desired, note2) <=7s (2500 ft runway separation)	<=3s

Sample Results

Average MSR vs Range for Two Aircraft at Different Altitudes

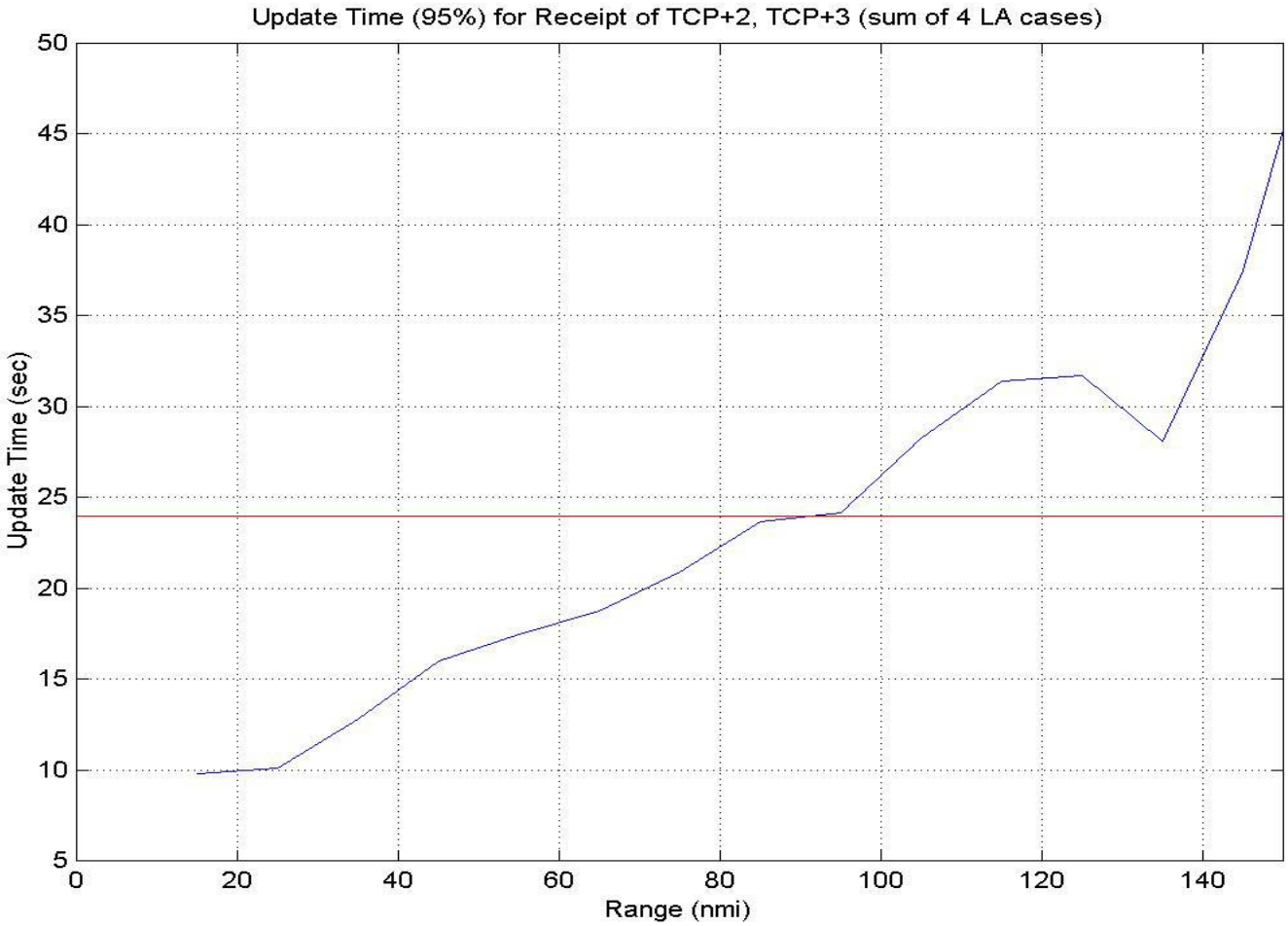


Update Times for Sum of Four LA Cases

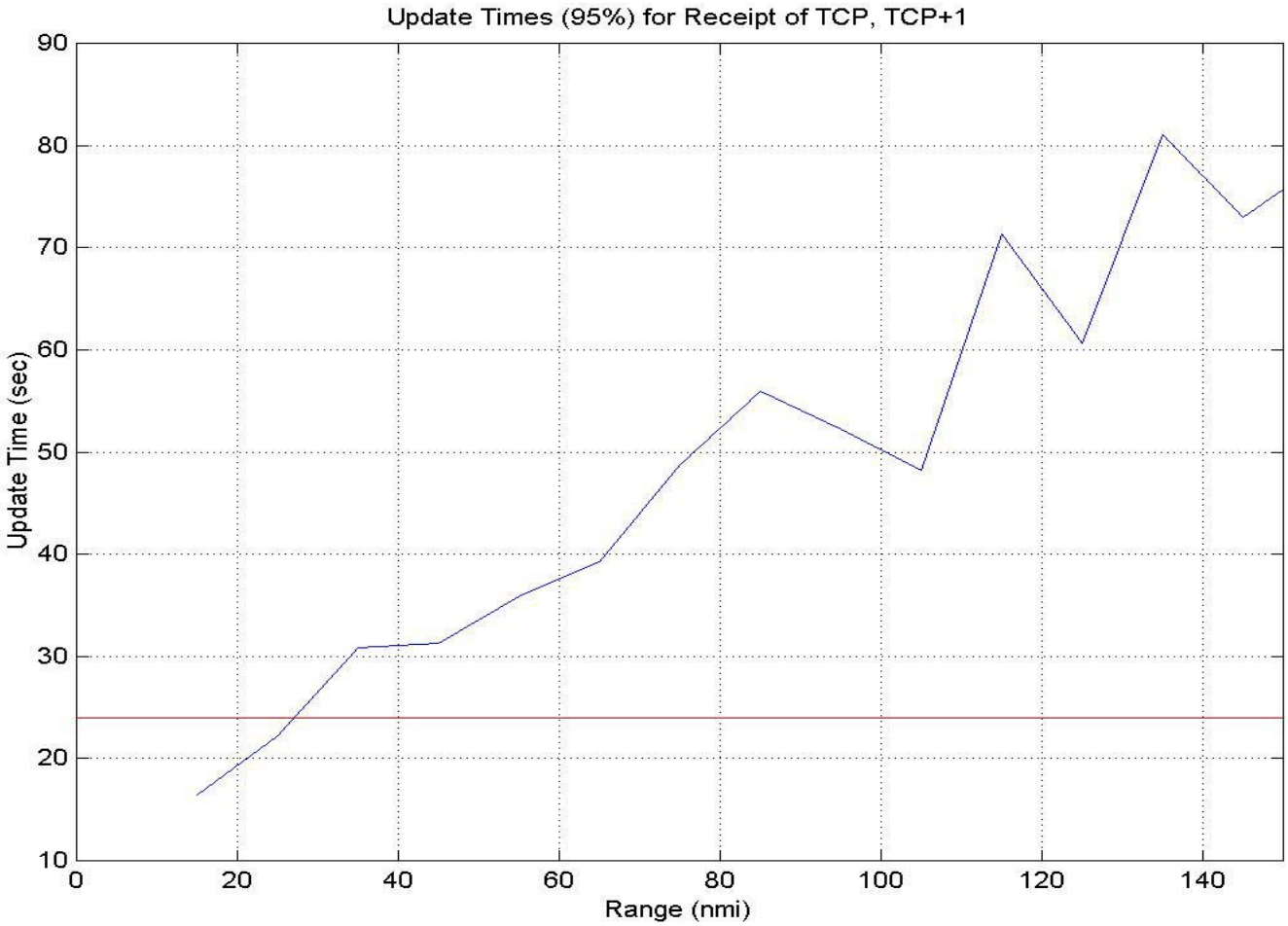


Update Times for Two Victims at Different Altitudes

Update Times for TCP, TCP+1 for Sum of Four LA Cases



Update Times for TCP+2, TCP+3 for Sum of Four LA Cases



Current/Future Work

System Analysis

- Further TLAT Work
  - Investigate LA 2020 1090 RF environment
  - Look at TIS-B assumptions, interim case
- Analyze Results
  - Sensitivity analyses
  - Determine contributors to performance
    - E.g., terrain effects

Broaden Scope

- FIS-B Analysis
  - Uplink of weather information to cockpit
- TAMDAR Analysis
  - Air-air and air-ground performance
- Examine system parameters of links
  - E.g., transmit powers