RTCA Special Committee 186, Working Group 5

ADS-B UAT MOPS

Meeting #5

Action Item 4-4
UAT Sensitivity

Presented by Larry Bachman

SUMMARY

This presentation covers (1) Receiver performance model, (2) A3 transmit power, (3) Reed-Solomon coding/message length, (4) Switched receiver reception, (5) Ground reception, and (6) Link 16 interference.

UAT Sensitivity

Presentation to Working Group 5

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Outline

- Receiver performance model
- A3 transmit power
- Reed-Solomon coding/message length
- Switched receiver reception
- Ground reception
- Link 16 interference

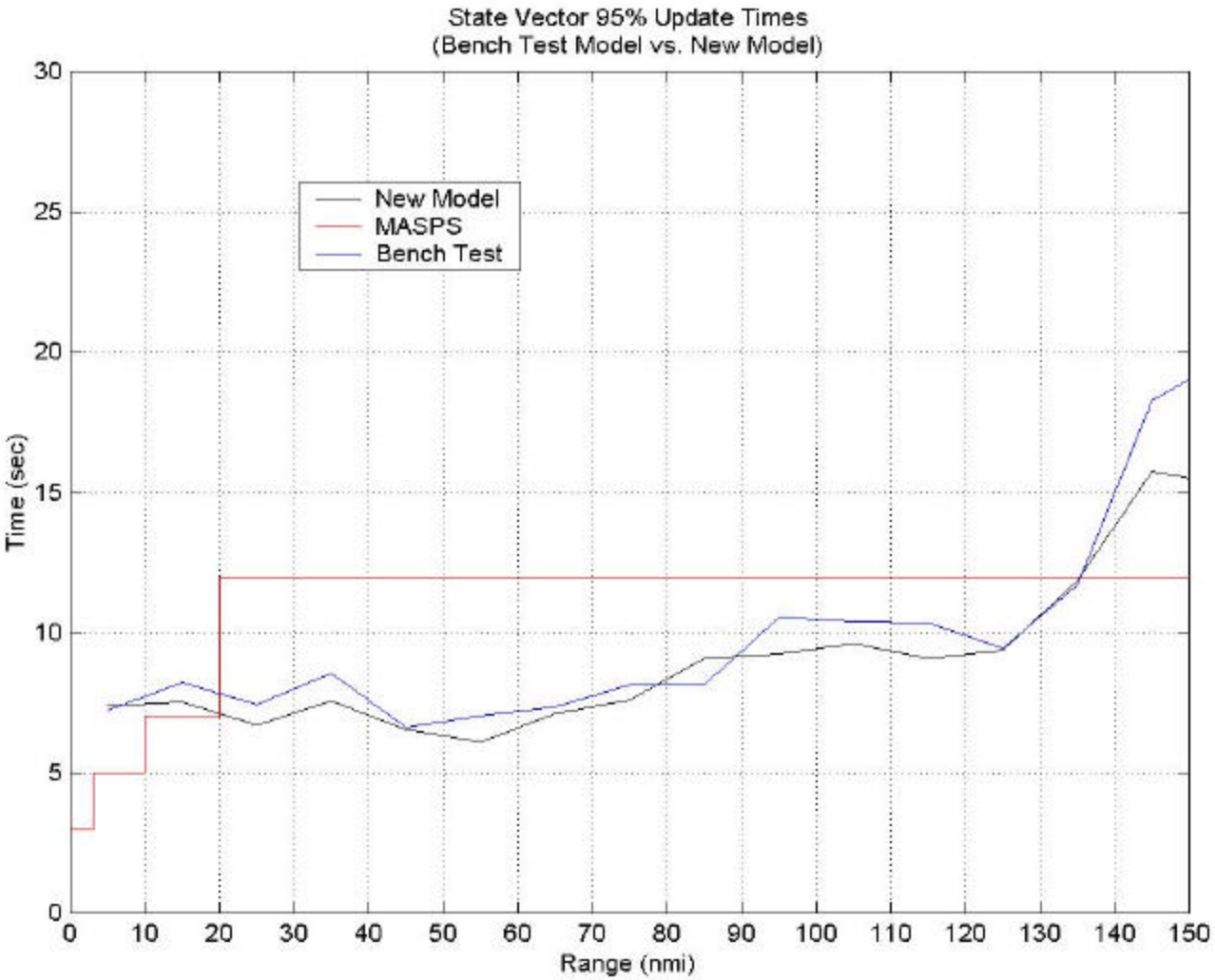
Purpose of New Receiver Performance Model

- "Old" model based on bench test measurements of specific equipment
- Modifications to equipment/UAT waveform could not be modeled using measurement data
  - Modified Reed-Solomon code/message length
  - Pulsed interference
  - Narrower bandwidth
  - Pulsed interference (DME/Link 16)

Receiver Performance Model Comparison

- Ran bench test model of receiver performance
- Implemented new receiver performance model
- Ran new model using same assumptions
  - Same UAT message structure and coding
  - Same scenario
- Compared results by looking at state vector update times (TLAT criterion)

New Receiver Performance Model Results



Receiver Performance Model Conclusions

- Theoretical receiver performance model results consistent with bench test performance for measured UAT equipment
- New model allows for modifications to UAT to be modeled in large-scale simulation (e.g., new Reed-Solomon, message lengths, L16, etc.)

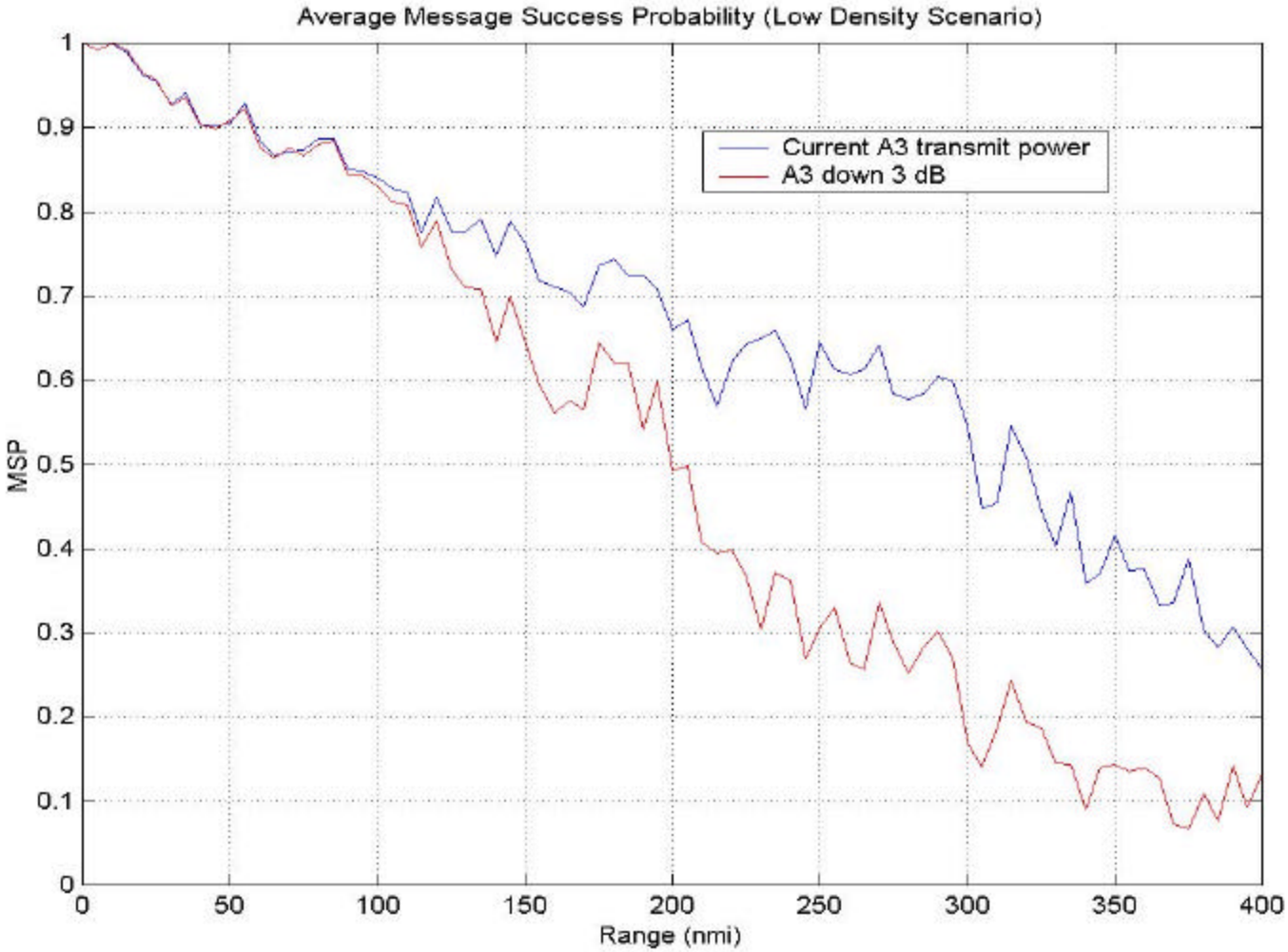
Modifications to UAT System Description

- Transmit powers
  - TLAT
    - A0/A1: 44-48 dBm
    - A2/A3: 50-54 dBm
  - New System
    - A0/A1: 37-41 dBm
    - A2: 41-45 dBm
    - A3: 50-54 dBm
- Message Sequence
  - TLAT
    - All aircraft transmitted one extended message per second
  - New System
    - A0/A1 transmit two basic messages per 4-second epoch

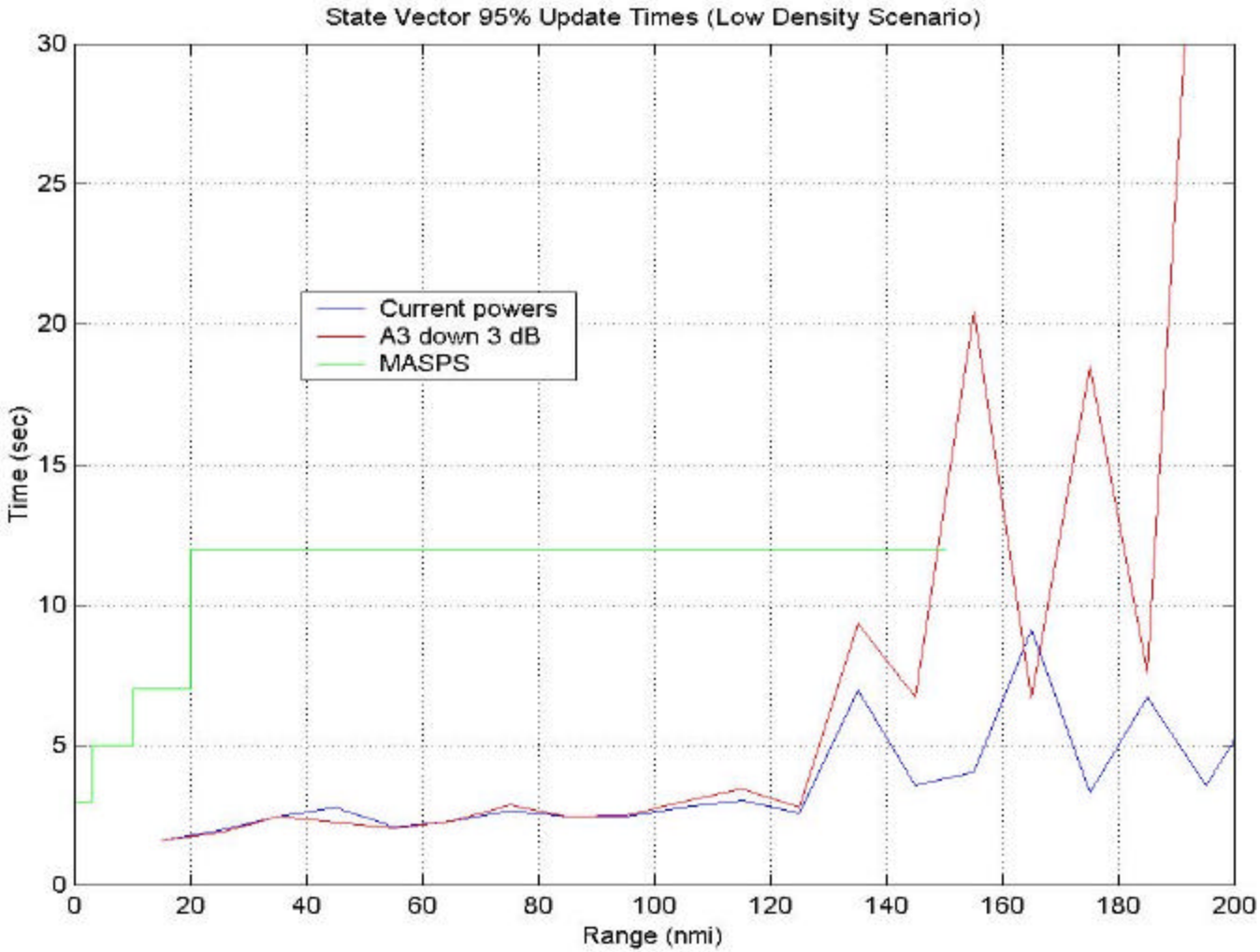
A3 Transmit Power

- Current proposed power levels
  - A0/A1: 5-12.5 watts
  - A2: 12.5-31 watts
  - A3: 100-250 watts
- Variation
  - A3: 50-125 watts
- Evaluation assumptions
  - New Reed-Solomon/message lengths
  - No L16/DME (looking at relative performance)
  - A3 receiver (highest number of aircraft in LOS)

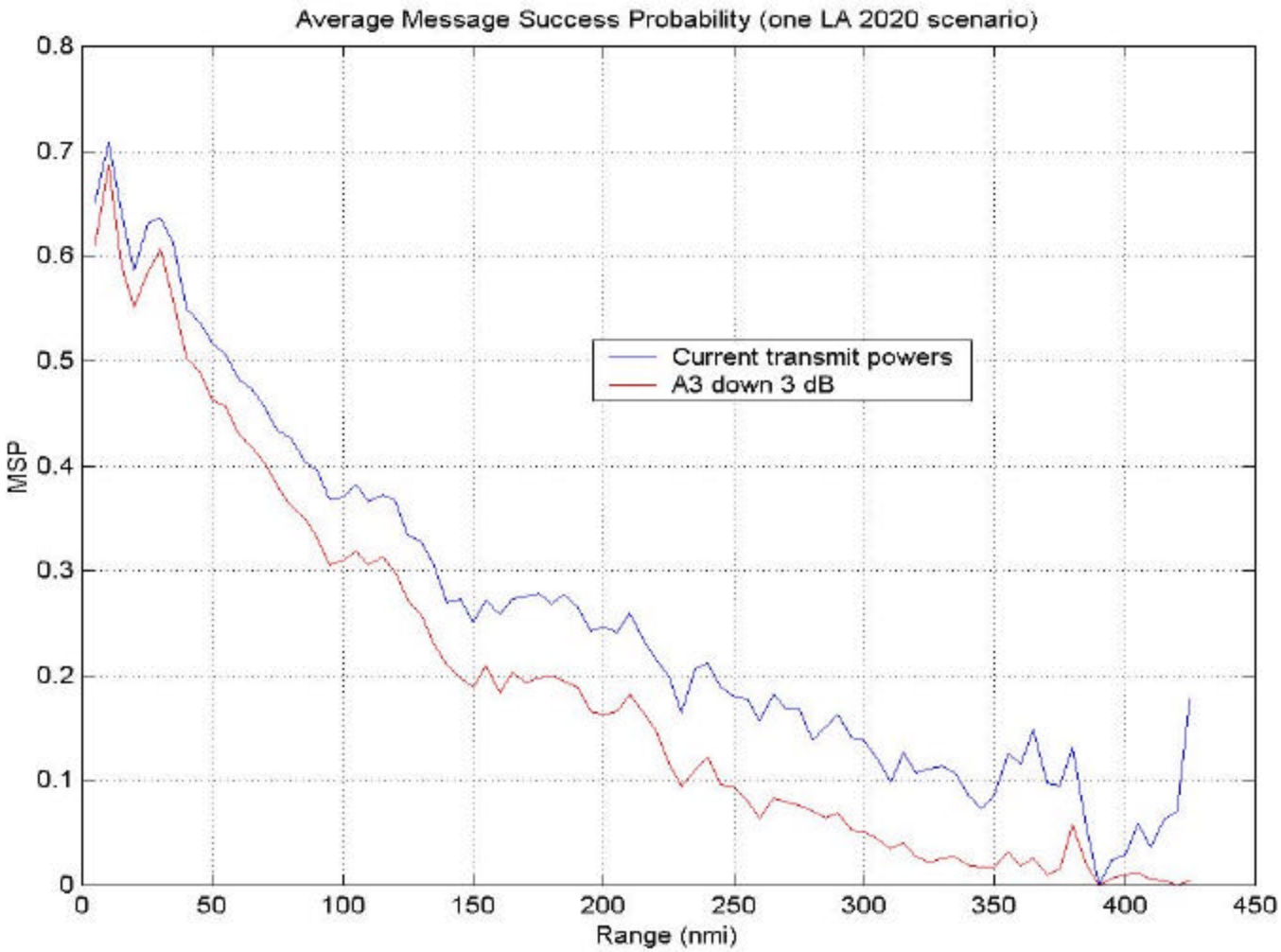
A3 Transmit Power (Low Density) Average Message Success Rate



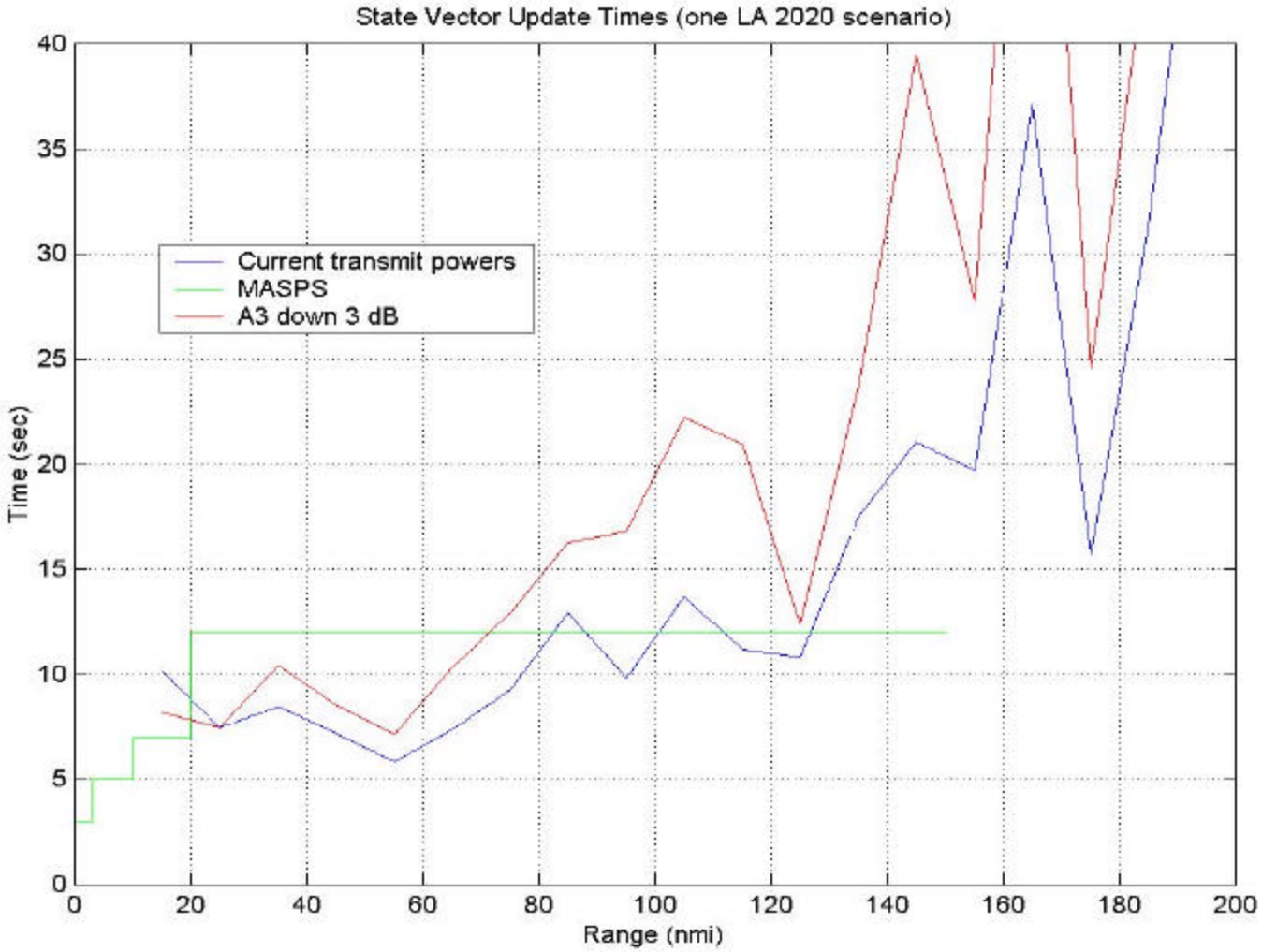
A3 Transmit Power (Low Density) State Vector Update



A3 Transmit Power (LA 2020) Average Message Success Rate



A3 Transmit Power (A 2020) State Vector Update



A3 Transmit Power Conclusions

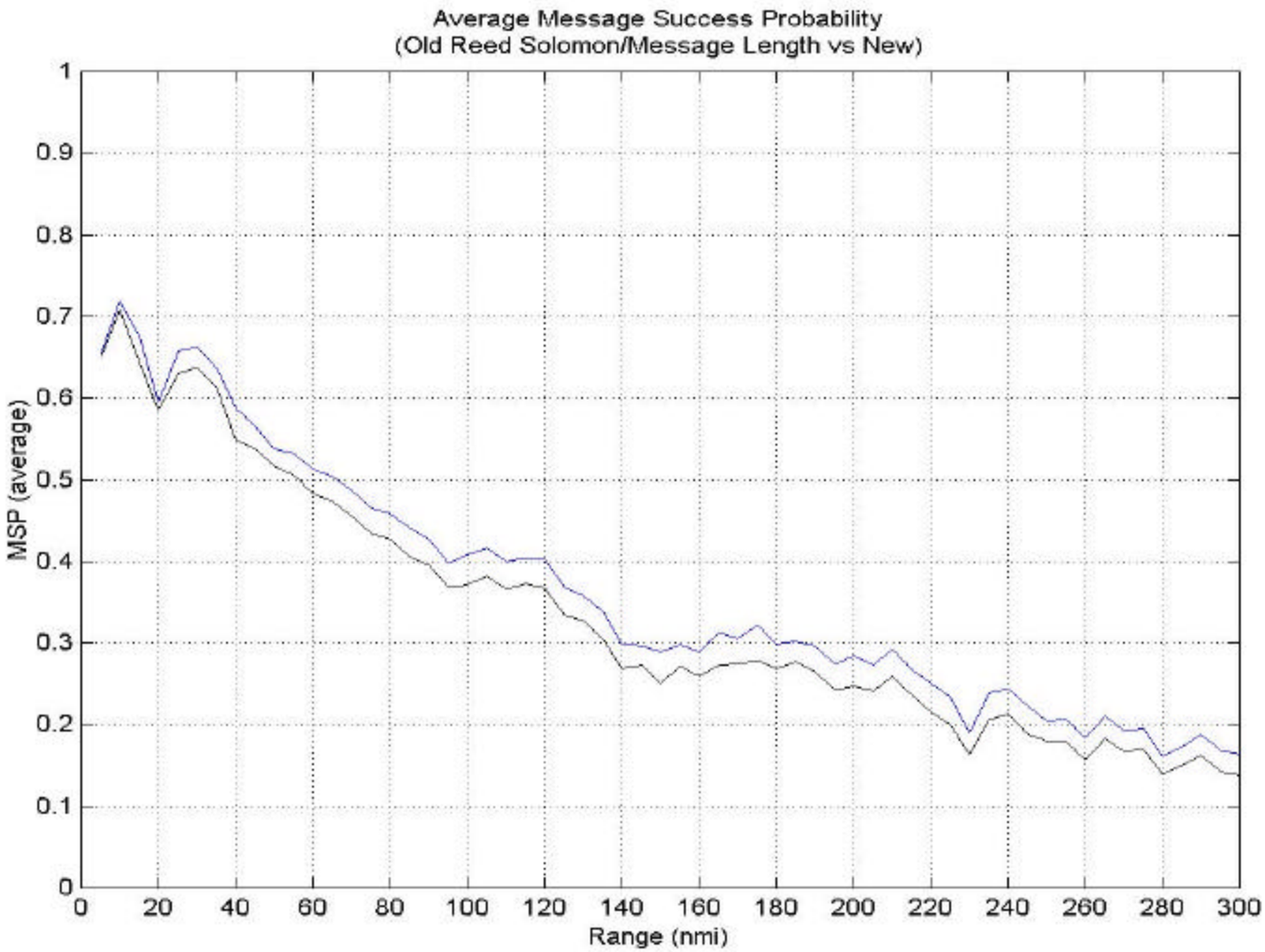
- Low Density scenario
  - Significant impact on average MSP at large distances
  - Still remains within MASPS state vector update criterion
- LA 2020 scenario
  - Impact on average MSP increases with distance
  - May have significant impact on state vector update rate

New Reed-Solomon Coding/Message Lengths

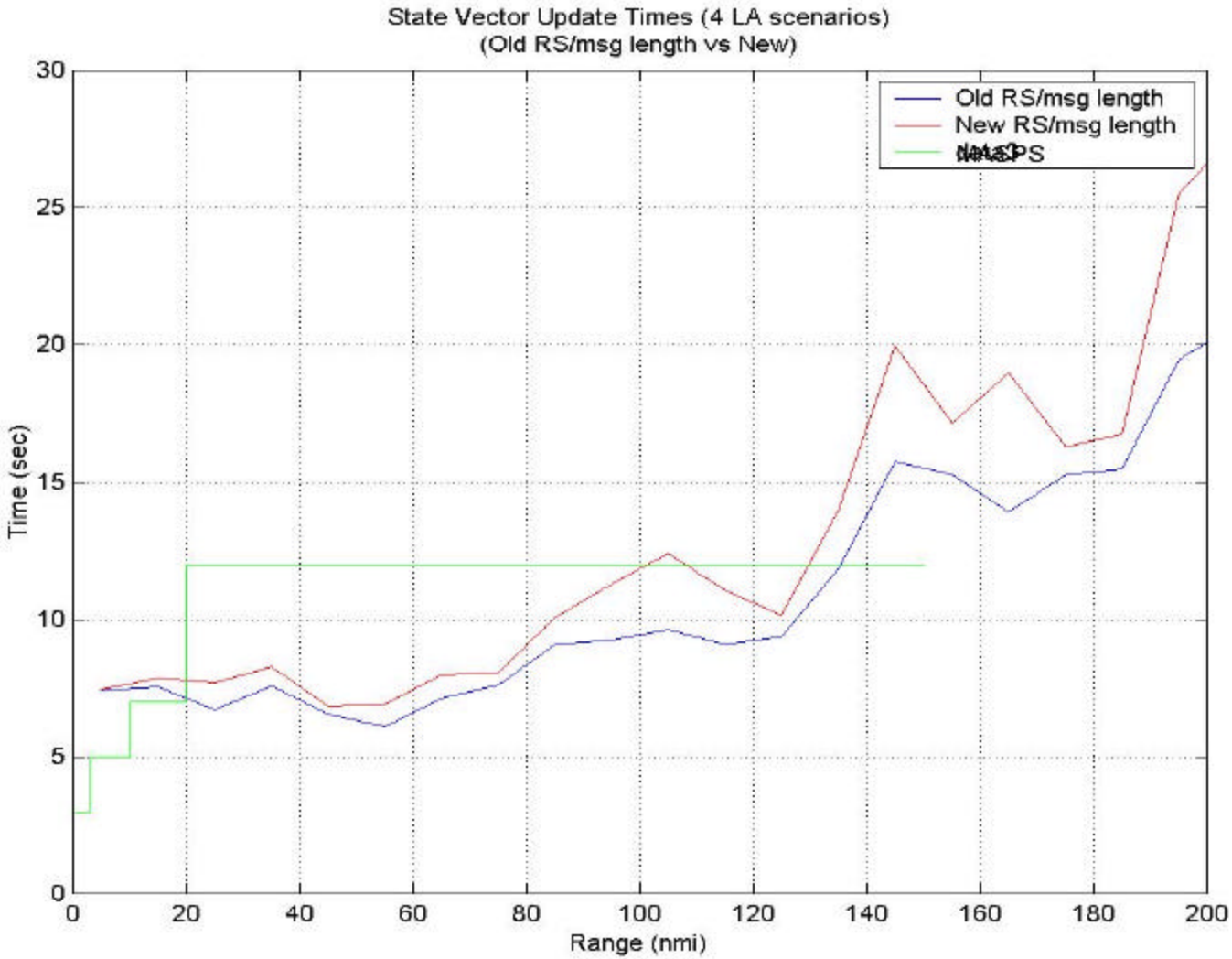
	RS Coding	Message Length
"Old" version	Basic: (25,19) Extended: (41,35)	Basic: 250 usec Ext: 370 usec
New version	Basic: (30,18) Extended: (48,34)	Basic: 273 usec Ext: 411 usec

- Purposes:
  - Provide resistance to L16/DME
  - Provide 10^{-8} PUME

Reed-Solomon/Message Length Comparison Results - MSP



Reed-Solomon/Message Length Comparison Results - SV Update



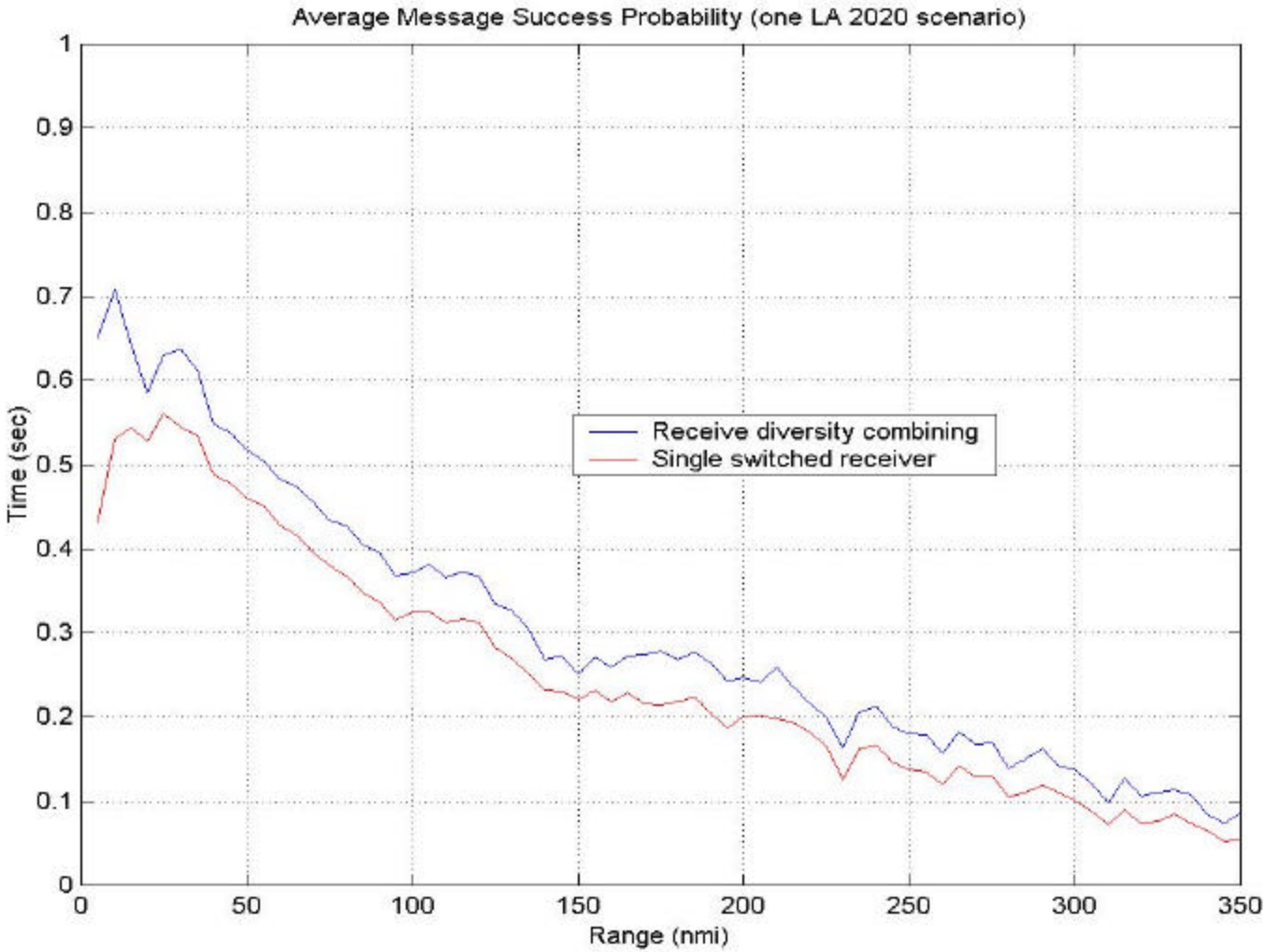
New Reed-Solomon Coding/Message Lengths Conclusions

- In the absence of pulsed interference:
  - Slight degradation of average message success probability
  - Slight degradation of state vector update
    - Likely to still be within MASPS limits
- Degradation due to increased message lengths increasing self-interference

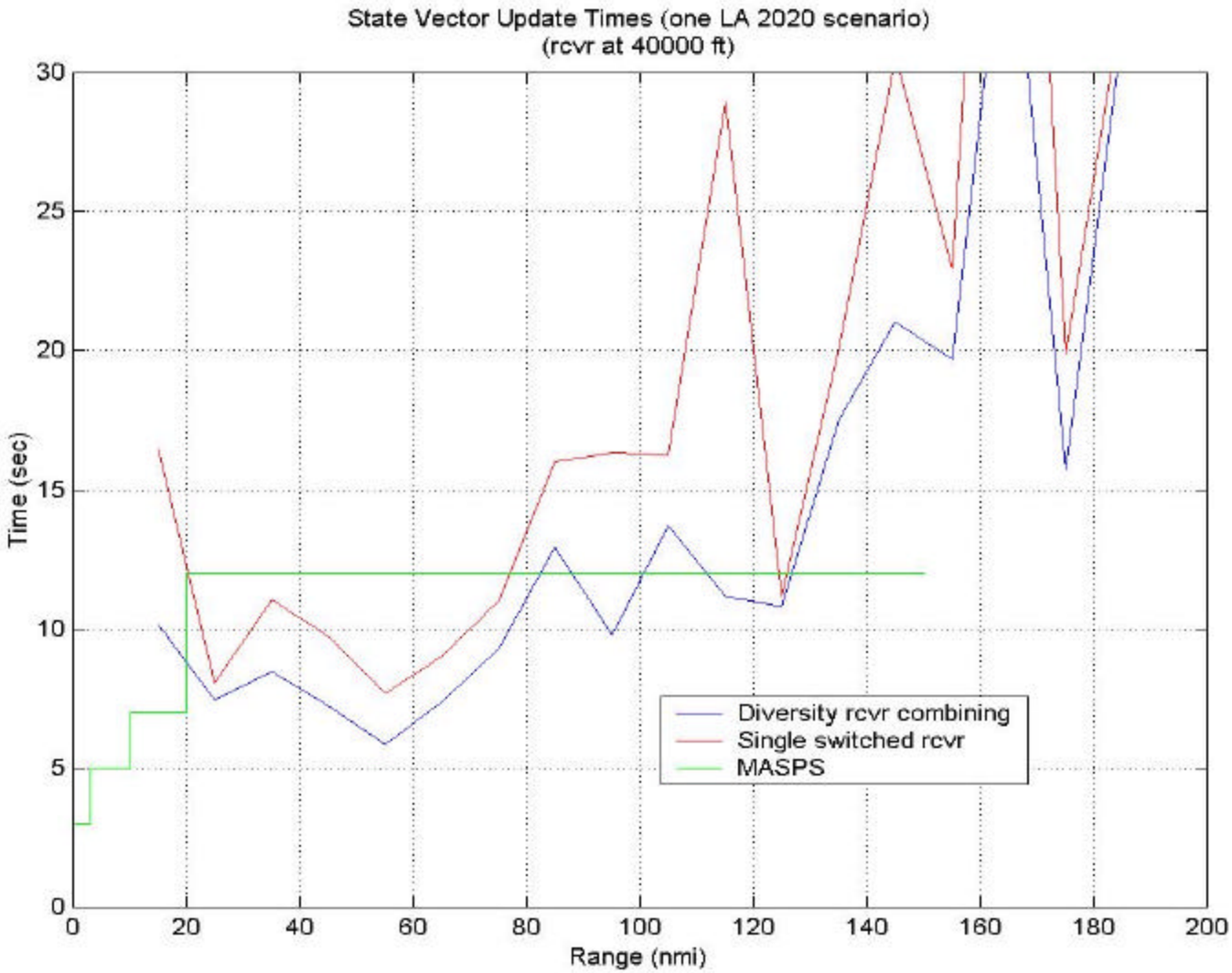
Switched Receiver Reception

- Proposed transmit powers assumed
- Two receivers
  - A2 receiver with largest number of aircraft in LOS
    - Used same aircraft called A3 in one LA 2020 scenario
  - A0/A1 receiver at same horizontal location
    - Altitude lowered to 15000 ft
- New Reed-Solomon/message lengths
- Assumed single switched receiver
  - Receive antenna on top and bottom
  - Receive pattern (alternating seconds): TBTBT…

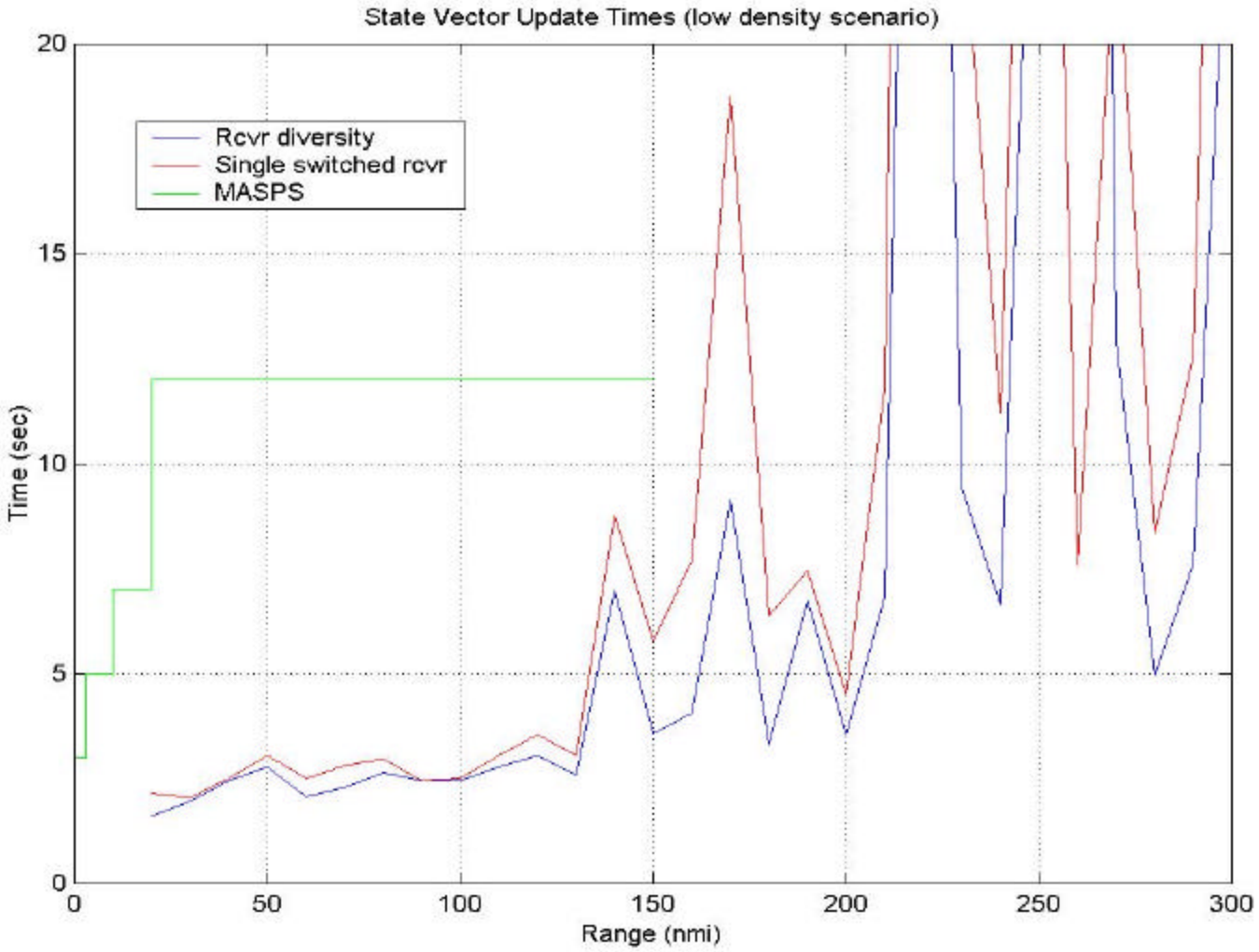
Average Message Success Rate (Single Switched Rcvr)



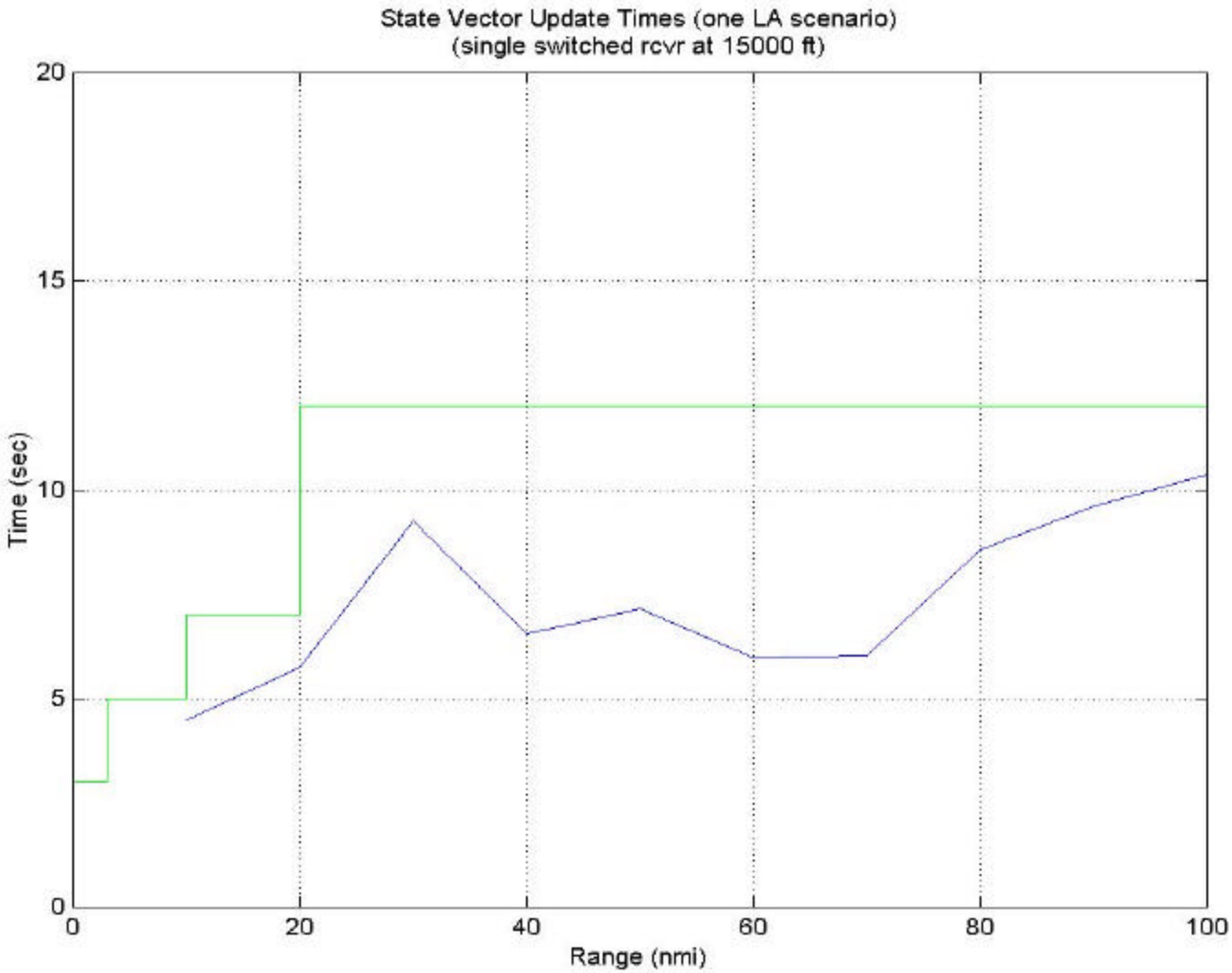
State Vector Updates (Single Switched Receiver)



State Vector Updates (Single Switched Receiver)



State Vector Updates (Single Switched Receiver at 15kft)



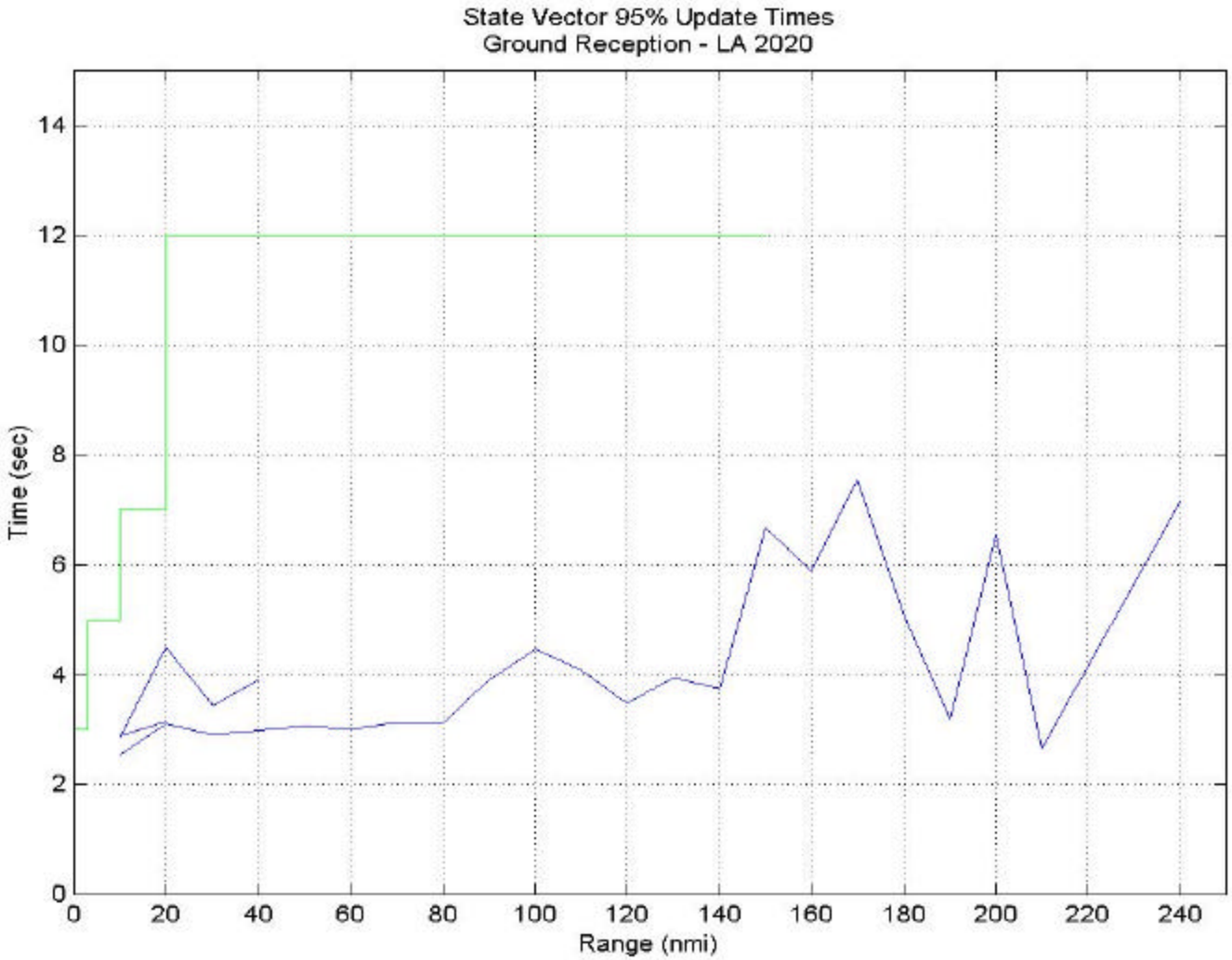
Single Switched Receiver Reception Conclusions

- A2 receiver
  - Reduction in MSP does not cause unacceptable degradation in state vector update rate at limit of requirement (40 miles) in high density scenario at high altitude
  - Same problem at small distances
- A0/A1 receiver
  - In high density scenario, well within MASPS criteria out to 100 miles (requirement reaches to 10-20 miles)

Ground Reception

- Proposed transmit powers assumed
- Receiver at ground level
  - Used center of scenario
- New Reed-Solomon/message lengths
- Assumed DME ground antenna pattern

Ground Reception Results



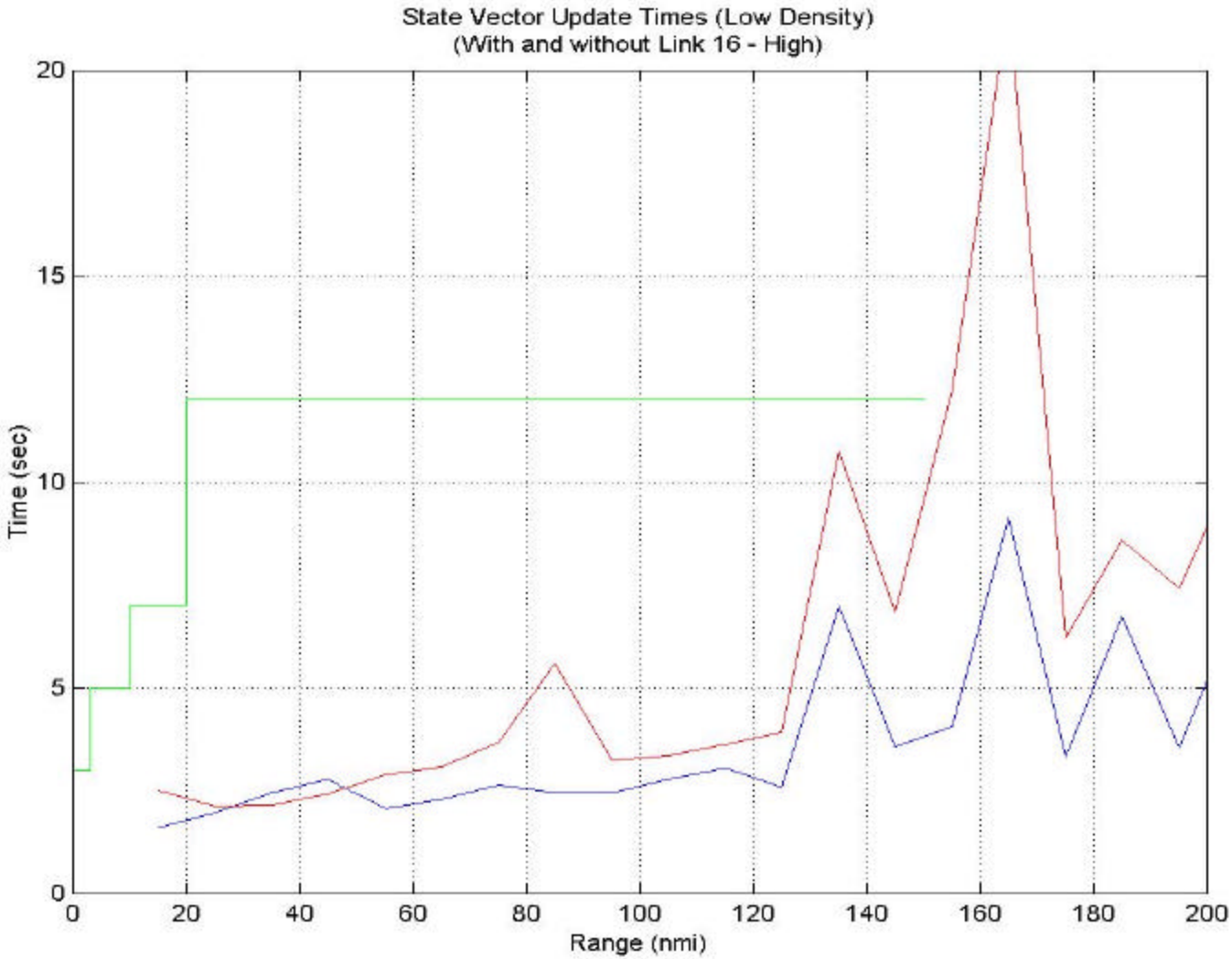
Ground Reception Conclusions

- Ground reception appears to be good

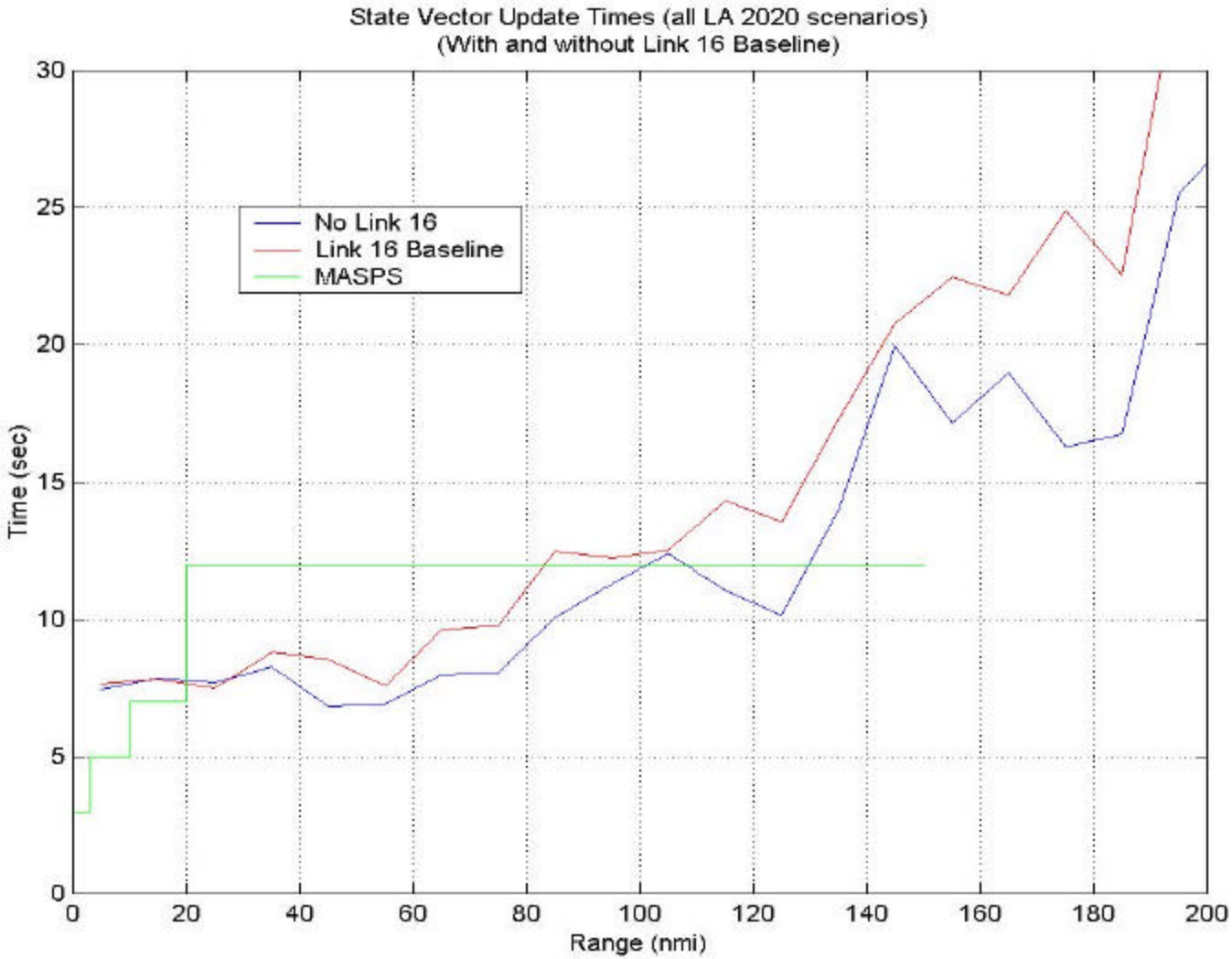
Link 16 Interference

- Ran two scenarios with UAT self-interference
  - Low density scenario
    - Link 16 High Density scenario
  - LA 2020 scenarios
    - Link 16 Baseline scenario

Link 16 Interference Results - Low Density Scenario



Link 16 Interference Results - LA2020 Scenarios



Link 16 Interference Conclusions

- Low Density results indicate sufficient margin to co-exist with even high density Link 16 scenario
- LA 2020 results inconclusive at this time