Preliminary UAT Model Results Presented to UAT MOPS WG

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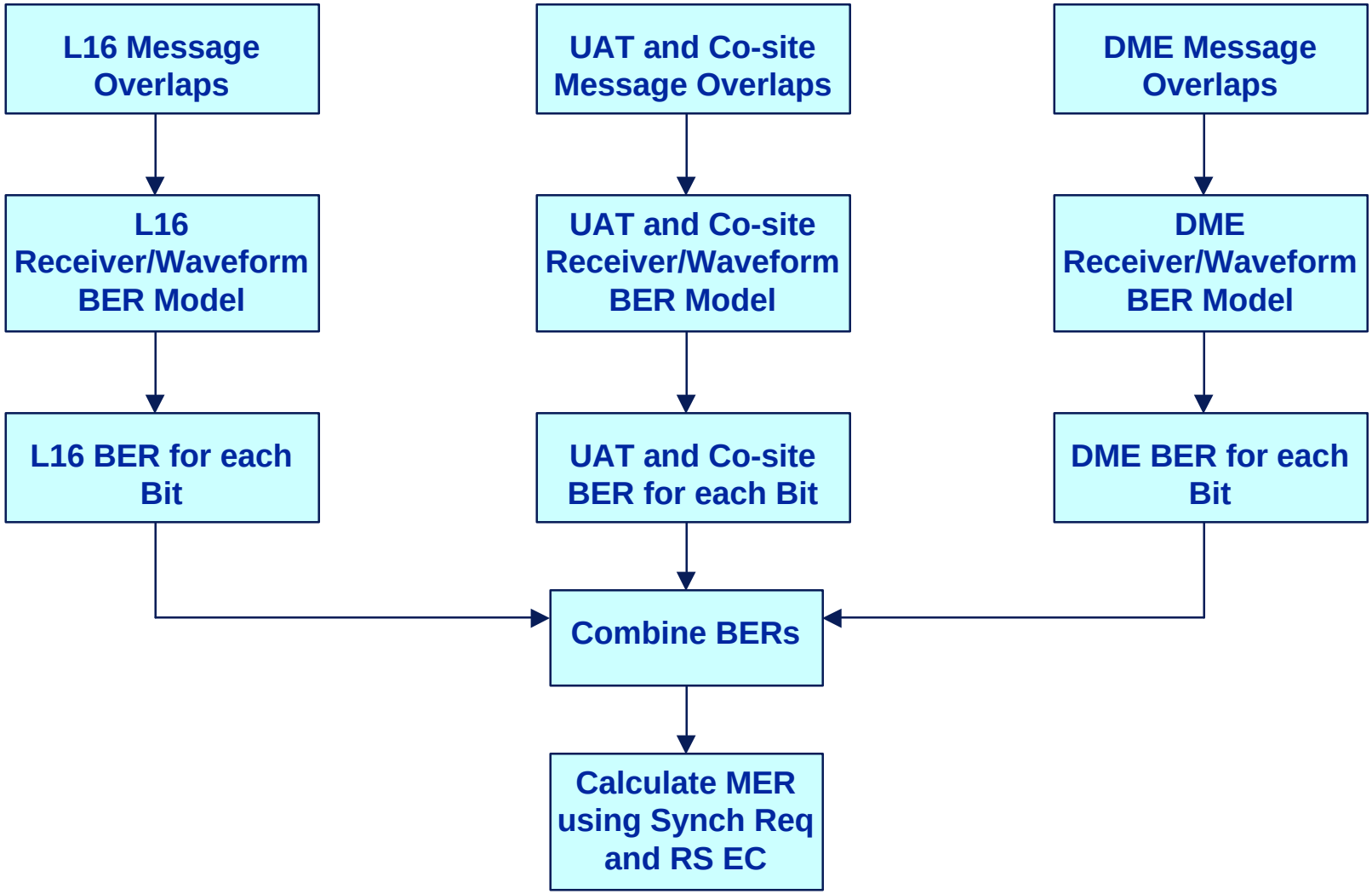
Recent Model Modifications

- Fixed memory leak
- Modified synch requirement (28/36 instead of 31/36)
- Added ground vehicles
  - LA 2020: 300 vehicles total
  - CE: 500 vehicles total
  - Transmit power: 28-32 dBm
  - 1 basic message/second
- Added receiver blanking of 2 msec before and after UAT on-board transmission
- Added pre- and post-key transmissions (interference)
  - 4 usec each in duration
  - 20 dB down from transmit power
- Added Link 16 bit-level model based on bench test data
- Improved DME interference handling

Update Times for Ground Vehicles to FL 150 CE Receivers at 15 nmi

AC Receiver Equipage	95% Update Time
A0	7.2 sec
A1	11.1 sec
A2	6.4 sec
A3	5.9 sec

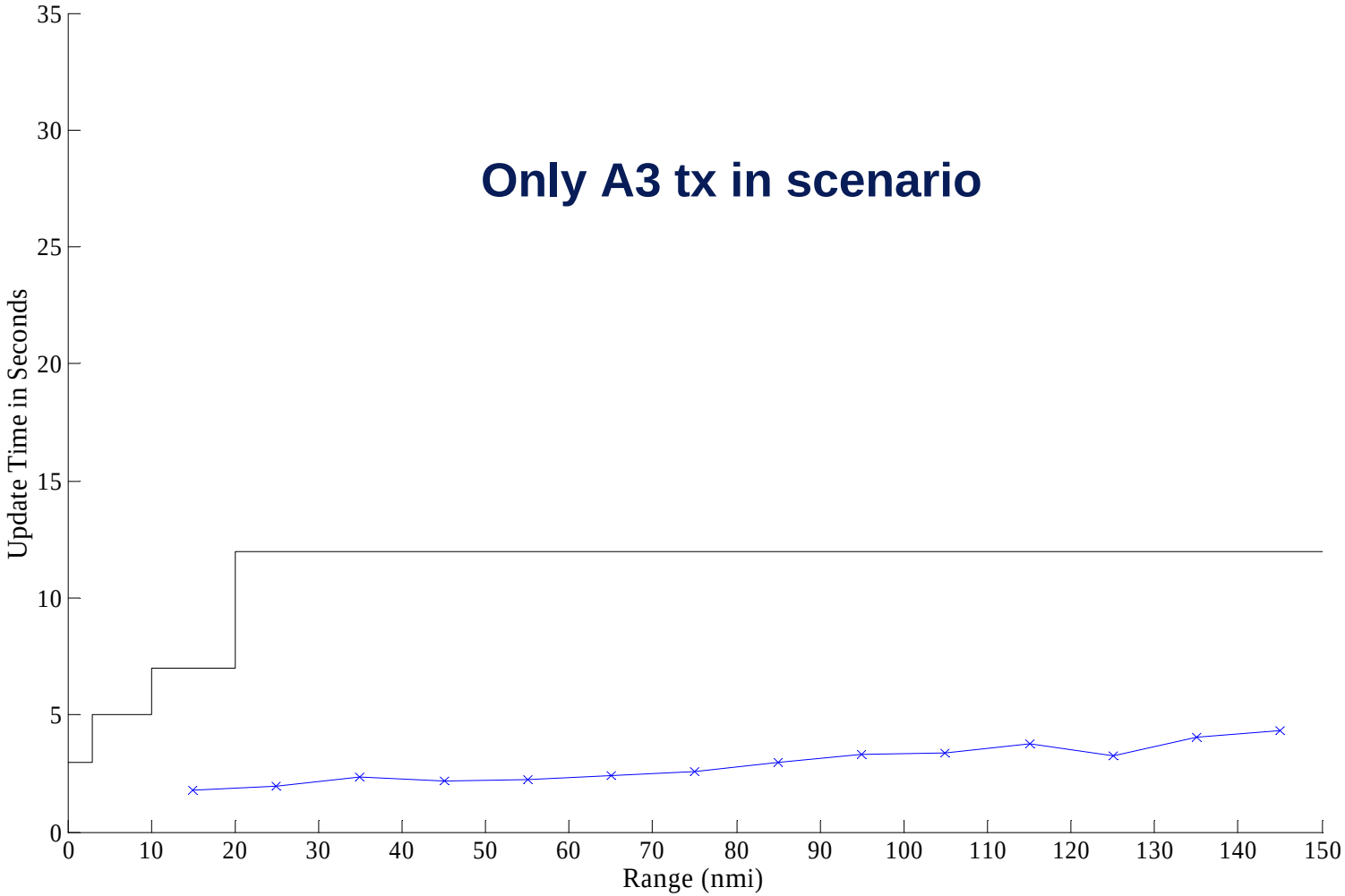
MER Modeling Diagram



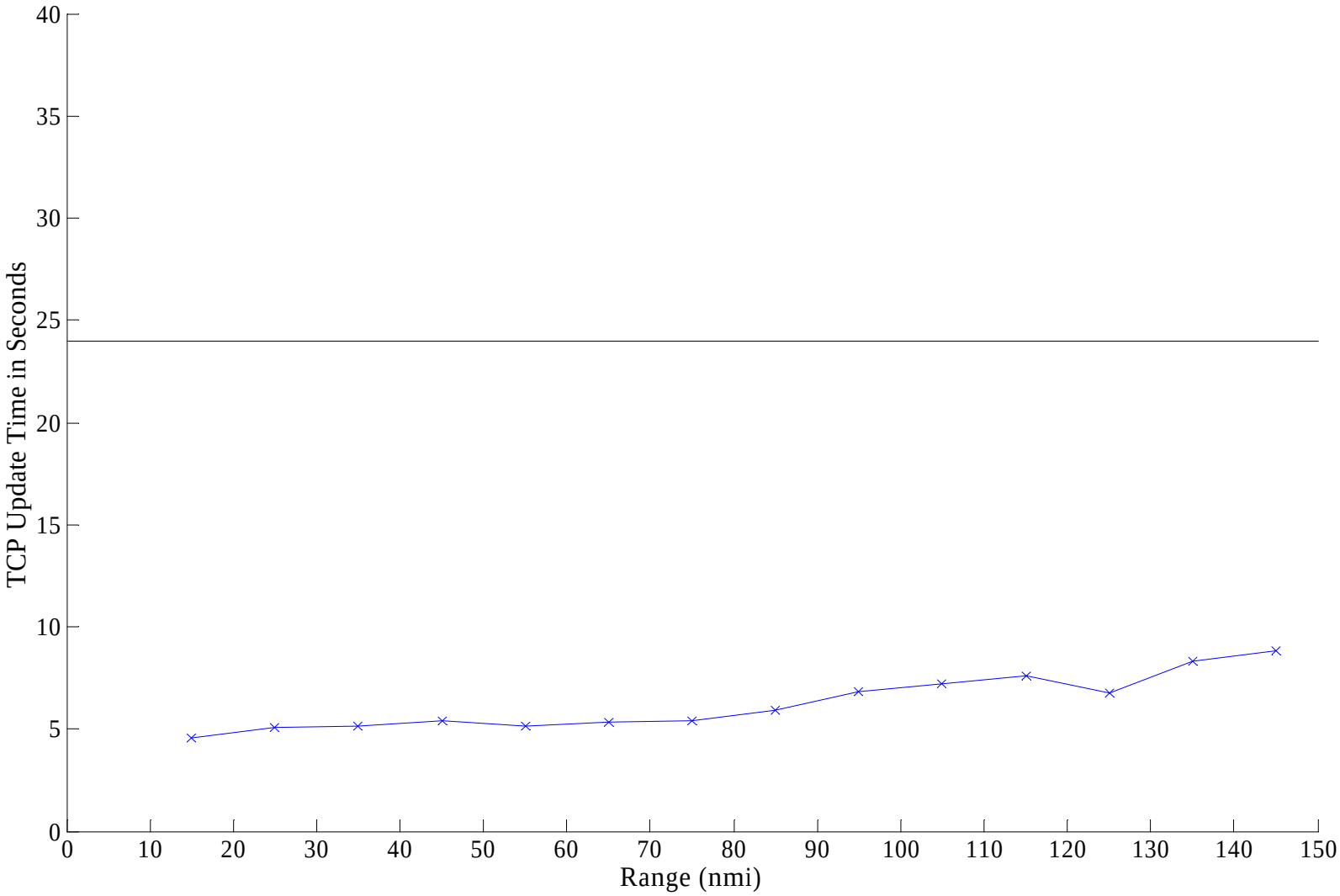
Low Density Case

- Traffic Scenario
  - 360 A3 aircraft in 400 nmi radius
  - FL 250 – FL 370
- High Altitude Diversity Receiver
- Heavy Link 16 Interference
- Core Europe 2015 DME Interference
- Used ten scenario instantiations to increase statistics

State Vector Update Times (95%) for High Altitude A3 Receiver



TCP Update Times (95%) for High Altitude A3 Receiver



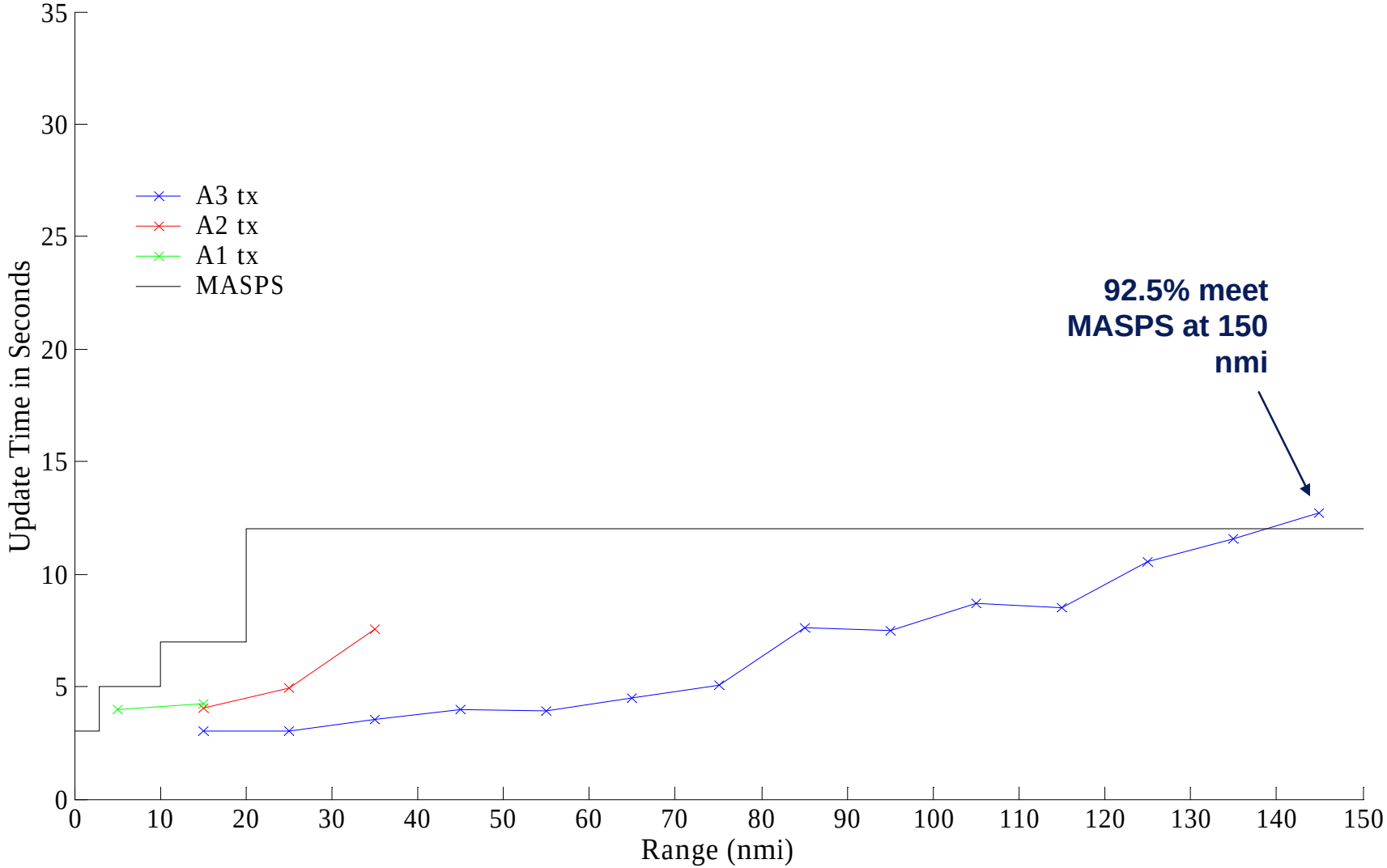
A3 Receiver Performance in Low Density Scenario

- Interference assumptions conservative
  - Severe DME environment
  - Heavy L16 interference
  - Heavy co-site environment
- A3 receiver meets all current air-air ADS-B MASPS update requirements to past 90 nautical miles

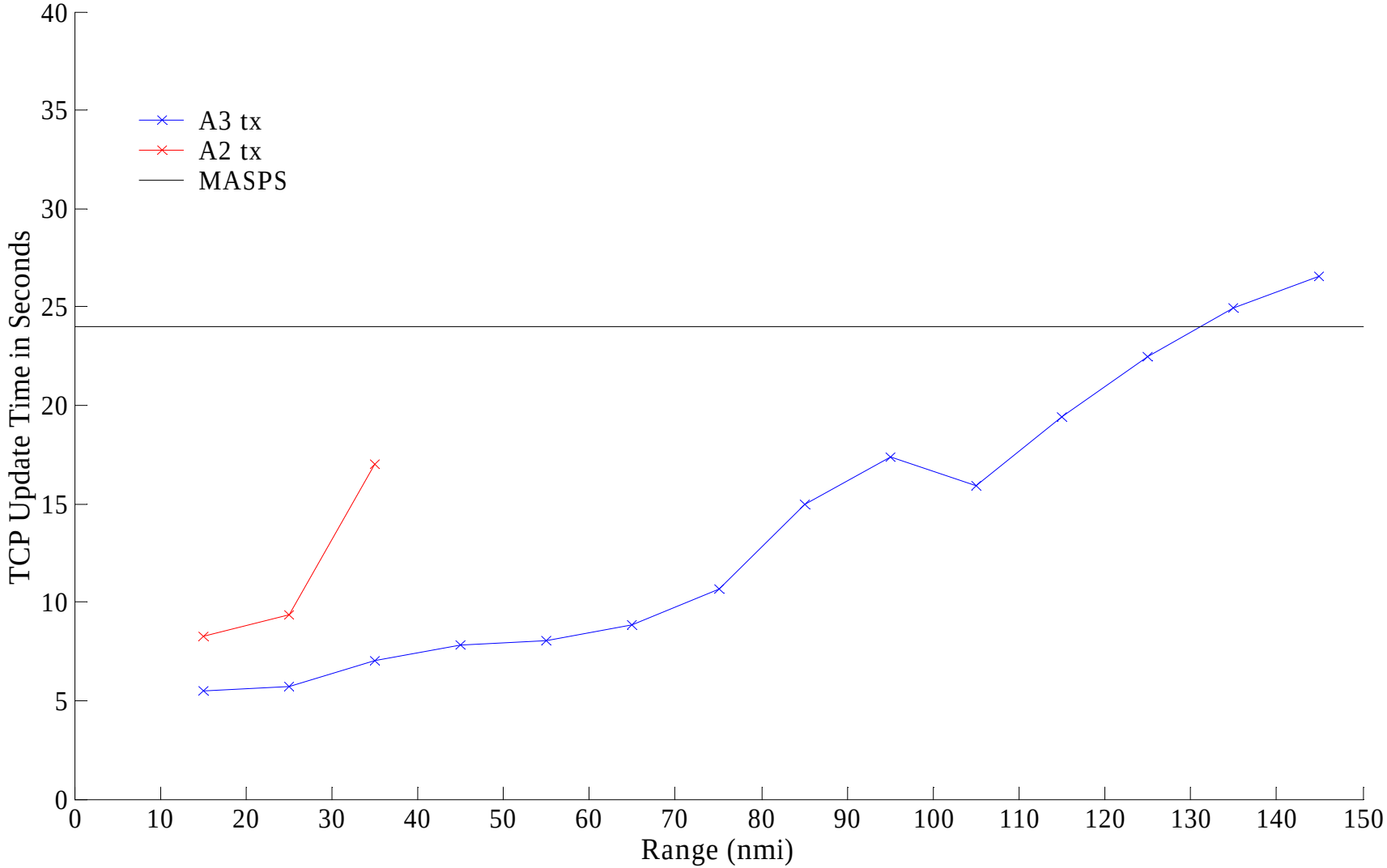
LA 2020 Case

- Traffic Scenario
  - 2694 aircraft (225 on surface) in 400 nmi radius
  - 300 ground vehicles
- Eight Receiver/Altitude Combinations
  - A3 (0.8 MHz filter) and A2 (1.2 MHz filter) Diversity Receivers
    - High Altitude
    - FL 150
  - A1 Switched Receiver (1.2 MHz filter)
    - High Altitude
    - FL 150
  - A0 Bottom-only Receiver (1.2 MHz filter)
    - FL 150
  - Ground Receiver (1.2 MHz filter)
- Baseline Link 16 Interference
- No DME Interference

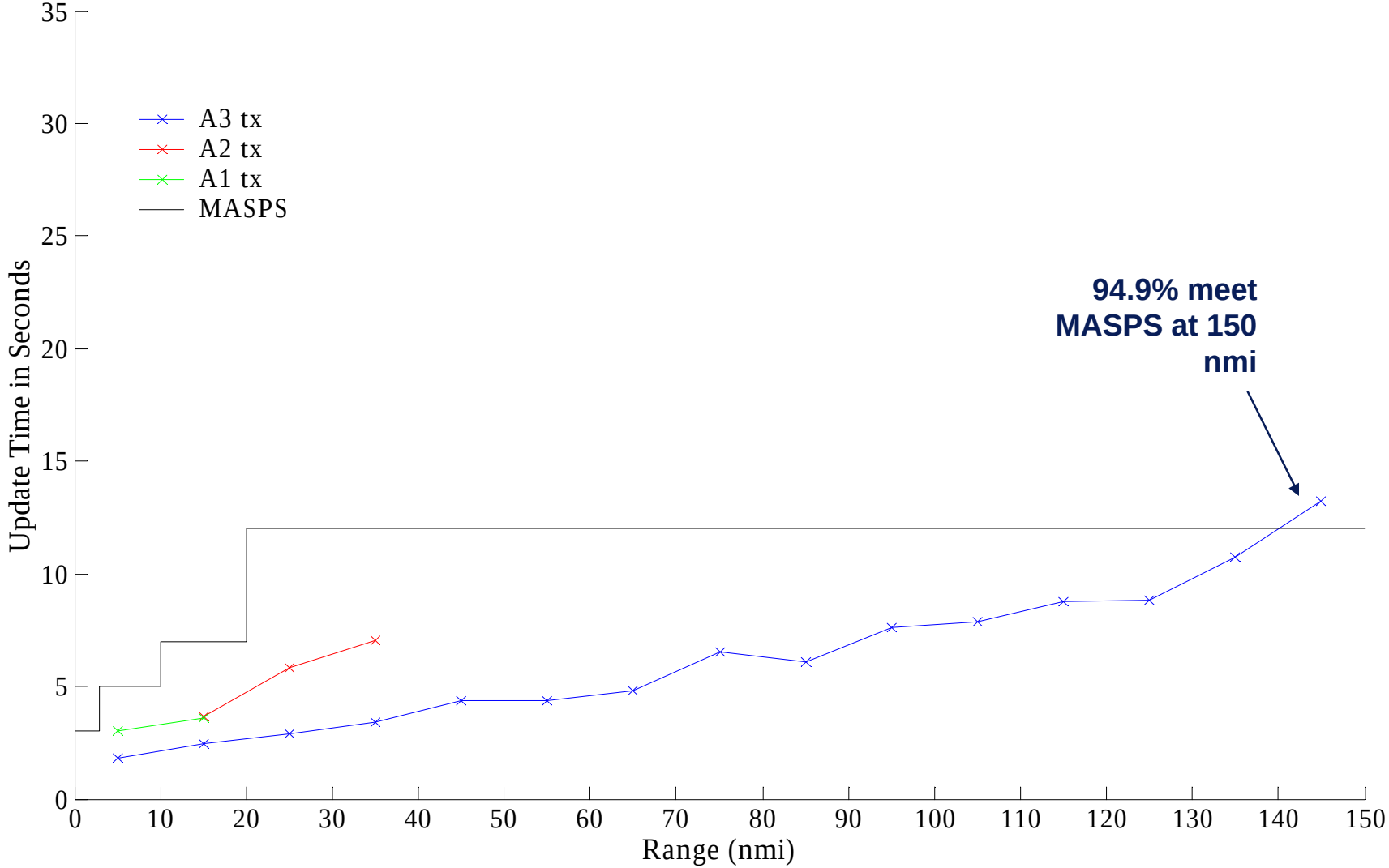
State Vector Update Times for an A3 Receiver at High Altitude



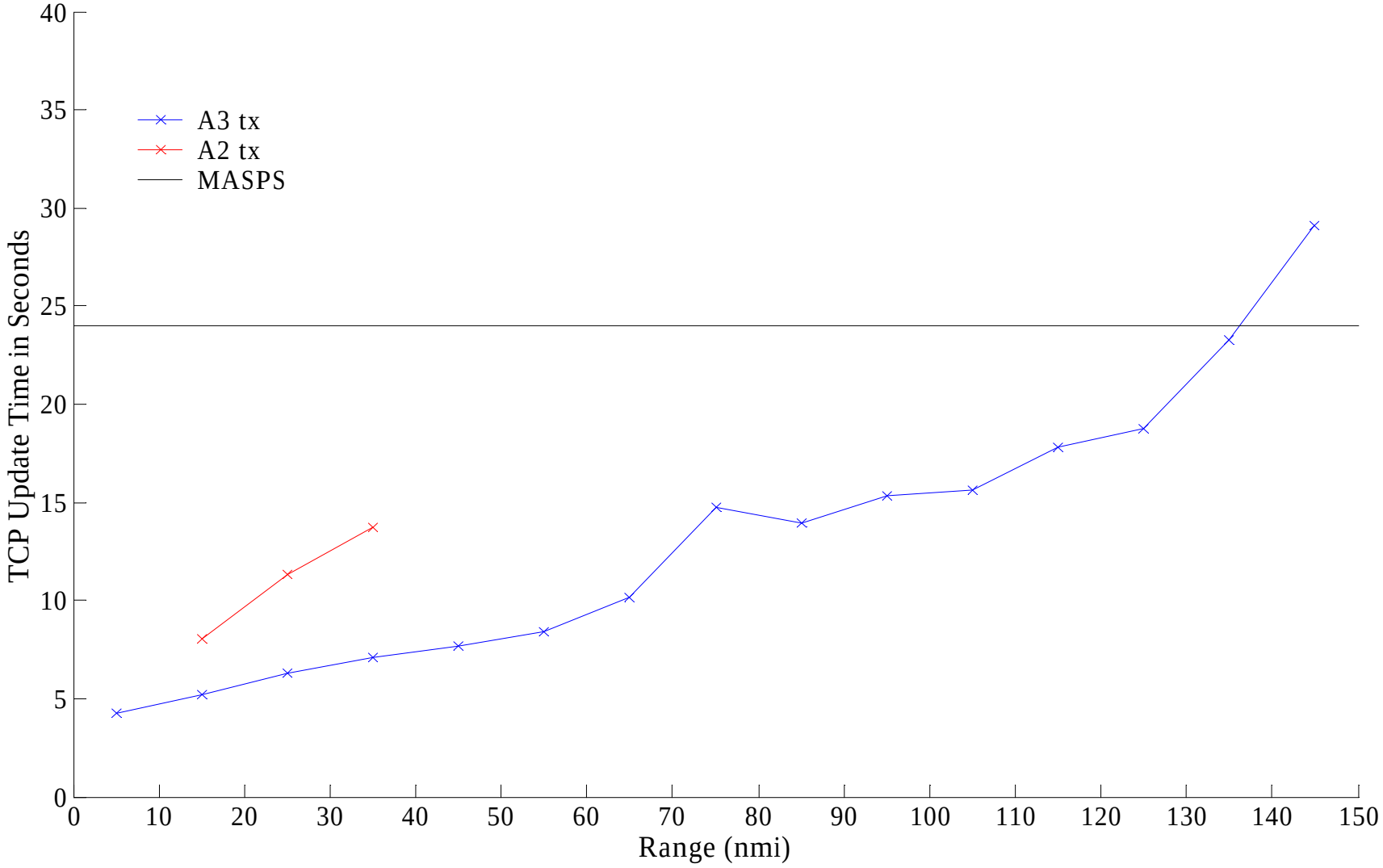
TCP Update Times for an A3 Receiver at High Altitude



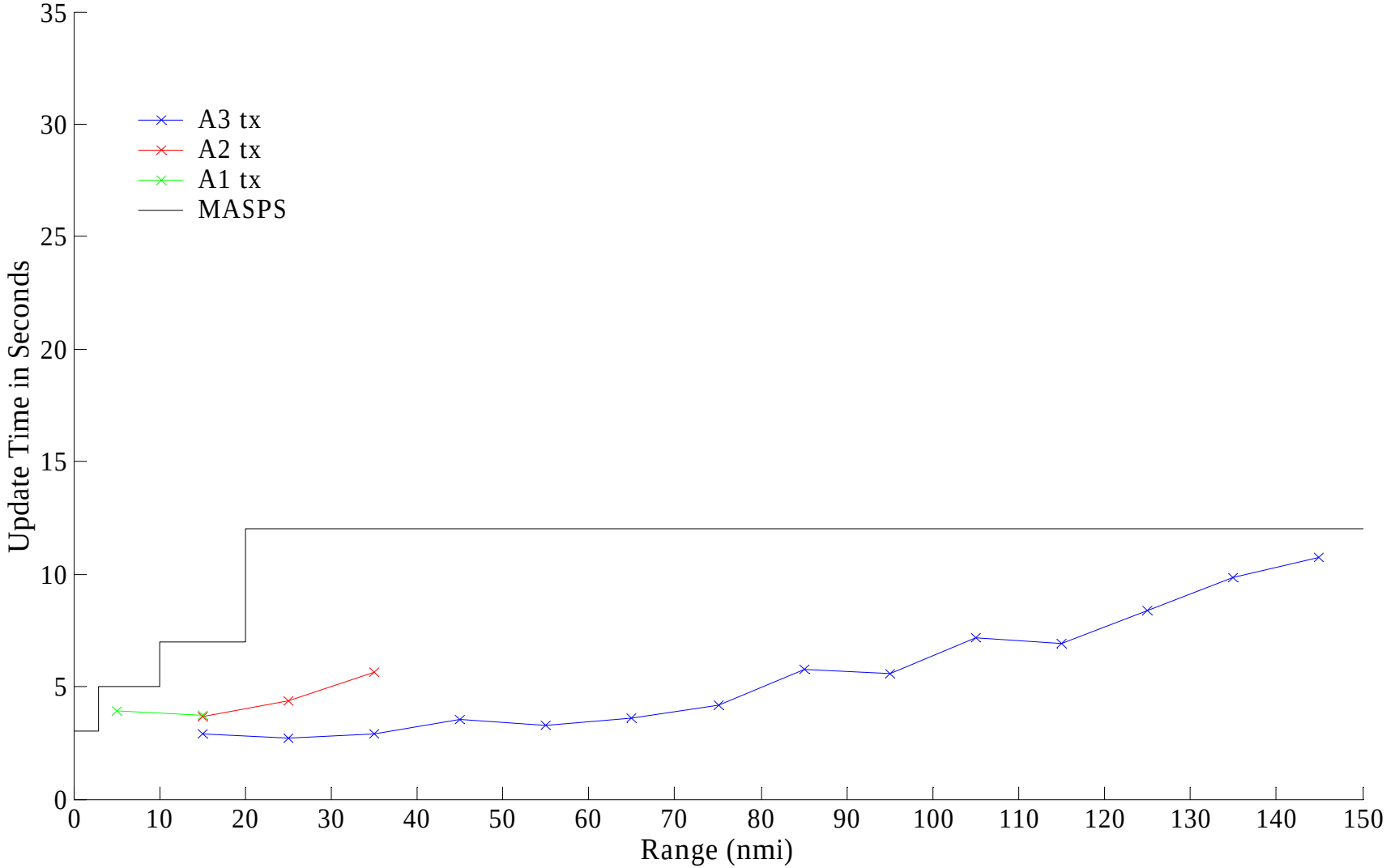
State Vector Update Times for an A3 Receiver at FL 150



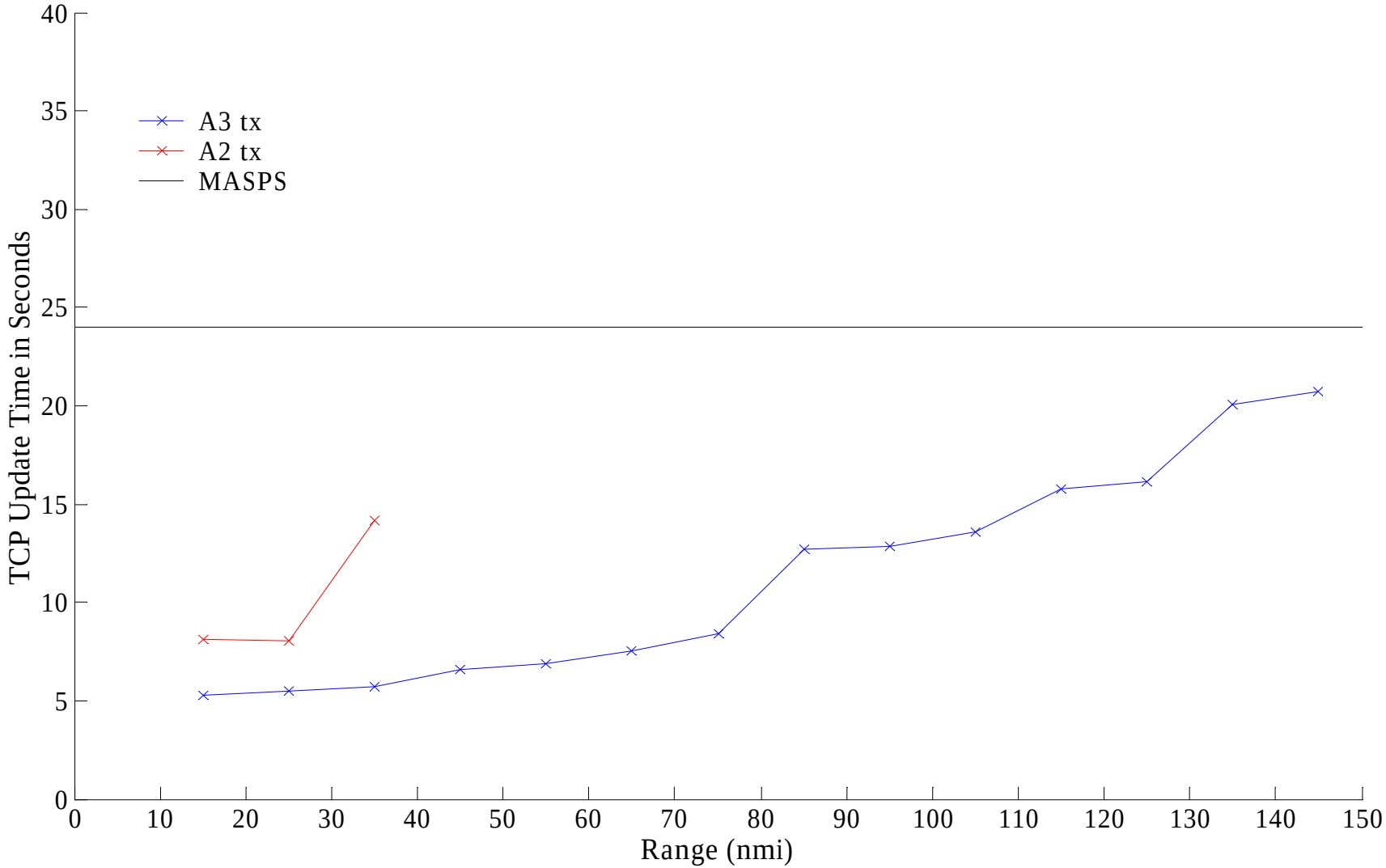
TCP Update Times for an A3 Receiver at FL 150



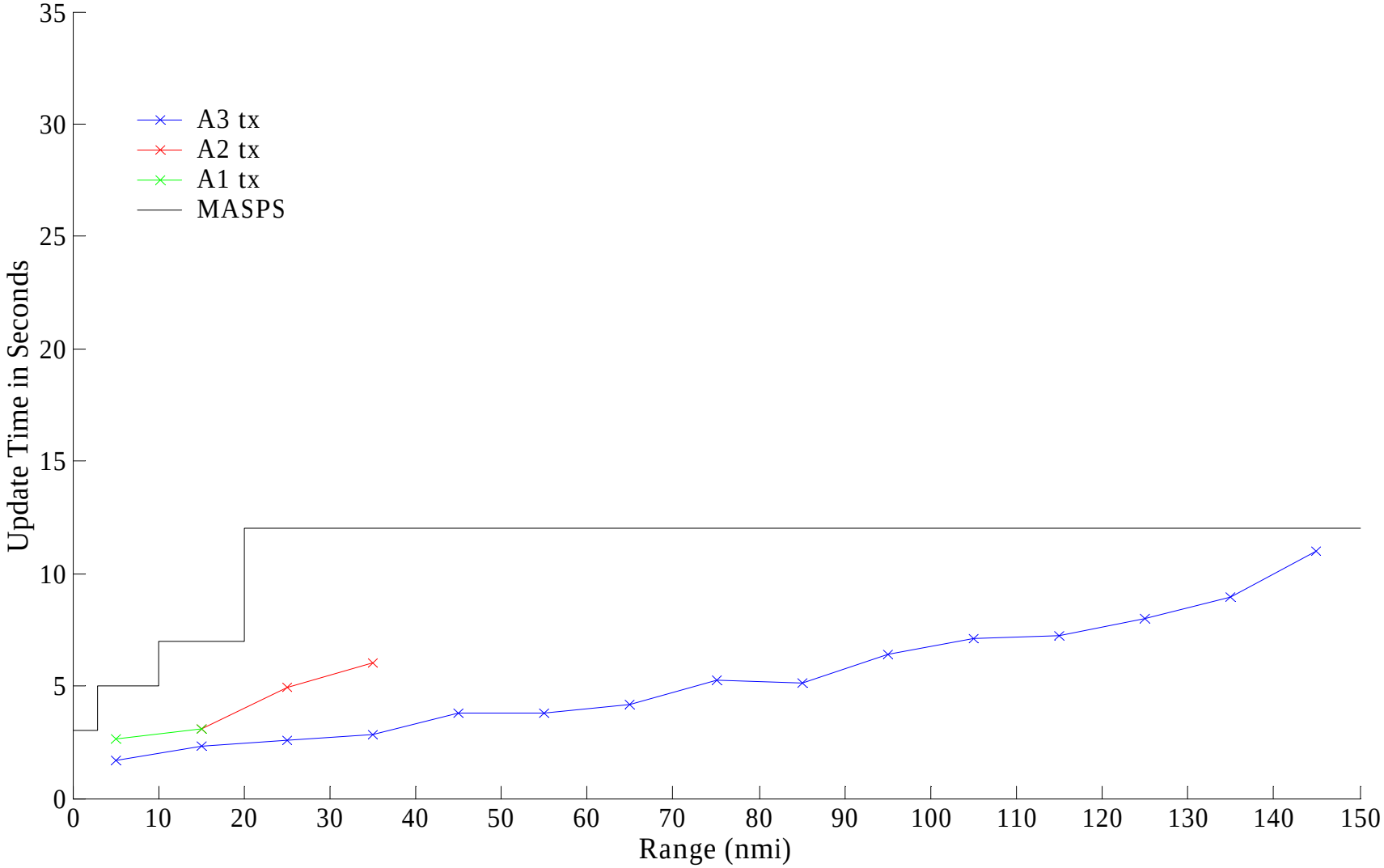
State Vector Update Times for an A2 Receiver at High Altitude



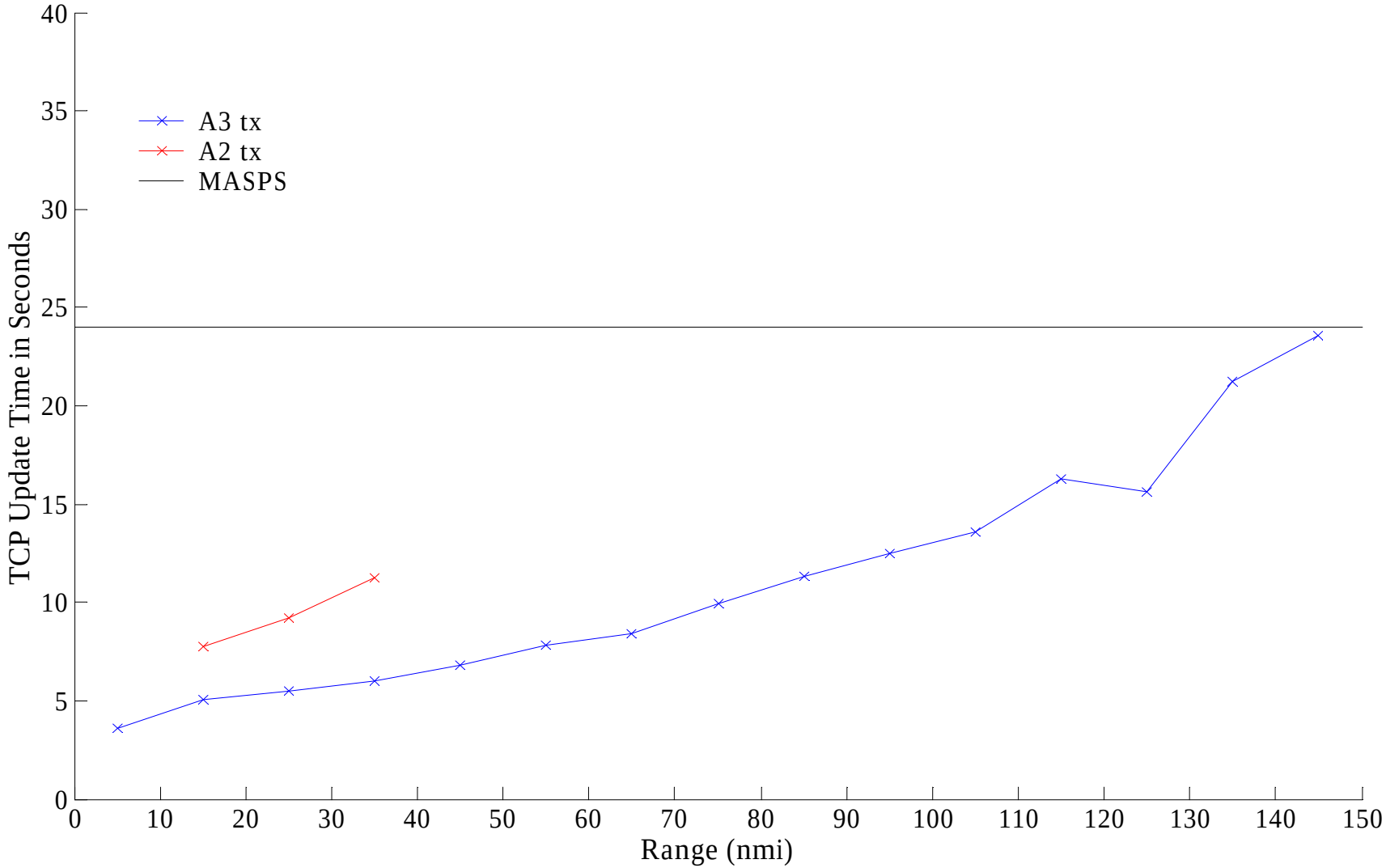
TCP Update Times for an A2 Receiver at High Altitude



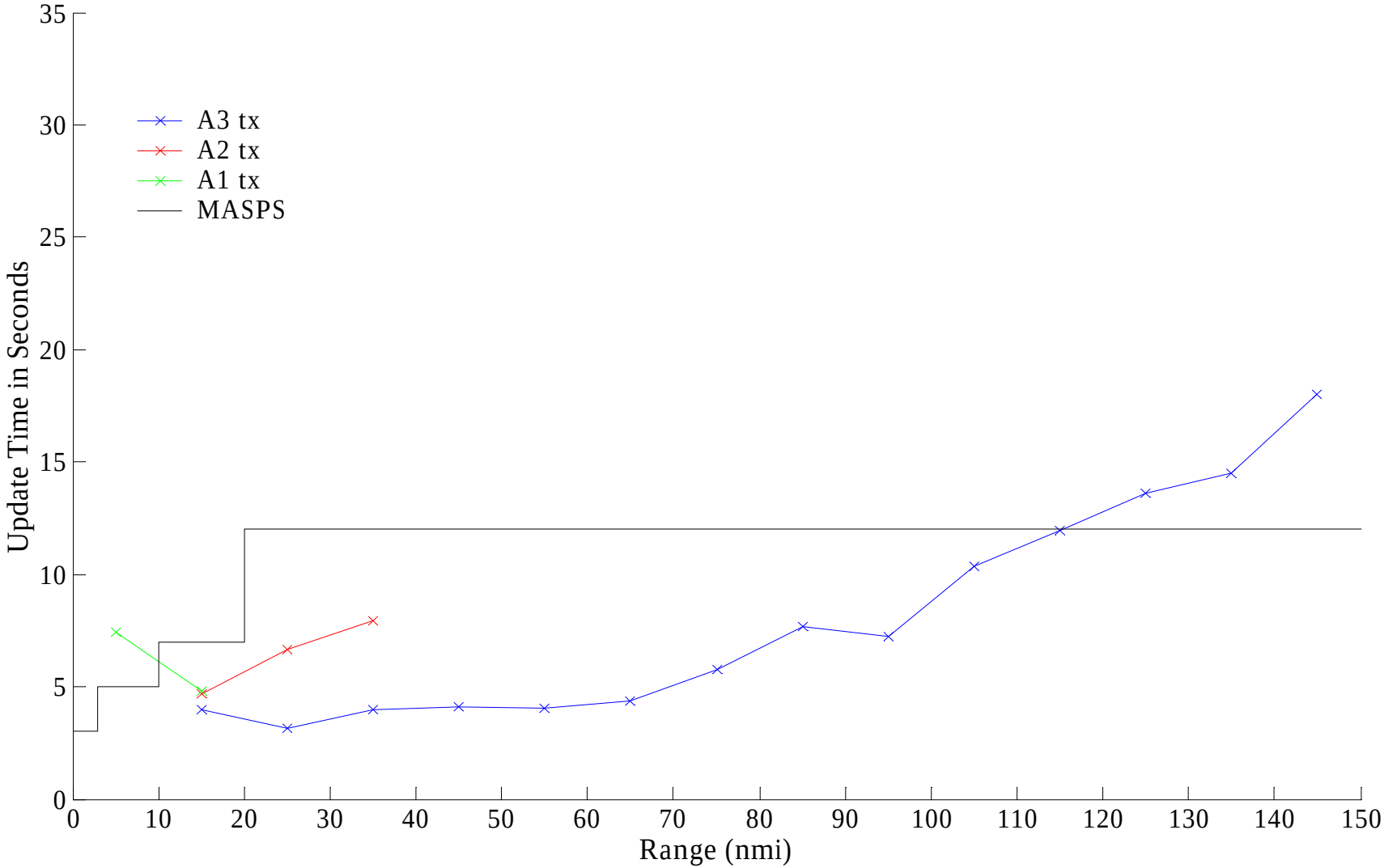
State Vector Update Times for an A2 Receiver at FL 150



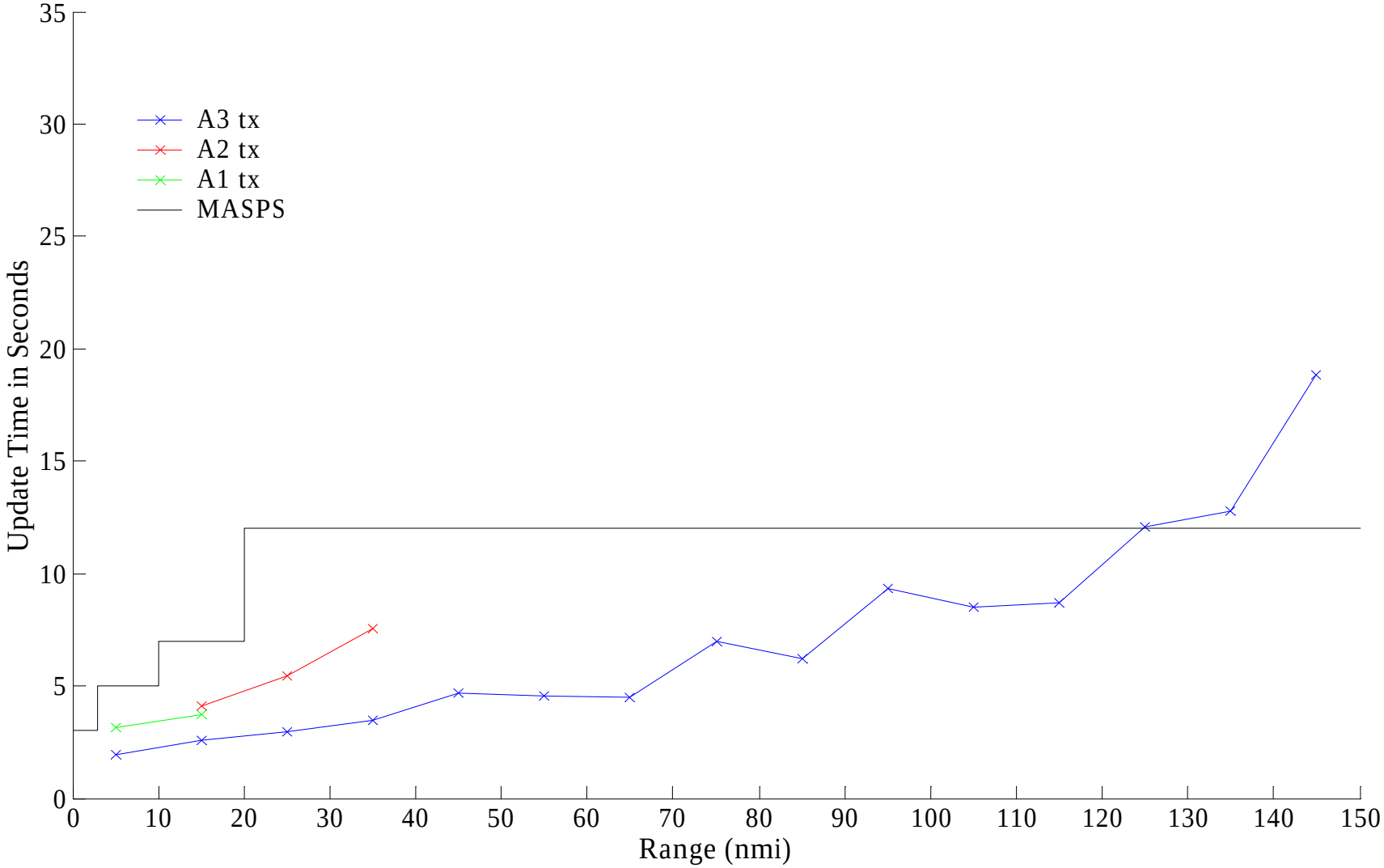
TCP Update Times for an A2 Receiver at FL 150



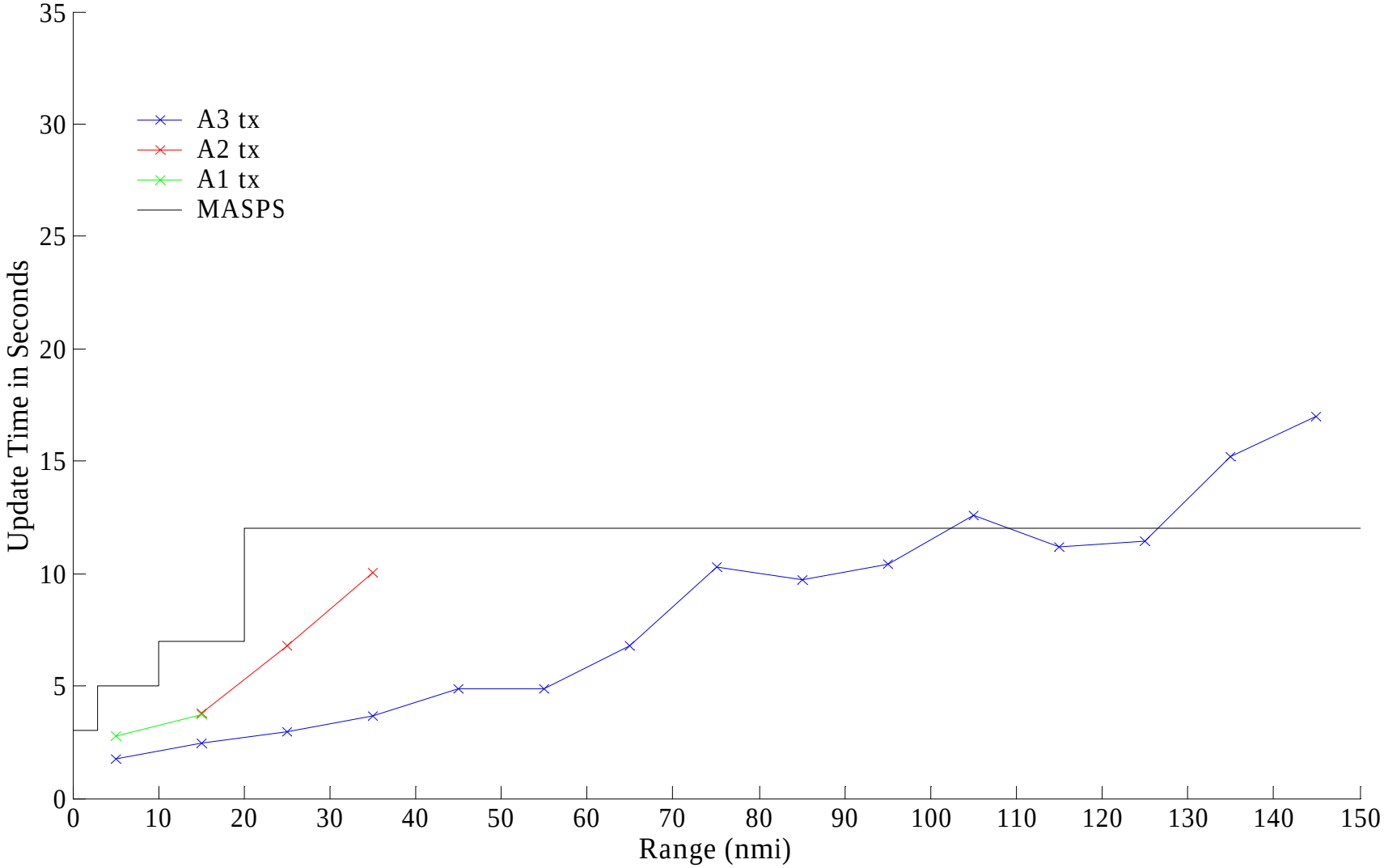
State Vector Update Times for an A1 Receiver at High Altitude



State Vector Update Times for an A1 Receiver at FL 150



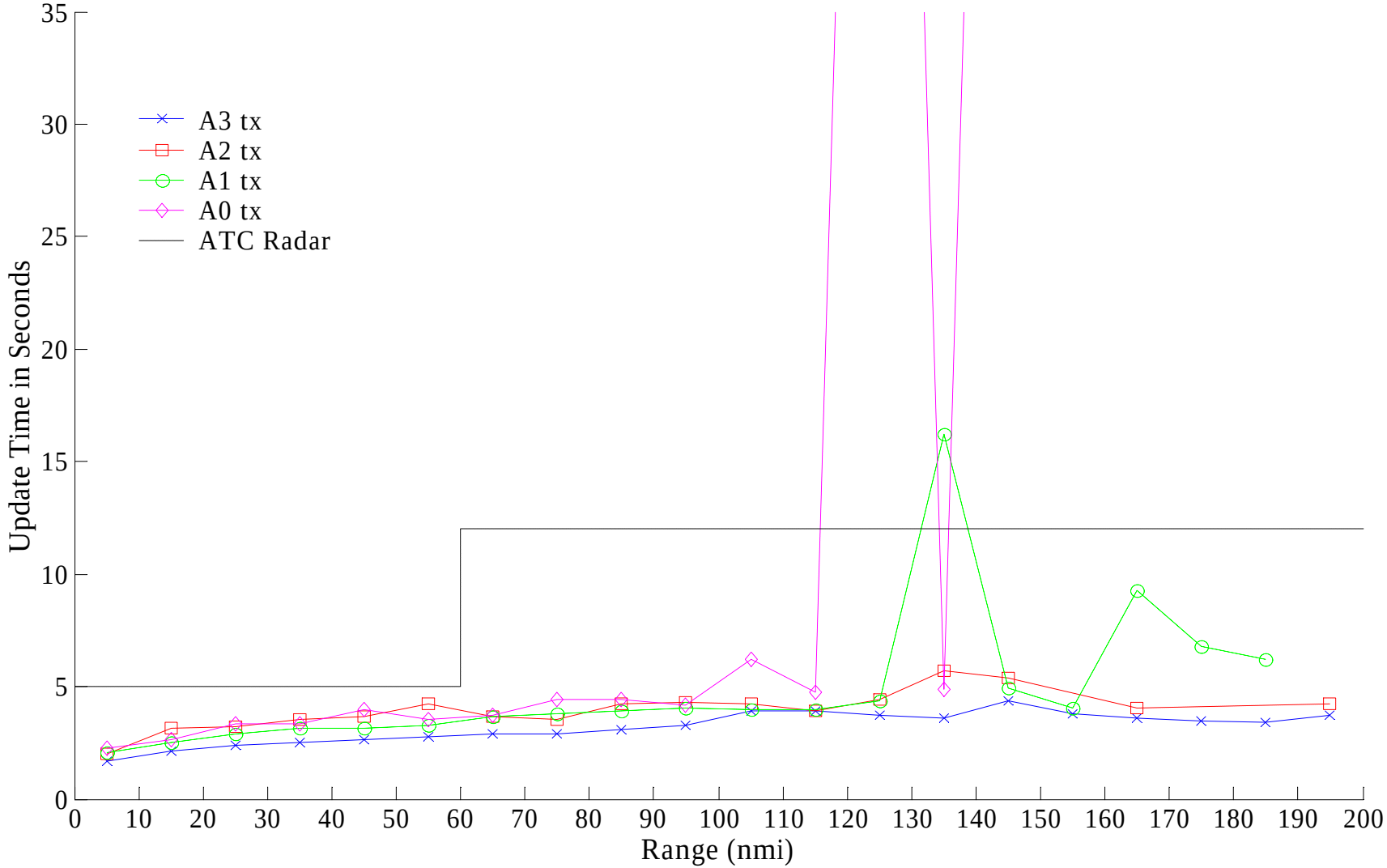
State Vector Update Times for an A0 Receiver at FL 150



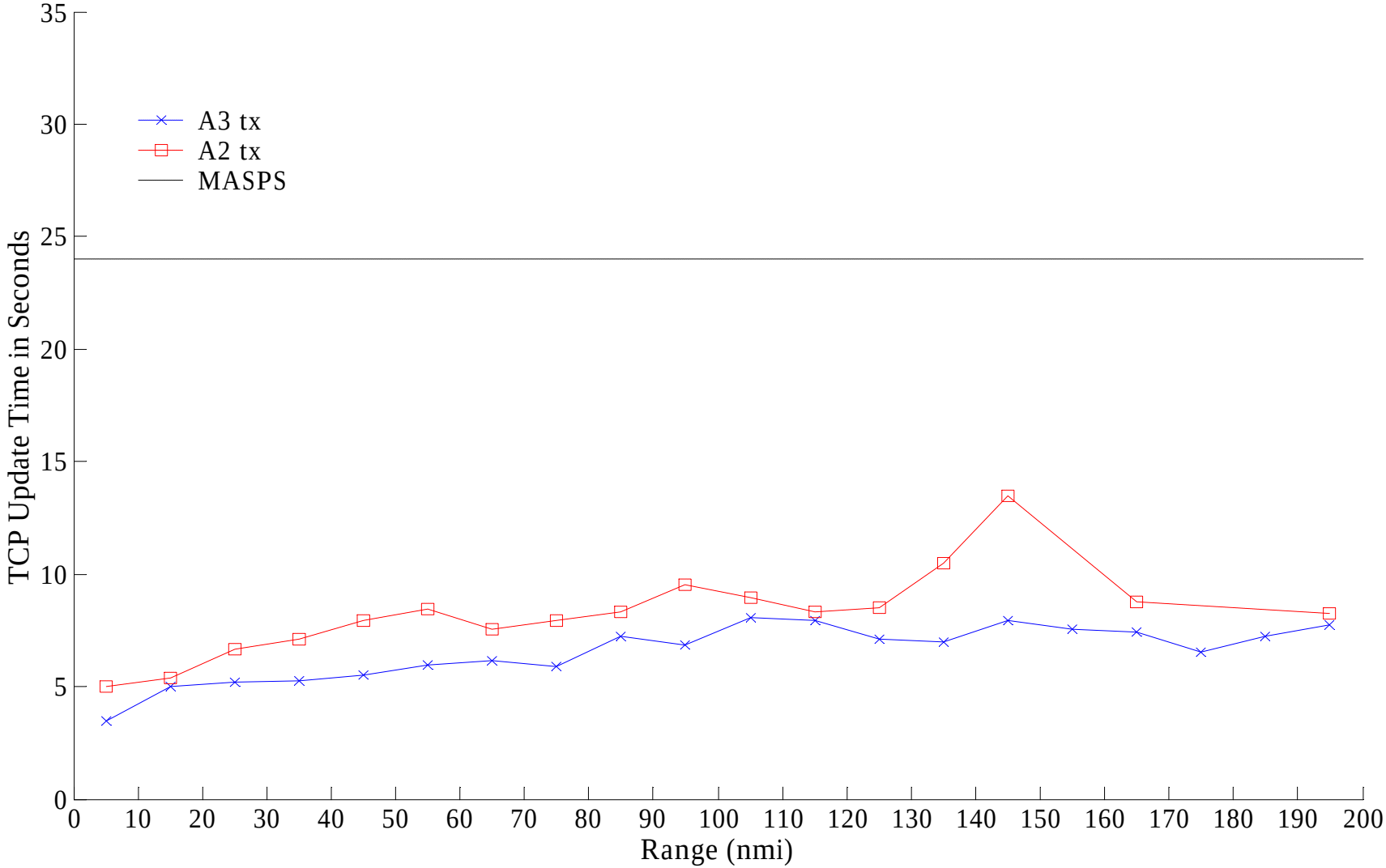
Airborne Receiver Performance in LA 2020 Scenario

- In general, all receiver types meet all current air-air ADS-B MASPS update requirements to stated ranges for both FL400 and FL150
- Issues
  - A0
    - Probe required
  - A1 at close range
    - Probe required
  - A2/A3 at 150 nmi
    - 1.2 MHz filter meets requirements
    - 0.8 MHz filter extremely close
  - What are ground vehicle requirements?

State Vector Update Times for Air-Ground in LA



Air-Ground TCP Update Times in LA



Ground Receiver Performance in LA 2020 Scenario

- Ground receiver meets all current air-air ADS-B MASPS update requirements to past 150 nautical miles
- Exception is A0, out to 110 nmi

Core Europe Case

- Traffic Scenario
  - Current
    - 1200 aircraft (500 on surface) in 300 nmi radius
    - 500 ground vehicles
  - 2015
    - 2091 aircraft (500 on surface) in 300 nmi radius
    - 500 ground vehicles
- Eight Receiver/Altitude Combinations
  - A3 (0.8 MHz filter) and A2 (1.2 MHz filter) Diversity Receivers
    - High Altitude
    - FL 150
  - A1 Switched Receiver (1.2 MHz filter)
    - High Altitude
    - FL 150
  - A0 Bottom-only Receiver (1.2 MHz filter) – at FL 150
  - Ground Receiver (1.2 MHz filter)

Core Europe Case (continued)

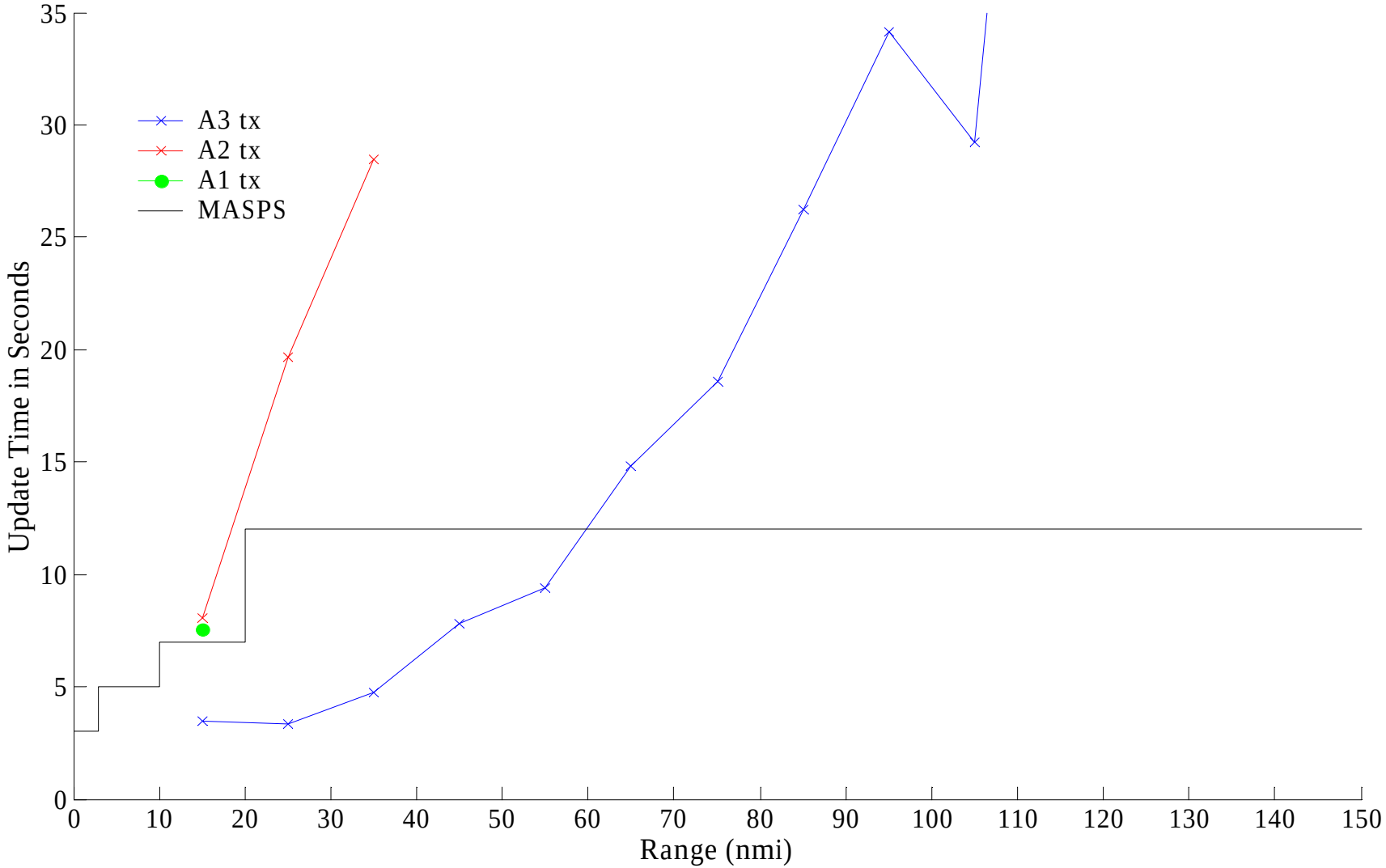
- Baseline Link 16 Interference
- DME Interference Environments (4 dB added)
  - Current (worst case DME environment)
    - 135 nmi east and 40 nmi south of Brussels
    - Added additional adjacent channel TACAN
  - 2015 (worst case UAT environment)
    - Over Brussels

DME Interference Levels

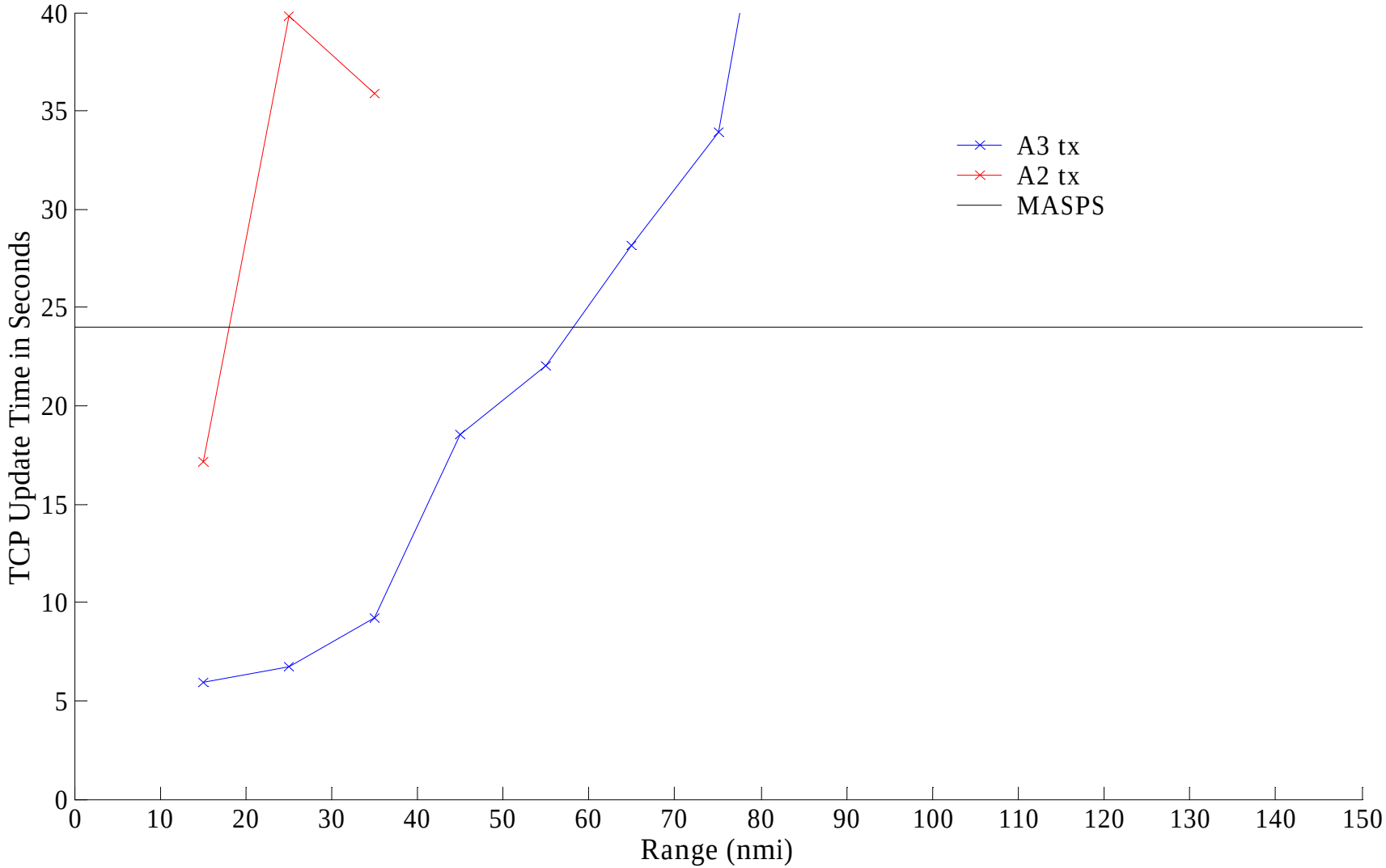
- Transmit powers as assigned
- Measured TACAN antenna pattern
- 8 dB rule implemented

Current			Future		
High Alt.	Channel/Type	FL 150	High	Channel/Type	FL 150
-70	On/TACAN	-72	-72	Adj./DME	-72
-70	On/TACAN	-72	-60	Adj./TACAN	-64
-70	On/TACAN	-73	-69	Adj./TACAN	-65
-53	Adj./TACAN	-49			
-71	Adj./TACAN	-74			

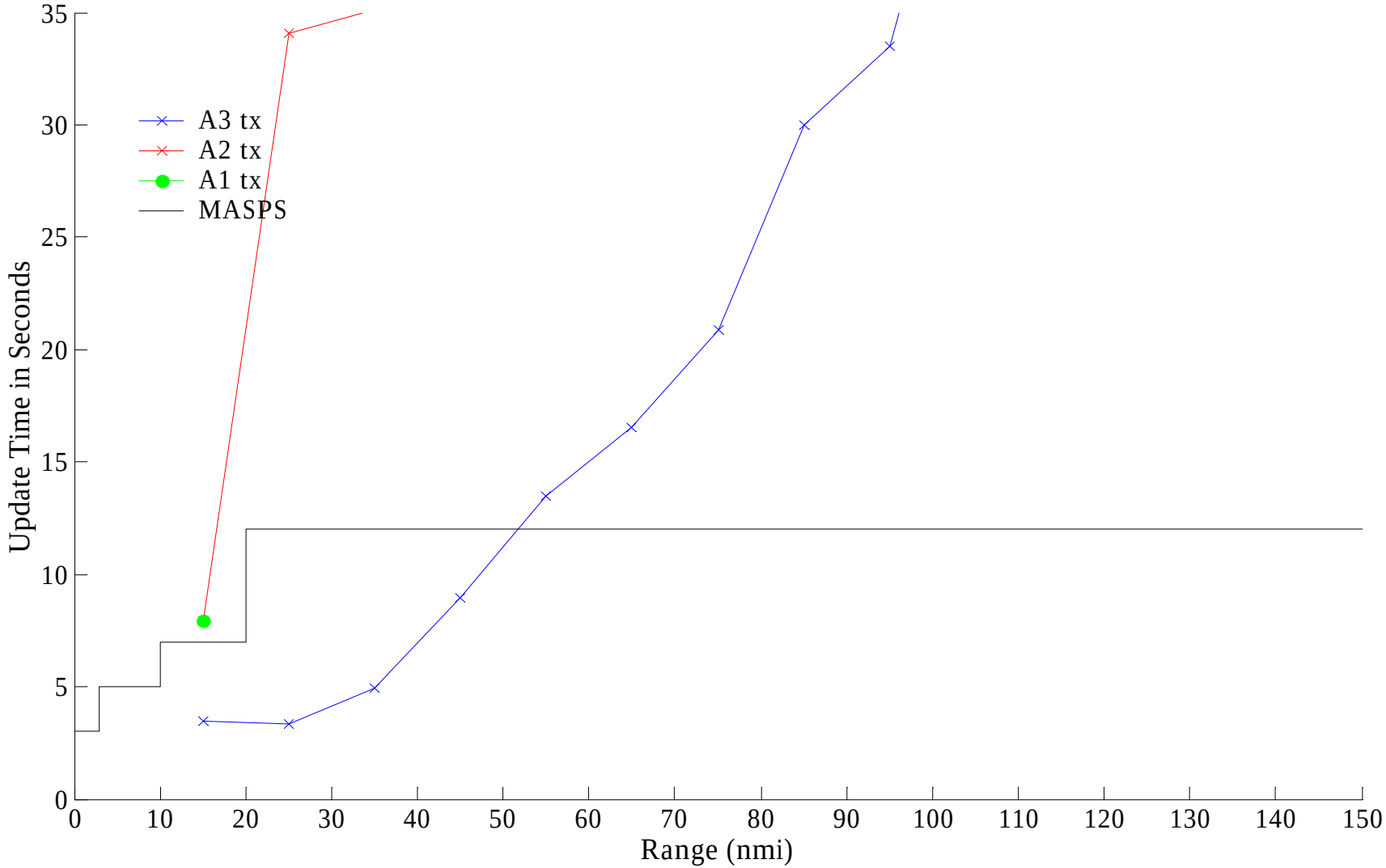
Current Europe State Vector Update Times - High Altitude A3 Receiver



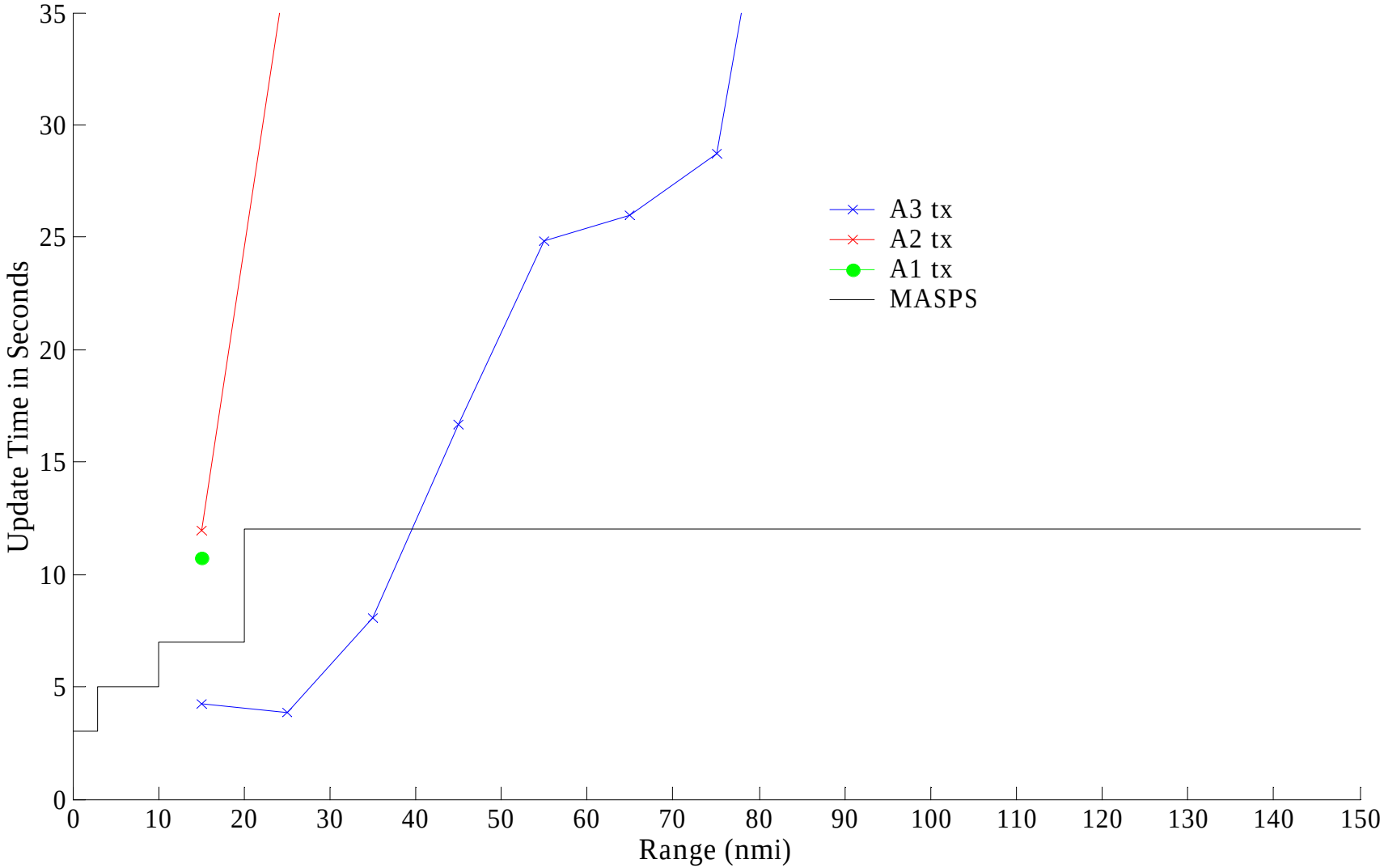
Current Europe TCP Update Times - High Altitude A3 Receiver



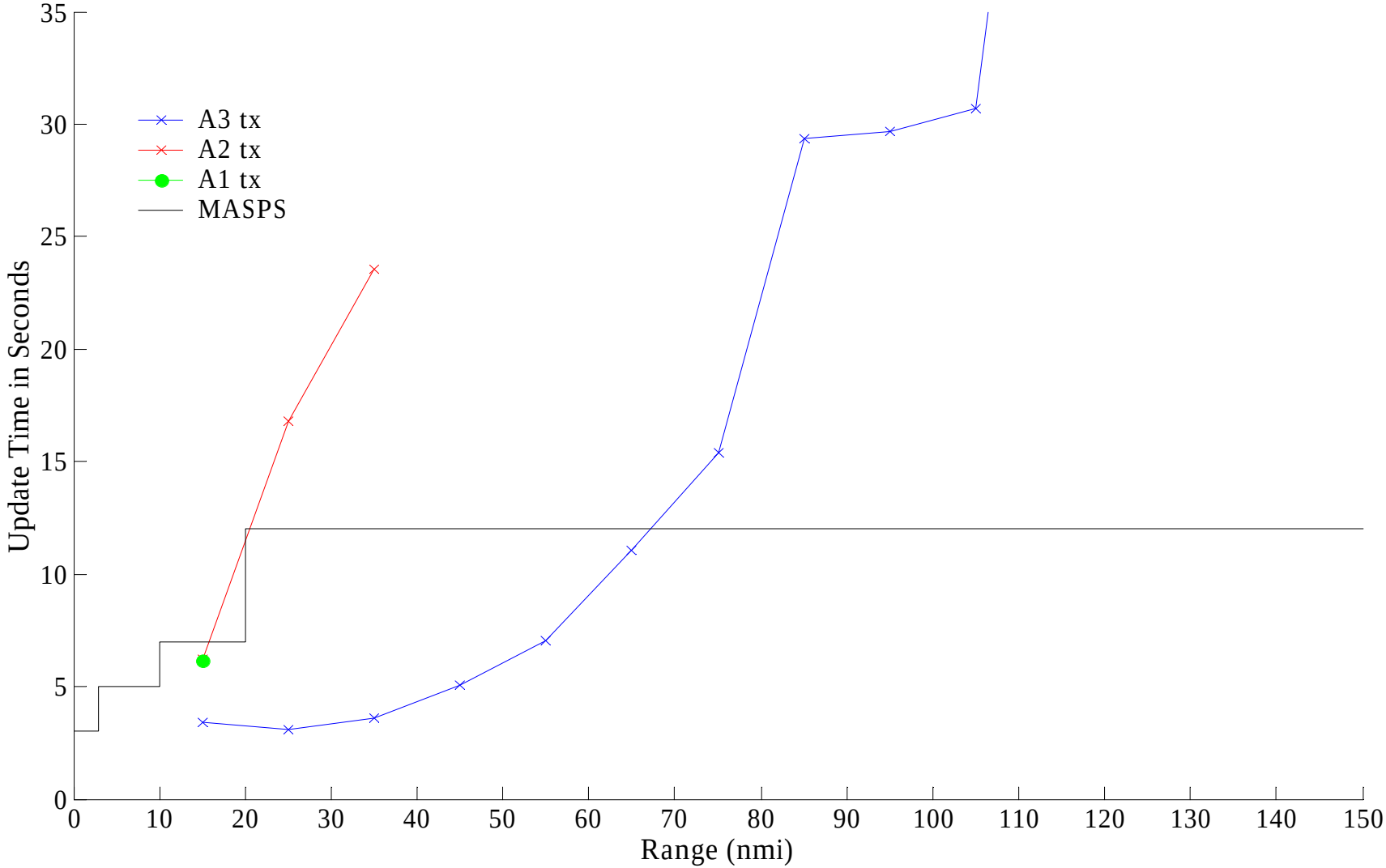
Current Europe State Vector Update Times - High Altitude A2 Receiver



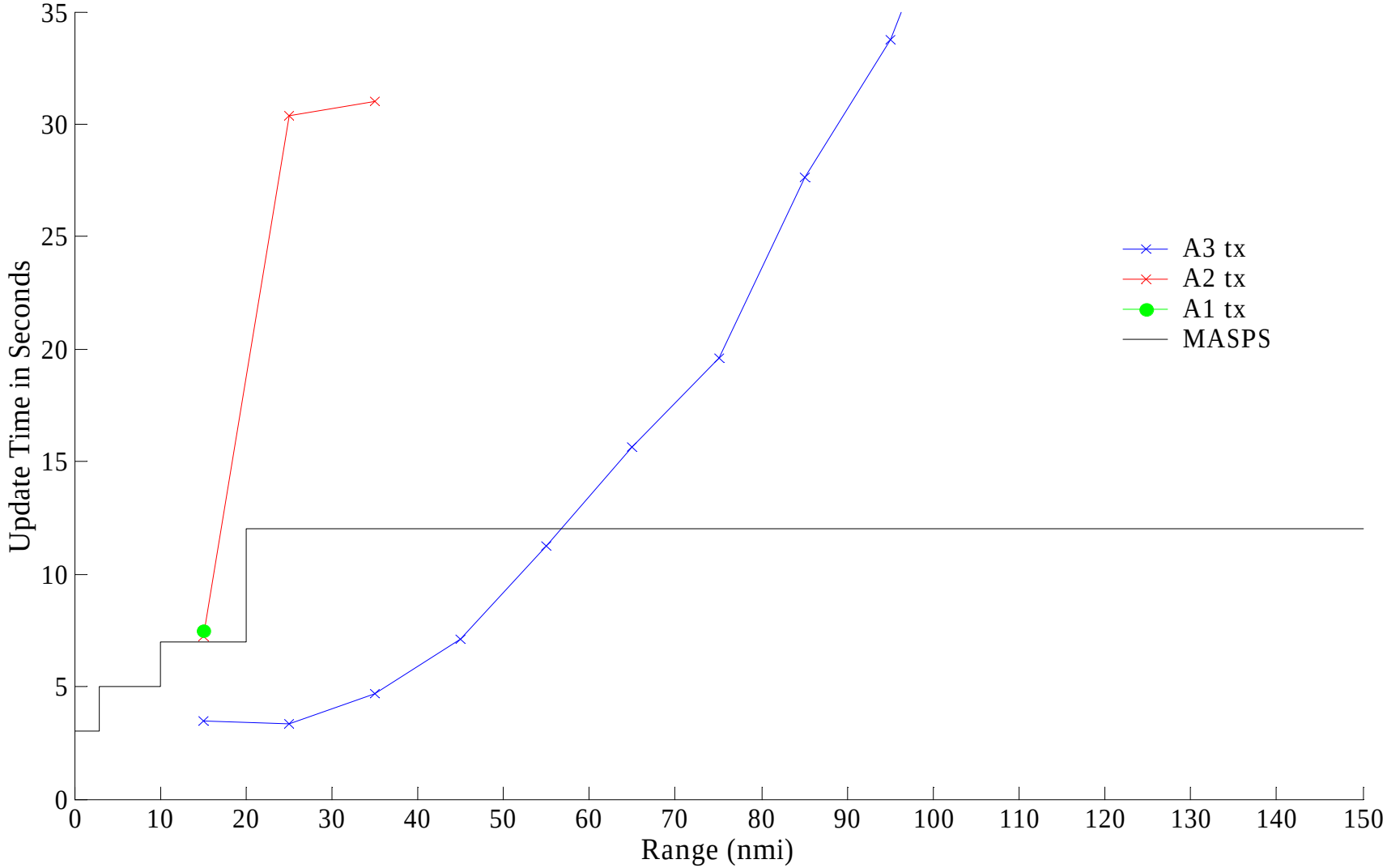
Current Europe State Vector Update Times - High Altitude A1 Receiver



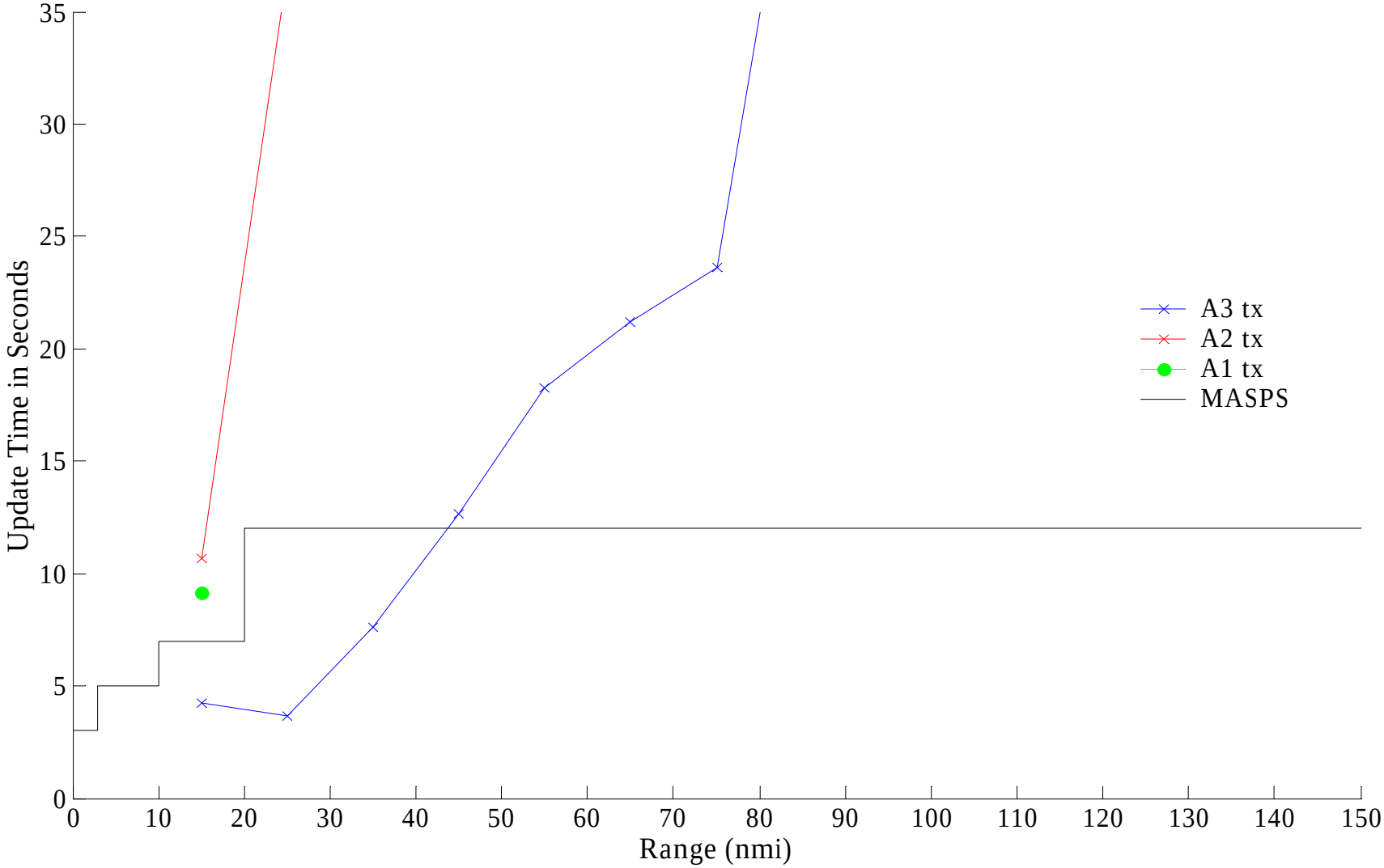
Current Europe State Vector Update Times - A3 Receiver at FL 150



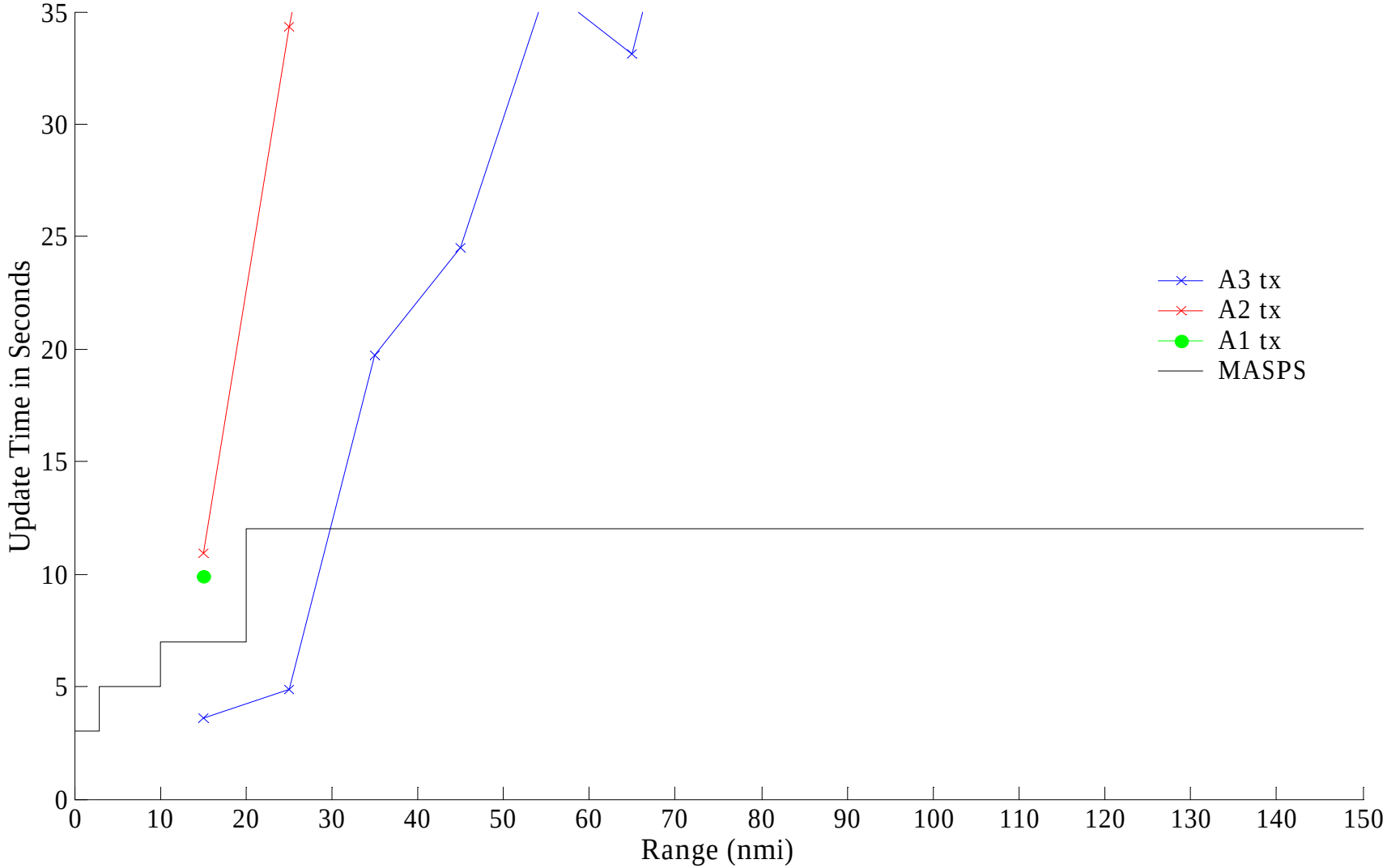
Current Europe State Vector Update Times - A2 Receiver at FL 150



Current Europe State Vector Update Times - A1 Receiver at FL 150



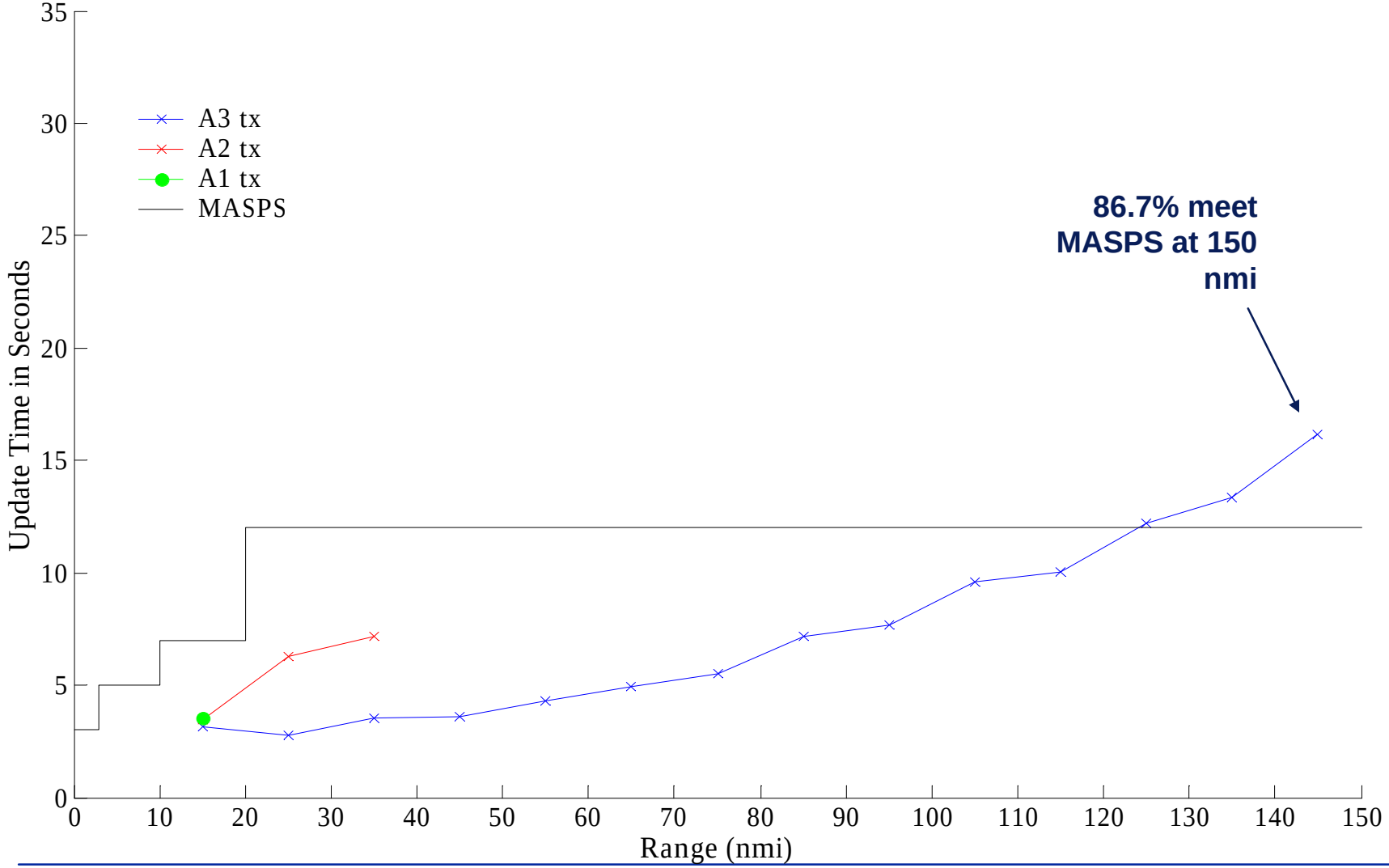
Current Europe State Vector Update Times - A0 Receiver at FL 150



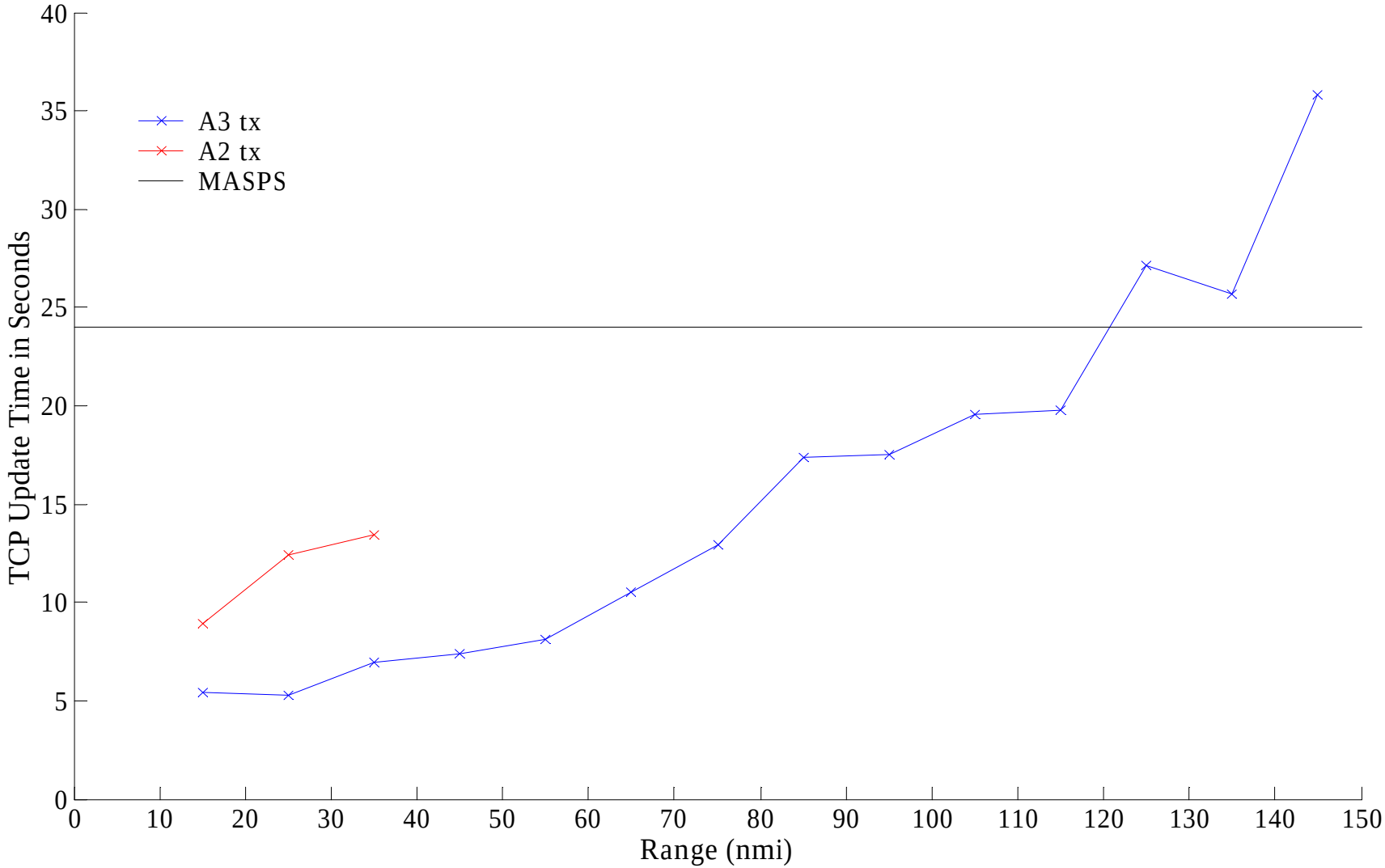
Results for Current European Scenario

- Five simultaneously-operating TACANs (three on-channel) at 4 dB above already high power levels, with added Link 16, cause UAT performance to suffer
- Performance is significantly worse than previously presented for four TACANs, with power levels as specified
- ADS-B MASPS requirements are not met

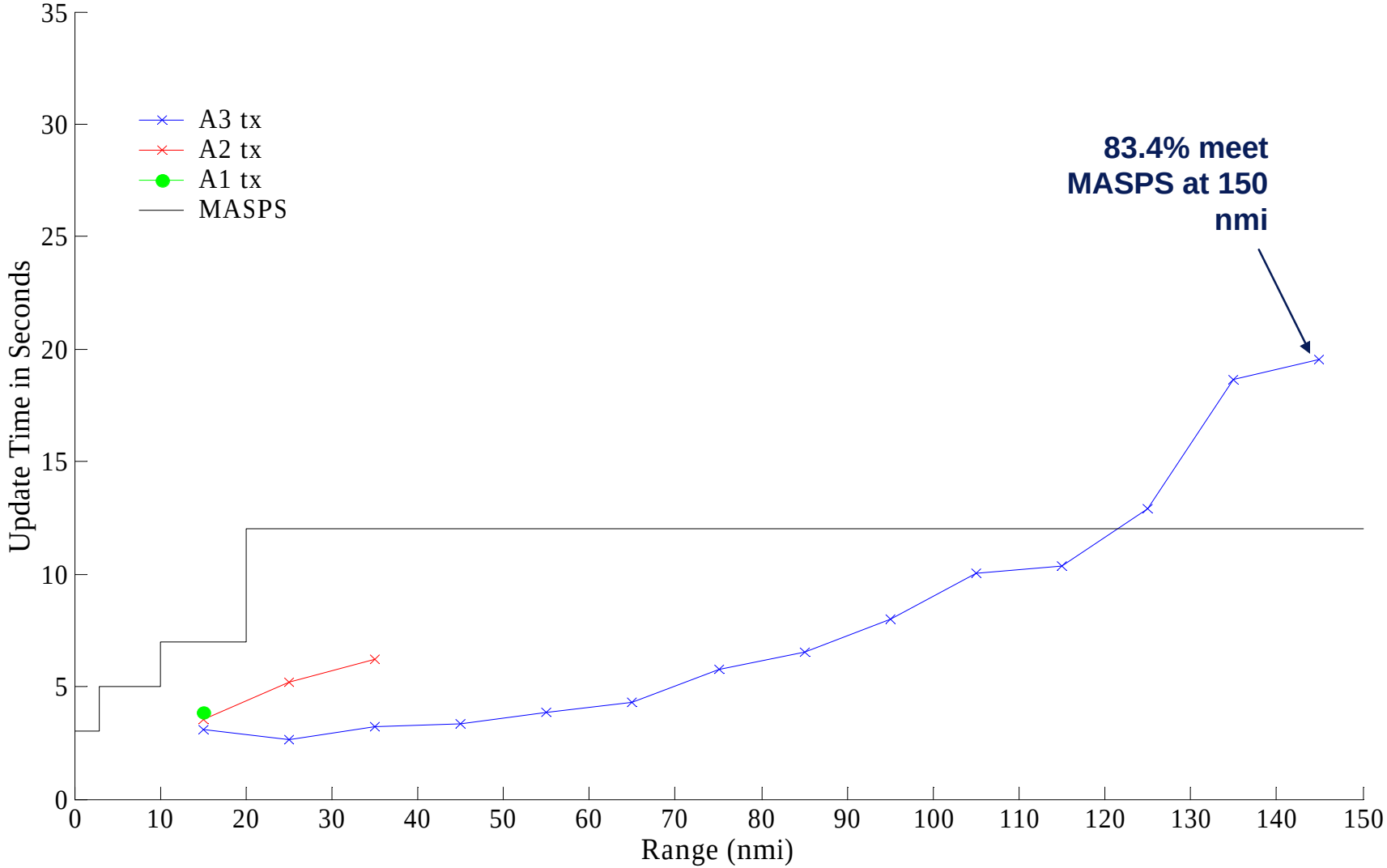
Future Europe State Vector Update Times - High Altitude A3 Receiver



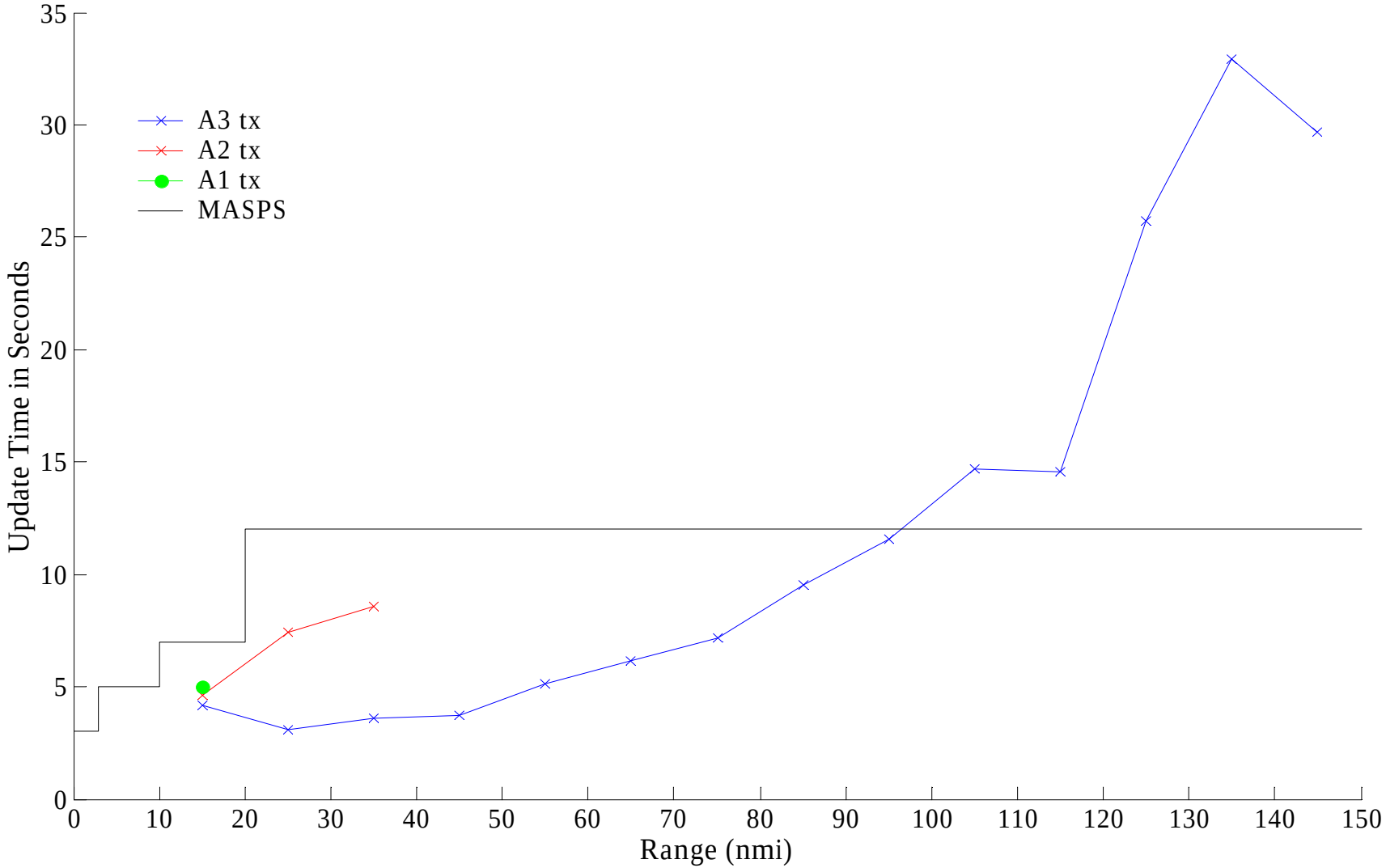
Future Europe TCP Update Times - High Altitude A3 Receiver



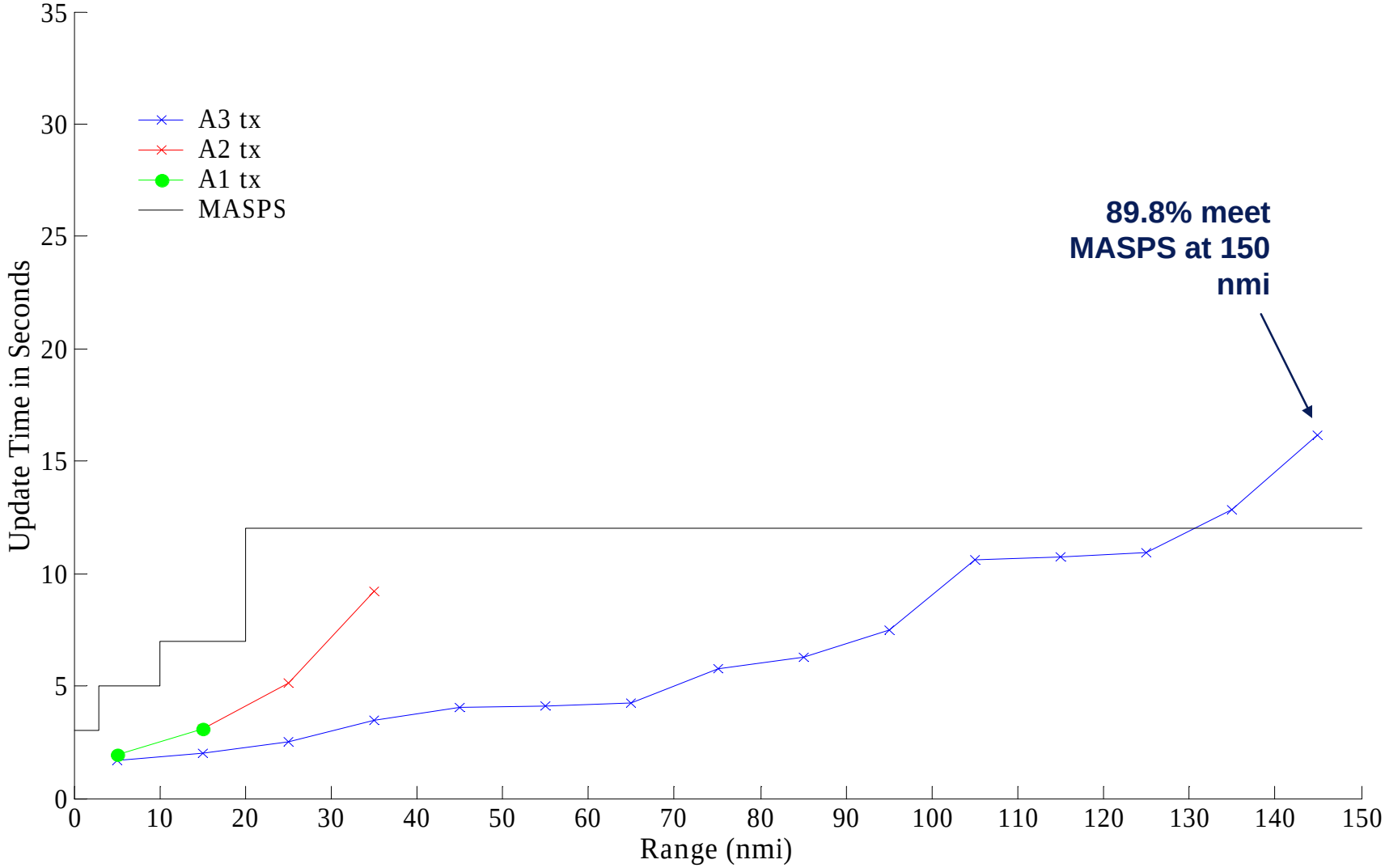
Future Europe State Vector Update Times - High Altitude A2 Receiver



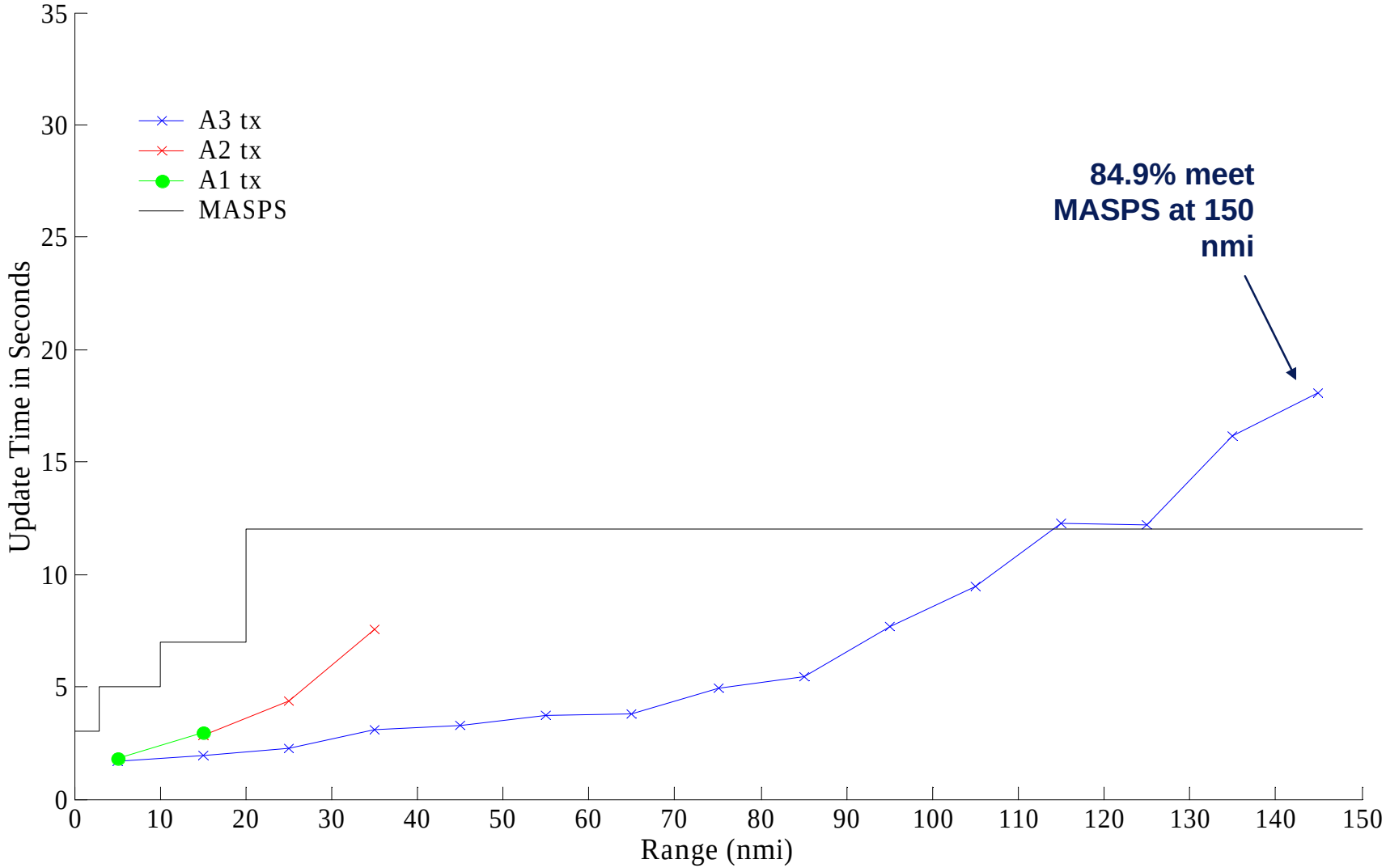
Future Europe State Vector Update Times - High Altitude A1 Receiver



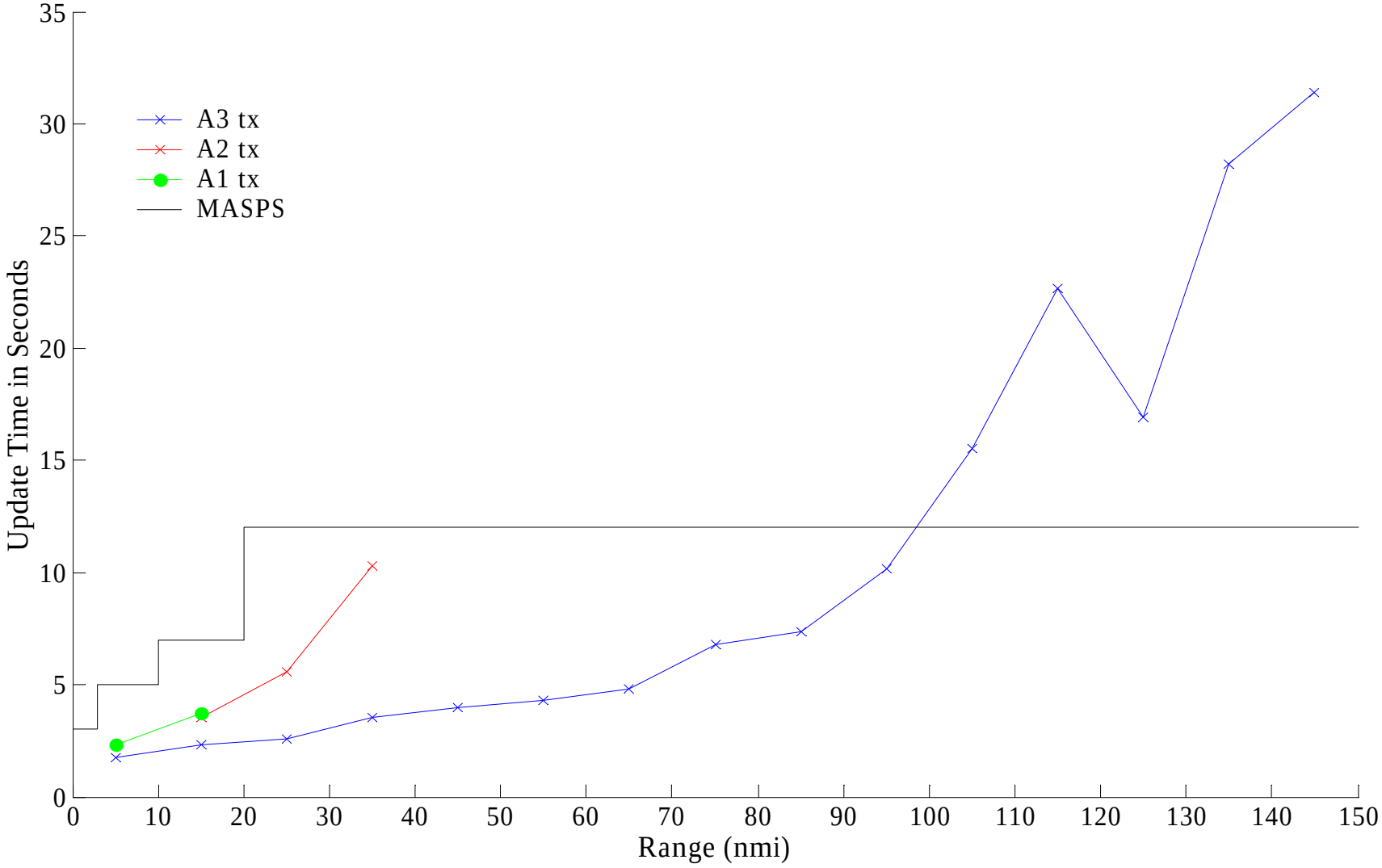
Future Europe State Vector Update Times - A3 Receiver at FL 150



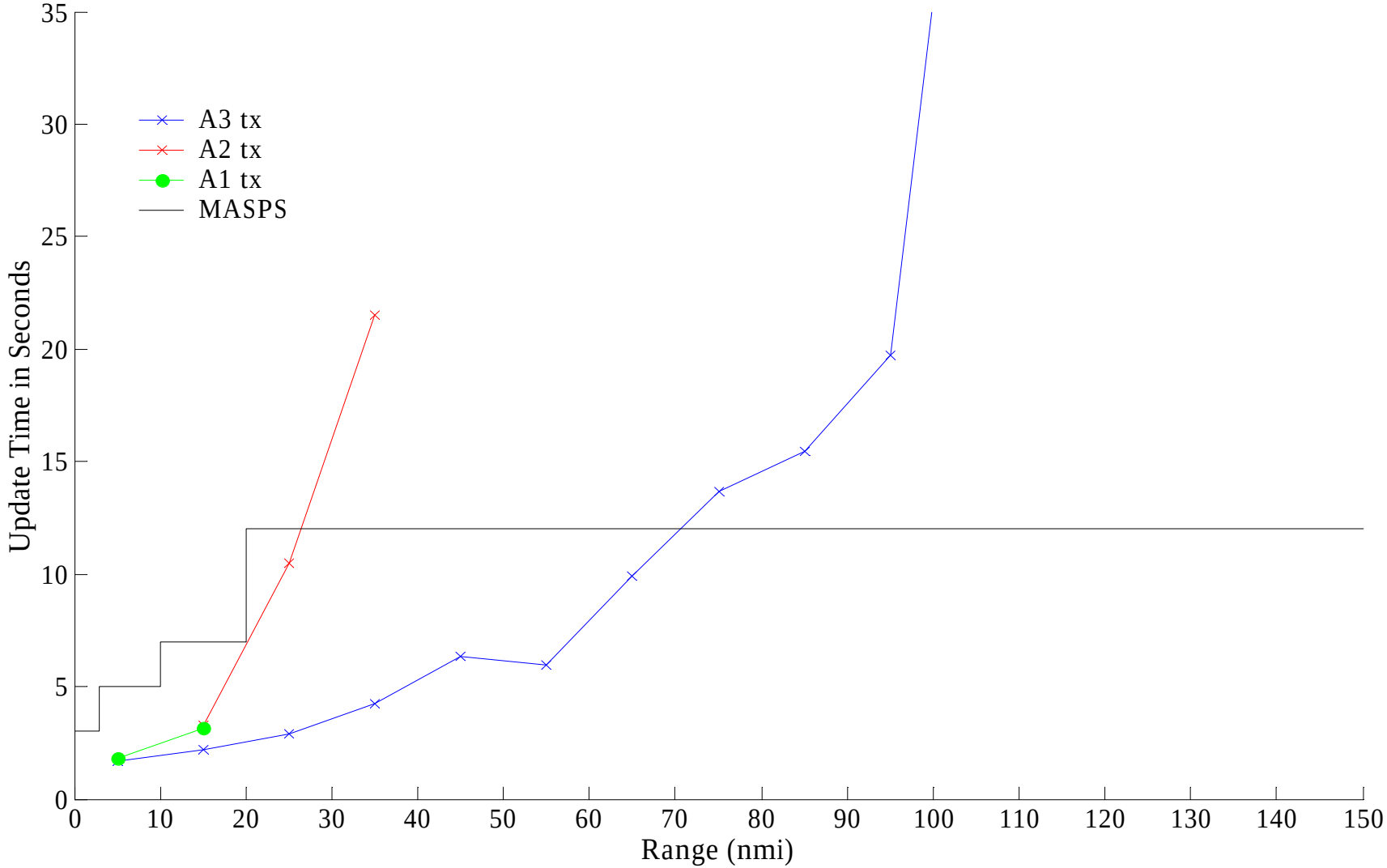
Future Europe State Vector Update Times - A2 Receiver at FL 150



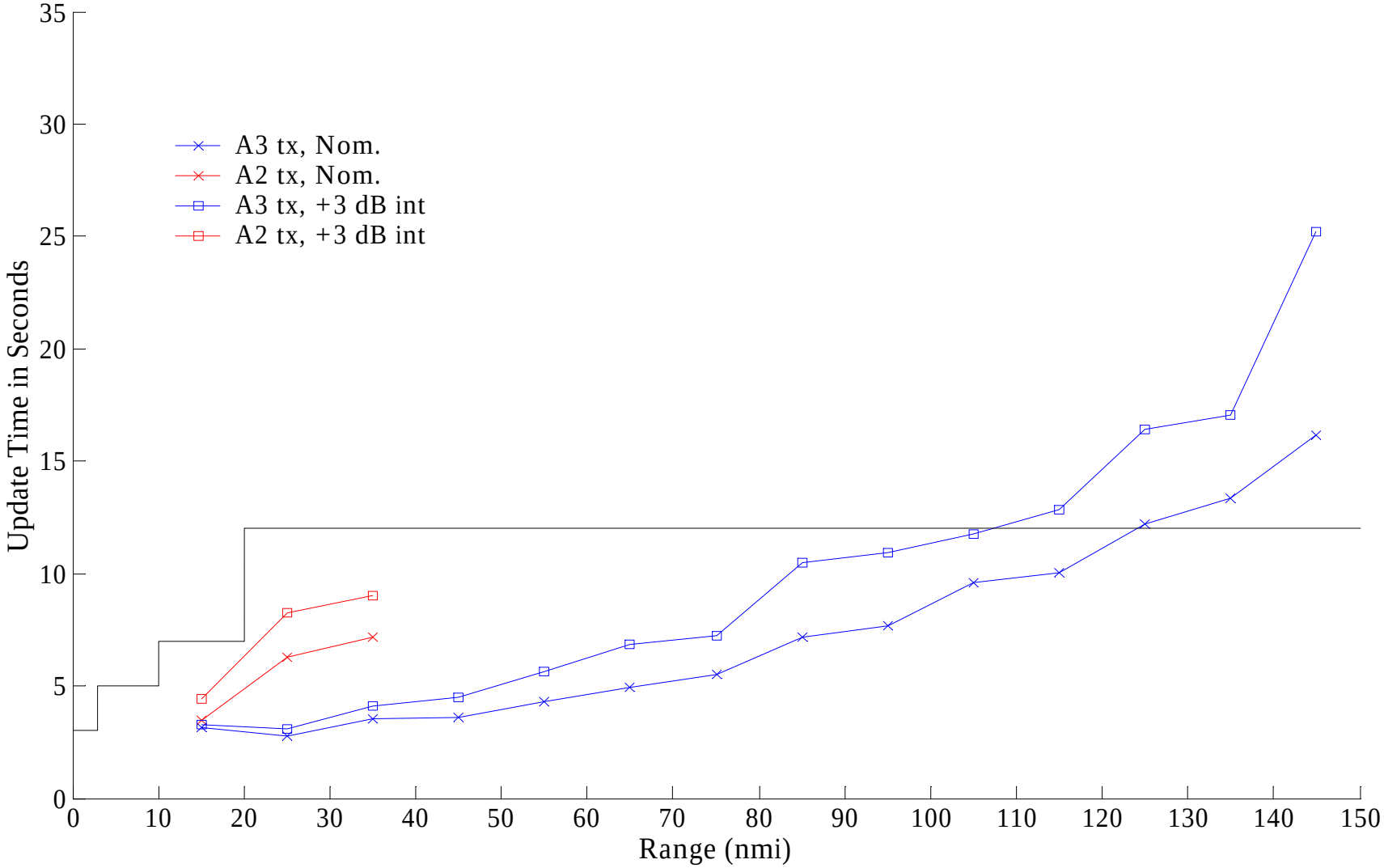
Future Europe State Vector Update Times - A1 Receiver at FL 150



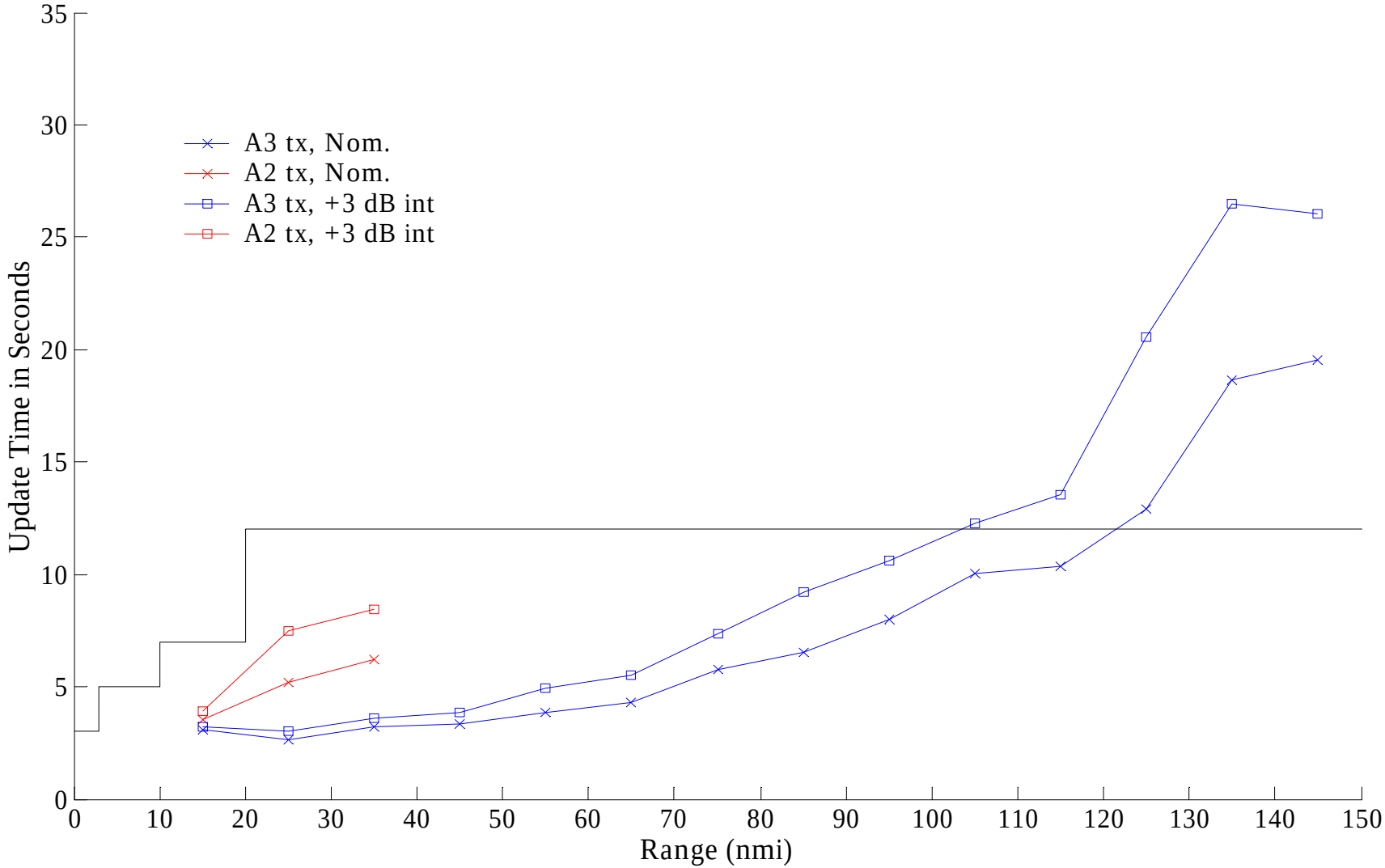
Future Europe State Vector Update Times - A0 Receiver at FL 150



Self-Interference Study – Effect of 3 dB Interference Increase on A3 at High Altitude



Self-Interference Study – Effect of 3 dB Interference Increase on A2 at High Altitude



Self-Interference Study

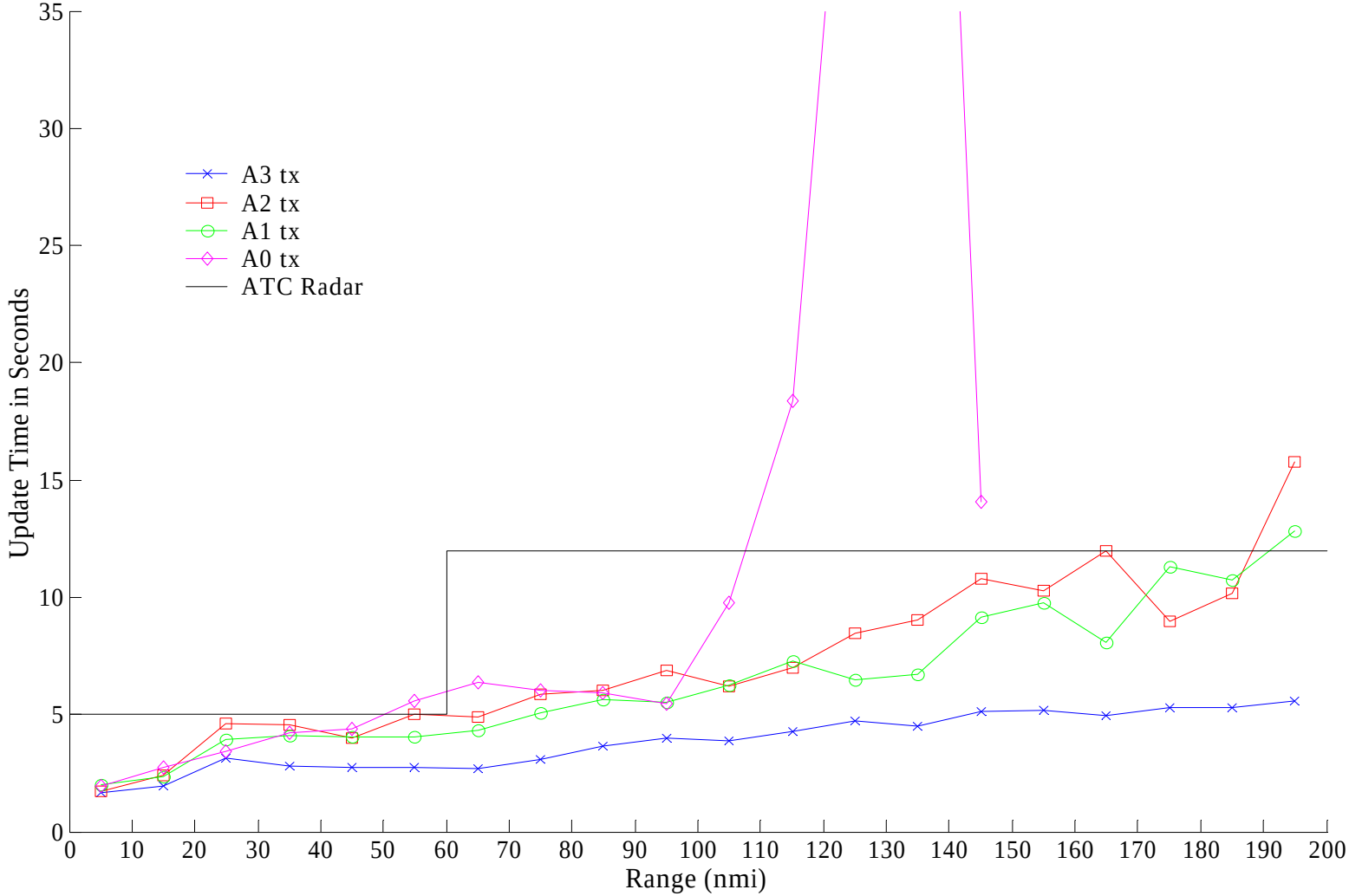
- Bracketed the problem
- More study required

Airborne Receiver Performance in CE 2015 Scenario

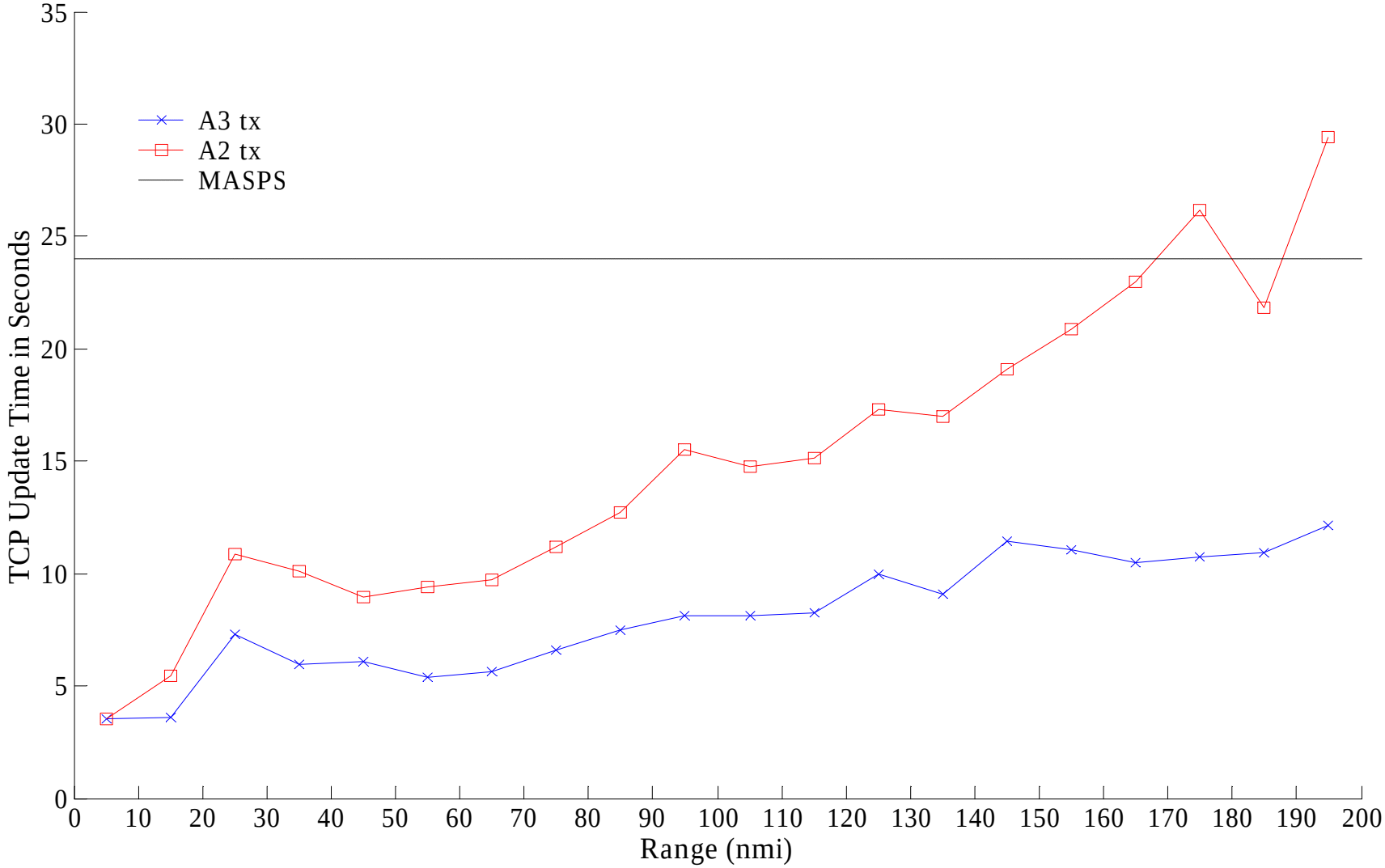
- In general, all receiver types meet all current air-air ADS-B MASPS update requirements to stated ranges for both FL400 and FL150
- Issues
  - A0
    - Probe required
  - A1 at close range
    - Probe required
  - A3 past 120 nmi

  - What are ground vehicle requirements?

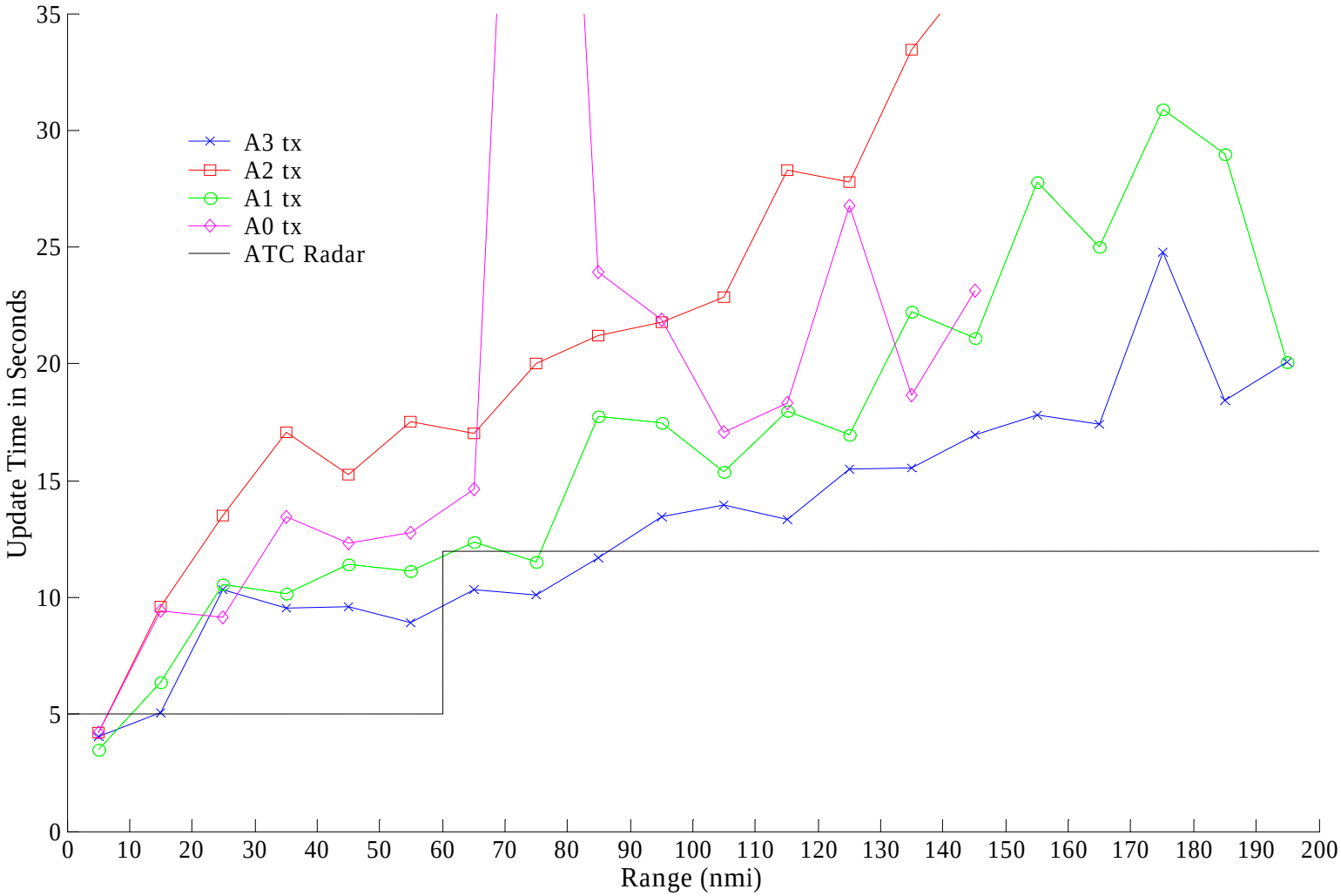
European Air-Ground Results
State Vector Update – No TACAN



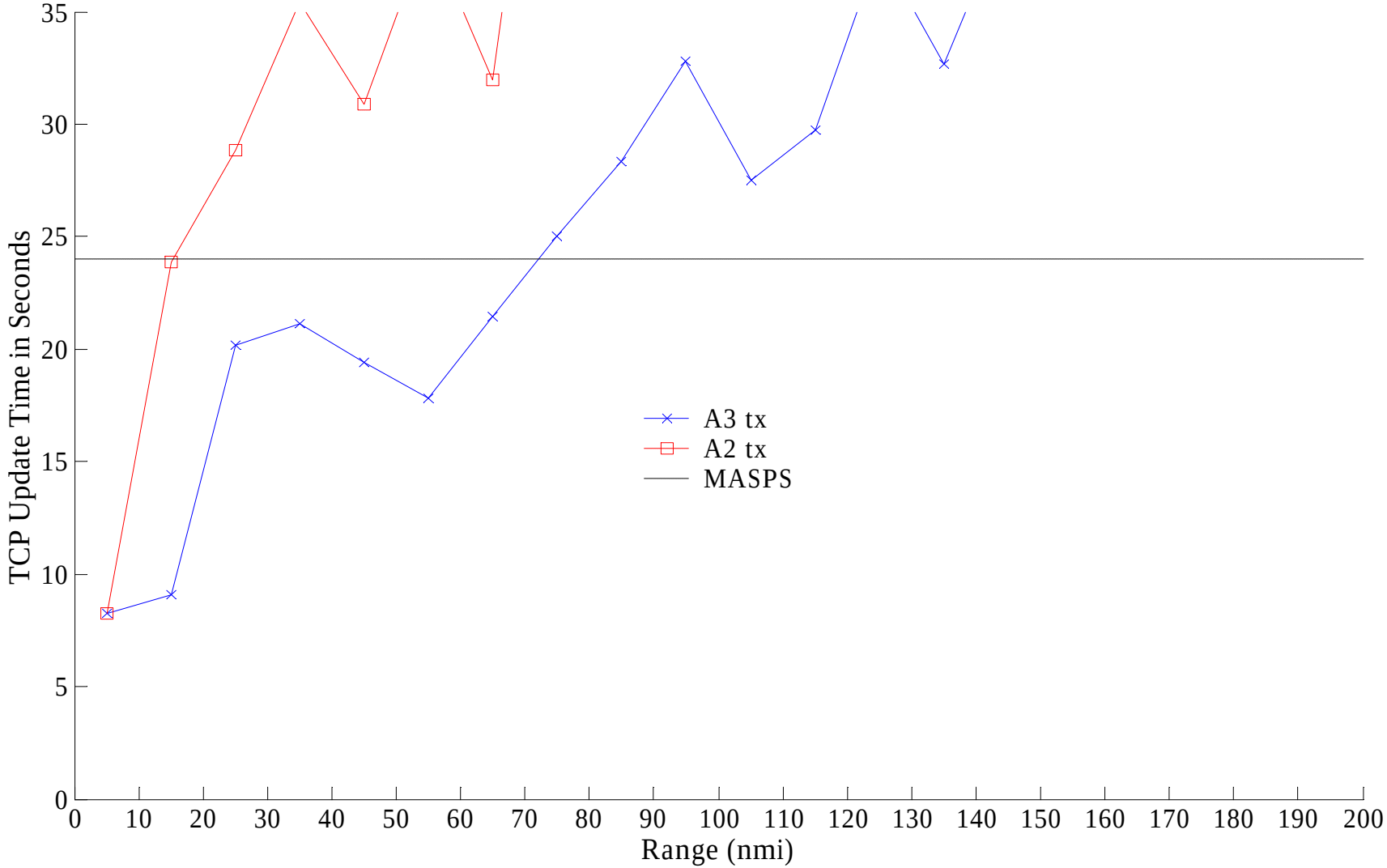
European Air-Ground Results
TCP Update - No TACAN



European Air-Ground Results – State Vector Updates with Collocated TACAN



European Air-Ground Results – TCP Updates with Collocated TACAN



Ground Receiver Performance in CE 2020 Scenario

- No co-located TACAN - ground receiver meets all current air-air ADS-B MASPS update requirements to past 150 nautical miles, with the exception of A0
- With co-located high-power adjacent channel TACAN – poor performance

Issues

- A1 sub-class
- Co-site interference
  - Top-bottom difference
  - Aircraft class differences
    - E.g., look at A0/A1 without DME
- A2 anomaly appears to be gone
- Implementation of UAT self-interference model