Preliminary Results for TAMDAR Transmission on ADS-B

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TAMDAR

- Meteorological data collected onboard aircraft and broadcast during flight
- Some Potential Applications:
  - Data used in weather forecasting
  - Hazardous Condition Alert
  - Forecast Validation during flight operations
- Targeted for General Aviation
  - Gap filler for non-commercial, non-peak time routes
  - Low Cost

ADS-B

- Automatic Dependent Surveillance – Broadcast
- Broadcasts state vector and other information
- U.S. ADS-B Systems
  - 1090 Mode-S Extended Squitter
  - Universal Access Transceiver (UAT)

Data in TAMDAR Report

- Aircraft info
  - ID (16)
  - Aircraft Type (8)
  - Date (16)
  - Time (20)
  - Roll Angle (4)
  - Phase of Flight (4)
- State Vector
  - Latitude (20)
  - Longitude (20)
  - Pressure Alt. (16)
- Wind
  - Speed (8)
  - Direction (8)
  - Temperature (12)
- Turbulence
  - Average (8)
  - Peak(8)
- Water
  - Humidity (8)
  - Icing (4)
  - Liquid Vapor Mixing Ratio (8)
- Research
  - Peak Liq. Water Content (8)
  - Ave. Liq. Water Content (8)
  - Super Cooled Large Droplet (4)

ADS-B Transmitting TAMDAR

- GA aircraft are represented in ADS-B MASPS by A1 and A0 equipage levels
- ADS-B provides Aircraft and State Vector information given:
  - Position inputs to TAMDAR
  - Date/Time stamp on reception
  - ADS-B ID is suitable
  - Aircraft type can be inferred
- 92 bits of data remain

Number of ADS-B Messages Required for TAMDAR Report

- 1090 Extended Squitter
  - Two dedicated messages
  - Adds extra transmissions from A1 and A0 equipages to ADS-B environment
- UAT
  - One message for A0 and A1L
  - Two messages for A1H
  - Weather data loaded into unreserved bit fields of messages currently broadcast on ADS-B
  - No extra ADS-B transmissions required

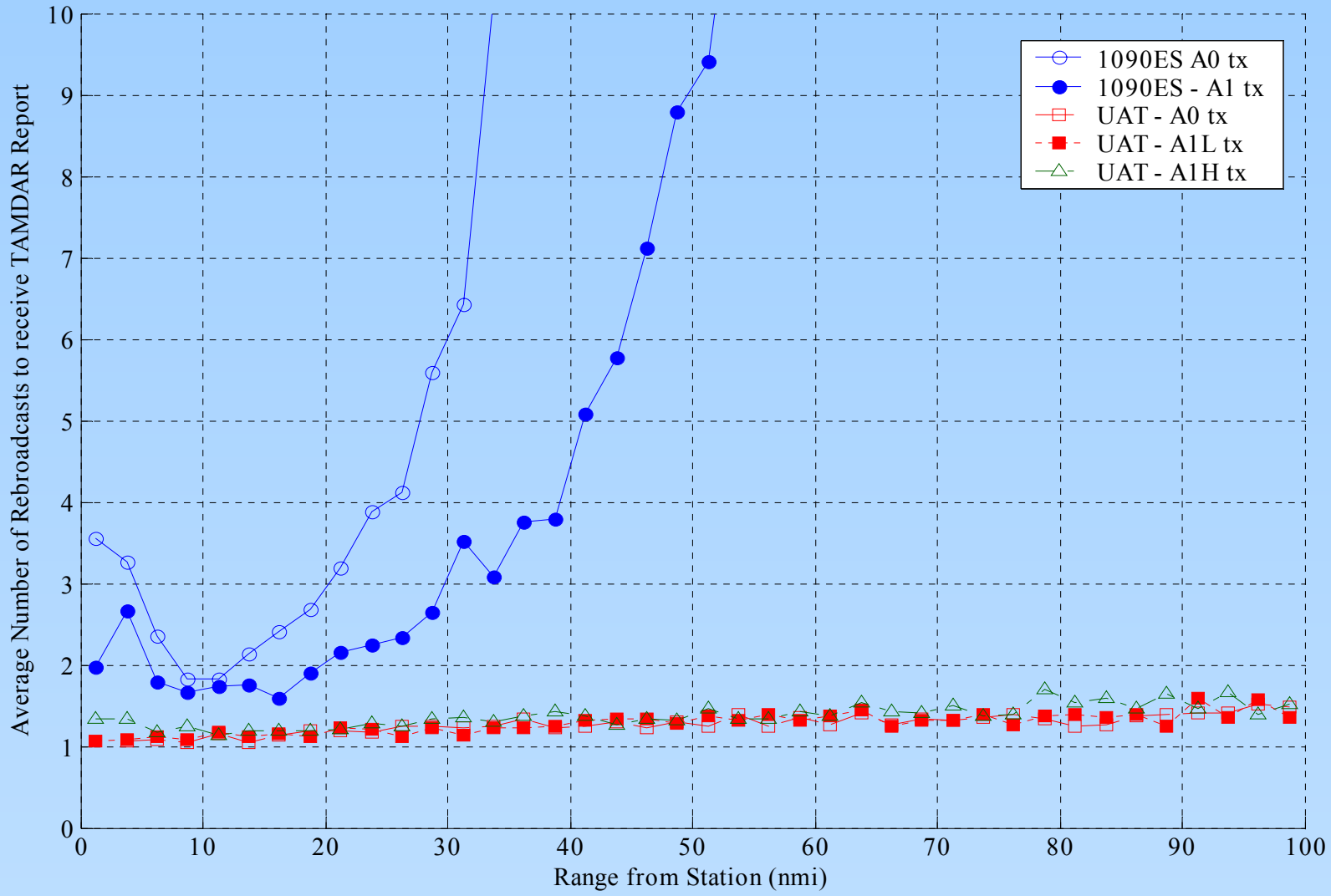
Simulation Assumptions

- Periodic Transmit Rates:

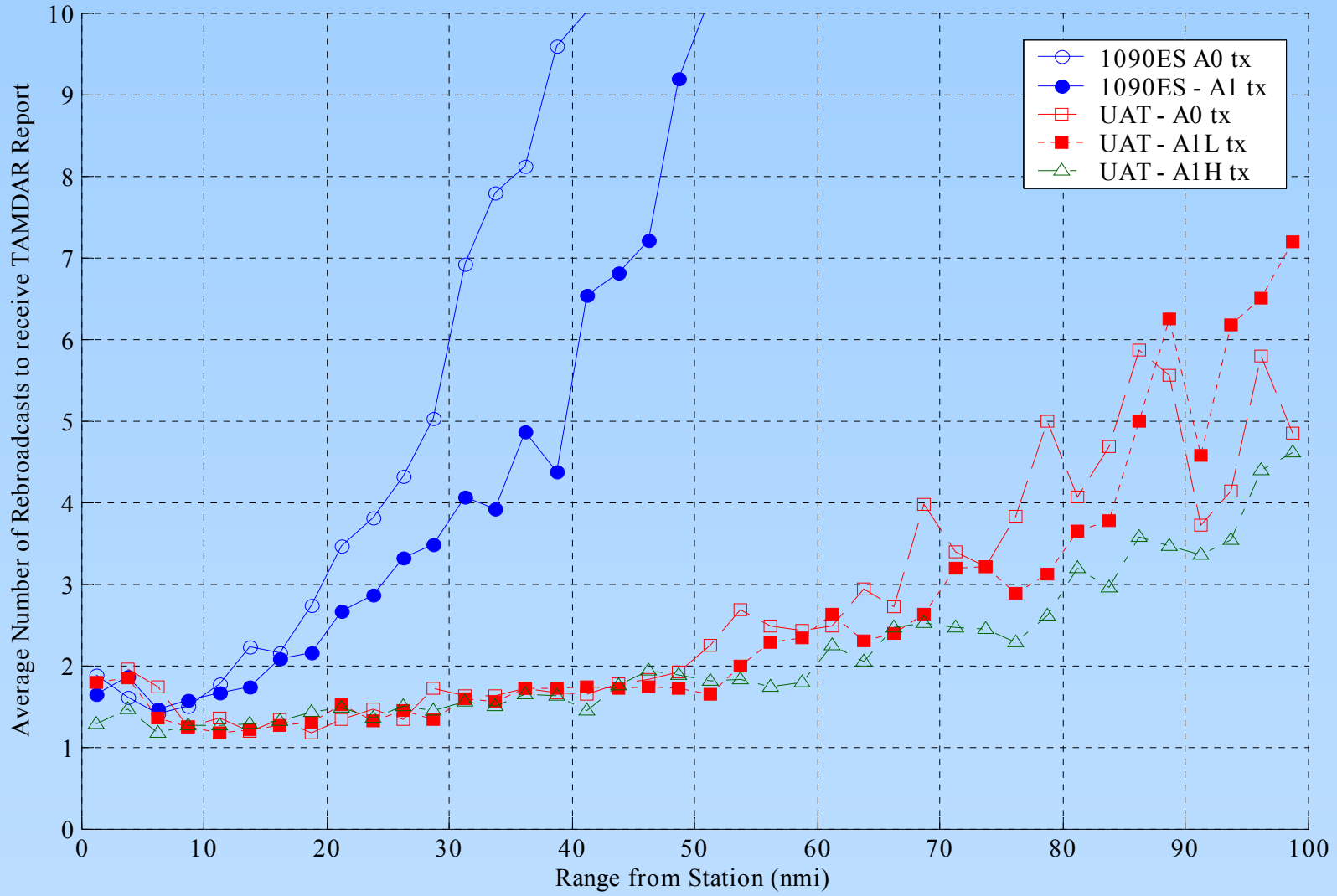
Phase of Flight	Messages/min.	Interval (sec)
Ascent	10	6
En route	1/3	180
Descent	1	60

- Air Traffic Scenario is LA Basin (400 nmi radius around LAX) in years 2007 & 2015
- 2103 aircraft (176 on surface) in 2007
- 2435 aircraft (206 on surface) in 2015

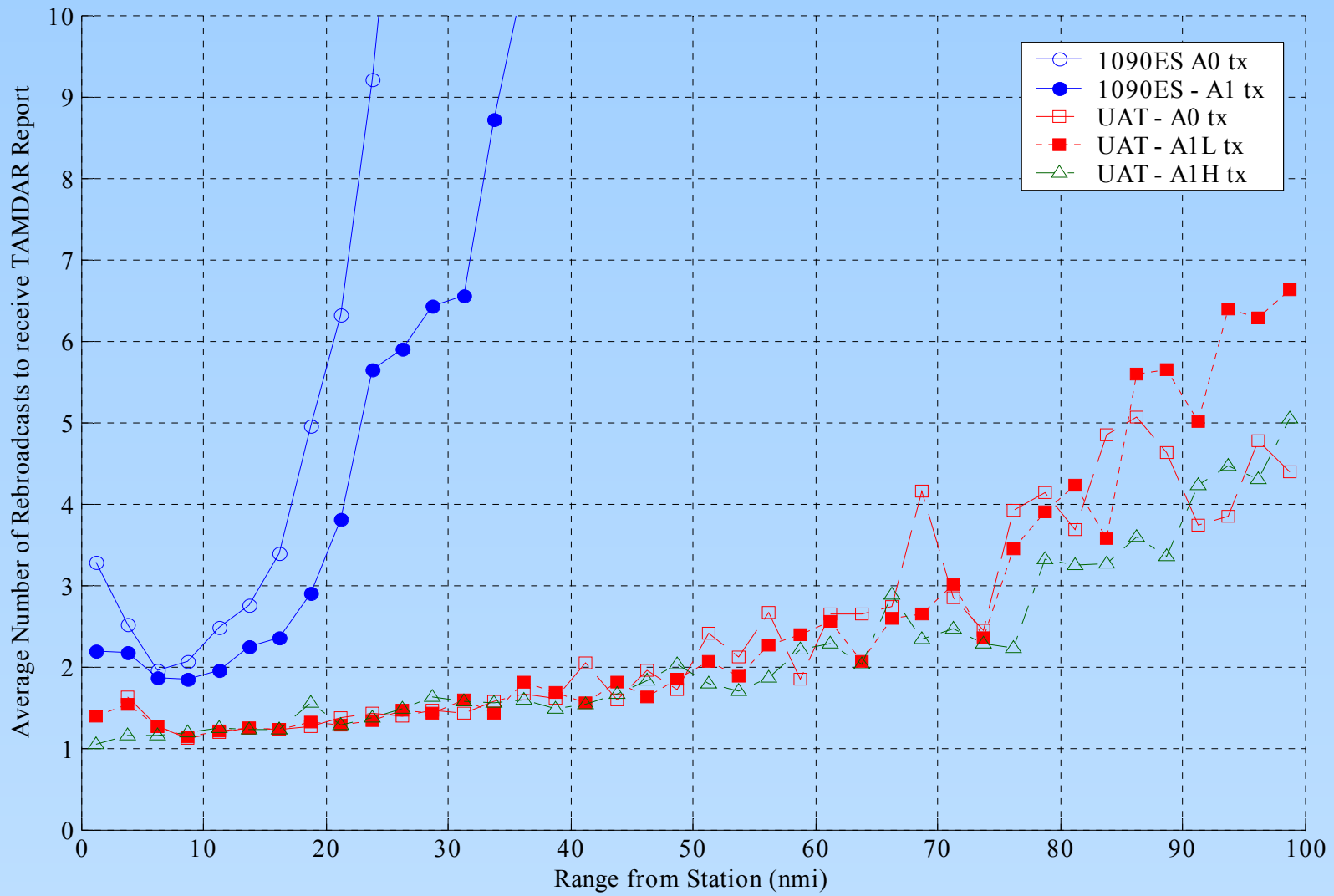
Rebroadcasts for Ground Reception in LA 2007



Rebroadcasts for A1 Reception in LA 2007



Rebroadcasts for A0 Reception in LA 2007



Calculating Transmit Rates

- To determine if transmit rates can support TAMDAR reception, use:

$$\frac{broadcasts}{Interval} \cdot \frac{messages}{report} = \frac{messages}{Interval}$$

  - Broadcasts (numerator) - number of rebroadcasts required to receive report (from plots)
  - Interval is reporting interval for phase of flight
  - Messages/report is number of ADS-B messages required to transmit TAMDAR report
- Example: A1H tx to A1 rx on UAT
  - 1.3 rebroadcasts @ 20 nmi
  - Ascent interval – 6 seconds

⇒ 1.3/6 * 2 = 26 /min

Transmit Rates

System	1090		UAT		
Equipage	A0	A1	A0	A1L	A1H
Phase of Flight (approx. range)	Transmit Rate (messages/min)				
Ascent (20)	60	60	20	13	26
Descent (40)	12	12	2	2	4

Still investigating en route phase of flight

Findings

- TAMDAR data transfer likely to be supported by both links
- UAT appears to be more efficient delivering TAMDAR data
- Effect on ADS-B performance
  - 1090 ES unaffected if TAMDAR transmit rate (A0 & A1 only) is 20 messages per minute or less
  - Assumed that UAT does not require additional ADS-B messages
- Coverage is an issue in enroute portion for 1090 ES due to use of omni-directional receive antenna

Future Work

- Refine 1090 ES ground receiver antenna requirements for further simulations
- Refine payload requirements
- Validate ADS-B data as input to TAMDAR
- Define transmit rates (change in position ?)
- Define the level of assurance of receiving TAMDAR Report (e.g. 90th percentile…)