

LA 2020 Scenario

RTCA Special Committee 186, Working Group 3
ADS-B 1090 MOPS, Revision A
Meeting #13

Preliminary 1090 Performance Simulation Results

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Outline

- Assumptions
- Methodology
- Receiver Performance Model Approach and Validation
- Preliminary Results

Assumptions/Parameters I

- Full ADS-B equipage
- LA 2020 scenario
 - ◆ 2469 airborne aircraft
 - ◆ 225 ground aircraft
 - ◆ Ground vehicles (Preliminary runs do not include)
 - ◆ Aircraft equipage
 - A3: 30%
 - A2: 10%
 - A1: 40%
 - A0: 20%
 - ◆ Interrogators as defined by Volpe/TASC with modifications for future radar upgrades

Assumptions/Parameters II

- Transmit characteristics
 - ◆ Transmission rates – baseline case
 - All aircraft
 - ◆ *Position squitters: 2 per second*
 - ◆ *Velocity squitters: 2 per second*
 - ◆ *Aircraft ID squitter: once every 5 seconds (0.2/sec)*
 - ◆ *Status: once every 2.5 seconds (0.4/sec)*
 - Additional A2/A3
 - ◆ *Target State squitters: once every 1.25 seconds (0.8/sec)*
 - ◆ Transmitter power at antenna
 - A3: 53-56 dBm
 - A1/A2: 51-54 dBm
 - A0: 48.5-51.5 dBm
 - ◆ Alternate transmissions from top and bottom antennas for A1-A3
 - ◆ A0 transmit on top only

Assumptions/Parameters III

- Receive characteristics
 - ◆ MTL at antenna
 - A1: ≤ -74 dBm
 - A2: ≤ -79 dBm
 - A3: ≤ -84 dBm
 - ◆ Receiver diversity for A1-A3 (two receivers)
 - ◆ Receiver blanked during co-site transmissions (ADS-B, ATCRBS, TCAS, DME)
 - ◆ Not interested in A0 reception (link decision)

Assumptions/Parameters IV

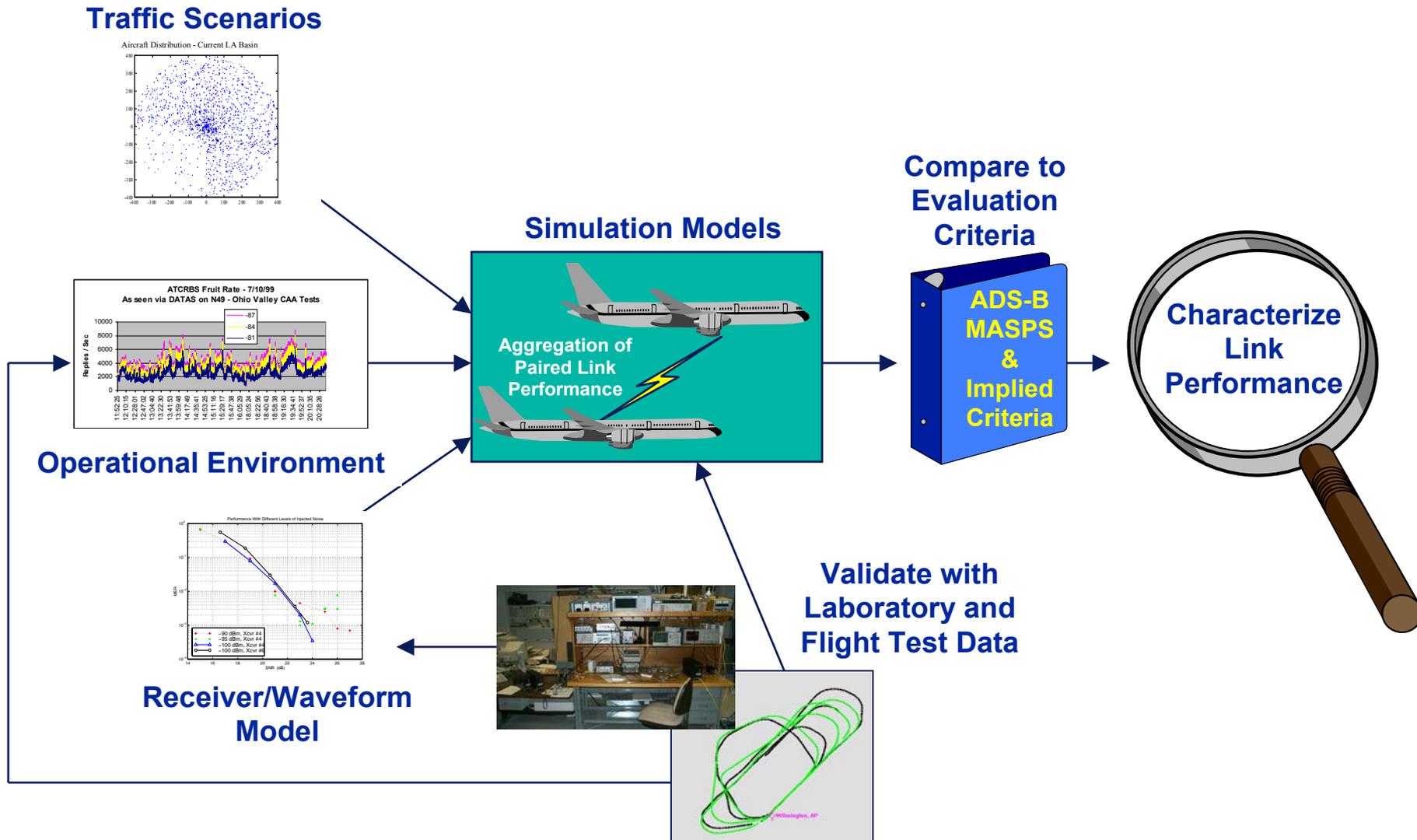
● Other Issues

- ◆ Equipment mix (TCAS, decoder types)
 - TCAS future equipage same as current in LA Basin (40%)
 - Baseline evaluation will focus on enhanced decoder (A2/A3)
- ◆ TCAS operation
 - Reply rate is modeled as ideal
 - Future LA scenario assumes terrafix no longer required
- ◆ FIS-B implementation will be on UAT, so no 1090 uplink messages
- ◆ No Mode S datalink load (**Is this correct?**)
- ◆ Results vs. ATCRBS rate
 - Starting from no-terrain results
 - **What rates are of interest?**

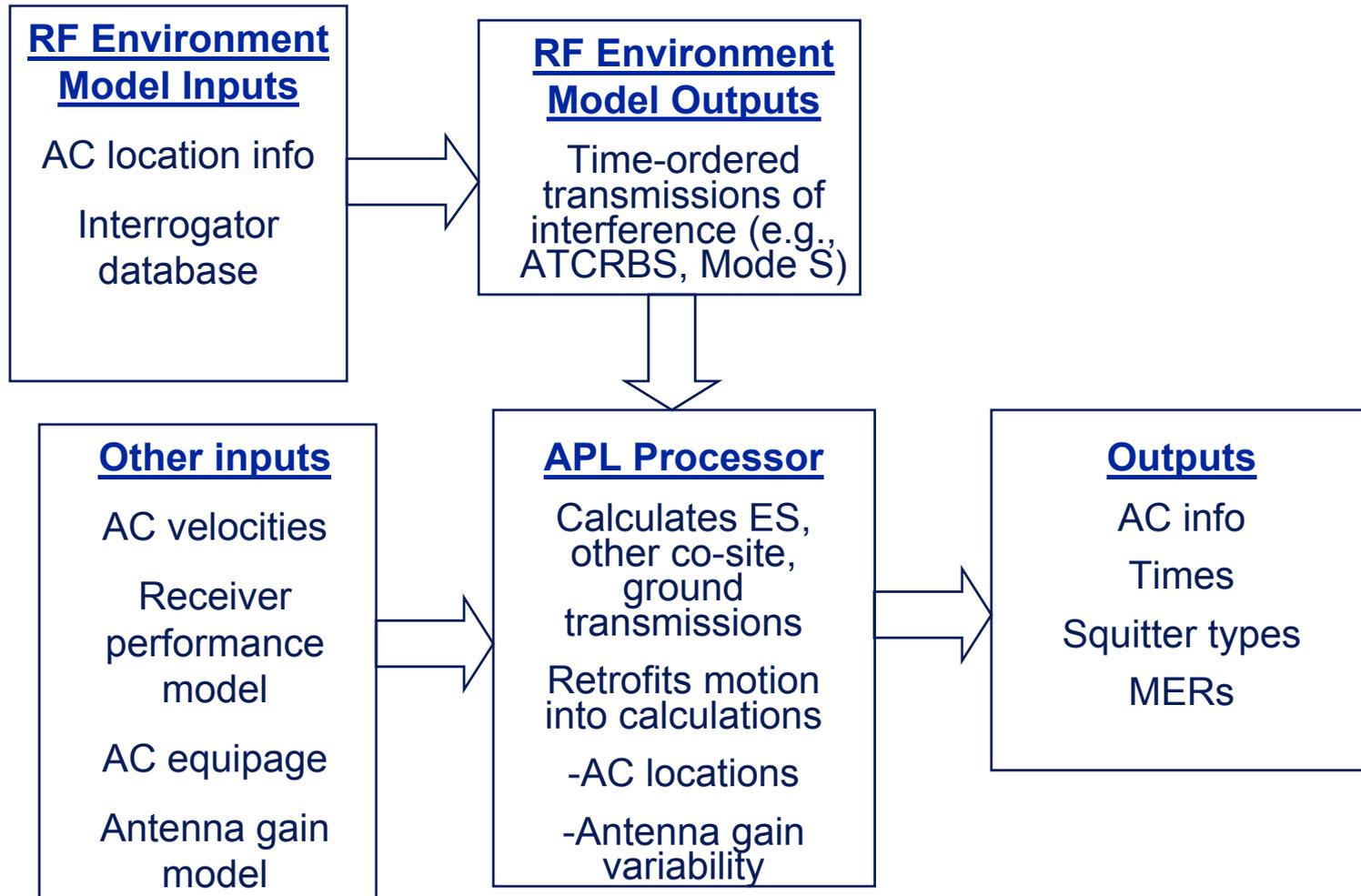
Multi-Aircraft Simulation

- Simulate transmissions of all aircraft in scenario
 - ◆ RF environment
 - ◆ Extended squitter reception
- Accurately model receiver performance
 - ◆ Complex environment, decoder
 - ◆ Validate with bench testing
- Worst case location

Modeling Diagram



Simulation Flow Diagram



Receiver Performance Modeling Approach I

- Motivation
 - ◆ Estimate impact of Enhanced Decoder on TLAT, etc. multi-aircraft network simulation results
 - Expected to show substantially better performance than LDPU
- Constraints:
 - ◆ Limited measurements / simulation results available to characterize Enhanced Decoder performance
 - Simulations of Enhanced Decoder performance by LL and FAA-TC give different results
 - ◆ Limited time available to create new model
- General approach is therefore:
 - ◆ Quick modifications to the LDPU receiver performance model used by the TLAT
 - ◆ Capture first-order performance of Enhanced Decoder

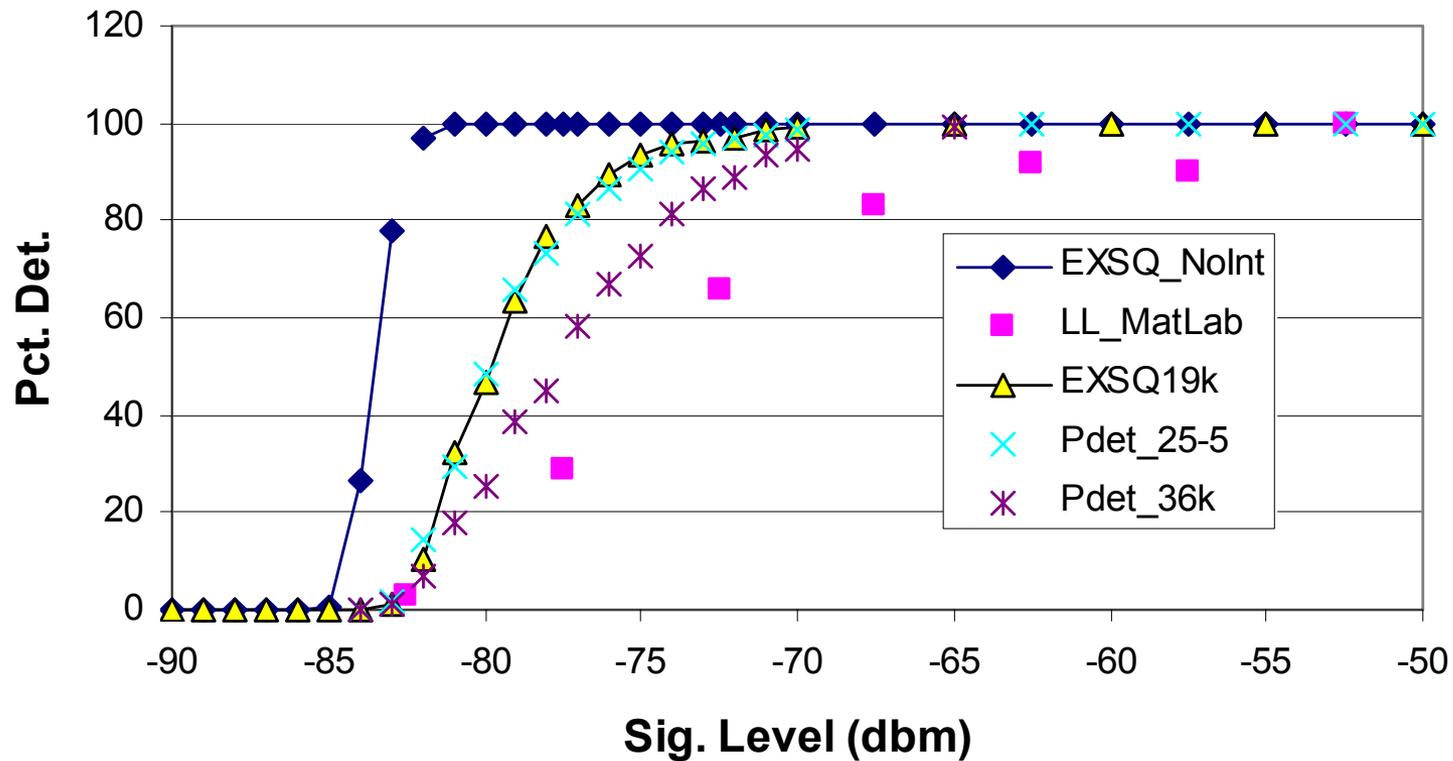
Receiver Performance Modeling

Approach II

- ATCRBS interference model
 - ◆ For ATCRBS at or above MTL:
 - Minimum changes to LDPU model to match the simulation results
 - ◆ Two versions of receiver model created for ATCRBS interference:
 - One to estimate results from LL simulations (predicts worse performance)
 - Other to estimate results from FAA-TC measurements / simulations (predicts better performance)
 - ◆ ATCRBS and Squitter interference below MTL:
 - Assume same impact as (continuous) Gaussian noise

Enhanced Decoder Model Performance Comparison

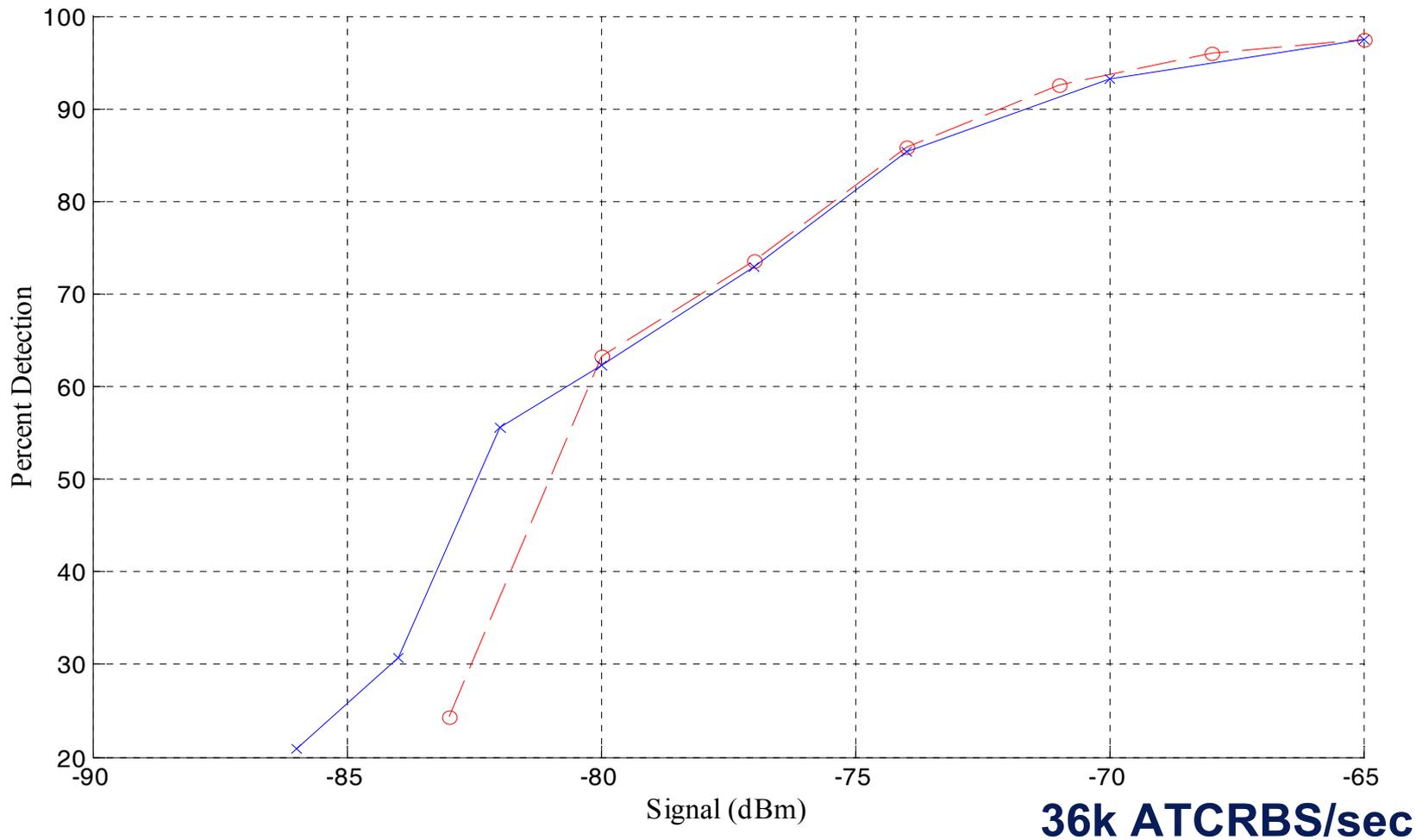
EX. Sq. Detection - With Interference



Observations

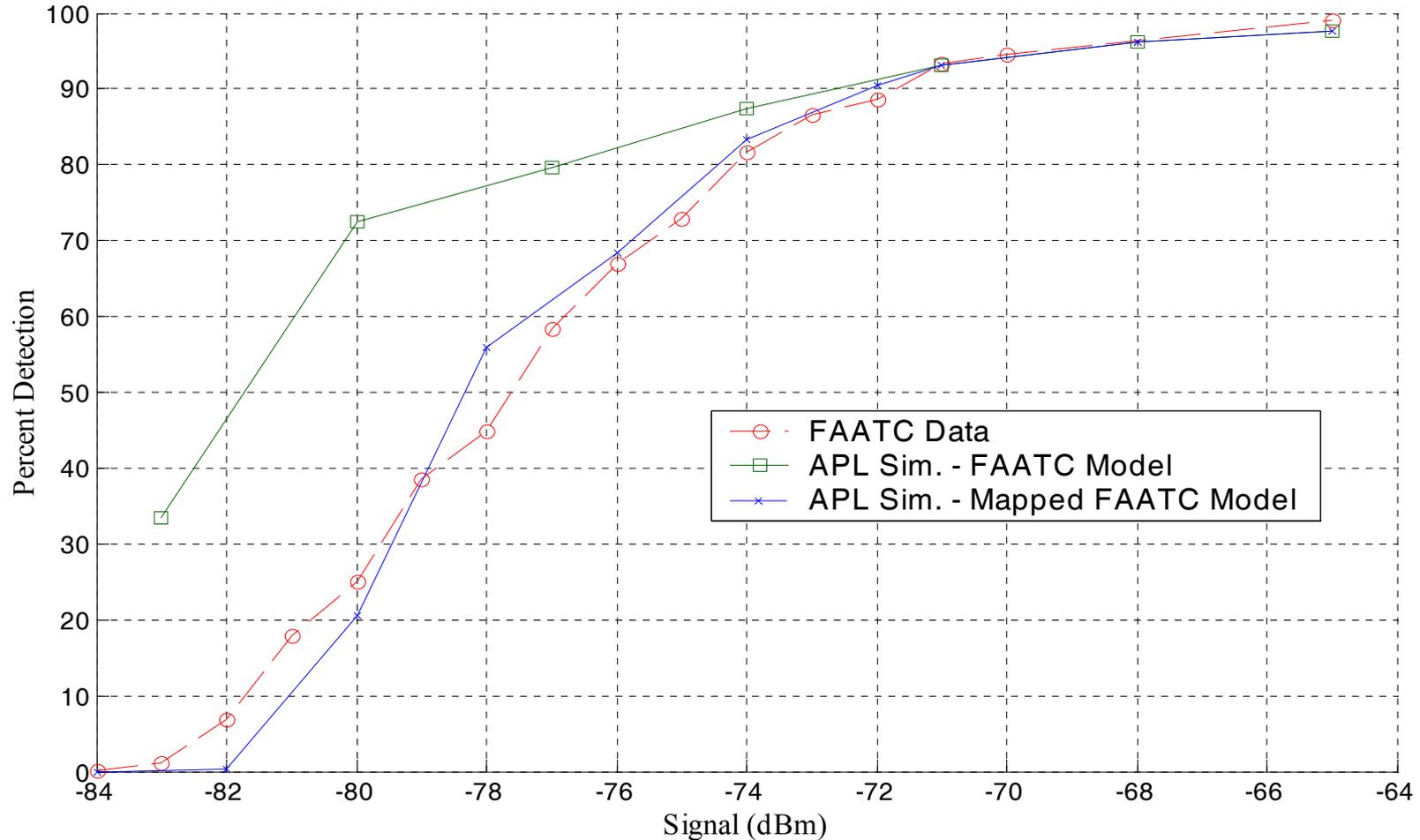
- FAATC model
 - ◆ MTL is -82.5 dB – A2 type
 - ◆ Compare APL receiver performance model at -82.5 dB sensitivity for 36K ATCRBS/sec
- LL model
 - ◆ MTL adjusted to -84 dB
 - ◆ Case shown includes Mode S/ES + 30K ATCRBS?
 - ◆ Compare APL receiver performance model at -84 dB MTL

Receiver Performance Sensitivity to MTL (-84 dB vs -82.5 dB)



36k ATCRBS/sec

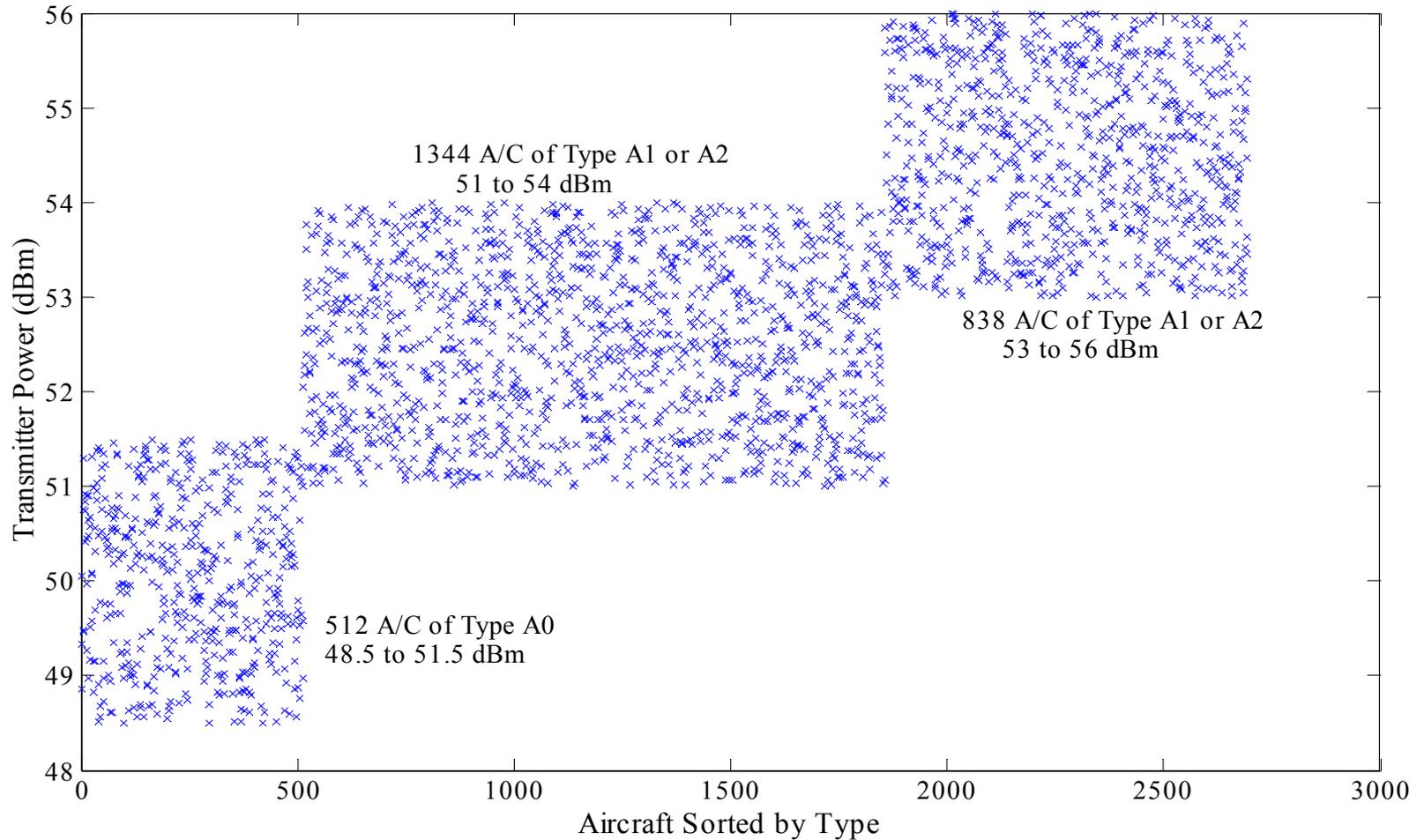
Performance in 36k Fruit Environment – Simulation and FAATC Data



Enhanced Decoder Performance Model Summary

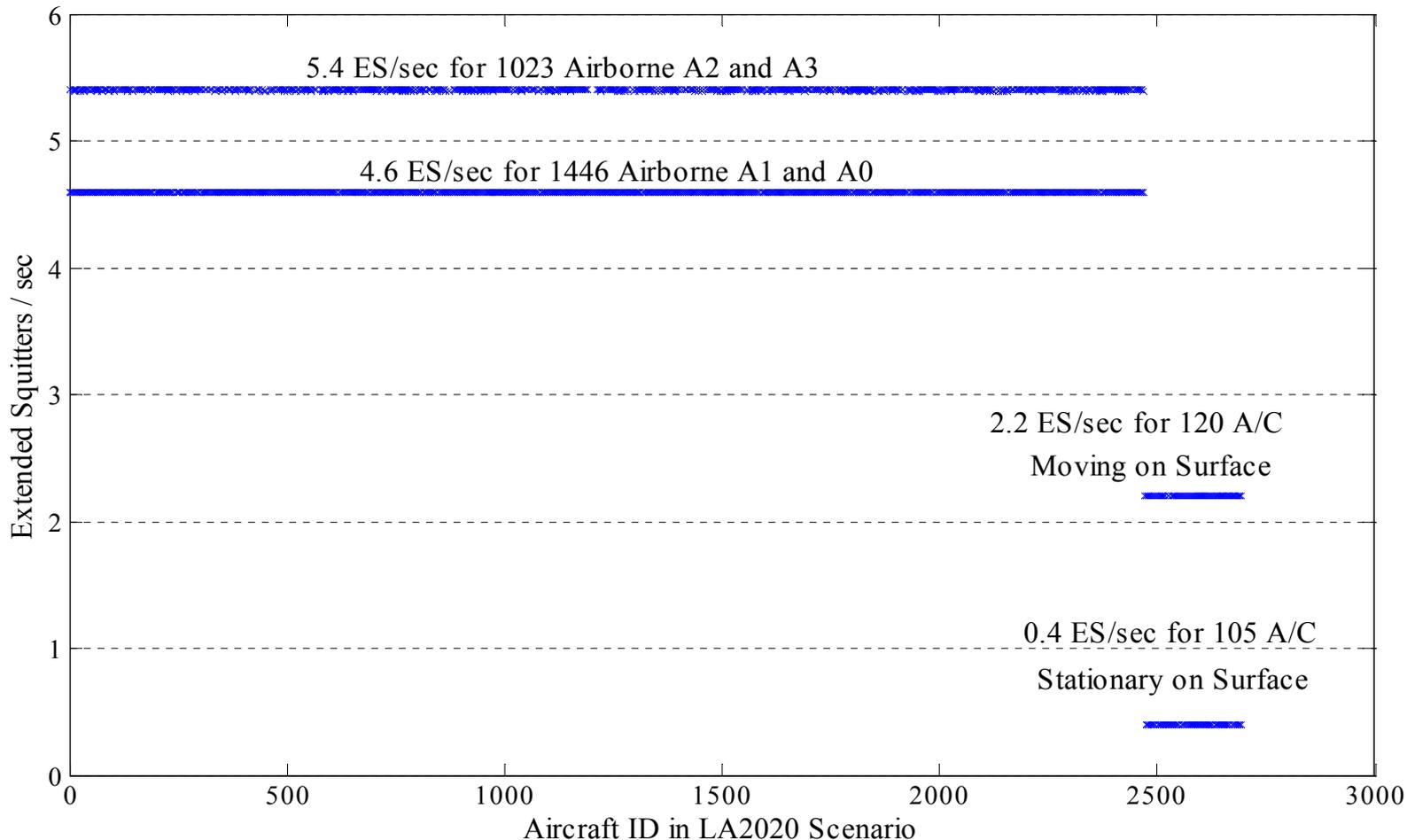
- Have “mapped” receiver performance model to FAATC results for ATCRBS (other techniques possible)
- Mode S/Extended Squitter interference performance left unchanged
- Valid only for high ATCRBS environment
- Yet to do:
 - ◆ Validate receiver performance model against FAATC results for combined interference
 - ◆ Perform same comparisons/adjustments to match LL results

Transmitter Power

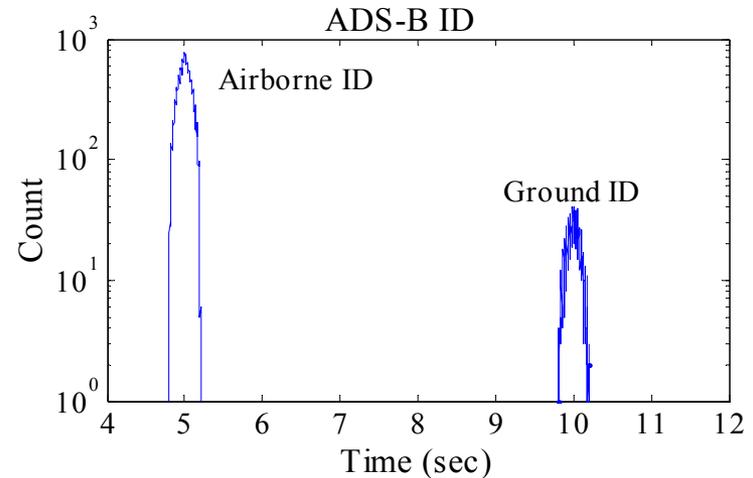
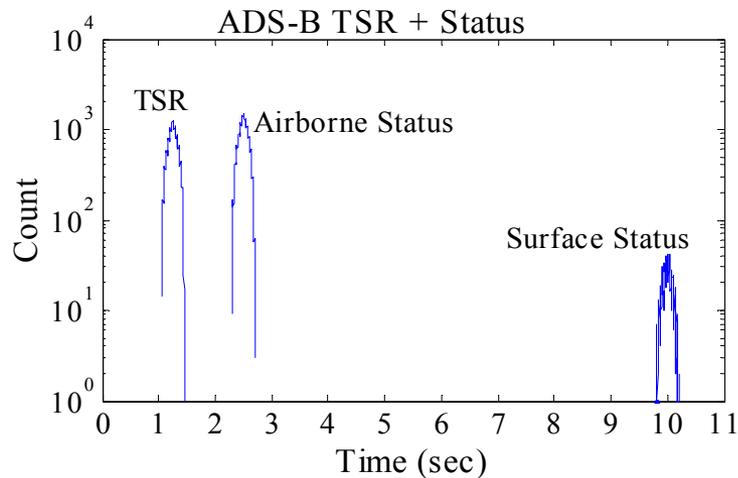
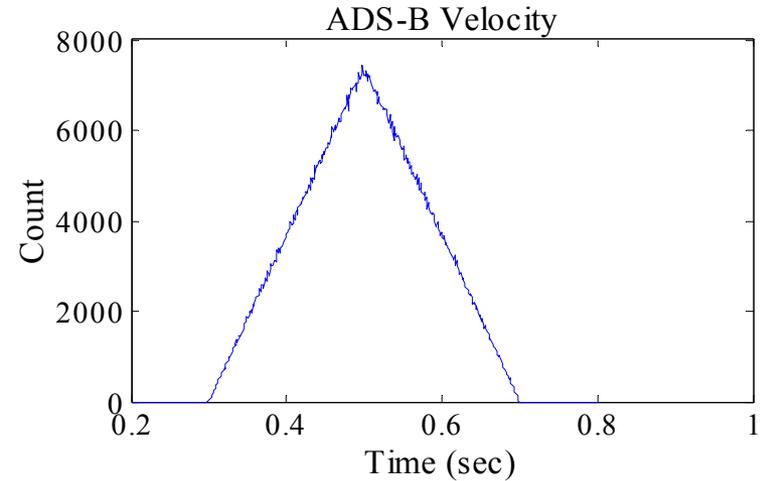
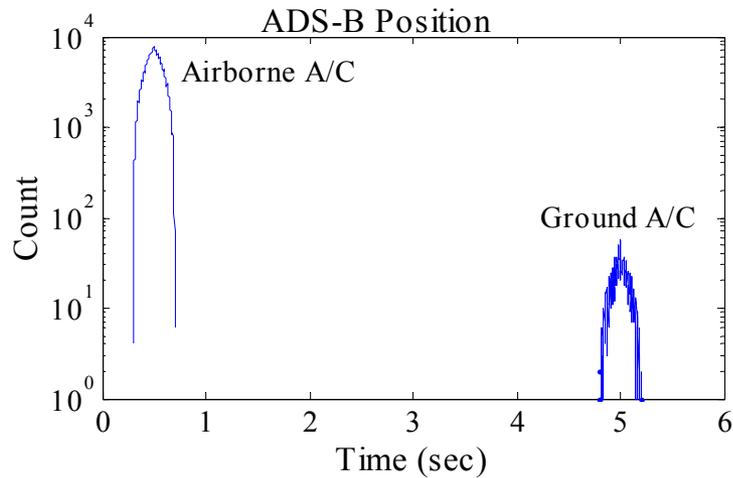


LA 2020 Scenario #1

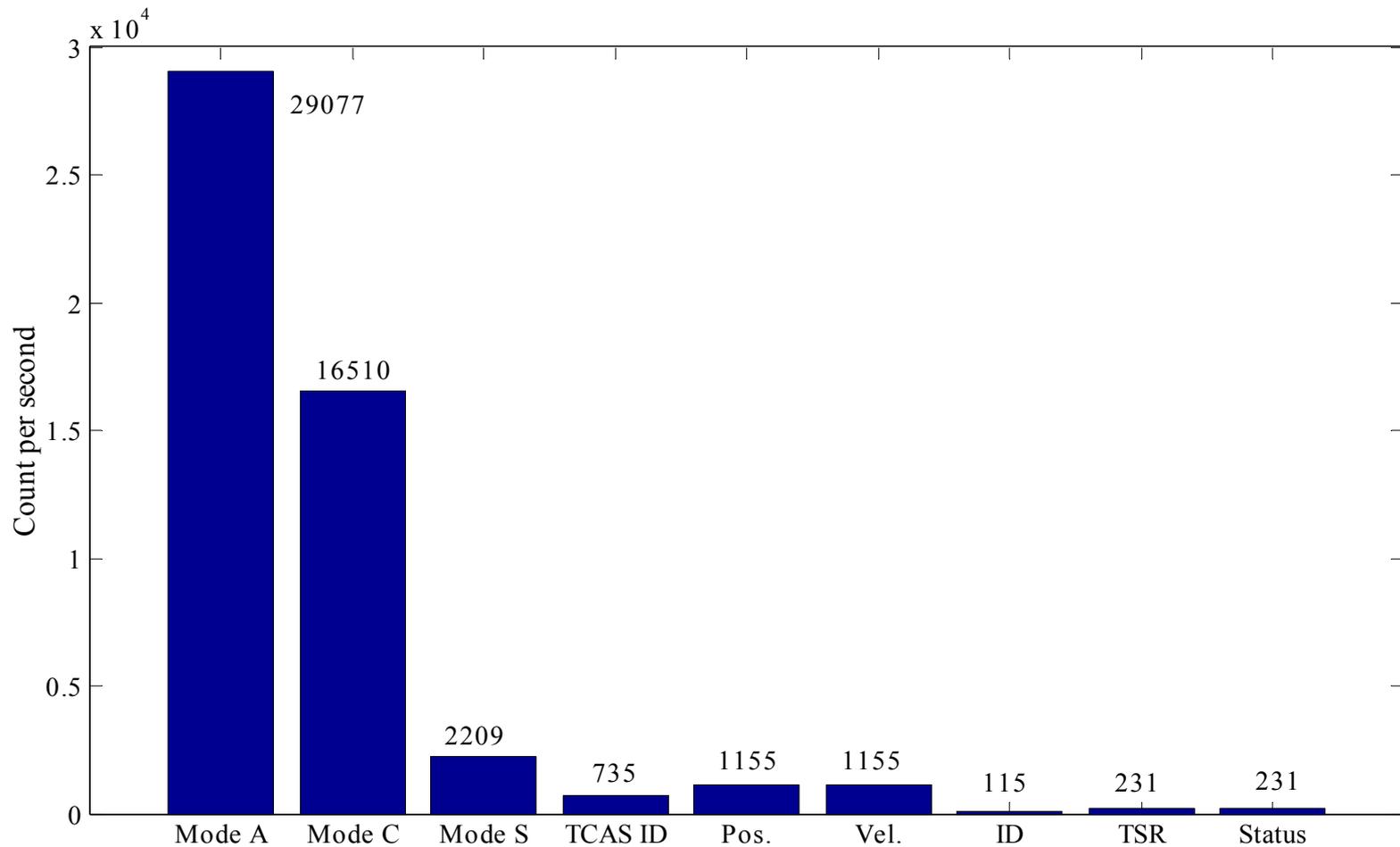
Extended Squitter Transmission Rates



Interval Between Successive ADS-B Messages

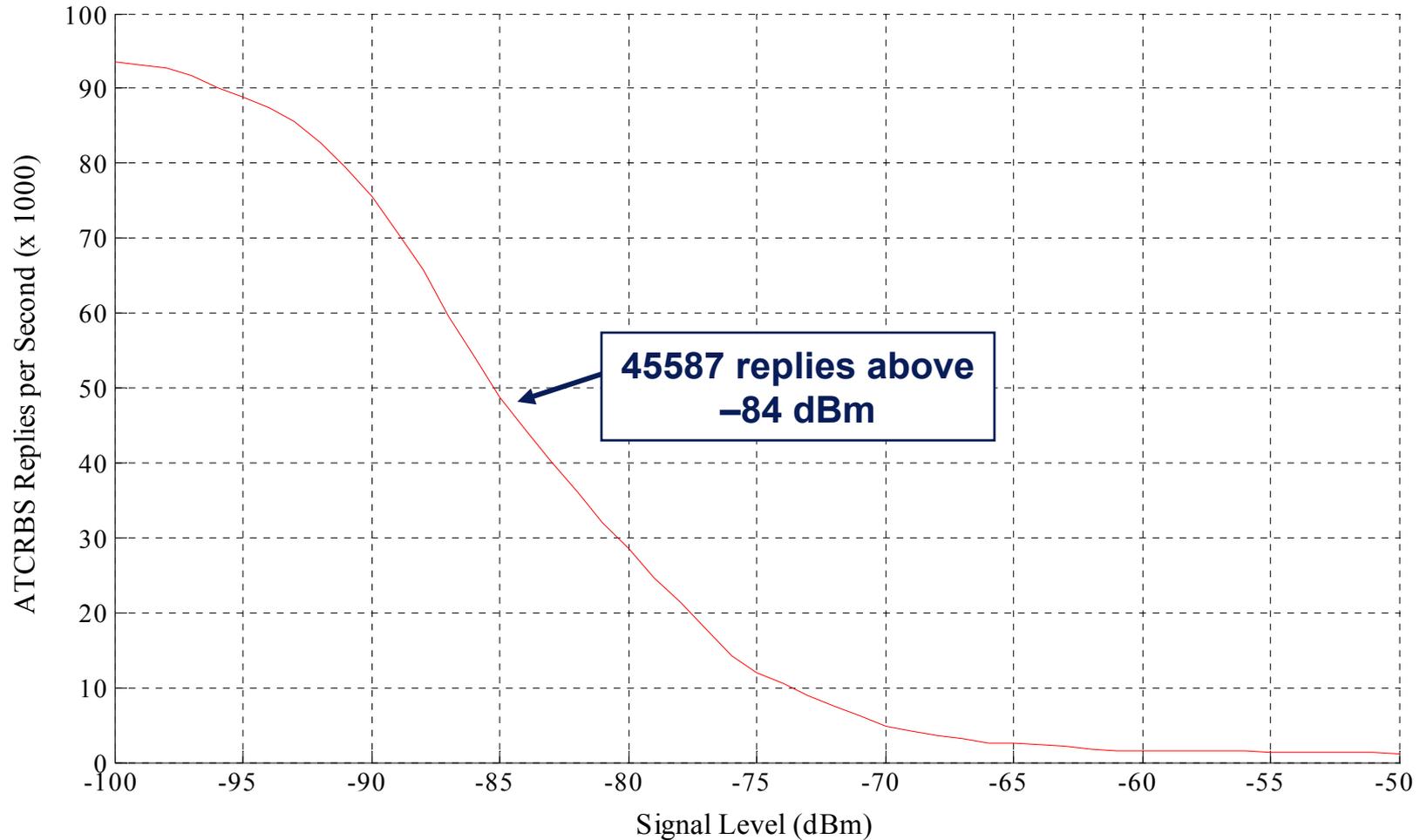


Received Messages per Second (> -84 dBm)

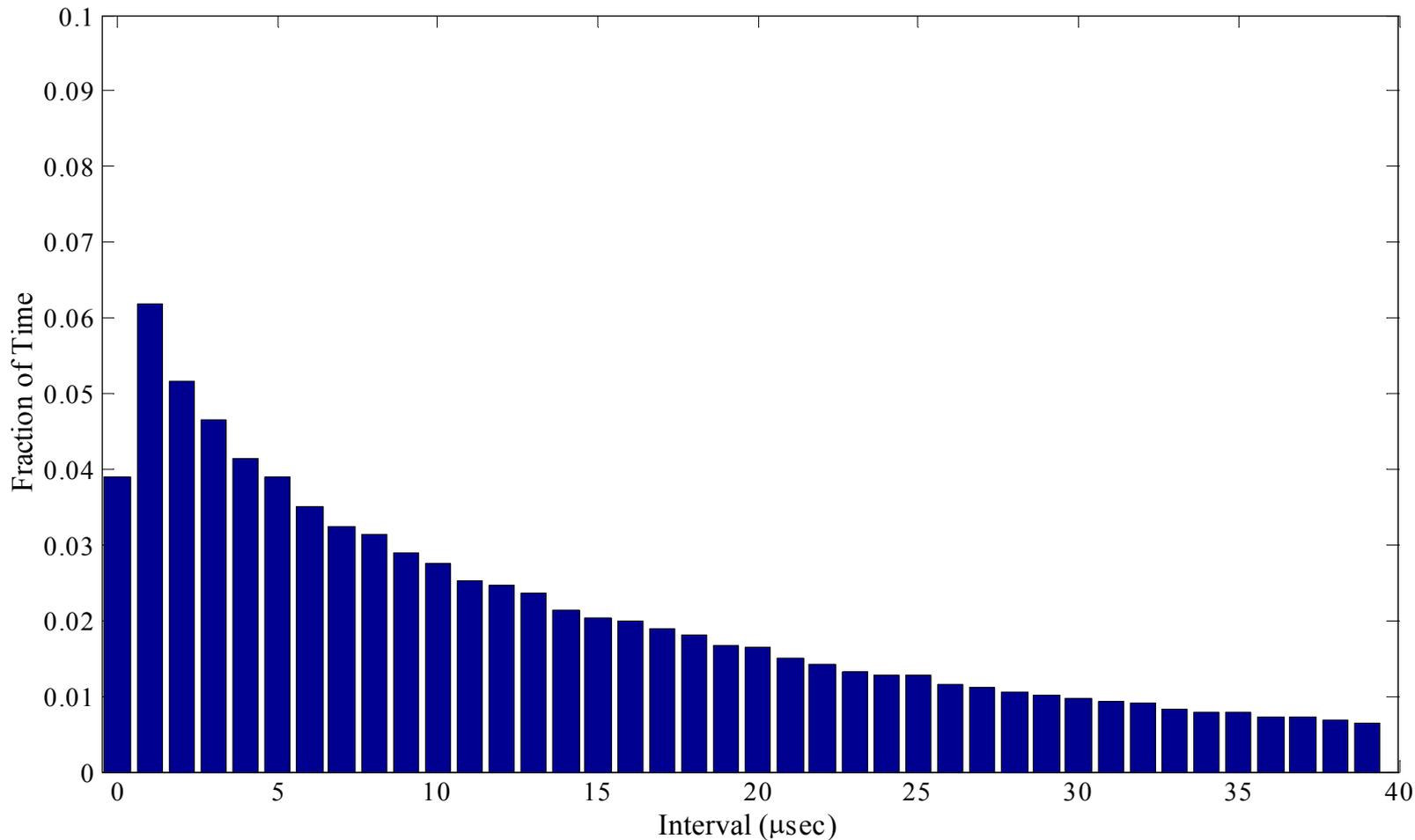


LA2020 Scenario #1

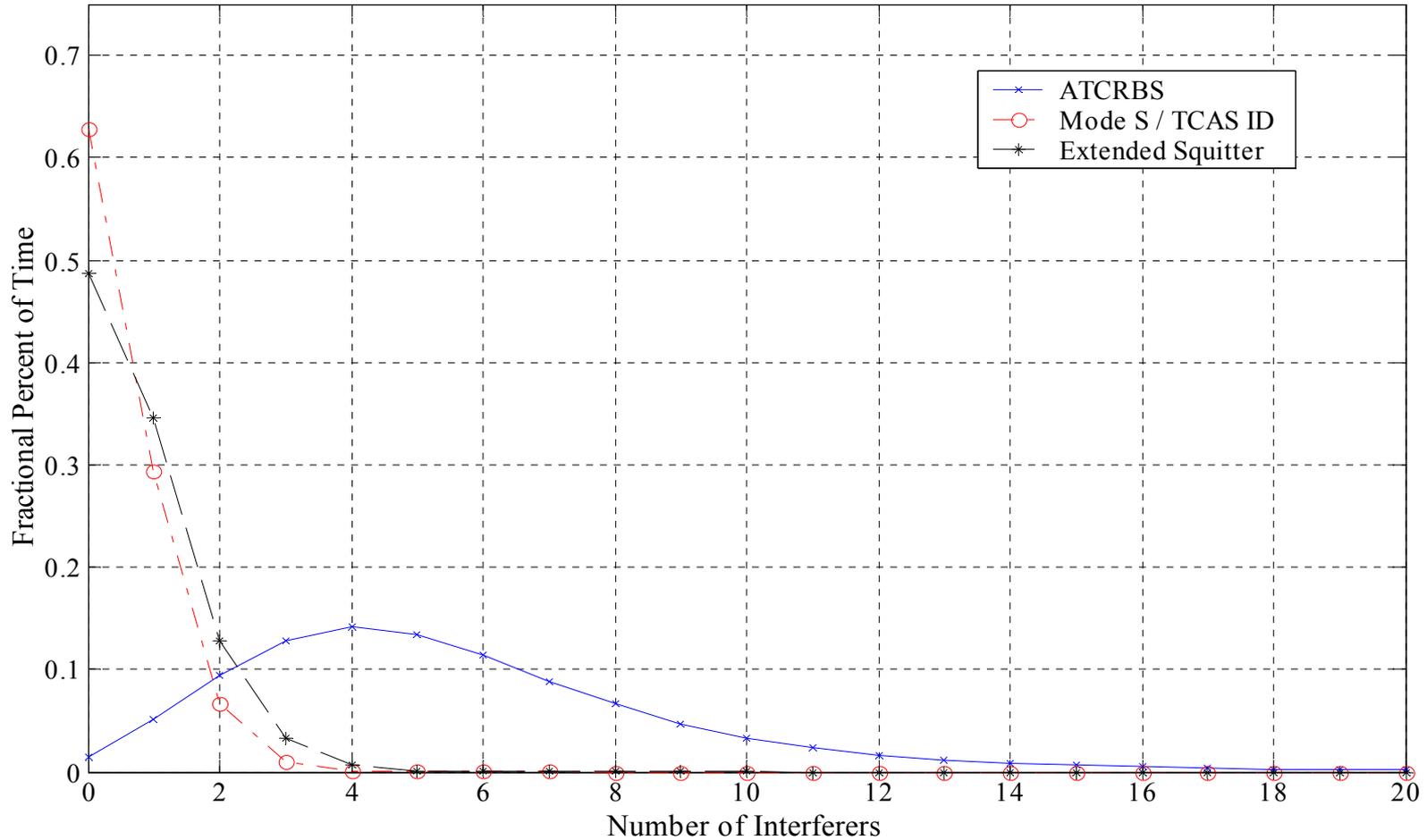
ATCRBS Replies per Second



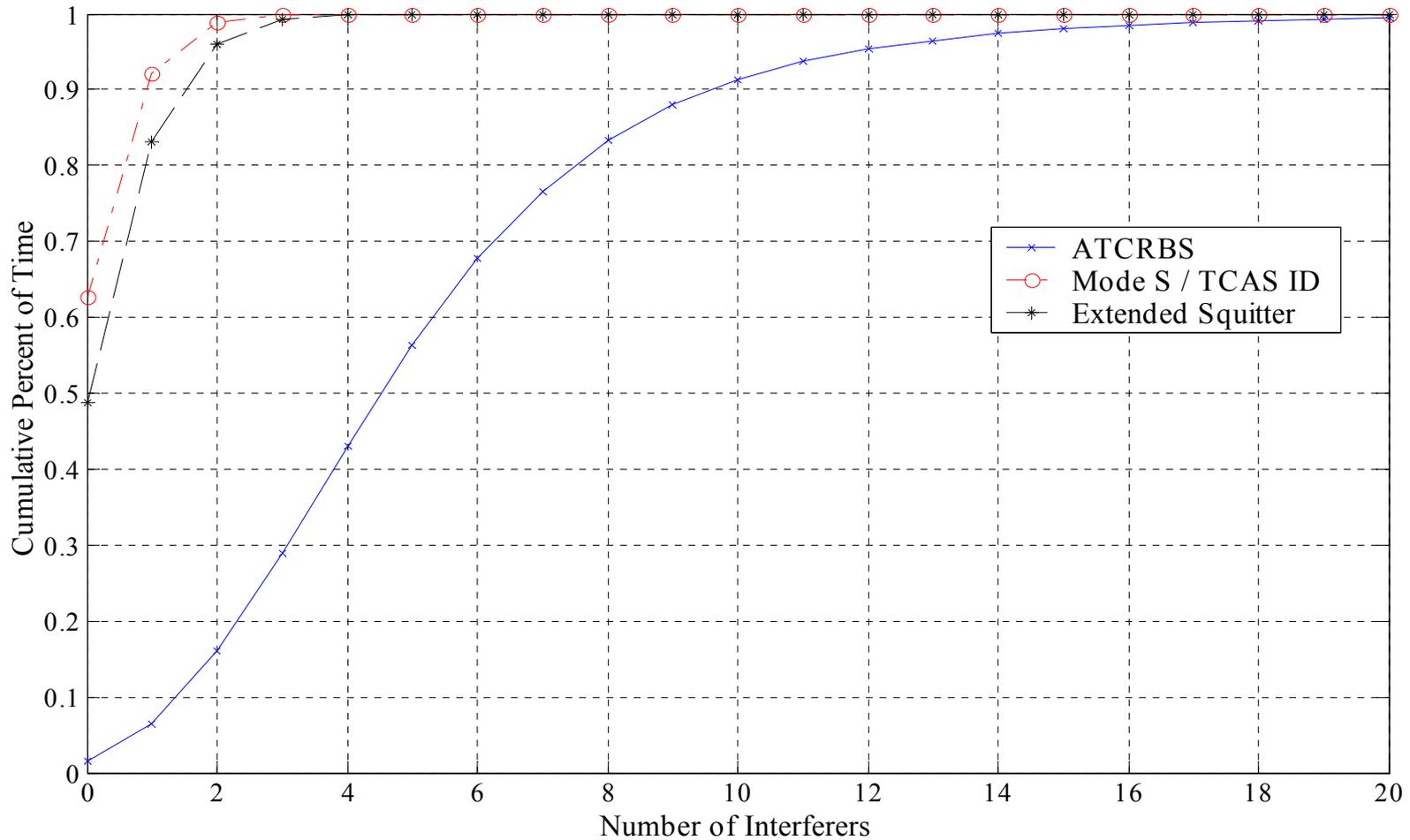
Interval Between Successive ATCRBS Messages (> -84 dBm)



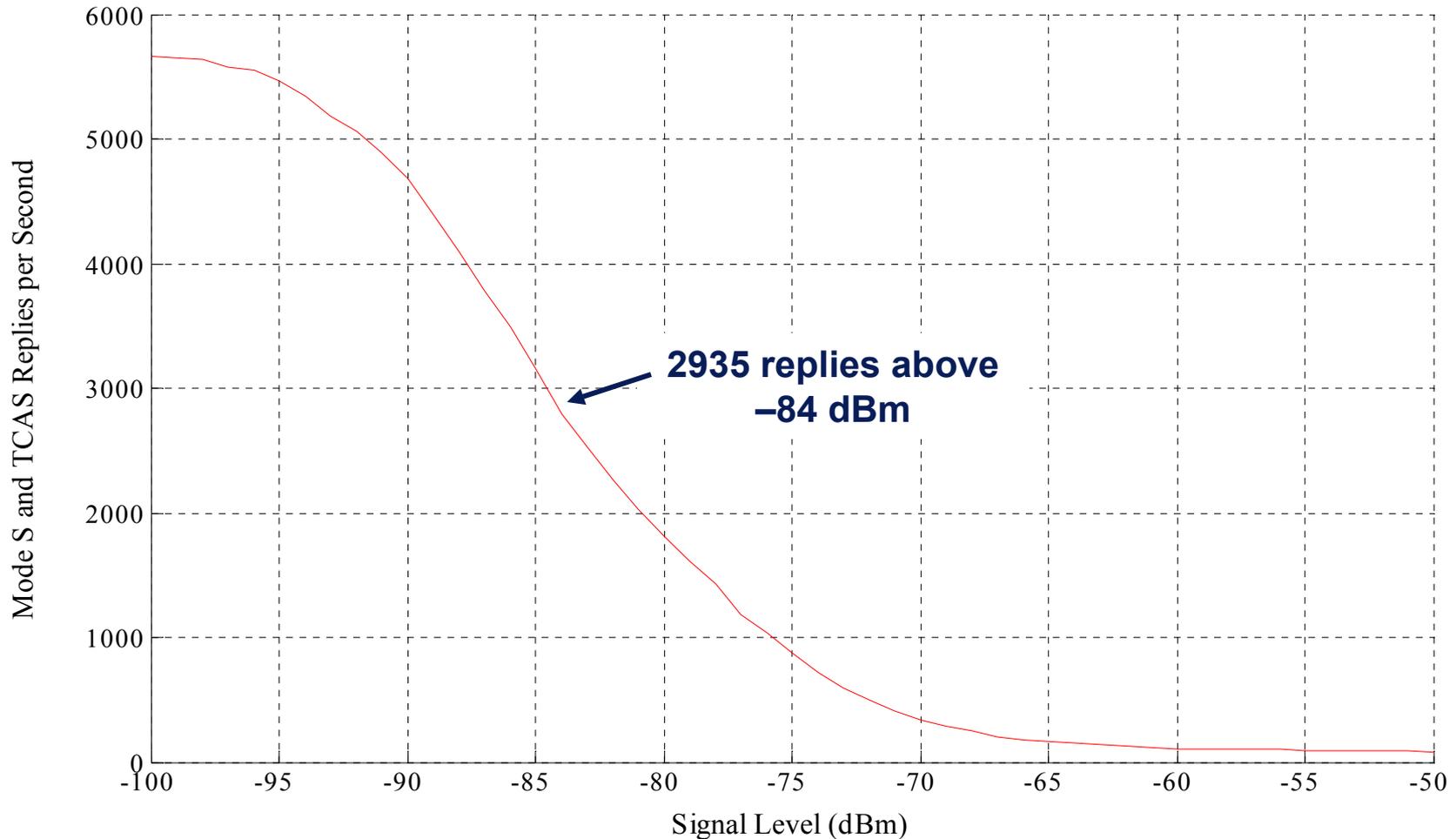
Number of Interferers by Message Type



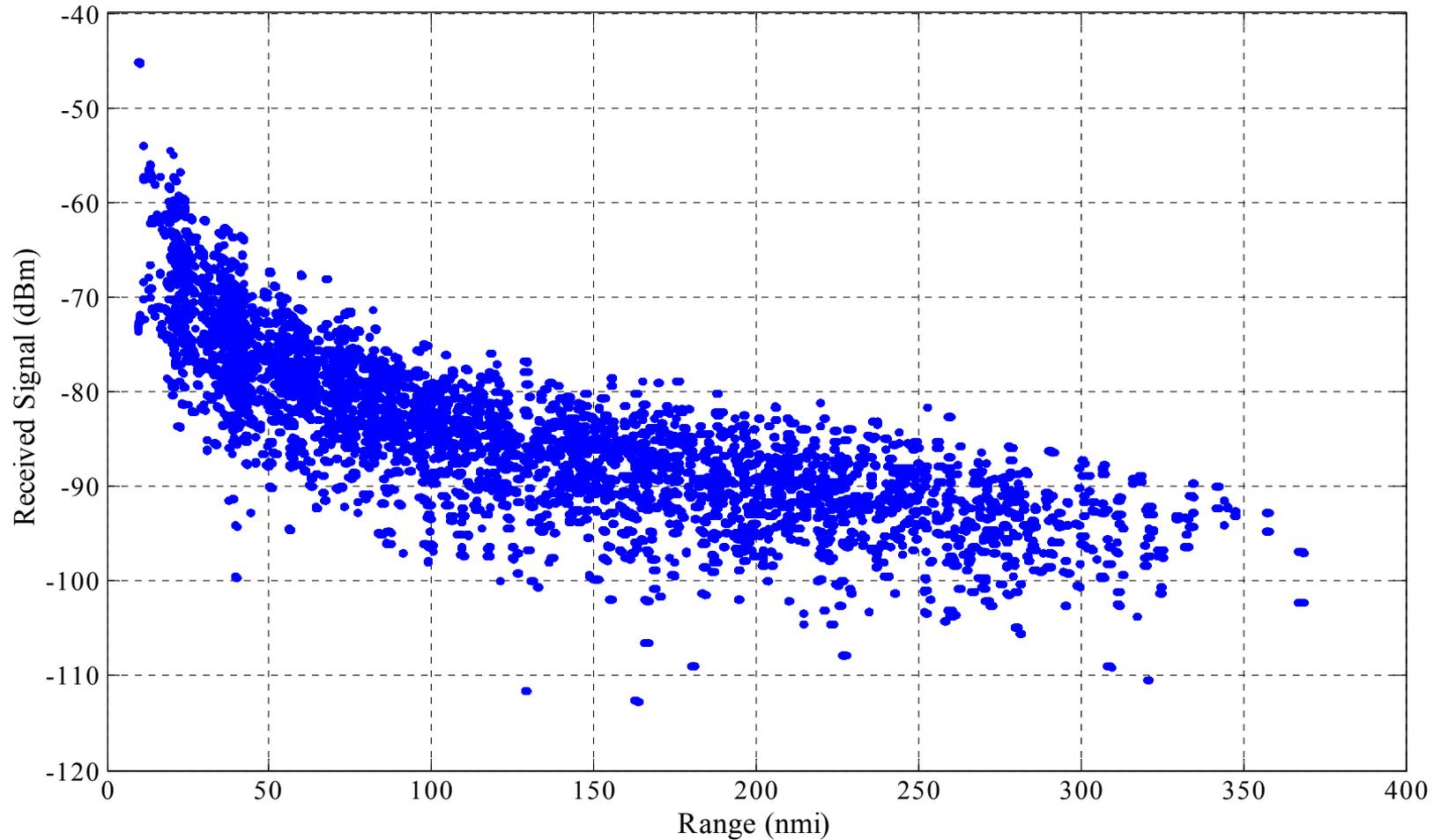
Received Interference CDF by Type



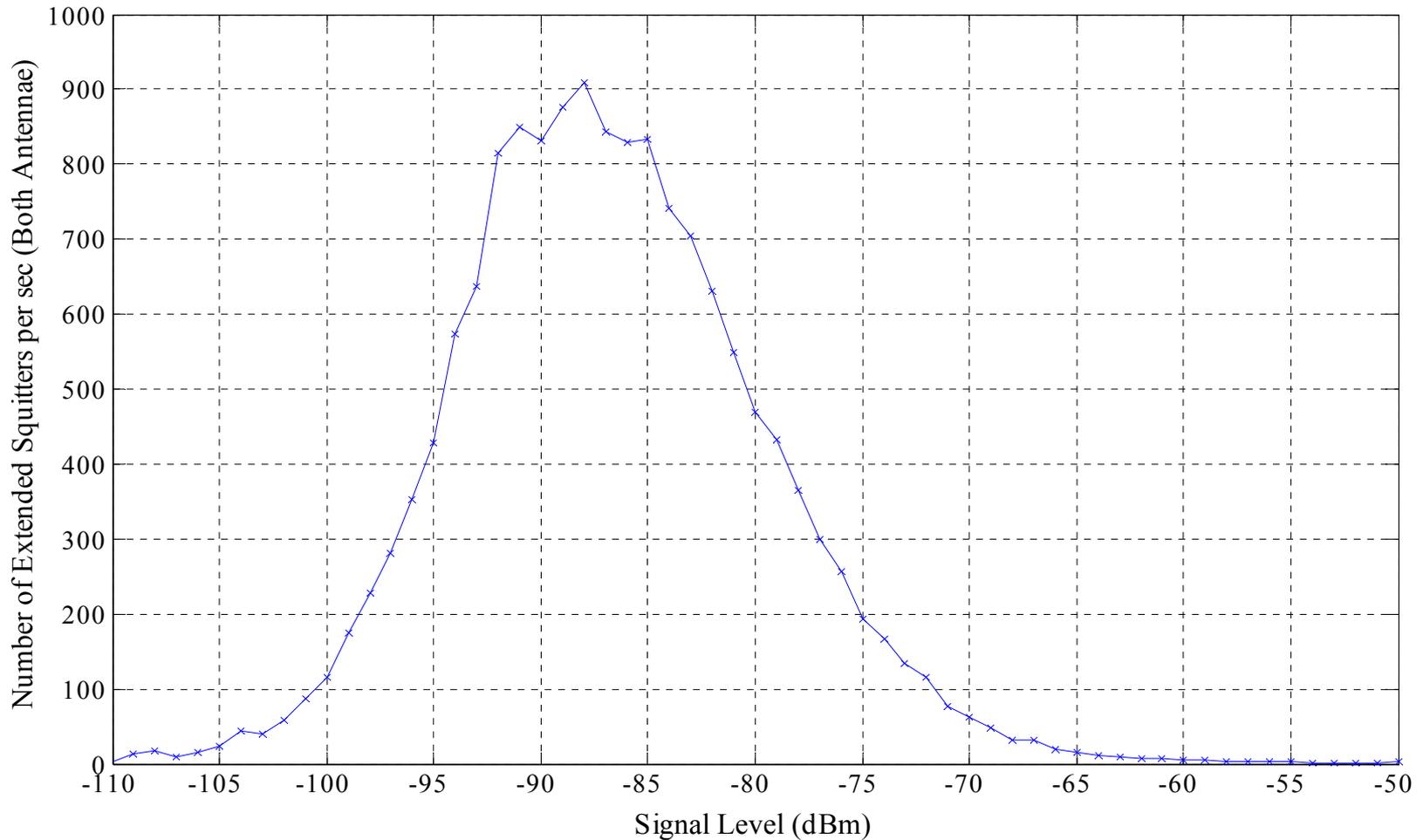
Mode S and TCAS ID Replies Per Second



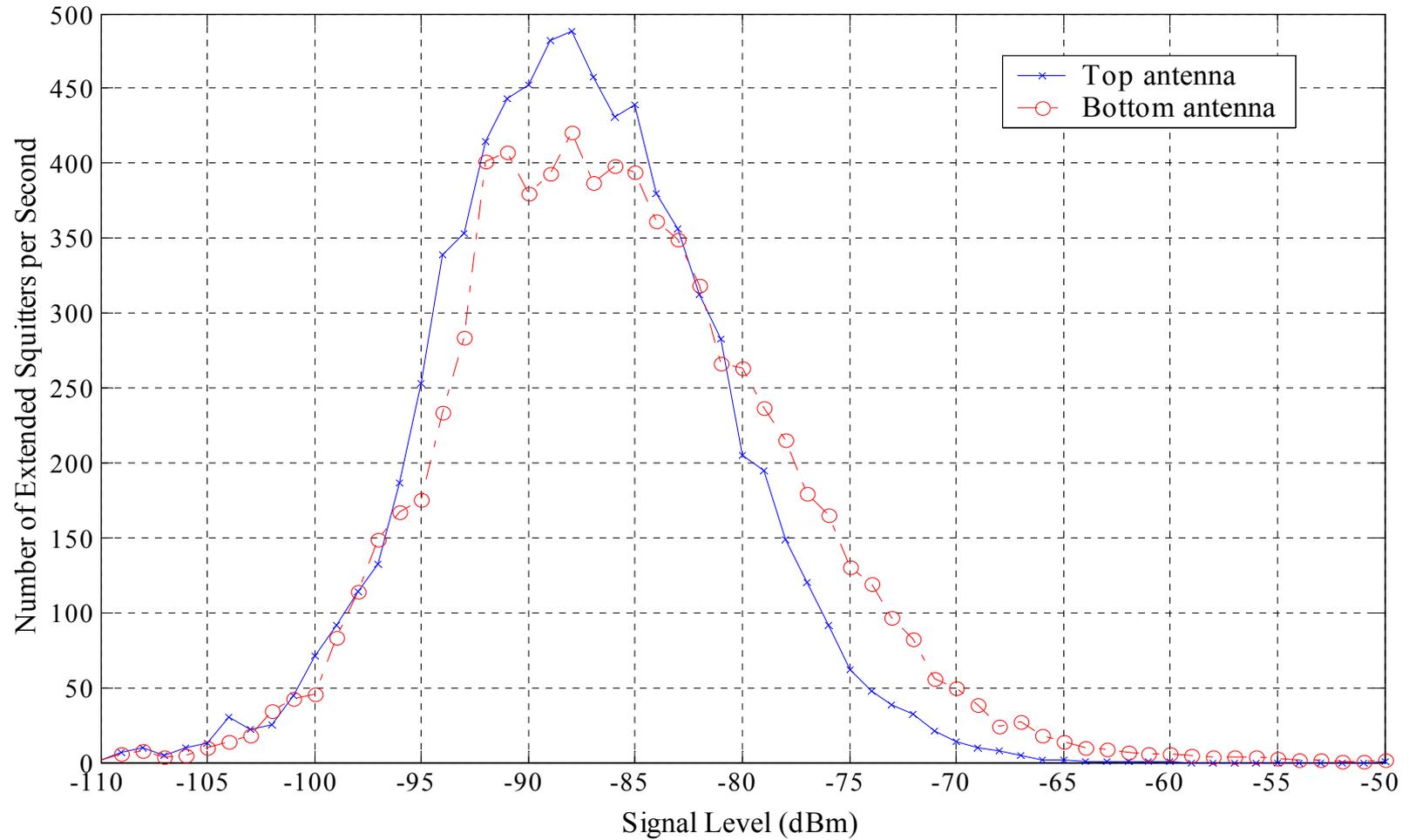
Signal Level vs. Range



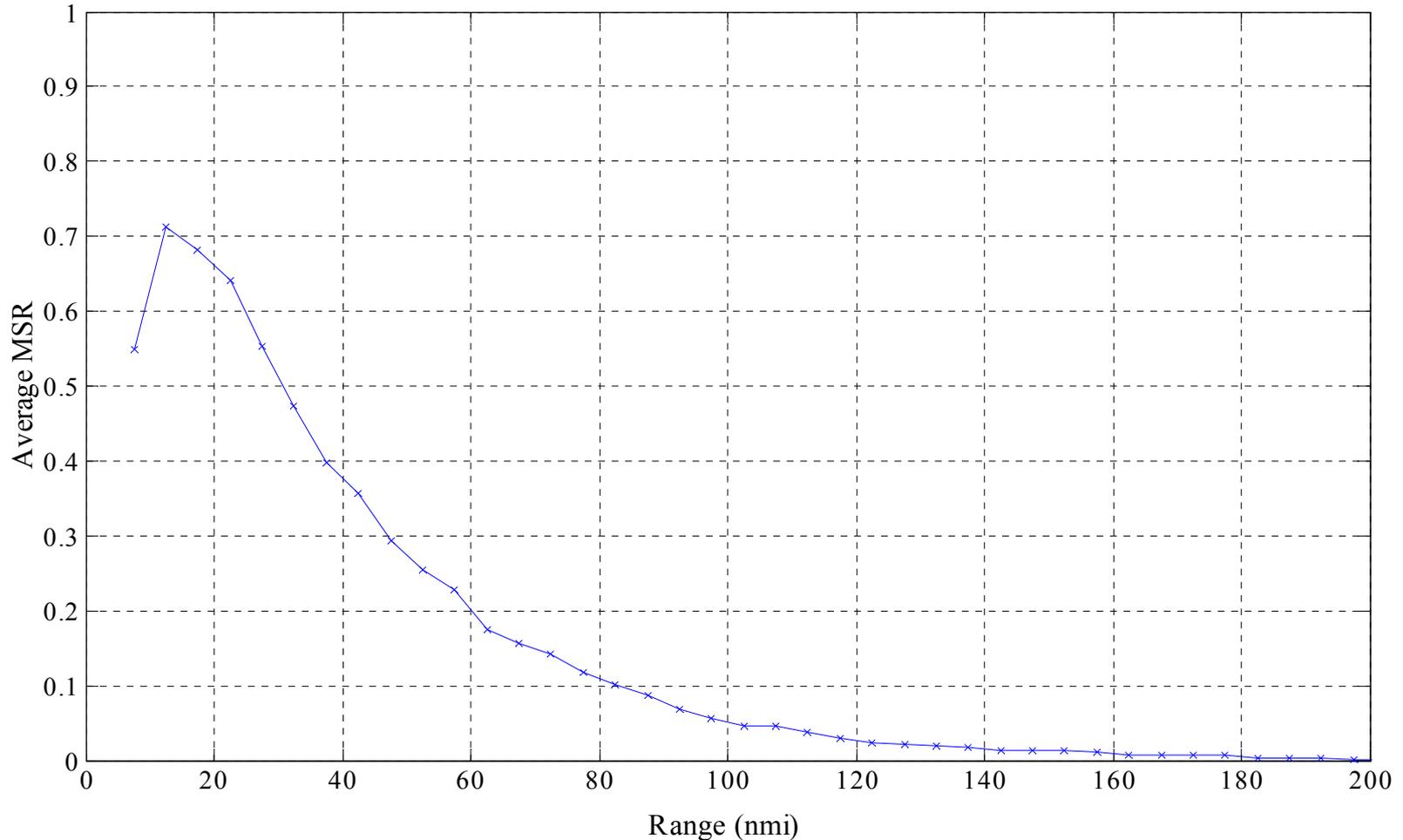
Received Signal Levels (at antennas)



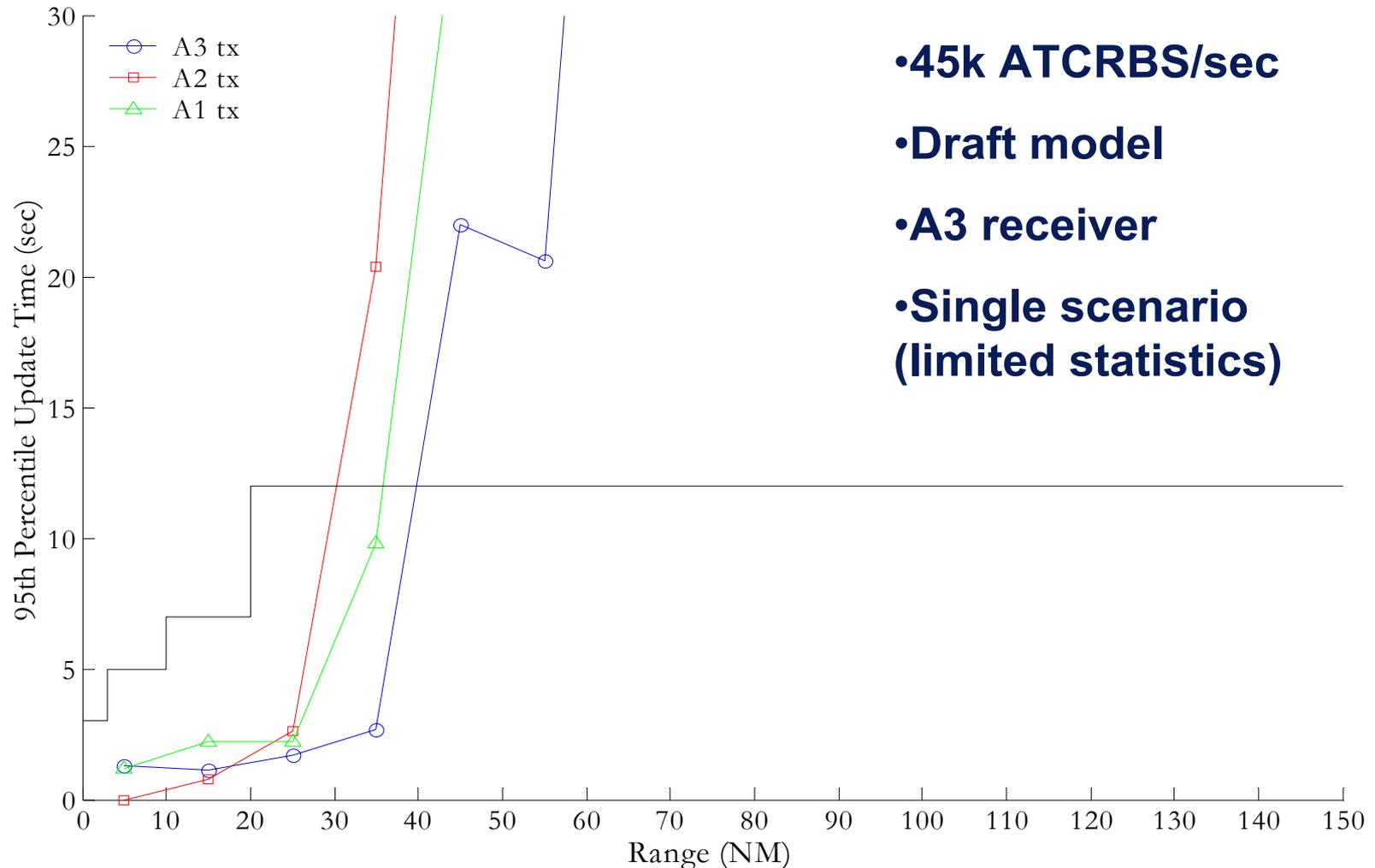
Received Signal Levels by Antenna



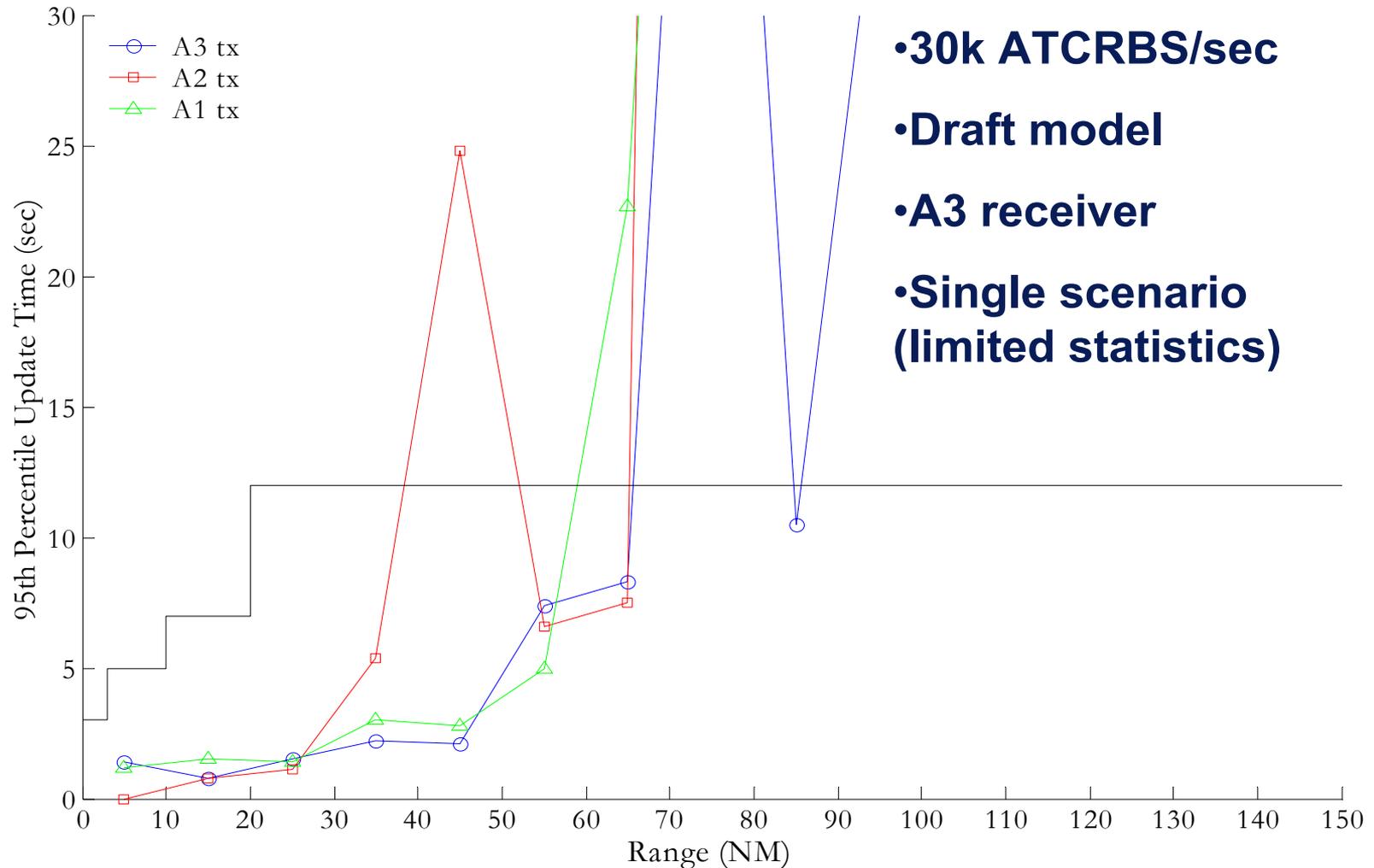
Average Extended Squitter MSR vs. Range (before mapping)



95th Percentile Update Times for Mapped MER Model



95th Percentile Update Times for LA2020 30k Fruit Environment



1090 Performance Summary

- Defined scenario assumptions/parameters
- Currently validating/refining enhanced decoder performance model
- Generated first-look results for LAX 2020 scenarios