GPS-ABC Workshop
Wired (Conducted) Test Results

GPS-ABC Workshop V

RTCA Washington, DC

October 14, 2016

Karl Shallberg, Zeta Associates Inc.

Volpe The National Transportation Systems Center

Advancing transportation innovation for the public good

U.S. Department of Transportation
Office of the Secretary of Transportation
John A. Volpe National Transportation Systems Center

Overview

- Tests executed week of 25 July with 14 GNSS receivers
  - Representative set of equipment from chamber testing from each receiver category (except space)
  - Receivers tested were USG provided
- Same test instrumentation for wired as with radiated tests
  - GNSS playback (MITRE)
  - Interference system with modifications to support OOBE and acquisition test requirements
- Presentation focuses on L1 C/A test observations

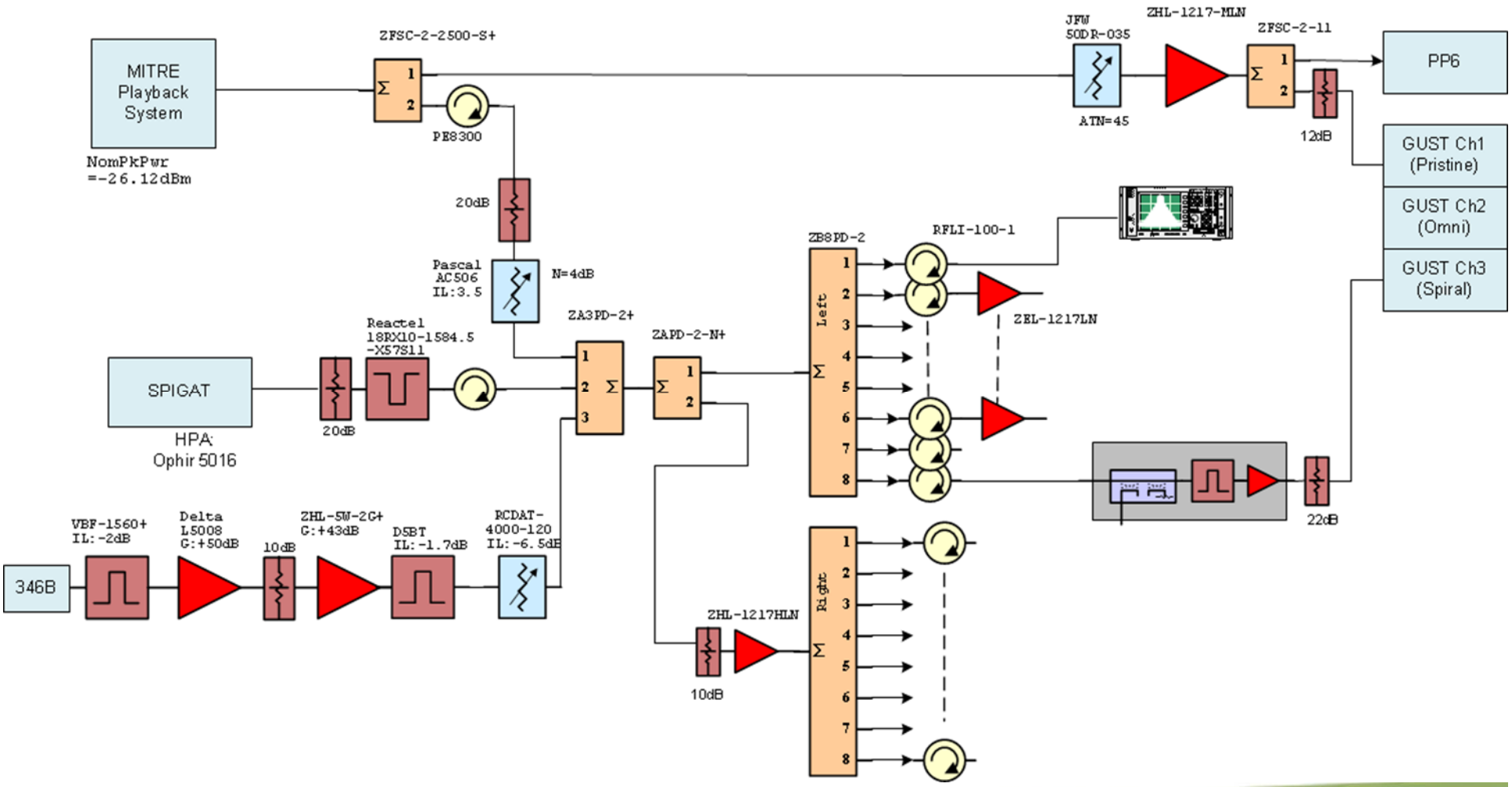
Wired Test Objectives

- Receiver/antenna comparison with chamber results
- OOBE interference at prescribed and proposed levels w/LTE uplink and downlink signals
- GNSS signal acquisition characterizations

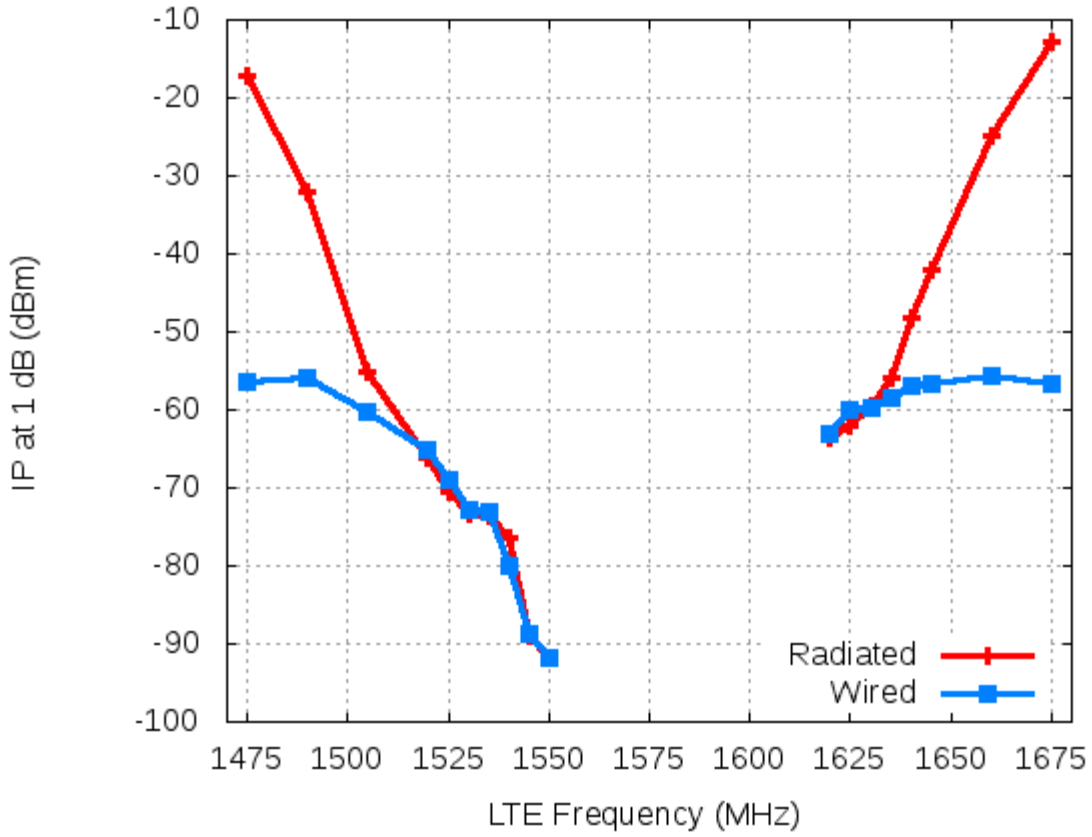
Test Execution Notes

- Type 2 (10 MHz LTE) and Type 1 (1 MHz Bandpass Noise) tests executed per ABC test plan
  - Repeat of chamber tests
- OOBE levels included in RNSS band and executed with adjacent-band LTE signals
  - FCC limit of -70 dBW/MHz
  - Proposed limits of -100 (base stations) and -105 (handsets) dBW/MHz
- GNSS signal acquisition execution described in later slides

Wired Test Configuration

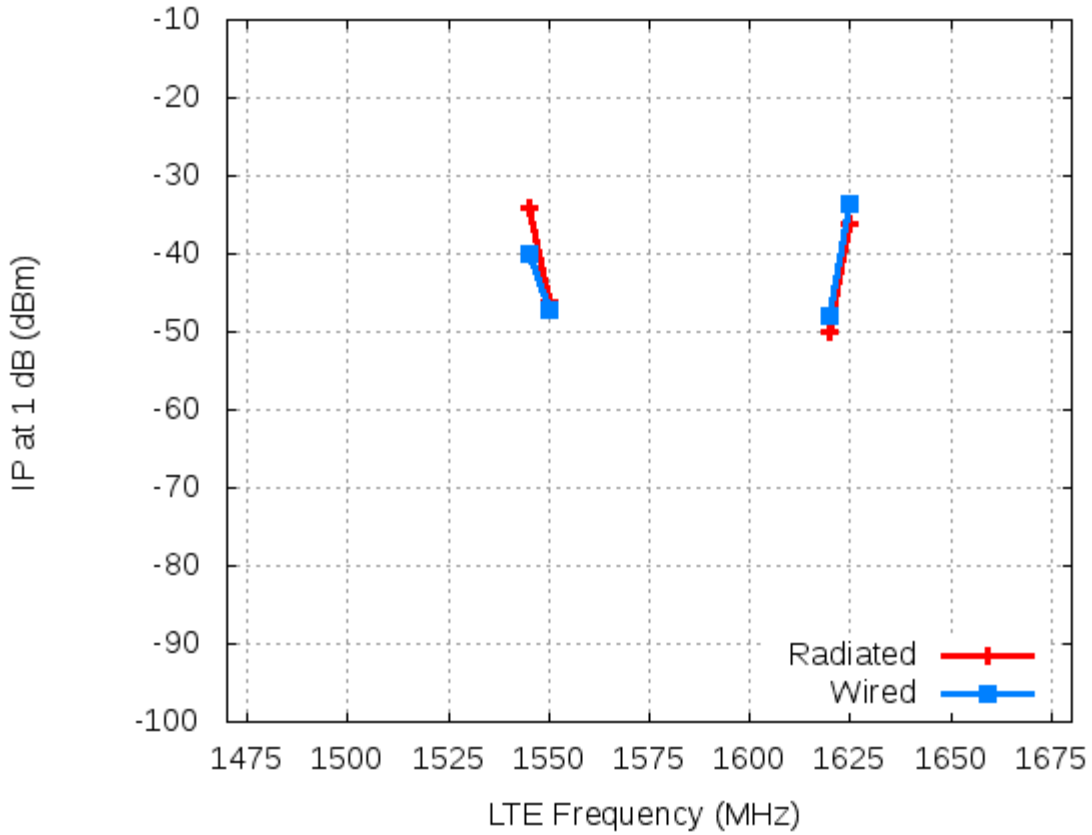


DUT A



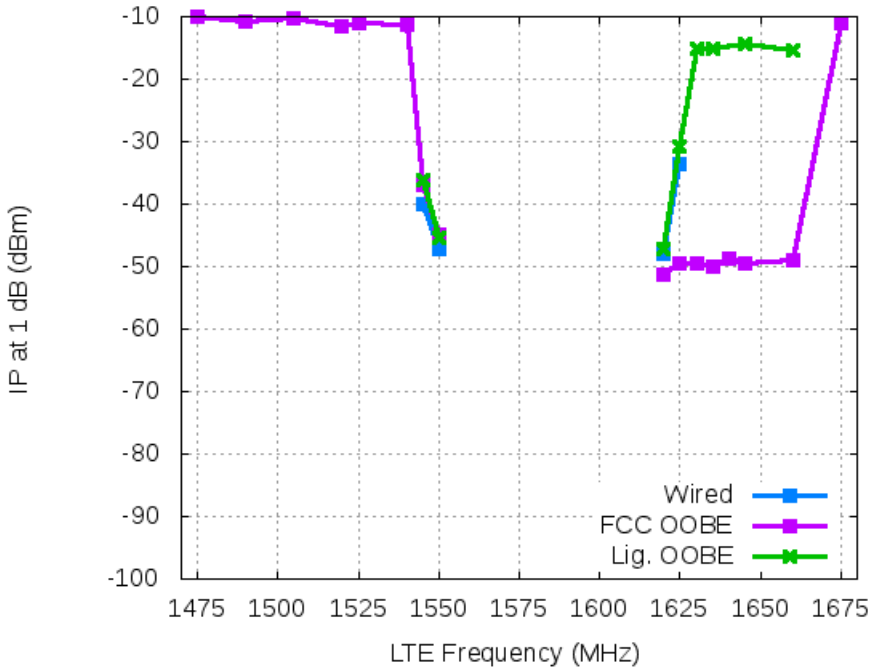
Antenna not characterized but filtering evident in comparison of radiated and wired 1 dB ITM's

DUT B

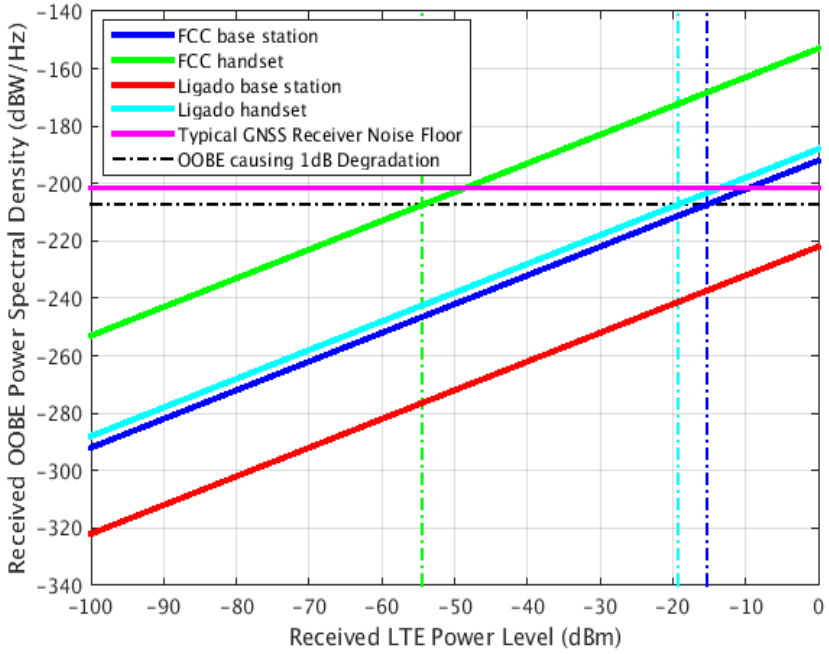


Radiated and wired 1 dB ITM's in good agreement consistent with expectations since both tests used device filter/LNA

DUT B OOBE Results

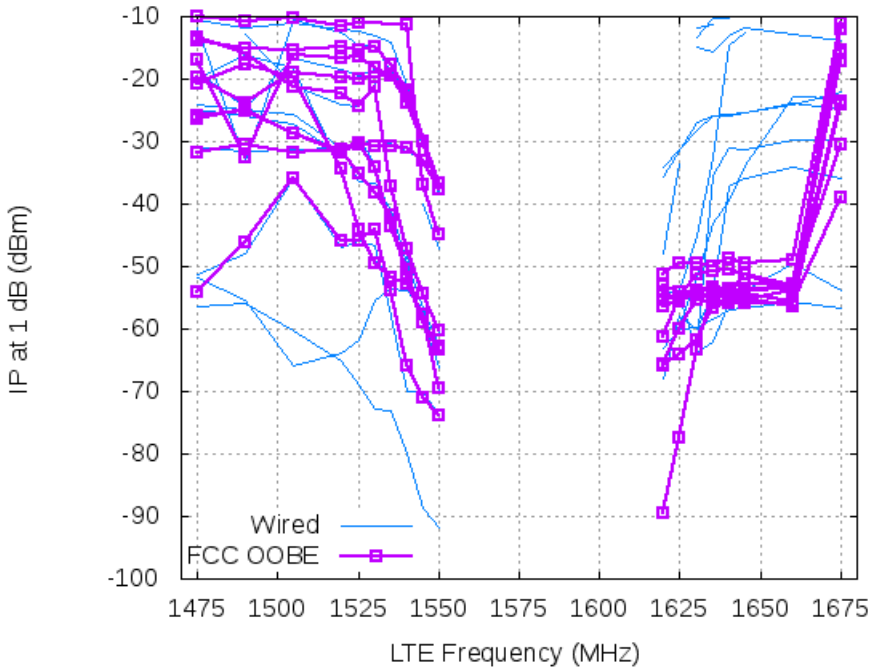


Example of OOBE effects from wired testing. Degradation levels consistent with predicted 1 dB ITM's

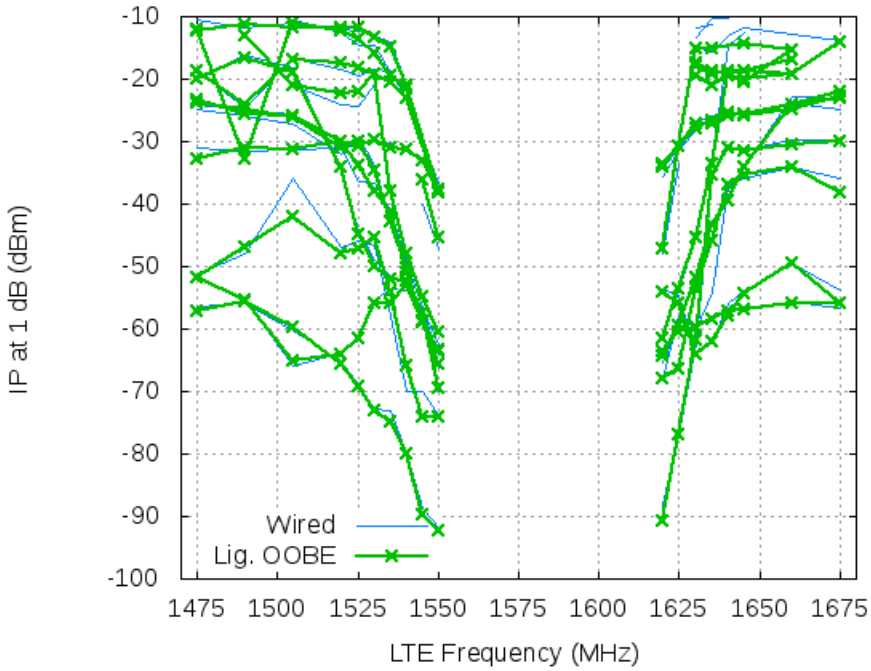


Predicted 1 dB ITM's predicted assuming receiver noise floor of -201.5 dBW/Hz

Wired Baseline vs. OOBE Results



FCC OOBE Levels

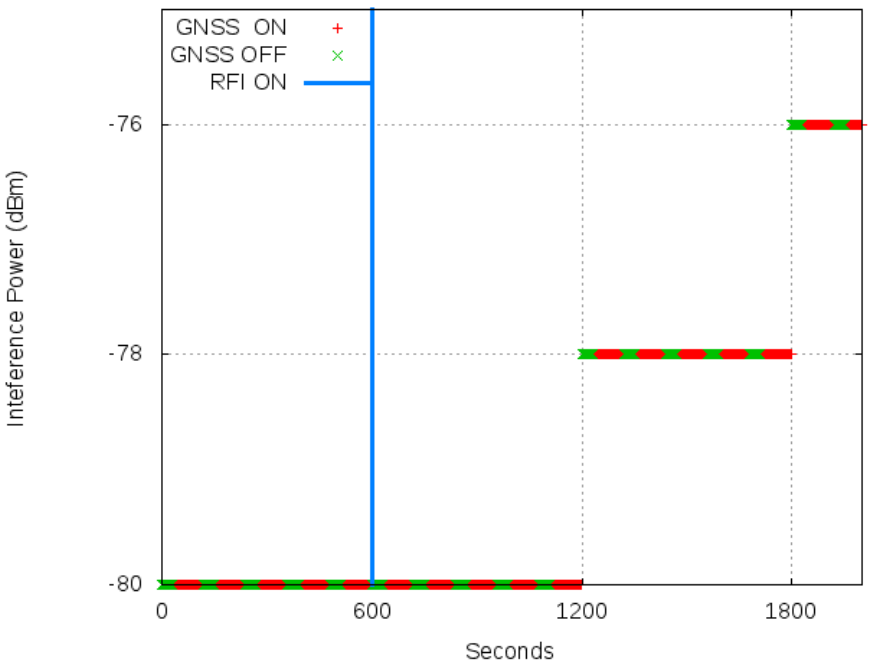


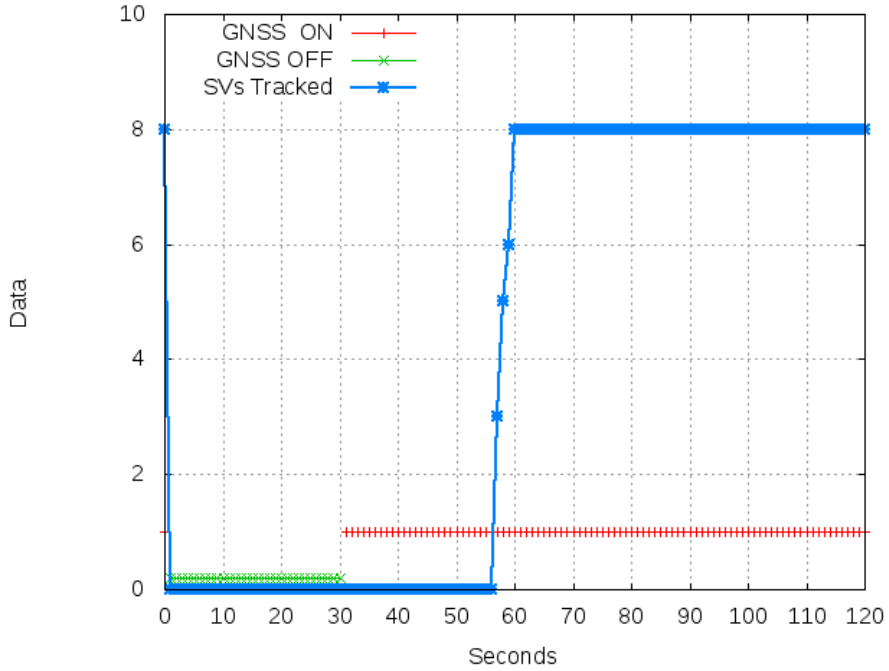
Proposed OOBE Levels

Acquisition Testing

- Signal acquisition tests executed at four adjacent frequencies using Type 2 (10 MHz LTE) signals
  - Test frequencies were 1525, 1550, 1620 and 1645 MHz
- Average satellite acquisition times computed for satellites at specified minimums (e.g. -128.5 dBm for L1 C/A) and for one satellite emulating low elevation conditions
  - Low elevation satellite (PRN-24) was 10 dB lower than minimums
- Acquisition results compared with interference power (IP) causing 1 dB C/No degradation (IP @ 1 dB) estimated from wired tests for L1 C/A signal

Acquisition Test Sequence/Processing

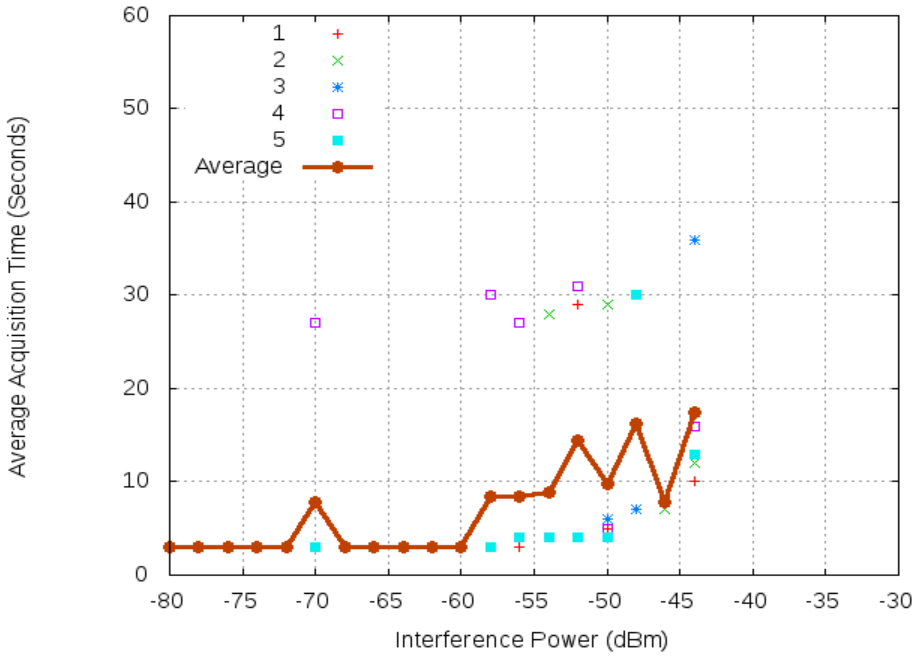




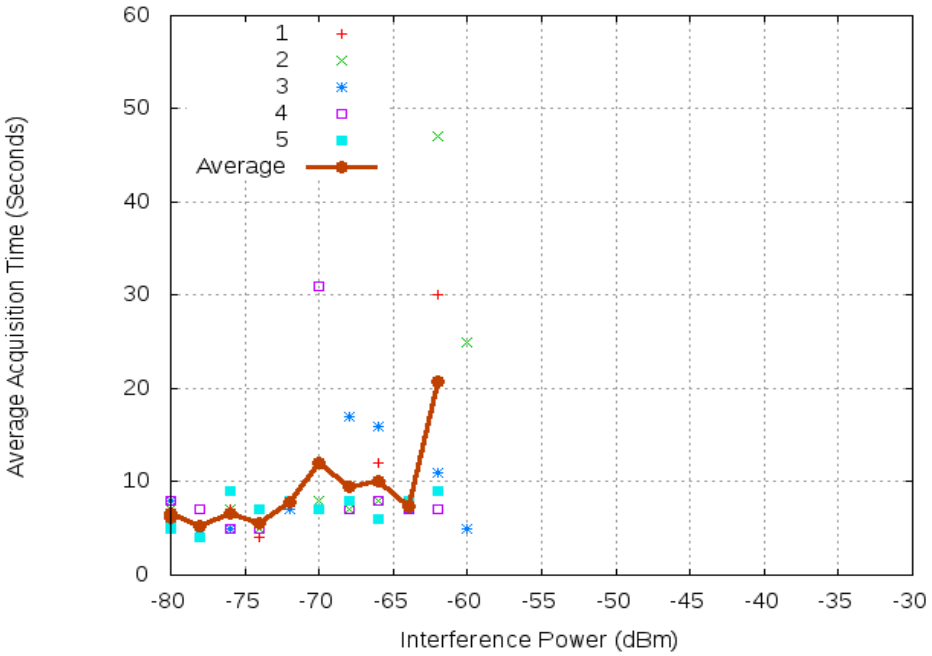
Signal acquisition was observed by removing GNSS signals every 90 seconds for a duration of 30 seconds. Interference power was increased in 2 dB steps after five iterations. Power tested from -80 to -30 dBm for 1550/ 1620 MHz and -60 to -10 dBm for 1525/1645 MHz.

"Acquisition time" for nominal signals was defined as the duration from GNSS signal reintroduction to four or more SVs being tracked. Time for example above is 28 seconds.

Examples of Acq. Time Variation over 5 Iterations at each Power Level

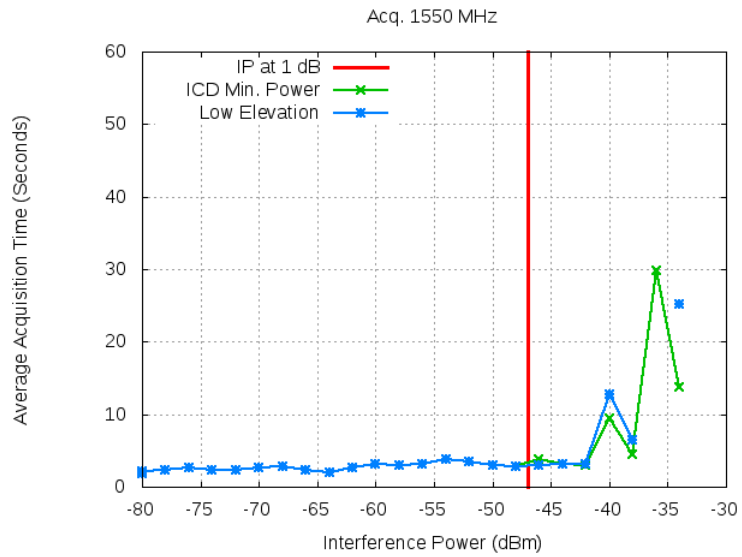


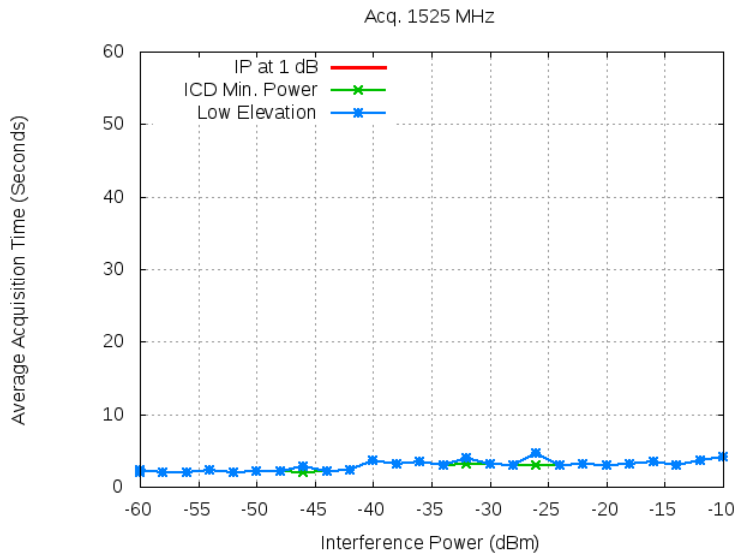
ICD Min. Power

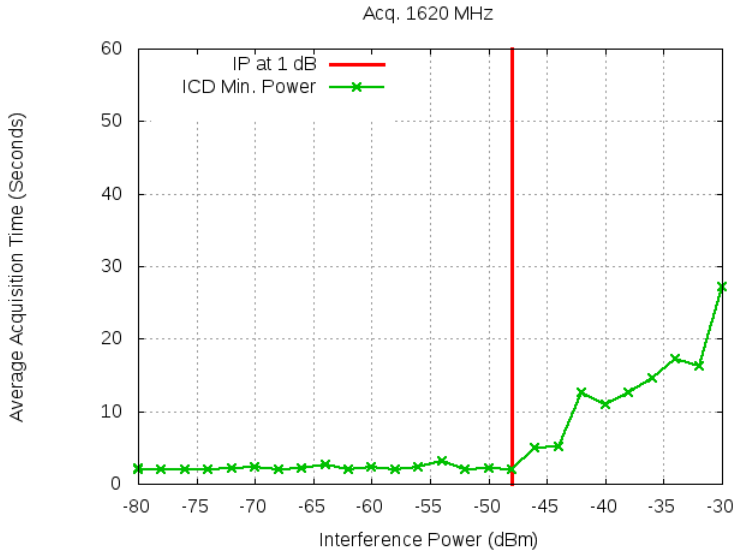


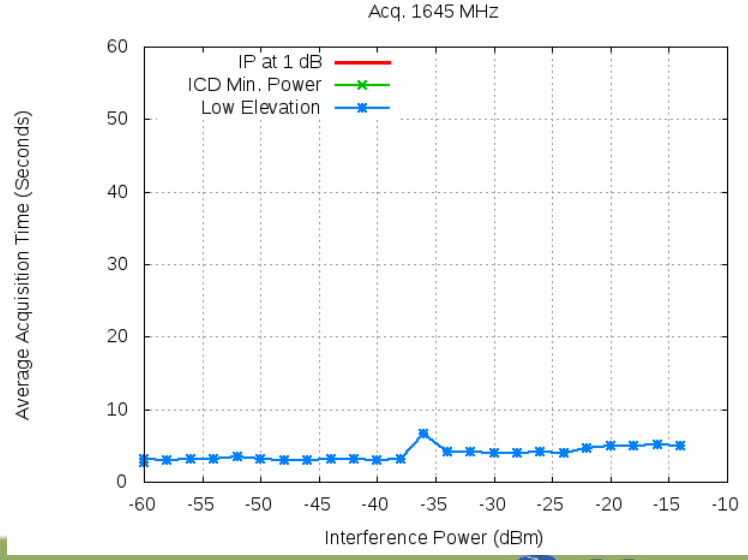
Low Elevation

DUT B

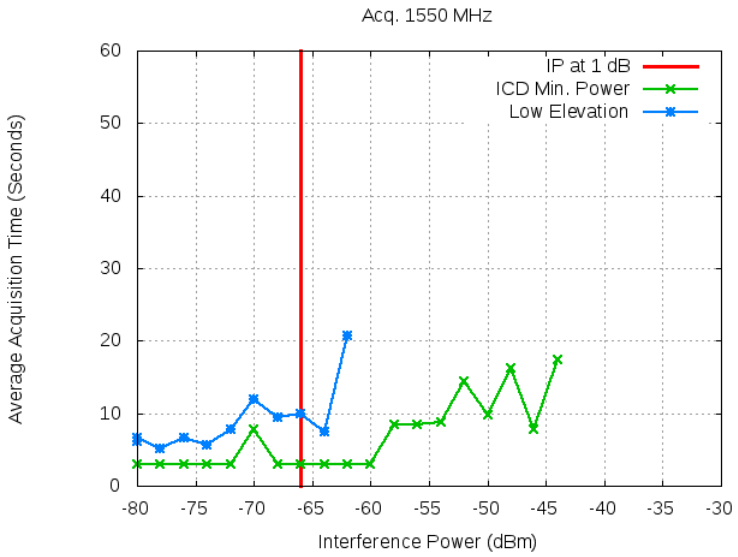

Acq. 1550 MHz
IP at 1 dB
ICD Min. Power
Low Elevation
Average Acquisition Time (Seconds)
Interference Power (dBm)
60
50
40
30
20
10
0
-80 -75 -70 -65 -60 -55 -50 -45 -40 -35 -30

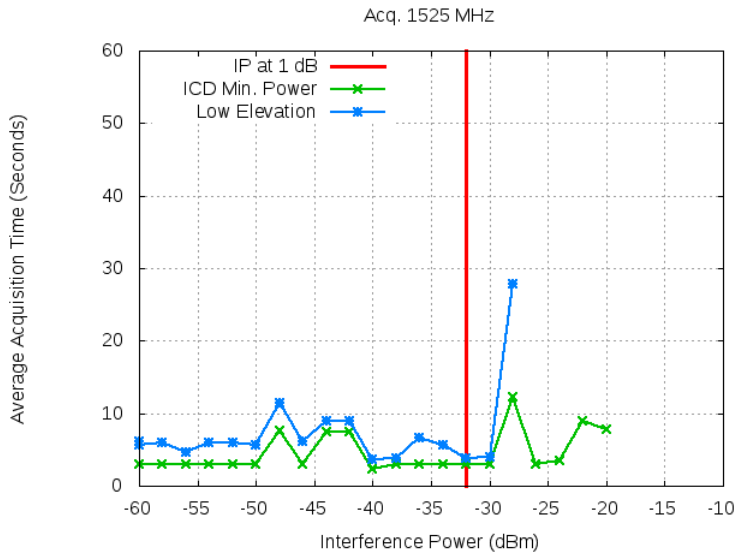

Acq. 1525 MHz
IP at 1 dB
ICD Min. Power
Low Elevation
Average Acquisition Time (Seconds)
Interference Power (dBm)
60
50
40
30
20
10
0
-60 -55 -50 -45 -40 -35 -30 -25 -20 -15 -10

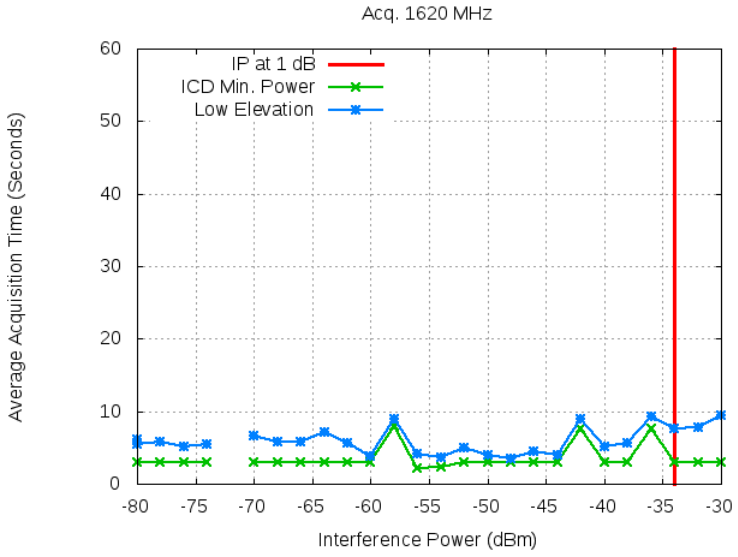

Acq. 1620 MHz
IP at 1 dB
ICD Min. Power
Average Acquisition Time (Seconds)
Interference Power (dBm)
60
50
40
30
20
10
0
-80 -75 -70 -65 -60 -55 -50 -45 -40 -35 -30

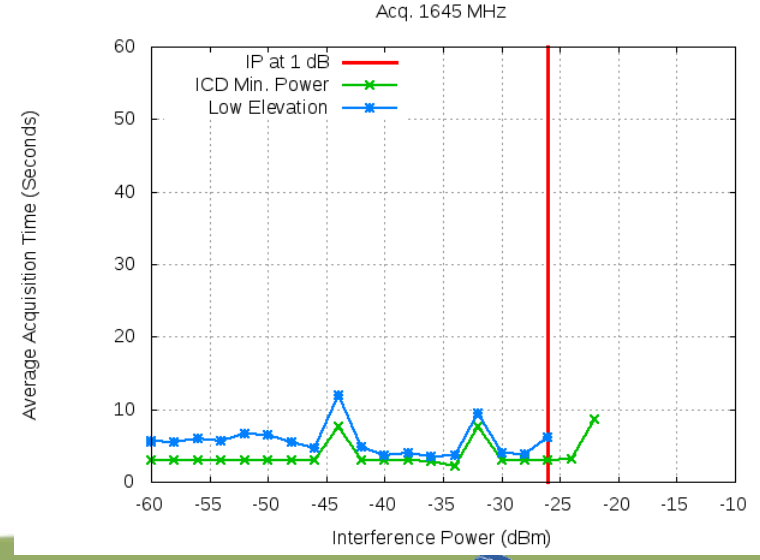

Acq. 1645 MHz
IP at 1 dB
ICD Min. Power
Low Elevation
Average Acquisition Time (Seconds)
Interference Power (dBm)
60
50
40
30
20
10
0
-60 -55 -50 -45 -40 -35 -30 -25 -20 -15 -10

DUT D

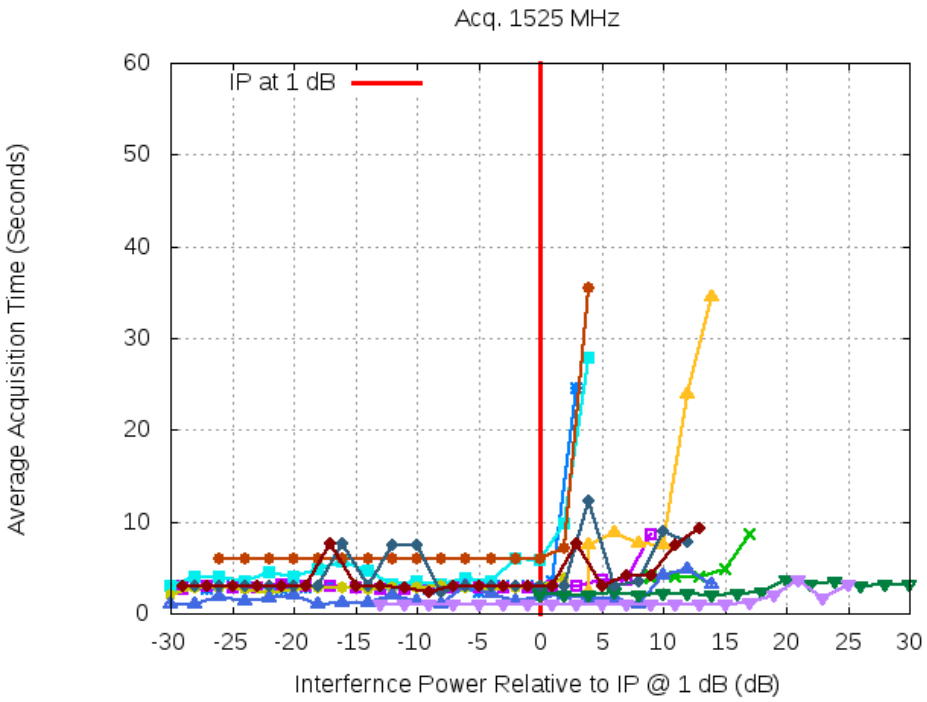

Acq. 1550 MHz
IP at 1 dB
ICD Min. Power
Low Elevation
Average Acquisition Time (Seconds)
Interference Power (dBm)


Acq. 1525 MHz
IP at 1 dB
ICD Min. Power
Low Elevation
Average Acquisition Time (Seconds)
Interference Power (dBm)

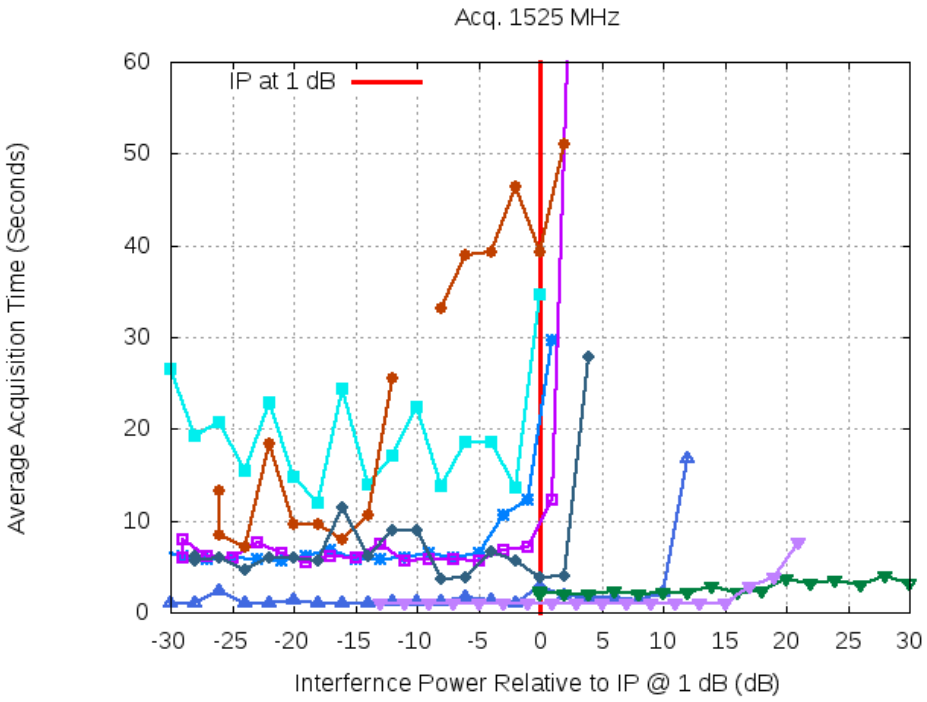

Acq. 1620 MHz
IP at 1 dB
ICD Min. Power
Low Elevation
Average Acquisition Time (Seconds)
Interference Power (dBm)


Acq. 1645 MHz
IP at 1 dB
ICD Min. Power
Low Elevation
Average Acquisition Time (Seconds)
Interference Power (dBm)

Acquisition Performance -1525 MHz

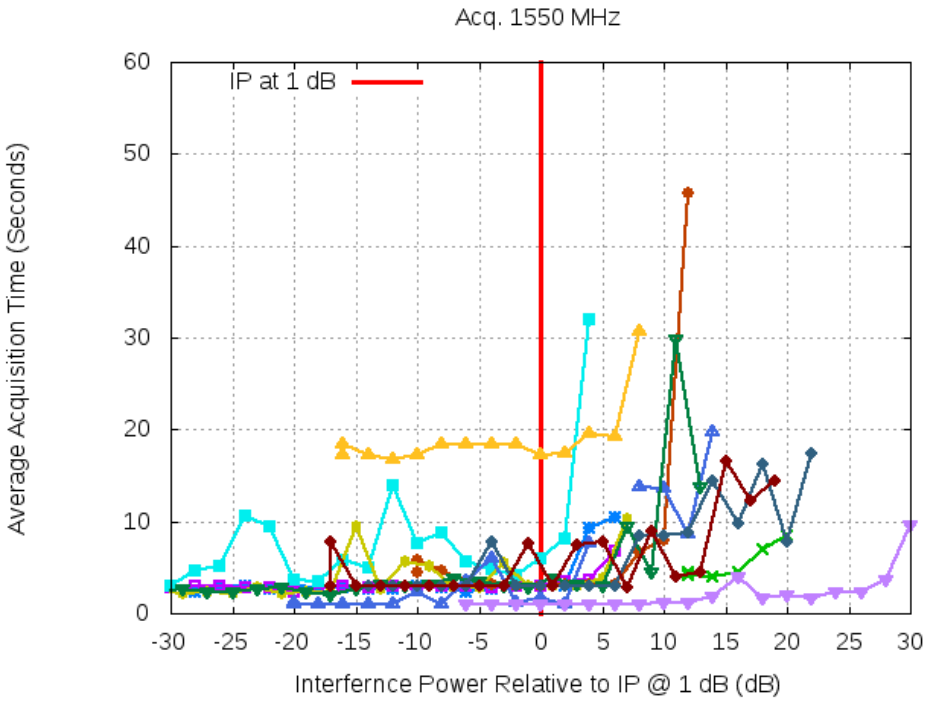


ICD Min. Power

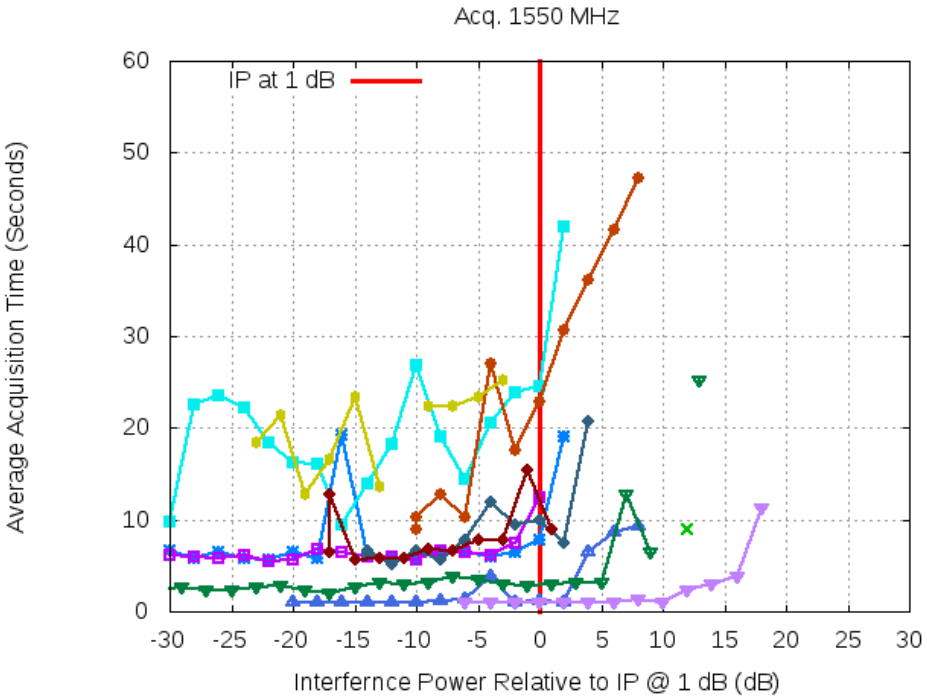


Low Elevation

Acquisition Performance -1550 MHz



ICD Min. Power



Low Elevation

Summary

- Comparison of radiated and wired tests show good agreement
  - Differences attributable to bypassing of active antennas in wired test
- Wired OOBE results confirm predictions for tested levels
- Acquisition results show degradation at interference level similar to IP @ 1 dB
  - Suggests exceeding 1 dB interference level can adversely affect receiver performance by slowing satellite acquisition times