

GPS-ABC Recap and Milestones

GPS-ABC Workshop VI

RTCA Washington, DC

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Objective

- ❑ Propose adjacent band transmit power levels that can be tolerated by existing GNSS receivers for civil applications [excluding certified aviation applications - those are considered in a parallel FAA effort]
- ❑ Accomplish this through:
 - An open and transparent approach
 - Development of Use Case scenarios
 - GNSS Receiver and Antenna Testing – Radiated, Wired, and Antenna characterization
 - Development of 1 dB Interference Tolerance Masks (ITMs)
 - Development of generic transmitter (base station and handheld) scenarios
 - Inverse and propagation modeling

Open and Transparent Approach Through Workshops

- ❑ Workshop-I held on September 18, 2014 at the Volpe Center
 - Overview of DOT GPS Adjacent Band Compatibility Assessment Plan and plans/timeline for implementation
 - Presentation on GPS use cases and list of representative GPS receivers
 - Description of GPS receiver and antenna information needed from manufacturers
- ❑ Workshop-II held on December 4, 2014 at Aerospace Corporation
 - Feedback on the program's implementation plan
 - GPS receiver Use Case information shared
 - Applicable testing and associated challenges discussed
- ❑ Workshop-III held on March 12, 2015 at Aerospace Corporation
 - Discussion/Identification of GPS and Global Navigation Satellite System (GNSS) receivers to be considered for testing
 - Discussion/feedback on a GPS/GNSS receiver test plan
 - "Today's" GPS receivers [also] include GNSS receivers
- ❑ Workshop-IV held on October 2, 2015 at RTCA
 - Draft test plan overview
 - Radiated emissions test approach
- ❑ Workshop-V held October 14, 2016 at RTCA
 - Radiated and Wired testing overview and results
 - Antenna Characterization results
 - Summary of Collected GNSS receiver Use Cases

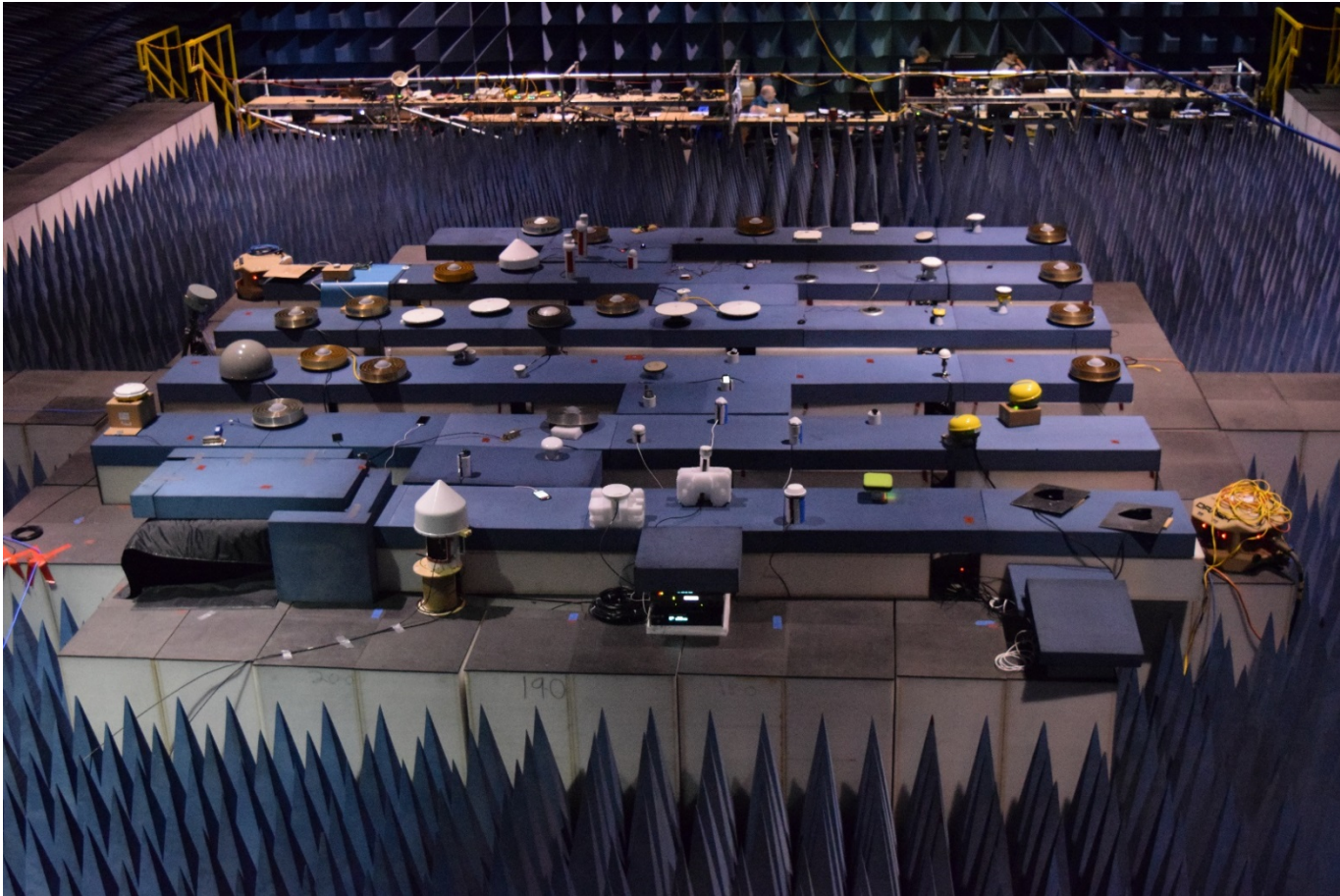
Major Milestones

- ❑ Use case data collection effort with Federal Partners and Industry
- ❑ Released a public GNSS receiver test plan and developed an in depth GNSS receiver test procedure
- ❑ Carried out GNSS testing
 - Radiated test data: collected in an anechoic chamber [White Sands Missile Range (WSMR)]
 - Conducted test data: collected in a laboratory environment [Zeta Associates]
 - Antenna characterization data [The MITRE Corporation]
 - Integrated antennas: collected in an open sky environment
 - External antennas: collected in an anechoic chamber
- ❑ Produced 1 dB Interference Tolerance Mask (ITM) results
- ❑ Provided ITMs and other results at the last workshop

Radiated Testing Overview

- ❑ GNSS receiver testing was carried out April 25-29, 2016 at the Army Research Laboratory's (ARL) Electromagnetic Vulnerability Assessment Facility (EMVAF), White Sands Missile Range (WSMR), NM
- ❑ Participation included DOT's federal partners/agencies (USCG, NASA, NOAA, USGS, and FAA) and GPS manufacturers
 - Air Force/GPS Directorate conducted testing week of April 18th
- ❑ 80 receivers were tested representing six categories of GPS/GNSS receivers: General Aviation (non certified), General Location/Navigation, High Precision & Networks, Timing, Space Based, and Cellular
- ❑ Tests performed in the anechoic chamber:
 - Linearity (receivers CNR estimators are operating in the linear region)
 - 1 MHz Bandpass Noise (Type 1)
 - 1 MHz In-Band Noise (Type1)
 - 10 MHz Long Term Evolution (LTE) (Type 2)
 - Intermodulation (effects of 3rd order intermodulation)

Chamber Test Grid and Setup



Wired Test Overview

❑ Test objectives:

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

❑ 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 OOB and re-acquisition test requirements

Antenna Characterization Overview

- ❑ Such characterization is needed to:
 - Compare radiated and conducted (wired) test results
 - Apply interference tolerance masks (ITMs) to use cases where adjacent band transmitters are seen by GPS/GNSS receiver antennas at any direction besides zenith (antenna boresight)

- ❑ Antennas relative gain patterns were measured for the purpose of linking ITMs to tolerable transmit power for the case of off-bore sight incident interference power:
 - For Right-hand/left-hand circular polarization (RHCP/LHCP), vertical (V), and horizontal (H) polarizations
 - at 22 frequencies: 1475, 1490, 1495, 1505, 1520, 1530, 1535, 1540, 1545, 1550, 1555, 1575, 1595, 1615, 1620, 1625, 1630, 1635, 1640, 1645, 1660, and 1675 MHz

Questions?

Next Steps

- ❑ Finalize Use Case Analysis Based on Feedback from Workshop
- ❑ Complete DOT GPS Adjacent Band Compatibility Assessment Final Report
 - Will include certified avionics and non certified receivers
- ❑ Issue Final Report for Public Review and Comment