

# GPS Device Testing Based on User Performance Metrics

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Adjacent Band Compatibility Workshop  
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Ken Zdunek, Ph.D.  
Chief Technology Officer  
Roberson and Associates, LLC

# About Roberson and Associates

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- Technology and Management Consulting Company Founded in 2008
- Services Include
  - RF Spectrum Management
  - RF Measurements and Analysis
  - Technology Strategy
  - Technology Development
- Combined 400 Years of High Technology Management and Technical Leadership Experience with Strong Wireless Communications Focus with Firms Including:
  - Motorola
  - ARRIS
  - Bell Labs/Alcatel-Lucent
  - Cisco
  - Google
  - IBM
  - Nokia
  - Illinois Institute of Technology

# Topics

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- Rationale for a Test Program Based on User Performance Metrics
- Roberson and Associates Test Program
- Status of, and Revisions to, the Roberson and Associates Test Program
- Comparison of Roberson and DoT/Volpe Programs

# Rationale for Testing Based on User Performance Metrics

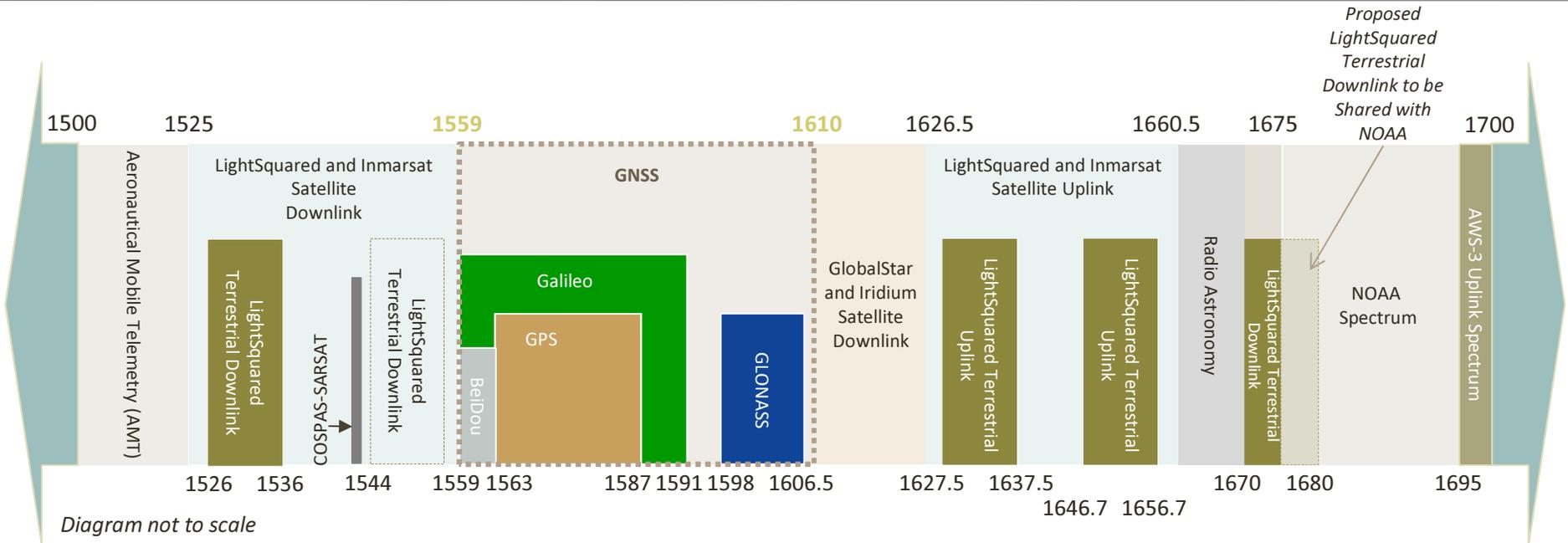
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- Focus on Identifying and Resolving Compatibility Issues, if any, Between Terrestrial LTE Operations Proposed by LightSquared and Reliable GPS Operation
- FCC Definition of *Harmful Interference* (47 CFR 2.1)
  - Interference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with [the ITU] Radio Regulations. (CS)
- Evaluate Change or Meaningful Degradation of GPS Device Function From the End-User Perspective
- Focus on Key Performance Indicators (KPI), for Example:
  - Position Accuracy
  - Timing Accuracy
- Understand the Interaction of these KPIs with Respect to Other System Data
  - Change in  $C/N_0$
  - Satellites in View
  - Dilution of Precision
- Measure Devices That are Representative in the Marketplace
- Analyze Collected Data in Use Cases That Replicate Typical Operating Conditions
- Identify Specific Types of GPS Device Compatibility Issues and Compare with Best-in-Class, Achievable Device Performance to Understand Options to Achieve Improved Device Resiliency

## Key Elements of Roberson Measurement and Analysis Approach

- Incorporate Knowledge Gained in 2011 TWG
  - Understanding of GPS Device Susceptibility to LTE Emissions
- Incorporate Revised LightSquared LTE Deployment Plan: Frequencies and Power
- GPS Device Measurements:
  - Radiated RF Measurements of GPS Devices' Susceptibility to LTE Emissions
  - Identification of LTE "Threshold of Harm" Level Based on GPS Service (User) KPI Impact
- Statistical Analysis of Geographic and Temporal Impact to GPS Device in LTE Environment
- Identification of Characteristics of GPS Devices Compatible with LightSquared Terrestrial LTE operations
- Identification of Compatibility Solutions for GPS Devices Not Currently Compatible

# GNSS Spectrum Neighborhood and LightSquared Spectrum



1526-1536  
Downlink

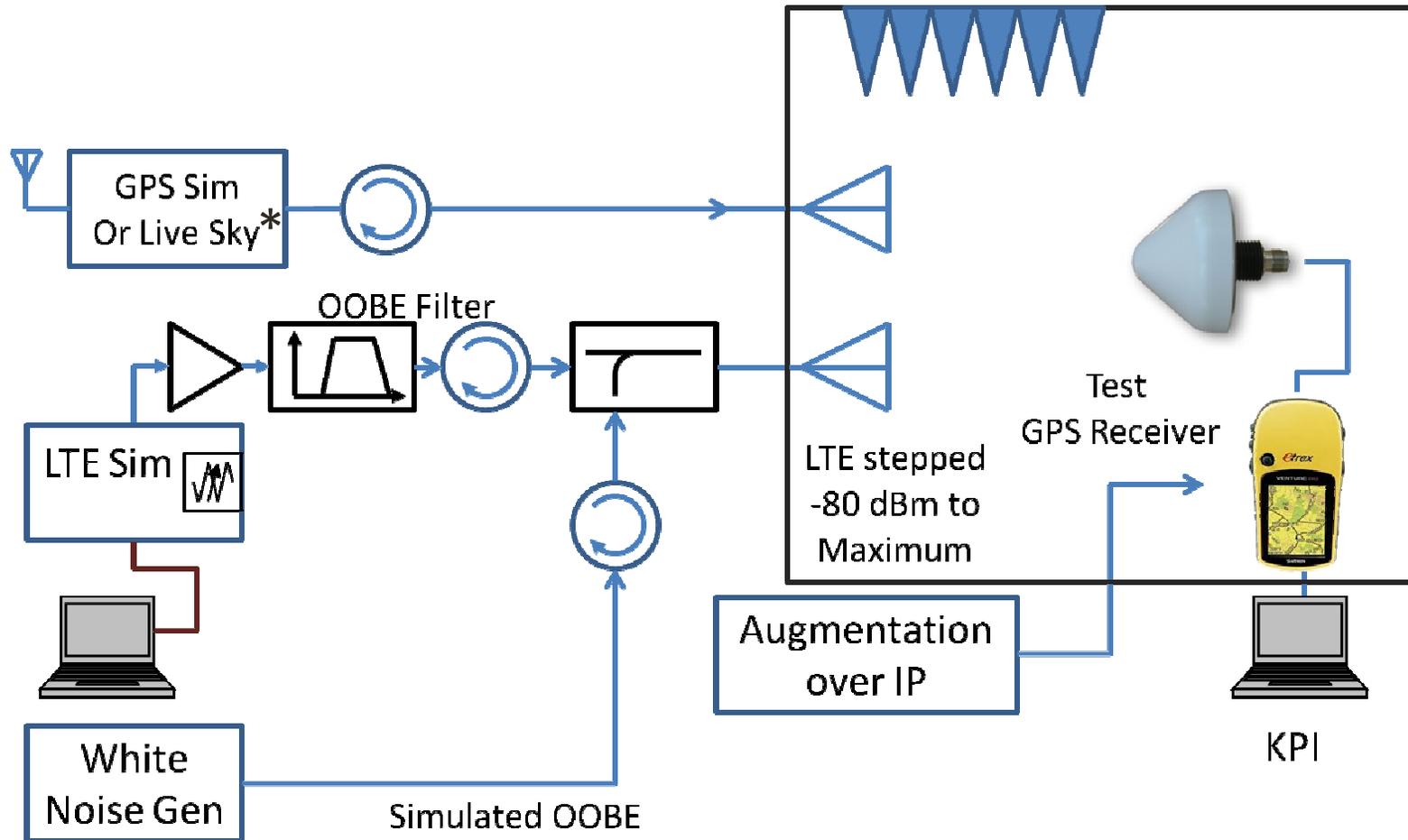
1627.5-1637.5  
Uplink

1646.7-1656.7  
Uplink

1670-1680  
Downlink

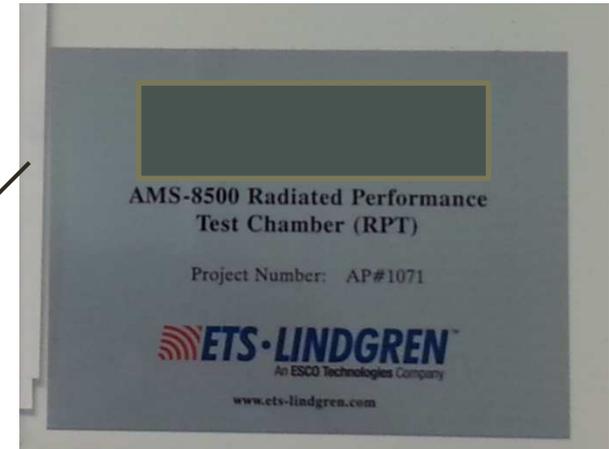
LTE Signals in the Frequencies Shown Utilized for Radiated Tests

# Test Schematic Example



\* Live Sky for MSS-Augmented GPS

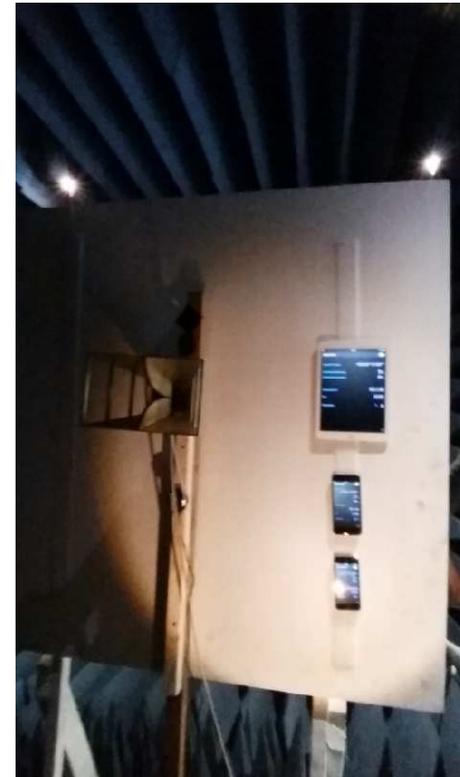
# KPI Test Bed: Anechoic Chamber



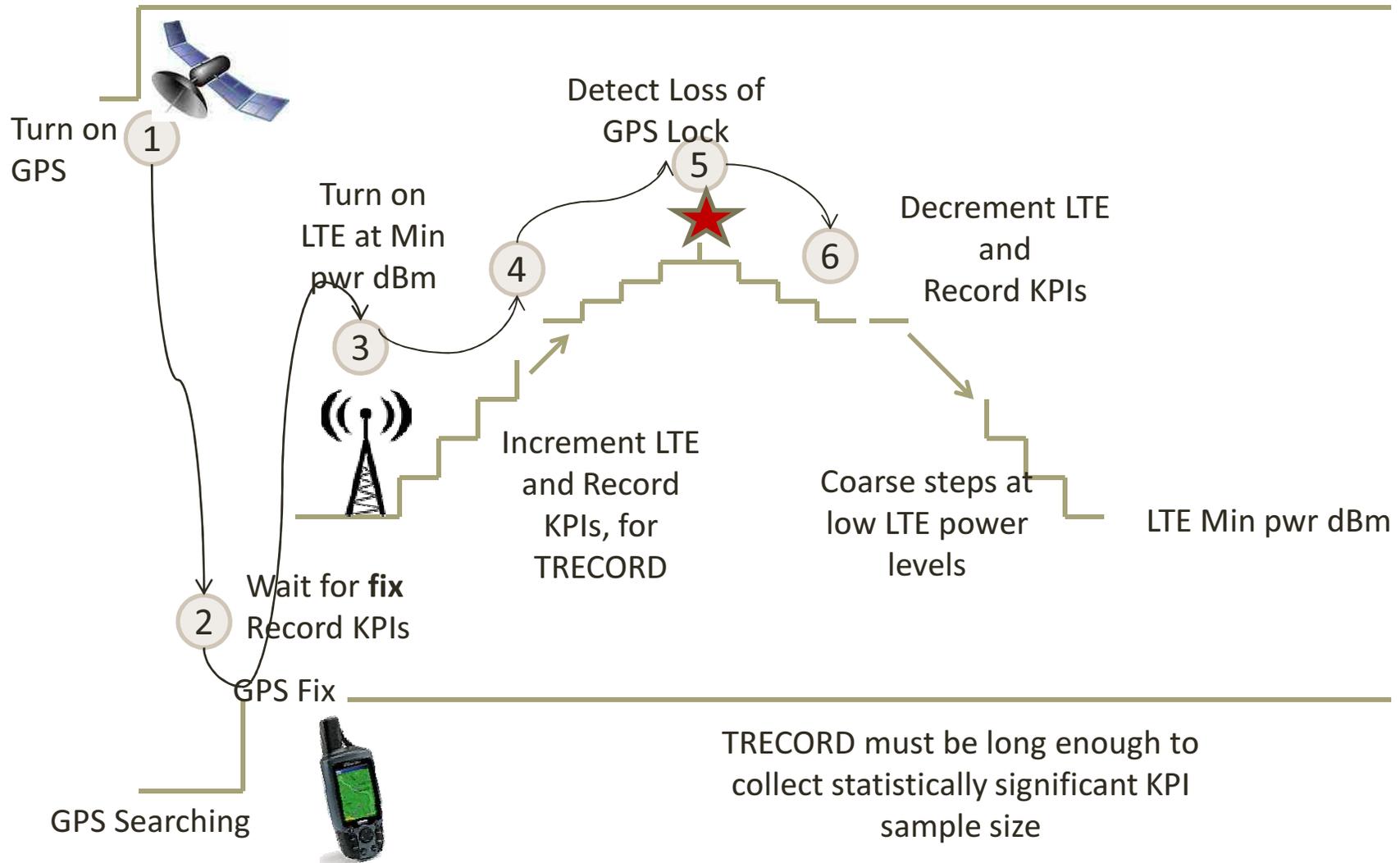
LTE and GPS Antennas



Devices Under Test



# Basic KPI Measurement Sequence



# KPIs and System Data Recorded, and Device Categories

	<b>Aviation (Cert)</b>	<b>Aviation (Uncert.)</b>	<b>HP (High Precision)</b>	<b>Timing</b>	<b>Cellular</b>	<b>General Nav</b>
<b>KPI</b>	1) 3D Position Error	1) 3D Position Error	1) 3D Position Error 2) Loss of RTK	1) Timing Error	1) 3GPP KPIs 2) 2D Position Error	1) 2D Position Error
<b>System Data</b>	1) C/N <sub>0</sub> 2) WAAS message error rate 3) DOP	1) Satellites in view 2) C/N <sub>0</sub> 3) DOP 4) WAAS message error rate	1) Augmentation Signal Quality 2) Satellites in View 3) C/N <sub>0</sub> 4) DOP	1) Frequency Error 2) Satellites in view 3) C/N <sub>0</sub> 4) DOP	1) Satellites in View 2) C/N <sub>0</sub> 3) DOP	1) Satellites in View 2) C/N <sub>0</sub> 3) DOP

# Status of Roberson and Associates Testing

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- Initial Measurements on 30+ GPS Devices
  - GPS Baseline- No LTE
  - LTE Applied for 4 Frequencies
  
- Remaining Measurements Ongoing
  
- Validation of Procedure and Results: in Process
  
- GPS User Performance Metrics Process Learning
  - Most GPS Devices Have NMEA or Proprietary Outputs (e.g. GPX) from which LTE Impact on KPIs can be Derived (e.g. Position Error)

GPS Device Testing Based on User Performance Metrics (KPIs) is Feasible  
With Appropriate Test Process

### **Accepted feedback and modified Test Plan, including:**

- Added WAAS (Wide Area Augmentation Signal) to the GPS signals.
  - Permits WAAS enabled receivers to function at improved baseline position accuracy.
- WAAS message loss rate will be characterized for Aviation devices.
- Additional testing will be performed on select devices, such devices used by Public Safety, up to -10 dBm LTE Power.
- Devices used by Public Safety devices will be tested for re-acquisition with LTE signals present as requested by NPSTC.

# Comparison of R&A and Proposed DoT/Volpe Process

Category	DOT Volpe Test Plan	Roberson and Associates Test Plan
Overall Goal	Identify tolerance profile for existing GPS receivers	Identify joint GPS receiver design, and LTE deployment , compatibility solutions
Compatibility Metric	C/N <sub>0</sub> , an RF metric	Position Error /User KPI, a functional metric
Test Frequencies	1475MHz to 1675MHz	Focused on LightSquared LTE deployment 1526 - 1536MHz; 1670 - 1680MHz 1627 - 1637MHz; 1647 - 1657MHz
GNSS Test Signals	Generate all GNSS signal as practical (GPS SBAS, GLONASS, Galileo, QZSS, BeiDou)	Generate GPS signals and augmentation only (Include devices with other GNSS capability)
Stressed GPS Condition	No plans to test	Real-World, stressed GPS simulated (reduced SVs and Power)
Adjacent Band Signal	Bandlimited 10MHz and 1MHz narrowband noise signals.	Testing with typical commercial 10MHz LTE signal
Time to First Fix	No plans to test	Testing Time to First Fix for public safety units Per NPSTC request
3rd Order Intermodulation	Injecting two signals (such as 1530 and 1550MHz) to measure the 3rd order IM	No plans to test 3rd order IM, since planned deployments do not have this problem