NIST
National Institute of Standards and Technology
U.S. Department of Commerce

CTL Communications Technology Laboratory

VCAT Meeting

October 18, 2016

Dereck Orr
Acting Director, Communications Technology Laboratory

Overview

- CTL Overview
- Public Safety Communications Research (PSCR)
- National Advanced Spectrum and Communications Test Network (NASCTN)
- Spectrum Sharing
- 5G
- Microwave Metrology

CTL Overview

Mission: *The Communications Technology Laboratory (CTL) promotes the development and deployment of advanced communications technologies, through the conduct of leading edge R&D on both the metrology and understanding of physical phenomena, materials capabilities, and complex systems relevant to advanced communications.*

Public Safety Communications Research

Innovation Accelerator

Pulling the Future Forward

Section 6303 of the Middle Class Tax Relief and Job Creation Act of 2012 (the "Act") provides for $300M in auction funding to NIST to perform R&D critical to the success of a dedicated, nationwide LTE broadband network. The five focus areas are depicted to the right.

Tools for Innovation

Internal NIST research

- ✓ Utilize internal expertise by partnering with various NIST programs

Prize Challenges

- ✓ Partnered with NASA's Center of Excellence for Collaborative Innovation

Convening stakeholders

- ✓ Collaborate with public safety, industry, and government throughout project lifecycles

Federal Funding Opportunities

- ✓ Research grant opportunities
  - ✓ Mission Critical Voice
  - ✓ Location-based Services
  - ✓ Analytics

Public Safety Communications Research

PSCR-sponsored NIST Research Efforts

Location-based Services

- ✓ Roadmap published – May 2015
- ✓ Summit – October 2015
- ✓ Indoor localization & tracking – partnered with NIST ITL
- ✓ Indoor mapping & navigation – partnered with NIST ITL
- ✓ Enhanced 3D geolocation – partnered with NIST PML

Analytics

- ✓ Roadmap published – March 2016
- ✓ Summit – August 2016

Enhanced User Interface

- ✓ Roadmap published – March 2017
- ✓ Summit – Summer/Fall 2017
- ✓ User Interface and Usability project – partnered with NIST ITL

Mission Critical Voice

- ✓ Mission Critical Voice over LTE Roundtable – March 2016
- ✓ ProSe Direct Mode Communications project – NIST Wireless Network Division
- ✓ Voice over LTE on public safety broadband project – PSCR Division

Network Security

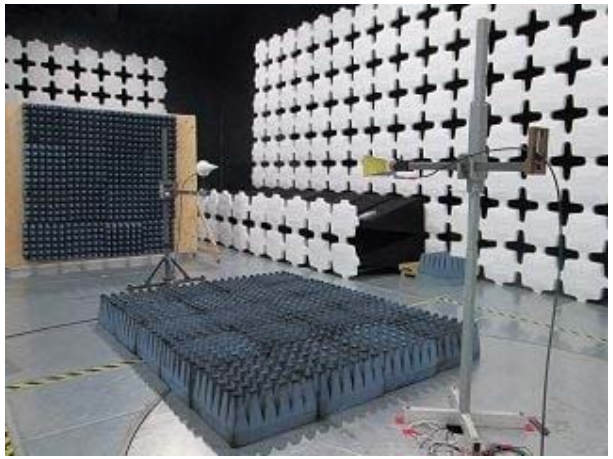
- ✓ Mobile Application & Data Isolation project – partnered with NIST ITL
- ✓ Identity Management project – partnered with NIST ITL

NASCTN

The National Advanced Spectrum and Communications Test Network (NASCTN), established by NIST, DoD and NTIA in 2015, provides the testing, modeling and analysis necessary to develop and deploy spectrum-sharing technologies and to inform future spectrum policy.

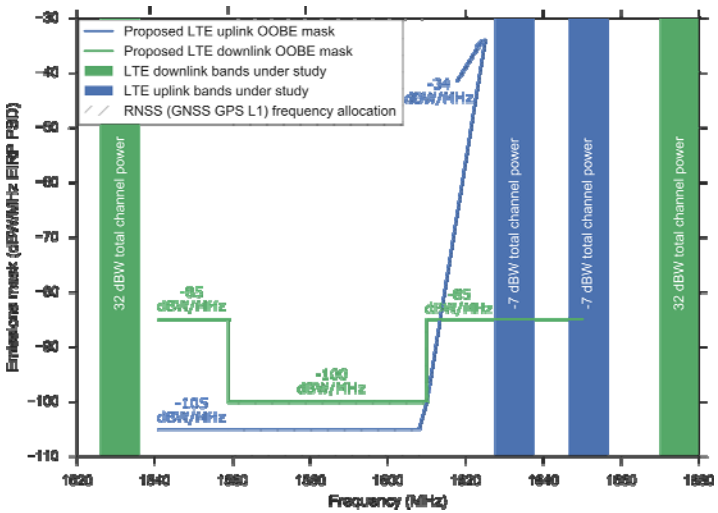
In 2016, NASCTN initiated three significant spectrum-sharing projects proposed by industry and Federal agencies:

- Waveform Measurements of Radars Operating in the 3.5 GHz Band *(proposed by Federated Wireless)*
- Out-of-Band Emissions Measurements of LTE Devices Operating in the AWS-3 Band *(proposed by Edwards Air Force Base)*
- Impact of LTE Signals on GPS Receivers *(proposed by Ligado Networks)*



NASCTN's Impact of LTE Signals on GPS Receivers Project

- Ligado Networks (formerly LightSquared) proposed that NASCTN develop the test methodology and perform measurements to investigate the impact of LTE signals in frequencies bands adjacent to the GPS L1 frequency band.
- Highly controversial project of interest to Federal agencies, GPS manufacturers, spectrum regulators, legislators and (even) bloggers as GPS devices are ubiquitous and potential interference from a proposed wireless communication system in an adjacent frequency band must be well understood.



Proposed LTE uplinks and downlinks adjacent to GPS L1 frequency band

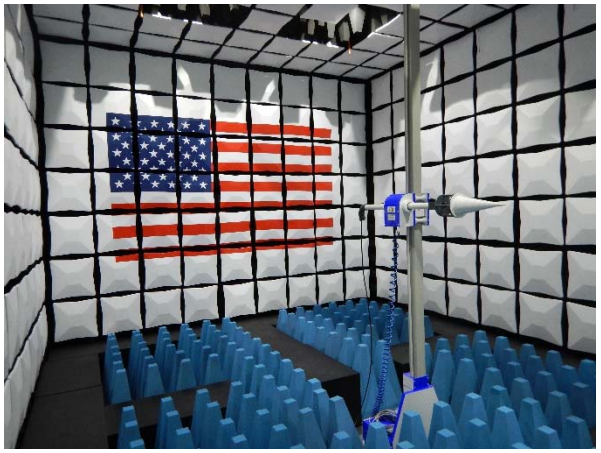
- NASCTN was established to address this specific topic because a neutral, third-party organization was needed to provide trusted data to help inform future spectrum policy.
- NASCTN has leveraged its network of engineering expertise, equipment and laboratories from NIST, DoD and NTIA to support this project and has already presented preliminary data to spectrum regulators within six months of the project's initiation.

Spectrum-Sharing Research

Citizens Broadband Radio Service (CBRS)
Develop requirements, test methods and reference data to support the standardization and testing of commercial CBRS systems that will share the frequency band with DoD in the 3.5 GHz band.

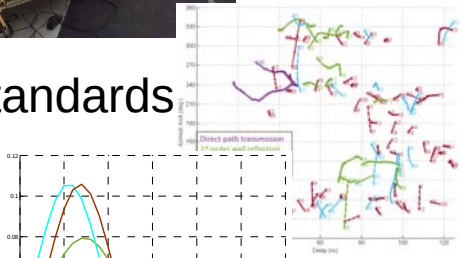
Wireless Coexistence
Construction of NIST Broadband Interoperability Test (NBIT) facility to develop the next generation of next-generation of radiated field measurements and standards related to spectrum sharing.

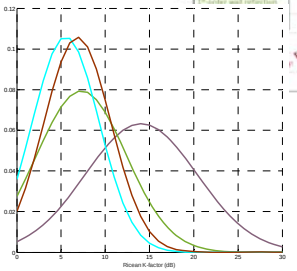
Wireless Forensics
Develop the necessary metrology to identify and locate signals in a shared-spectrum environment with enough fidelity to determine if communications systems are adhering to spectrum-sharing policies.



NBIT Anechoic Chamber

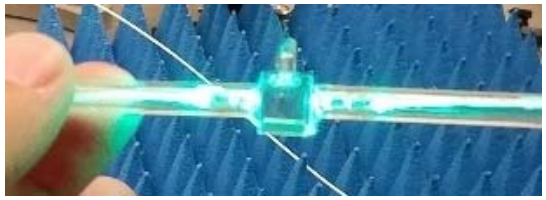
5G & Beyond



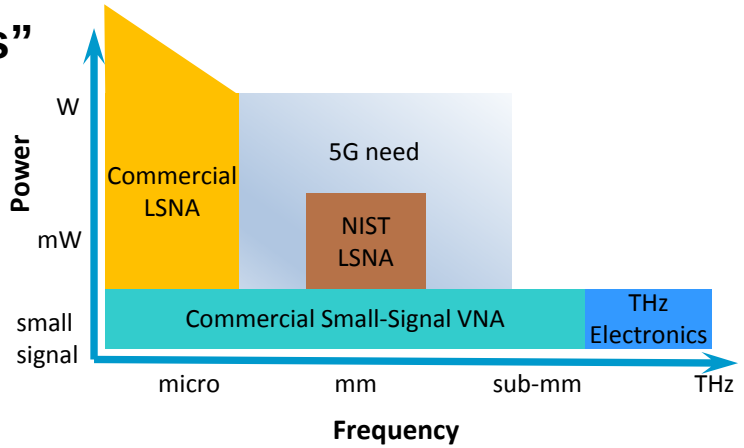


- **Channel sounders for 83.5, 28, and 60 GHz**
  - Unique capabilities for measuring mobile channel
  - Channel propagation models and contributions to pre-SDO standards
  - Over-the-air test of calibrations
- **Traceability for modulated mm-wave signals**
  - Developing IEEE Best Practices: Uncertainty in EVM
- **5G mmWave Channel Model Alliance**
  - Over 125 participants representing 75 organizations worldwide
  - Sponsoring workshops at major communications conferences: IEEE VTC-2016, IEEE GLOBECOM 2016.
  - Data measurement & modeling repository live in Q1FY17
- **Next generation communication key gaps and R&D challenges**
  - Launched multidisciplinary working group including over 45 members representing industry, government and academia in August 2016 & complete report in early FY17.
  - More info is available here: https://www.nist.gov/programs-projects/metrology-support-wireless-innovation

Microwave Metrology



- **Quantum e-field probe** (400 MHz – 1 THz)
  - Self-calibrated, high sensitivity, non-perturbing
- **Metrology to enable engineered functional materials**
  - Resolved sub-nanosecond response time of nonlinear dielectrics and filters
- **Established traceability for microwave remote sensing**
  - Operational weather forecasting, long-term climate monitoring
- **Major step toward "first-pass design success" for mm-wave transistors**
  - Separated measurement errors from manufacturing variability
- **CTIA standard for testing large form-factor devices**
  - Machine-to-machine cellular devices



Next …

- **Rigorous uncertainty analysis for wireless coexistence evaluation**
- **State-of-the-art facility for MIMO antenna metrology**
- **Intermodulation distortion metrology**
- **"Best Practices" for verification of channel sounders/metrology**

Questions?