Communications Technology Laboratory Overview

Marla Dowell, Director

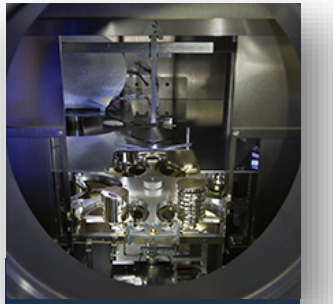
Mission: *conduct and facilitate leading edge R&D for both metrology and standards development to accelerate the development and deployment of advanced communication systems*

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

CTL Communications Technology Laboratory

NIST Laboratory Programs

Material Measurement Laboratory



Physical Measurement Laboratory

Engineering Laboratory

Information Technology Laboratory

Communication Technology Laboratory

NIST Center for Neutron Research

CTL Organization Structure

Established FY15 with proceeds from NIST and the Public Safety Trust Fund

Dereck Orr

PSCR

Public Safety Communication Research

Supports development of Nationwide Public Safety Broadband Network

Melissa Midzor

NASCTN

National Advanced Spectrum and Communications Test Network (NASCTN)

neutral body to address spectrum-sharing challenges among commercial and federal users

Mike Janezic

RF Technology

Fundamental RF metrology research and standards to characterize both integrated circuits and systems, wired and wireless.

Nada Golmie

Wireless Networks

theoretical and experimental research in wireless networks, protocols, digital communication systems and components

CTL Priority Areas

Fundamental Metrology for Communications

1 Public Safety

To support standards research, development, test, and evaluation for first responder communications.

2 Trusted Spectrum Testing

To coordinate and provide robust test processes, validated data, and trusted analysis to improve spectrum-sharing agreements, and inform future spectrum policy and regulations.

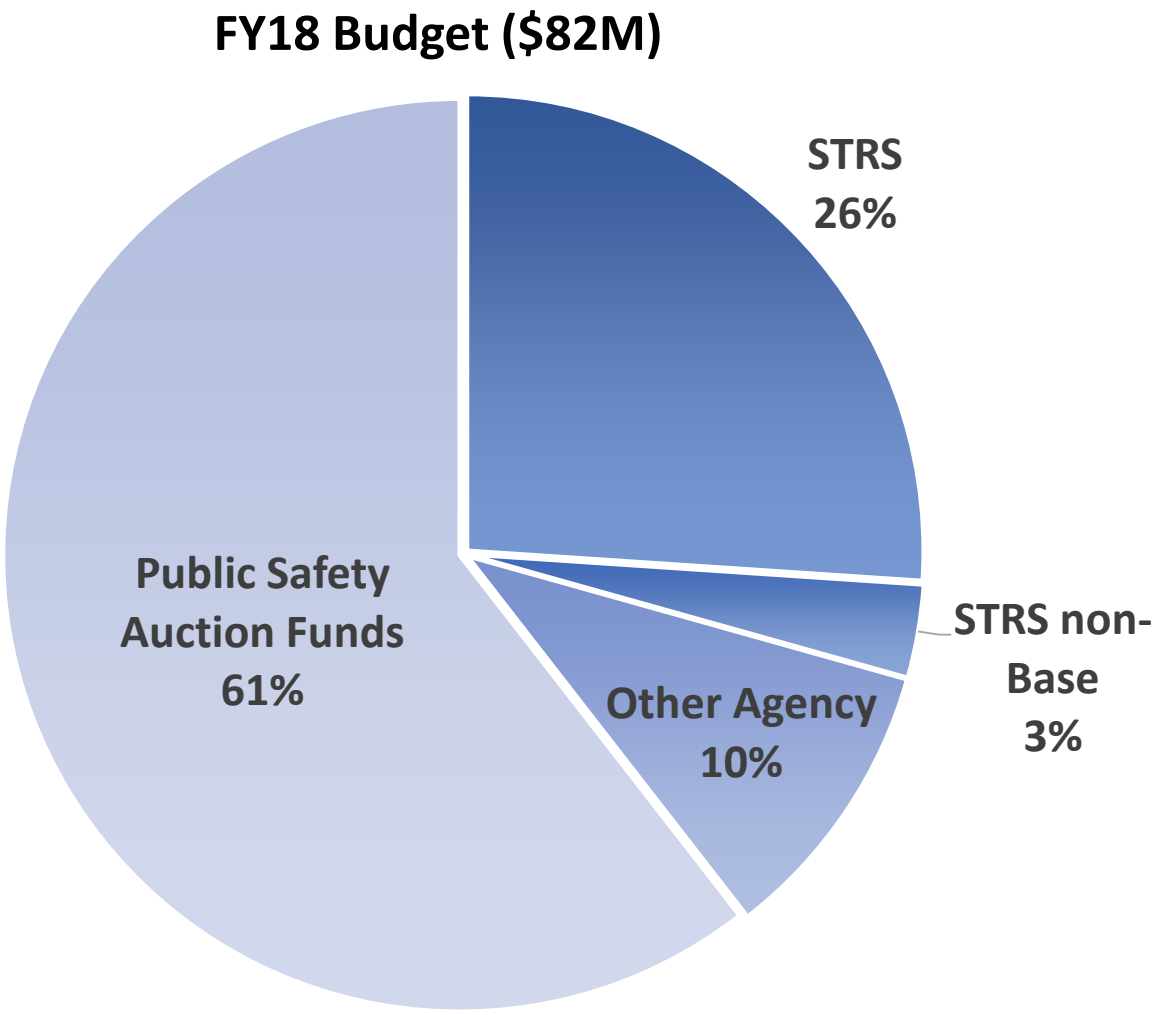
3 Spectrum Sharing

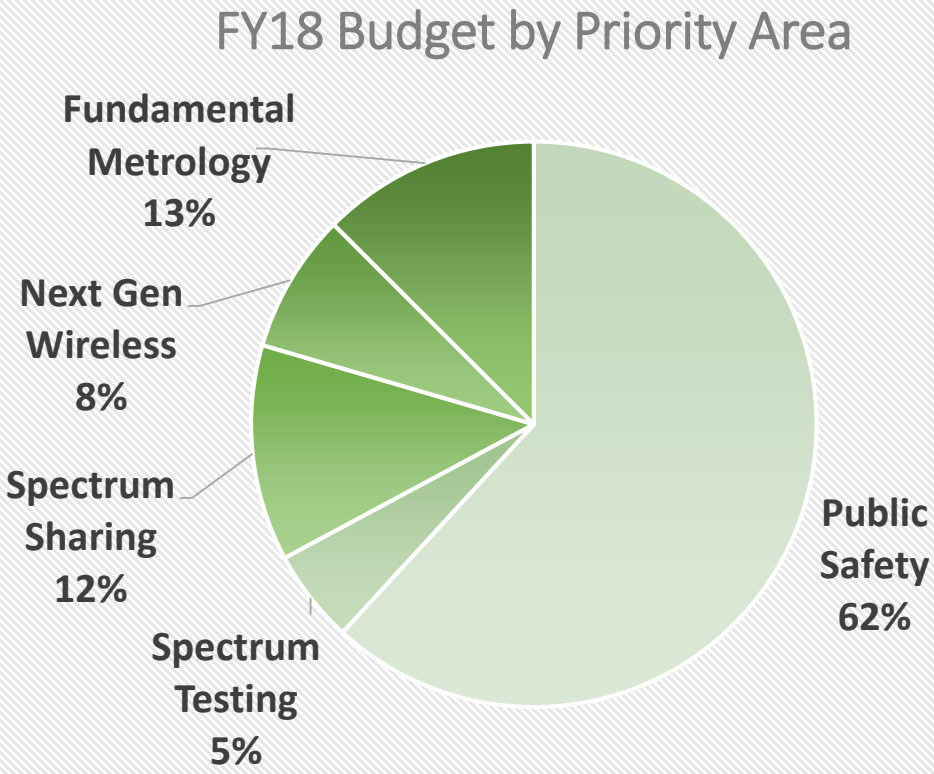
To advance measurement science infrastructure to investigate, quantify, and mitigate the many factors that impact the ability, and inability, of disparate wireless communications systems to coexist and operate as intended.

4 Next Generation Wireless

To advance the measurement science infrastructure for next generation wireless communication systems, e.g., mmWave radio channels.

CTL Priority Areas and Budget





3 Divisions
NASCTN Program Office
- strategic partnerships w/DOD, NTIA, NASA, NOAA, Johns Hopkins

70 career Federal Employees
41 term Federal Employees
83 Associates

Public Safety Overview

GOAL: Transform public safety operational capabilities and contribute a measurable impact on public safety's ability to save lives and property. These 5 areas show how PSCR is best positioned to deliver value to the public safety community:

1. Increasing Research Capacity
2. Disruptive Approaches & Technology
3. Standards
4. Products
5. Public Safety Methods

SUCCESSES

- New capabilities: new NIST labs, additional 40 NIST staff, partnership with FirstNet.
- 4 grant programs and 5 Prize Challenges totaling over $56M in funding.

STAKEHOLDERS

- PSCR Annual Stakeholder Conference brings over 500 stakeholders from industry, academia, and public safety
- > 150 organizations receive funding through Prize Challenges, grants and cooperative agreements.

Public Safety Innovation Accelerator Program (PSIAP)

2018 PSIAP User Interface/User Experience (UI/UX) Grant Recipients

NC STATE UNIVERSITY

traclabs

OPTERA

Georgia Tech Research Institute

Duke UNIVERSITY

NEXTGEN Interactions

TEXAS A&M UNIVERSITY CONSTRUCTION SCIENCE

CONTEXT

Need for external R&D effort in Public Safety:

- Location-based services, Mission Critical Voice, Data Analytics, User Interface/User Experience, Broadband transition

IMPACT

In 3 years, established partnerships with over 150 private and public sector organizations through prize challenges, grants, and cooperative agreements.

FUTURE

Increase external research capacity and fast track tech transfer to shorten the time it takes to get these technologies into the hands of public safety.

Public Safety User Interface Research

CONTEXT

User Interface research portfolio was created to ensure public safety device interfaces are designed around the operational needs of the end users.

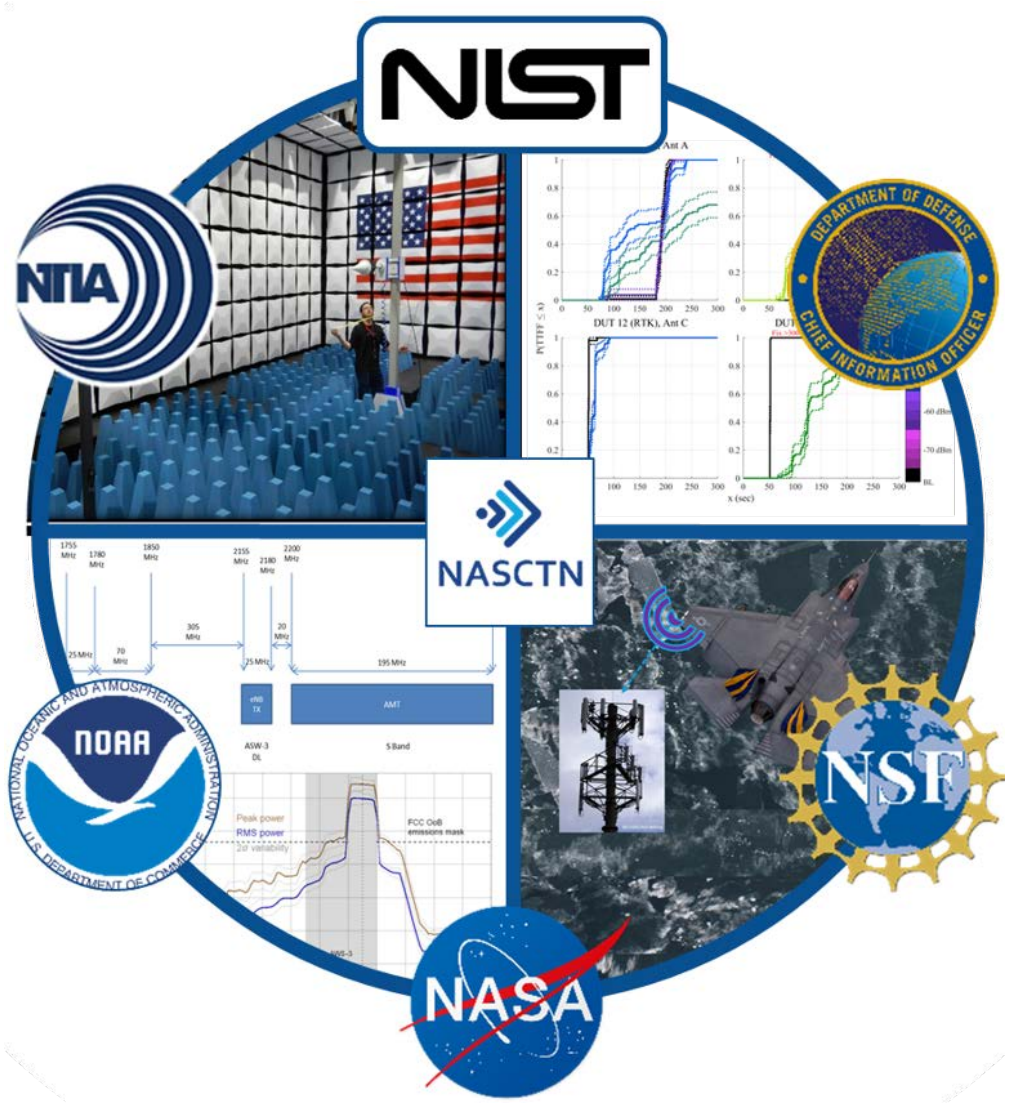
IMPACT

NIST efforts have led to the development of proof of concept Heads Up Displays and engagement with 19 external organizations.

FUTURE

Expand open source library of scenarios and tasks for rapid prototyping and development of new user interfaces for public safety through strategic partnerships.

Trusted Spectrum Testing Overview



GOAL: Increase Commercial and Federal access to spectrum by accelerating the design and deployment of spectrum-sharing technologies by:

- Providing a neutral, trusted forum to evaluate spectrum-sharing technologies (NASCTN)
- Developing independent test methodologies and providing validated data.

SUCCESSES

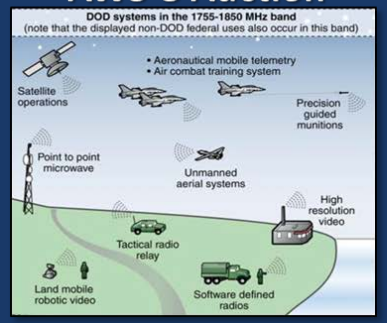
- 4 projects uniting private and public sectors
- Enabled spectrum sharing test facilites
- Provide critical data to DoD SST&D program for early entry into the AWS-3 auctioned bands

STAKEHOLDERS

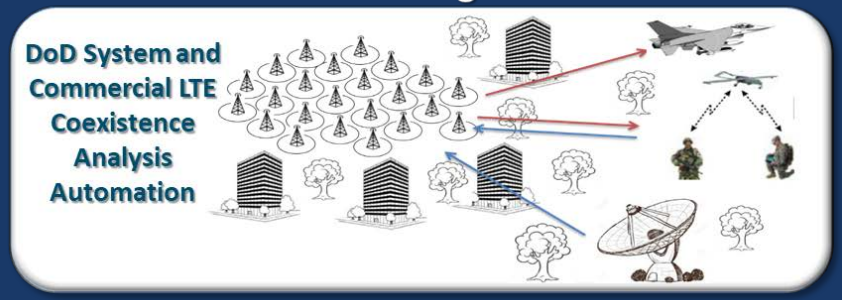
- National network of Federal, academic, and commercial test facilities (DoD, NTIA, NOAA, NASA, and NSF).
- Facilities include NBIT, Fort Story VI, Pt Loma CA, MITRE, John Hopkins University, and Edwards AFB.

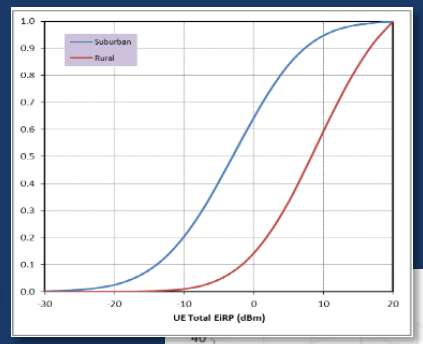
Trusted Spectrum Testing: Aggregate AWS-3 LTE Emissions

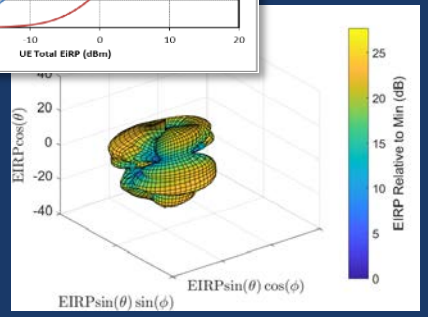
AWS-3 Auction



SST&D Program







CONTEXT

New metrology required to characterize cumulative and complex interactions for cell phone emissions.

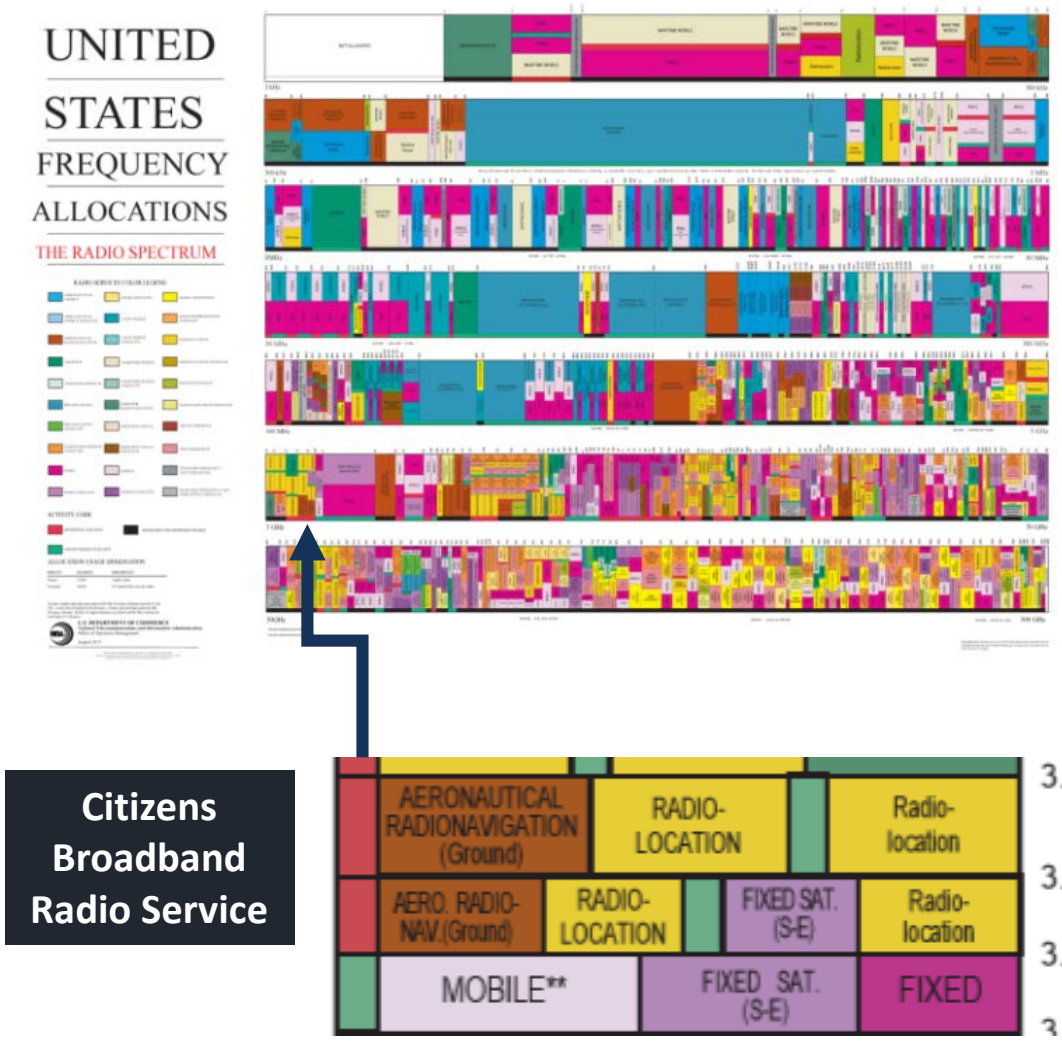
IMPACT

Informing interference models used by DoD for expedited and expanded entry of commercial deployments into the 1755-1780 MHz band

FUTURE

NASCTN is working with agencies to identify potential key measurements in advance of the 2024 Spectrum auction.

Spectrum Sharing Overview



GOAL: Expand availability of wireless spectrum by developing new signal detection and classification methods, statistical models for interference and spectrum occupancy, and measurement methods and standards for wireless coexistence.

SUCCESSES

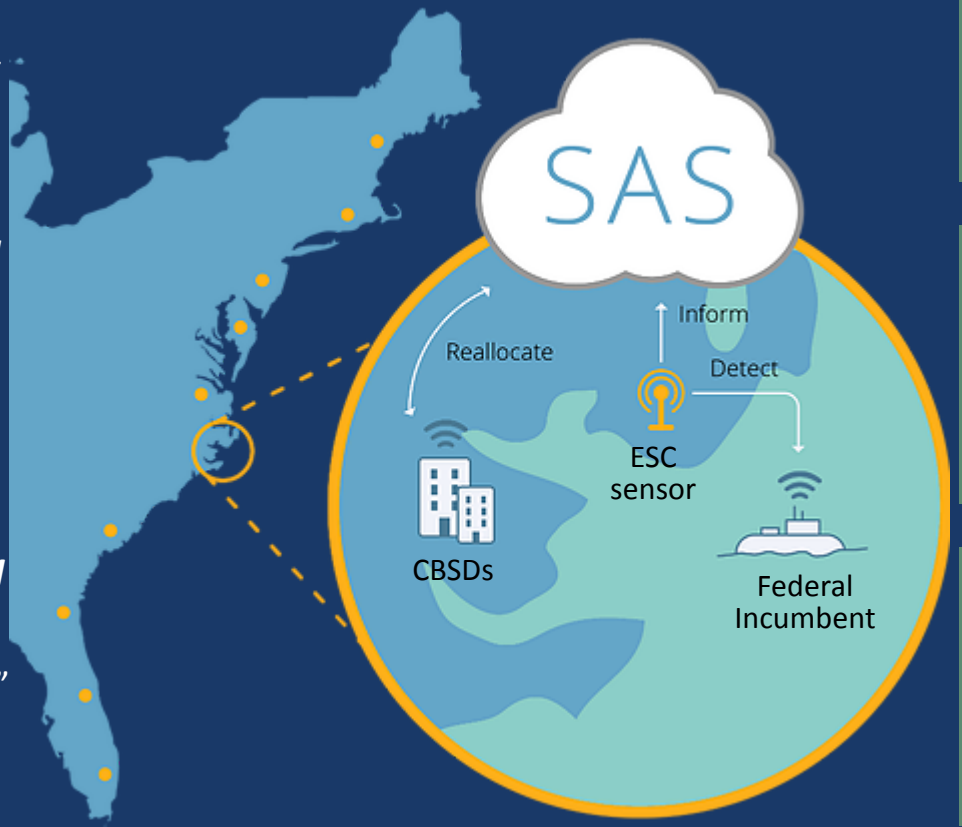
- Improved signal detection and classification using machine learning techniques.
- WINNF adoption of test procedures to certify commercial wireless systems in the CBRS band.
- FDA adoption of standards for wireless healthcare devices.

STAKEHOLDERS

- Standards Organizations (IEEE, WINNF)
- Operators (AT&T, Verizon, Federated Wireless)
- Equipment vendors (Nokia, Ericsson, Sony, Motorola)
- Chipset manufacturers (Intel, Qualcomm)

Spectrum Sharing –
Citizens Broadband Radio Service

"The efforts of our company, NIST and the other members of the WINNF SSC to establish standards, testing and certification for spectrum sharing are setting the stage for improving wireless service indoors, expanding broadband services to rural areas, and providing private wireless capabilities for industrial users. It's an ***outstanding example of public-private collaboration****."*
– Kurt Schaubach, CTO, Federated Wireless



Source: https://www.cbrsalliance.org/blog

CONTEXT

The Citizens Broadband Radio Service makes 150 MHz of new spectrum available for commercial use on a shared basis with the federal government .

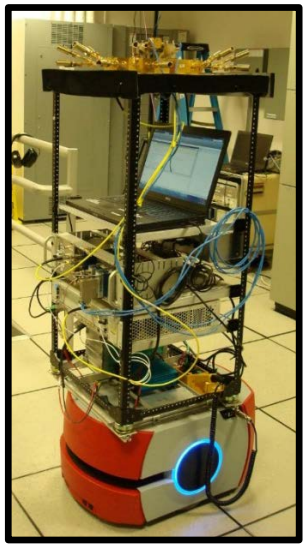
IMPACT

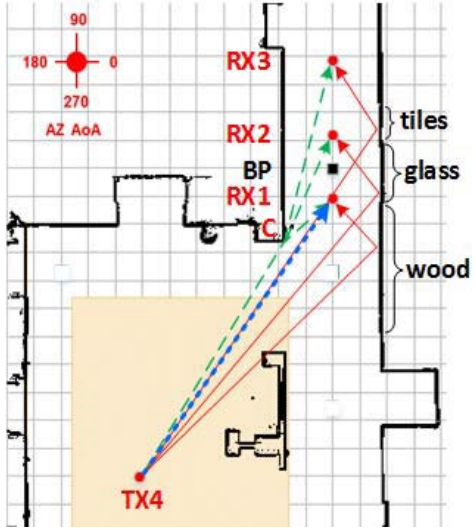
NIST developed test procedures and a reference implementation to help regulators certify commercial systems mediating access to this RF band.

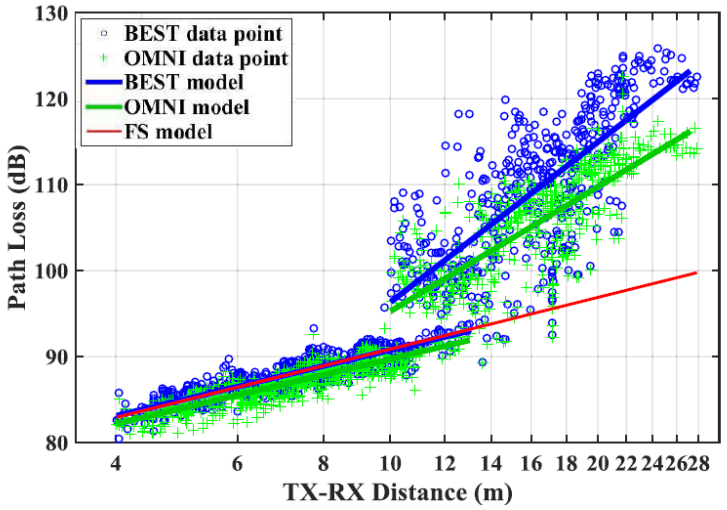
FUTURE

Research in radar signal detection, sensor deployment for efficient dynamic protection coverage.

Next Generation Wireless Overview







GOAL: Accelerate the development and use of accurate measurements, system calibrations, and models in support of next generation wireless communications.

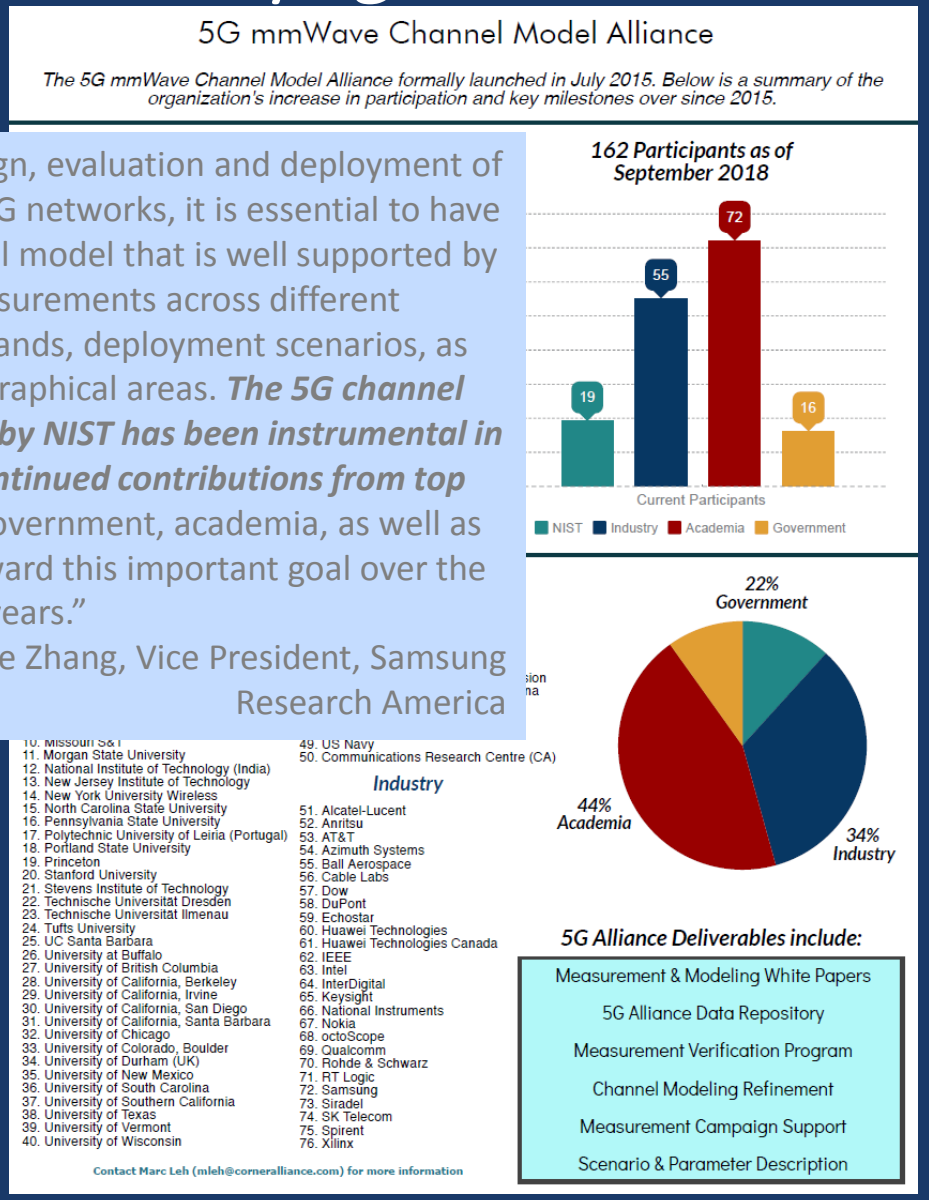
SUCCESSES

- Construction of channel sounding systems
- Development of channel models adopted by IEEE
- Establishment of 5G mmWave Channel Model Alliance & data repository

STAKEHOLDERS

- Equipment vendors (Samsung, Keysight), operators (AT&T, Verizon, Sprint), chipset manufacturers (Intel, Qualcomm)
- 5G mmWave Channel Model Alliance members
- Telecom Infro Project members (e.g. Facebook, Deutsche Telecom)

Next Generation Wireless –
mmWave Propagation Measurements and Modeling



For the design, evaluation and deployment of the future 5G networks, it is essential to have a 5G channel model that is well supported by diverse measurements across different frequency bands, deployment scenarios, as well as geographical areas. ***The 5G channel alliance led by NIST has been instrumental in inspiring continued contributions from top experts*** in government, academia, as well as industry toward this important goal over the last couple years."

– Charlie Zhang, Vice President, Samsung Research America

CONTEXT

Accurate channel propagation characterization is key to 5G and beyond development, standardization and deployment.

IMPACT

- Channel sounders at 28, 60, & 83 GHz
- Contributions to standards and modeling tool development (Mathworks/WLAN Toolbox).

FUTURE

- Channel sounders for phased-arrays.
- Development of 28 GHz urban canyon channel model (NIST, NYU, USC, Ilmneau, UBC, CRC, NCSU, Durham).

Fundamental Metrology for Communications

NIST Large Antenna Positioning System

GOAL: Provide state-of-the-art radio-frequency metrology to enable the development and commercialization of a broad range of RF electronics and wireless communications technologies.

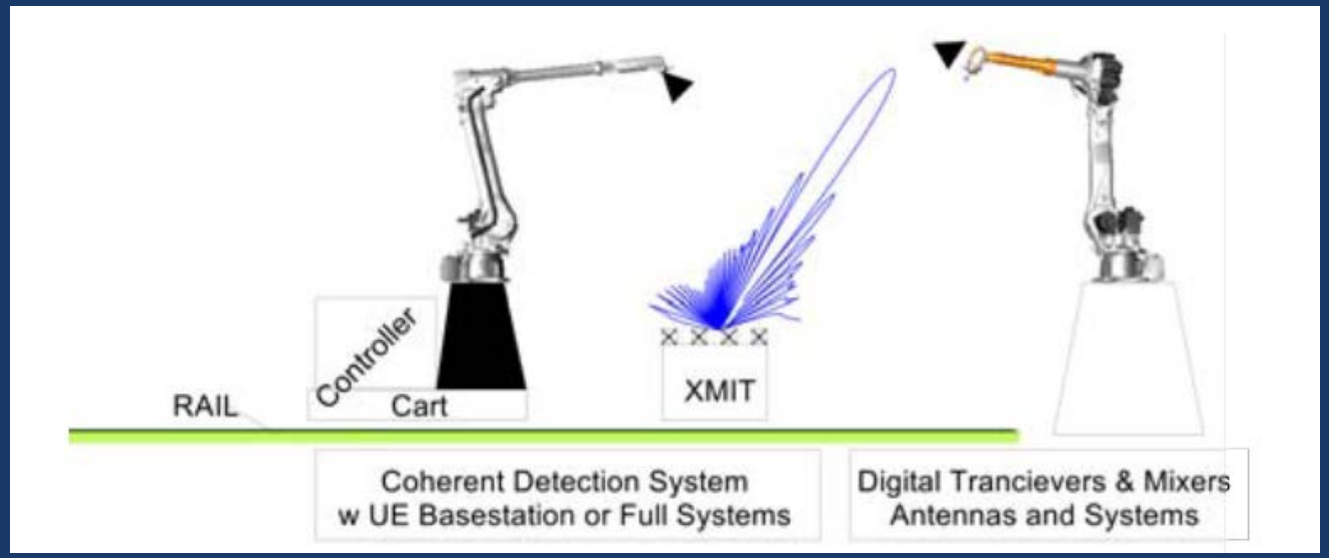
SUCCESSES

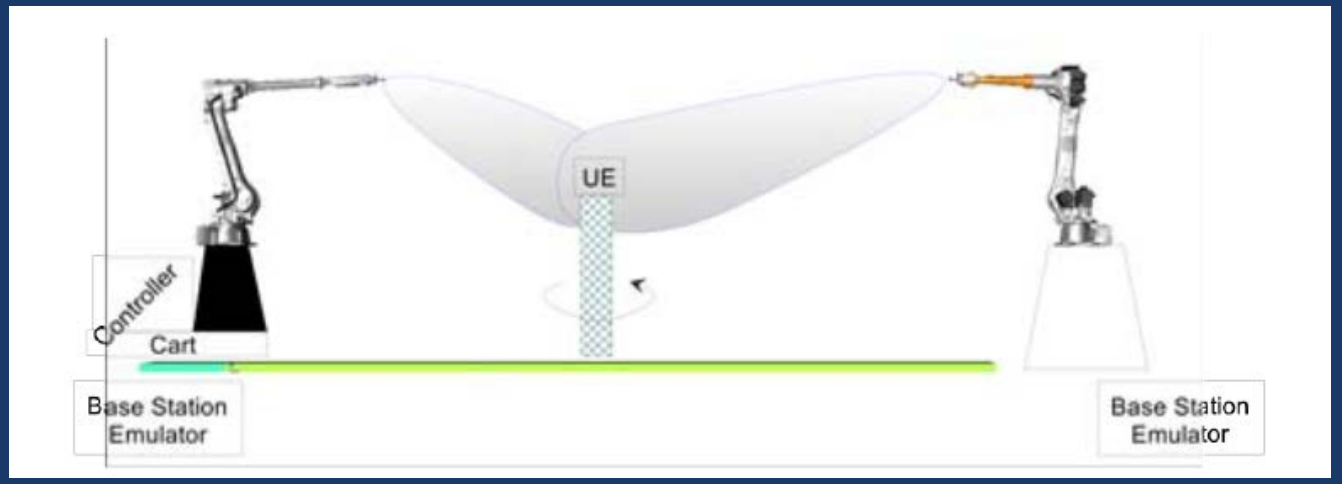
- First over-the-air test method for physically-large wireless systems (adopted by CTIA)
- Traceability for signal generation and measurement
- New Large Antenna Positioning System
- New NIST Broadband Interoperability Test Network

STAKEHOLDERS

- End Users
- Test Equipment Manufacturers
- Federal agencies (DARPA, DoD, FCC, NTIA, NIJ, DHS, FDA)
- Standards organizations (CTIA, ANSI, IEEE)

Fundamental Metrology for Communications: *Advanced Antenna Metrology*





CONTEXT

Next-generation communication systems will include beamforming antennas that can steer radiated signals to the desired location

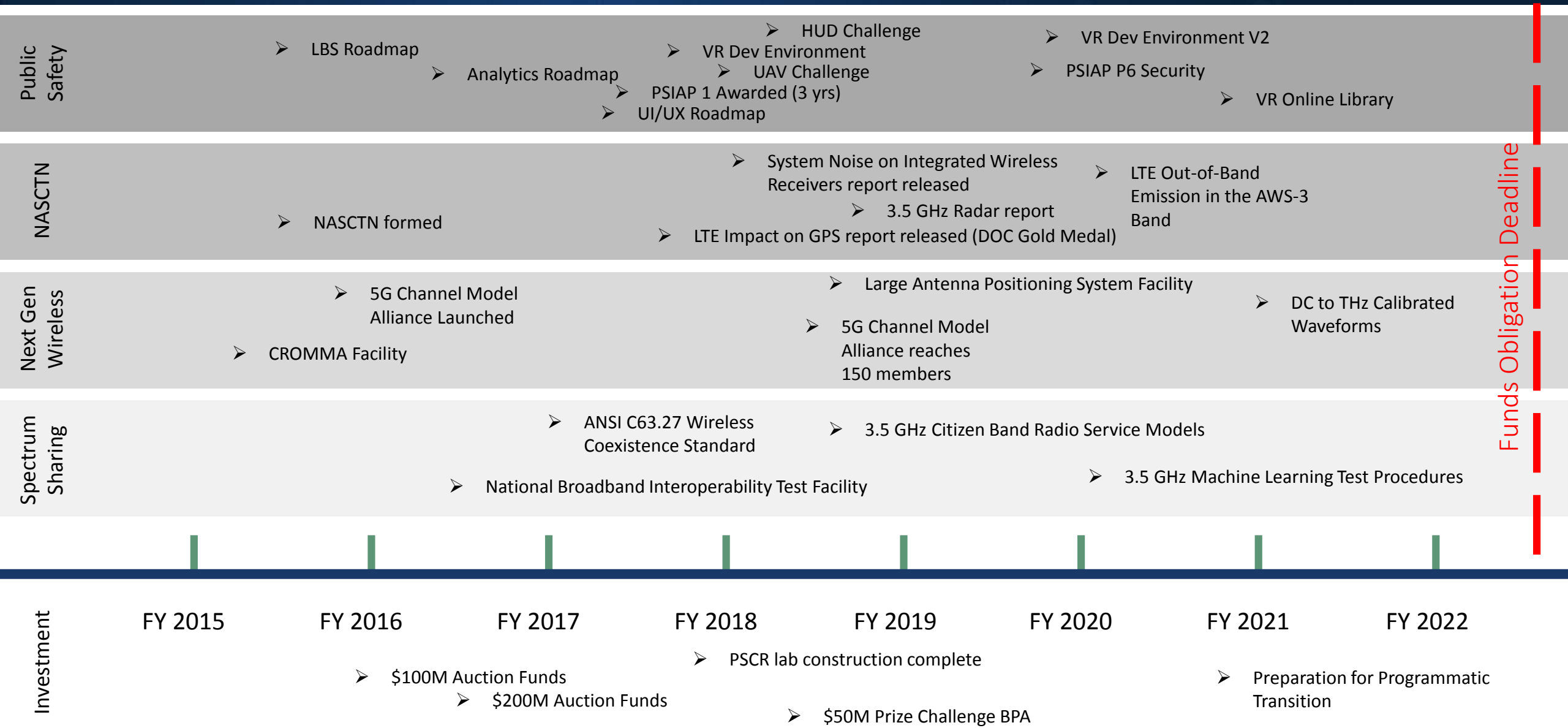
IMPACT

- Robotics-based antenna test methods developed by NIST now adopted by industry (e.g. Boeing)
- NIST awarded two patents related to new antenna measurement capability

FUTURE

New methods for measuring integrated antennas, which cannot be removed from a communications system, must be developed

CTL History


Public Safety
LBS Roadmap
Analytics Roadmap
HUD Challenge
VR Dev Environment
UAV Challenge
PSIAP 1 Awarded (3 yrs)
UI/UX Roadmap
VR Dev Environment V2
PSIAP P6 Security
VR Online Library
NASCTN
NASCTN formed
System Noise on Integrated Wireless Receivers report released
3.5 GHz Radar report
LTE Impact on GPS report released (DOC Gold Medal)
LTE Out-of-Band Emission in the AWS-3 Band
Next Gen Wireless
5G Channel Model Alliance Launched
CROMMA Facility
Large Antenna Positioning System Facility
5G Channel Model Alliance reaches 150 members
DC to THz Calibrated Waveforms
Spectrum Sharing
ANSI C63.27 Wireless Coexistence Standard
National Broadband Interoperability Test Facility
3.5 GHz Citizen Band Radio Service Models
3.5 GHz Machine Learning Test Procedures
Funds Obligation Deadline
FY 2015
FY 2016
FY 2017
FY 2018
FY 2019
FY 2020
FY 2021
FY 2022
Investment
$100M Auction Funds
$200M Auction Funds
PSCR lab construction complete
$50M Prize Challenge BPA
Preparation for Programmatic Transition

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

STAY IN TOUCH

CONTACT US

NIST.gov/ctl

@usnistgov

Working with NIST

NIST Communication Technology Laboratory

Informal collaborations: visiting scientists, sabbaticals, joint peer-reviewed papers,

Cooperative Research and Development Agreements (CRADAs): formal partnership to facilitate work with U.S. companies, academia, and other organizations on joint projects.

Use of Designated Facilities: NIST has several unique and valuable laboratory facilities available for use by U.S. organizations for both proprietary and non-proprietary research. Access to these designated facilities is generally provided on a first-come, first-served cost-reimbursable basis.

marla.dowell@nist.gov
(303) 497-7455

NIST

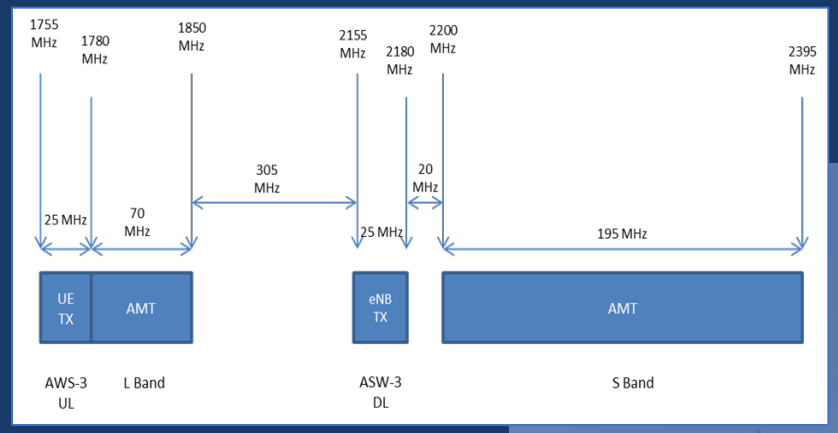
Manufacturing Extension Partnership: nationwide network of resources for manufacturing and business expertise for U.S. companies

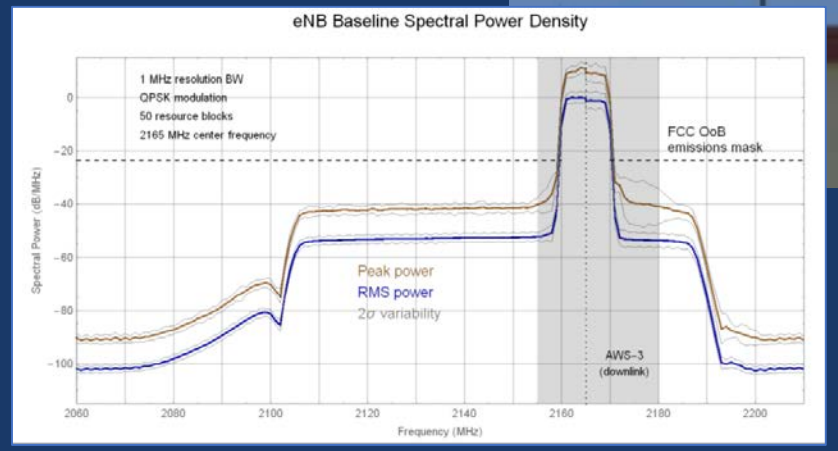
Colorado Association for Manufacturing and Technology: http://newcamt.camt.com/

301-975-2573
tpo@nist.gov

General inquiries about patents, licensing, and NIST Small Business Innovation Research Program

Trusted Spectrum Testing: LTE Out-of-Band Emission in the AWS-3 Band





CONTEXT

Complex measurement problem to identify LTE impact on DoD Test ranges due to spectrum auction.

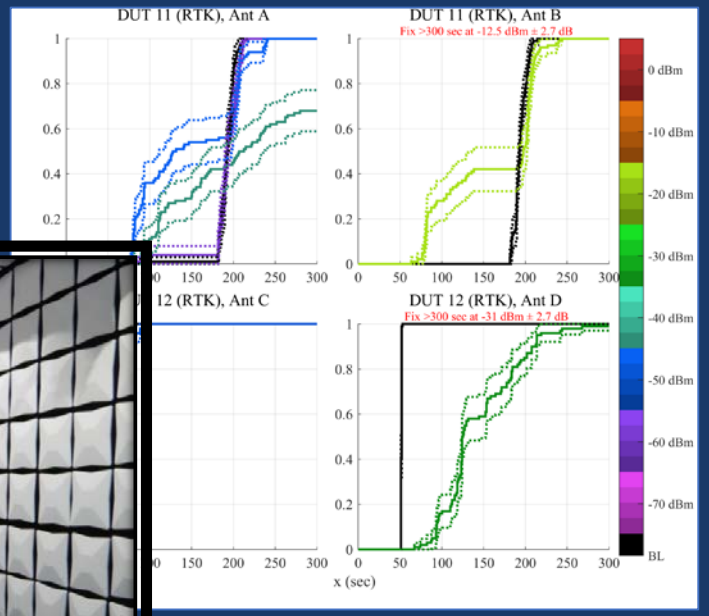
IMPACT

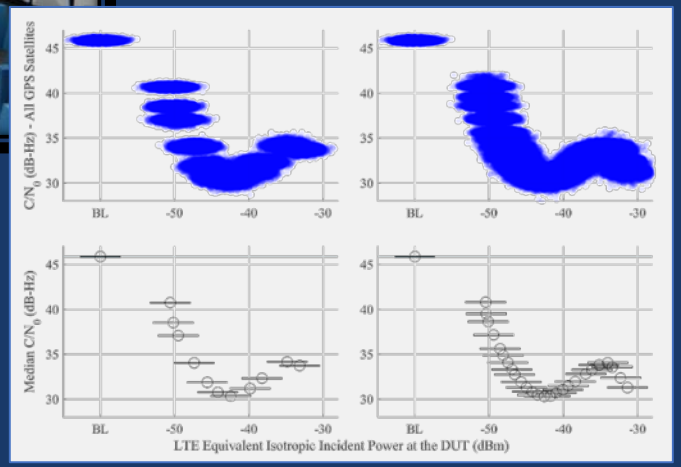
Enabled DoD to identify specific filters to mitigate impact, maximize performance at select ranges.

FUTURE

NASCTN is working with agencies to identify potential key measurements in advance of the 2024 Spectrum auction.

Trusted Spectrum Testing: LTE Impacts on GPS L1





CONTEXT

A trusted neutral party was required to investigate and measure effects of LTE signals on GPS receivers operating in nearby frequency bands.

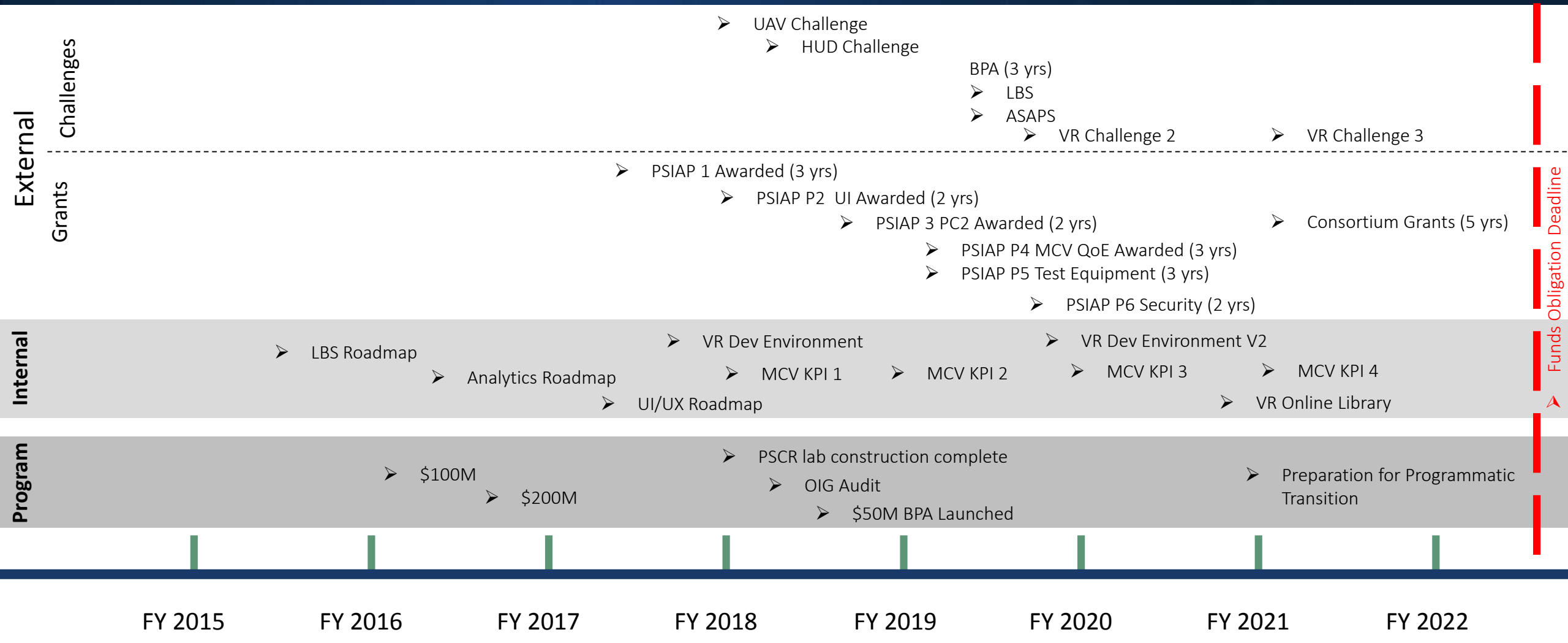
IMPACT

Final Policy decisions by regulators and Federal Agencies are currently in progress, utilizing this test data.

FUTURE

NASCTN is working with agencies to identify potential key measurements in advance of the 2024 Spectrum auction.

CTL History


External
Challenges
UAV Challenge
HUD Challenge
BPA (3 yrs)
LBS
ASAPS
VR Challenge 2
VR Challenge 3
Grants
PSIAP 1 Awarded (3 yrs)
PSIAP P2 UI Awarded (2 yrs)
PSIAP 3 PC2 Awarded (2 yrs)
Consortium Grants (5 yrs)
PSIAP P4 MCV QoE Awarded (3 yrs)
PSIAP P5 Test Equipment (3 yrs)
PSIAP P6 Security (2 yrs)
Internal
LBS Roadmap
VR Dev Environment
VR Dev Environment V2
Analytics Roadmap
MCV KPI 1
MCV KPI 2
MCV KPI 3
MCV KPI 4
UI/UX Roadmap
VR Online Library
Program
$100M
PSCR lab construction complete
$200M
OIG Audit
$50M BPA Launched
Preparation for Programmatic Transition
Funds Obligation Deadline
FY 2015
FY 2016
FY 2017
FY 2018
FY 2019
FY 2020
FY 2021
FY 2022

CTL SWOT

STRENGTHS

- Strong research programs tied to external partners
- Cross-cutting strategic focus areas uniting laboratory programs
- Strong ties to other NIST Labs

WEAKNESSES

- Strong stakeholder focus impacts exploratory research efforts
- Administrative delays impact timely mission execution; only 48 months remain on PSCR auction funds

OPPORTUNITIES

- Introduce measurements into spectrum auction decision process
- Industrial Internet of Things (CTL/EL/ITL)
- Optical communications (CTL/ITL)

THREATS

- Loss of spectrum auction funds → too small to succeed
- Other agencies encroaching on NIST mission
- Recruiting staff with communications expertise

CTL Leadership and Budget

Marla Dowell, CTL Director
Melissa Midzor, NASCTN Program Manager
Dereck Orr, Public Safety Communications Research Division
Michael Janezic, Radio Frequency Technology Division
Nada Golmie, Wireless Technology Division
Brian Copello, Executive Officer

leadership with pictures
Budget pie chart – emphasis
No base funds for public safety
Supports other NIST labs – EL, ITL, PML
Supports external organizations

Total budget pie chart
Public safety – prize challenges, NIST CTL, NIST other

No workforce numbers

STRS Base	STRS non-Base	STRS Total	RA	PSCRF	Other WCF	OU Total
21,394	2,708	24,102	8,324	49,691	292	82,410

Division Name	STRS Budget ($K)	Total Budget ($K)	Federal workers	U.S Assoc.	Foreign Assoc.	Total Workers
HQ	868	868	10	3	2	**15**
NASCTN	1,448	4,348	5	6	0	**11**
Public Safety	0	50,418	35	12	0	**47**
RF Technology	15,339	17,431	38	40	4	**82**
Wireless Networks	6,447	9,345	21	3	13	**37**
Total	**24,102**	**82,410**	**109**	**64**	**19**	**192**