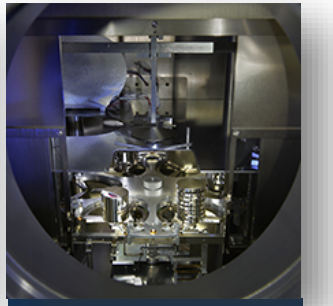
Communications Technology Laboratory Overview

Marla Dowell, Director

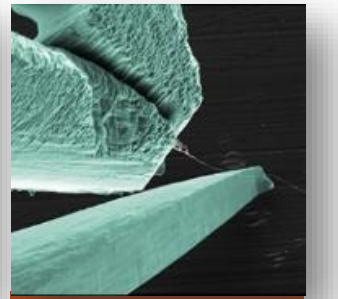
National Institute of Standards and Technology
U.S. Department of Commerce

CTL Communications Technology Laboratory

NIST Laboratory Programs






Material Measurement Laboratory

Physical Measurement Laboratory

Engineering Laboratory

Information Technology Laboratory

Communication Technology Laboratory

Center for Nanoscale Science and Technology

NIST Center for Neutron Research

Metrology Laboratories

Technology Laboratories

National User Facilities

Driving Innovation through Measurement Science and Standards

Accelerating the adoption and deployment of advanced Technology solutions

Providing world class, unique, cutting-edge Research facilities

CTL Mission

To promote the development and deployment of advanced communications technologies through dissemination of high-quality measurements, data, and research supporting U.S. innovation, industrial competitiveness, and public safety.

CTL Organizational Structure

Established in 2014 with proceeds from NIST and the Public Safety Trust Fund

Paul Hale

RF Technology

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

Melissa Midzor

NASCTN

National Advanced Spectrum and Communications Test Network (NASCTN)

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

Dereck Orr

PSCR

Public Safety Communication Research

Supports development of Nationwide Public Safety Broadband Network

Nada Golmie

Wireless Networks

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

Public Safety Communications Research Division (671)

PSCR

Dereck Orr

Staff : Feds (Perm/Term): 15/21
Associates: 24
Budget: $48.5M; $25M extramural funding

Goal: Accelerate adoption and implementation of most critical public safety communication technologies through rigorous measurement-based methodologies through NIST research programs and external partnerships.

Key Research Areas:

- Land Mobile Radio (LMR) to LTE
- Mission Critical Voice (MCV)
- Location-Based Services (LBS)
- User Interface/User Experience (UI/UX)
- Public Safety Analytics
- Security
- Resilient Systems

Key Stakeholders:

- FirstNet
- DHS
- Public safety professionals, e.g., law enforcement, fire fighters
- Secondary responders, e.g., utilities, transportation, hospitals
- Device manufacturers
- Service providers

Outcomes:

- Technology roadmaps
- Documentary standards
- Increased research capacity through grants and prize challenges
- Stakeholder tools and metrics, e.g., use cases, mobile applications, video analytics

RF Technology Division (672)

Paul Hale

Staff : Feds (Perm/Term): 29/5
Associates: 52
Budget: $17M

Goal: develops theory, metrology and standards that drive the future of wireless communications – from transistors and antennas to integrated circuits and systems.

Key Research Areas:

- Spectrum sharing
- Channel Measurements
- milimeter Wave (mmWave) electronics
- Multiple Input Multiple Output (MIMO) antennas and beam forming
- Over-the-Air Testing
- Internet of Things
- 5G and Beyond

Key Stakeholders:

- Test Equipment Manufacturers
- Device Manufacturers
- Federal agencies
- Standards Development Organizations
- Major manufacturers of communication systems
- Satellite manufacturers
- mmWave Channel Model alliance
- 5G data repository

Outcomes:

- Documentary Standards (IEEE 802, 3GPP, ANSI, CTIA)
- Publications and presentations
- Patents
- Measurement Services
- Microwave Uncertainty Framework
- Unique measurement facilities

Wireless Networks Division (673)

Nada Golmie

Staff : Feds (Perm/Term): 19/2
Associates: 23

Budget: $9M

Goal: Develop, deploy, and promote emerging technologies and standards that will dramatically improve the operation and use of wireless networks.

Key Research Areas:

- Metrology for next generation wireless networks
- Spectrum Sharing test methods and requirements for Citizens Broadband Radio Service
- Performance evaluation and modeling for mission critical voice

Key Stakeholders:

- 5G mmWave Channel Model Alliance
- Standards Development Organizations (IEEE, 3GPP, WinnForum)
- Service providers, wireless equipment manufacturers, and modeling tool vendors

Outcomes:

- Simulation models and software tools
- 5G channel model and measurement repository (https://5gmm.nist.gov/)
- Future Generation Wireless Research and Development Gaps Report (NIST SP 1219)
- Radio-resource allocation and beamforming algorithms

National Advanced Spectrum and Communications Test Network

NASCTN
National Advanced Spectrum and Communications Test Network


Melissa Midzor

NIST Staff :	Feds (Perm/Term): 3/0 Associates: 10
Budget:	$5M

Goal: Provides testing, modeling and analysis necessary to develop and deploy spectrum-sharing technologies and inform future spectrum policy and regulations through a national network of Federal, academic, and commercial test facilities.

Key Functions:

- Test plan development with independent technical experts
- National network of test facilities
- Neutral, independent oversight
- Validated test results and methodologies
- Protection of proprietary, sensitive, and classified information

Key Stakeholders:

- DOD, NTIA, NOAA, NASA, and NSF
- MITRE
- Johns Hopkins University
- Device manufacturers
- Network providers

Outcomes:

- Quantitative metrics with NIST traceability and uncertainty analyses
- Data to DOD for evaluation of impact of AWS-3 auction
- Implemented 6 key spectrum sharing projects that brought together Commercial partners and Federal agencies

CTL Administrative Excellence Critical to Organizational Success

Brian Copello

Linda Derr
NASCTN

Bryan Gamble
RF Technology

Danni Leicht
PSCR

Lucy Tedesco
Wireless Networks

Streamlining our administrative processes to match the speed of this industry is absolutely critical to our success

Key Attributes:

- Provides critical support for mission functions
- Innovative financial management tools
- Leverage partnerships with other NIST organizations to accelerate outcomes
- Early adopter of new service models
- Serves as NIST Boulder Laboratory headquarters

Unique Opportunities

- Creating career ladders for administrative staff
- Administrative staff serve on NIST committees to improve administrative processes
- Leadership development
- Continuous learning

Award Winning Outcomes:

- DOC Silver Medal for Building 3 renovation project
- NIST Excellence in Administration Award for HR hiring tool
- NIST Crittenden Award for establishing new administrative organizations

CTL Priority Areas

Collaborative research organization with research activities spanning organizational boundaries in support of CTL priority areas

1 Public Safety Communications

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

Champion: Dereck Orr

2 Trusted Spectrum Testing

To improve spectrum-sharing agreements, and inform future spectrum policy and regulations through independent validated testing.

Champion: Melissa Midzor

3 Next Generation Wireless

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

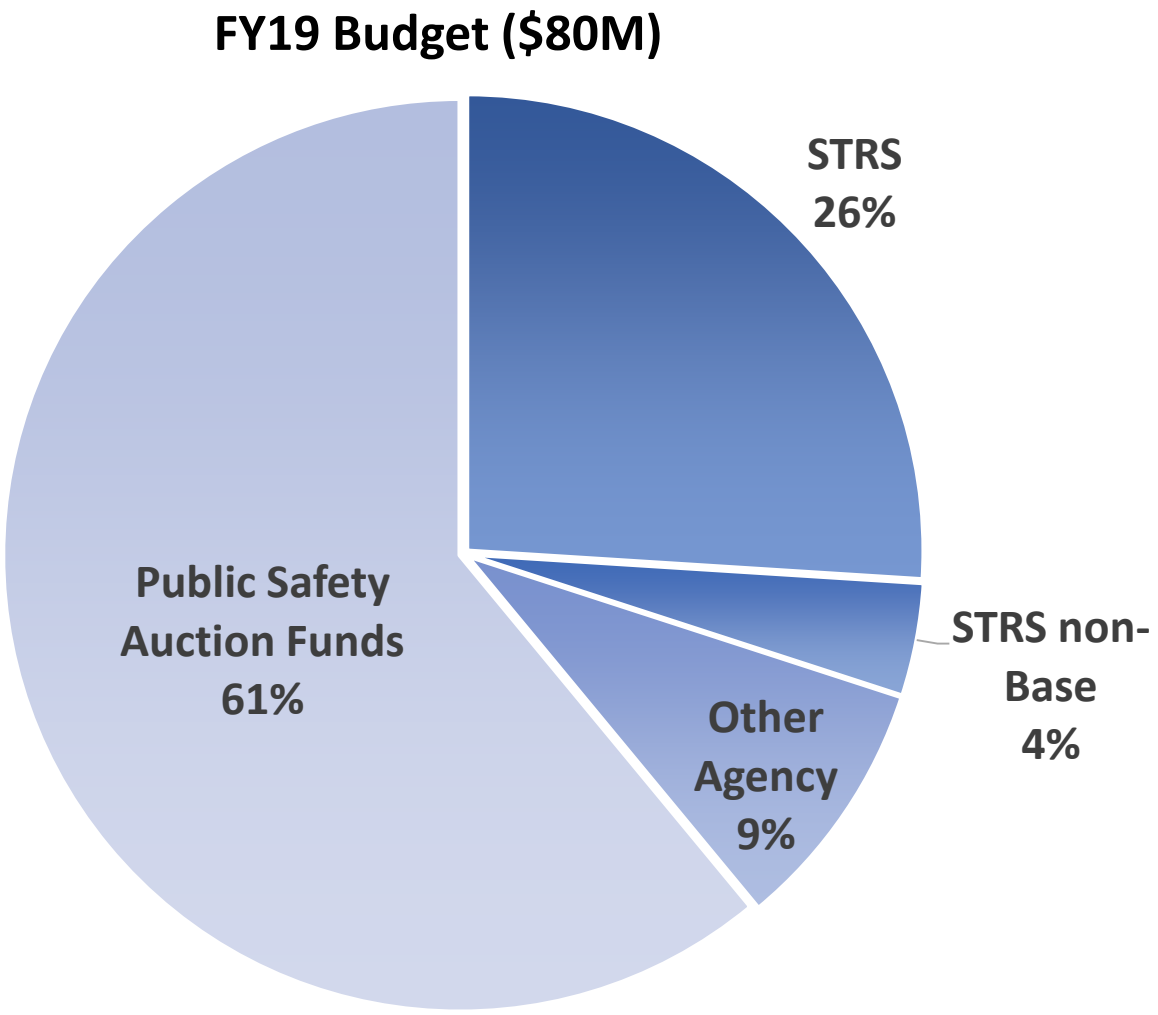
Champion: Nada Golmie

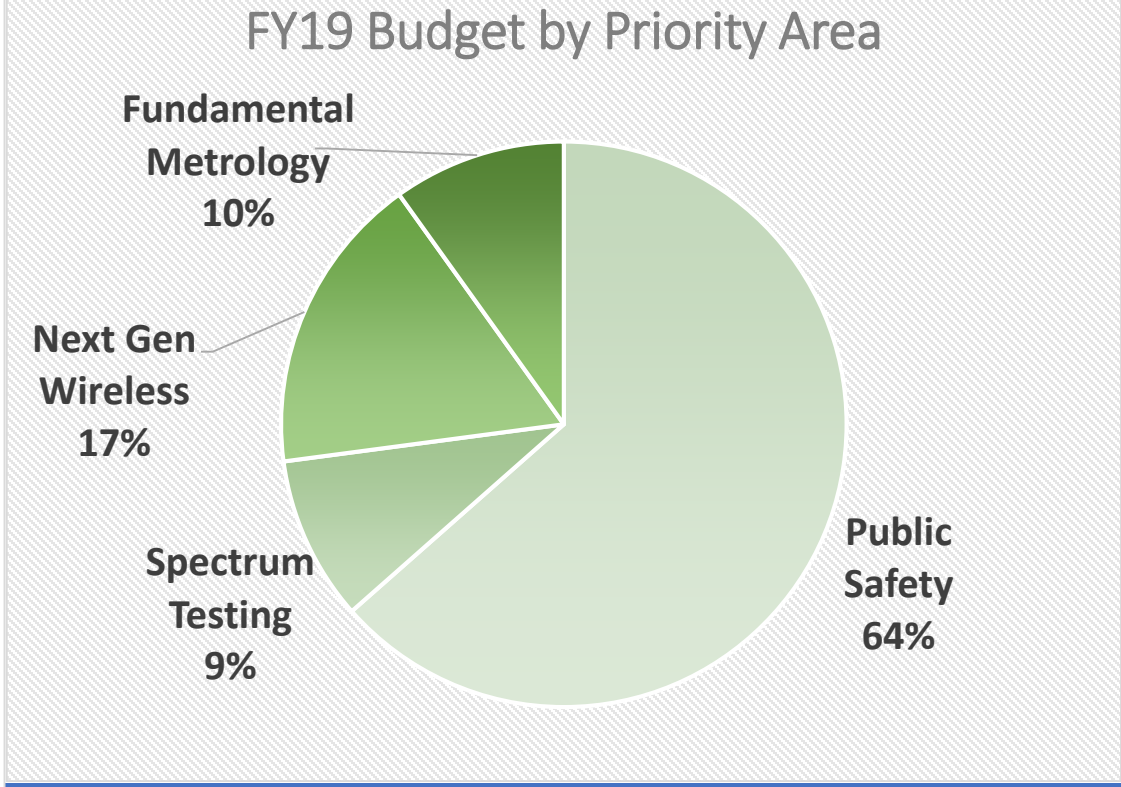
4 Fundamental Metrology for Communications

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

Champion: Paul Hale

CTL Priority Areas and Budget





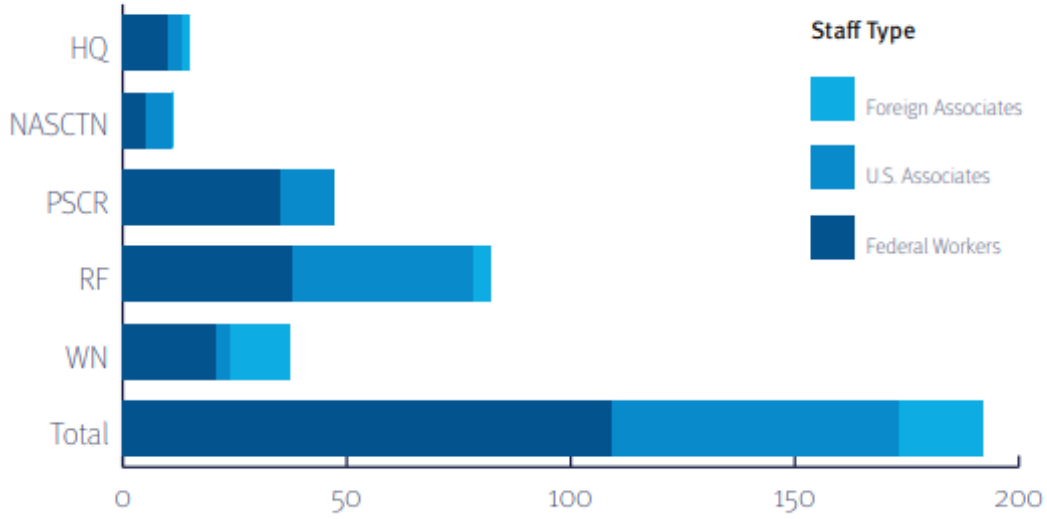
Staffing:

- **75 career Federal Employees**
- **29 term Federal Employees**
- **115 Associates**

CTL Staff

- Rely on mix of permanent and temporary staff to carry out mission
- Temporary staff include associates and term-limited federal employees
- Leveraging NIST Leadership Development Program and external professional development opportunities
- Mentoring
- Staff hold leadership positions in professional societies and standards development organizations.
- Staff have leadership positions across NIST.

Making Fighting Fires in Virtual Reality More Like Real Reality



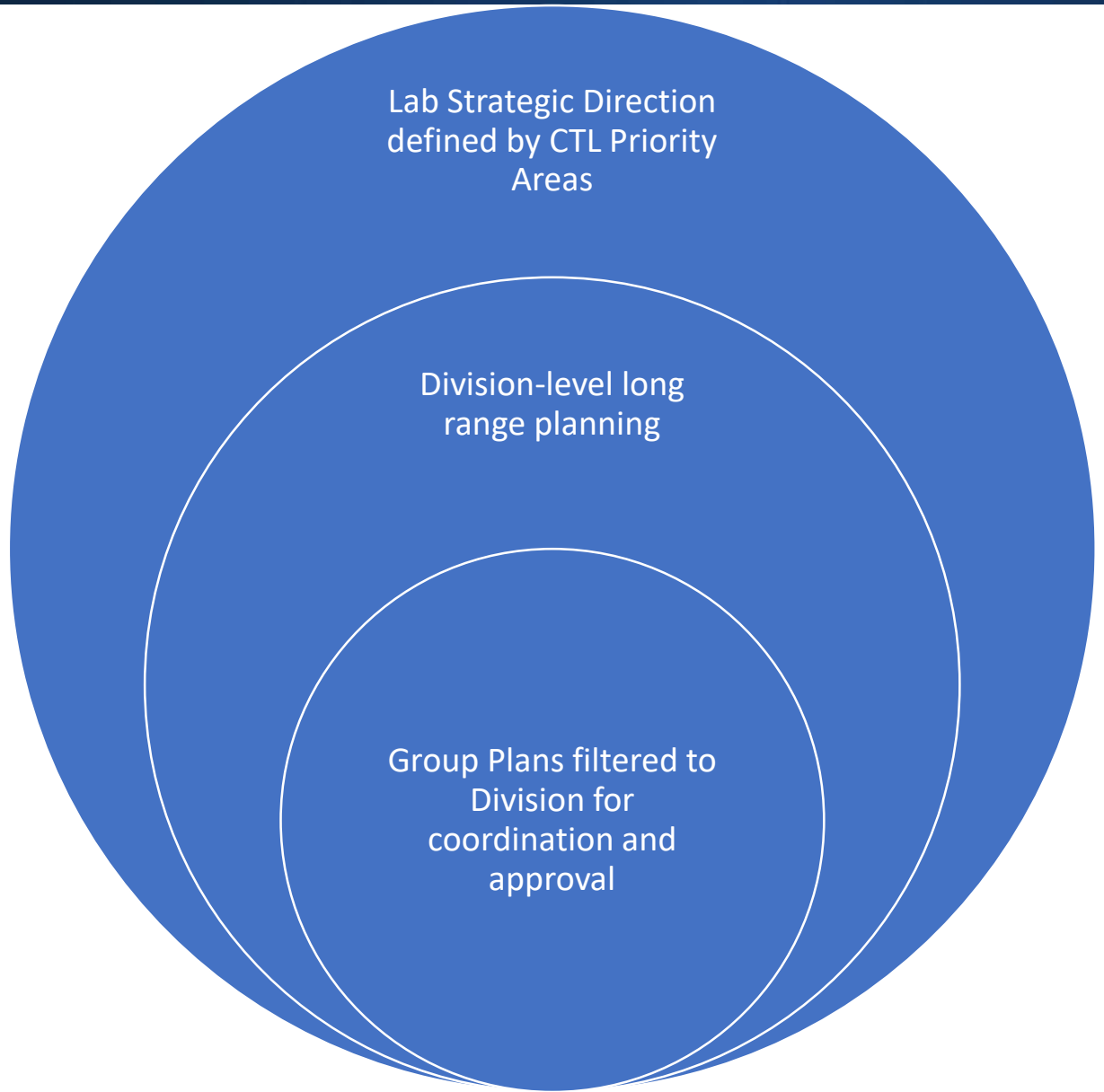
Federal Workers include a mix of career and term-limited employees

Staff Feedback: 2018 Federal Employee Viewpoint Survey

Supportive, yet demanding work environment

	Positive CTL (NIST)	Negative CTL (NIST)
My supervisor supports my need to balance work and other life issues	100 % (87 %)	0 % (6 %)
Supervisors support employee development	85 % (76 %)	7 % (10 %)
I can disclose a suspected violation without fear of reprisal	86 % (71 %)	7 % (12 %)
Employees in my work unit share knowledge with each other	94 % (79 %)	6 % (9 %)
Skill level in my work unit has improved in the past year	86 % (58 %)	3 % (12 %)
I feel encouraged to come up with new and better ways of doing things.	82 % (74 %)	3 % (12 %)
My workload is reasonable	48 % (59 %)	34 % (22 %)

CTL Strategic Planning



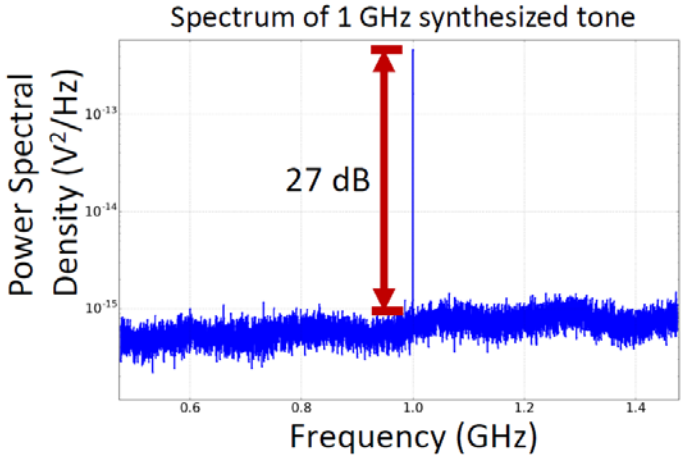
Resources focused on meeting CTL priorities

Asking the important question, "What do you need to accomplish task x?" is a better approach than asking the question, "How much can you get done with $y?"

CTL Innovations in Measurement Science

Programmable Waveform Synthesizers with Quantum-based Accuracy

Quantum-synthesized waveforms from DC to 300 GHz

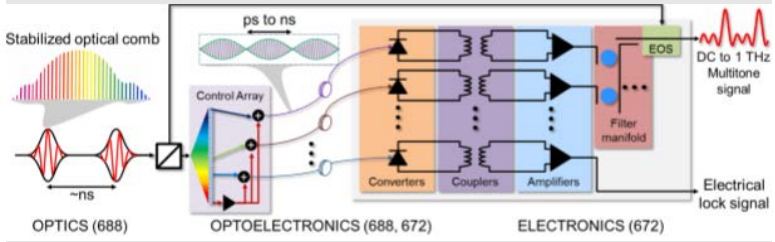


Start: FY16
$6.7M over 5 years
Collaborators: NIST PML

DC to 1 THz Large-Amplitude Optoelectronic Multitone Electrical-Signal Synthesizer

Enabling precise tests on modern electronics operating > 40 GHz

Moving beyond trial-and-error device design for high-bandwidth, low-latency applications from telecommunications to robotics

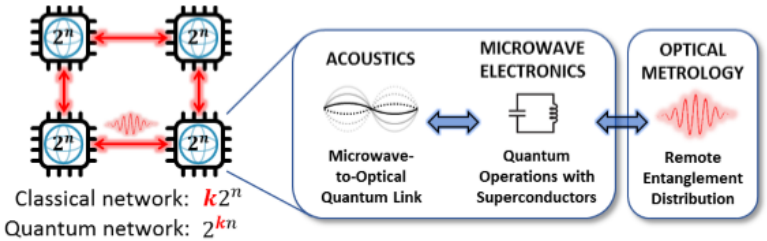


Start: FY18
$6.5M over 5 years
Collaborators: NIST PML

Establishing the S&T of networks for superconducting quantum computing

World's first small-scale quantum network for standards development

Leveraging NIST expertise in superconducting qubits and communications



Start: FY19
$6 M over 5 years
Collaborators: NIST PML and ITL

CTL Outputs and Technology Transfer

Actively pursuing outreach and partnership opportunities to support our stakeholders

Publications, Talks, Patents

- **Peer-review publications, e.g., IEEE, AIP**
- **Industry Roadmaps**
  - Future Generation Wireless R&D Gaps Report
- **Trade journal articles**
- **Social media**

Customer Engagement and Partnerships

- **5G mmWave Alliance**
- **Cooperative Research and Development Agreements**
  - 700 MHz Public Safety Broadband Demonstration Network
- **Prize Challenges**
  - Tech to Protect Challenge
- **Standards Development Organizations**

Workshops

- **Annual Public Safety Broadband Stakeholder Meeting**
- **PSCR Internet of Things**
- **Machine Learning for Optical Communications**
- **Joint NASCTN U.S. Strategic Command Workshop on Electromagnetic Battle Management**
- **DOC Space Commerce R&D Needs**

CTL Opportunities

Industrial Internet of Things

New channel measurements and models in highly reflective environments

New equipment for high-bandwidth, low-latency devices (> 40 GHz)

Partnering with NIST Engineering Laboratory

NIST Public Safety Innovation Accelerator Program

Optical Communications

- Trusted training data for optical network performance and planning
  Partnership opportunities with NSF test beds
- Quantum Networks IMS program
  - Defining measurements, specifications, & standards

  Partnership with NIST Physical Measurement and Information Technology Laboratories

Integrating Trusted Spectrum Testing into FCC Auctions

- Enable risk-based business decisions based on quantitative measurements
- Neutral, Independent identification of quantitative metrics and methods for spectrum sharing decisions

CTL Opportunities

Industrial Internet of Things

New channel measurements and mo
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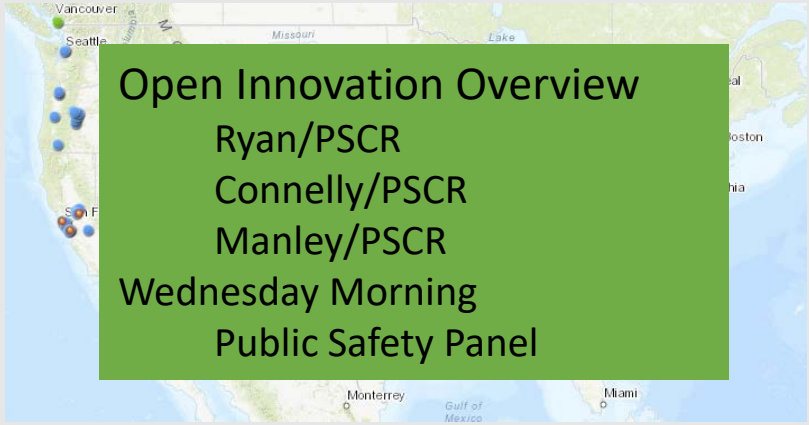
Partnering with NIST Engineering Laboratory

Over-the-Air Test Lab Tour
- Remley/RF Technology

Wednesday Morning
- Metrology for Advanced Communications Panel

NIST Public Safety Innovation Accelerator Program



Open Innovation Overview
- Ryan/PSCR
- Connelly/PSCR
- Manley/PSCR

Wednesday Morning
- Public Safety Panel

Optical Communications

- Trusted training
  performance ar
  Partnership opportu
- Quantum Netw
  - Defining me

Partnership with NIS
Laboratories

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Optical Networks
- Dowell/CTL
- Hale/RF Technology

Tuesday Afternoon
- Metrology for Advanced Communications Panel

Integrating Trusted Spectrum Testing into FCC Auctions

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AWS-3 Presentation
- Coder/RF Technology
- Midzor & Wunderlich/NASCTN

Tuesday Afternoon
- Metrology for Advanced Communications Panel

CTL Challenges and Threats

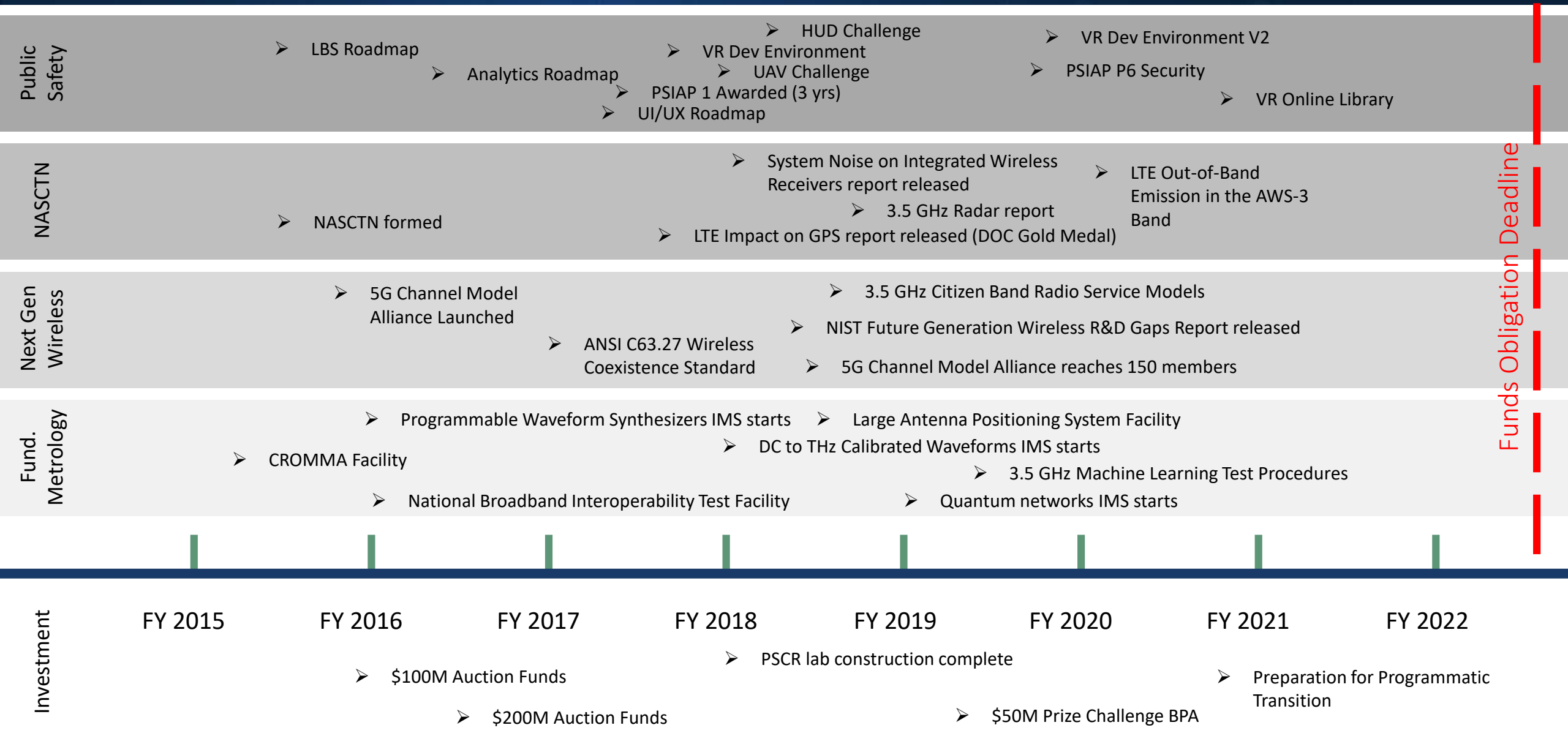
Expiring Public Safety Auction Funds in FY22	Public Safety Innovation Accelerator Program NIST-wide public safety research program
Maintaining Neutrality for Trusted Spectrum Testing	Success in controversial projects like NASCTN LTE Impacts on GPS requires NASCTN to remain unbiased, accurate, and trusted by the community NIST 5G mmWave Alliance serves as neutral convener for industry and academia
DOC Boulder Laboratory oversite	CTL Headquarters responsibility Aging facilities infrastructure impacts research capabilities • inadequate IT infrastructure • lack of suitable office and lab space in Gaithersburg
Timeliness of federal processes	Procurement delays Hiring Legal review delays for grants, prize challenges, cooperative agreements, interagency funding

2015 NRC Findings: We heard you!

Recommendation	Response
CTL should develop a more defined research agenda that outlines in detail its research goals and future plans.	CTL engages staff in a rigorous annual research planning process focused on CTL priority areas of public safety, trusted spectrum testing, and metrology for advanced communications.
CTL should maintain a position of leadership in the 5G Millimeter Wave Channel Model Alliance, seek to expand the membership of the alliance	NIST's establishment of the alliance has grown to more than 175 participants from over 80 organizations; industry cites it as "instrumental in inspiring continued contributions from top experts in government, academia, as well as industry"
CTL should quickly hire and train personnel to establish a leading-edge skill set in areas associated with their research goals and upgrade aging facilities and instrumentation.	CTL has brought on approximately 100 new staff, expanding skill sets with expertise in LTE, security, and VR. CTL has made significant investments in its antenna facilities and public safety research facilities
National Advanced Spectrum and Communications Test Network should be made fully functional as soon as possible to be able to handle the important mission that it has been assigned.	Expanded membership includes DOD, NASA, NOAA, NSF, and NTIA. Completed projects include LTE impact federal systems in the AWS-3 Band, LTE impact on GPS receivers, as well as effects of LTE out-of-band emissions in the AWS-3 Band.

Your input helps inform CTL programs

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
ANSI C63.27 Wireless Coexistence Standard
3.5 GHz Citizen Band Radio Service Models
NIST Future Generation Wireless R&D Gaps Report released
5G Channel Model Alliance reaches 150 members
Fund. Metrology
CROMMA Facility
Programmable Waveform Synthesizers IMS starts
National Broadband Interoperability Test Facility
Large Antenna Positioning System Facility
DC to THz Calibrated Waveforms IMS starts
3.5 GHz Machine Learning Test Procedures
Quantum networks IMS starts
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

QUESTIONS?