Advanced Communications

VCAT 3/27/26

NIST COMMUNICATIONS TECHNOLOGY LABORATORY

CTL's R&D is integrated across the whole communications ecosystem, from chip level to networks to spectrum usage to applications.

Strategic Planning

CTL Strategic Roadmaps

In process

6G Communications

RF Metrology and Calibration Services

Quantum Communications

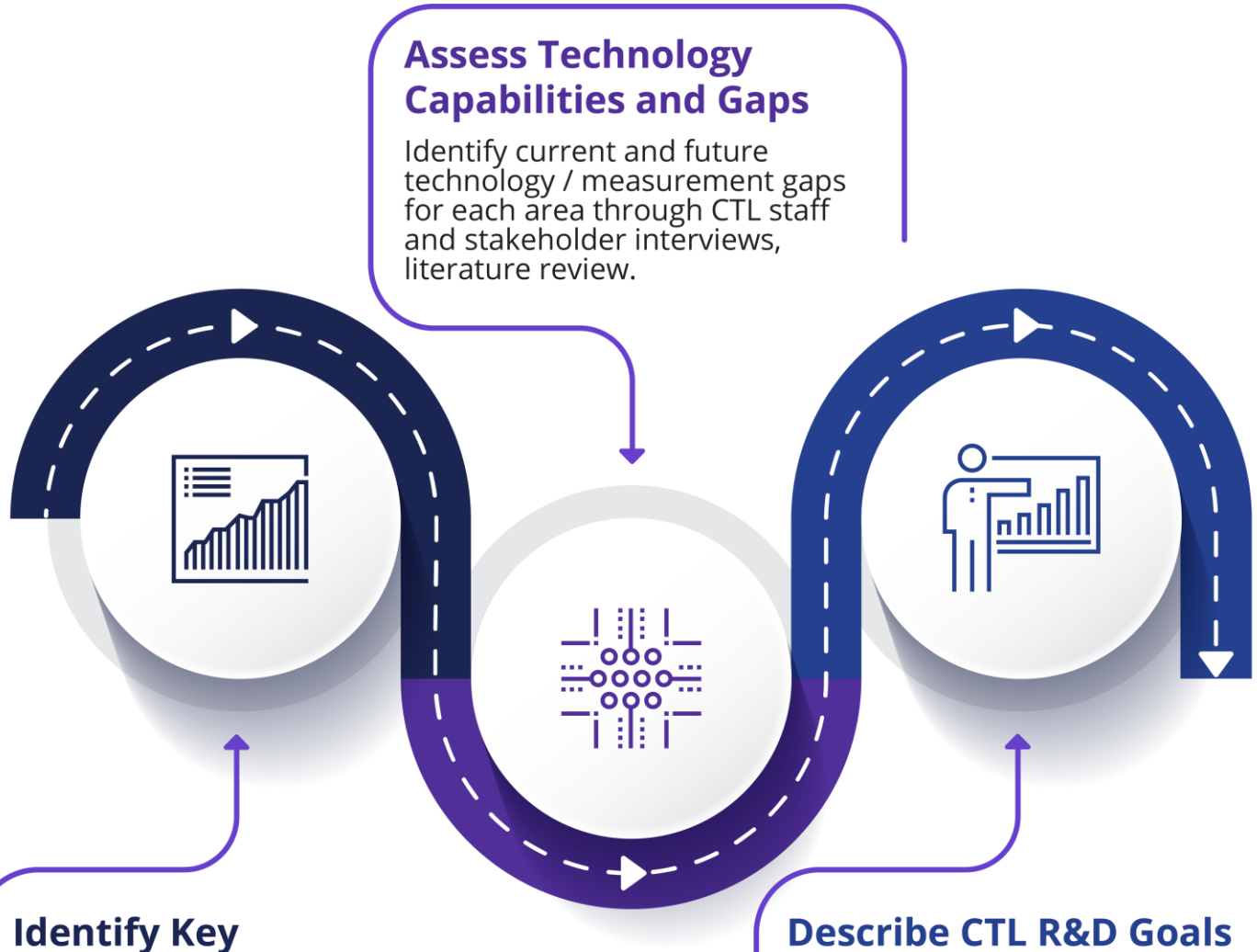
Public Safety Communications

Spectrum Science

New!

Space Communications

Roadmap Framework



Assess Technology Capabilities and Gaps

Identify current and future technology / measurement gaps for each area through CTL staff and stakeholder interviews, literature review.

Identify Key Trends and Drivers

Describe the current activities and external factors driving the need for innovation in each area.

Describe CTL R&D Goals

Describe specific R&D opportunities for CTL to prioritize in this area. Describe the importance and impact of working towards those goals.

6G Roadmap Goals

1. Enable AI-Native 6G Applications
2. Enable Sensing
3. Make 6G Systems More Robust and Resilient
4. Make 6G Infrastructure Secure
5. Validate Design of 6G Hardware

Goal 1: Enable AI-Native 6G Applications. The objective of this goal is to develop high-quality datasets for training, baselining, and benchmarking AI applications in 6G networks.

Action: Define the Top 5 categories for the data CTL would provide (e.g., propagation, sensing, spectrum usage, public safety user data).

Standards Contributions: Collaborate with 3GPP to incorporate AI models for propagation, interference, and sensing into specifications

Research Impacts & Future Direction

6G Communications

Set to launch in 2030, 6G is expected to offer enhanced capabilities and substantial improvements in speed, latency, capacity, and connectivity.

Integrated Sensing and Communications

R&D in RF measurement, instrumentation and support for standard development

AI-native Networks

Collection, curation, and dissemination of measurement-based datasets

Ubiquitous and resilient coverage

Support of multi-hop relay, sidelink, and extension of NTN capabilities (3GPP)

6G Highlights

RF measurements and multi-modal datasets

Development of context-aware channel sounding with LIDAR, camera and RF.

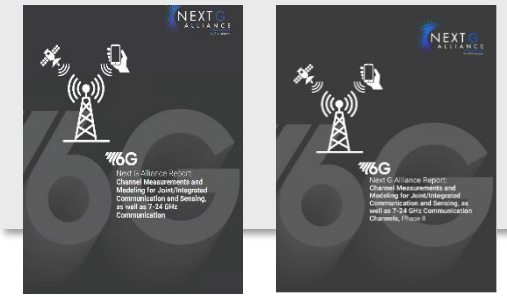
Wide dissemination of measurement-based, multi-modal datasets for digital replicas and AI/ML training on nextg.nist.gov.

Photo Credit: Jelena Senic

Integrated Communications and Sensing

Partnership with ATIS/NGA members to provide channel measurements and modeling techniques for integrated sensing and communications.

Contributions to 3GPP RAN1 and extension of TR 38.901



Standard Development

R&D in wireless communications, protocol modeling, testing, and performance evaluation in support of participation and contributions to 3GPP, IEEE, O-RAN Alliance, ITU-R, IETF.

RF Metrology and Calibrations

Fundamental RF metrology supports electronic test and measurement across multiple sectors, including communications, aerospace, defense, microelectronics, and transportation

Enhancing

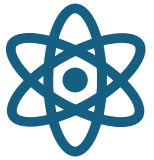
Enhancing Traditional Measurement Services: Continuously improving established calibration methods to meet evolving industry needs.

Innovating

Innovating Measurement Techniques: Developing new measurement techniques and services for dynamic, connector-less, and high-frequency systems.

Establishing

Establishing an Advanced Uncertainty Analysis Framework: Creating a scalable framework that includes correlations and extends across complex calibration chains.



Bridging

Bridging Classical and Quantum Metrology: Applying expertise in classical communications and electromagnetics to advance quantum computing and quantum communications.

RF Metrology Highlights

New Atom-Based Thermometer

Developed a high-accuracy temperature measurement method using “Rydberg” atoms. It offers precise, factory-calibration-free readings based on quantum physics.

DOI:10.1103/PhysRevResearch.7.L012020

Photo Credit: Noah Schlossberger

On-wafer Standard Reference Material

Establishing a traceable new on-wafer standard to enable high-frequency semiconductor materials and circuit metrology

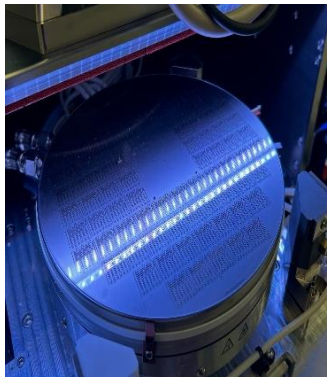


Photo Credit: Nate Orloff

Quantum Voltage

New traveling measurement system to validate voltage standard SRIs that are intrinsically accurate based on quantum effects of superconductors

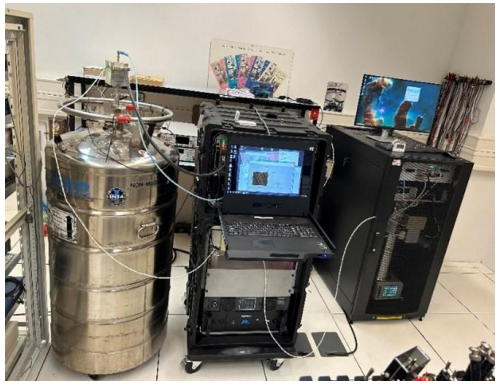


Photo Credit: Sam Benz

Spectrum Science

Develop and demonstrate modernized test methodologies that provide robust data to overcome the Nation's most pressing spectrum science and wireless coexistence challenges.

Technology Transfer

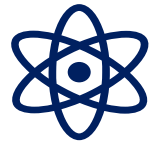
Plays a crucial role in technology transfer to bring proof-of-concept to American innovation. We lead the way in optical time transfer and enable commercial innovation.

Research Innovation

Innovative measurement methods to advance science and influence international standards. Develop first-of-their-kind measurement standards to enable wireless coexistence measurements.

Trusted Partner

Building community trust in spectrum measurements by addressing data gaps and sharing with government and industry partners for informed decision-making.



Facilities

Purpose-built facilities enable state-of-the-art measurements and unique perspectives. Carrier-grade equipment ensures replication of real-world scenarios a controlled, laboratory setting.

Spectrum Science Highlights

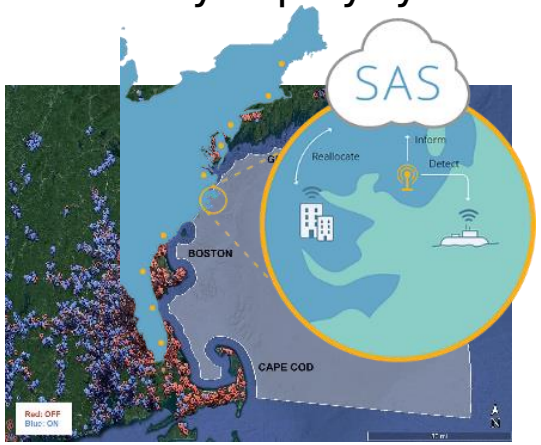
Time Transfer

NIST Lays Groundwork for Future Ultra-Precise Timing Links to Geosynchronous Satellites. Two Nature articles cover a groundbreaking method combining frequency combs' accuracy with quantum-limited sensitivity, and demonstrate optical time transfer between Hawaiian Islands, providing 10,000x better performance than traditional microwave techniques.

DOI: 10.1364/LS.2025.LM1F.1

NASCTN Sharing Ecosystem Assessment

Providing previously unavailable characterization of emissions in the newly available CBRS communication band, which has resulted in several operational adjustments for Commercial carriers as they deploy systems.



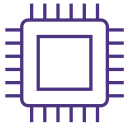
Coexistence in the Mining Industry

Partnering with the National Institute of Occupational Safety and Health (NIOSH) to develop the first coexistence framework suitable for the mining industry in above and below-ground mines.

Photo Credit: NIOSH

Quantum Communications

Developing key metrology crucial for next generation quantum communications



Scaling Quantum Computing

Developing new circuits and materials to overcome scalability challenges

Transduction

Connecting superconducting qubits to the optical domain

Quantum Routing

Constructing the Quantum Infrastructure of Tomorrow

Quantum Communications Highlights

MEMS-based switch for cryogenic testing

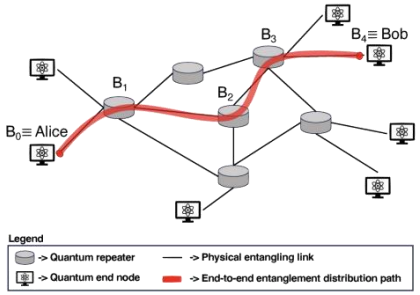
Developed a cryogenic switch for making high-throughput, calibrated, characterization measurements of microwave quantum and classical devices in a dilution refrigerator.

menlo micro

DOI:10.1109/JMW.2025.3638273

Multiverse Quantum Network Simulator

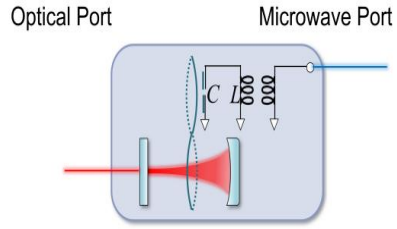
A discrete-event simulator that enables quick evaluation of entanglement distribution under dynamic configurations offering configurable routing algorithms, swapping strategies, purification schemes, and memory management policies.



DOI:10.48550/arXiv.2512.22937

Characterization of 2-mode squeezed states in a Quantum Transducer

Demonstrated generation and transduction of quantum information through an opto-electro-mechanical transducer, allowing for characterization of efficiency and noise of the device, and capacity to transmit quantum information



DOI: 10.1364/QUANTUM.2025.QTh4C.2

Space Communications Roadmap

Existing research themes

- Enabling Reliable Systems
- Spectrum Efficiency and Sharing
- Joint Communications and Sensing
- Antenna Characterization
- Remote Sensing Metrology
- High Frequency Electronics for Communications

FY27 publication

Photo Credit: Adobe Stock