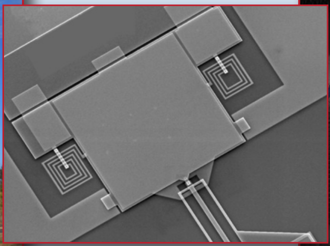
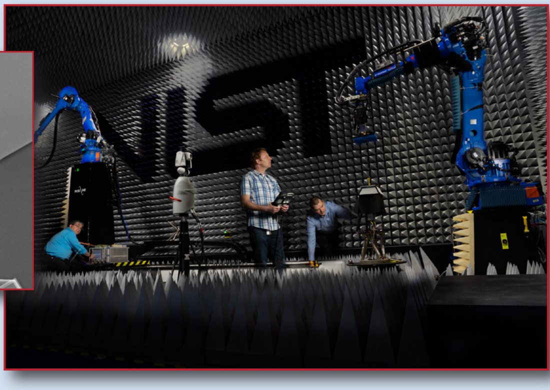
FABS and LABS

NIST's Communications Technology Laboratory: Pushing Metrology to Quantum Scale





The U.S. National Institute of Standards and Technology (NIST) is charged with maintaining traceable standards built on a foundation of measurement science, a mission essential to the country's scientific and economic health. NIST was established by Congress in 1901 to improve U.S. competitiveness by strengthening the country's measurement infrastructure to keep up with countries such as Germany and the U.K. NIST closed the gap and has achieved a preeminent position in metrology. As part of the Department of Commerce, NIST's budget for fiscal year 2022 is approximately $1.1 billion, and the Biden administration's proposed 2023 budget increases the agency's funding some 40 percent, which reflects NIST's important role supporting emerging technologies and advanced manufacturing.

NIST's Communications Technology Laboratory (CTL), based in Boulder, Colo., supports the development of advanced communications technologies and focuses on four areas: 5G and future standards, public safety communications, spectrum testing and communications metrology. The first of these, called "5G & Beyond," encompasses channel measurement, modeling and algorithms for over-the-air testing of massive MIMO. One example of the work in this area: to accurately characterize the propagation of a mmWave or sub-THz channel, NIST has developed an integrated platform named the Quasi-Deterministic (Q-D) framework, an open-source tool that combines the Q-D methodology with ray tracing to simulate the channel between nodes (antenna pairs) in a network.

In the area of 'communications metrology,' the laboratory is developing a hybrid anechoic/reverberation chamber to test mmWave IIoT devices under realistic and repeatable multipath conditions.

Another project at the edge of microwave technology—"Getting from Qubit to Mega-Qubit Quantum Computers with RF Calibrations"—aims to develop the world's most sensitive vector network analyzer (VNA). This collaboration between CTL and NIST's Physical Measurement Laboratory and Materials Measurement Laboratory is designing a way to make ultra-sensitive, calibrated, cryogenic on-chip microwave and modulated-signal measurements to support the development of quantum computing. CTL is extending its expertise with VNA measurements to measure microwave signals with orders-of-magnitude greater sensitivity than currently possible. The roadmap for the five-year program includes developing a broadband, high dynamic range Josephson parametric amplifier for the front-end of the VNA to establish the capability for weak modulated-signal and single photon measurements.

To support these varied endeavors, CTL operates five facilities: 1) The Antenna Communication and Metrology Laboratory uses dual robots and NIST's "Configurable Robotic MilliMeter-wave Antenna" to characterize steered-beam and other antennas from 300 MHz through 500 GHz. 2) The NIST Broadband Interoperability Test Bed combines large anechoic and reverberation chambers to study wireless coexistence, enabling researchers to assess how radar, LTE, Wi-Fi and other systems interact in a real-world environment. 3) The 5G Coexistence Testbed is dedicated to 5G spectrum sharing, coexistence and interference testing, focusing on spectrum sharing among government and commercial organizations. 4) The Public Safety Communication Innovation Laboratory supports first responders to extend their communication capabilities. 5) The NIST "Synthetic Aperture Measurement Uncertainty in Angle of Incidence" (SAMURAI) Over-the-Air Testbed for mmWave beamforming 5G and IIoT products.

In the 121 years since NIST was formed, the world has changed dramatically. Standards for distance, mass and time seem almost antiquated compared to the sub-THz and quantum challenges CTL is embracing today. NIST has kept ahead of these changes in technology, providing the metrology to help create the future.

www.nist.gov/ctl