Measurements and Metrology for 5G

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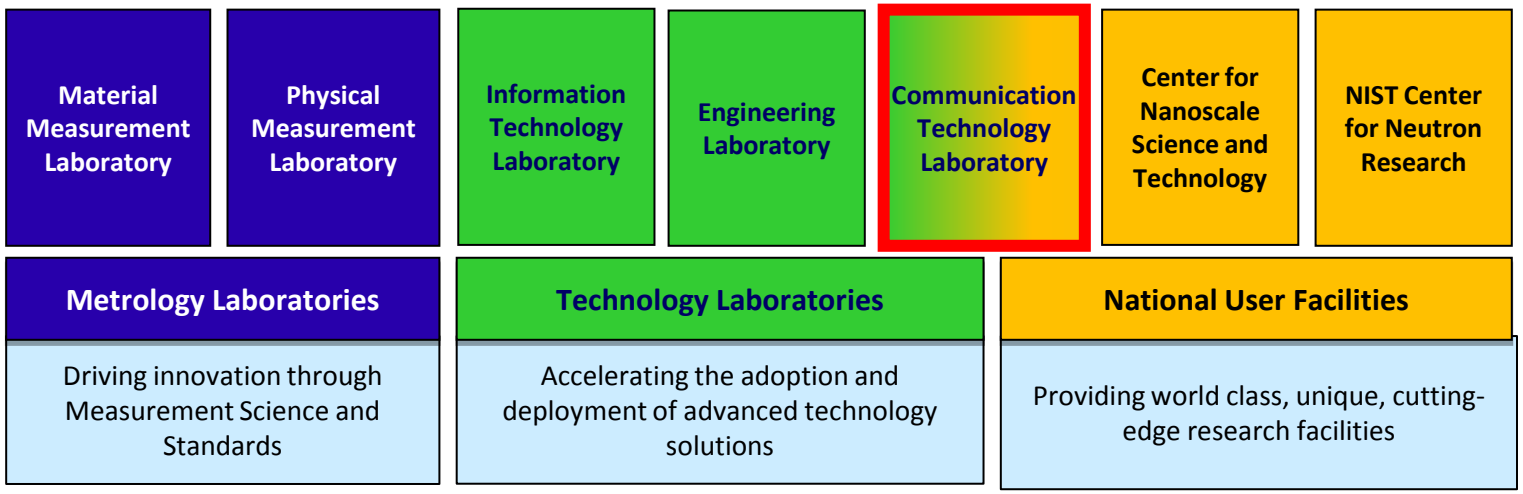
National Institute of Standards and Technology

CTL Communications Technology Laboratory

NIST's Communication Technology Laboratory - Mission



To promote 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;
- Research to support testing, including the development of precision instrumentation, validated test-protocols, models, and simulation tools;
- A "Center for Advanced Communications" to leverage collaborative R&D and broader access to test-bed resources.

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5G Technical Thrusts

- Massive MIMO
- Ultra-dense networks
- Millimeter wave metrology

Drivers

- Exponential increase in demand for wireless data transmission – massive increases in:
  - capacity >1,000x
  - connectivity (billions of users and machines)
- Top administration priority
- Widely recognized need to develop greater resource efficiencies – including temporal, spectral, coding, and spatial
- Integrated-circuit technology provides components, antennas at mmWave frequencies

"This new era in global technology leadership will only happen if there is adequate spectrum available to support the forthcoming myriad of wireless devices, networks, and applications that can drive the new economy."

–President Barack Obama

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June 28, 2010

Presidential Memorandum: Unleashing the Wireless Broadband Revolution

D AGENCIES

, in part, upon the availability of additional
esurgence of American productivity growth
ies, the public sector, and citizens in the
ernet. The Internet, as vital infrastructure,
creating unprecedented opportunities for
next transformation in information

The White House
Office of the Press Secretary
For Immediate Release

June 14, 2013

Presidential Memorandum -- Expanding America's Leadership in Wireless Innovation

MEMORANDUM FOR THE HEADS OF EXECUTIVE DEPARTMENTS AND AGENCIES

SUBJECT: Expanding America's Leadership in Wireless Innovation

A combination of American entrepreneurship and innovation, private investment, and smart policy has positioned the United States as the global leader in wireless broadband technologies.

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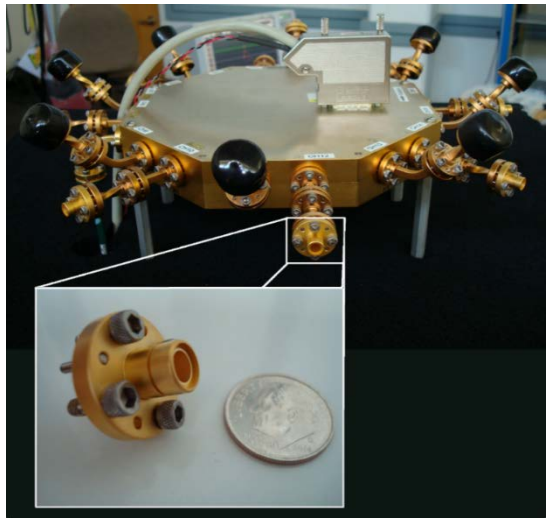
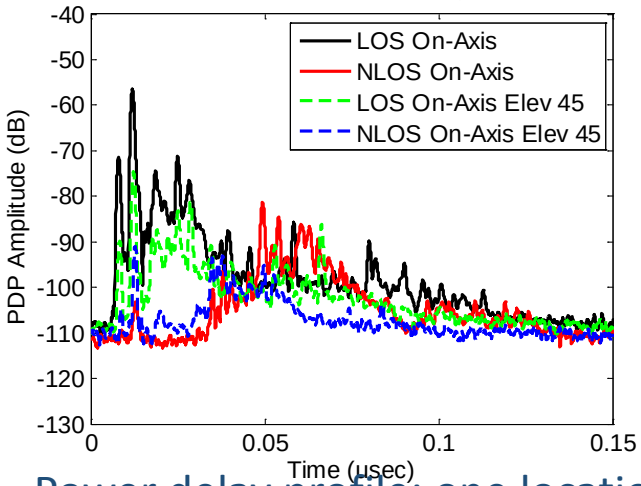
NIST Capabilities – mmWave Channel Measurement

- Design extends the state of the art
- Compact system only a 30 cm (one foot) in diameter from antenna element to antenna element
- Scalar feed horn antennas at each element only about the size of a US dime (~2 cm)
- 16 receive antennas
- Fully automated and repeatable
- Fast: electronic switching and direct digitization
- Can collect GBs of data in just minutes
- Robotic, laser-guided navigation system, millimeter accuracy (indoor)
- GPS equipped (outdoor)
- 28 and 60 GHz systems forthcoming

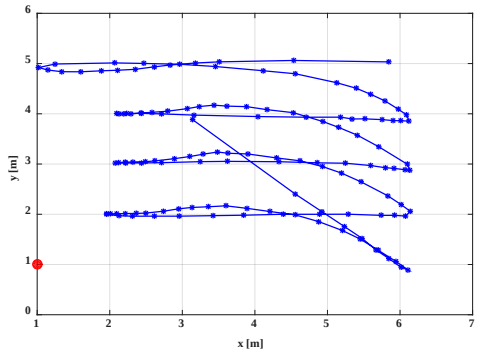
83.5 GHz channel measurements in NIST lab



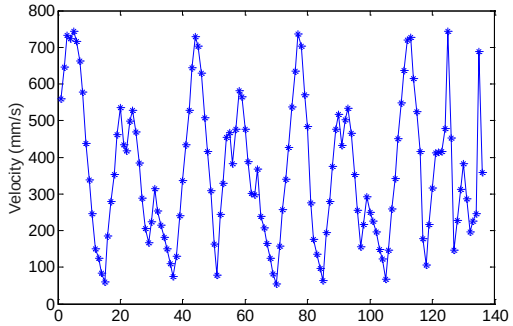


Power delay profile: one location

TX



Receive array location



Receive array velocity

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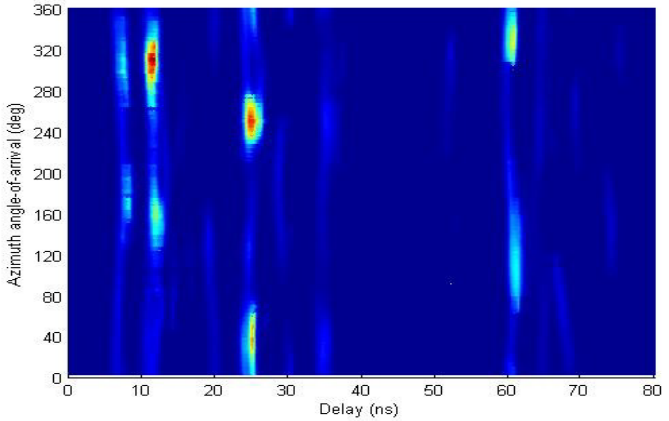
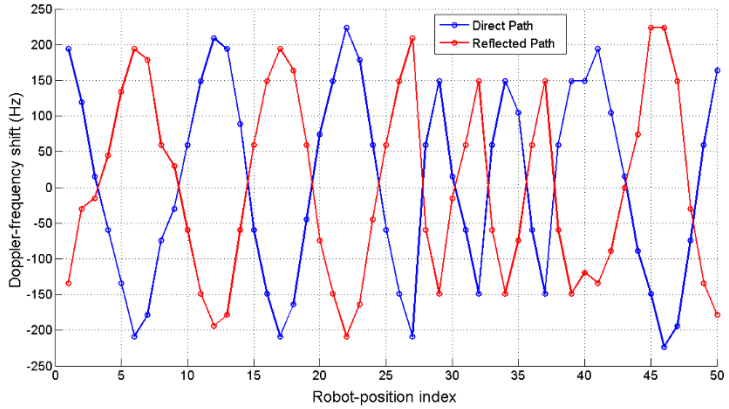
NIST Capabilities – mmWave Channel Modeling

Multidimensional power profiles

- Each path indexed according to delay, azimuth, and elevation
- Enables parameterizing Saleh-Valenzuela-type models
- RMS-delay/angle spread and coherence bandwidth
- Example shown is power vs. azimuth and delay



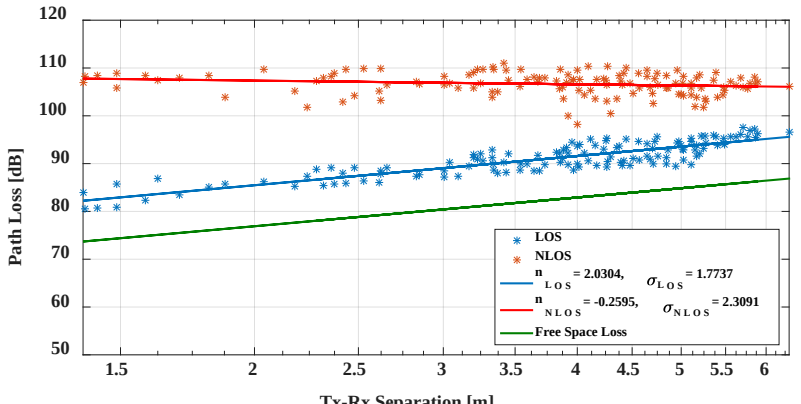


Small-scale fading and Doppler-frequency shift

- Fading distribution (Rayleigh, Rician, etc.) and Doppler-frequency shift computed for each path
- Coherence time computed from Doppler-frequency spread over all paths
- Example confirms that the direct path and the wall-reflected path have opposite Doppler shift

Large-scale path loss and shadowing

- The path loss for each path can be computed separately
- Example shows path loss exponent of direct LOS path is ~2.0



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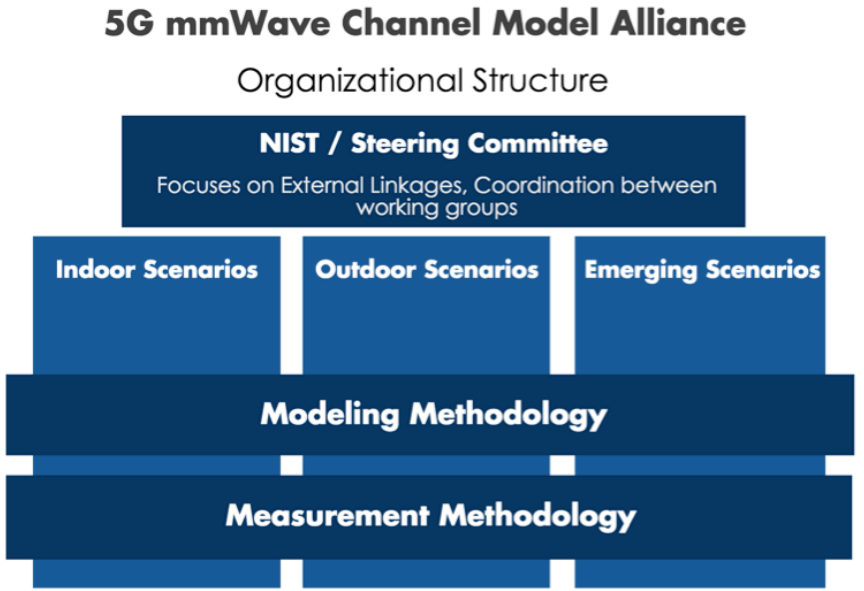
Response to Industry Need

1. Need to establish a more visible group of 5G mmWave researchers focused on long-term research.
2. Industry needs accurate mmWave channel models ASAP for standardization and to optimize hardware design for a variety of different usage scenarios and environments.
3. Individual research organizations do not have the scale, visibility or resources to characterize mmWave propagation across a sufficiently broad spectrum.
4. Need for increased partnership and communication between Industry and Academia.
5. Lack of understanding of current mmWave research efforts and need for improved coordination.

NIST Establishes 5G Millimeter Wave Channel Model Alliance

NIST has launched the 5G mmWave Channel Model Alliance to provide a forum for supporting the development of more accurate, consistent, and predictive channel models for millimeter wave communication systems above 6 GHz.

- Development of channel models is needed before commercial wireless communication systems can be deployed.
- The Alliance is composed of over 70 representatives from industry, academia, and government organizations.
- NIST convened the Alliance's first meeting on July 8-9, 2015, in Boulder, to discuss the present state of channel measurement and modeling and to develop plans for the Alliance's organization and future activities.



https://sites.google.com/a/corneralliance.com/5g-mmwave-channel-model-alliance-wiki/home

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