5G Millimeter Wave
Channel Model Alliance

Next Generation Wireless

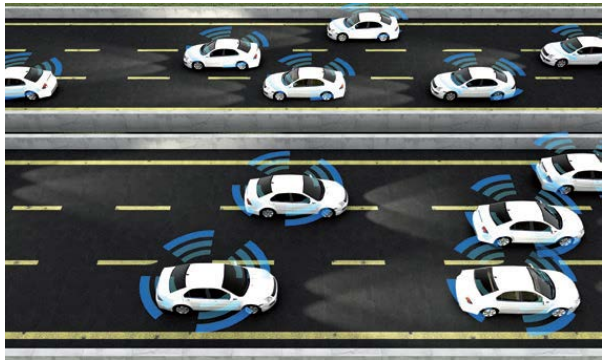
Nada Golmie

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

CTL Communications Technology Laboratory

Next Generation Wireless: 5G & Beyond

"The new networks, coming in the next few years, will handle **huge amounts of data at lightning-quick speeds with near-zero latency**. As a result, electronic devices will respond to each other — and to humans — in the blink of an eye. "



"The world is going to change dramatically"

5G & Beyond Context

Improved Communications Capabilities

Use Cases

Different demand, size, complexity

Connectivity

Users, Infrastructures,Things
Cellular, Vehicular, Drones,
Direct, Hotspot

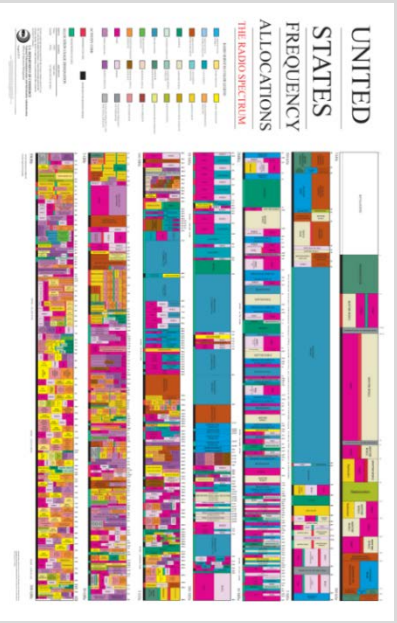
Adaptability

Autonomous Resilient
Low overhead
Environment aware

High Capacity

Modulation schemes
Multiple Antennas
mmWave bands
Network densification

Efficient Spectrum Utilization

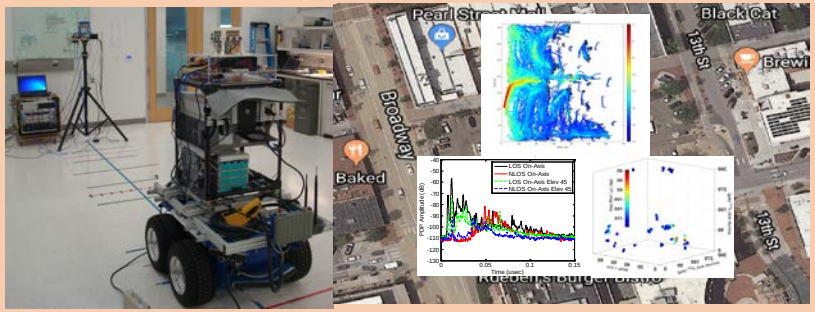


NIST's Efforts Related to 5G & Beyond

Advances in Communications Metrology

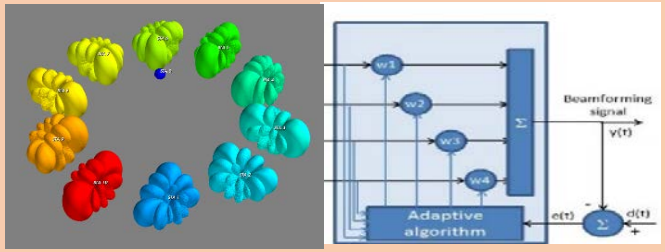
Public Safety Communications Research

Advanced Manufacturing

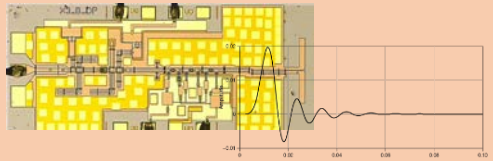


Channel propagation measurement and modeling, standards development

Antenna Meas. Facility
MIMO/OTA Testing

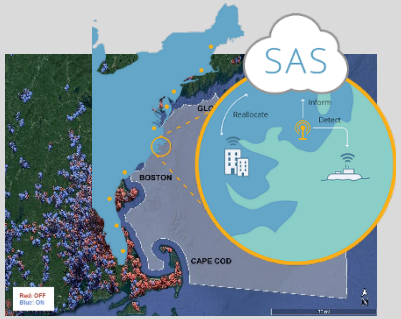


Beamforming modeling and system level performance evaluation



mmWave measurement signal characterization

Trusted Spectrum Testing



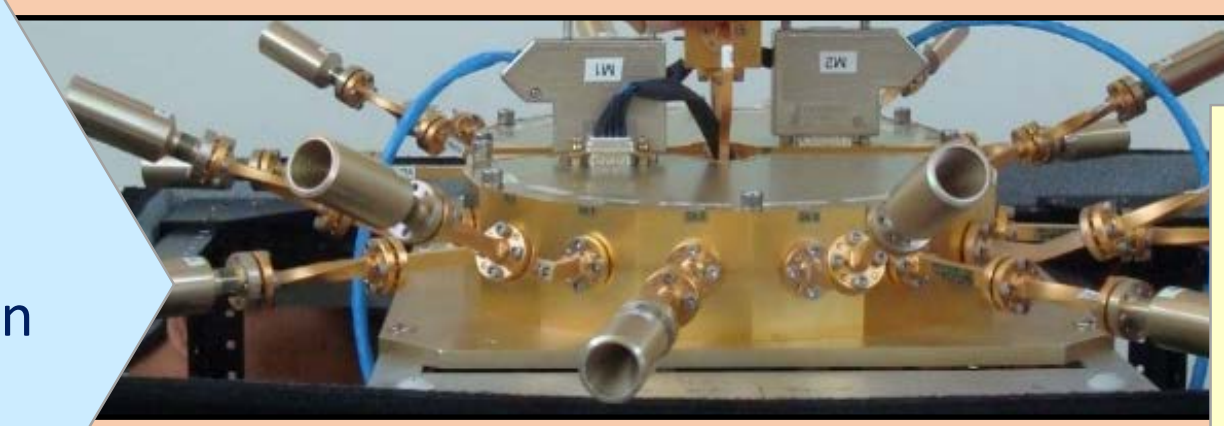
Coexistence metrology, spectrum sharing measurement and modeling, standard development

Security of advanced communications technologies & applications

CTL's 5G & Beyond Program

- **Interference** and coexistence in high density deployment
- Wireless **propagation** properties at higher frequencies
- Multiple Input Multiple Output (**MIMO**) antenna testing

Hardware measurement
Signal characterization
System-level evaluation

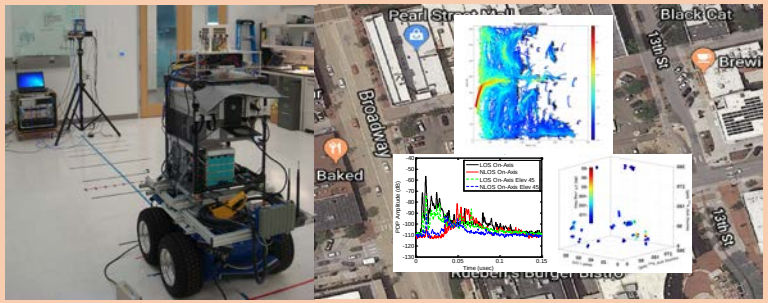


Addressing Key Communications Measurement Challenges

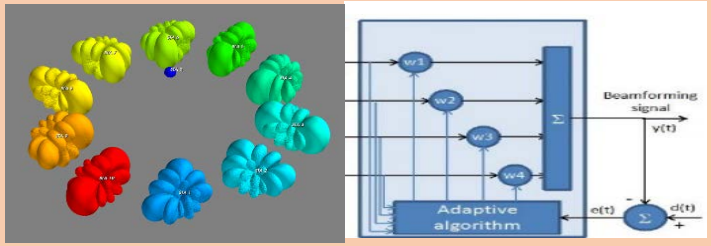
Contributions to standards
Testing methodologies
NIST reports/ Guidelines
Measurement data
Software models/tools
Peer-reviewed publications

5G & Beyond Program: Highlights

Measurement science to enable and expedite the development of next generation wireless

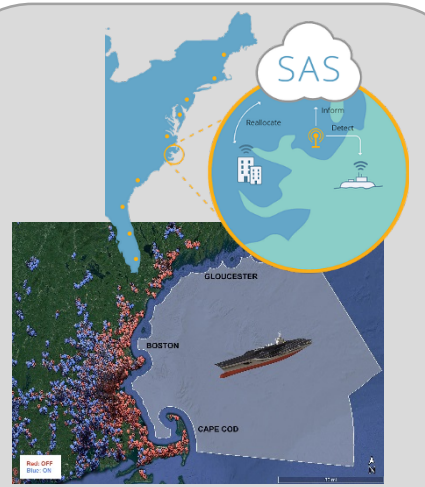


mmWave Channel propagation measurement and modeling



Beamforming modeling and system level performance evaluation

Antenna Meas. Facility
MIMO Antenna Testing

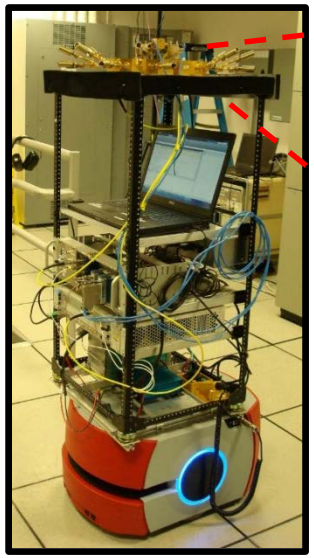


Spectrum sharing measurement and modeling, standard development

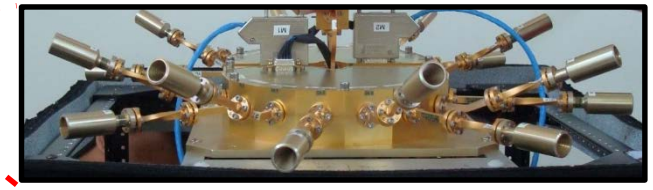
NIST mmWave Measurement & Modeling Capabilities

Channel Sounders for 83.5, 28, and 60 GHz

TX ARRAY



RX ARRAY



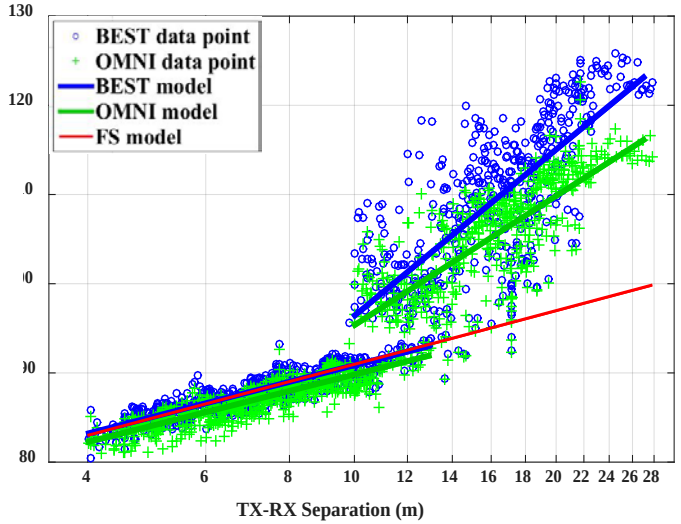
Zoom RX Array

- *P.B. Papazian, C. Gentile, K.A. Remley, J. Senic, J.-K. Choi, N. Golmie "A Radio Channel Sounder for Mobile Millimeter-Wave Communications: System Implementation and Measurement Assessment," IEEE Trans. on Microwave Theory and Techniques, vol. 64, no. 9, pp. 2924-2932, Sept. 2016.*

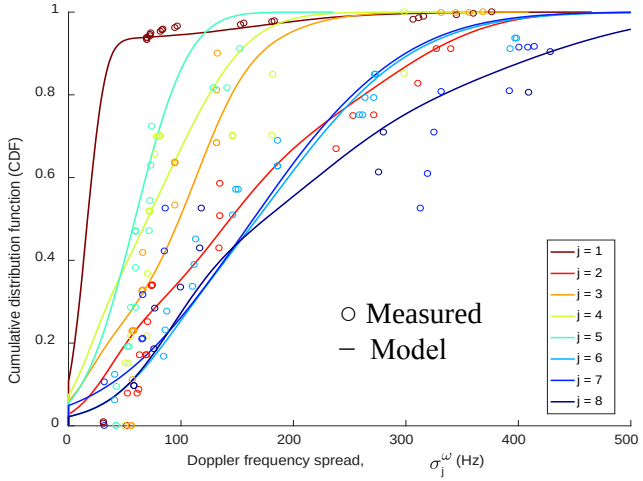
- *D. Caudill, P.B. Papazian, C. Gentile, J. Chuang, N. Golmie, "Omnidirectional Channel Sounder with Phased-Array Antennas for 5G Mobile Communications," IEEE Trans. on Microwave Theory and Techniques, April 2019.*

Path Loss

"Pathloss Models for Indoor Hotspot Deployment at 83.5GHz," C. Gentile, J. Senic, P. Papazian, J-K. Choi, K. Remley, IEEE Globecom 2016.

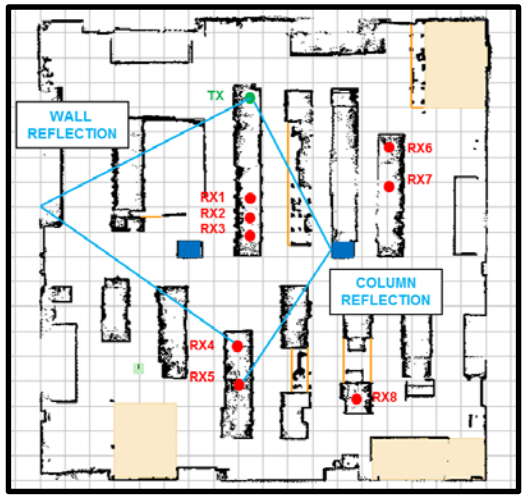


Doppler Spread

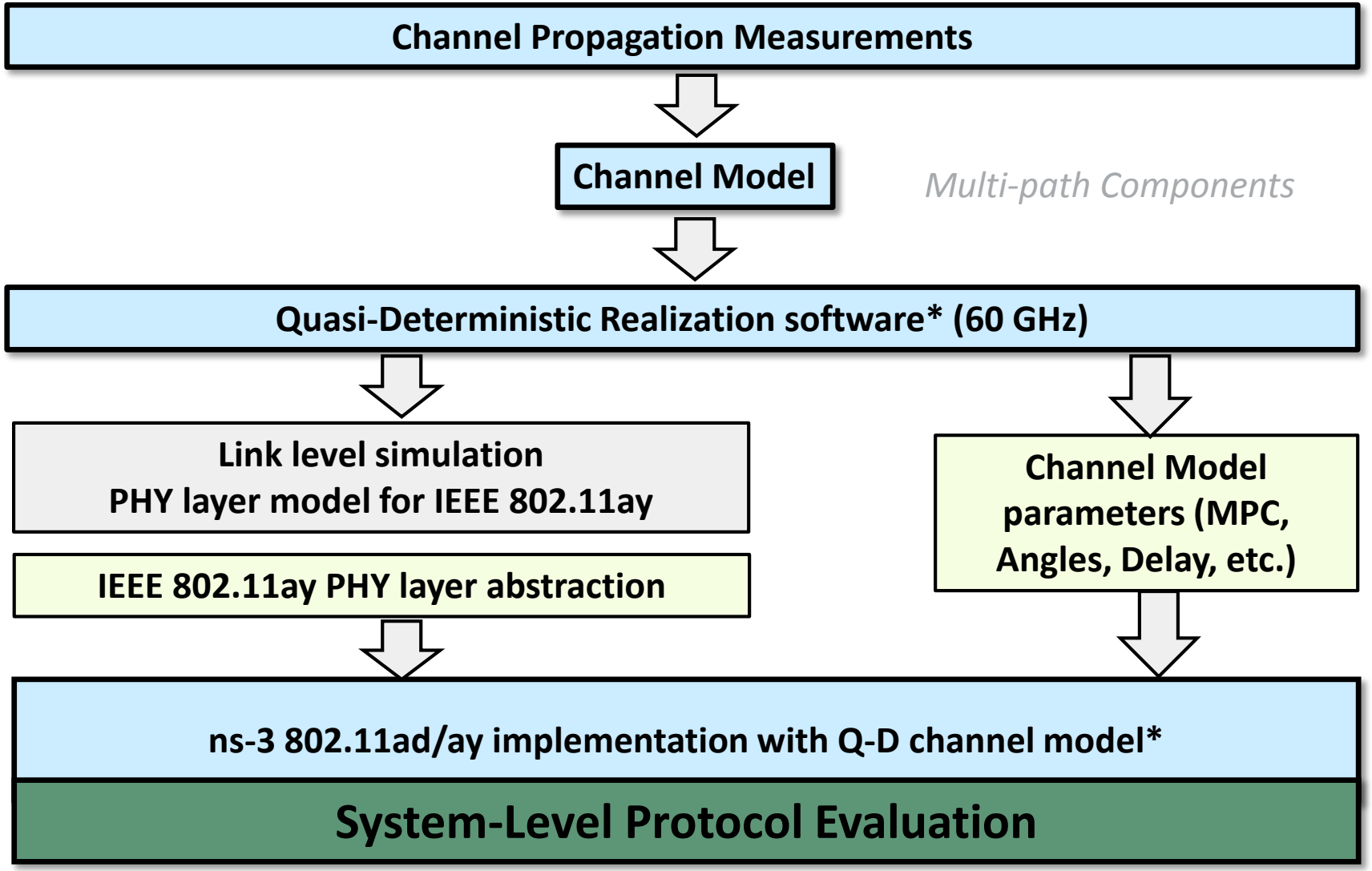


J. Wang, C. Gentile, P.B. Papazian, J.K. Choi, and J. Senic, "Quasi-Deterministic Model for Doppler Spread in Millimeter-wave Communication Systems," IEEE Antennas and Wireless Propagation Letters, vol. 16, pp. 2195 - 2198, May 2017.

Map-Based Dispersion Models



High Fidelity System-Level Modeling



* Publicly Available: https://github.com/wigig-tools

5G mmWave Channel Model Alliance

- Established user community: https://sites.google.com/a/cornerallliance.com/5g-mmwave-channel-model-alliance-wiki/home

- Repository of data measurements and models available online: https://5gmm.nist.gov/

- Sponsored workshops and face-to-face meetings co-located with major conferences & events: IEEE ICC, VTC, GLOBECOM, NSF mmWave Research Coordination Network, others.

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Organizations Represented

Academia

1. Beijing Jiaotong University
2. Boise State University
3. Carleton University (Canada)
4. Florida International University
5. Fraunhofer Institute
6. Georgia Institute of Technology
7. Indian Institute of Science
8. ITRI (Taiwan)
9. Michigan Technological University
10. Missouri S&T
11. Morgan State University
12. National Institute of Technology (India)
13. New Jersey Institute of Technology
14. New York University Wireless
15. North Carolina State University
16. Pennsylvania State University
17. Polytechnic University of Leiria (Portugal)
18. Portland State University
19. Princeton
20. Stanford University
21. Stevens Institute of Technology
22. Technische Universität Dresden
23. Technische Universität Ilmenau
24. Tufts University
25. UC Santa Barbara
26. University at Buffalo
27. University of British Columbia
28. University of California, Berkeley
29. University of California, Irvine
30. University of California, San Diego
31. University of California, Santa Barbara
32. University of Chicago
33. University of Colorado, Boulder
34. University of Durham (UK)
35. University of New Mexico
36. University of South Carolina
37. University of Southern California
38. University of Texas
39. University of Vermont
40. University of Wisconsin
41. Universita Degli Studi Di Padova

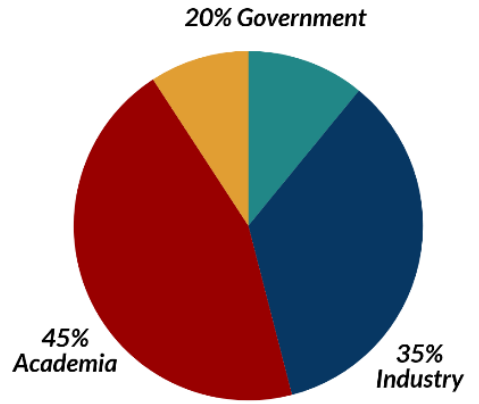
Government

42. DARPA
43. Defense Spectrum Organization
44. ETRI (South Korea)
45. Federal Communications Commission
46. National Institute of Metrology, China
47. National Science Foundation
48. NIST
49. NTIA
50. US Navy
51. Communications Research Centre (CA)

Industry

52. Alcatel-Lucent
53. Anritsu
54. AT&T
55. Azimuth Systems
56. Ball Aerospace
57. Cable Labs
58. Dow
59. DuPont
60. Echostar
61. Facebook
62. Forsk
63. Huawei Technologies
64. Huawei Technologies Canada
65. IEEE
66. Intel
67. InterDigital
68. Keysight
69. National Instruments
70. Nokia
71. octoScope
72. Qualcomm
73. Rohde & Schwarz
74. RT Logic
75. Samsung
76. Siradel
77. SK Telecom
78. Spirent
79. Sporton International
80. Xilinx

Contact Marc Leh (mleh@cornerallliance.com) for more information



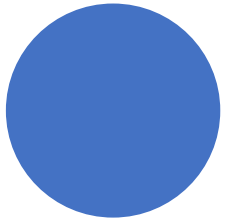
5G Alliance Deliverables include:

- Measurement & Modeling White Papers
- 5G Alliance Data Repository
- Measurement Verification Program
- Channel Modeling Refinement
- Measurement Campaign Support
- Scenario & Parameter Description

Working Together

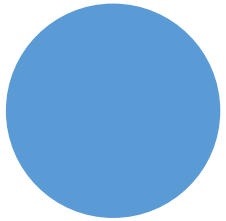
For the design, evaluation and deployment of the future 5G networks, it is essential to have a 5G channel model that is well supported by diverse measurements across different frequency bands, deployment scenarios, as well as geographical areas. ***The 5G channel alliance led by NIST has been instrumental 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



MEASUREMENTS AND MODELING

- Contributions to standards: IEEE 802, 3GPP, CTIA.
- Modeling tool development: (Mathworks/WLAN Toolbox, RF planning, ns-3).
- Dataset dissemination

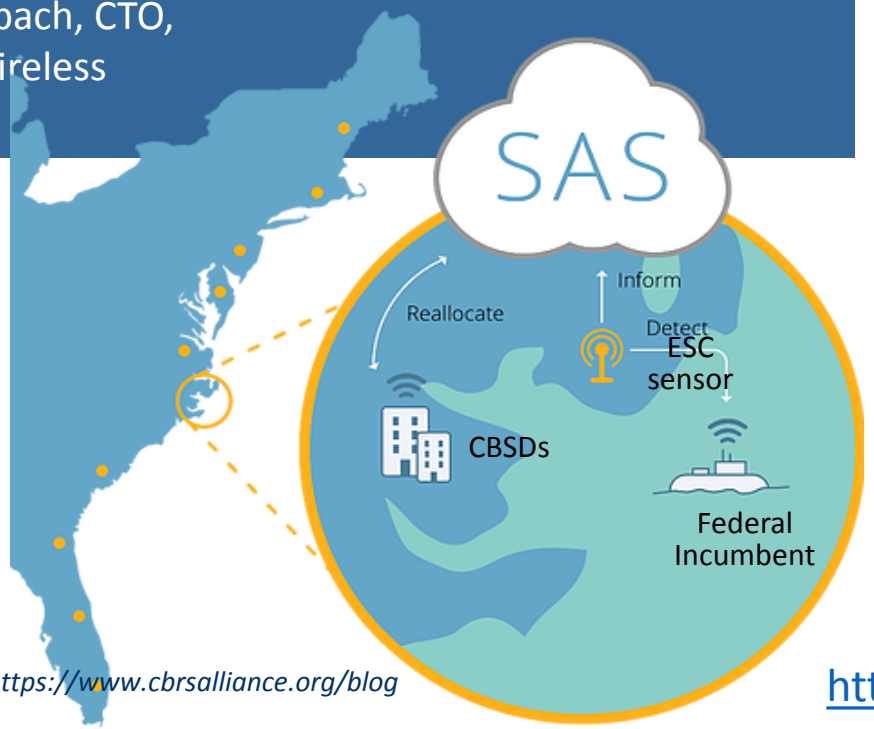


INDUSTRIAL COLLABORATIONS

- Channel model alliance
- Telecom Infra Project
- Tool vendors: e.g. Mathworks, Siradel
- Chip set vendors: e.g. Qualcomm, Intel

Spectrum Sharing at 3.5 GHz
Citizens Broadband Radio Service (CBRS)

"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

INCUMBENT SIGNAL DETECTION

- 3.5 GHz radar waveform measurements (NASCTN)
- Machine-learning radar detection and classification algorithms
- RF signal data sets
- Sensor placement and configuration

CONTRIBUTIONS to WIRELESS INNOVATION FORUM CBRS STANDARDS

- Federal incumbent protection test procedures and reference model.

https://github.com/Wireless-Innovation-Forum/Spectrum-Access-System.

Metrology for MIMO Antennas

SUCCESSES

- 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

Developing new methods for measuring integrated antennas that cannot be removed from a communications system

Questions?

nada.golmie@nist.gov