5G Millimeter Wave
Channel Model Alliance

The Role of Standards and Measurements in 5G

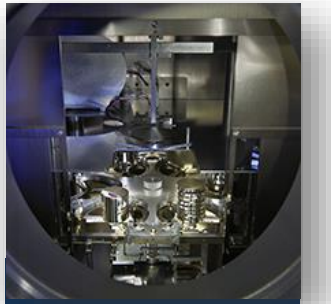
Nada Golmie

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

CTL Communications Technology Laboratory

NIST Laboratories

Material Measurement Laboratory



Physical Measurement Laboratory

Engineering Laboratory

Information Technology Laboratory

Communication Technology Laboratory

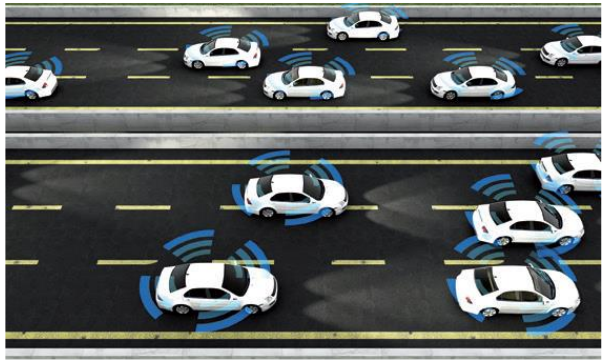
NIST Center for Neutron Research

Mission: Conduct and facilitate leading edge R&D for both metrology and standards development to accelerate the development and deployment of advanced communication systems

5G Vision

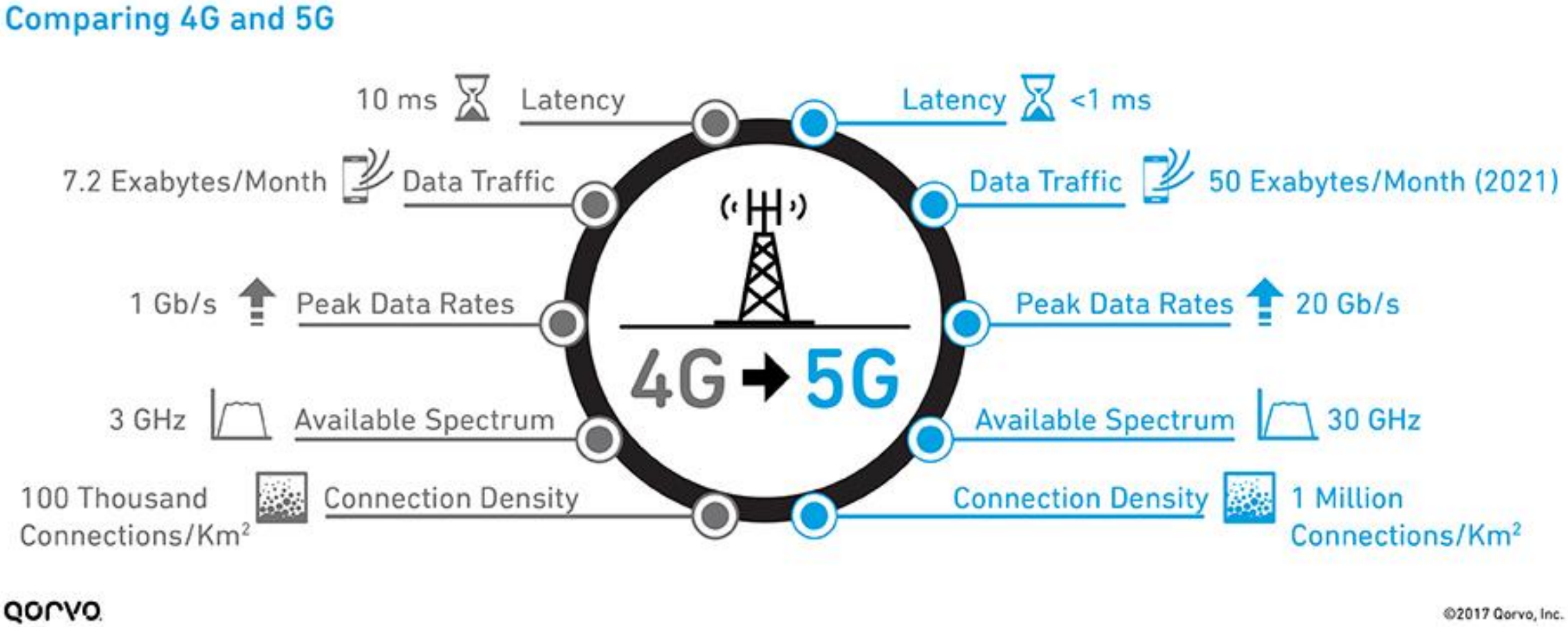
"5G technology (…) will enable new use cases beyond what we can imagine today. "

"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"

4G to 5G


Comparing 4G and 5G
10 ms
Latency
7.2 Exabytes/Month
Data Traffic
1 Gb/s
Peak Data Rates
3 GHz
Available Spectrum
100 Thousand Connections/Km²
Connection Density
4G → 5G
Latency
<1 ms
Data Traffic
50 Exabytes/Month (2021)
Peak Data Rates
20 Gb/s
Available Spectrum
30 GHz
Connection Density
1 Million Connections/Km²
qorvo
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What is 5G?

Improved Communications Capabilities

Use Cases

Different demand, size, complexity

Connectivity

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

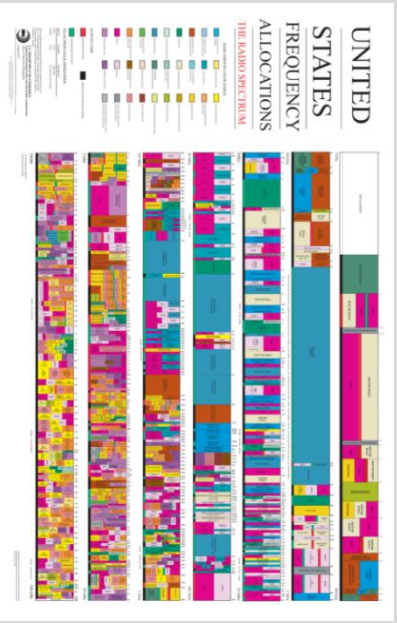
Adaptability

Autonomous Resilient
Low overhead
Environment aware

High Capacity

Modulation schemes
Multiple Antennas
mmWave bands
Network densification

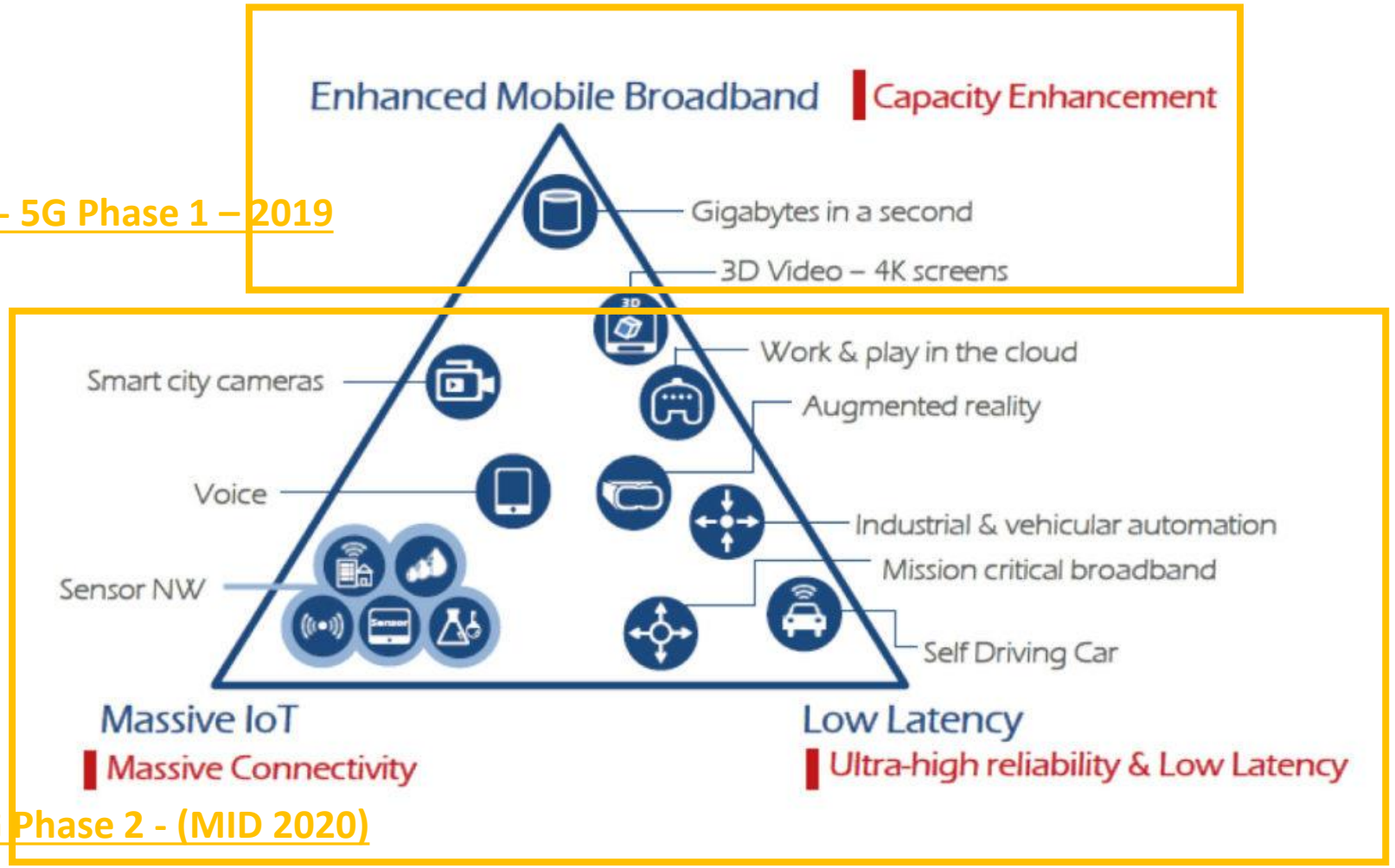
Efficient Spectrum Utilization



5G Standards

- International Telecommunication Union (**ITU**): coordinates the global use of the radio spectrum (ITU-R); assists in the development of ICT technical standards; sets requirements and criteria for selection of 5G radio interface technologies (***IMT-2020***).
- Third Generation Project Partnership (**3GPP**): is working on technical specifications for 5G (starting in 3GPP Release 15).
- Institute of Electrical and Electronics Engineers, Project 802 (**IEEE 802**): develops radio interface specifications for wireless local area networks (WLANs) family of standards – IEEE 802.11(ac;ax;ad;ay;ba).
- Internet Engineering Task Force (**IETF**): develops specifications to evolve the Internet protocols in support of 5G architecture and security features, virtual network functions (VNFs), software defined networks (SDNs), and IP security (IPSec).
- European Telecommunication Standards Institute (**ETSI**): coordinates the development and promotion of 5G standards (verticals, use cases, technology specific)

3GPP Perspective: 5G *New Radio*



3GPP R15 - 5G Phase 1 – 2019

3GPP R16 – 5G Phase 2 - (MID 2020)

Source: ITU-R-M-2083

5G Measurement Challenges

Interference in high density deployment

Wireless **propagation** properties at higher frequencies

Multiple Input Multiple Output (**MIMO**) antenna calibration and testing

Over The Air (**OTA**) testing

Telemetry for autonomous control

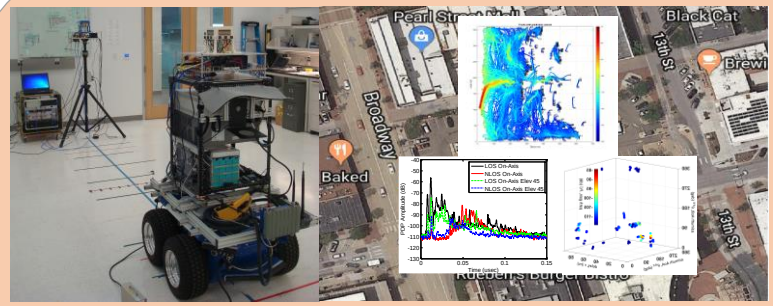
Image credit: OFCOM

NIST's Efforts Related to 5G

Advances in Communications Metrology

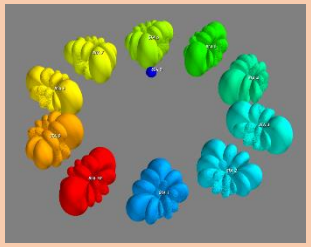
Public Safety Communications Research

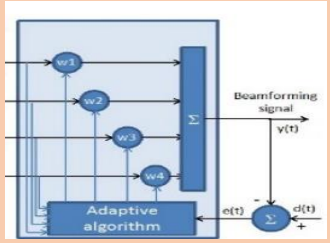
Advanced Manufacturing



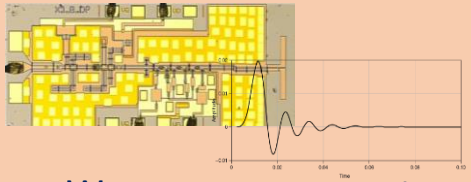
Channel propagation measurement and modeling, standards development

Antenna Meas. Facility
MIMO Antenna Testing

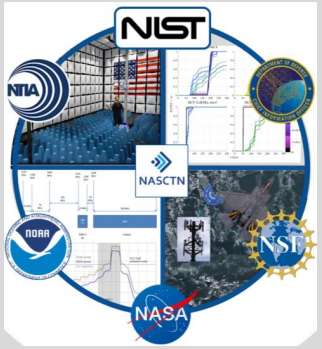




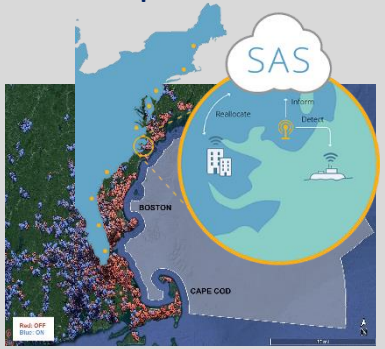
Beamforming modeling and system level performance evaluation



mmWave measurement
Signal characterization



Trusted spectrum testing



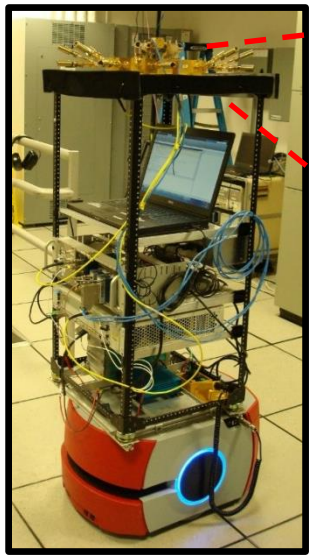
Spectrum sharing measurement and modeling, standard development

Security of advanced communications technologies & applications

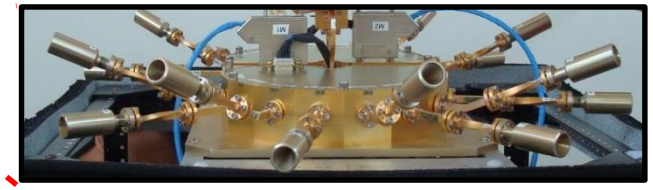
NIST mmWave Measurement & Modeling Capabilities

Channel Sounders for 83.5, 28, and 60 GHz

TX ARRAY



RX ARRAY

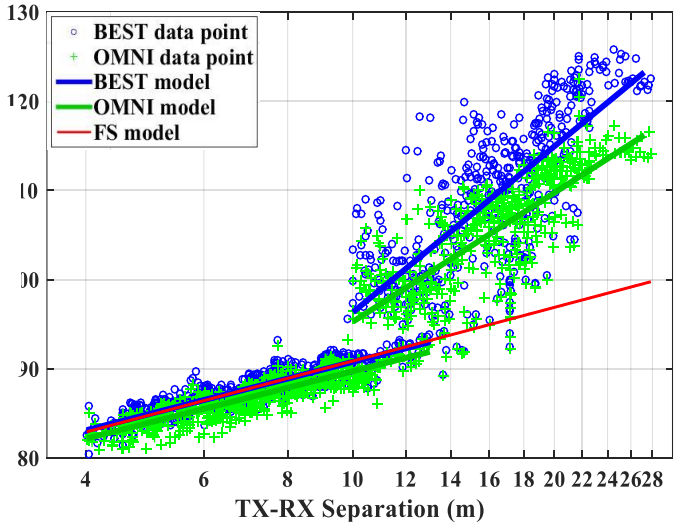


Zoom RX Array

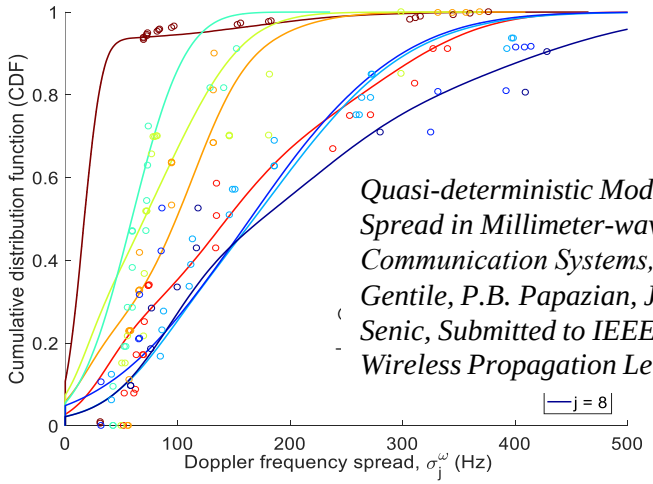
P.B. Papazian, C. Gentile, K.A. Remley, J. Senic, J.-K. Choi, N. Golmie "A Radio Channel Sounder for Mobile Millimeter-Wave Communications: System Implementation and Measurement Assessment," IEEE Trans. on Microwave Theory and Techniques, vol. 64, no. 9, pp. 2924-2932, Sept. 2016.

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.

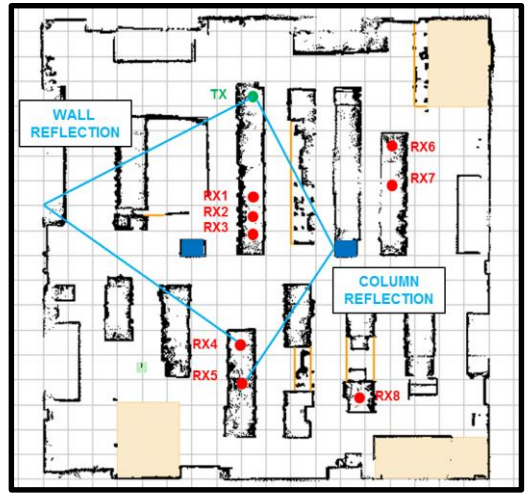


Doppler Spread



Quasi-deterministic Model for Doppler Spread in Millimeter-wave Communication Systems," J. Wang, C. Gentile, P.B. Papazian, J.-K. Choi, J. Senic, Submitted to IEEE Antennas and Wireless Propagation Letters.

Map-Based Dispersion Models



5G mmWave Channel Model Alliance

- Established user community: https://sites.google.com/a/corneralliance.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

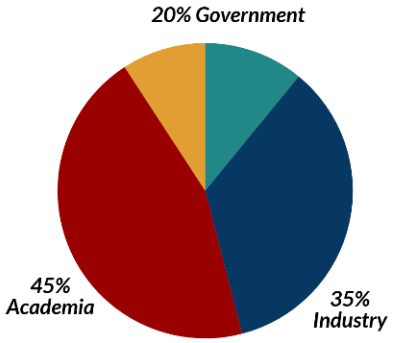
Government

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@corneralliance.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

Contact: Nada Golmie, nada.golmie@nist.gov

Fundamental Metrology for Communications

Provide state-of-the-art radio-frequency metrology to enable the development and commercialization of a broad range of RF electronics and wireless communications technologies.

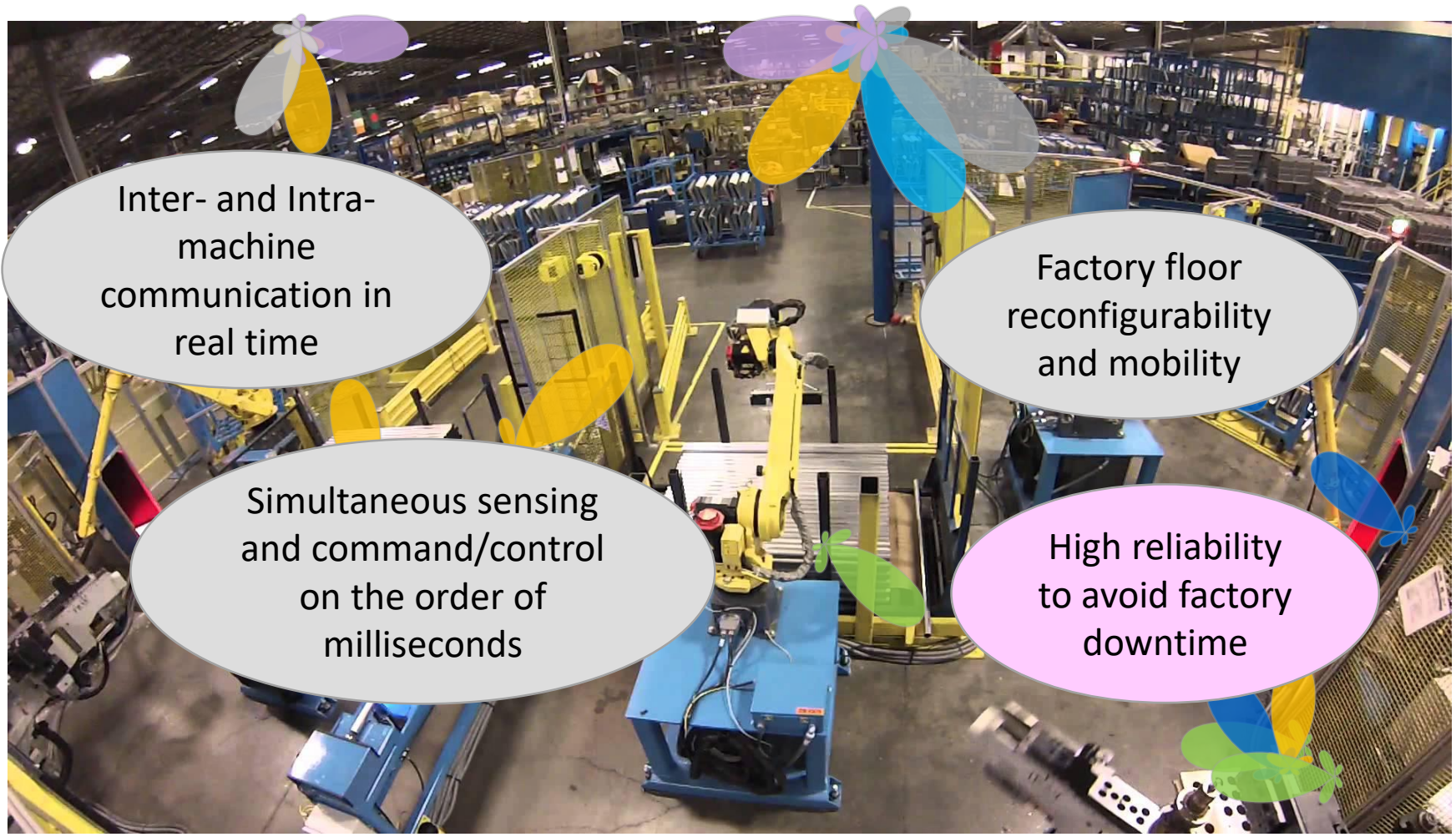
SUCCESSES

- First over-the-air test method for physically-large wireless systems (adopted by CTIA)
- Traceability for signal generation and measurement
- New Large Antenna Positioning System
- New NIST Broadband Interoperability Test Network

STAKEHOLDERS

- End Users
- Test Equipment Manufacturers
- Federal agencies (DARPA, DoD, FCC, NTIA, NIJ, DHS, FDA)
- Standards organizations (CTIA, ANSI, IEEE)

5G for Smart Manufacturing



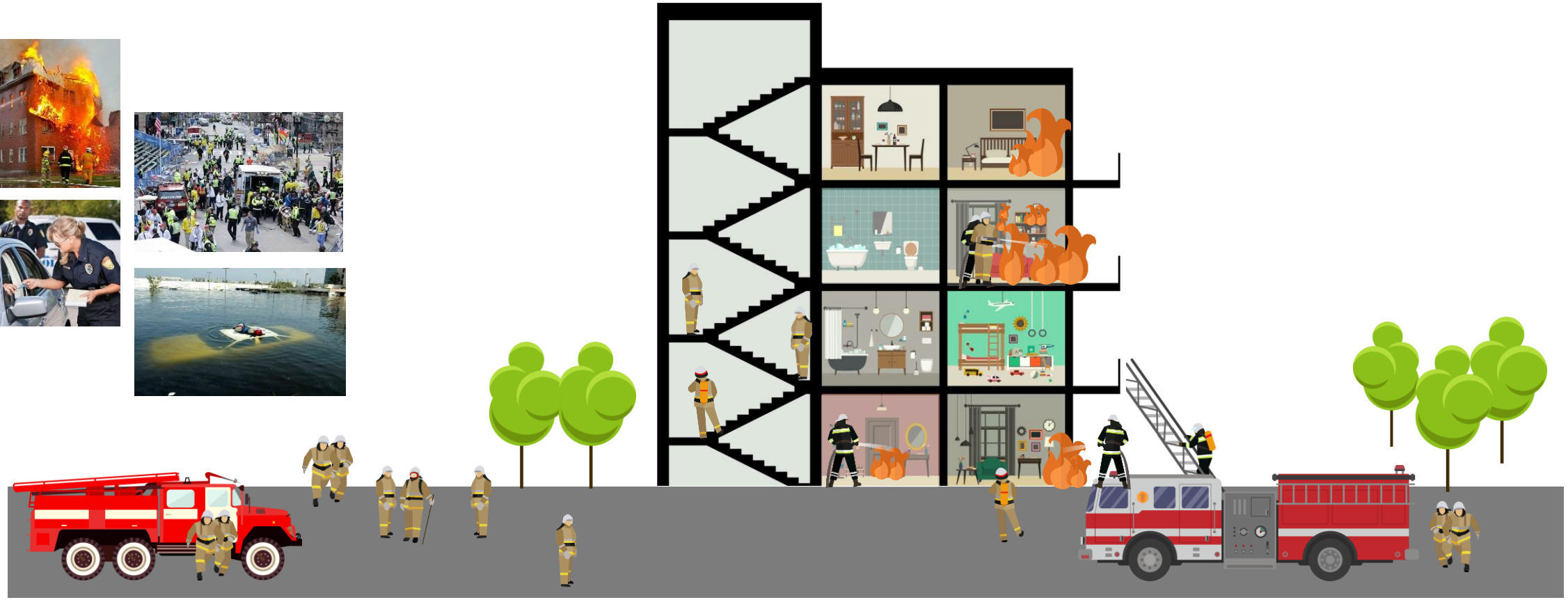
The Enablers:

New wireless technologies => breakthroughs in manufacturing

The Challenges:

- Harsh wireless-channel conditions
- Stringent communication requirements:
  - Low latency (fast)
  - High reliability
  - Scalable: few or many nodes

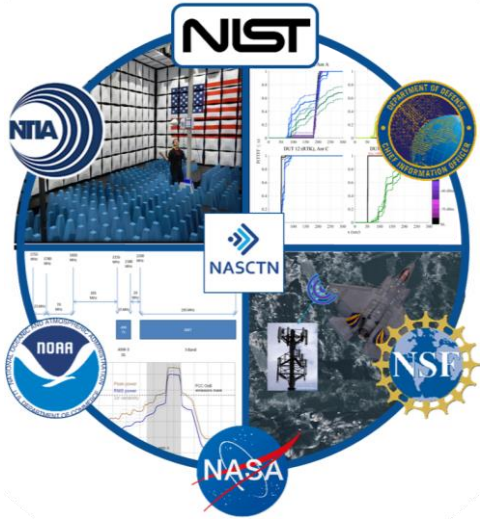
5G for Public Safety Communications



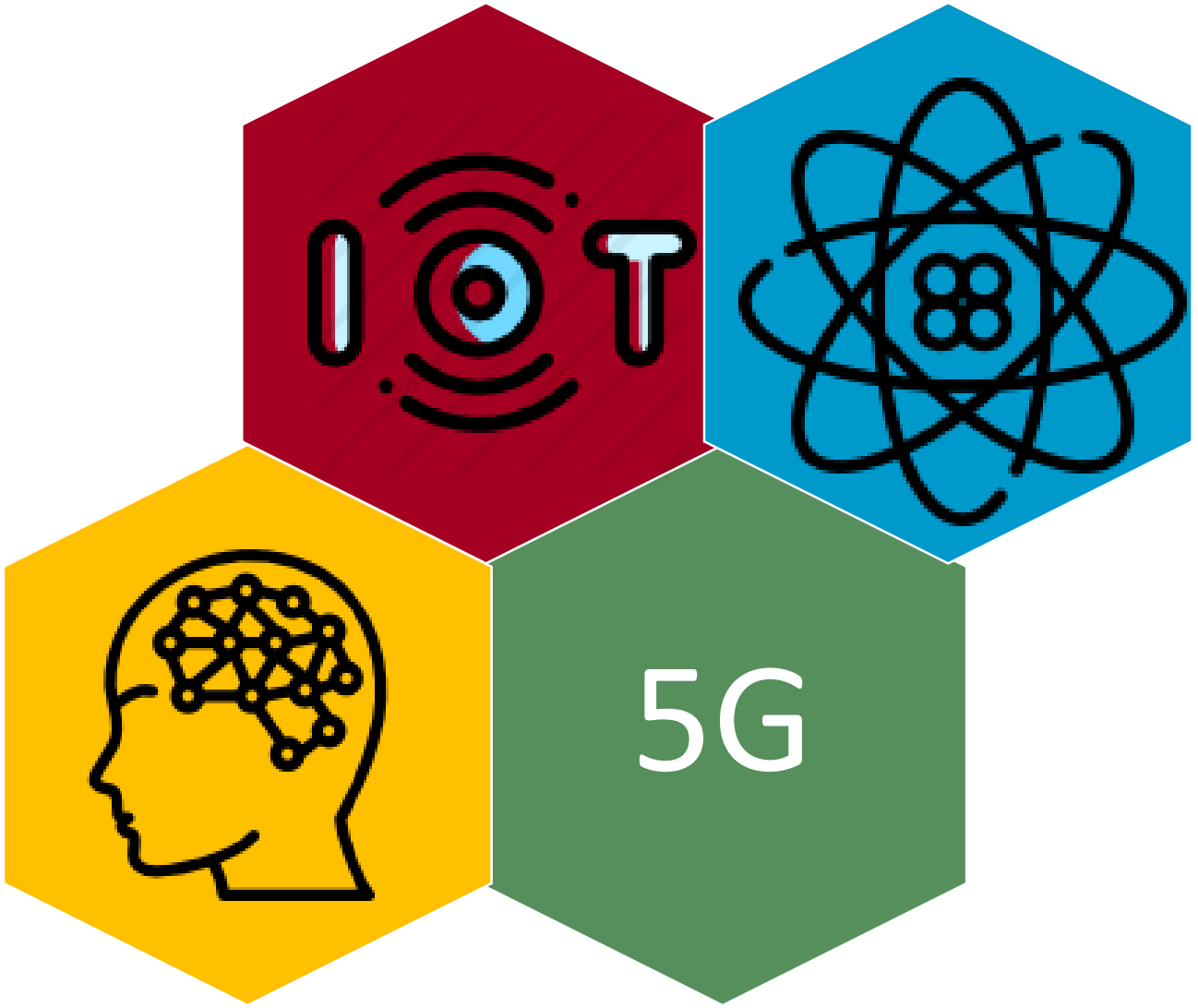
5G Collaborations

- **Documentary standard development**: 3GPP, IEEE, ANSI, Wireless Innovation Forum Spectrum Sharing Committee, CTIA, Telecom Infra Project.
- **Partnerships** across government, industry, academia.
- Public safety innovation accelerator program: > 150 partnerships through ***prize challenges***, ***grants*** and ***cooperative agreements***.

5G Millimeter Wave Channel Model Alliance



Industries of the Future



Questions?

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