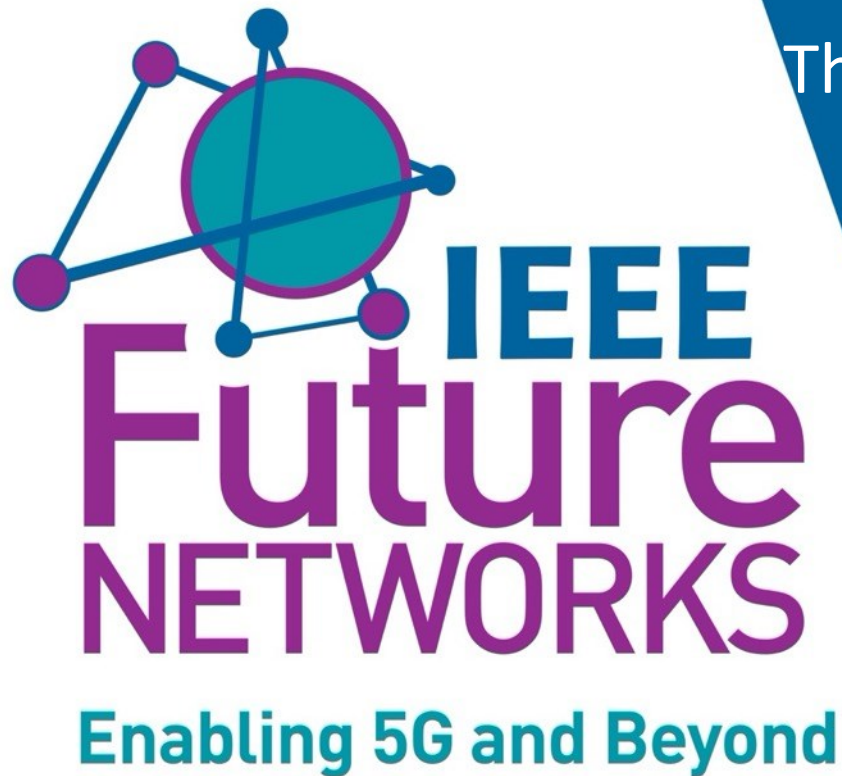




Future Networks: The INGR Vision and the Path to 6G

First IEEE Next G Summit

June 14, 2022

Narendra Mangra, GlobeNet, LLC
IEEE INGR and Applications & Services WG Co-Chair



IEEE Future Directions Coverage for 2022



Graduated Initiatives



*Last year in Future Directions

[ieee.org/futuredirections](https://www.ieee.org/futuredirections)

IEEE Future Networks Initiative

Collaboration

IEEE ComSoc
IEEE Communications Society

IEEE Photonics Society

IEEE SA

IEEE VTS
Connecting the Mobile World

IEEE Reliability Society

MTT-S

20+ IEEE societies

Content

IEEE Future Networks Tech Focus
Issue 14, April 2022

technical newsletter, podcasts,
videos, articles

Events

IEEE Future Networks
WORLD FORUM • 2022

IEEE Connecting the UNCONNECTED
An IEEE Future Networks Program

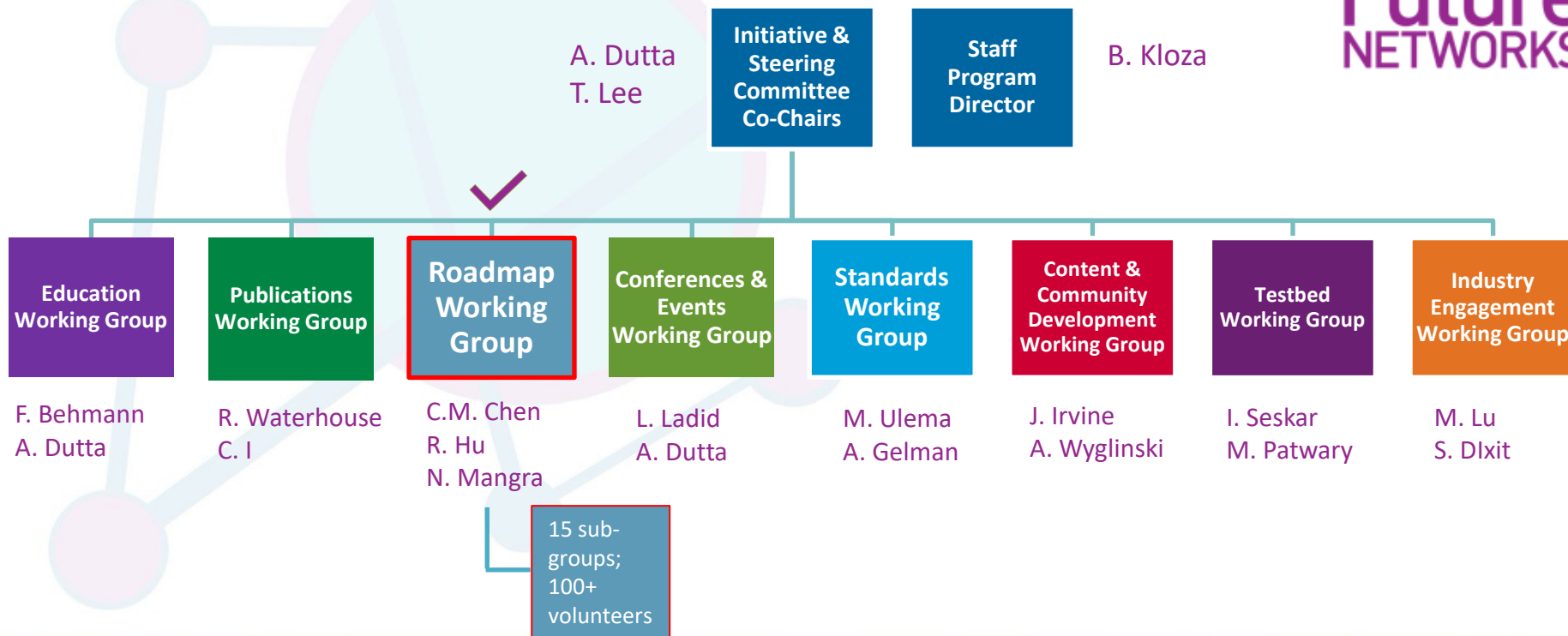
+ more!

Research &
Education

IEEE INGR International Network
Generations Roadmap

+ eLearning, white papers,
tutorials, webinar series

IEEE Future Networks Initiative Organization Structure



INGR Editions



Scope.

- High-level perspective and projection of how the industry could evolve
- Highlights of common needs
- Challenges to achieving those needs
- Potential solutions to those challenges

Projections

- INGR projections for the next 10 years:
 - Key Timeframe points at 3, 5, and 10 years.

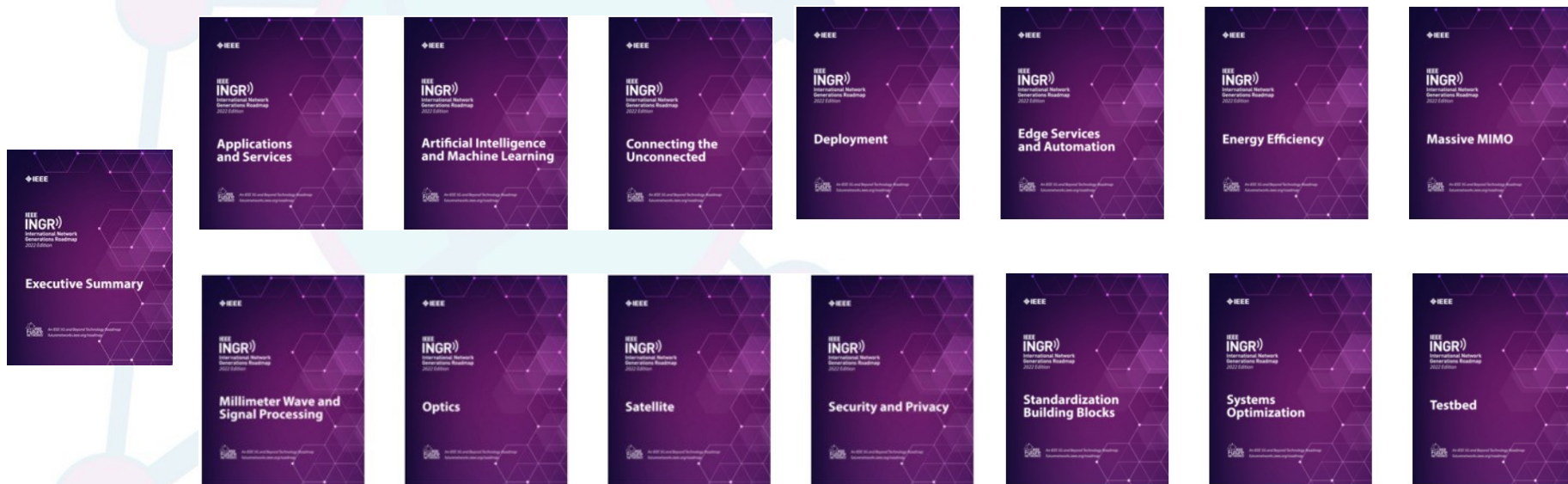
Foundation for future editions

- This INGR 1st edition was released in 2020 and was followed by 2021 and 2022 Editions. They laid the foundation for subsequent editions that will include a description and evaluation of 6G and other future network enhancements.

2023 Edition

- Extend the range and depth of the 2022 Edition

IEEE International Networks Generations Roadmap (INGR) 2022 Edition



<https://futurenetworks.ieee.org/roadmap>

IEEE INGR Structure and Working Groups

CATEGORY	DESCRIPTION	INGR WORKING GROUP CHAPTERS
User Access	This group describes how the users reach the network	- Satellites - Deployment - Connecting the Unconnected (CTU)
Network Components and Performance	This group describes how the networks are interconnected	- Edge Automation Platform - Massive MIMO - System Optimization - Optics - mmWave
Systems and Standards	This group describes system standards and testability	- Standardization Building Blocks - Testbed - Energy Efficiency
Services and Enablers	This group represents all the elements that enable deployment, assure functionality and security and address impact on society and environment	- Security - Applications and Services - Artificial Intelligence and Machine Learning (AI/ML)

IEEE INGR Working Groups - Access

INGR CTU WG Focus

- Promote visibility, development and standardization, and collaborate to connect the unconnected with affordable access across the globe.



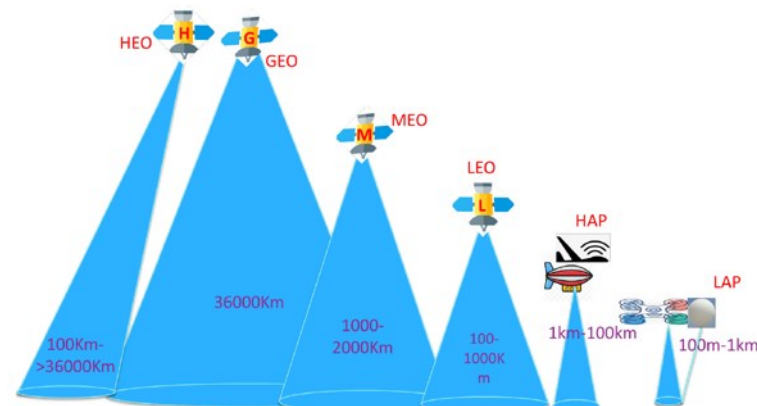
INGR Deployment WG Focus

- Serve as a bidirectional conduit for the
 - Public sector, governmental, and tribal stakeholders
 - Wireless industry including service providers and vendors



INGR Satellite WG Focus

- Define a new body of standards where the satellite 5G component is fully integrated with terrestrial systems.



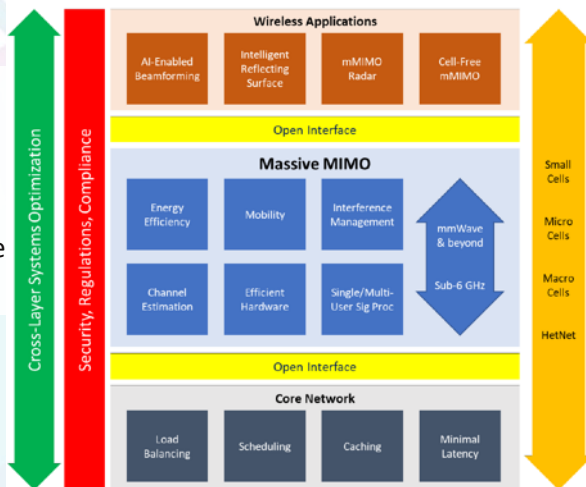
IEEE INGR Working Groups – Networks (1)

INGR Massive MIMO WG Focus

- Framework to support large number of active users with massive connectivity

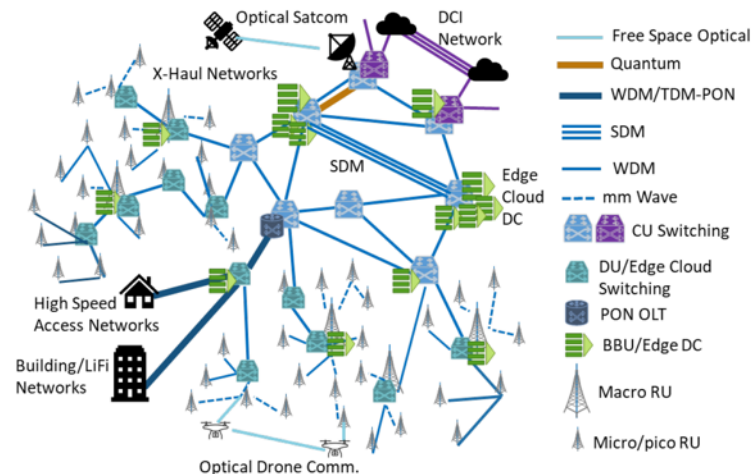
INGR Millimeter Wave and Signal Processing WG Focus

- Millimeter-wave architectures, hardware capabilities, and signal processing techniques to enable 5G systems



INGR Optics WG Focus

- Identify and build roadmaps for key optical technologies



IEEE INGR Working Groups – Networks (2)

INGR Edge Services and Automation

- Edge services and use cases via
 - Edge Service Platform Framework (ESPF-2021)
 - Edge Automation Platform Framework (EAPF-21)

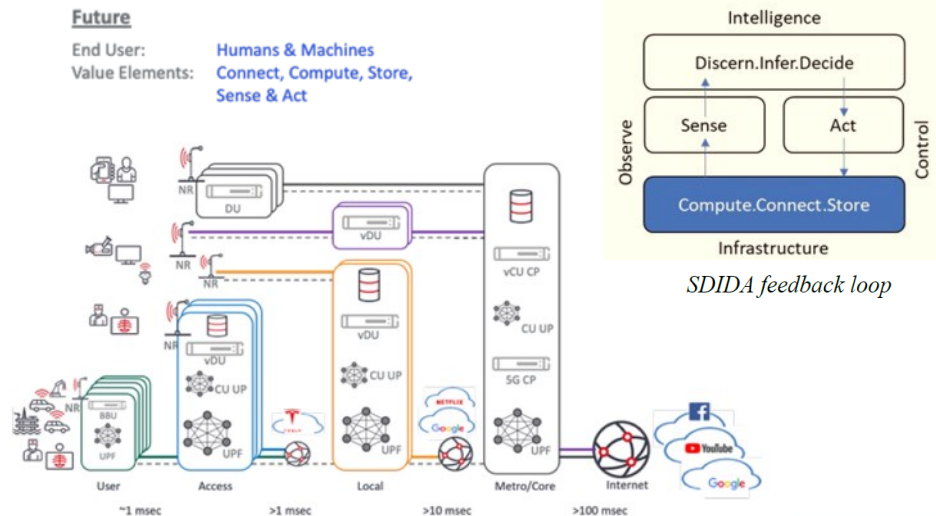


INGR Systems Optimization WG Focus

- Form a scientific community to define Self-Organizing Systems (SORs)
- Identify key problems, and provide solutions based on various tools ranging from machine learning and autonomic/autonomous decision-making solutions to complex systems theory, and many others..



Edge Service	Vertical	throughput	latency	jitter	Reliability	Power requirement	Energy Efficiency	Mobility	Commute High-core count	5G & Beyond
AV/IT/V2X	Automotive	10gbps	100 usec	NA	59s	high	High	240 km/hr	GPU needed	Y
IIOT	Industry 4.0	< 5 mbps	< 100 usec	NA	59s	normal	High	20 km/hr	High core count mmc	Y URLCC
Telehealth	eHealth	<1Gbps	<1ms	NA	59s	normal	High	NA	High compute	Y
Content Delivery	CDN / Smart City	<10 Mbps	<10ms	NA	49s	high	High	240 km/hr	M2M/D2D	Y
xApps	MEC/RIC (Agri/ Drone)	1-10 Mbps	Sub 2 ms	NA	59s	constrained	High	240km/hr	low Compute/offload	Y (UPF)



IEEE INGR Working Groups – System and Standards

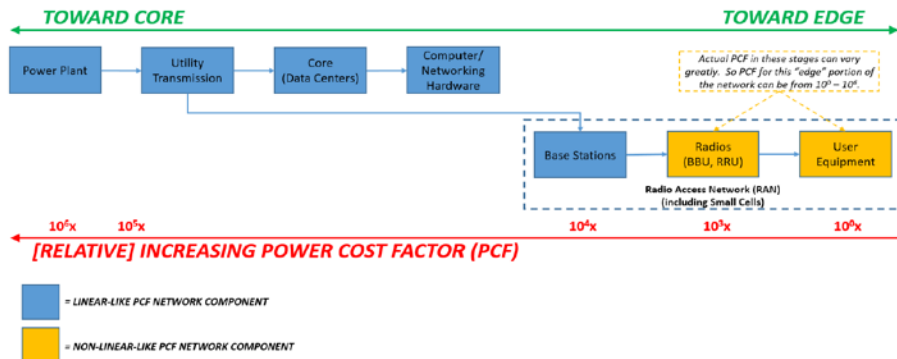
INGR Energy Efficiency WG Focus

- Provide visibility and resources to pragmatically reduce the utilization of energy and associated carbon footprint for global communications networks (including mobile telephony and fixed IP networks).

INGR Testbed WG Focus

- Develop testing standards and calibration methods
- Collaborate with the vendor and research community
- Organize workshops related to future networks experimental aspects (including use case scenarios, trials and proof-of-concept deployments)
- Create the IEEE Federation of Future Networks Testbeds covering all aspects of new technology research, experimentation, and evaluation

The 5G Power Value Chain



INGR Standardization Building Blocks WG Focus

- Identify its evolution and challenges for the ever-expanding Standardization Landscape
- Stakeholder community includes a much wider variety of Standards Developing Organizations (SDOs) and industry alliances

IEEE INGR Working Groups – Enablers and Users

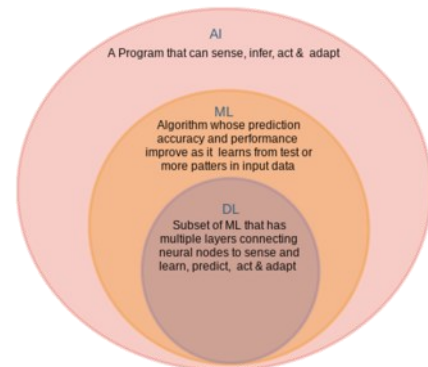
INGR Applications and Services WG

- Create a structured **transdisciplinary framework** for applications and services across end-to-end ecosystems, and caters to different stages of priorities, resources, and technologies



INGR AI/ML WG

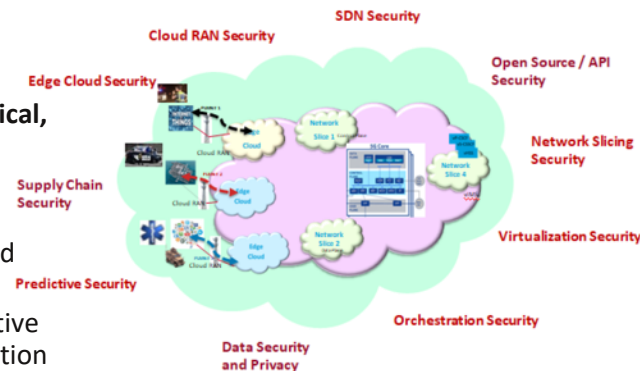
- Identify and define the taxonomy and state of **AI** (*sense, think, and act like a human*) and **ML** (*detection, classification, segmentation, predictions, and recommendations*).
- Survey existing frameworks and reference architectures



Venn diagram showing relationship between AI, ML and DL

INGR Security WG

- 5G security considerations across different layers (physical, network, and application).
- NIST Cyber Security Framework Alignment
- 5G security architecture and requirements
- Risk-based adaptive/proactive security SDN/NFV orchestration and optimization



5G Security Pillars

Ecosystem of Ecosystems



Governance Function of Functions

Strategic, Tactical, and Operational Functions

Trust and Privacy, Stakeholder Engagement, Multi-Tiered Security, Data Governance, Investments and Funding

INGR Contact Information

For questions about the INGR, please contact: 5GRoadmapInfo@ieee.org

International Network Generations Roadmap (INGR) Leadership Team:

IEEE Future Networks Initiative Co-chairs:

Ashutosh Dutta – ad37@caa.columbia.edu

Timothy Lee – tt.lee@ieee.org

IEEE International Network Generations Roadmap Co-chairs:

Chi-Ming Chen – chimingchen_ieee@yahoo.com

Rose Hu – rose.hu@usu.edu

Paolo Gargini – paologargini1@gmail.com

Narendra Mangra – nmangra@ieee.org

IEEE Program Director, Future Directions

Brad Kloza – b.kloza@ieee.org

IEEE Sr Content and Roadmap Specialist

Matt Borst – m.borst@ieee.org

IEEE FNI INGR Working Groups	Chairs	Email to contact to participate
INGR Co-Chairs	Chi-Ming Chen, Rose Hu, Narendra Mangra	5Groadmapinfo@ieee.org
Applications and Services	Ravi Annaswamy, Narendra Mangra	5GRM-appssvcs@ieee.org
Artificial Intelligence / Machine Learning	Deepak Kataria, Anwar Walid	5GRM-AIML@ieee.org
Connecting the Unconnected	Sudhir Dixit, Ashutosh Dutta	5GRM-connecting@ieee.org
Deployment	David Witkowski, Tim Page	5GRM-deployment@ieee.org
Edge Services and Automation	Prakash Ramchandran, Sujata Tibrewala, T.K. Lala	5GRM-eap@ieee.org
Energy Efficiency	Brian Zahntecheer, Francesco Carobolante	5GRM-energy@ieee.org
Massive MIMO	Chris Ng, Webert Montlouis	5GRM-massiveMIMO@ieee.org
Millimeter Wave and Signal Processing	Tim Lee	5GRM-mmWave@ieee.org
Optics	Dan Kilper, Shan Wey	5GRM-optics@ieee.org
Satellite	Sastri Kota, Giovanni Giambene	5GRM-satellite@ieee.org
Security and Privacy	Ashutosh Dutta, Eman Hammad	5GRM-security@ieee.org
Standardization Building Blocks	Alex Gelman, Reinhard Schrage, Mehmet Ulema	5GRM-standards@ieee.org
Systems Optimization	Lyndon Ong, Meryem Simsek	5GRM-sysopt@ieee.org
Testbed	Ivan Seskar, Mohammad Patwary	5GRM-testbed@ieee.org

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