International Network Generations Roadmap (INGR)

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IEEE INGR and Applications & Services WG Co-Chair
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IEEE

Agenda

- IEEE Future Networks Initiative and IEEE INGR
- IEEE INGR First Edition Highlights
  - New and Existing WGs
- IEEE Second Edition and Working Groups

Background

International Network Generations Roadmap (INGR) Initiative

5G may be viewed as a network of networks and may drive evolutions in various ecosystems that result in shifting industry structures and adjacent industry boundaries.

Roadmaps help address some of the technical and engineering risks associated with the new technology migrations.

The INGR roadmap may be used to stimulate an industry-wide dialogue for coordinated development and deployment of 5G.

A roadmap needs to evolve and adapt to ecosystem changes in order to avoid becoming obsolete, e.g. IEEE International Roadmap for Devices and Systems (IRDS) experience

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International Network Generations Roadmap

Executive Summary

1st Edition
2019

INGR
International Network Generations Roadmap

Refer to IEEE Executive Summary for additional details

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International Network Generations Roadmap

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IEEE INGR Working Groups and Focused Events

IEEE INGR WGs

- Applications and Services
- *Artificial Intelligence / Machine Learning (AI/ML) – New for 2019*
- *Connecting the Unconnected – New for 2019*
- *Deployment – New for 2019*
- Edge Automation Platform
- *Energy Efficiency – New for 2019*
- Hardware
- Massive MIMO
- Millimeter Wave and Signal Processing
- *Optics – New for 2019*
- Satellite
- Security
- Standardization Building Blocks
- *Systems Optimization – New for 2019*
- Testbed

INGR Focused Events

- INGR Workshop at the IEEE 5G World Forum in Dresden, Germany - 30 September to 2 October 2019
- International Network Generations Roadmap (INGR) Workshop - July 2019
- IEEE Beyond 5G Roadmap Workshop at ICC 2018, May 2018
- IEEE 5G Roadmap Workshop at ICC-2017, Paris France, 25 May 2017
- IEEE 5G Roadmap Workshop at Globecom 2016, 8 December 2016

Visit our website: https://futurenetworks.ieee.org/roadmap

INGR 1st Edition Release Overview

January 2020
Executive Overview and Edition 1 Chapters

- Applications and Services
- Edge Automation Platform
- Massive MIMO
- mmWave and Signal Processing
- Standardization Building Blocks

- Security
- Hardware
- Satellite
- Testbed

White Papers to be released in 1Q2020

- Deployment
- Optics
- Connecting the Unconnected

- Energy Efficiency
- Systems Optimization
- AI/ML

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IEEE INGR First Edition Highlights

IEEE INGR First Edition Highlights

Access

- mmWave and Signal Processing
- Massive MIMO
- Hardware
- Energy Efficiency
- Satellite
- Connecting the Unconnected
- Deployment

Service Delivery – Edge / Core Network

- Optics
- Edge Automation Platform (EAP)
- Artificial Intelligence / Machine Learning (AI/ML)
- System Optimization

Systems and Services

- Security
- Testbed
- Standardization Building Blocks
- Applications and Services

INGR First Edition

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 lays the foundation for the subsequent editions that will include a description and evaluation of 6G and other future network enhancements.

mmWave and Signal Processing WG
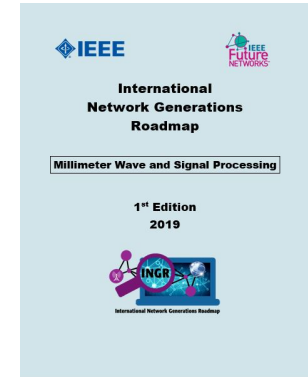
INGR mmWave and Signal Processing WG Focus

- Examines improvements in current millimeter-wave architectures, hardware capabilities and signal-processing techniques

INGR mmWave and Signal Processing Chapter Highlights include

- **10-year horizon** – address mid band and high band deployments of 5G hardware, and define 6G with potential use of high millimeter-wave bands (70- to 300-GHz)
- **High Bandwidth channels** to support 5G Use Cases
- **Active and Passive Components**
- **Design for 5G Test** – includes over-the-air (OTA) testing at component, cell and array levels
- **Design for Multiple Use Cases with Reconfigurable Hardware** – includes testing for resiliency, QoS and optimum utilization of resources

WG Recommendations / Potential 2nd Edition Topics

- Continue to **monitor analog, digital and hybrid beamforming technologies**.
- Continue to **monitor the competing advanced packaging technologies** for different substrate materials and processability for low-cost millimeter-wave modules
- Address in future editions the **pros and cons of different 5G waveforms** and their impacts on data rate, peak to average ratio and spectral efficiency.
- Address in future editions on **supply chain and security/trust issues**
- Address the concerns on **health, safety of 5G millimeter-wave radiation**

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Millimeter Wave and Signal Processing

1st Edition 2019

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IEEE INGR mmWave and Signal Processing WG

- *Roadmap Details – Refer to INGR WG chapter*
- *WG Participation –* 5GRM-mmWave@ieee.org

Massive MIMO WG

INGR Massive MIMO WG Focus

•. Support large number of active users with massive connectivity

INGR Massive MIMO Chapter Highlights include

- **mmWave Massive MIMO for HetNet** – Cell Association and Mobility Management, Big Data management, etc
- **MAC-PHY Cross Layer Design** for Massive MIMO in Future Wireless Systems – Physical and MAC Protocol Designs, etc
- **Secure Communications** in Massive MIMO Wireless Systems – Precoding Schemes Design, Hardware Impairments, etc
- **Artificial Intelligence and Machine Learning (AI/ML) Applications** in Massive MIMO –Resource Allocation, Channel Estimation, etc
- **Enabling Massive Connectivity** with Massive MIMO –Low Complexity Channel Estimation, Cloud/Edge Network, etc
- **Autonomous Massive MIMO** –Throughput-Optimized Massive MIMO, Reliability and Latency-Optimized Massive MIMO, etc

WG Recommendations / Potential 2nd Edition Topics

- **Key performance indicators (KPIs)** of different massive MIMO architectures.
- **Massive MIMO systems deployments in different configurations**, e.g. TDD, FDD, indoor/outdoor, small cells, etc.
- Support different **massive MIMO hardware implementation architectures**: e.g., digital, analog, hybrid.
- **Massive MIMO RAN transition from a passive network layer to an intelligent decision- making network component.**
- **Transition from cell-based topology to a dynamic, self- optimizing beam-based wireless ecosystem.**

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Massive MIMO

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IEEE INGR Massive MIMO WG
- *Roadmap Details – Refer to INGR WG chapter*
- *WG Participation –* 5GRM-massiveMIMO@ieee.org
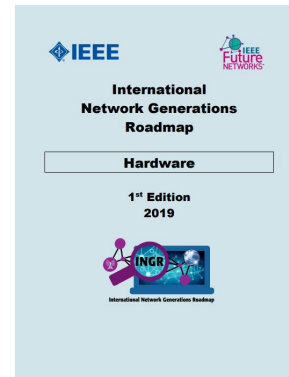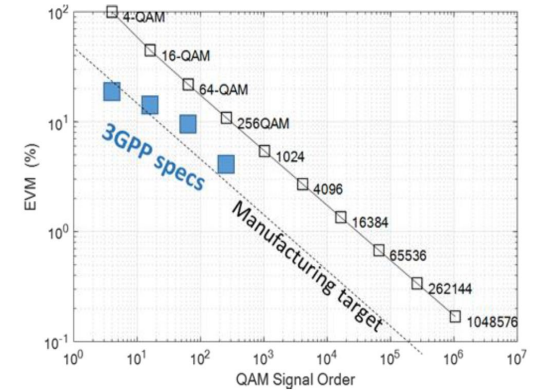
Hardware WG

INGR Hardware Focus

- Addresses links, mobile handsets, mesh- enabled radios and base stations to reach commercial viability and open ultra-high-bandwidth low- latency applications in mobile virtual reality, robotics, and automated manufacturing.

INGR Hardware Chapter Highlights include

- **Hardware Requirements for Ultra-Broadband mmWave Mobile Handsets, Mesh-Enabled Radios and Base stations**
- **10-year horizon** –Fixed mmWave communications between base stations and subscribers (the last mile), mmWave communications to automobiles and other mobile platforms, and cost-effective energy-efficient mobile mmWave handsets able to capitalize on ubiquitous reach of close-by base stations and mesh-networked continuously powered mobile nodes.

WG Recommendations / Potential 2nd Edition Topics

- **Breaking the current efficiency/linearity tradeoff** to allow for improved energy efficiency while maintaining adequate linearity.
- **Developing compact cost-effective packaging solutions** with integrated antennas and superior thermal-management capabilities.
- **Improving the energy efficiency of digital processing for high data rate communications**

IEEE INGR Hardware WG
- *Roadmap Details – Refer to INGR WG chapter*
- *WG Participation –*
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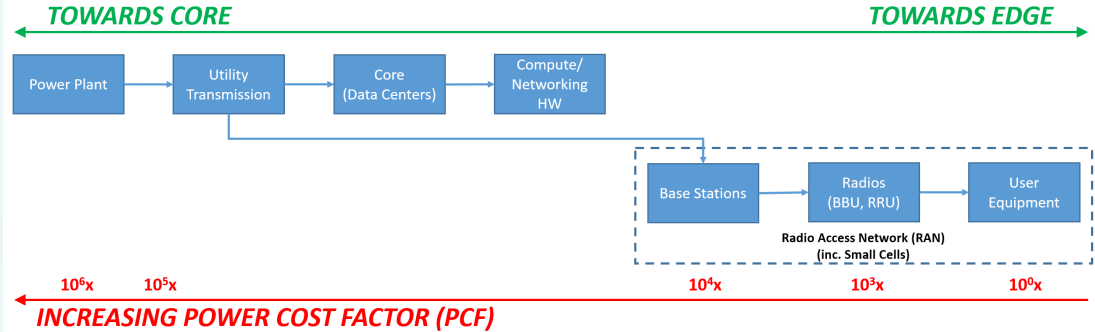
Energy Efficiency – New WG

•Committed to the education of energy-related issues/concerns/opportunities across all industry stakeholders and associated, extended ecosystems.

INGR Energy Efficiency WG Areas of Interest include:

- **The Power Value Chain (PVC)**
- **Embodied Energy** – Manufacturing, Application, End of Life
- **Network Energy Architecture** - Global Telecommunications Energy Footprint, "5G Energy Gap", Safety and Security Concerns
- **Network-Level Energy Analysis**
- **Optimizing Energy Utilization** - Component, System, Edge, Base Station, Data Center, Network, and Utility Grid levels
- **Engineering Resources**
- **Natural Resources / Sustainability**

R_x **The 5G Power Value Chain**

TOWARDS CORE → ← TOWARDS EDGE

Power Plant → Utility Transmission → Core (Data Centers) → Compute/ Networking HW

Base Stations → Radios (BBU, RRU) → User Equipment

Radio Access Network (RAN) (inc. Small Cells)

10^6x 10^5x 10^4x 10^3x 10^0x

INCREASING POWER COST FACTOR (PCF)

Potential Energy Efficiency Topics for INGR 2nd Edition includes:

- **Energy Impact of Massive Small Cell,** i.e. – HetNet Deployment
- **End-to-End Network Energy Analysis**
  - **Generation** – Distribution, Stability, Power Value Chain (PVC)
  - **Utilization** - Distribution Losses, Conversion Losses, System Utilization, Energy Storage, Networks (the 5G Energy Gap)
  - **Mitigation** - Efficiency Efforts, Eliminating Primary Energy Storage
  - **Sustainability** - Embodied Energy

IEEE INGR Energy Efficiency WG
- *Whitepaper – Q1 2020*
- *WG Participation –* 5GRM-energy@ieee.org

Satellite WG
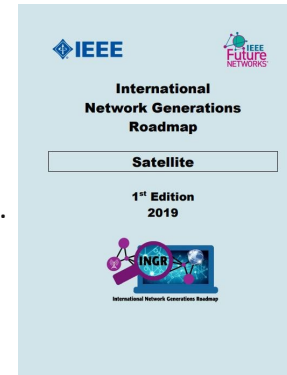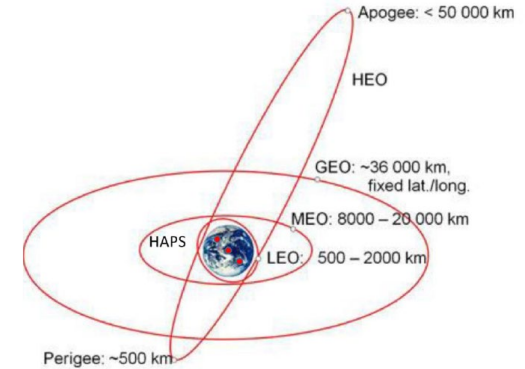

INGR Satellite WG Focus

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

INGR Satellite Chapter Highlights include

- **10-year horizon** – Refined satellite 5G testbeds, new technologies for satellite 5G (e.g. MIMO, advanced digital payload, AI-driven satellites, optical communications, new satellite/aerial component), and satellite network virtualization.
- **Satellite Architectures, Integrated Satellite and Terrestrial Protocols and Interfaces**
- **Additional** – AI/ML, NFV, SDN, Security, Optics in Space and Intersatellite Links, etc

WG Recommendations / Potential 2nd Edition Topics

- **Definition of standardized 5G architectures**, including terrestrial RAN and aerial RAN (with multiple layers, as drones/HAPs/satellites).
- **Convergence towards a unified solution** with the terrestrial counterpart.
- **Virtualization of the satellite network** to facilitate the integration with the 5G system.
- **Advanced security mechanisms** based on quantum key distribution techniques and physical layer security.
- **Satellite system integration with terrestrial system** to achieve rural and remote connectivity along with urban areas.

IEEE INGR Satellite WG
- *Roadmap Details – Refer to INGR WG chapter*
- *WG Participation –* 5GRM-satellite@ieee.org

Connecting the Unconnected – New WG

INGR Connecting the Unconnected WG Focus

• Enable 5G and B5G technologies to be customized to be cost effective for meeting the unique needs of those who have yet to experience the value of the internet, mainly those who are digitally disadvantaged or living in rural and remote areas.

INGR Connecting the Unconnected WG Areas of Interest include:

• **Least cost wireless front-haul and backhaul** through beamforming and MIMO in refarmed spectrum, and the use of RF spectrum white spaces including the TV bands, in addition to other access technologies,

• **Trust, security and privacy** that meets the capabilities of the user community,

• **Simplified and intuitive human computer interfaces (HCI),**

• **Micro-operator ecosystems** to encourage local coverage and enablement of rollout of sustainable services, and

• **A dedicated network slice for the CTU use case**

Potential Connecting the Unconnected Topics for INGR 2nd Edition includes:

• **Reforms in government policies**

• **Engagement of United Nations, GSMA, ETSI, ITU, WWRF in CTU Working Group** through active partnership

• **Industry engagement**

• **Spectrum allocation**

• Focus on **technologies to improve radio range** and NLOS communication

• **Innovative business models** that encourage local entrepreneurship

IEEE INGR Connecting the Unconnected WG
• *Whitepaper – Q1 2020*
• *WG Participation –* 5GRM-ctu@ieee.org

Deployment – New WG

INGR Deployment WG Focus

• Inform the wireless industry about the tactical challenges of deployment in and around public right of way – including private properties adjacent to the public right of way affected by local government zoning/planning, and to highlight the particular needs and perspectives of local governments and municipal agencies where applications for deployment of wireless communications facilities will be reviewed and permitted.

INGR Deployment WG Areas of Interest include:

• **Local government factors** and perspectives affecting deployment.
• **Regulatory factors** affecting deployment.
• **Public/Community factors** and perspectives affecting deployment.
• **Technology issues affecting deployment**.

Potential Deployment Topics for INGR 2nd Edition includes:

• **IEEE public-facing documents**
• **Regulatory agency adoption of relevant standards.**
• **Stakeholder engagement** with industry, local governments, and standards bodies.
• Determine **challenges in industry & product management**
• **Connecting industry (product management) to governments and communities** – creating "Designed for Deployment"
• **Case studies** for the above.

IEEE INGR Deployment WG
• *Whitepaper – Q1 2020*
• *WG Participation –*
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Optics – New WG

INGR Deployment WG Focus

• Address the needed optical technologies that can be developed to meet the 5G vision and goals

INGR Deployment WG Areas of Interest include:

• **Flexible front-haul network**

• **CDCG ROADMs -** Colorless, Directionless, Contentionless Gridless (CDCG) Reconfigurable, Optical, Add/Drop Multiplexer (ROADM)

• **High-port-count switching solutions**

• **Radio over fiber**

Potential Deployment Topics for INGR 2nd Edition includes:

• **Infrastructure gaps**
  • Merchant Silicon for CDC-G, ROADM & Programmable ONT & ONUS equipments
  • Low Power high port optical switches, connectors and FPGAs with algorithms for CDC-G
  • Materials – Silicon Photonics and Production level supply for L2/L1 integration for Optics

• **Policy gaps**
  • Global Subsea Optical fiber and International standards impacted by trade wars
  • Research – Silicon Photonics is still emerging from research to production deployments

• **Skills gap**
  • Analog & Mixed Signal simulation experts to promote the Optics are rare to find
  • Programming, e.g. Go, Python, P4, POF are still evolving to define normative interfaces , abstractions & APIs

IEEE INGR Optics WG
• *Whitepaper – Q1 2020*
• *WG Participation –* 5GRM-optics@ieee.org

Edge Automation Platform (EAP) WG
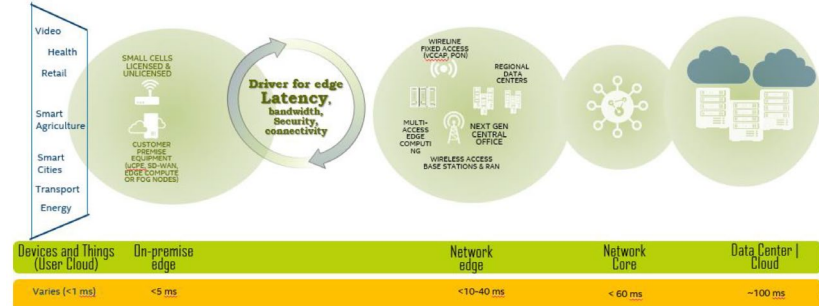
INGR Edge Automation Platform (EAP) WG Focus

- Work towards an open reference architecture for a cloud platform that uses compute, storage, and network resources distributed across the multi-access edge

INGR EAP Chapter Highlights include

- **10-year horizon** – Standardization of edge platform and application containers, QoE characterization, and Hyper Converged Infrastructure (HCI) - common infrastructure for heterogeneous cloud
- **Real or virtual functional distribution**, e.g. virtual network function (VNF), cloud-native network function (CNF)
- **Network connectivities** to support low-latency packet flows and high throughput communications

WG Recommendations / Potential 2nd Edition Topics

- **Define best known configuration (BKC)** - different workloads and models
- **Normative Definitions** - Reference Software/Stack for EAP (**RS-EAP**), Reference Intelligent Infrastructure for EAP (**RII-EAP**), Reference Offload Interface Cloud EndPoint to Edge End Point (**ROI-CEP-EEP**)
- **EAP compute/network intensive workload manager**

IEEE INGR Edge Automation Platform (EAP) WG

- *Roadmap Details – Refer to INGR WG chapter*
- *WG Participation –* 5GRM-eap@ieee.org

Artificial Intelligence / Machine Learning (AI/ML) – New WG

INGR Artificial Intelligence / Machine Learning (AI/ML) WG Focus

- AI/ML is a key enabler for prediction, learning, automation and intelligence.
  - Optimize the use of network and spectrum resources
  - Dynamically share radio spectrum (e.g., more efficient cognitive radio)
  - Offers much better QoS (Quality of Service) adaptation and QoE (Quality of Experience)

INGR Artificial Intelligence / Machine Learning (AI/ML) WG Areas of Interest include:

- **Traditional Techniques** - Supervised Learning, Unsupervised Learning, and Reinforcement learning
- **New Techniques** - Deep learning, Transfer learning, Real Time Stream Data Analytics, Generative Adversarial Networks (GAN), etc
- **Examples** - Traffic Prediction, traffic classification, studies using deep learning

Potential Artificial Intelligence / Machine Learning (AI/ML) Topics for INGR 2nd Edition include

- **AI/ML performance metrics** for Networks
- **AI/ML algorithms** at each of network layers
- **Framework of deploying AI/ML** in the networks
- **Format and types of data acquired by AL/ML** in networks
- Define typical **scenarios of using AL/ML for future networks**
- **Interfacing and standardization** (generalized or specified)
- **Identify possible holes (e.g., disadvantages)**

IEEE INGR Artificial Intelligence / Machine Learning (AI/ML) WG
- *Whitepaper – Q1 2020*
- *WG Participation –* 5GRM-AIML@ieee.org

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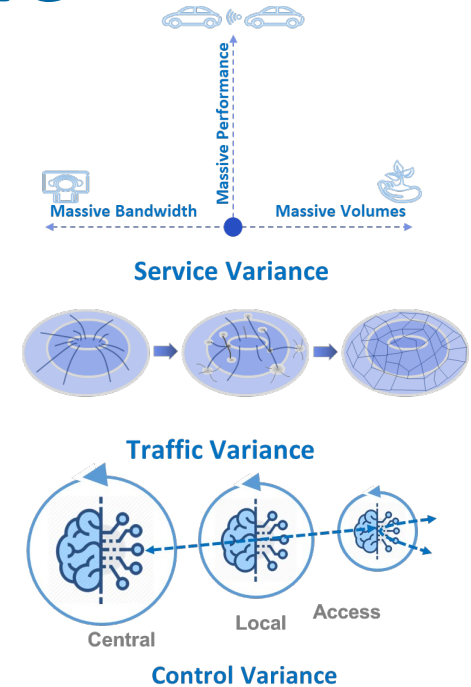# Systems Optimization – New WG

INGR Systems Optimization WG Focus

- Explore various approaches to manage complexity of future systems with non-traditional design and operational methodologies.

INGR Systems Optimization WG Areas of Interest include:

- **Emergent Intelligence**: results from the non-linear interactions between components at different levels of Cloud and Communications systems
- **Explore emergence to address full stack self-organizing systems**
  - Multi-layer, multi-domain self-organization/-optimization
  - Employ principles of "Emergence" to drive confluence of Cloud and Communication Systems
- **Distributed Security, Mobility management** across multiple RATs, **Handoff optimization**

Potential Systems Optimization Topics for INGR 2nd Edition includes:

- Examine future services resulting in **non-deterministic system requirements**
- Explore methods for addressing these with **self-organizing and self-optimizing principles**
- Validate/verify methods for some imminent **optimization challenges of future networks**
- **Collaboration with similar studies in conjunction with 6G activities** related to: Security, Edge Automation, AI, etc.

Service Variance

Traffic Variance

Central   Local   Access

Control Variance

IEEE INGR Systems Optimization WG

- *Whitepaper – Q1 2020*
- *WG Participation –* 5GRM-sysopt@ieee.org

Security WG

INGR Security WG Focus

- Develop and integrate security controls at every layer of the communications system.

INGR Security Chapter Highlights include

- **10-year horizon** – Risk-based adaptive identity management and access control usage, Computational intelligence processing artificial intelligence machine learning (CI/AI/ML).
- **Security Pillars** - Management / Orchestration Security, Edge Security, Third Party Security, Supply Chain Security
- **Data security and privacy**

WG Recommendations / Potential 2nd Edition Topics

- Perform an **in-depth security gap analysis** with current industry standards
- **Enable studies (research, verification)** via established 5G test-beds
- **Publications** to inform/guide/socialize 5G security directions/focus areas (informed by the roadmap).
- **Collaborations with ONF, ORAN, Linux Foundation** to develop an open source security framework
- **Engagement, education and socialization**, e.g. conferences, webinars, world forum
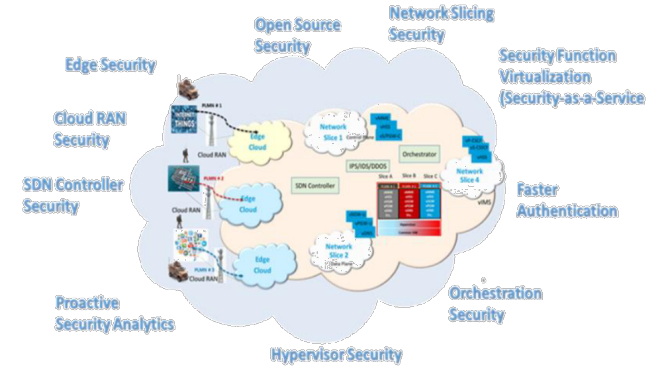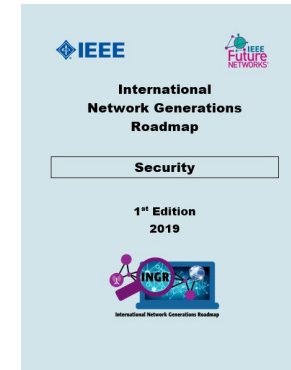

Figure 1. Various Security Pillars for 5G Networks

IEEE INGR Security WG
- *Roadmap Details – Refer to INGR WG chapter*
- *WG Participation –* 5GRM-security@ieee.org

Testbed WG

INGR Testbed WG Focus

- Interact with various existing testbeds and collaborate with the vendor and research communities.

INGR Testbed Chapter Highlights include

- 10-year horizon –
  - **Develop a bank of data sets** from participating testbed and pilot programs,
  - **Build up expected performance benchmark** for 5G and beyond,
  - **Establish testbed standards and experimental platforms** for 5G or 6G use cases development
  - **Influence next generation network architecture definition.**
- **Testbed harmonization and federation**

WG Recommendations / Potential 2nd Edition Topics

- Create a "testbed clearing-house" and ways to bring all testbeds in "the same room"
- **Standardization** (in both testbed design and metrology) and experimental repeatability;
- Identified a need to continuously **ensure that testbeds get input from other technology groups** on their testing needs.
- **Collaborate with vendor and research communities** to expand existing testbeds with next generation of technologies (as available)

Table 3. Proposed Driver Metric Chart

Technology Gaps	Potential Way Forward
Lack of Scale	PPP (Government, industry and academia cooperation; cooperative approach from the existing testbeds)
Proliferation of specialized (vertically) testbeds without common elements	Cooperative approach from the existing testbeds; open source contribution, workshops for engagement, and professional community engagement)
Lack of 5G feature (eMBB, mMTC, URLLC) optimized experimentation platform	Open source hardware and software platform, (white-box component from OEM or equivalent)
Lack of inter-testbed cooperation	Introduction of certification on testbed vertical compliance and interoperability to promote cooperation and component reuse.
Lack of use cases	Public events, such as hackathons, exhibitions, school level and university (UG/G/PG) research promotion in partnership with industry.
Lack of platform for universal data sharing	Promotion and demonstration of the value/requirement of the data generated from users, applications and networks; develop technology and business models for data sharing along with standard (certain level of commonality, while generating or translation)
Lack of skills	Establish dedicated testbed for skill enhancement. IEEE to provide online webinar to facilitate live event, if possible from a testbed site.

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Testbed

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IEEE INGR Testbed WG
- *Roadmap Details – Refer to INGR WG chapter*
- *WG Participation –* 5GRM-testbed@ieee.org

Standardization Building Blocks WG

INGR Standardization Building Blocks WG Focus

• Extend beyond traditional telecommunication standards developing organizations (SDOs) and stakeholder community and include a much wider variety of industry alliances

INGR Standardization Building Blocks Chapter Highlights include

• **10-year horizon** – standardization activities from Major System Integrators SDOs, and Core Technology SDOs, and Industry Alliances
• **Cooperation** between SDOs and Open Source Communities
• **Standardization of Emerging Technologies**
• **Standardization Building Blocks Overlay** for INGR WGs - includes Applications and Services, Edge Automation Platform (EAP), Massive MIMO, mmWave Technology, Satellite Technology, and Testbed

WG Recommendations / Potential 2nd Edition Topics

• **Harmonize standardization efforts** for long-term technology evolution.
• **Continue Cross Team Meetings**
• **Identify/quantify/metrify elasticity parameters** of INGR offerings to enable as seamless as possible interworking of components
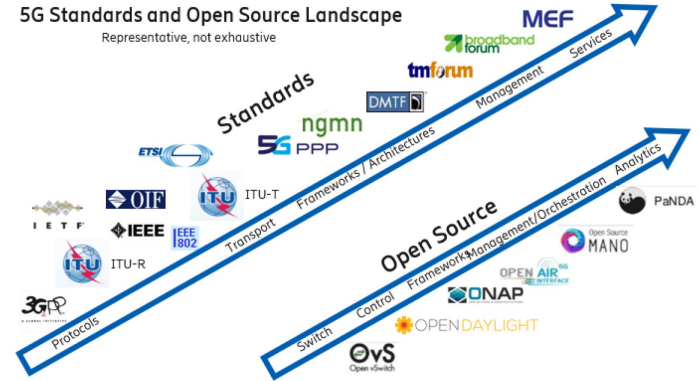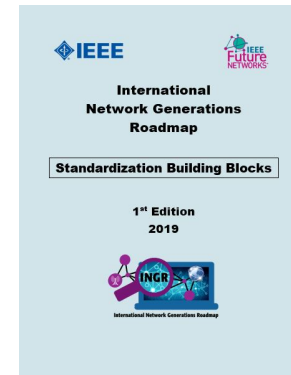• **Standardizing methodology of metrics**

Figure 1. 5G Standards and Open Source Landscape

IEEE INGR Standardization Building Blocks WG
• *Roadmap Details – Refer to INGR WG chapter*
• *WG Participation –* 5GRM-standards@ieee.org

Applications and Services WG

IEEE Future Networks INGR Applications and Services Working Group

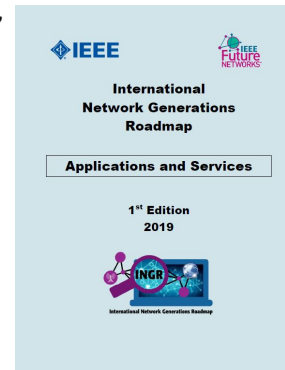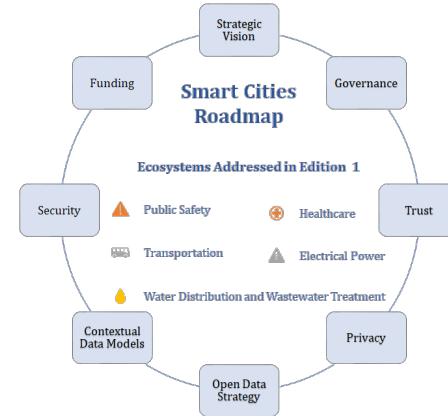### INGR Applications and Services WG Focus

- Provide a structured, flexible, adaptable, and scalable methodology for applications and services that extends across end-to-end ecosystems in urban and non-urban areas.

INGR Applications and Services Chapter Highlights include

- **10-year horizon** – Initial urban smart city focus on ecosystems with different technology adoption rates.
- **Smart Cities Framework** –sustainable interconnected ecosystem of ecosystems end-to-end approach (includes governance, performance, etc)
- **Ecosystems** - Public Safety, Transportation, Health Care, Electrical Power, Water Distribution and Wastewater Treatment

WG Recommendations / Potential 2nd Edition Topics

- **Enhance current ecosystem frameworks** – Additional details on governance structure and ecosystems (public safety, healthcare, transportation, electricity, water & wastewater)
- **Add new ecosystems**, e.g. Agriculture, Education, Finance, etc
- **Highlight interdependencies among ecosystems**

Smart Cities Roadmap

Strategic Vision · Governance · Funding · Trust · Security · Privacy · Open Data Strategy · Contextual Data Models

Ecosystems Addressed in Edition 1
- Public Safety
- Healthcare
- Transportation
- Electrical Power
- Water Distribution and Wastewater Treatment

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Applications and Services
1ST Edition 2019
INGR — International Network Generations Roadmap

IEEE INGR Applications and Services WG

- *Roadmap Details – Refer to INGR WG chapter*
- *WG Participation –*
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Summary

Roadmaps

- Roadmaps help to address some of the technical and engineering risks associated with the new technologies.
- The IEEE INGR provides a high-level perspective and projection of how the industry could evolve, with highlights of common needs, the challenges to achieving those needs, and the potential solutions to those challenges as nine initial chapters.
- It is the purpose of the INGR roadmap to stimulate an industry-wide dialogue to synchronously address all the facets of the development and deployment of 5G in a well-coordinated manner, starting with the year 2020 and going beyond.

INGR First Edition

- This first edition roadmap lays the foundation for the next edition that will include a description and evaluation of 6G and other future enhancements.
- **INGR 1st Edition Chapters are available at https://futurenetworks.ieee.org/roadmap**
- *Additional* **white papers to follow in Q1' 2020 for new WGs**

INGR Second Edition

- As work continues with the Second Edition, new experts are encouraged to participate, to evolve and strengthen this crucial document. Join us!
- **https://futurenetworks.ieee.org/roadmap#workingGroups**

Contact Information

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

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INGR Working Groups

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Optics – New for 2019	Feras Abou-Galala, Prakash Ramchandran	5GRM-optics@ieee.org
Connecting the Unconnected – New for 2019	Sudhir Dixit, Ashutosh Dutta	5GRM-ctu@ieee.org
Energy Efficiency – New for 2019	Brian Zahnstecher	5GRM-energy@ieee.org
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As work continues with the Second Edition, new experts are encouraged to participate, to evolve and strengthen this crucial document.

Join us !

Visit our website: https://futurenetworks.ieee.org/roadmap

INGR 1st Edition Release

- Access the documents online at
futurenetworks.ieee.org/roadmap

- INGR is a program of the **IEEE Future Networks Initiative**

Additional Information

INGR WG Participation

Roadmap Working Group Teams

- Teams reflect key topic areas
- Expertise covers major technology and/or manufacturing disciplines of the industry
- Dependent relationships among teams
- Task is to forecast
  - Technology and/or manufacturing needs
  - Challenges to overcome
  - Areas of needed innovation and potential solutions

Working Group Team Member Activities

- Overall time commitment is 2-3 hours per month for a 12-18 month cycle
  - Assess industry needs, challenges, and solutions for working group topic
  - Attend working group team calls, quarterly progress updates, and roadmap workshop
  - Develop roadmap content
  - Co-write a roadmap report at end of process cycle
  - Review roadmap reports

  - Time commitment will be higher for 2-day roadmap workshops and during the 2-month writing report writing period, depending on amount of content each team writer agrees to submit.

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Working Group Team Member Activities - Details

- Attend 2 working group WebEx meetings each month. Time commitment is 1 hour each call
  - Contribute during these "working calls" in roundtable discussions
  - Develop the roadmap content during these calls

- Attend quarterly progress webinars (15-30 minute progress presentations by each team)
  - Team members can optionally attend these 3-4 hour sessions each quarter

- Attend face-to-face roadmap workshops per year in the United States.
  - 2-day workshops, co-located at IEEE Future Networks or other conferences to leverage travel expenses
  - Face-to-face meetings will have WebEx capability to enable those who cannot travel to participate virtually
  - Team members are expected to arrange travel and take advantage of room block discounts and pay for their own travel using their own organization resources