IEEE Future NETWORKS

Enabling 5G and Beyond

International Network Generations Roadmap (INGR)

Virtual Workshop

Applications and Services

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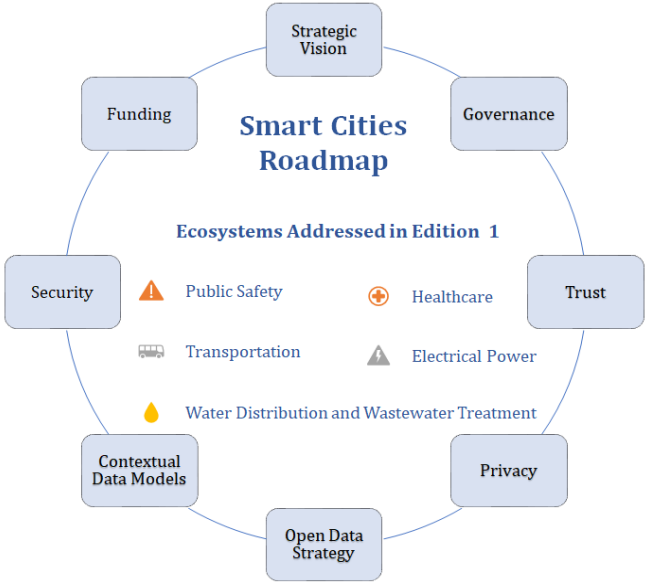
16 June 2020

IEEE

Scope

- **Create a structured, flexible, adaptable, and scalable framework for applications and services.**
  - Caters to different localized stages of priorities, resources, and technologies across geographical, political, and cultural boundaries.
  - Align functions within and among ecosystems for a coordinated response.



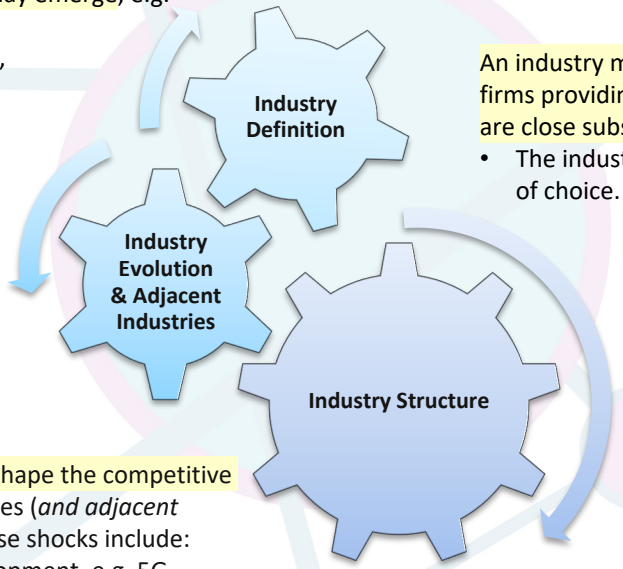
Second Edition to include:

- **Additional depth and breadth** of First Edition topics
  - **Ecosystem function extension** beyond smart cities
  - **Key Technology Components** – Access, Service Delivery, Operations & Customer Management, Interoperability
  - **Use Case Categories** – eMBB, mMTC, URLLC, and Network Operations Enhancements
- **New ecosystems** - includes Agriculture, Education and Entertainment
- **Cross-Ecosystem Touchpoints**
- **Key Performance Indicators (KPIs)**
- **Standardization Landscape** – includes PAR 1950.1 (Smart Cities framework)
- **Scenarios** –Pandemic and Disaster Planning, Smart Cities/Regions, etc

Subsequent editions to address additional ecosystems such as Financial Systems, Smart Buildings, Waste Management, etc

Today's Landscape

Adjacent industries may emerge, e.g.
- Connected Cars,
- Connected Health,
- Smart Grid,
- Mobile Money



An industry may be defined as a group of firms providing products or services that are close substitutes for each other.
- The industry boundaries is a matter of choice.

Industry shocks may reshape the competitive landscape as new services (*and adjacent industries*) emerge. These shocks include:
- Technological Development, e.g. 5G
- Macro Economics
- Customer Trends
- Regulatory Effects
- Geopolitical Forces

Industry landscape evolves over time

Industry structure shaped by forces such as:*
- *Threat of New Entrants*
- *Threat of Substitutes*
- *Bargaining Power of Suppliers*
- *Bargaining Power of Customers*
- *Intensity of Competitive Rivalry*

** Porter's Five Forces*

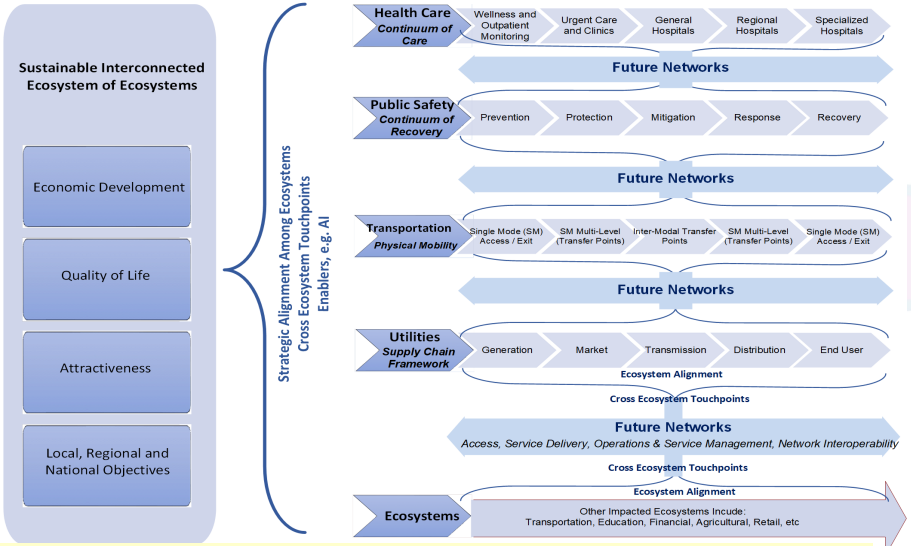
- **Most applications and services are fragmented** with technology-centric activities that aim to solve a small subset of problems. e.g. parking, lighting.
- **Technology standards are still being developed** and will subsequently need chipsets, spectrum, and network deployments for mainstream use.
- **Experimentation with new ideas among industries**
- **Ecosystems are made up of several industries** with an interconnected set of applications and services
  - *Firms → Industries → Ecosystems*

Applications and Services are contextualized within ecosystem frameworks

10-year Vision

	Introductory Stage	Growth Stage	Maturity Stage	Decline Stage
Industries within Ecosystems	Experimentation with fragmented solutions	Alignment of solutions. Early best practices emerge. Specialized and low cost solutions will emerge that is positioned for the needs of different segments.	Successful actors emerge. Industry structure and market positioning becomes critical. Tangential sectors that may include combinations of various ecosystems.	Seamless interoperable connected ecosystem of ecosystems with a smaller set of successful actors.

Ref to First Edition for details on
- **Ecosystems and associated stages**
- **Smart Cities Framework Scenario – ecosystem convergence**



Sustainable Interconnected Ecosystem of Ecosystems Framework

A sustainable interconnected ecosystem of ecosystems framework for applications and services
- *Technological convergence*
- *Coordinated inter-ecosystem functions*
- *Each ecosystem has a different development rate*
- *Local areas have different sets of capabilities and constraints.*

Applications and Services Roadmap will enable basic strategies such as:
- **Better, Cheaper, Faster**
  - – Do what you do more efficiently (improve operational efficiencies, expand reach of existing capabilities)
- **Shaping Strategy**
  - - Do different things with what you have (explore different markets, add new features to increase depth of services)

Top Needs for 10-year Vision

Artificial Intelligence (AI)

- includes *assisted* (repeatable tasks), *augmented* (new use cases requiring business model changes), and *autonomous* (requires a high degree of trust)

Connectivity and the Digital Divide

- Connectivity should be viewed as the fifth utility and it is needed to bridge the digital divide.
- Access to mobile communications increase the potential for local economic development and access to services.

Contextual Data Models

- ecosystem specific data models to enhance the data economy or the monetization of data. It includes core network data accounting, data model frameworks including ecosystem specific data, and compatible and consistent semantics (interpretation of data) and KPI definitions.

Digital Twins

- Create a digital version of processes, products, services, people, places, things to analyze and monitor systems for operations, maintenance, and future improvements.

Funding and Investment

- Cities should develop a portfolio of funding that includes multiple government and private sources

Governance Models

- integrator vs market based deployment models, policy development, stakeholder engagement

Multi-tiered security

- network, device, data and users may need different levels of security to support mission critical, shared, dedicated or non-critical applications. Allowances should be made for users that do not wish or do not have the means to participate in applications or services that request user identities.

Spectrum

- includes globally harmonized spectrum, ecosystem specific spectrum, and dynamic spectrum sharing capabilities

Trust and Privacy

- support the needs of a complex stakeholder mix. Alternatives such as psychometrics, anonymized group, etc. data may be used in lieu of user specific data and facial recognition. It may be necessary to separate access from identity.

Ecosystem Challenges and Solutions to Meet Needs

Single Ecosystem View **- Develop/Align Ecosystem Stages (New/existing ecosystems)**

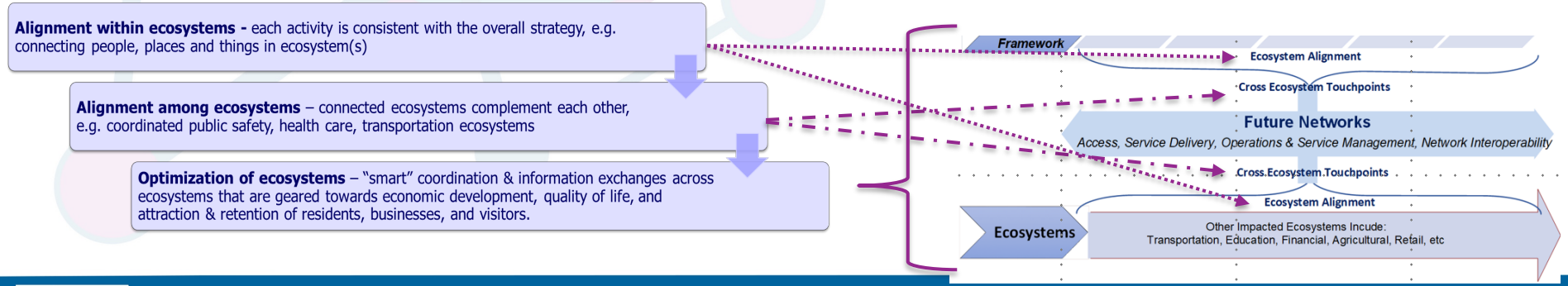
- Each ecosystem should have an informational supply chain context and/or specialized focus.

Multiple Ecosystems View **- Define Cross-Ecosystem Functions**

- Identify and address cross ecosystem touchpoints, e.g. EV charging and electrical system load
- **New business models may emerge** - industry lifecycle stages, i.e. *Introductory, Growth, Maturity and Decline* stages

Localized View **– Local capabilities and constraints**

- The framework needs to be
  - Structured, flexible, adaptable, and scalable.
  - Extensible across end-to-end ecosystems
  - Dynamic to address different stages of priorities, resources, and technologies.
  - Broad to address end-to-end ecosystems that may span geographical, political, and cultural boundaries.
  - Practical and easy to use. Scenarios will be provided to assist with pandemic and disaster planning, smart cities/regions



Ecosystem Challenges and Solutions to Meet Needs (Specific Ecosystems)

Agriculture (new) *– food supply chains*	•*dissemination of best practices including precision farming, food supply source and inspection stations, rural development and environmental preservation*
Education (new) *- students*	•*extrinsic and intrinsic learning achievement for different types of intelligence traits, learning styles, and learning rates*
Electrical Power – electrical power supply chain	•support the forward and reverse market generation, transmission, distribution, and consumption
Entertainment (new) - *arts, gaming, media, music, sports*	•*development, distribution and consumption of arts, gaming, media, music, sports*
Health Care – wellness and patients / continuum of care	•wellness / outpatient monitoring, local clinics, general / regional hospitals, specialized hospital centers (e.g. trauma centers, pediatric hospitals)
Public Safety – events / continuum of recovery	•Prevention - increase awareness and readiness level •Protection - detect and identify threats •Mitigation - improved situational awareness and decision making •Response - tactical assets and technological capabilities •Recovery - planning, tactics, and operations before / after events
Transportation - physical multimodal/intermodal mobility	•Roadways - primary, secondary, and arterial roads •Railways - heavy and light commuter rail, freight lines •Airways - public and private airports, personal air transportation system •Waterways - ferries, cargo ships, small vessels •Micro mobility - pedestrian, e-scooters, etc
Water Distribution and Wastewater Treatment – water inflows/ outflows	•support the forward and reverse market production, distribution, and end user consumption

Technological Challenges and Solutions to Meet Needs

***Technology and Networks View* - Technological Convergence**

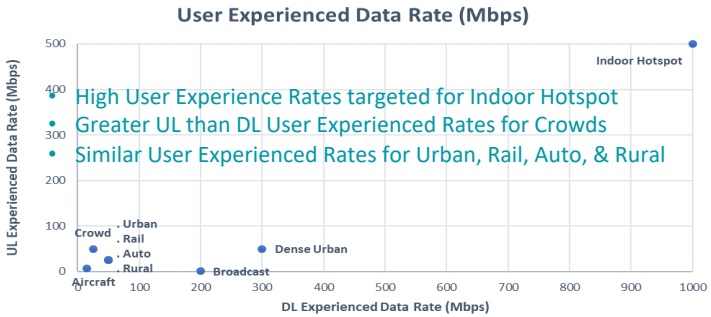
- Combined 5G and non-5G networks (e.g. fixed, other mobile, satellite, Wi-Fi)

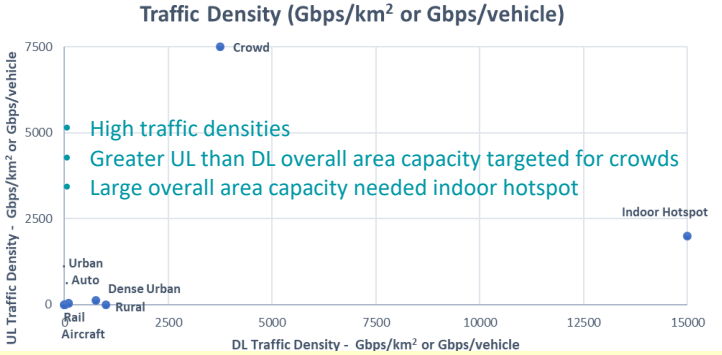
***Network Subsystem View* - Key Network Component Functions and Innovations**

- Access (e.g. RAN)
- Service delivery (edge/core services)
- Operations and customer support
- Network interoperability

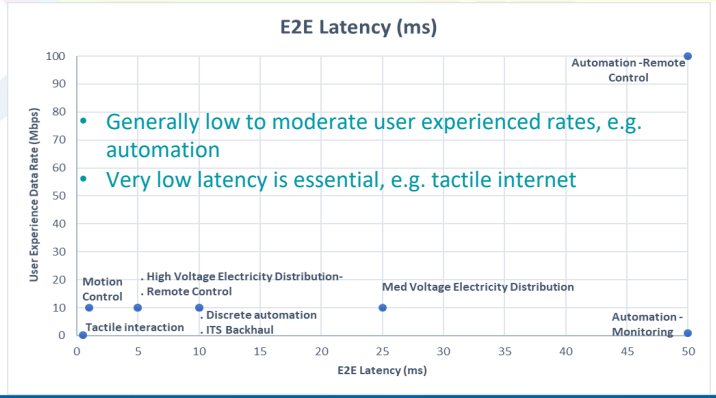
***Implementation View* - Use Case Categories and Deployment Assumptions**

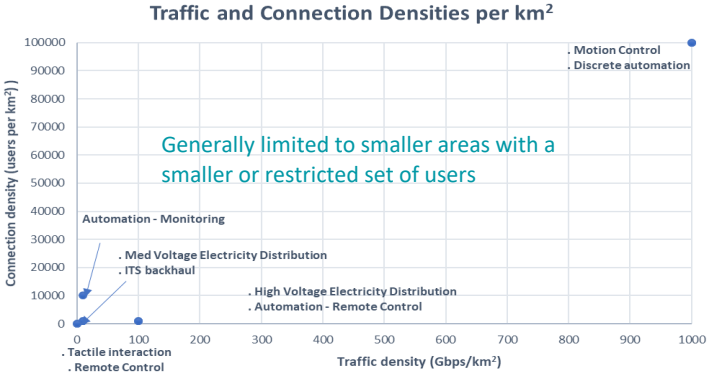
- Assess the need for eMBB, URLLC, mMTC, network operations enhancements, and associated technology enablers.





5G Drivers: high data rate, low latency, connection & traffic density, reliability, position accuracy, mobility





Technological Challenges and Solutions (5G Network Operations Enhancements)

Network Slicing	Ability to create dedicated logical networks within a shared infrastructure
Multiple Access Technologies	Support for 3GPP and non-3GPP network connectivity with potential simultaneous services.
Network capability exposure	Extend network capabilities to 3rd party providers e.g., APIs, QoS policy, dynamically customization of dedicated network slices that support diverse use cases.
Flexible broadcast/multicast service	Supports multicast/broadcast network design, live adhoc broadcasts that may not have been stored on a video server, and simultaneous user access to unicast data and broadcast service.
Markets requiring minimal service	Adaptability for difficult environments (e.g., remote areas,) with local operations constraints (availability and reliability of local interdependencies, e.g. power). Support for minimal user experience, e.g. 100kbps with 50ms latency, while prioritizing emergency services.
Extreme long-range coverage in low density areas	Long range coverage (up to 100 km) in low density areas (up to 2 user/km^2), a minimum user throughput of 1 Mbps DL and 100 kbps UL.
Multi-network connectivity and service delivery across operators	Service providers may enable users to access multiple networks simultaneously.

Source: 3GPP TS 22.261

Note – Non 5G Technologies are also considered, e.g. Satellite, Fixed Networks, Other Mobile Terrestrial Networks, etc

Metrics and Standards Challenges and Solutions to Meet Needs

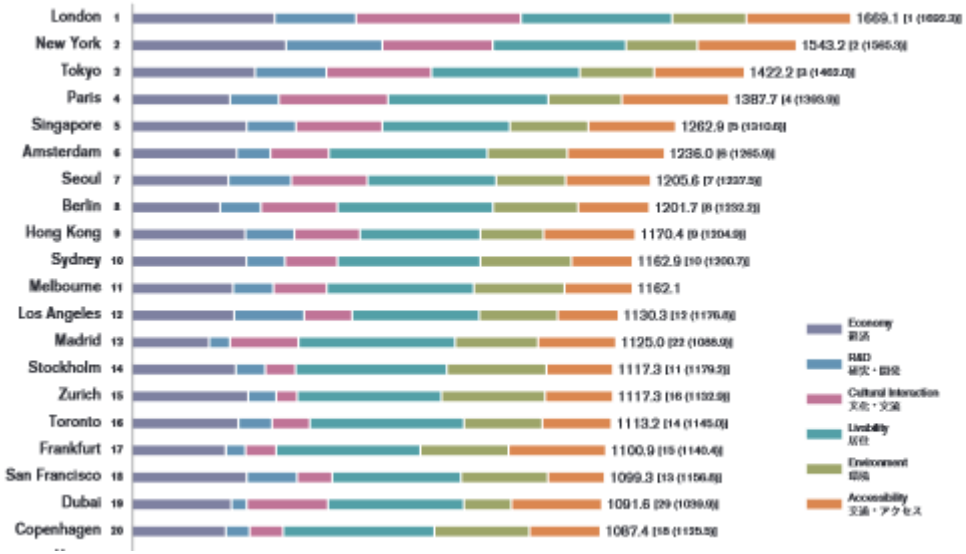
Metrics **– Key Performance Indicators (KPIs)**

- Define different types of KPIs that enable easy comparisons
- Techniques such as Multi-Actor, Multi-Criteria Analysis **(**MAMCA) for the analysis of alternatives and choices from the perspective of different groups of stakeholders and judgement criteria.
    - This may help shape strategic and policy initiatives

Standards View **– Standardization Landscape and Vision**

- Proactive view needed to accelerate economies of scope and scale
- Identify standards and more importantly, the lack of standards

Note – P1950.1 (Communications Framework) initiated based on first edition.



Smart City Example: Mori Foundation – GPCI 2019 Cities (Top 20 shown)
Functions - Economy, R&D, Cultural Interaction, Liveability, Environment and Accessibility.
Stakeholders - Managers, Researchers, artists, visitors and residents.

Metrics and Standards enable economies of scope and scale

Source: Global Power City Index 2019, Mori Foundation

Applications and Services WG Stakeholders

Internal Stakeholders

IEEE Future Networks INGR Working Groups

- *Applications and Services*
- Artificial Intelligence & Machine Learning
- Connecting the Unconnected
- Deployment
- Edge Automation Platform
- Energy Efficiency
- Hardware
- Massive MIMO
- Millimeter Wave and Signal Processing
- Optics
- Satellite
- Standardization Building Blocks
- Security
- Systems Optimization
- Testbed

External Stakeholders

- **Academia**: Technological innovations and access to education—Universities, colleges, K-12
- **Government**: Multi-tiered governance structure—federal, state, county, municipal, and local government entities
- **Industry**: Organic clustering of commercial interests within ecosystem(s)—firms, workforce development, end-to-end supply chain vendors and service providers, clusters /business districts
- **Investors**: Innovation, access to talent, high-tech industry clusters, density, wages and income, and openness and diversity—Innovation and Green Fund Investments
- **Residents**: Economic development, attractiveness, quality of life—ease of transportation, access to health care, utilities, public safety, sanitation services, etc.
- **Standards Development Groups**—global standard creation and adoption, e.g. IEEE, Internet Engineering Task Force (IETF), 3GPP, etc

Contributing Working Group Members

- Evangelos Markakis
- Ilias Politis
- Narendra Mangra
- Souma B. Wanta
- Srini Gottumukkala
- Thomas Olsen

Cross Team Meeting Schedule for June 17 and 18

Please reach out to respective working group co-chairs if you plan to attend cross-team meetings for the Webex Links

June 17

Start Time										
8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM
Apps & Svcs AI ML				Apps & Svcs Deployment		EE Hardware	Apps & Svcs EE		EE Deployment	
			EAP Massive MIMO	EAP Security		EAP Standards	EAP Testbed			
	Satellite Standards	Satellite Testbed		Massive MIMO Hardware		Massive MIMO Deployment	Massive MIMO Standards			Deployment CTU
				Standards CTU	Sys Opt CTU		Security Sys Opt		CTU Testbed	Sys Opt Testbed
					Satellite Security	Satellite AI ML				
			Security AI ML							

June 18

Start Time										
8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM
	Apps & Svcs Satellite			AI ML EAP	Apps & Svcs EAP			Apps & Svcs Security		Apps & Svcs Sys Opt
	AI ML Massive MIMO				AI ML CTU		EAP EE	EAP Deployment		
					Security Testbed	Standards Testbed	Standards Security		EE Sys Opt	
								AI ML Testbed		

Summary

Applications and Services and Ecosystem Framework

- Applications and services may be contextualized through an ecosystem framework
  - Firms → Industries → Ecosystems
- A sustainable interconnected ecosystem of ecosystems is needed to address thee needs of a diverse stakeholder set
- *Each ecosystem has a different development rate and local areas have different sets of capabilities and constraints.*

Applications and Services Roadmap Development

- Key interdisciplinary areas of interest include
  - Technological Convergence
  - Intra / Inter Ecosystem Functions
  - Contextual Data Models and Related Policies
  - Metrics and Standardization Landscape
  - Varying Levels of Innovation, Capabilities and Constraints at the local level
- Refer to First Edition for details on Electrical Power, Health Care, Public Safety, Transportation, Water Distribution and Wastewater Treatment, and Smart Cities Framework

IEEE INGR Applications and Services WG

First Edition -https://futurenetworks.ieee.org/roadmap

WG Participation – 5GRM-appssvcs@ieee.org

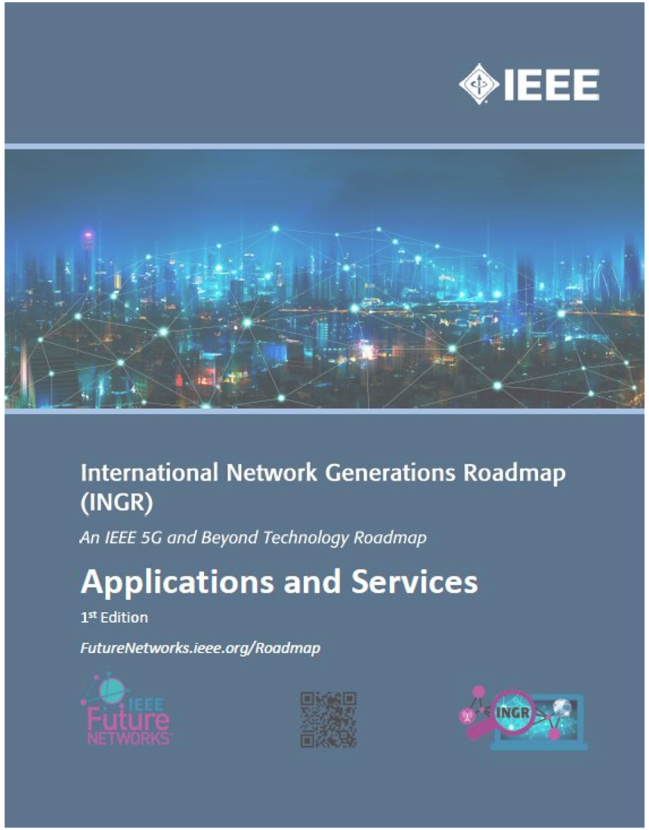
Roadmaps and Identification of Positive and Negative Risks

- Roadmaps such as the IEEE INGR may help to mitigate negative risks and pursue positive risks (opportunities)
- Volunteers are welcome to join the Applications and Services WG roadmap development effort
  - Applications and Services WG interdisciplinary scope includes a number of diverse topics and skillsets.

Get involved!

5GRM-appssvcs@ieee.org

QUESTIONS?



IEEE INGR Applications and Services WG

- ***Roadmap Details***

https://futurenetworks.ieee.org/roadmap

- ***Applications and Services WG Participation –***

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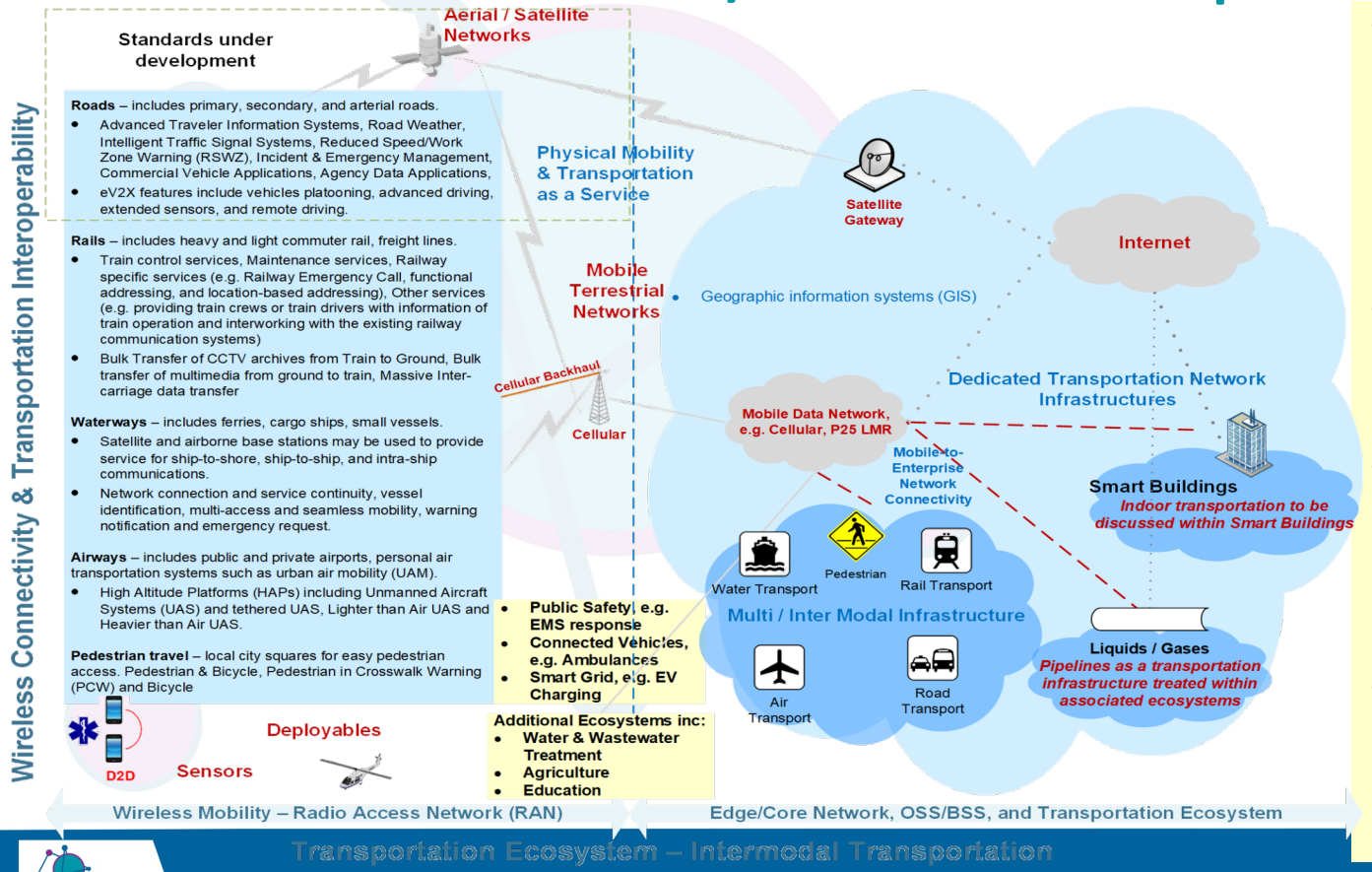
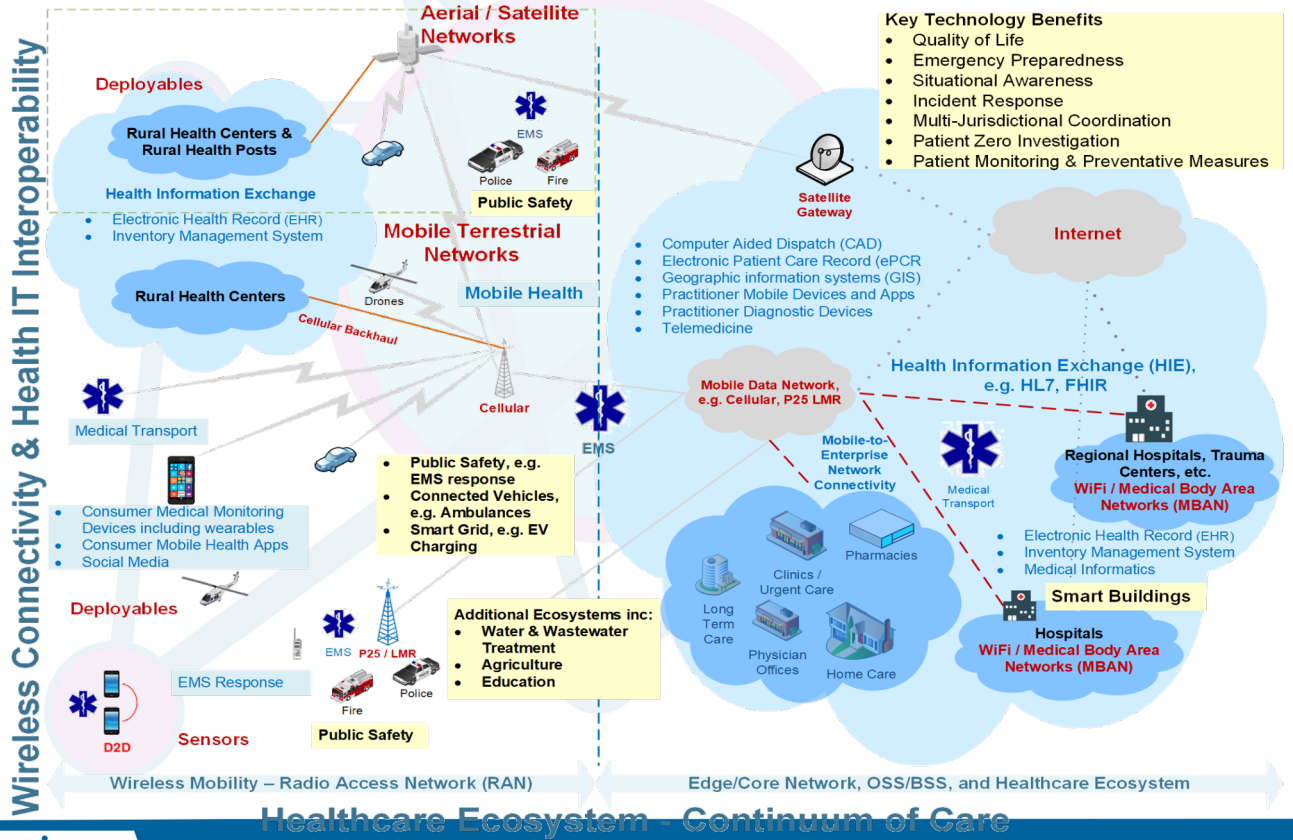
Ecosystem References

Multimodal / Intermodal Transportation



- **What capabilities are needed to support the physical transportation infrastructure modes?**
  - Roads
  - Rails
  - Maritime
  - Air
  - Pedestrian / Micro Mobility
- **What are the main drivers?**
  - Physical Infrastructure
  - Public, private travel access points
  - Intramodal and Intermodal transfer points
- **How do we translate the needs into technical requirements?**
  - eMBB
  - mMTC
  - URLLC
  - Network Operation Enhancements
- **What is the roadmap vision?**
  - Access
  - Service Delivery
  - Network Operations & Customer Support
  - Network extensions

Healthcare Ecosystem – Continuum of Care

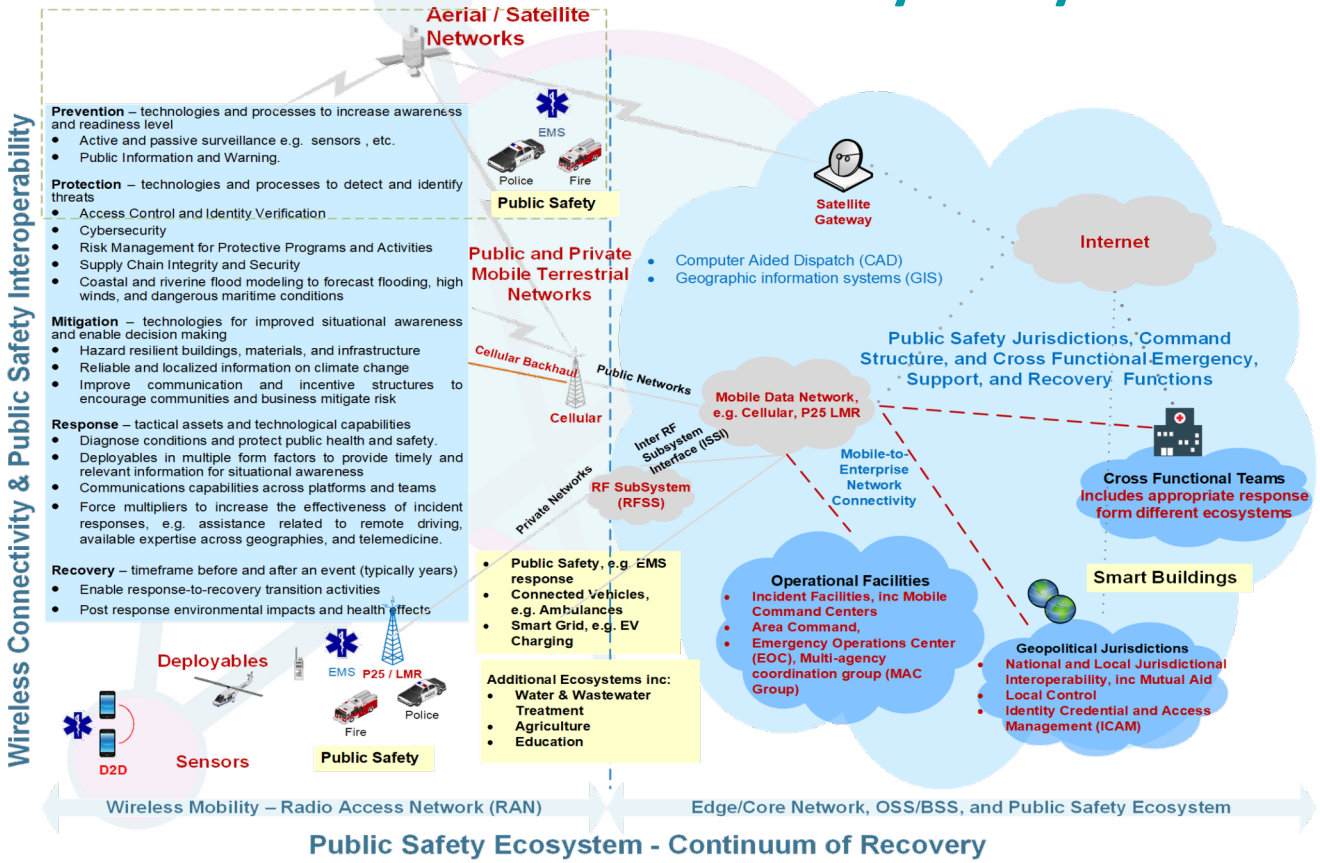


- **How does a city optimize the interconnected ecosystems?**
  - Healthcare
  - Public Safety, e.g EMS
  - Transportation, e.g. connected ambulances
  - Electricity, e.g. smart grid for EV charging
  - Agriculture, e.g. diseases,
  - Smart Buildings, e.g. hospital design
- **What are the main drivers?**
  - Contextual data models
  - Privacy & Security
  - Communications capabilities
- **How do we translate the needs into technical requirements?**
  - eMBB
  - mMTC
  - URLLC
  - Network Operation Enhancements

What is the roadmap vision?

- Access
- Service Delivery
- Network Operations & Customer Support
- Network extensions

Public Safety Ecosystem



What capabilities are needed to support the different continuum of recovery phases?

- Prevention
- Protection
- Mitigation
- Response
- Recovery

What are the main drivers?

- Geopolitical
- Tactical command structure
- Number of first responders
- Duration
- Inter ecosystem alignment (Cross Functional Emergency Support and Recovery Functions)

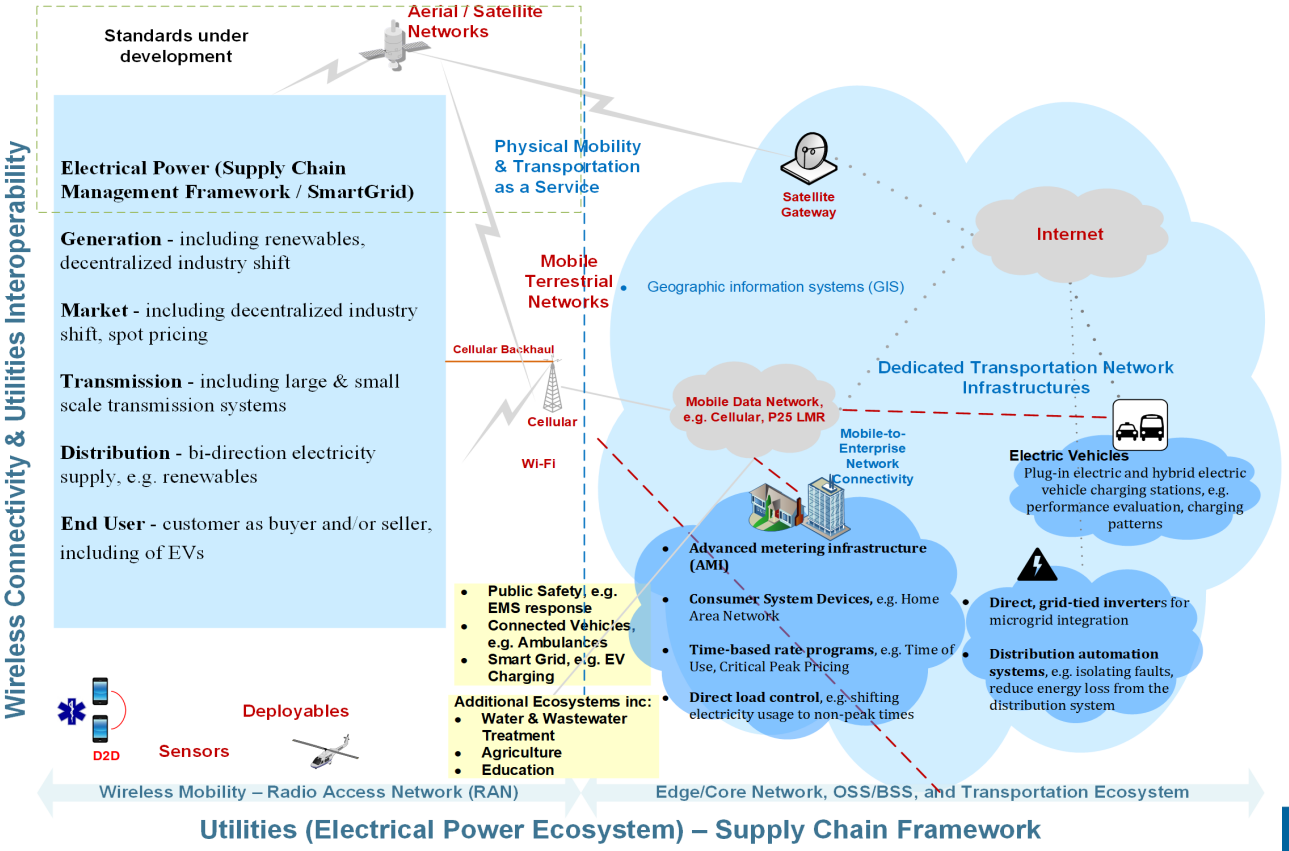
How do we translate the needs into technical requirements?

- eMBB
- mMTC
- URLLC
- Network Operation Enhancements

What is the roadmap vision?

- Access
- Service Delivery
- Network Operations & Customer Support
- Network extensions

Electrical Power - Supply Chain Framework



Note –
Water Distribution and Wastewater Treatment may also use an end-to-end supply chain management framework

Electrical Power Ecosystem

Generation	• includes renewables, decentralized industry shift
Market	• includes decentralized industry shift, spot pricing
Transmission	• Includes large- and small-scale transmission systems
Distribution	• bi-direction electricity supply, e.g., renewables
End User	• customer as buyer and/or seller, including of EVs

IEEE INGR Applications and Services WG Roadmap Details

https://futurenetworks.ieee.org/roadmap

Water Distribution and Wastewater Ecosystem

Production	• Includes movement towards unified facilities
Market	• Includes cellular and satellite based platform with message queuing telemetry transport (MQTT), and other standardized protocols, and cloud services.
Distribution	• Includes monitoring at intermediate distribution points for leak detection. Movement towards virtualization and more cloud based systems
End User	• Includes smart meters, remote metering and other low throughput applications

IEEE INGR Applications and Services WG Roadmap Details

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