IEEE Future NETWORKS

Enabling 5G and Beyond

International Network Generations Roadmap (INGR) Virtual Industry Forum

Applications and Services Working Group

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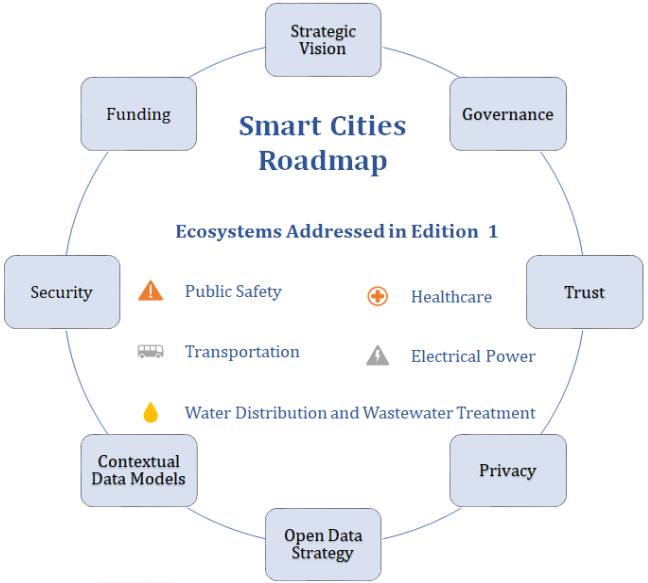
IEEE

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.

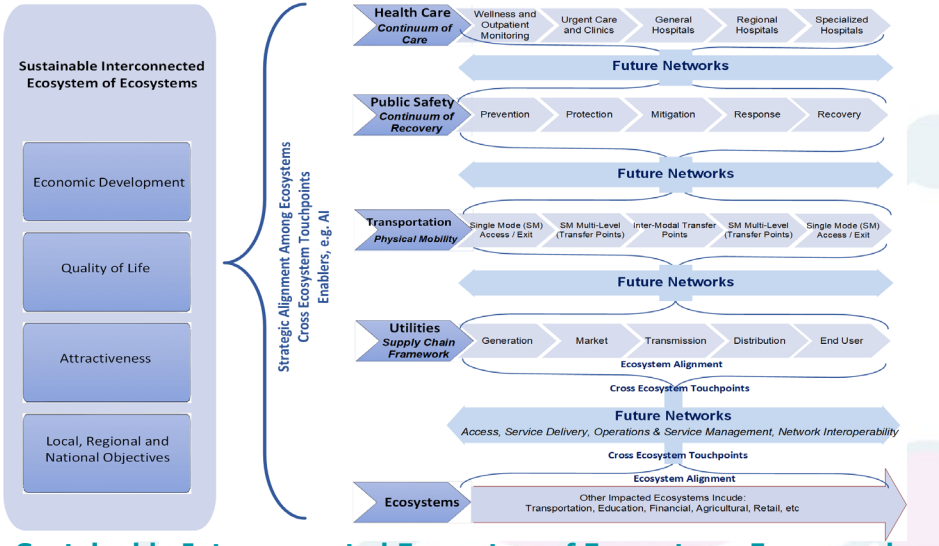


Second Edition to include:

- **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

10-year Vision



Sustainable Interconnected Ecosystem of Ecosystems Framework **Applications and Services WG - 2nd Edition Ecosystems**

Applications and Services are contextualized within ecosystem frameworks

- *Ecosystems → Industries (similar products and services) → Firms (may participate in one or more industries/ecosystems)*
- *Each ecosystem has a different development rate.*

- *The Sustainable Interconnected Ecosystem of Ecosystems Framework includes:*
  1. *Ecosystem of Ecosystems Perspective*
  2. *Technology and Networks Perspective*
  3. *Standards and Performance Perspective*

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 *also* increases 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

- Includes integrator vs market-based deployment models, data governance model, 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 decouple access from identity.

Challenges and Solutions to Meet Needs

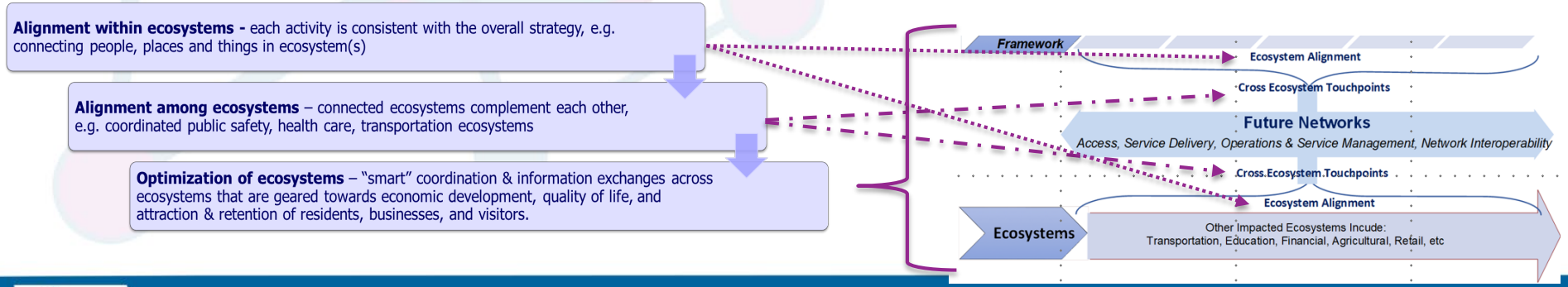
1. Ecosystem of Ecosystems Perspective
2. Technology and Networks Perspective
3. Standards and Performance Perspective

1 - Ecosystem of Ecosystems Perspective

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



2 – Technology and Networks Perspective

Technology and Networks View **- Technological Convergence**

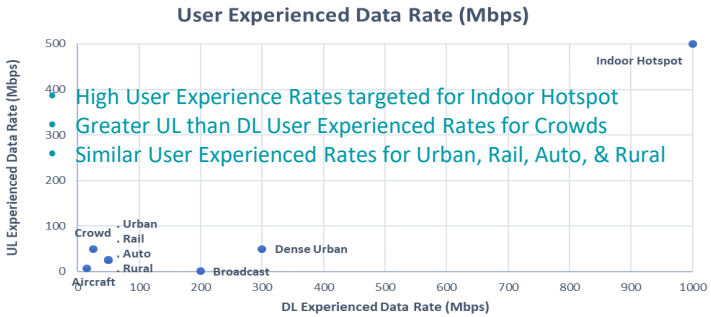
- Combined 5G and non-5G networks (e.g. fixed, other mobile, satellite, Wi-Fi)

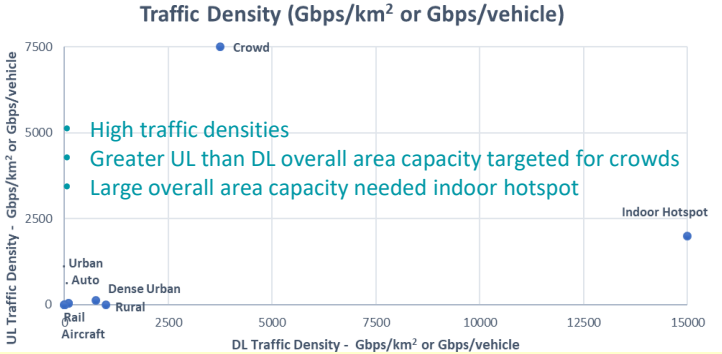
Functional Requirements View **- Use Case Categories and Deployment Assumptions**

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

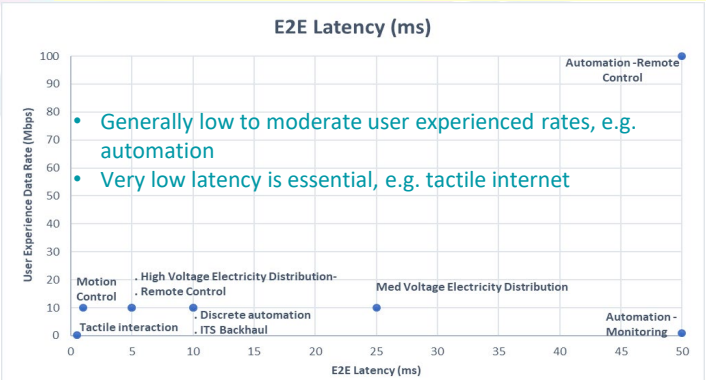
Network Subsystem View **- Key Network Component Functions and Innovations**

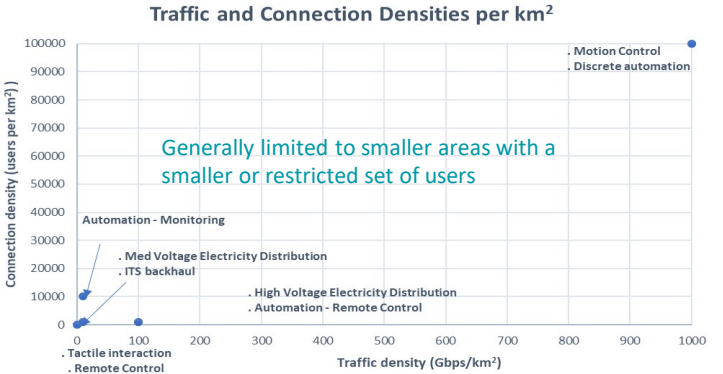
- Access (e.g. RAN)
- Service delivery (edge/core services)
- Operations and customer support
- Network interoperability





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





Technological Challenges and Solutions (5G Network Operations Enhancements)

- Connectivity models
- 5G LAN-type service
- Context aware network
- Critical medical applications
- Cyber-physical control applications in vertical domains
- Dynamic policy control
- Energy efficiency
- Ethernet transport services
- eV2X aspects
- Extreme long-range coverage in low density areas
- Flexible broadcast/multicast service
- Markets requiring minimal service levels
- Messaging aspects

- Minimization of Service Interruption
- Multi-network connectivity and service delivery across operators
- Multiple access technologies
- Network capability exposure
- Network Slicing
- Non-public networks
- Priority, QoS, and policy control
- QoS Monitoring
- Steering of roaming
- Subscription aspects
- UAV Aspects
- Video, imaging and audio for professional applications

Source: 3GPP TS22.261

3 - Standards and Performance Perspective

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

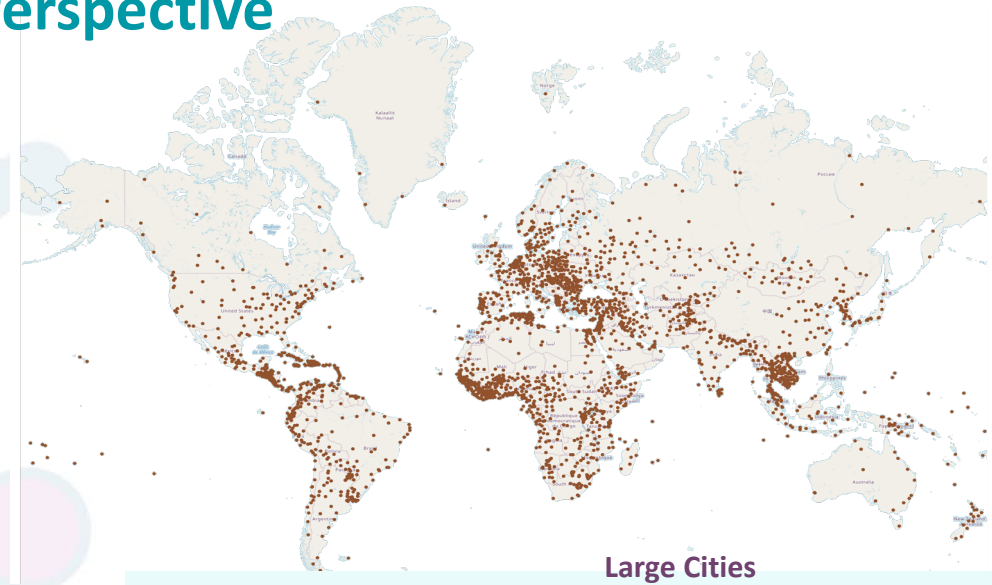
- Define different types of KPIs that enable easy comparisons
- Techniques such as *Multi-Actor, Multi-Criteria Analysis (MAMCA)* for the analysis of alternatives and choices from the perspective of different groups of stakeholders and judgement criteria.
    - This may help shape strategic and policy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

Metrics and Standards enable economies of scope and scale



Sources: Open Street Map (OSM), QGIS

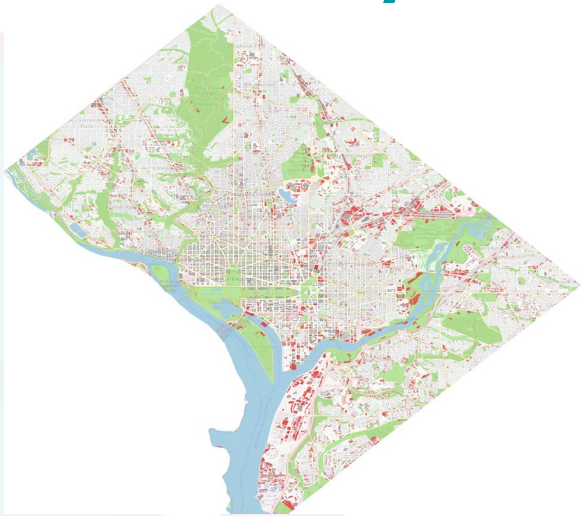
Large Cities

Smart City KPI Example: Mori Foundation – Global Power City Index (GPCI)
Functions - Economy, R&D, Cultural Interaction, Liveability, Environment and Accessibility.
Stakeholders - Managers, Researchers, Artists, Visitors and Residents.

- Criteria and metrics are helpful for harmonizing global performance measurements
- Smart Cities and non-urban areas may use a combination of common and area-specific KPIs as needed.

Transportation Ecosystem Example and Pandemic Planning Scenario

Transportation Ecosystem Example



Intra Ecosystem Alignment (Transportation Example)

- Technology Innovations, e.g. connected vehicles
- Traffic management, e.g. traffic lights (brown dots), congestion management, HOV lanes, reversible lanes during rush hour, transit signaling priority,
- Intermodal transportation efficiency, e.g. roads (gray lines), rails (blue lines), Includes public transportation, bike lanes, etc

Inter Ecosystem Alignment

- Parking assistance for high traffic areas,
- Car free zones (personal) for specific areas
- Access and convenience to commercial, residential, government, and points of interest locations.
- Smart Buildings (buildings and transportation are major contributors to CO2 emissions)

Ecosystem of Ecosystems Governance (City Objectives)

- Land Use - Parking area conversion (red polygons) with adoption of connected vehicles
  - Population and Building density focus
- Access to physical mobility and alignment of services, e.g. workforce transportation to job centers

Transformation Includes Technology and Networks Perspective and the Standards and Performance Perspective

Sources: Open Street Map (OSM), QGIS

5G Enabled Transportation Innovations

Roads

- **eV2X –** vehicles platooning, advanced driving, extended sensors, and remote driving.
- **Non-Critical Vehicle to Network Communications** – maps, traffic updates from a centralized source, etc.

Rails

- **Train control and maintenance -** railway emergency call, functional addressing, location-based addressing, etc
- **Operational support** –information for train operations personnel on day-to-day operations, etc
- **Bulk data transfer** –CCTV archives from Train to Ground, multimedia from ground to train, massive Inter-carriage data transfer, etc.

Maritime

- **Satellite and airborne base stations** – ship-to-shore, ship-to-ship, and intra-ship communications.
- **Network connection and service continuity** –vessel identification, multi-access and seamless mobility, warning notification and emergency request, etc.

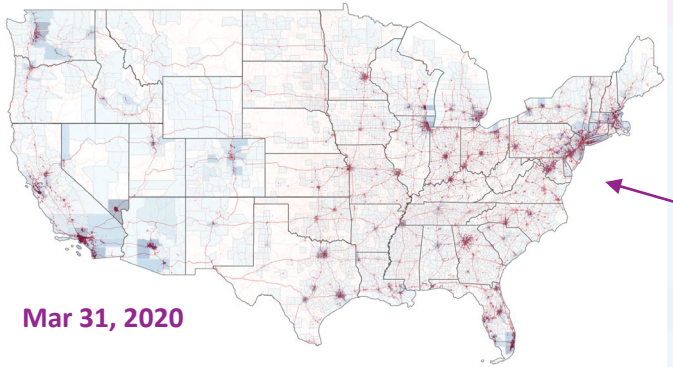
Air

- **Public & private airports, personal air transportation systems such as *urban air mobility (UAM)*** - High Altitude Platforms (HAPs) such as Unmanned Aircraft Systems (UAS) and tethered UAS, Lighter than Air UAS and Heavier than Air UAS.

Micro mobility

- **Pedestrian and micro mobility** – Pedestrian and Bicycle, Pedestrian in Crosswalk Warning (PCW), Bicycle warning systems, Electric scooter and pedestrian collision avoidance systems, etc

COVID-19 cases and vehicular traffic for selected roadways (CONUS Q1 2020)



Mar 31, 2020

1.00 - 25.00	1 - 25
25.00 - 50.00	25 - 50
50.00 - 75.00	50 - 75
75.00 - 100.00	75 - 100
100.00 - 200.00	100 - 200
200.00 - 400.00	200 - 400
400.00 - 600.00	400 - 600
600.00 - 800.00	600 - 800
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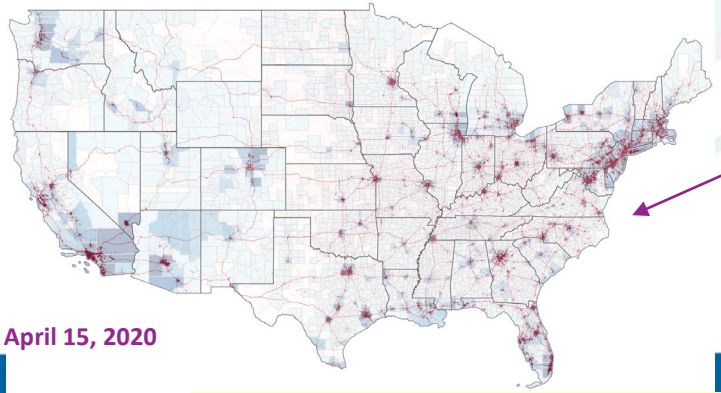
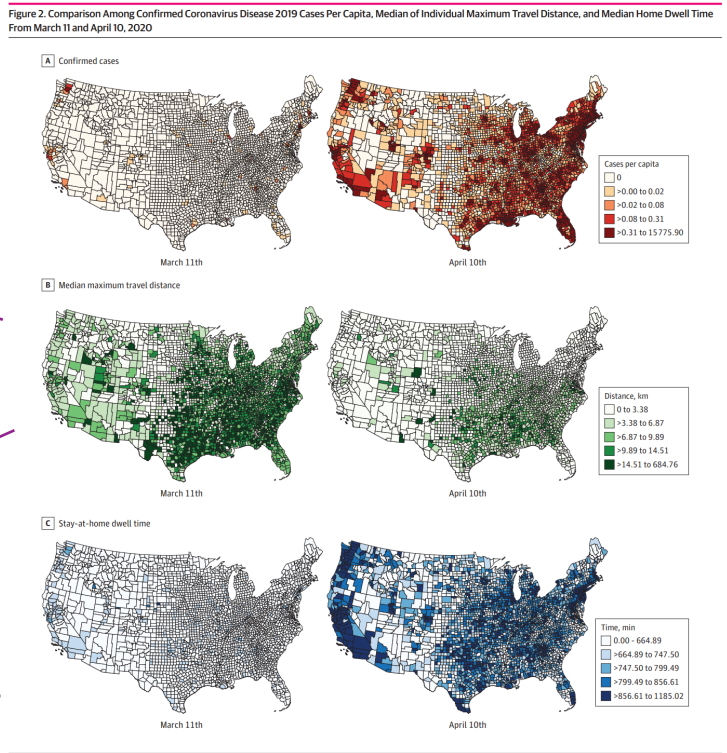
Virus infection drivers include population density, surface / building density, intermodal transportation mobility, etc



April 15, 2020

JAMA Findings

- Data from 45 M mobiles
- Median travel distance decreased
- Stay-at-home time increased across the nation (geographic variation).
- COVID-19 spread significantly after stay-at-home orders enacted.



Source: Association of Mobile Phone Location Data Indications of Travel and Stay-at-Home Mandates With COVID-19 Infection Rates in the US, JAMA, Sep 2020

Framework may be used to optimize local response through an ecosystem of ecosystems approach

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

Key Contributing Working Group Members

- Fawzi Behman
- Frederica Darema
- Pramud Rawat
- Narendra Mangra
- Souma B. Wanta
- Thomas Olsen

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
  - Intra / Inter Ecosystem Functions
  - Technology and networks
  - 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!

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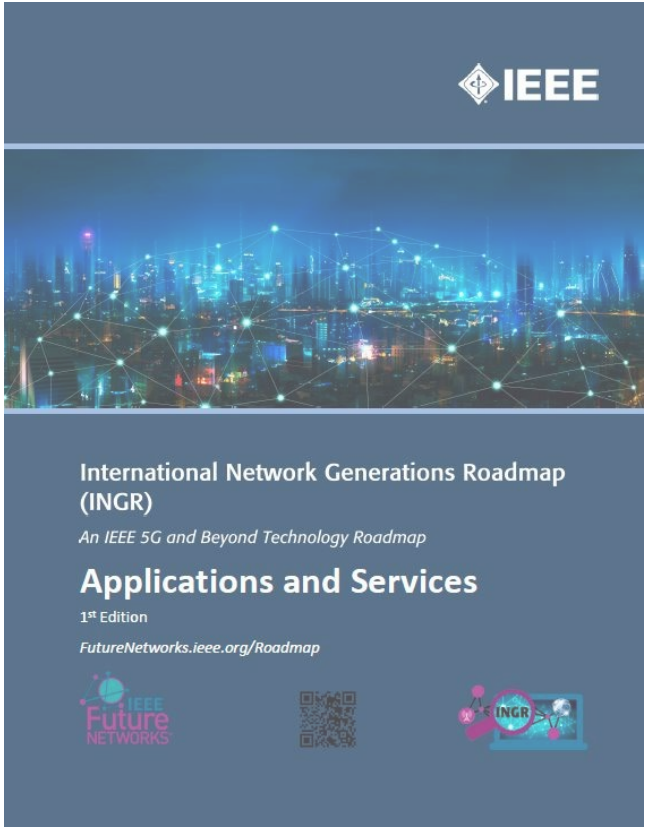
QUESTIONS?



IEEE INGR Applications and Services WG

- ***Roadmap Details***

https://futurenetworks.ieee.org/roadmap

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

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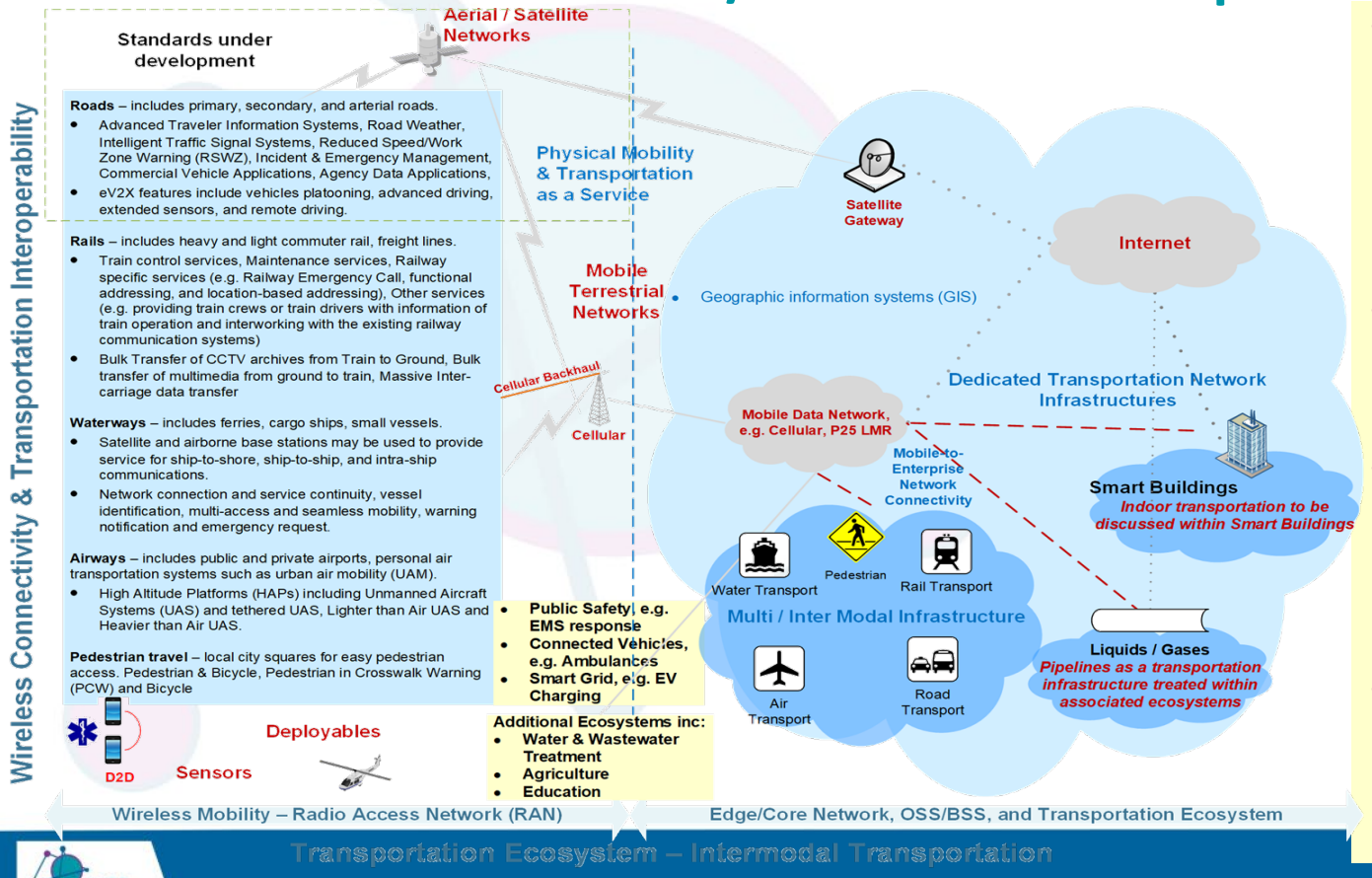
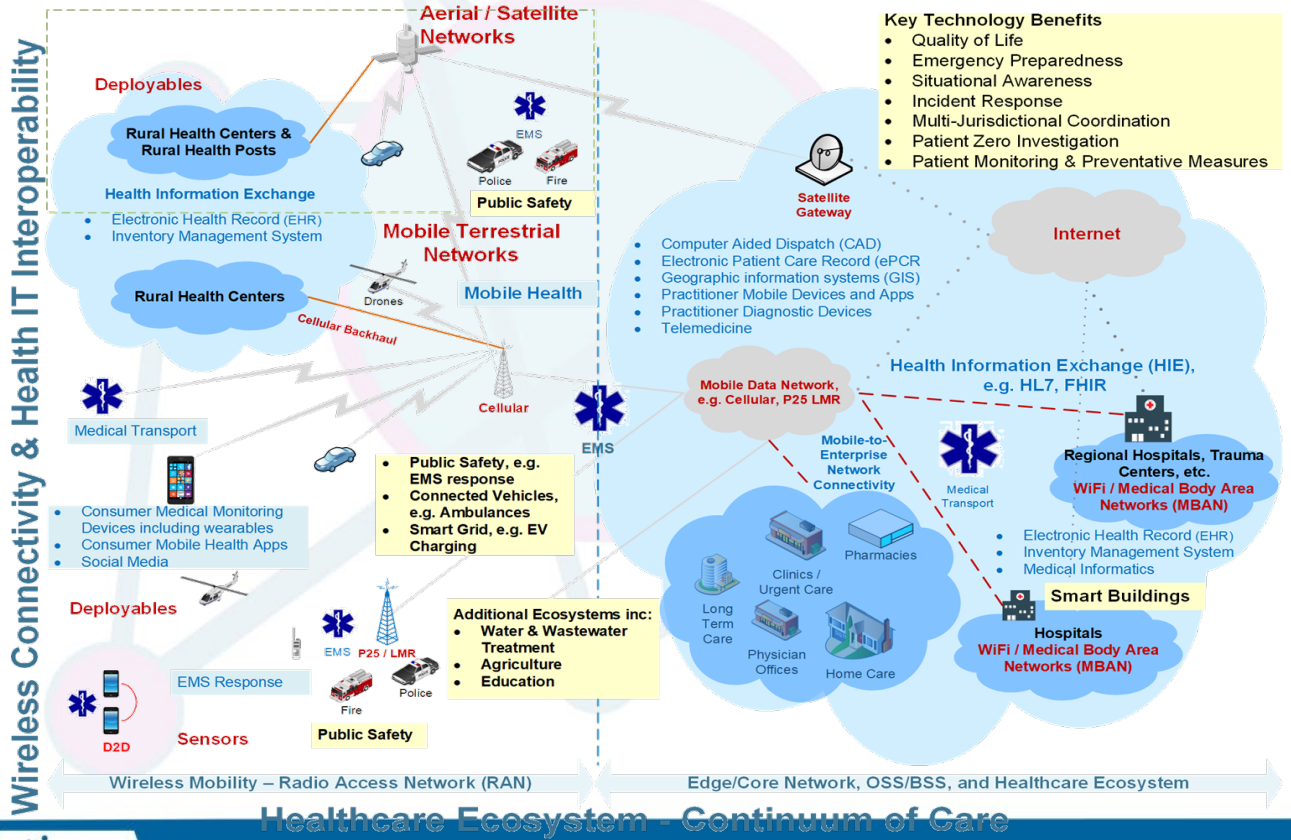
Ecosystem References

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

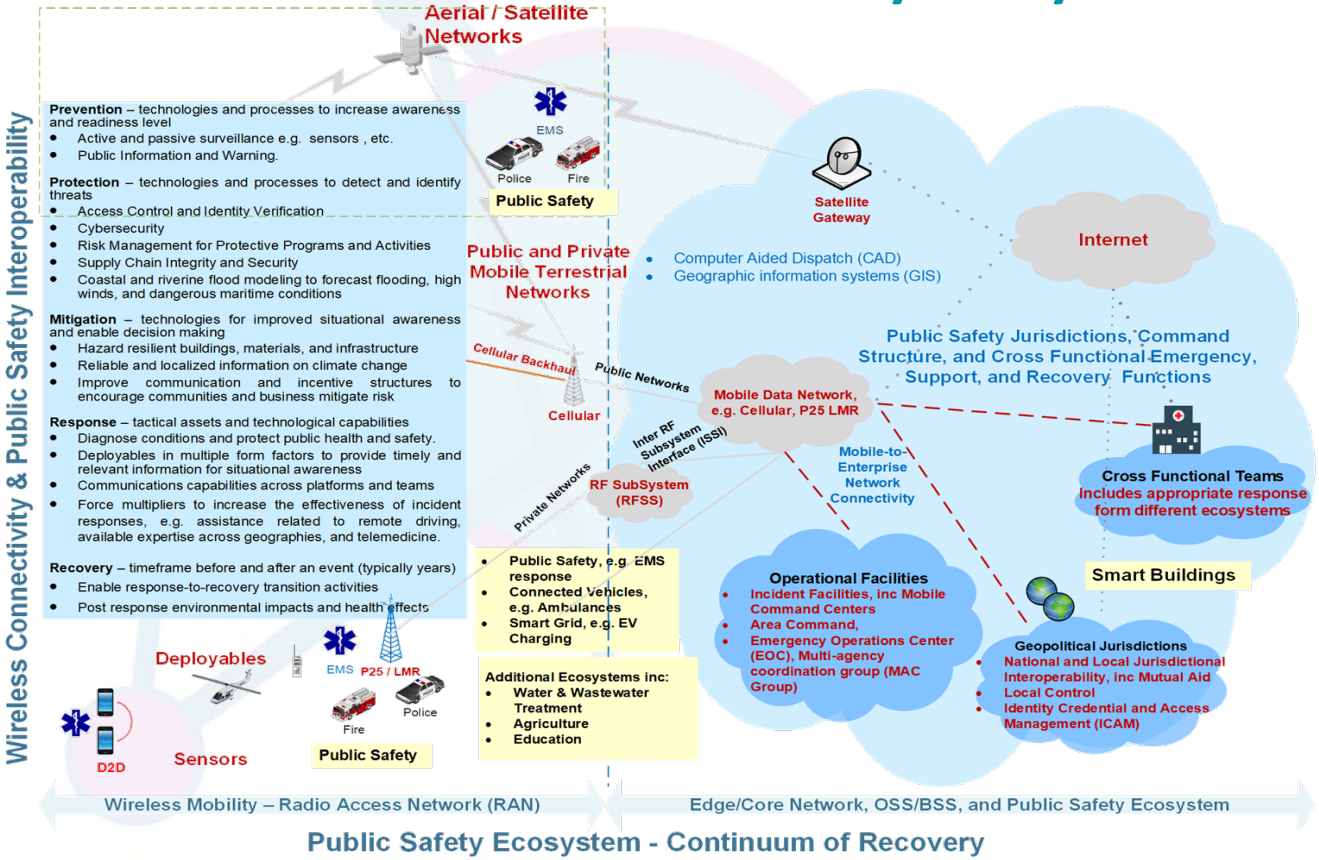


- **How does a city optimize the interconnected ecosystems?**
  - Healthcare
  - Public Safety, e.g EMS
  - Transportation, e.g. connected ambulances
  - Electricity, e.g. smart grid for EV charging
  - Agriculture, e.g. diseases,
  - Smart Buildings, e.g. hospital design
- **What are the main drivers?**
  - 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
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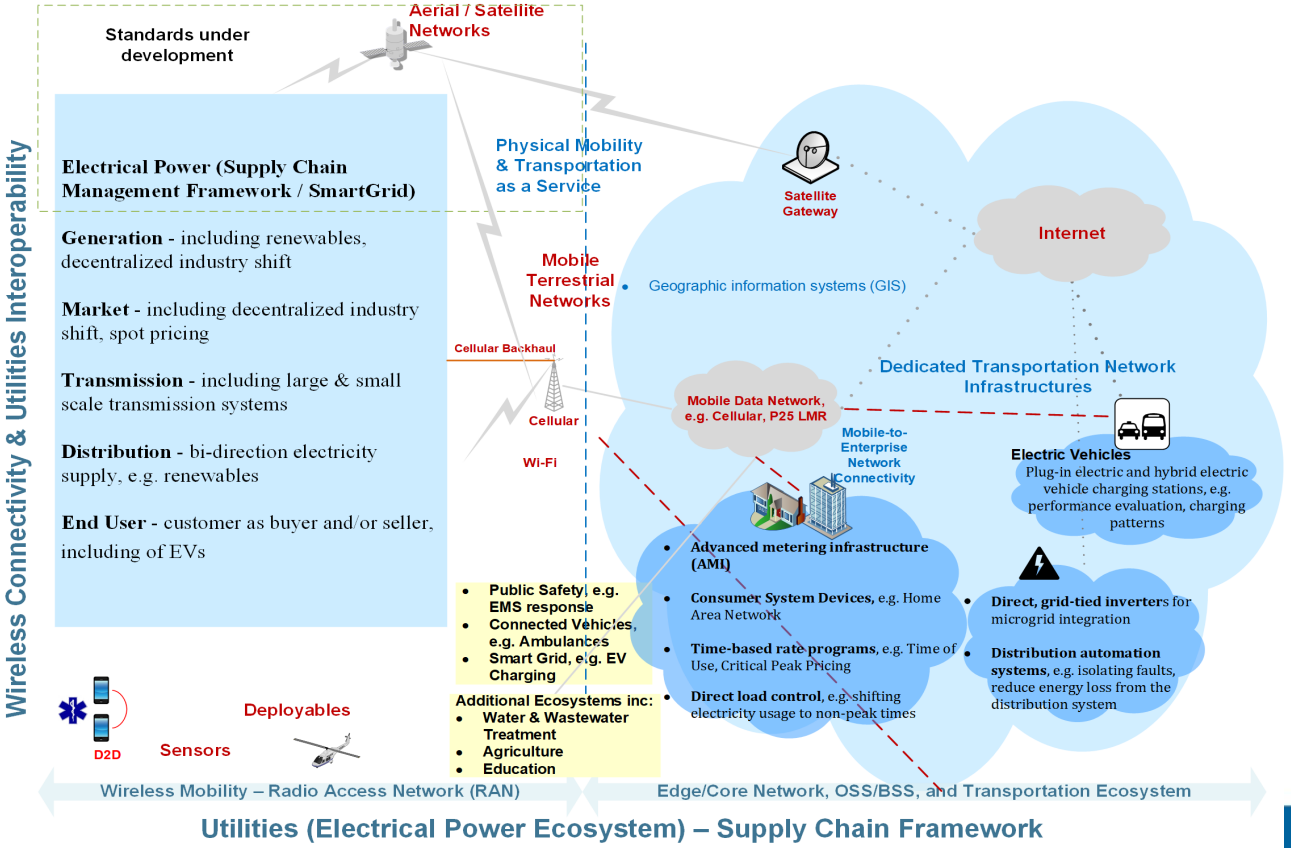
Electrical Power - Supply Chain Framework



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

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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

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