International Network Generations Roadmap

IEEE INGR Applications and Services WG

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IEEE

Agenda

- IEEE FNI INGR Applications and Services WG
- First Edition Ecosystems
- eMBB, mMTC, and URLLC Deployment Considerations
- Smart City Framework

Background

IEEE INGR - Applications and Services Roadmap

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.

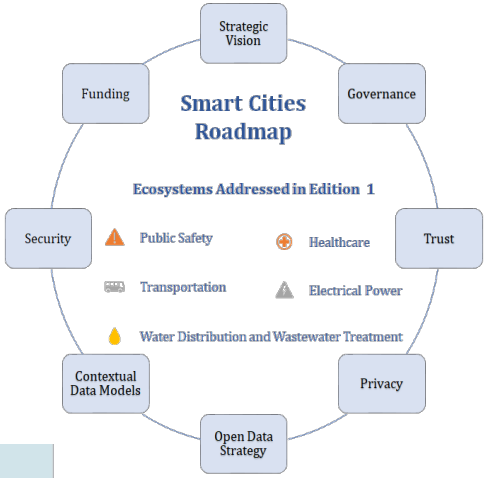
INGR Applications and Services Chapter Highlights include

- **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**

IEEE Future Networks INGR Applications and Services Working Group



IEEE INGR Applications and Services WG

- ***Roadmap Details***

https://futurenetworks.ieee.org/roadmap

- ***WG Participation –***

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Ecosystems and Smart Cities

Applications and Services

- Applications and Services use case categories include eMBB, mMTC, and URLLC and benefit from network operations enhancements.

Ecosystem Frameworks

- **Ecosystem frameworks are useful to contextualize the many different types of applications and services.**
- End-to-end ecosystems span geographical, political, and cultural boundaries.
- Ecosystems typically converge in urban environments, e.g. health care, transportation, and agriculture.

Smart Cities as a Sustainable Interconnected Ecosystem of Ecosystems

- Smart Cities are sustainable interconnected ecosystem of ecosystems that **link people, places and things to promote economic development, quality of life, and attractiveness for residents, businesses, and visitors.**

Challenges and Opportunities for Smart Cities

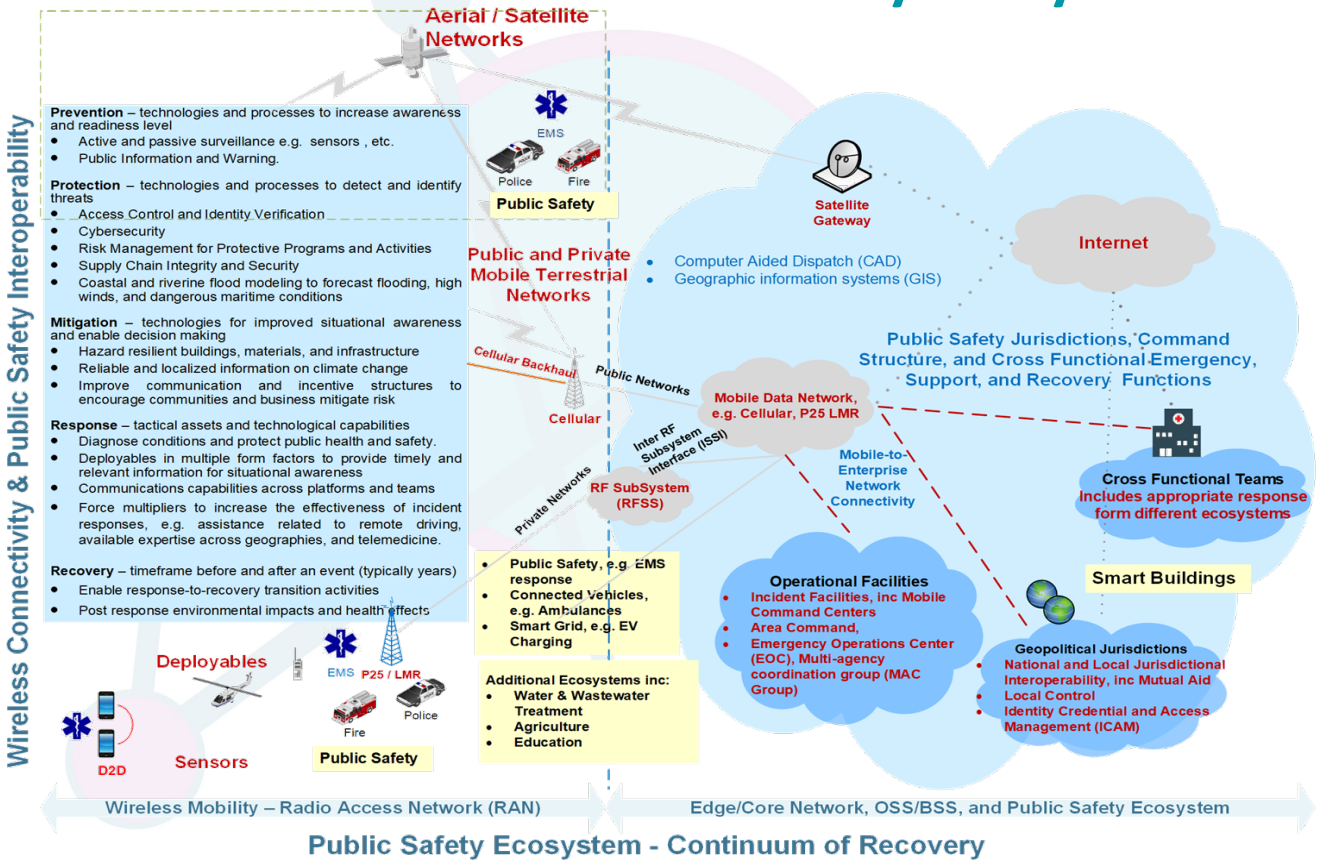
- **Applications and Services for smart cities provide several opportunities and challenges**
  - Urban population growth is increasing and exerts pressure on a city's existing infrastructure and resources.
  - End-to-end ecosystems may be impacted by other ecosystems and may involve a deeper level of strategic alignment, e.g., transportation and smart grid loading from electric vehicles.
  - Urban activities contribute to climate change through greenhouse gas emissions. **Cities are responsible for significant amounts of global CO_2 emissions primarily from transportation activities and buildings.**

IEEE FNI INGR
Applications and Services WG

Selected Ecosystems

Public Safety Ecosystem

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

Public Safety Ecosystem – Mission Areas (FEMA)

- **Prevention**—Avoid, prevent, or stop a threatened or actual imminent act of terrorism. This mission area is excusive to terrorist threats.
- **Protection**—Secure against acts of terrorism and manmade or natural disasters.
- **Mitigation**—Reduce loss of life and property by lessening the impact of disasters.
- **Response**—Save lives, protect property and the environment, and meet basic human needs after an incident has occurred.
- **Recovery**—Assist communities affected by an incident to recover effectively.

Source: FEMA.gov

Public Safety Ecosystem – Prevention Mission Area

***Prevention**—Avoid, prevent, or stop a threatened or actual imminent act of terrorism. This mission area is exclusive to terrorist threats.*

Needs

- **Technologies and processes to increase awareness and readiness level**, e.g. multipurpose sensors, video feeds, and mobile unit detection capabilities. Bulk provisioning of sensors with longer battery life.
- **Expand awareness and readiness for assets outside of terrestrial service areas** with available satellite services.
- **Use AI to enhance awareness and readiness**.

Challenges

- **Detect and reduce threats and hazards** that includes chemical threats, biological, radiological, nuclear and explosive (CBRNE) threats, cybersecurity threats, attacks on the electrical grid, new threat vectors emerge as more networks and devices become connected.
- **Increased vulnerability from multiple sources** used to improve awareness and readiness.
- **5G deployments may vary** across jurisdictions.

Potential Solutions

- **Active and passive surveillance,** e.g. bio surveillance, sensor technologies, or physical investigation and intelligence.
- **Public Information and Warning** (better information distribution precision). Advanced notifications of events due to improved latency, e.g., 1ms.
- **Tiered security levels** are needed for the appropriate levels of security.
- **Increase 5G services in priority areas** through service provider collaborations and/or private networks.
- **AI enabled guidance and threat reduction** for impacted areas.

Public Safety Ecosystem – Protection Mission Area

Protection—Secure against acts of terrorism and manmade or natural disasters.

Needs

- **Technologies and processes to detect and identify threats,** e.g. increase the number of multipurpose sensors, video feeds, and mobile unit-based threat detection and identification capabilities. Bulk provisioning of sensors with longer battery life.
- **Expand awareness and readiness for assets outside of terrestrial service areas** with available satellite services.
- **Use AI to enhance threat detection and identification capabilities.**

Challenges

- **Protection focus on** Critical Infrastructure Protection, Cybersecurity, Defense against Weapon of Mass Destruction (WMD) Threats, Defense of Agriculture and Food, etc
- **Increased vulnerability from multiple sources** used to improve threat detection and identification capabilities.
- **5G deployments may vary across jurisdictions.**

Potential Solutions

- **Access Control and Identity Verification**—verify identity and authorize, grant, or deny physical and cyber access to specific locations, information, and networks.
- **Cybersecurity**—ensure the security, reliability, integrity, and availability of critical information, records, and communications systems and services
- **Risk Management for Protective Programs and Activities**—identify and assess threats, vulnerabilities, and consequences for prioritized assets, systems, networks, and functions
- **Supply Chain Integrity and Security**—strengthen the security and resilience of the supply chain by focusing on key nodes, methods of transport between nodes, and materials in transit between a supplier and consumer
- **Tiered security levels** for appropriate levels of security.
- **Advanced notifications of events** from improved latencies.
- **Increase 5G services in priority areas** through service provider collaborations and/or private networks

Public Safety Ecosystem – Mitigation Mission Area

Mitigation—*Reduce loss of life and property by lessening the impact of disasters.*

Needs

- **Technologies for improved situational awareness and enable decision making,** e.g. increase the number of multipurpose sensors, video feeds, and mobile unit-based for improved situational awareness and decision-making capabilities. Bulk provisioning of sensors with longer battery life.
- **Expand awareness and readiness for assets outside of terrestrial service areas** with available satellite services.
- **Use AI to enhance situational awareness and decision-making capabilities**

Challenges

- **Identify risks and mitigate natural, technological / accidental, or adversarial / human-caused incidents** that includes natural hazards, disease, technological and accidental hazards, terrorist organizations or affiliates, cyber-attacks, etc
- **New threat vectors emerge as more networks and devices become connected.** Increased vulnerability from multiple sources used to enhance situational awareness and decision-making capabilities.
- **5G deployments may vary across jurisdictions. Increased use of UAVs may be used for increased enhance situational awareness and decision-making capabilities.**

Potential Solutions

- **Hazard resilient** buildings / materials / infrastructure, improved building / land-use / engineering codes / standards
- **Reliable and localized information on climate change**
- **Hardware, software, internet-based systems and applications** (including GIS and incident management software)
- **Social media for situation awareness and information dissemination**.
- **Tiered security levels** are needed for the appropriate levels of security.
- **Advanced notifications of events** from improved latencies.
- **Increase 5G services in priority areas** through service provider collaborations and/or private networks.
  - Deployables and mutual aid agreements become necessary

IEEE INGR Applications and Services WG Roadmap Details

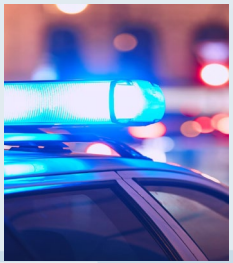
https://futurenetworks.ieee.org/roadmap

Public Safety Ecosystem – Response Mission Area

***Response**—Save lives, protect property and the environment, and meet basic human needs after an incident has occurred.*

Needs

- **Tactical assets and technological capabilities.** Increase the number of multipurpose sensors, video feeds, and mobile unit-based for improved situational awareness and decision-making capabilities. Bulk provisioning of sensors with longer battery life.
- **Expand awareness and readiness for assets outside of terrestrial service areas** with available satellite services.
- **Use AI to enhance tactical assets and technological capabilities**



Challenges

- **Emergency support functions (ESFs)** related to critical transportation; environmental response/health and safety; fatality management services; fire management and suppression; infrastructure systems; logistics and supply chain management; mass care services; mass search and rescue operations; on-scene security, protection, and law enforcement; operational communications; public health, health care, and emergency medical services; and situational assessment.
- **New ESF 14 related to Cross-Sector Business and Infrastructure**—supports the coordination of public and private sector operations and includes the stabilization of key supply chains and community lifelines among infrastructure owners and operators, businesses, and their government partners.

Potential Solutions

- **Improved situational awareness** through satellite and aerial platforms.
- **Technology and analytics to diagnose conditions and protect public health and safety.**
- **Deployables in multiple form factors**
- **Communications capabilities across platforms and teams**, e.g., multiple radio technology platforms, private networks, deployable cell sites with multiple form factors, mission critical communications, priority and pre-emption.
- **Force multipliers** to increase the effectiveness of incident responses, e.g. remote driving, available expertise across geographies, and telemedicine.
- **Local control** for multi-jurisdictional response
- **Identity, credential, and access management (ICAM)**
- **Network Priority**—includes priority service access, preemption of users, roaming priority
- **Device-to-device communications, proximity services, and group communications system enablers.**

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Public Safety Ecosystem – Recovery Mission Area

Recovery—Assist communities affected by an incident to recover effectively.

Needs

- **Planning, tactics, and operations before and after an event (typically years). Expand awareness and readiness for assets outside of terrestrial service areas** with available satellite services.
- **Use AI to enhance situational awareness and decision-making capabilities**

Ref - FEMA Incident Complexity Types, Incident Command System (ICS), and Incident Management Team (IMT)

Challenges

- **Recovery support functions (RSFs)** related to economic recovery, health and social services, housing, infrastructure systems, and natural and cultural resources
- **Identify risks and mitigate natural, technological / accidental, or adversarial / human-caused incidents,** e.g. natural hazards, disease, technological and accidental hazards, terrorist organizations or affiliates, cyber-attacks, etc
- **New threat vectors emerge as more networks and devices become connected.**
- **5G deployments may vary across jurisdictions.** Increased use of UAVs may be used for increased enhance situational awareness and decision-making capabilities.

Potential Solutions

- **Enable response-to-recovery transition activities** through the assessment of threats, hazards, vulnerabilities, and capabilities
- **Hardware, software, internet-based systems and applications** (including GIS and incident management software)
  - Social media for situation awareness and information dissemination.
  - **Local, nationwide, and international interoperability** for emergency preparedness, emergency response and disaster recovery operations. This includes deployable communications capabilities.
  - **Local control** for multi-jurisdictional response
  - **Identity, credential, and access management (ICAM)**
  - **Network Priority**—includes priority service access, preemption of users, roaming priority
  - **Device-to-device communications, proximity services, and group communications system enablers.**.

See Reference Slides at the end of presentation for highlights on:

Transportation Ecosystem
Health Care Ecosystem
Electrical Power Ecosystem
Water Distribution and Wastewater Treatment

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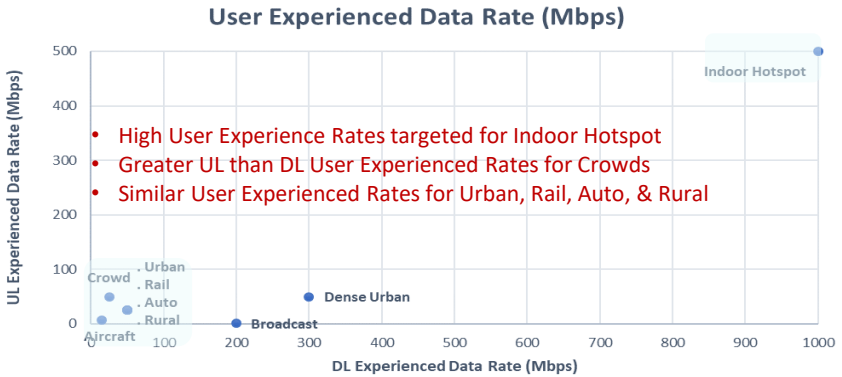
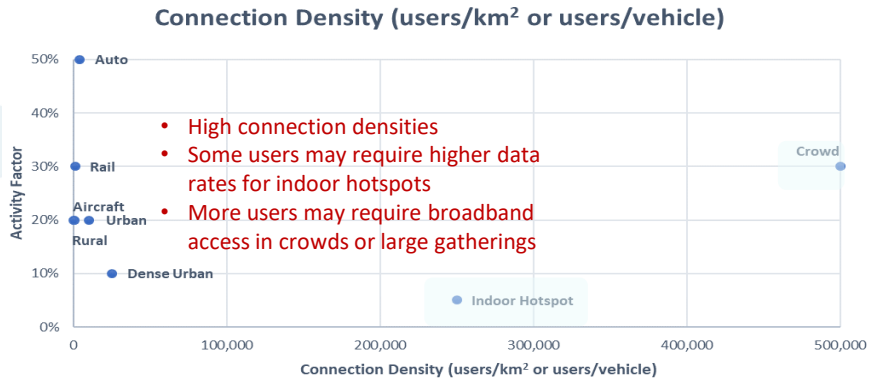
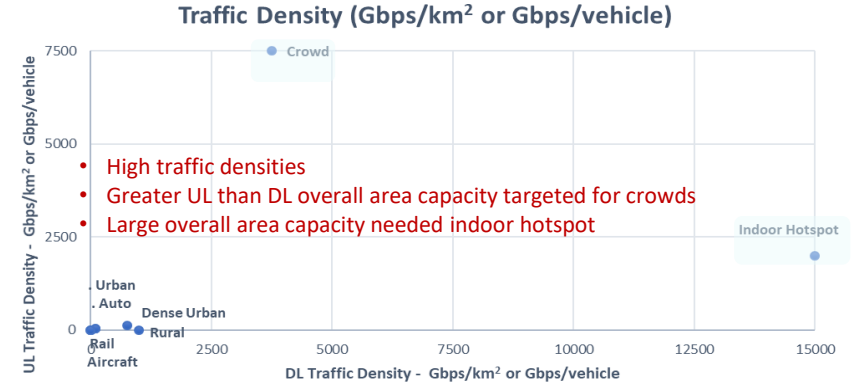
eMBB, mMTC, and URLLC Deployment Considerations

Enhanced Mobile Broadband (eMBB) Deployment Considerations







5G Drivers: High data rate, low latency, traffic density, connection density, varying levels of mobility

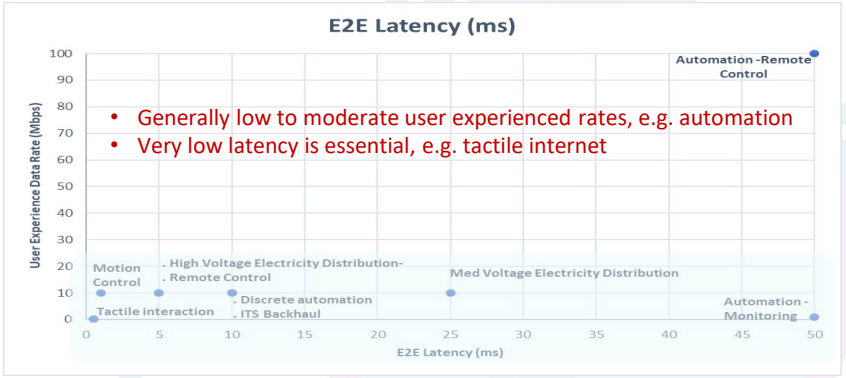
5G Deployments: Indoor/Outdoor Local and Wide Area Connectivity

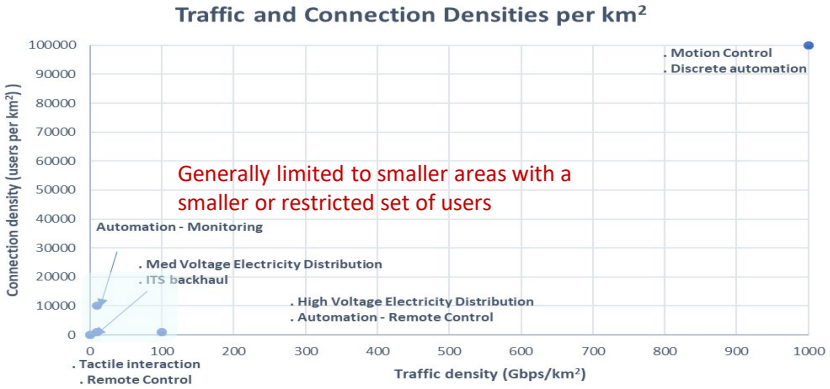
Fixed Mobile Convergence: combined use of fixed broadband access, e.g. fiber, and 5G access network.

Femtocell Deployment: seamless user experience over radio access and Femtocell access using fixed broadband networks.

Source: 3GPP TS 22.261

mMTC and URLLC Deployment Considerations





Massive Machine Type Communications

5G Drivers: Communications efficiency, traffic density, communications density, position accuracy

Operational: network servers/applications and devices support to identify and reach each other, IoT security

Connectivity: Direct 3GPP connection (e.g., a sensors), indirect 3GPP connection (e.g., a smart wearable communicating via a smart phone), direct device connection (e.g., a biometric devices that communicate directly with other biometric devices.

Resource Efficiency: include bulk provisioning, resource efficient access, optimization for device originated data transfer, and mobility management efficiencies for stationary or limited mobility devices.

5G Drivers: Low latency, reliability, traffic density, position accuracy

Mission Critical Services: critical communications that may require a higher communications priority, e.g. first responders, disasters.

Other Considerations

- Availability, e.g. deployables
- Reliability, e.g. industrial control, drone connectivity
- Positioning Accuracy, e.g. connected vehicles

Source: 3GPP TS 22.261

Smart City Applications – 5G Network Operations

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.

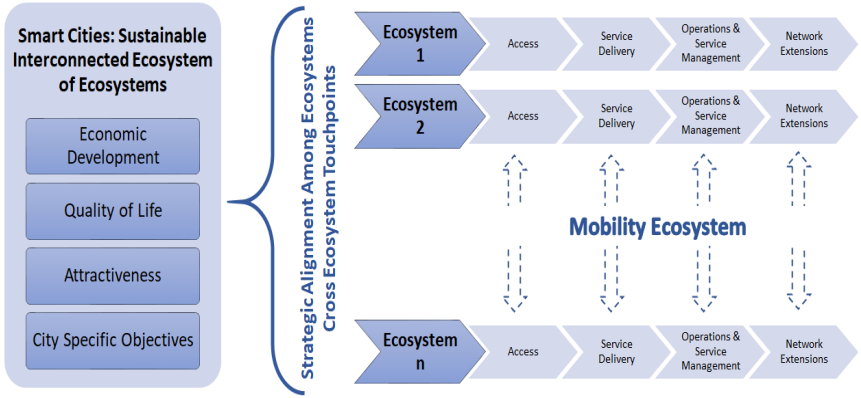
Source: 3GPP TS 22.261

Smart City Framework

Smart Cities Framework

1. **Strategy Development** – Combine roadmap (e.g. IEEE INGR), usage trends, technological resources, operational data, city competitive data, financial resources, culture, and other capabilities and constraints.
2. **Targeted Ecosystems Deployments** - Implement strategy through prioritized deployments based on an ecosystem structure, e.g. IEEE INGR Applications and Services Chapter. Priorities may differ across cities based on their unique circumstances.
3. **Systems Assessment** – **Assess prioritized ecosystems needs** based on a combination of enhancements for access, service delivery, operations and service management, and network extensions, e.g. IEEE INGR WGs
4. **Push-Pull Subsystem Assessment** – **Prioritize subsystem deployments** based on the forecast horizon. Proceed, defer deployments, or accelerate developments, e.g. technological improvements, technology availability in the local geographical area, financial priorities, etc,
5. **Ecosystem Alignments** – **Align ecosystems to maximise aggregated direct and indirect improvements for all the ecosystems**. Note - ecosystems develop at different rates.
6. **Policies** - **Cities may be policy driven and technology enabled** to achieve its overarching goals, e.g. economic development or to steer resources to meet a targeted need such as access to transportation in unserved or underserved areas.
7. **City Performance** – **Optimize ecosystems** through performance data, competitive data and other related KPIs. May use pre-defined or city-specific metrics.

The city may repeat the cycle as needed. Order may vary based as necessary



Alignment within ecosystems - each activity is consistent with the overall strategy, e.g. connecting people, places and things in ecosystem(s)

Alignment among ecosystems – connected ecosystems complement each other, e.g. coordinated public safety, health care, transportation ecosystems

Optimization of ecosystems – "smart" coordination & information exchanges across ecosystems that are geared towards economic development, quality of life, and attraction & retention of residents, businesses, and visitors.

Summary

Ecosystem Framework

- Applications and services may be contextualized through an ecosystem framework
- Ecosystems converge in an urban environment
- Multiple opportunities and challenges in urban environments or cities

Comprehensive smart cities

- Alignment within ecosystems
- Alignment among ecosystems
- Optimized performance based on top down and bottom up usage trends

Global landscape

- Cities compete on a global scale
- Cities may use a combination of predefined metrics and city specific metrics.

Multi-dimensional approach

- Cities may use a combination of strategy, technologies, policies, performance to achieve a comprehensive solution

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)
- **Applications and Services WG will continue working on the 2nd edition**

IEEE INGR Applications and Services WG

- ***Roadmap Details***

https://futurenetworks.ieee.org/roadmap

- ***WG Participation –***

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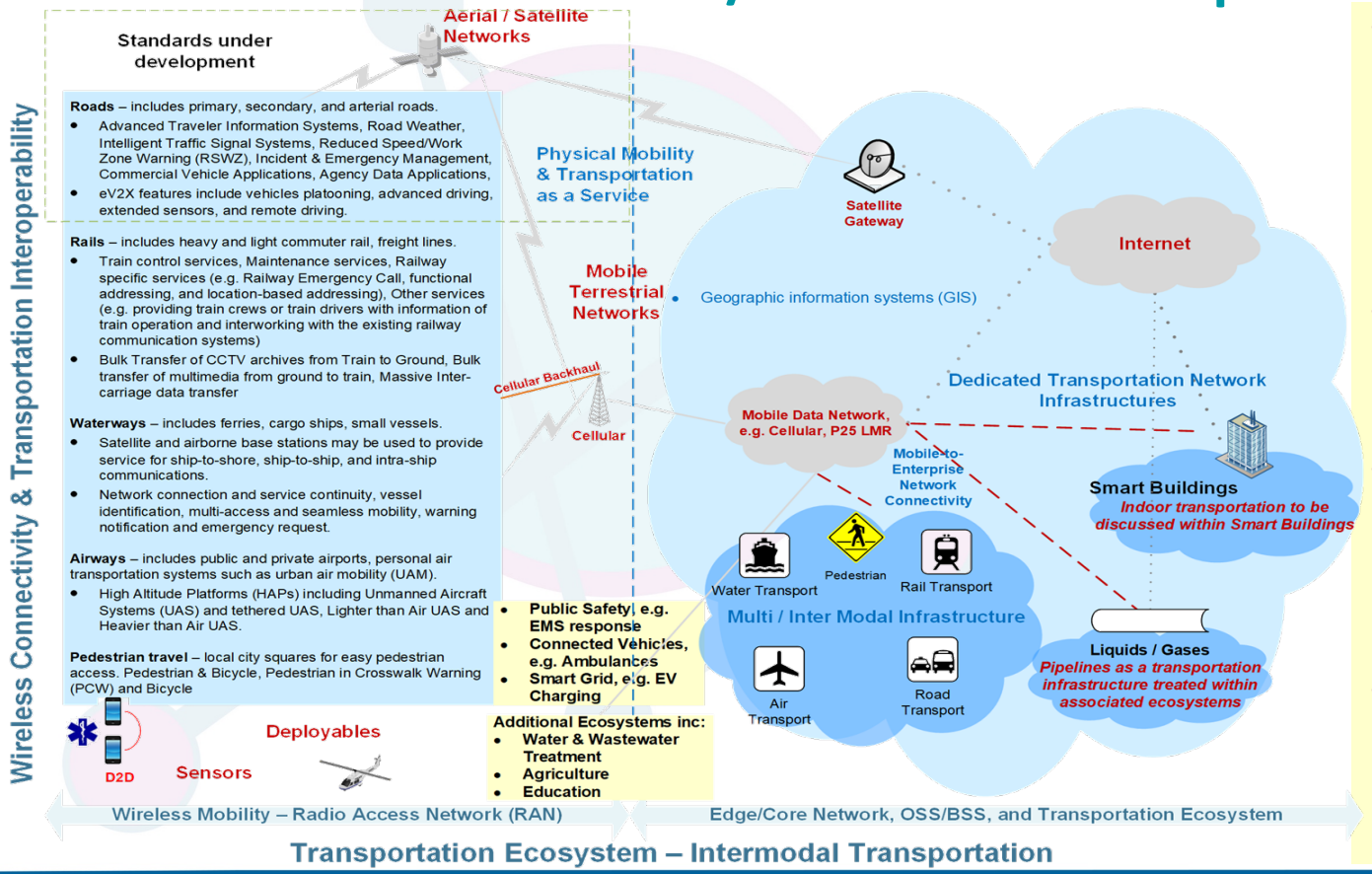
Reference Slides

Additional IEEE INGR Applications and Services (First Edition) Ecosystems

Transportation
(Multi/Inter Modal Transportation)

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

Transportation Ecosystem – Roadways

Needs

- **Roadway transportation communication needs for primary, secondary, and arterial roads.** May also include undeveloped roadways
- **Wireless roadside unit backhaul** requiring 99.9999% reliability and maximum end-to-end latency of 30 ms
- **Extended service area and extended roaming capabilities** across geographies and jurisdictions

Challenges

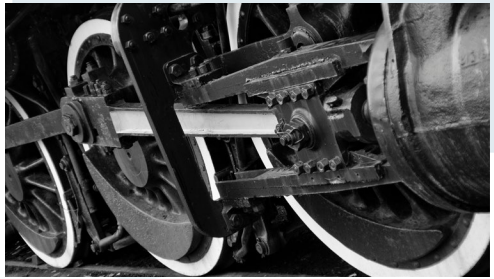
- **5G service availability**. Initial deployments are typically concentrated in core areas.
- **Roadside units** will need to be deployed approx. every 1 to 2 km
- **Legal and insurance** to address mixed use roadways

Potential Solutions

- **Vehicle to network communications** that do not require critical communications, e.g., loading of maps, traffic updates from a centralized source.
- **Primary deployment considerations** include Advanced Traveler Information Systems, Road Weather, Intelligent Traffic Signal Systems, Reduced Speed/Work Zone Warning (RSWZ), Incident and Emergency Management, Commercial Vehicle Applications, Agency Data Applications,
- **eV2X** features include vehicles platooning, advanced driving, extended sensors, and remote driving.

Transportation Ecosystem – Rail

Needs	Challenges	Potential Solutions
• **Railway communications** for heavy and light commuter rail, freight lines.	• **Prioritized emergency group communication, train control data and video service** • **Seamless connectivity** in high speed railway moving environments • **Low latency and high reliable data and video service** • **Real time train monitoring and management** for safe train operation • **Reliable location tracking** including tunnel condition • **Legacy railway communication interworking** to GSM-R system	• **Train control services, Maintenance services, Railway specific services** (e.g., Railway Emergency Call, functional addressing, and location-based addressing), • Other services (e.g., providing train crews or train drivers with **information of train operation and interworking with the existing railway communication systems**) . • **Bulk Transfer** of CCTV archives from Train to Ground, Bulk transfer of multimedia from ground to train, Massive Inter-carriage data transfer.



2nd edition to include additional details on the rail, air, and maritime communications

Transportation Ecosystem – Air, Maritime, Pedestrian

Maritime

- **Waterways transportation needs include ferries, cruise ships, cargo ships, small vessels.**
- Primary deployment considerations include:
  - Satellite and airborne base stations may be used to provide service for 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.
- *3GPP TR 22.119: Maritime Communication Services over 3GPP system*

Air

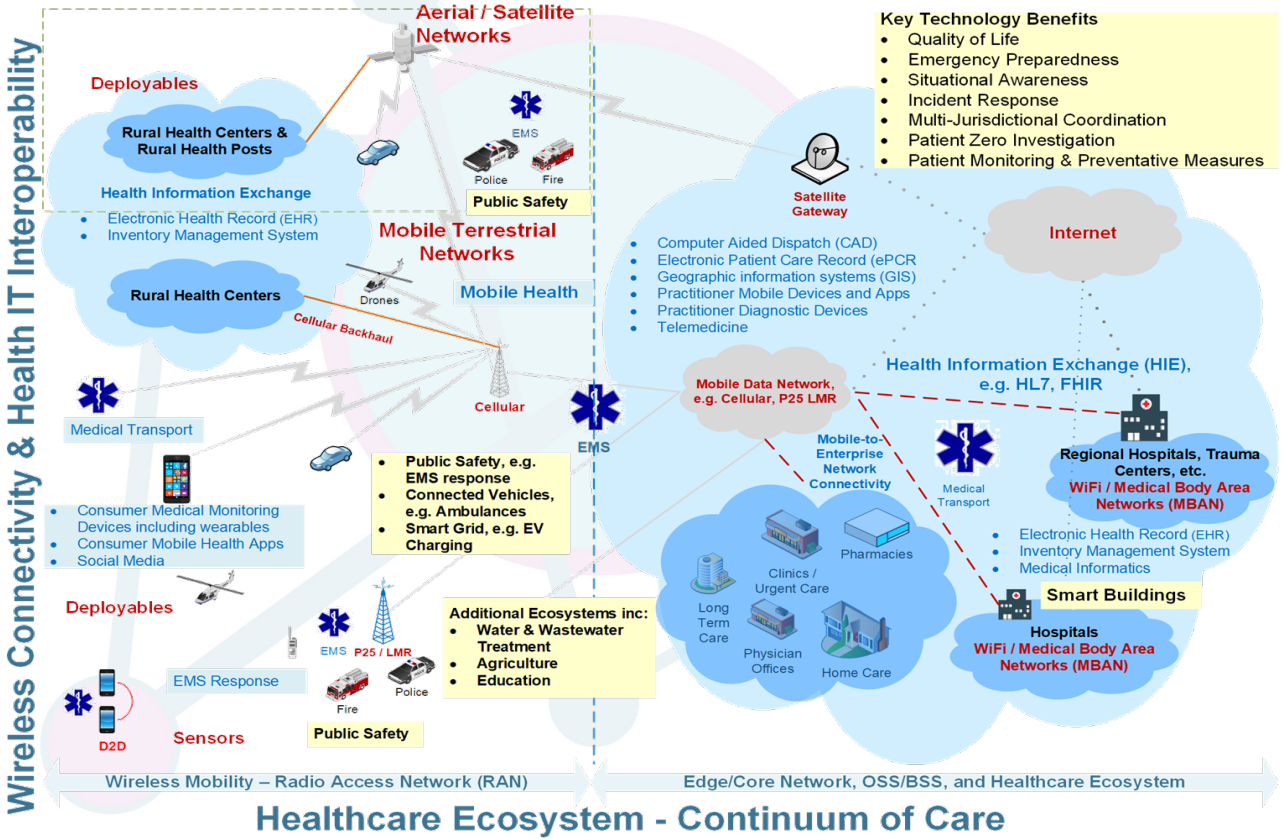
- **Airways transportation needs include public & private airports, personal air transportation systems such as urban air mobility (UAM)**
- Primary deployment considerations include High Altitude Platforms (HAPs) including Unmanned Aircraft Systems (UAS) and tethered UAS, Lighter than Air UAS and Heavier than Air UAS.
- *3GPP TR 38.811: Study on New Radio (NR) to support non-terrestrial networks*

Pedestrian

- **Pedestrian and micro-mobility transportation needs include local city squares for easy pedestrian access.**
- Primary deployment considerations include Pedestrian and Bicycle, Pedestrian in Crosswalk Warning (PCW), Bicycle warning systems, Electric scooter and pedestrian collision avoidance systems

Healthcare

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

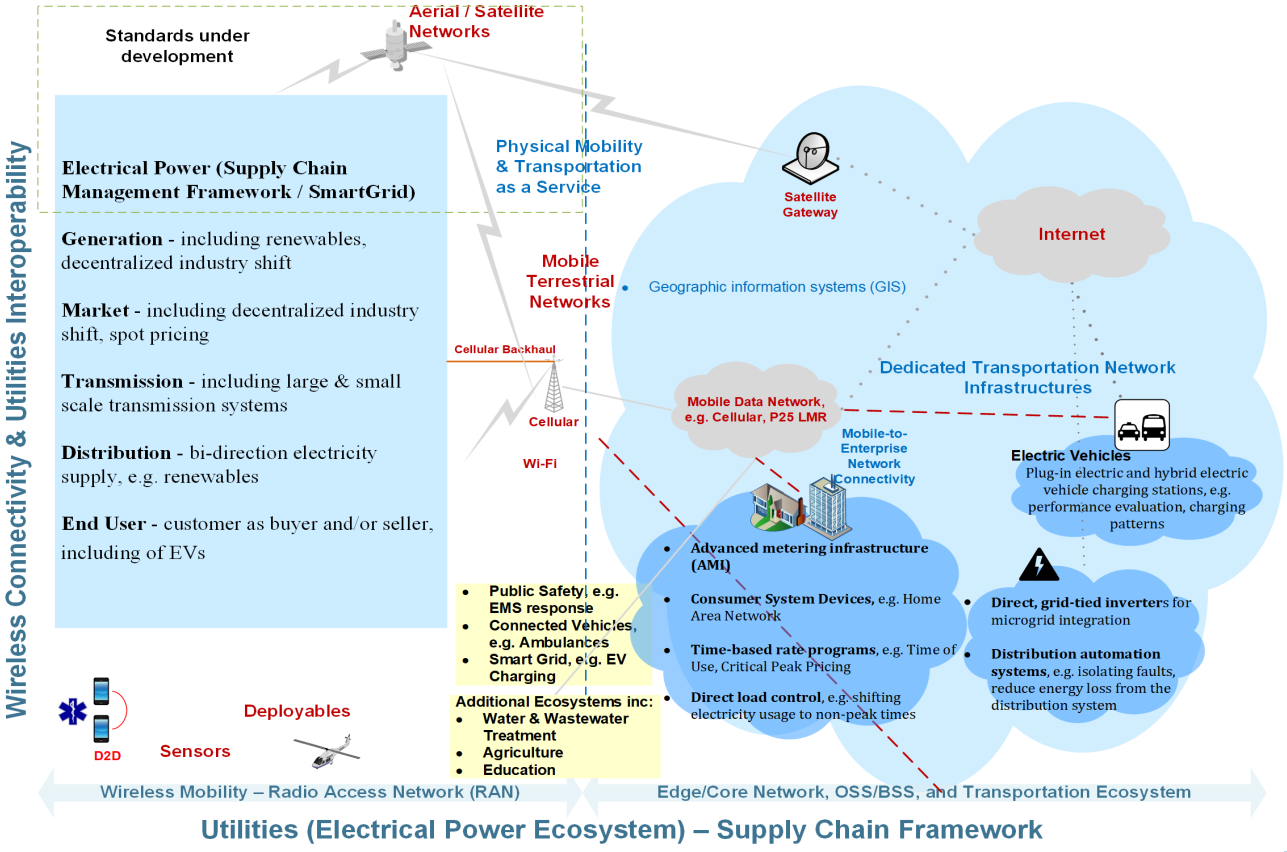
Healthcare Ecosystem – Continuum of Care

Needs	Challenges	Potential Solutions
• **Healthcare communications for continuum of care** across trauma centers, hospitals, EMS, outpatient monitoring covering technologies across health care IT, health information exchange (HIE), broadband communications, MBANs, etc	• **Ubiquitous communications availability** and readiness for wireless transition • **Range of latency requirements** for wearables, Sensors, Reporting, MIoT • **Different spectrum bands** • **Privacy and Security** compliance for individuals data within a complex legal framework and country specific guidelines	• **Convergence of telecom and IT solutions.** • **Various wireless low latency solutions to address different requirements** • **Fair allocation of spectrum towards health care applications**, e.g. (un)suitability of spectrum auctions for health care providers • **Privacy and Security policy updates, convergence and evolution of practices**. A central security implementation to work on instant detection and reduction of vulnerabilities,

2nd edition to include additional details

Utilities

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

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