Smart Cities Framework

Vision to Reality - a structured, adaptable, and scalable approach towards a sustainable interconnected ecosystem of ecosystems

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IEEE INGR Applications & Services WG

Smart Cities – A Framework from Vision to Reality

- Applications & Services Use Case Categories
- Contextual Ecosystem Frameworks
- Smart Cities Framework
  - Strategy and Roadmaps
  - Tactics
  - Performance
- Global Competitive Landscape

Smart Cities

Applications and Services

- Applications and Services use case categories include eMBB, mMTC, and URLLC and benefit from network operations enhancements.
- New business models will emerge for areas of operations that span urban and non-urban environments.

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

- Applications and Services for ecosystems in an urban environment may be addressed through a smart cities roadmap.
- 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.

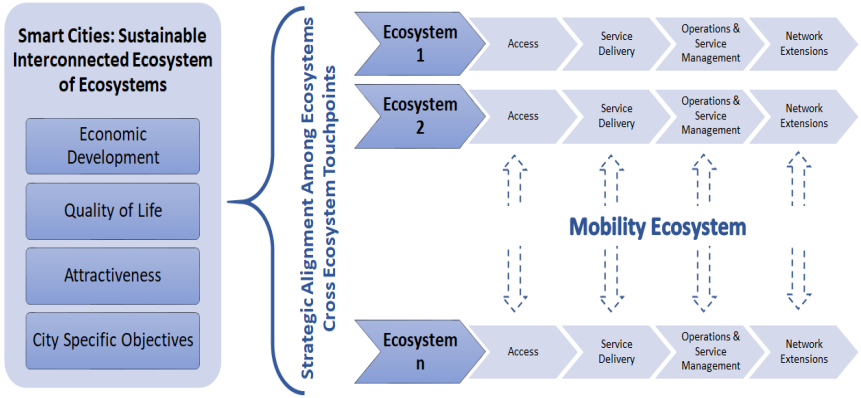
Challenges and Opportunities for Smart Cities

- 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.

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.

Strategy

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.

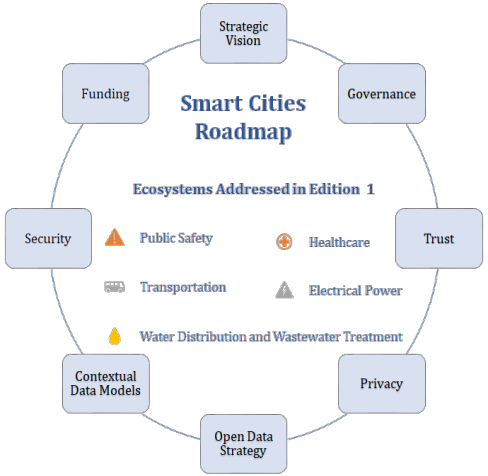
INGR Applications and Services Chapter Highlights include

- **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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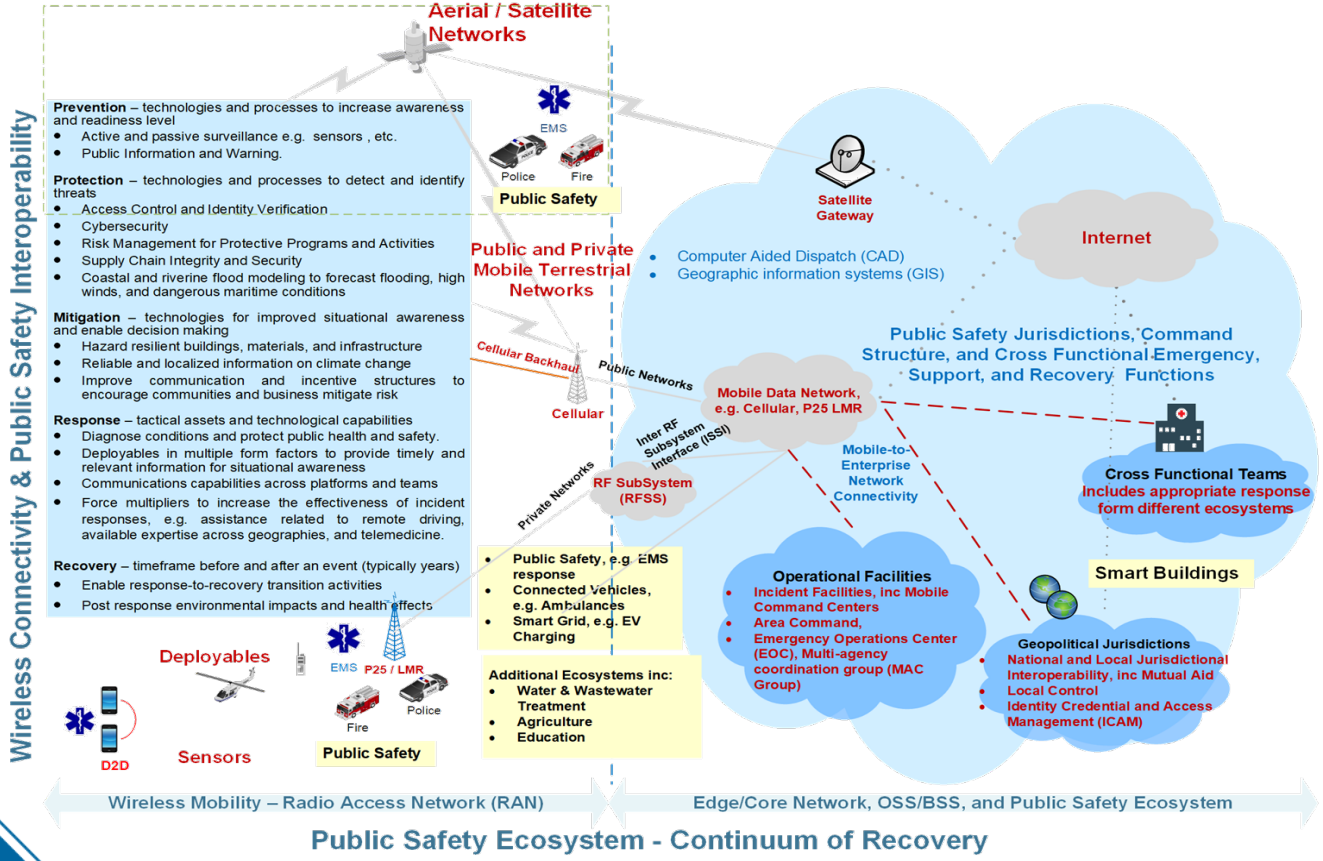
Public Safety Ecosystem example – (Sub) System Alignments



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)

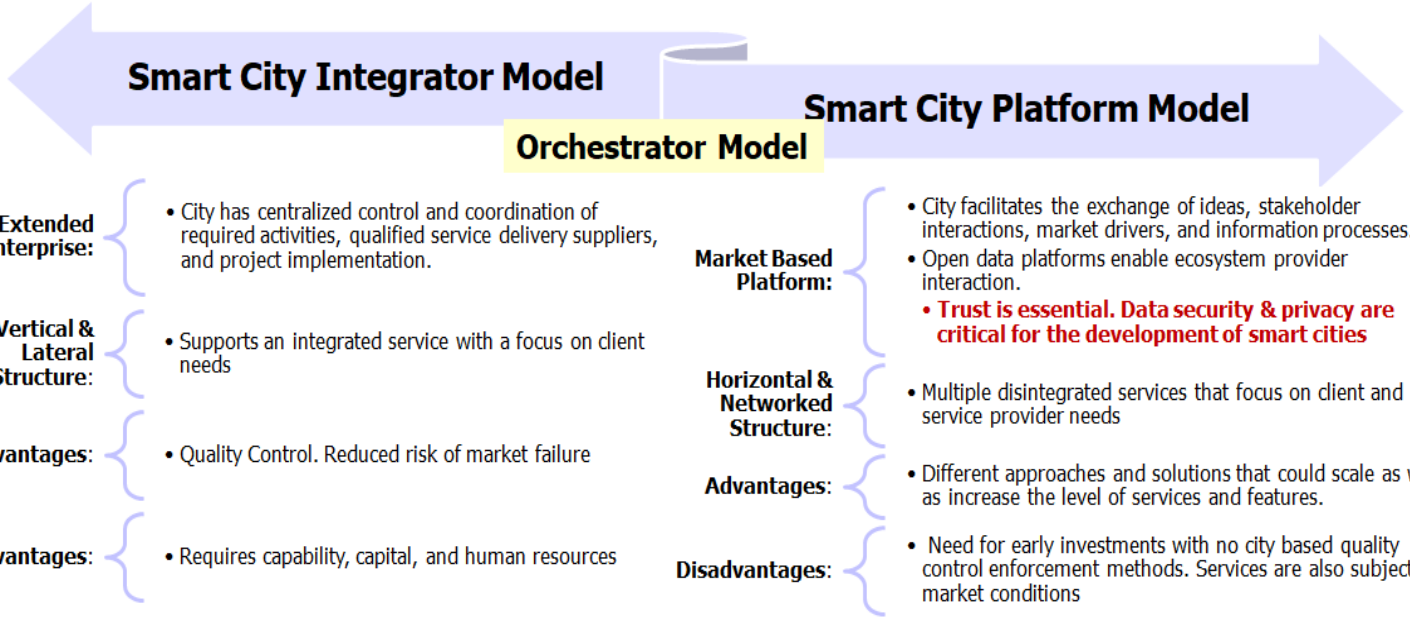
How do we translate the needs into technical requirements?

- eMBB
- mMTC
- URLLC
- Network Operation Enhancements

What is the roadmap vision?

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

Smart City Governance and Finance – Needs and Challenges



Orchestrator Model: dynamically adjust between Integrator or Platform to evolve
Ecosystem of Ecosystems Structure: Multiple complex connected ecosystems with multiple stakeholders and technologies.

- Trust, Privacy, and Data Security are essential
- Cities may use the Orchestrator Model to adjust for financial resources, stakeholder needs, and quality control
- Funding pipeline from national & local governments, PPP, entrepreneurs, and communities may help with the implementation of the project portfolio

Source - Governing the City: Unleashing Value from the Business Ecosystem, Ivanka Visnjic, Andy Neely, Carmelo Cennamo, and Nikola Visnjic, California Management Review, 2016, Vol. 59

Ecosystem Alignments

Smart Cities Ecosystem of Ecosystems

- Economic Development, Quality of Life, and Attractiveness for Residents, Businesses, and Visitors
- Technologies: Analytics to support congestion relief increase tourism, stimulate economic activity, etc
- Cross-Ecosystem Interactions: Governance and coordination of complex interacting ecosystems.

Transportation Ecosystem

- Transportation Modes: Roads, Rails, Waterways, Air Travel, Pedestrians, Bicycles
- Technologies: DSRC, V2X, CBTC, PTC
- Cross-Ecosystem Interactions: EV charging and electrical grid loading, public safety

Healthcare Ecosystem

- Continuum of Care: trauma centers, hospitals, EMS, outpatient monitoring
- Technologies: Health IT, EHR, Broadband Communications, MBANs
- Cross-Ecosystem Interactions: EMS / Connected Vehicles, Analytics to track outbreaks, citywide continuum of care, etc

Energy & Utilities Ecosystems

- Broad range of utility services: Smart Grids / Electricity, Waste Management / Sanitation, Water, Gas
- Technologies: Meshed networks, narrowband RF, LPWA, AMI
- Cross-Ecosystem Interactions: energy conservation, spot pricing for utility market, energy efficiency & cost reduction for smart buildings,

Public Safety Ecosystem

- Safety and Emergency Response: First Responder / Public Safety, Municipal Services / Public Works, Environmental
- Technologies: 5G, LMR, WLAN, satellite communications for fleet management, emergency response
- Cross-Ecosystem Interactions: connected vehicles, priority and preemption for first responders, etc

Agricultural Ecosystem

- Information and monitoring services, food supply chain visibility, mobile financial services,
- Technologies: 5G, LPWA, WLAN (inc TV white spaces), satellite communications
- Cross-Ecosystem Interactions: food supply chain visibility inc urban food desert reduction, massive IoT, connected vehicles, public safety,

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Deployments

Smart City Challenges

Funding: Single source of funding may not be sufficient. Cities may need a combination federal, state, municipal, community, and investor funding sources

Trust, Privacy, and Security: Trust is essential for smart city development. Cities will need to promote an open data model that balances security and privacy. May include localized ethical and societal policy framework.

Different priorities and levels of technological innovation: Cities may focus on different priorities within a varied technological landscape. Roadmap will need to accommodate

Sustainability: Urban population growth is increasing and increases the pressure on a city's infrastructure, e.g. 50% of water resources are wasted due to leaky infrastructures,

Residential and commercial buildings consume 1/3 of the global energy produced

Cultural Sensitivity: Cities already have an intrinsic culture and value system. Smart city development and operations should blend seamlessly within each city's unique characteristic.

Technology Standards: Standards are currently in development. Ecosystems may have application specific standards that may be proprietary.

Contextual Data Models: Contextual data and associated data models may be needed for optimized solutions and the reduction of industry silos

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Smart City Technology Enablers

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, e.g. easy access to transportation from residences to workplaces.

Multi-tiered security for network, device, data and users

Support mission critical, shared, dedicated or non-critical applications.

Some users may not wish or do not have the means to participate in applications or services that request user identities.

Needs based positioning technologies

New standards and technologies that may serve a specific segment across all ecosystems, e.g.

- McX (voice data, video),
- Personal mobility (multiple form factors),
- Unmanned Aerial Vehicles (UAVs),
- Vehicle-to-Everything (V2X),
- Energy Efficiency (IEEE 192x)

Air access rights

Cities may pursue monetization of air access for taller structures and UAVs

Digital Twins

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

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 & consistent semantics (interpretation of data)

Artificial Intelligence (AI)

Assisted use (repeatable tasks),

Augmented use (new use cases that may include business model changes)

Autonomous (requires a high degree of trust)

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Performance

Cities already compete on an international scale!

- Cities compete on an international scale
- Criteria and metrics are helpful for harmonizing global performance measurements
- Cities may use a combination of common and city-specific KPIs as needed.

Functions - Economy, R&D, Cultural Interaction, Liveability, Environment and Accessibility.
Stakeholders - Managers, Researchers, artists, visitors and residents.

Source: Global Power City Index 2018, Mori Foundation

Summary

Ecosystem Framework

- City based applications and services may be contextualized through an ecosystem framework
- Multiple opportunities and challenges

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

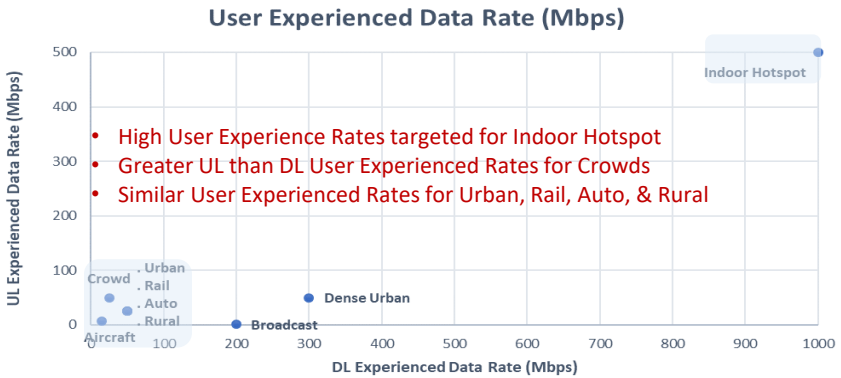
Positive and Negative Risks

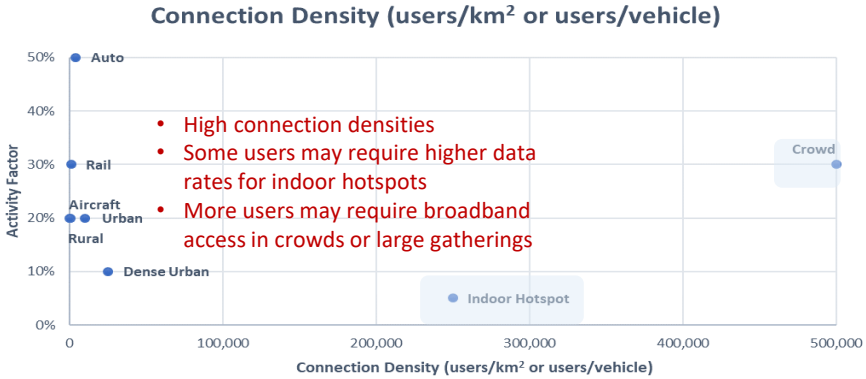
- Roadmaps such as the IEEE INGR may help to mitigate negative risks and pursue positive risks (opportunities)

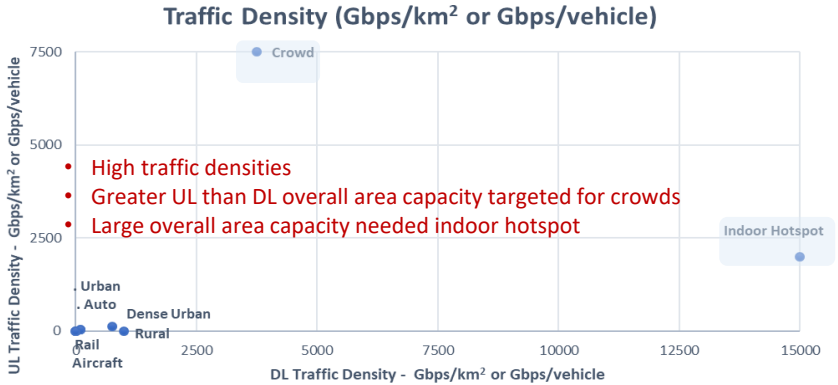
Reference Slides

Deployment Considerations

Enhanced Mobile Broadband (eMBB) Deployment Considerations







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

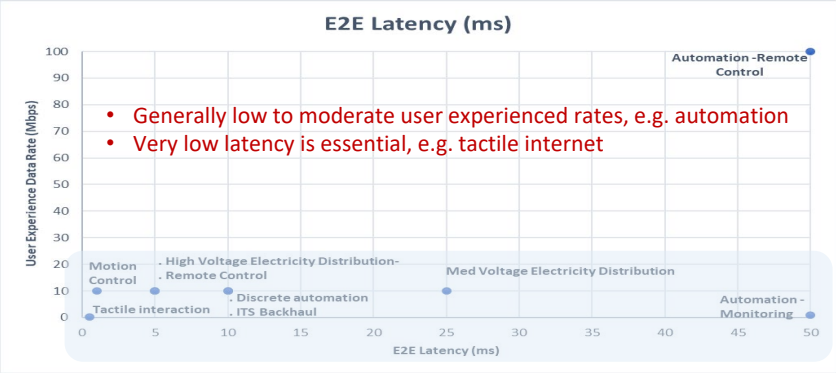
5G Deployments: Indoor/Outdoor Local and Wide Area Connectivity

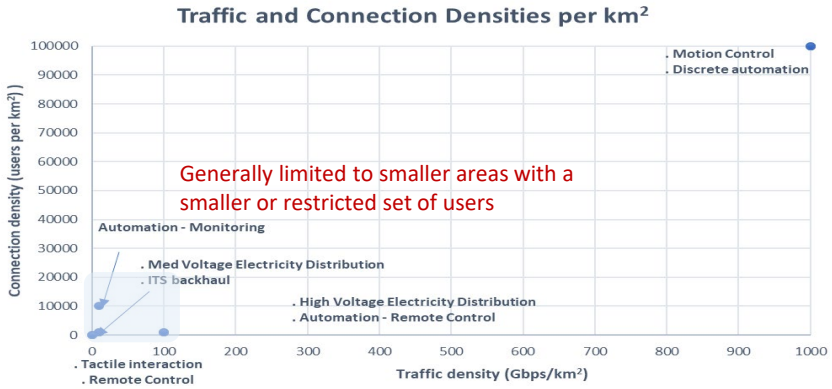
Fixed Mobile Convergence: combined use of fixed broadband access, e.g. fiber, and 5G access network.

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.

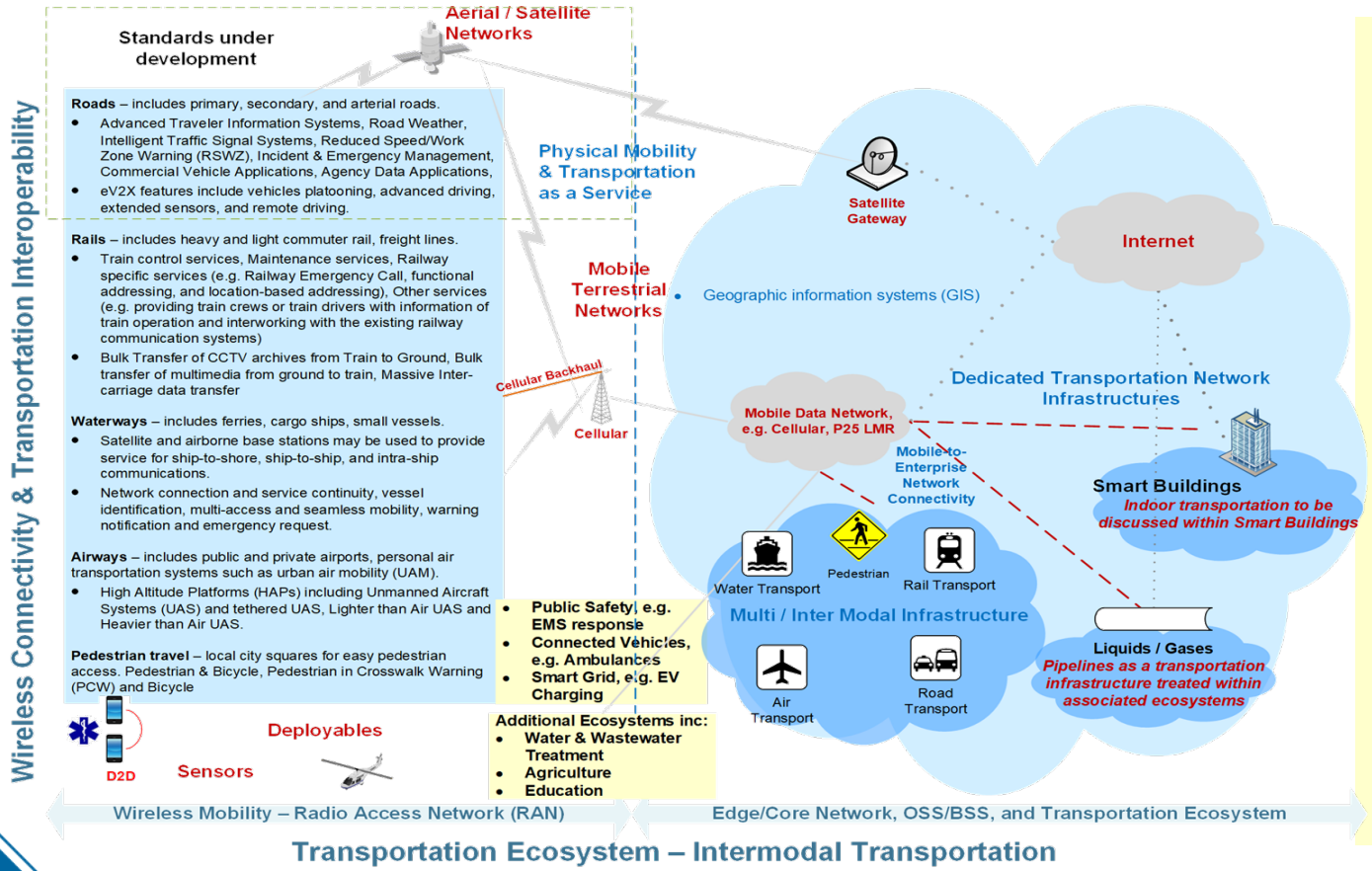
Other Considerations

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

Source: 3GPP TS 22.261

Additional IEEE INGR Applications and Services (First Edition) Ecosystems

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
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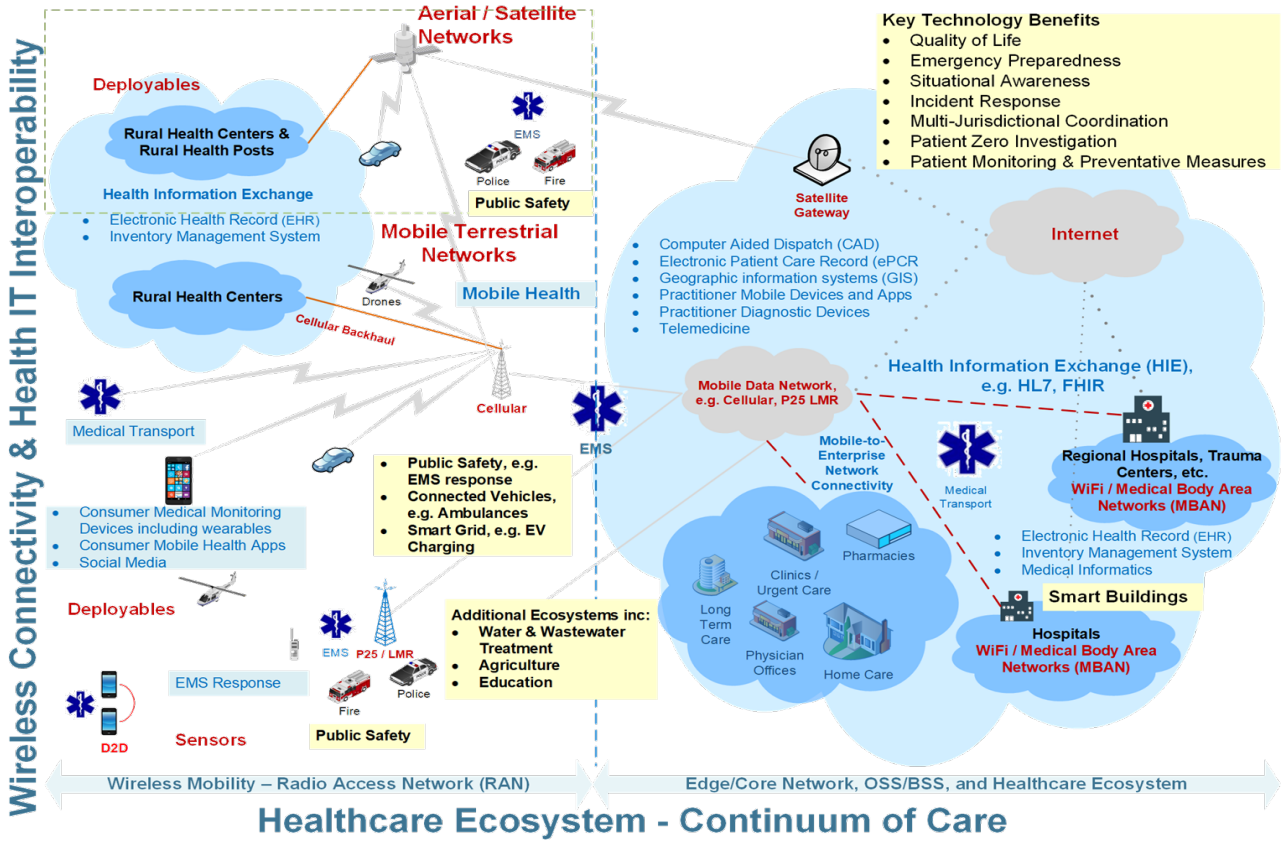
Healthcare Ecosystem – Continuum of Care



- **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?

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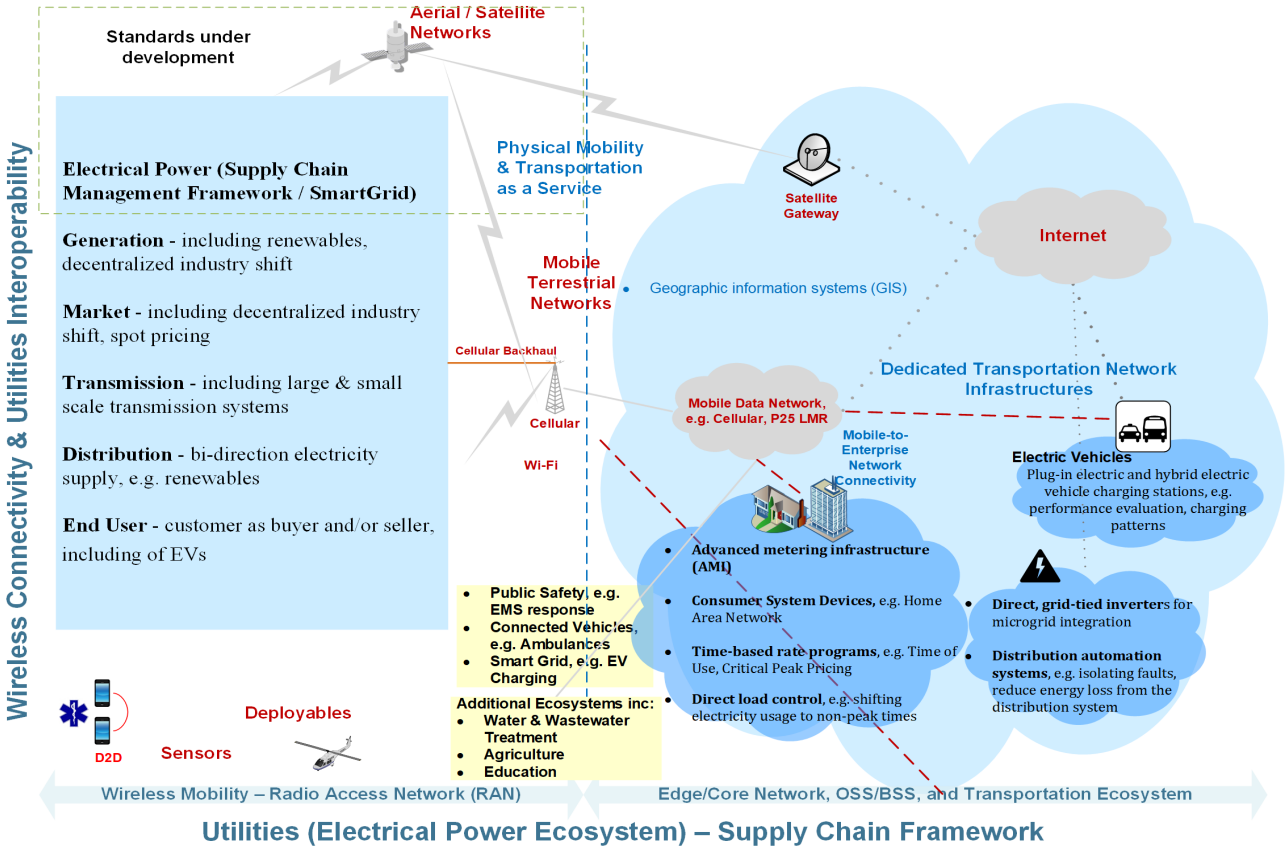
Electrical Power - Supply Chain Framework



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