IEEE 5G Initiative

Smart Cities Overview

July 28th, 2018

Narendra Mangra, GlobeNet

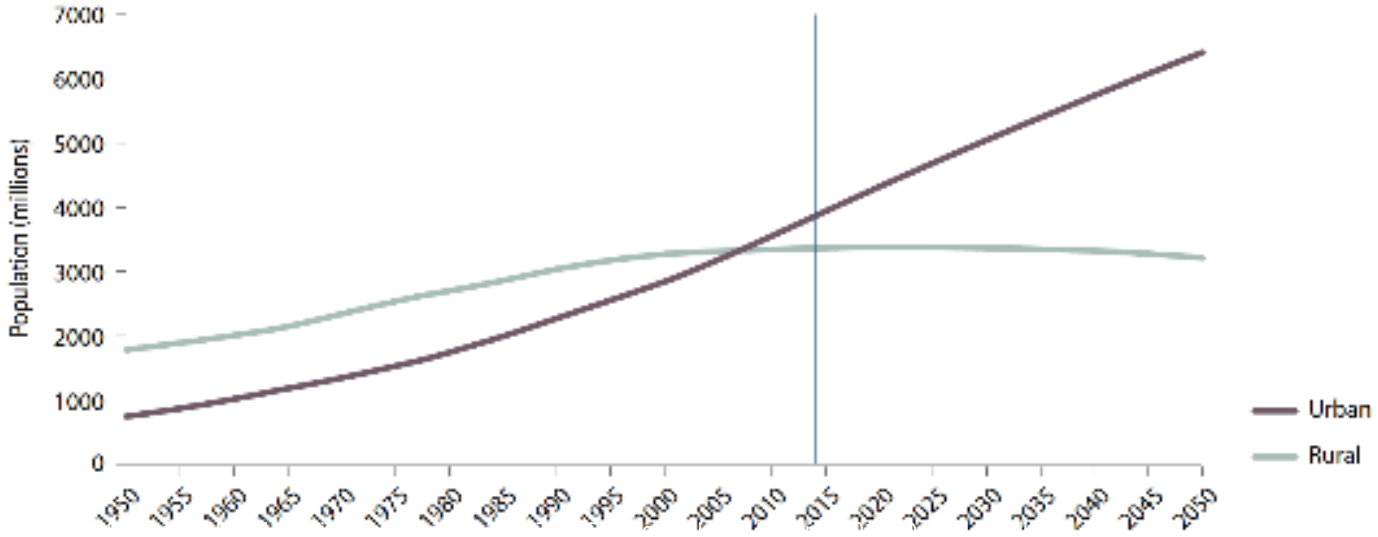
Smart Cities Overview

IEEE 5G

Strategy & Governance

Motivation

- Cities produce 80% of the world's carbon emissions. Natural resources are exploited and wasted in cities, e.g. 50% of water resources are wasted due to leaky infrastructures, and residential and commercial buildings consume 1/3 of the global energy produced.
- There are more urban residents than rural residents across the globe. Global urban population increases by 2 people every second !
- Cities strive towards economic development, improve quality of life, and attract and retain residents, businesses, and visitors.
- Venture capital investment tends to be highly concentrated in center cities and are influenced by innovation, access to talent, high tech industry clusters, density, wages and income, and openness and diversity.



https://esa.un.org/unpd/wup/Publications/Files/WUP2014-Highlights.pdf

Global mobile industry GDP contribution
2017 - $3.6 trn (4.5%)
2022 - $4.6 trn (5.0%)

Source: The Mobile Economy 2018, GSMA Intelligence

Urban Population increases by 2 people ever second!

Natural resources are strained

Cities compete with each other to attract and retain residents, businesses, and visitors

Wireless Mobility Enables GDP growth

Direct Benefits

- **GDP growth** - strong correlation between mobile penetration rate & GDP growth
- **Job Creation** - Mobile industry, retail, etc
- **Productivity** - Business Expansion, Employment Search, Entrepreneurism, mobile banking, reduce transaction costs
- **Tax Revenues** - Significant tax revenues from mobile telecoms
- **Value-Add from Mobile Operator** - Regulatory & spectrum fees, Corporate social responsibility, etc

Indirect Benefits

- **Entrepreneurism & Job Search** - reduces business start-up & operating cost,
- **Reduces information asymmetry** - increases bargaining power & knowledge about market opportunities
- **Help correct market inefficiencies** – access to information improves employment opportunities, reduces information gaps, saves time & cost, & strengthens access of service providers to rural populations.
- **Substitute for Transportation** - enables information flow without the need for travel

Intangible Benefits

- **Disaster Relief** - Mobile number can act as a fixed identity point and enables keeping in touch with one's community
- **Education & Health** - Communities may receive locally generated & locally relevant educational & health information, e.g. SMS
- **Social Capital & Social Cohesion** - Mobiles may be used as an amenity or a shared commodity, to mediate strong links with family & friends, and to mediate weak links with individuals outside of the community, e.g. businessmen, government officials

Source: The Role of Mobile Phones in Sustainable Poverty Reduction, World Bank, June 15, 2008

Global mobile industry GDP contribution
2017 - $3.6 trn (4.5%)
2022 - $4.6 trn (5.0%)

Source: The Mobile Economy 2018, GSMA Intelligence

Smart Cities Strategy Development

Smart Cities may be described as an ecosystem of ecosystems where the underlying communications infrastructure is critical for economic growth and quality of life.

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.

Smart City strategy should combine activities that fit and reinforce each other.

Strategic fit is difficult as it requires integration of decisions & actions across different ecosystems

- Ecosystem structures, systems, & processes need to be aligned with overall strategy
- Governance activities needs to address strategic goals, culture, trust, resources, technologies, policies, and a diverse stakeholder mix

Smart City Ecosystem Governance

Smart City Integrator Model

Extended Enterprise:
- City has centralized control and coordination of required activities, qualified service delivery suppliers, and project implementation.

Vertical & Lateral Structure:
- Supports an integrated service with a focus on client needs

Advantages:
- Quality Control. Reduced risk of market failure

Disadvantages:
- Requires capability, capital, and human resources

Orchestrator Model

Smart City Platform Model

Market Based Platform:
- City facilitates the exchange of ideas, stakeholder interactions, market drivers, and information processes.
- Open data platforms enable ecosystem provider interaction.
- **Trust is essential. Data security & privacy are critical for the development of smart cities**

Horizontal & Networked Structure:
- Multiple disintegrated services that focus on client and service provider needs

Advantages:
- Different approaches and solutions that could scale as well as increase the level of services and features.

Disadvantages:
- Need for early investments with no city based quality control enforcement methods. Services are also subject to market conditions

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

***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*

Connected Ecosystems of Ecosystems

- **Smart Cities Ecosystem of Ecosystems**
  - Quality of Life and Economic Growth: attract and retain Commercial, Business, Entertainment, & Residential interests
  - Technologies: Analytics to support congestion relief (e.g. parking apps), increase tourism (e.g. AR/VR), and stimulate economic activity
  - **Cross-Ecosystem Interactions: Governance of ecosystem structure to coordinate complex interacting ecosystems.**
- **Connected Vehicles 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**
- **Connected Health 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 Governance: First Responder / Public Safety, Municipal Services / Public Works, and Environment applications
  - 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,**

Smart City development should address pain points and address goals & aspirations while retaining the unique culture of each city.

Solutions should be aligned with the underlying strategy and complement each other.

IEEE 5G

Connected Ecosystem of Ecosystems

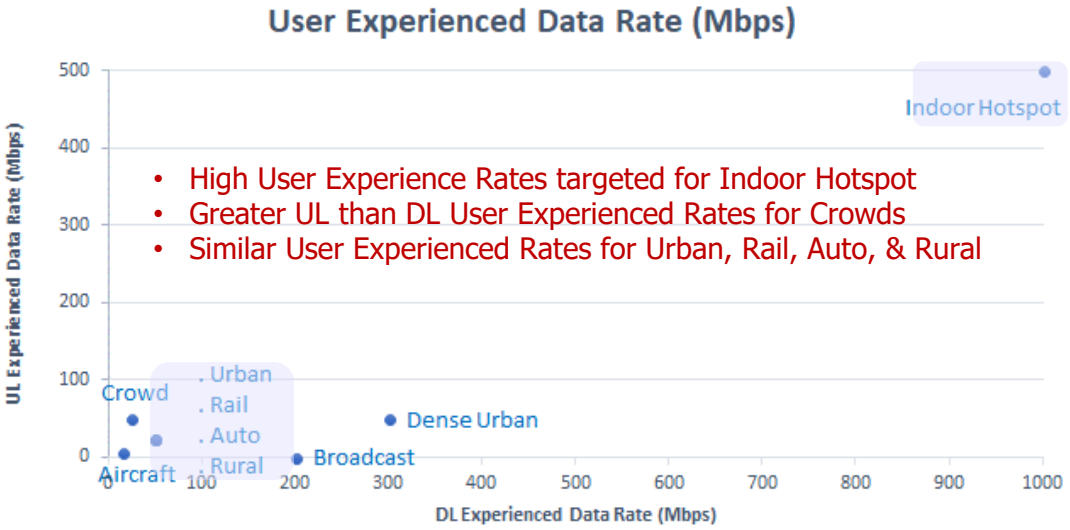
5G & Smart Cities Roadmap

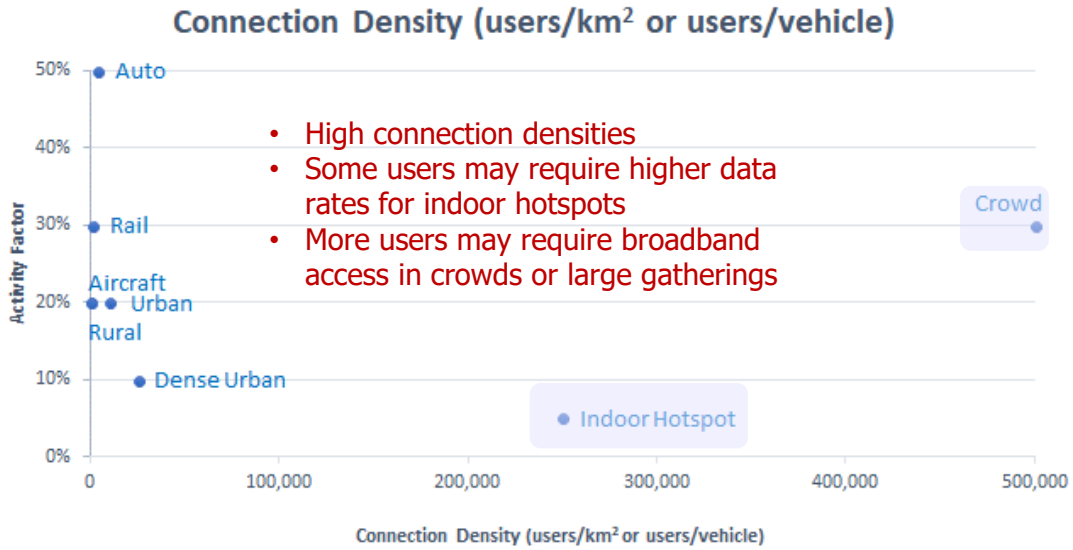
Smart City Applications – 5G Network Operations

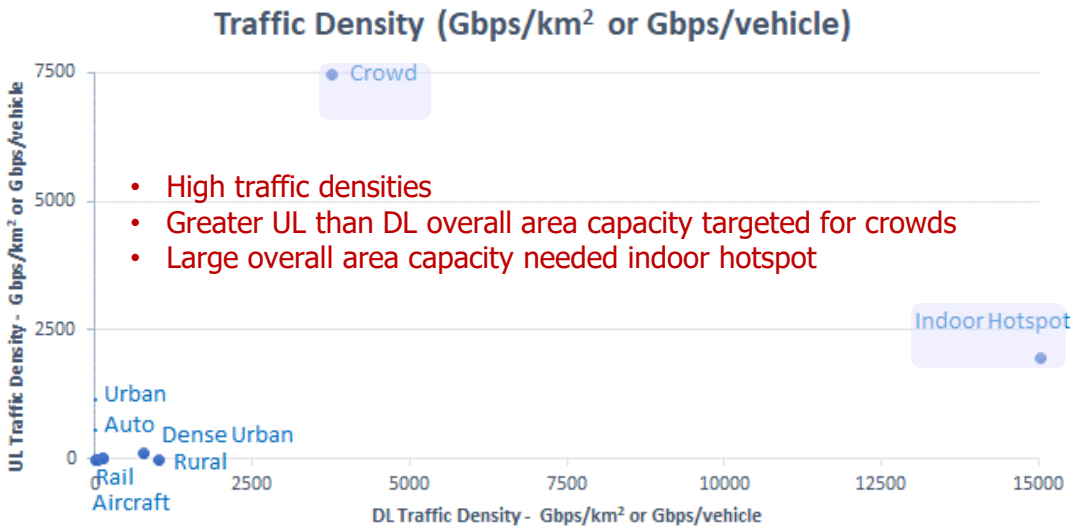
Network Slicing	Ability to create dedicated logical networks within a shared infrastructure
Multiple Access Technologies	Support for 3GPP and non-3GPP network connectivity with potential simultaneous services.
Network capability exposure	Extend network capabilities to 3rd party providers e.g., APIs, 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

Enhanced Mobile Broadband (eMBB) Considerations







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

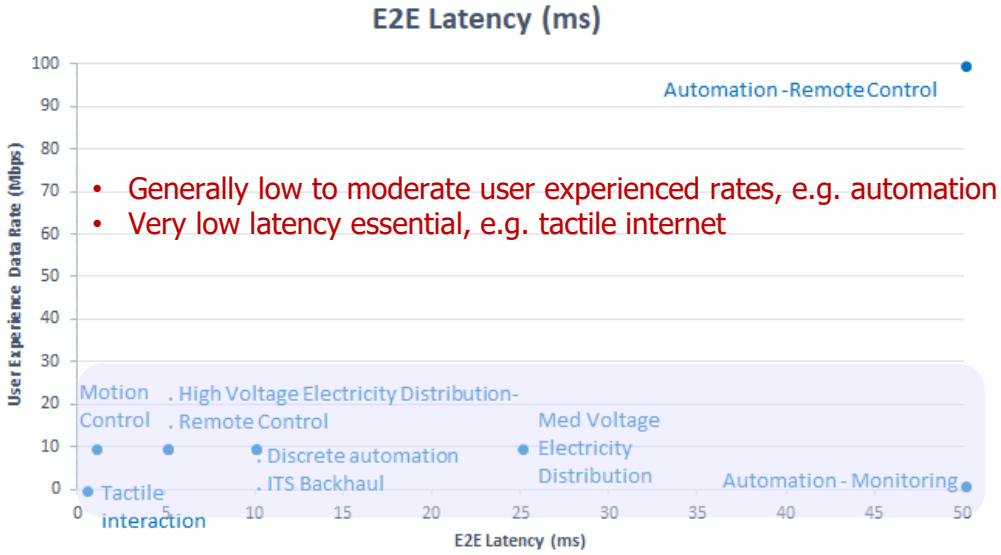
5G Deployments: Indoor/Outdoor Local and Wide Area Connectivity

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

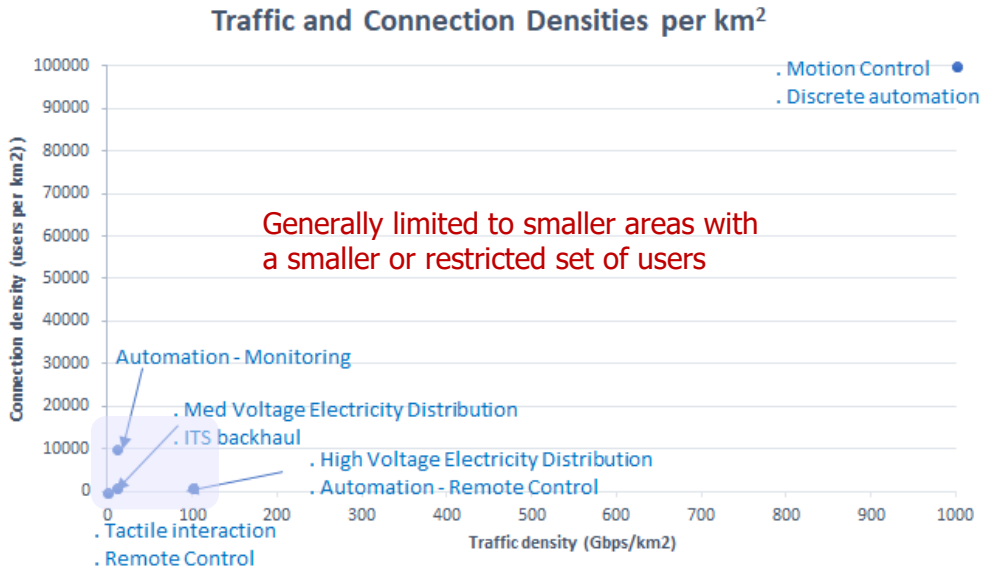
Femtocell Deployment: seamless user experience over radio access and Femtocell access using fixed broadband networks.

Source: 3GPP TS 22.261

Critical Communications Considerations



- Generally low to moderate user experienced rates, e.g. automation
- Very low latency essential, e.g. tactile internet



Generally limited to smaller areas with a smaller or restricted set of users

Other Considerations

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

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.

Source: 3GPP TS 22.261

Massive IoT & eV2X

Massive Internet of Things (MIoT)

- **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.

Source: 3GPP

eV2X

- **5G Drivers:** High data rate, low latency, reliability, traffic density, connection density, varying levels of mobility, high position accuracy
- **Vehicles Platooning**: All the vehicles (may be autonomous) in the platoon receive periodic data from the leading vehicle.
- **Advanced Driving**: enables semi-automated or fully-automated driving. Vehicles and/or RSU shares data obtained from its local sensors with vehicles in proximity,.
- **Extended Sensors**: enables data exchanges from local sensors or live video data among vehicles, RSUs, devices of pedestrians and V2X application servers.
- **Remote Driving**: enables a remote driver or a V2X application to operate a remote vehicle.

Source: 3GPP TS 22.261

Smart City Deployment Considerations

Implementation Drivers	High data rates **(User Experienced Data Rate**: the minimum data rate required to achieve a sufficient quality experience)
	Low latencies
	Reliability
	Resiliency
	Traffic density (e.g. traffic within certain area of interest)
	Connection density (e.g. number of connections within a certain area)
	Speed / Mobility
	Accuracy of position determination

Smart Cities Roadmap Considerations

Ecosystem	Introductory Stage	Growth Stage	Maturity Stage	Decline Stage
Smart Cities	Experimentation with fragmented solutions **Complex interdependent ecosystem coordination with a diverse set of stakeholders working with a disparate set of technologies evolving at different rates.**	Alignment of solutions. Early best practices emerge. Specialized and low cost solutions will emerge that is positioned for the needs of different city segments. Urban planners begin to incorporate more technologies that transparently blends into the inner fabric of the city.	Successful actors emerge. Industry structure and market positioning becomes critical. Tangential sectors that may include combinations of various ecosystems. The efficiency and effectiveness of a complete smart city deployment is dependent on the ability for connected people, places, and things.	Seamless interoperable connected ecosystem of ecosystems with a smaller set of successful actors. Smart Cities evolve to the next generation
Core Component Ecosystems with varying rates of Industry Structure Life Cycle Stages				
Communications Ecosystem: Broadband Communications, e .g. Terrestrial 3GPP and non-3GPP mobile, Satellite, Fixed Broadband				
Connected Vehicles: Transportation Modes, e.g. Roads, Rails, Air (*includes emerging Urban Air Mobility*), Waterways, Pedestrian.				
Connected Health: Continuum of Care, e.g. trauma centers, community hospital, clinics, emergency transport, outpatient services				
Public Safety: First Responders, e.g. Police, Fire, EMS, and situational awareness for overall safety and security				
Utilities and City Services: Electricity, Gas, Water, Sanitation, Public Works				
Agriculture: Information and monitoring services, food supply chain visibility, mobile financial services				
Other Ecosystems				

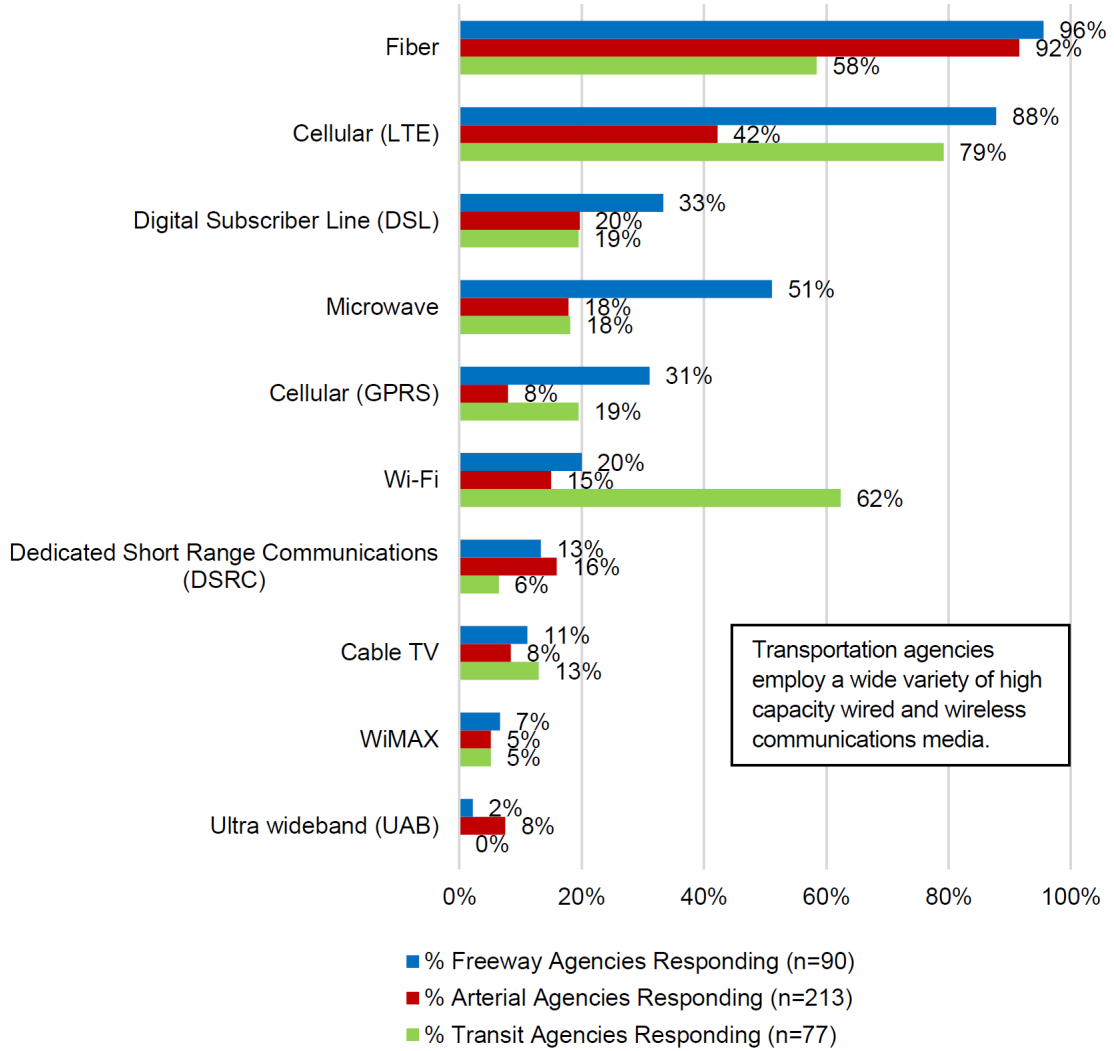
IEEE 5G

Connected Ecosystem Examples

Road Based Transportation – DoT ITS Survey Results

Transportation Modes - Roads, Rails, Air, Waterways, Pedestrian
Urban Air Mobility (UAM) is an emerging area

Freeway	Arterial	Transit
Agencies Planning for Connected Vehicle Deployment		
62%	35%	33%
Primary Deployment Considerations		
• Advanced Traveler Information Systems • Road Weather • Intelligent Traffic Signal Systems • Reduced Speed/Work Zone Warning (RSWZ) • Incident & Emergency Management • Commercial Vehicle Applications • Agency Data Applications	• Intelligent Traffic Signal Systems • Advanced Traveler Information Systems • Incident & Emergency Management • Pedestrian & Bicycle • Road Weather	• Multi-Modal Intelligent Traffic Signal Systems (MMITSS) such as Transit Signal Priority • Advanced Traveler Information Systems • Fee Payments • Pedestrian in Crosswalk Warning (PCW) and Bicycle



Source: Deployment of Intelligent Transportation Systems: A Summary Of the 2016 National Survey Results

Source: Oak Ridge National Laboratory

Connected Vehicles Pilot - NYC

New York City Pilot Deployment Site Map

NYCDOT – Devices	Estimated Number
Roadside Unit (RSU) at Manhattan and Brooklyn Intersections and FDR Drive	353
Taxi Equipped with Aftermarket Safety Device (ASD)*	5,850
MTA Fleet Equipped with ASD*	1,250
UPS Truck Equipped with ASD*	400
NYCDOT Fleet Equipped with ASD*	250
DSNY Fleet Equipped with ASD*	250
Vulnerable Road User (Pedestrians/Bicyclists) Device	100
PED Detection System	10 + 1 spare
Total Equipped Vehicles	8,000

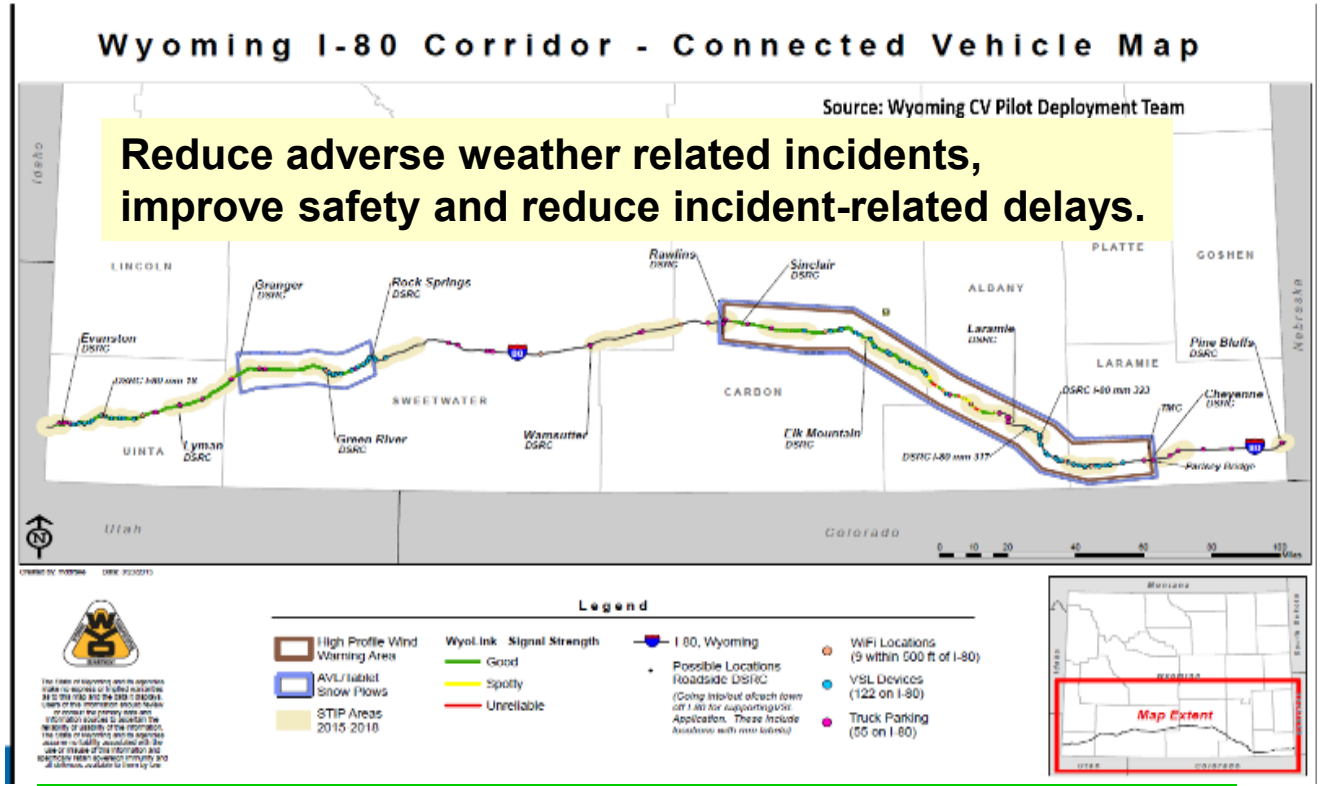
Source: http://www.its.dot.gov/pilots/wave1.htm

Evaluate connected vehicle technology and applications in tightly-spaced intersections that is typical within a dense urban transportation system.

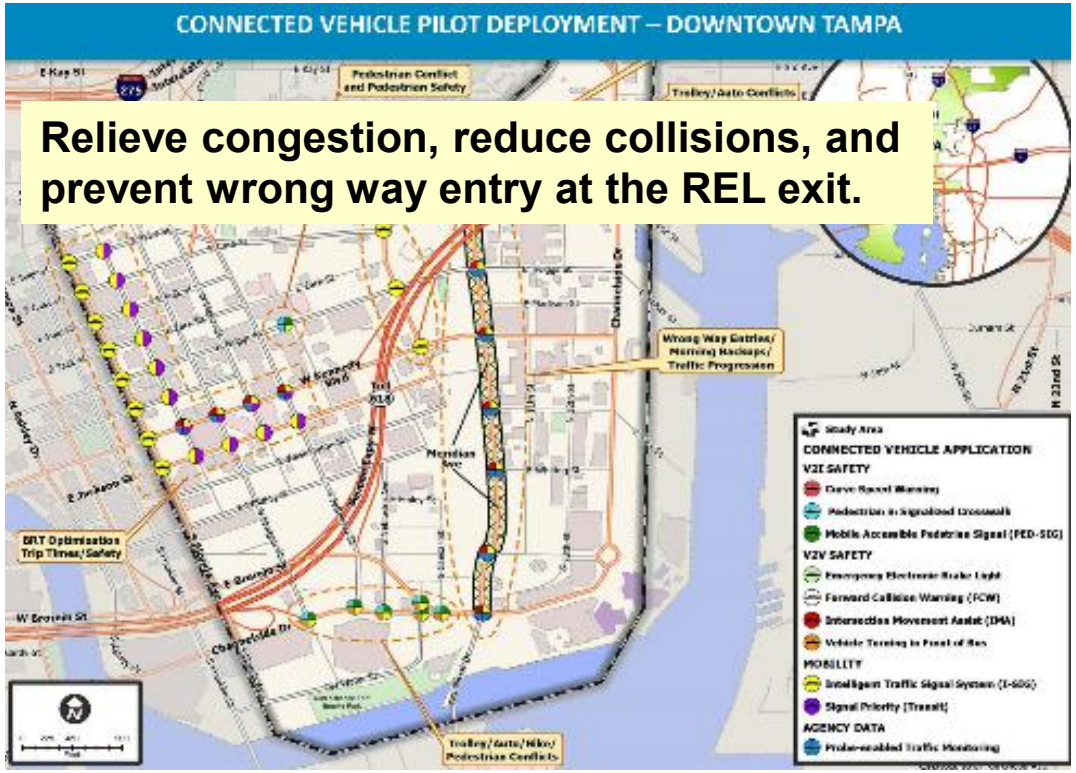
This is anticipated to be the largest connected vehicle technology deployment to date

Connected Vehicles Pilots – Wyoming & Tampa

Pilot Location



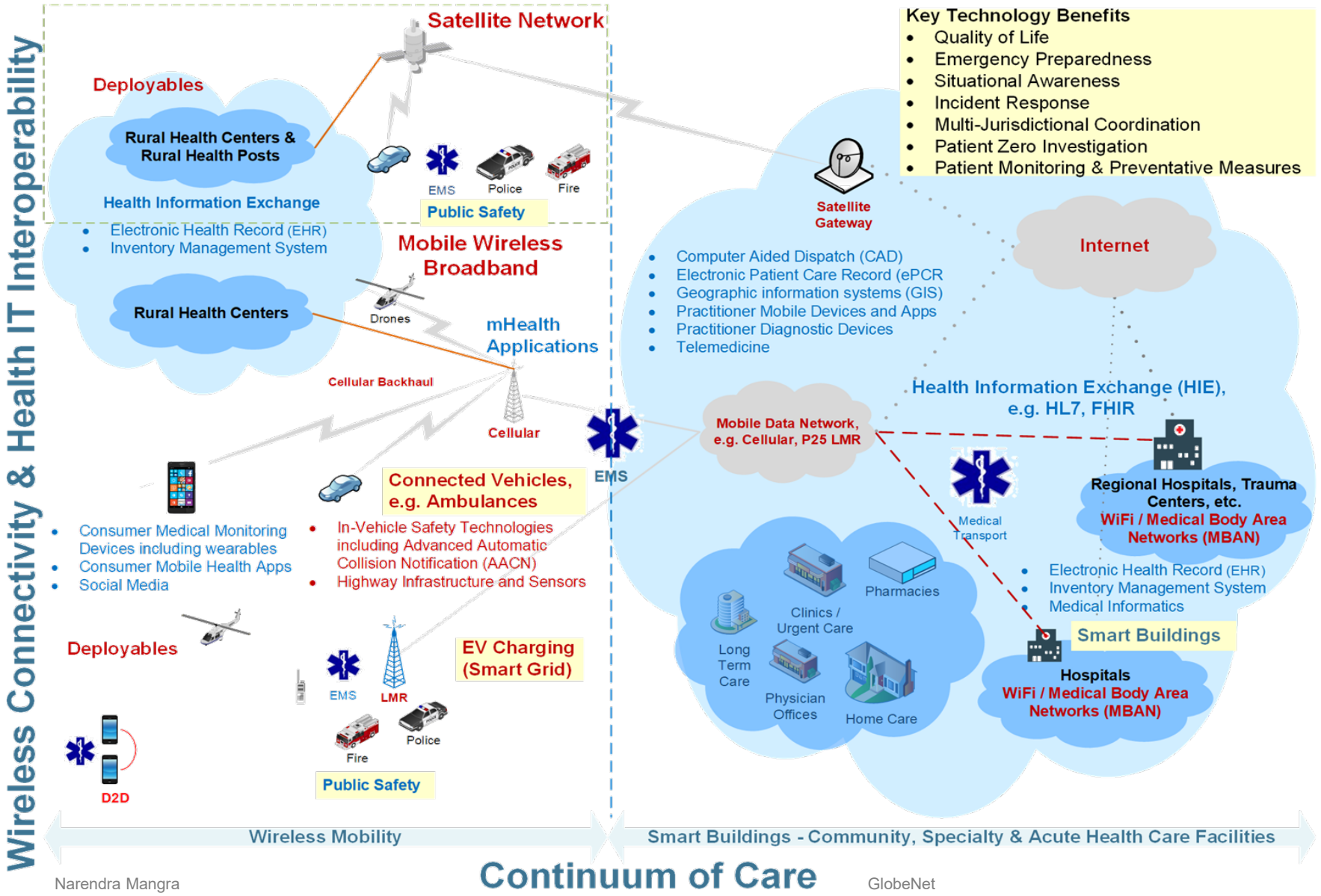
ICF/WYDOT – Devices	Estimated Number
Roadside Unit (RSU)	75
WYDOT Fleet Subsystem On-Board Unit (OBU)	100
Integrated Commercial Truck Subsystem OBU	150
Retrofit Vehicle Subsystem OBU	20-30
Basic Vehicle Subsystem OBU	100-150
Total Equipped Vehicles	400



Tampa (THEA) – Devices	Estimated Number
Roadside Unit (RSU) at Intersection	40
Vehicle Equipped with On-Board Unit (OBU)	1,500
Pedestrian Equipped with App in Smartphone	500
HART Transit Bus Equipped with OBU	10
TECO Line Street Car Equipped with OBU	10
Total Equipped Vehicles	1,520

Source: http://www.its.dot.gov/pilots/wave1.htm

Connected Health and Adjacent Ecosystems



Ecosystems shown

- Connected Health
- Connected Vehicles
- Public Safety
- Smart Grid
- Smart Buildings

Each Ecosystem contains a distinct blend of technologies and functions

Ecosystem Transformation

- New Business Models
- Extended Reach of Services through different network access
- Tactile Internet and Global Care
- Rapid dissemination of information
- Improved situational awareness and incidence response,

Summary and Conclusion

- Smart Cities is a Connected Ecosystem of Ecosystems
- Each city may have different approaches for economic development, quality of life, attraction & retention of residents, businesses and visitors
- Address trust, privacy and security concerns related to the open data model, e.g. personal information.
- Smart city governance: orchestrator, integrator and platform models
- Technologies will need to be interoperable
  - *within* each vertical (e.g. intermodal transportation coordination between connected vehicles and railroad crossings) and
  - *across* major verticals (e.g. electric vehicle charging and impact to smart grid).
- Technology should operate seamlessly in the background to connect people, places, and things

Smart Cities presents both opportunities and challenges to address sustainability, resource conservation, economic and technology development initiatives.

The evolution to smart cities may create competition to attract and retain key stakeholders through a connected ecosystem of ecosystems.

Smart City is a connected ecosystem of ecosystems that spans diverse technologies, governance approaches, privacy, and security, and other stakeholder considerations that include economic growth and quality of life.

Q & A

IEEE 5G Education

https://5g.ieee.org/education
https://5g.ieee.org/roadmap