

“Getting to Smart” Connected Cities Tour

**Network Technologies:
4G/5G, IoT, Fiber, Small Cell and Wi Fi
Transforming how Society Connects.
Be part of the Solution
www.densetworks.com**

2018 / 2019 Event Schedule

October 4	Baltimore
January 30	Miami
February 21	Tampa
March 7	Denver
April 11	Atlanta
May 9	Philadelphia
June 13	Las Vegas

**The UN predicts Global Population Growth
Greater than 30% by 2050**

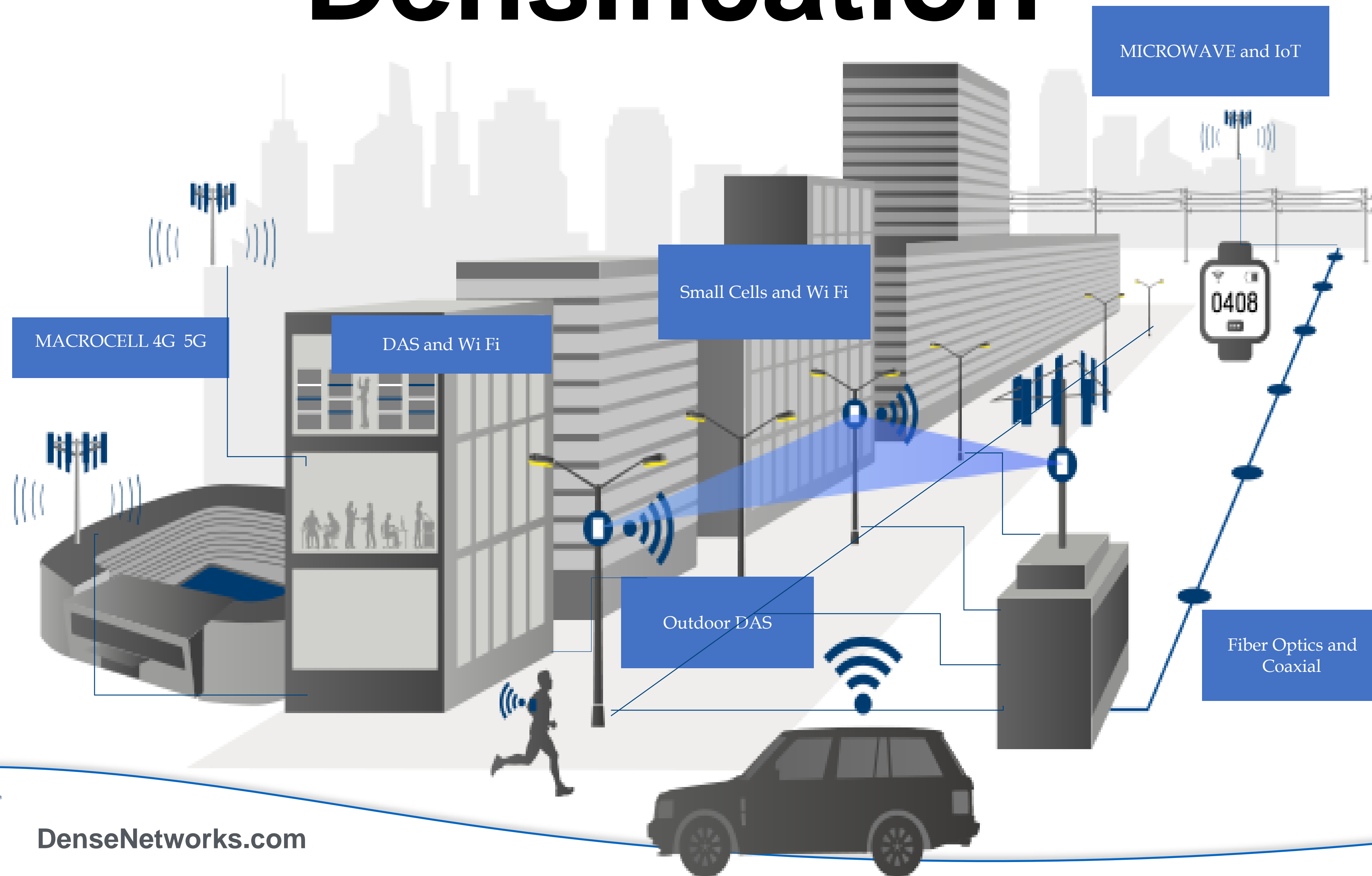


The Majority will be in Cities



Connected City
Smart City

Densification

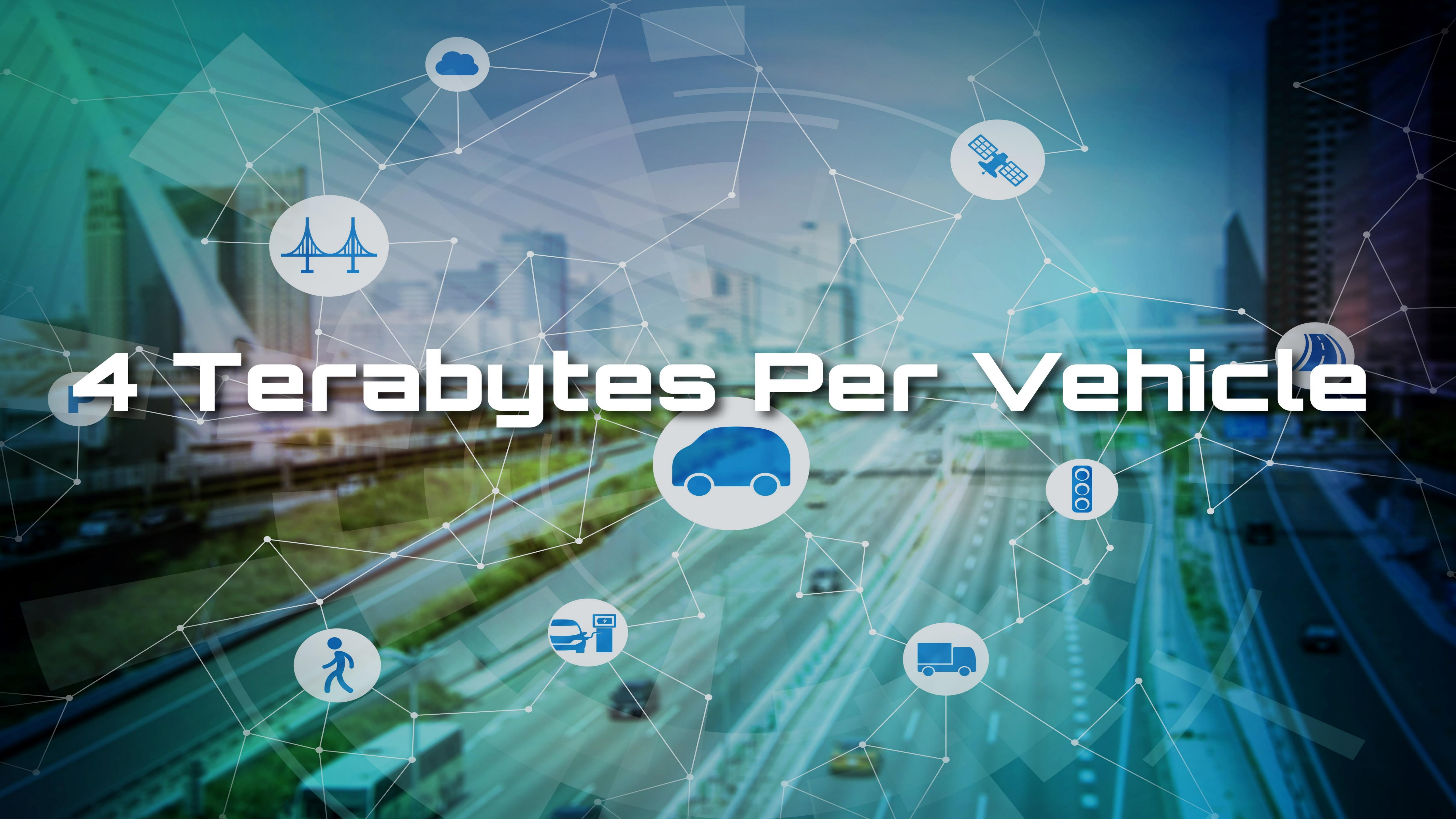


Autonomous



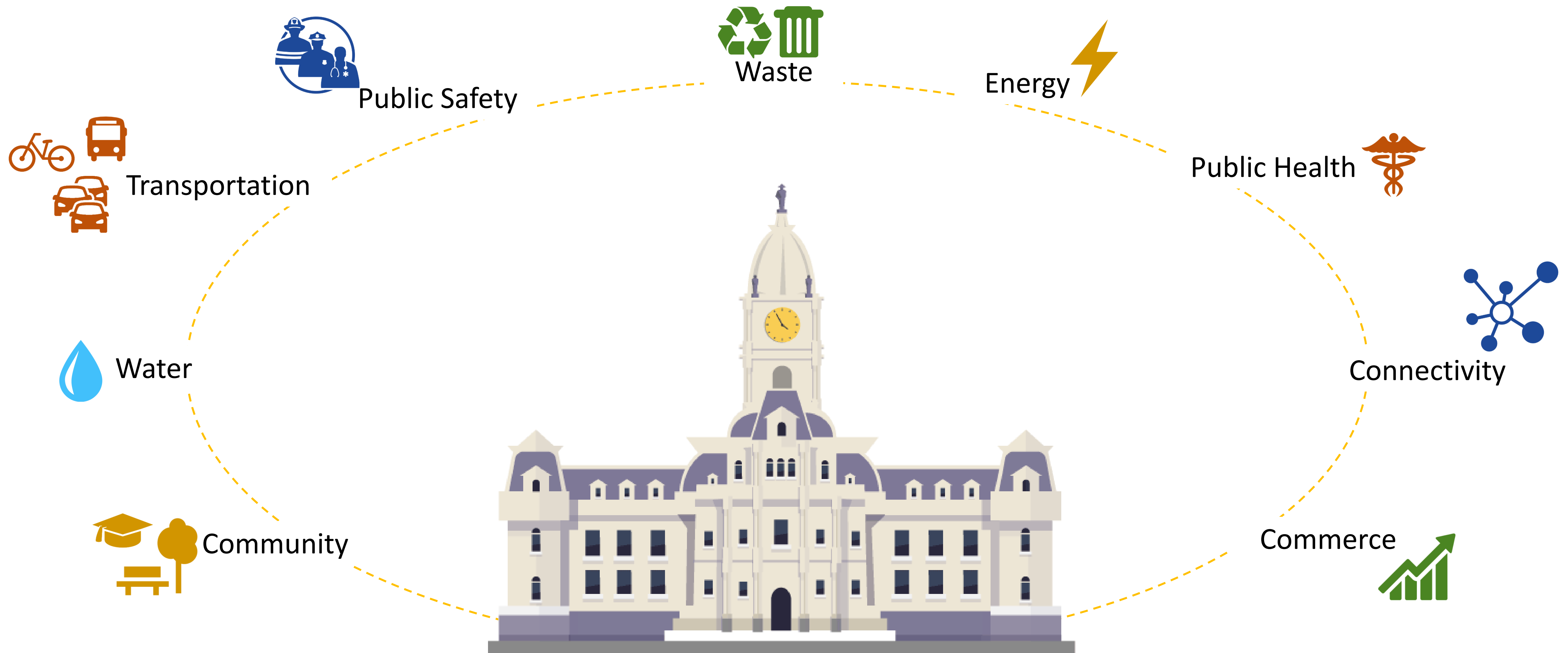
Connected

4 Terabytes Per Vehicle



The Big Picture

Smart Collaboration > Improved Efficiency > Faster Response > Better Service





The Smart Cities Framework

TECHNOLOGY
ENABLERS

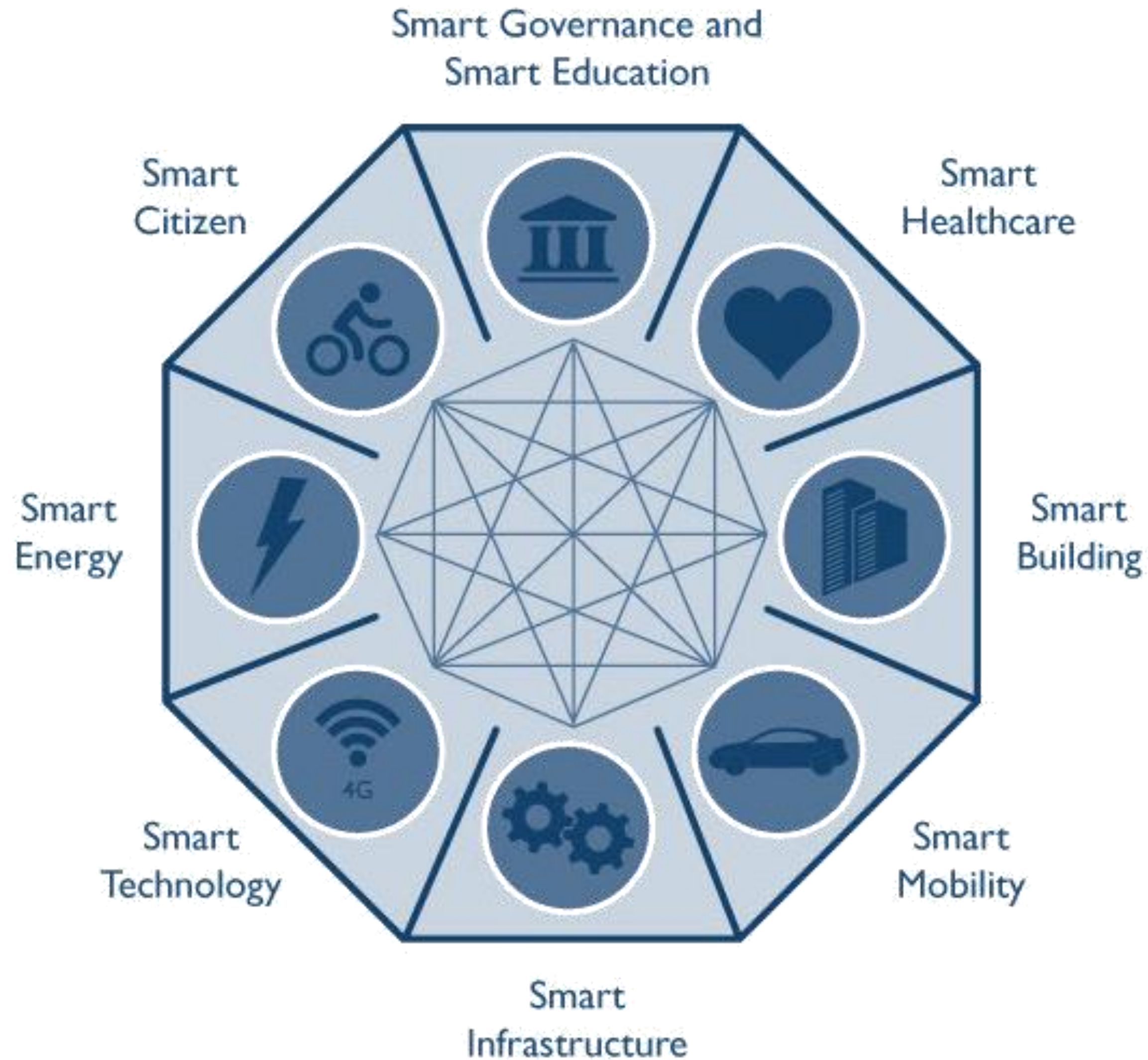
Universal Aspects	Built Environment	Energy	Telecommunications	Transportation	Water and Wastewater	Health and Human Service	Public Safety	Payments and Finance	Waste Management
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Instrumentation and Control									
Connectivity									
Interoperability									
Security and Privacy									
Data Management									
Computing Resources									
Analytics									



How Does Orlando Define Smart City?

Using *technologies* to enhance the livability, workability and sustainability of Orlando.



WELCOME TO LAKE NONA

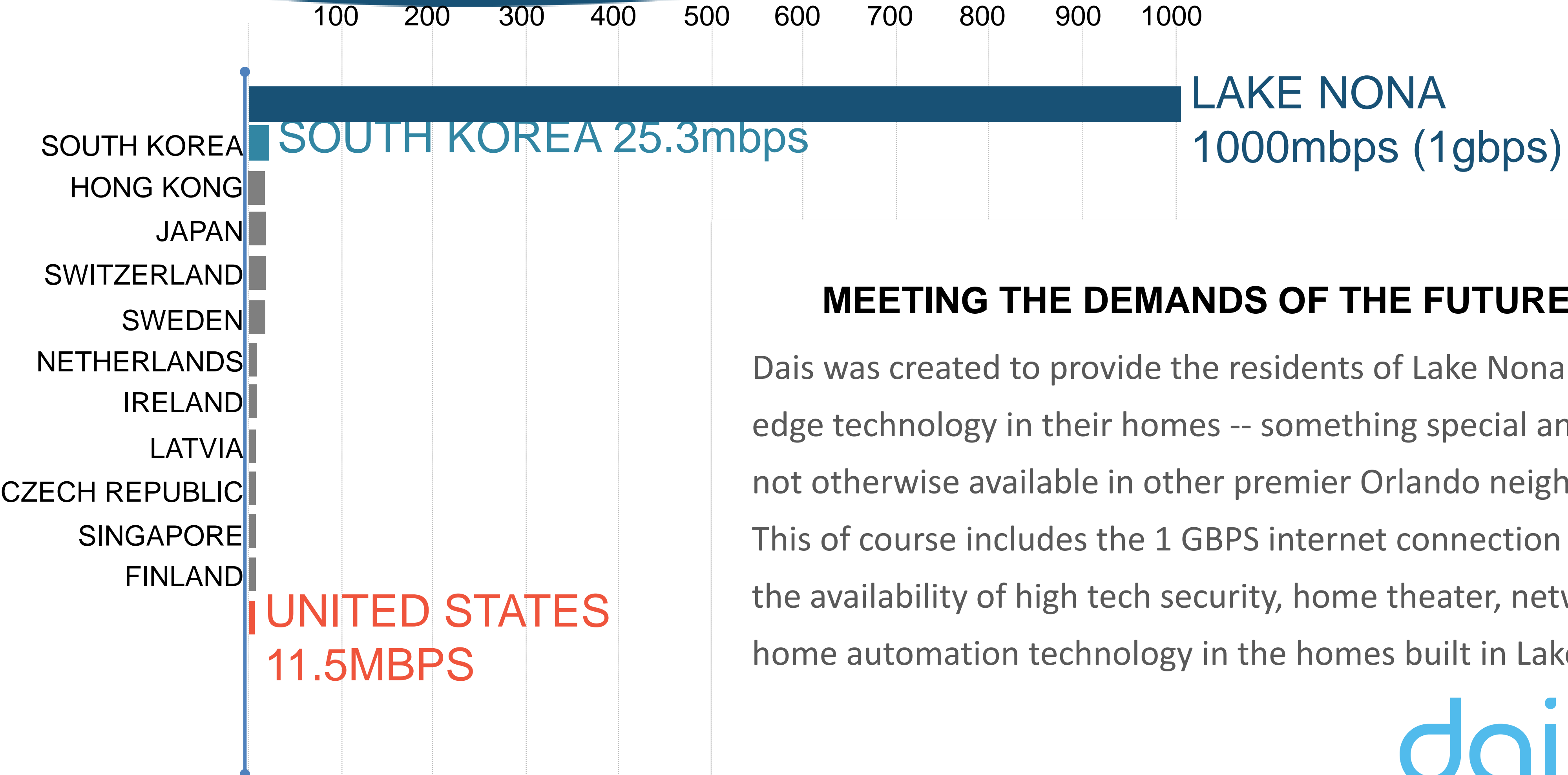
LAKE NONA®


“Lake Nona: How to Build a Great American City.”

FORTUNE



TECHNOLOGICAL INFRASTRUCTURE



Source: Akamai Technologies, Q4 2016

MEETING THE DEMANDS OF THE FUTURE - TODAY

Dais was created to provide the residents of Lake Nona with cutting-edge technology in their homes -- something special and exciting, and not otherwise available in other premier Orlando neighborhoods. This of course includes the 1 GBPS internet connection It also includes the availability of high tech security, home theater, networking and home automation technology in the homes built in Lake Nona. “

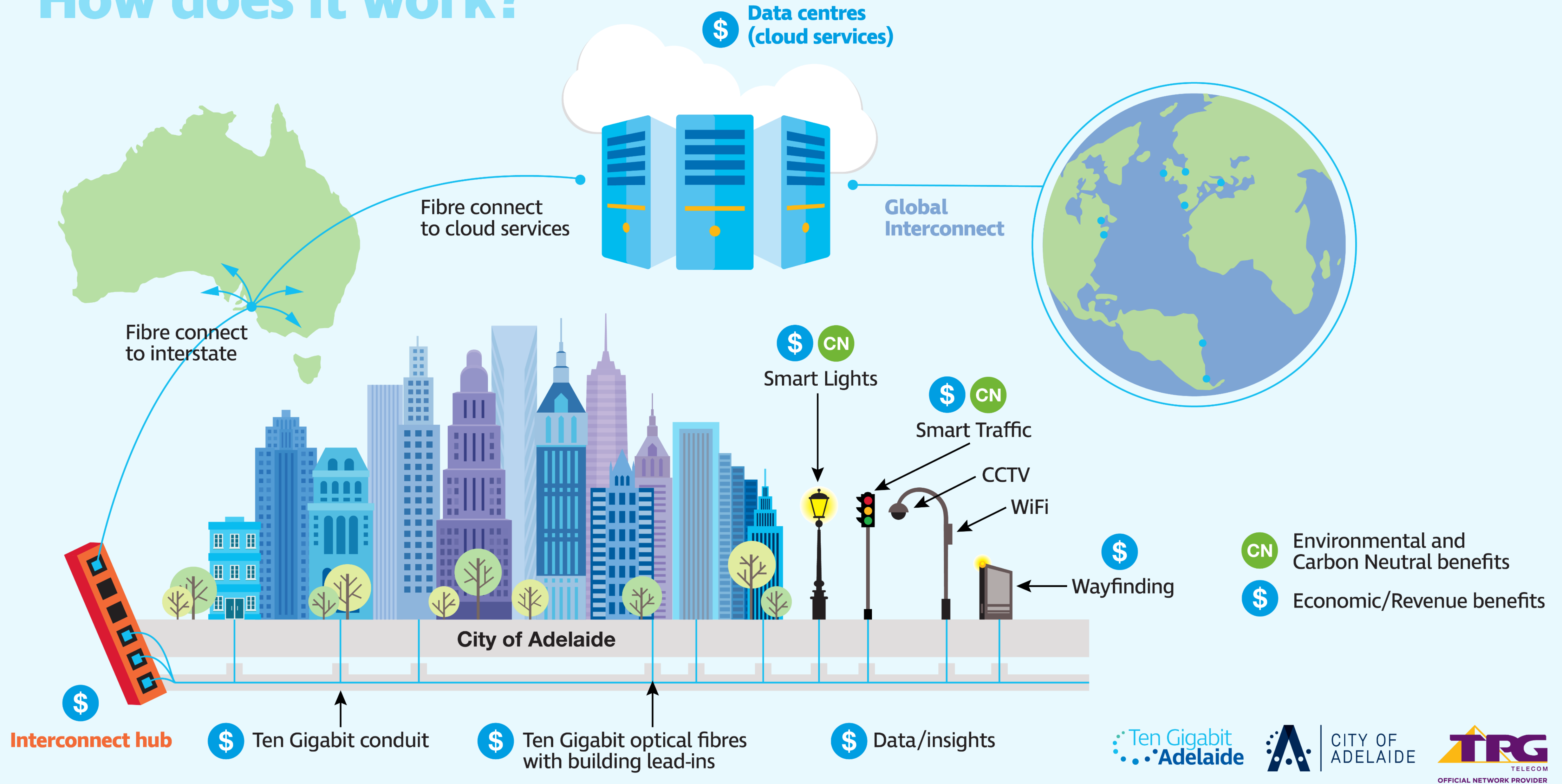


Ookla: Minneapolis has the fastest mobile internet among US cities



If you live in or often visit Minneapolis, Ookla has good news for you: the company says that locale tops the list of US cities with the fastest mobile internet, with a mean download speed of 44.92 Mbps. Ookla, which analyzed data from its Speedtest app from the first half of the year, said Minneapolis' Twin Cities brethren Saint Paul was in second place, followed by Fort Wayne, Indiana; San Francisco; and Irvine, California. Atlanta and Pittsburgh followed those cities, while Minnesota was also the fastest state.

How does it work?



Broadband Strategy

Hybrid Approach – 80% results for 20% effort

	Government-led	Hybrid model <u>(Recommended)</u>	Market-led
Summary	<p>Cities building full fiber networks is expensive, complex, and risky</p> <p>Too Risky</p>	<p>Cities that welcome private investment with appropriate guidance are most successful</p> <p>Just Right</p>	<p>Cities with laissez faire broadband stagnate as cable-telecom duopolies</p> <p>Too Ineffective</p>
Key Takeaways	<ul style="list-style-type: none"> • Seattle, Palo Alto and others have determined that city-led full fiber build-outs are not practical, after detailed assessments • Chattanooga’s unique buildout included control by the utility and federal funds 	<ul style="list-style-type: none"> • Seattle leveraged streamlined policies to drive competition and massive fiber buildout • NYC used franchise agreements to drive fiber build-out 	<ul style="list-style-type: none"> • Broadband speed and price cluster to the bottom of the peer set • No substantial competition in any market-led city
Potential costs	<p>Very high. City-owned fiber-to-the-premise would cost \$800M+.</p>	<p>Moderate. Working with carriers could cost \$50-250M based on build types.</p>	<p>Very low or none. City relies on private sector investment.</p>
Results	<p>Peers show 90%+ fiber build-out.</p>	<p>Peers show 55-70% fiber build-out.</p>	<p>Peers show 0-5% fiber build-out.</p>

Broadband Strategy

Emerging landscape for voice and DATA

Effective in Dense Urban, Urban, and Suburban

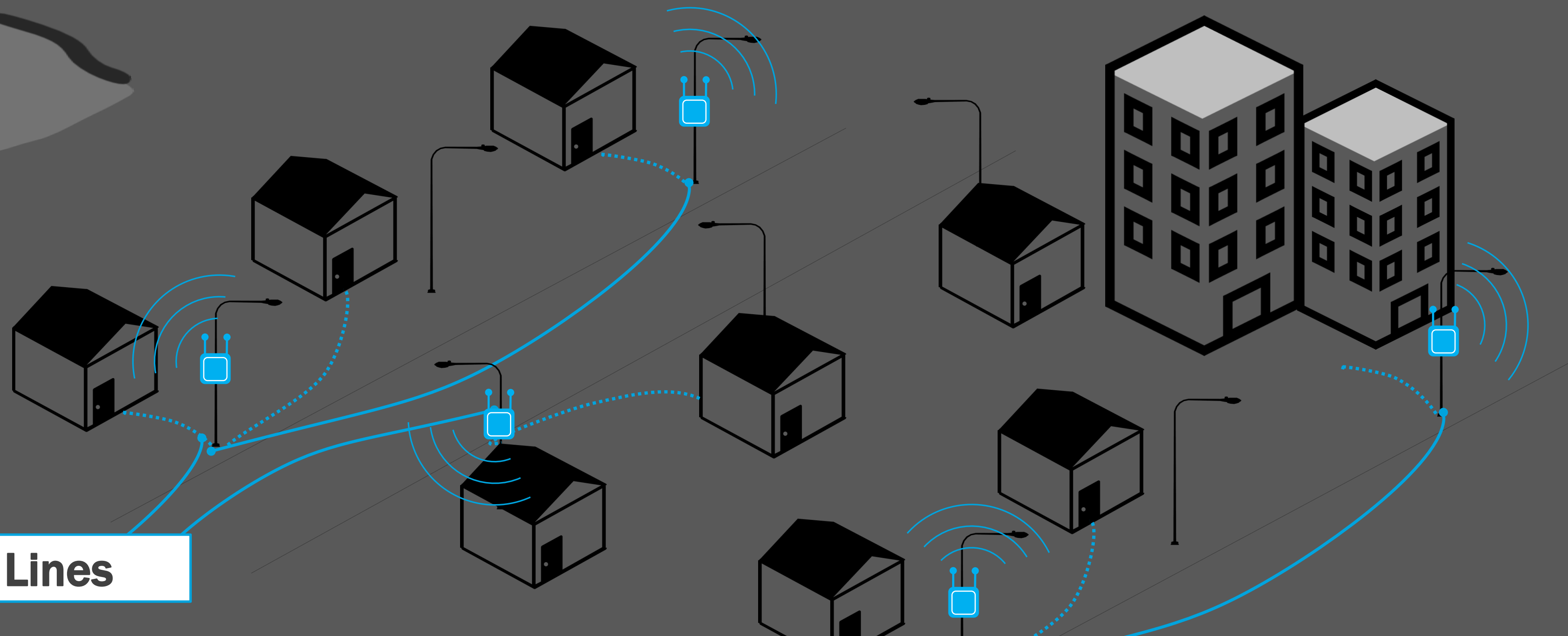
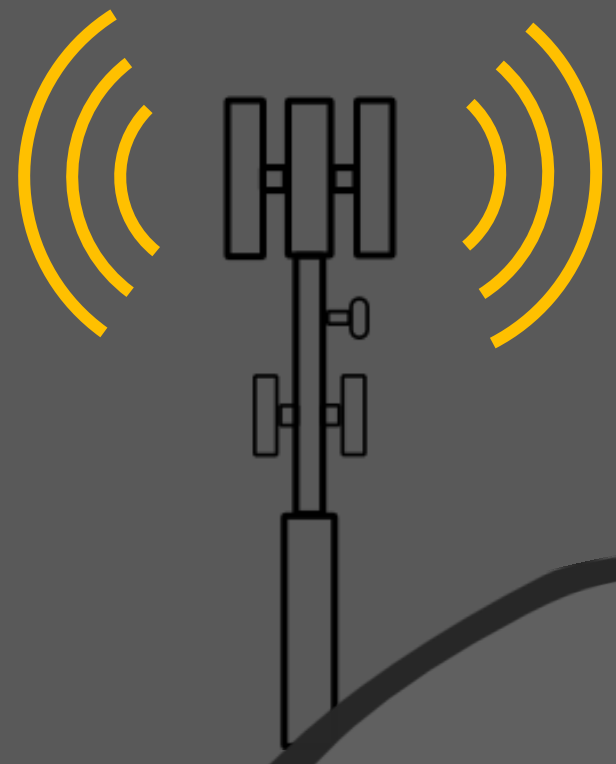
Cell towers: carry all mobile voice & some data

 **4G/5G Small-Cells**

Gigabit speed
up to 50x faster

Fiber Lines

Light pole is most valuable asset for broadband



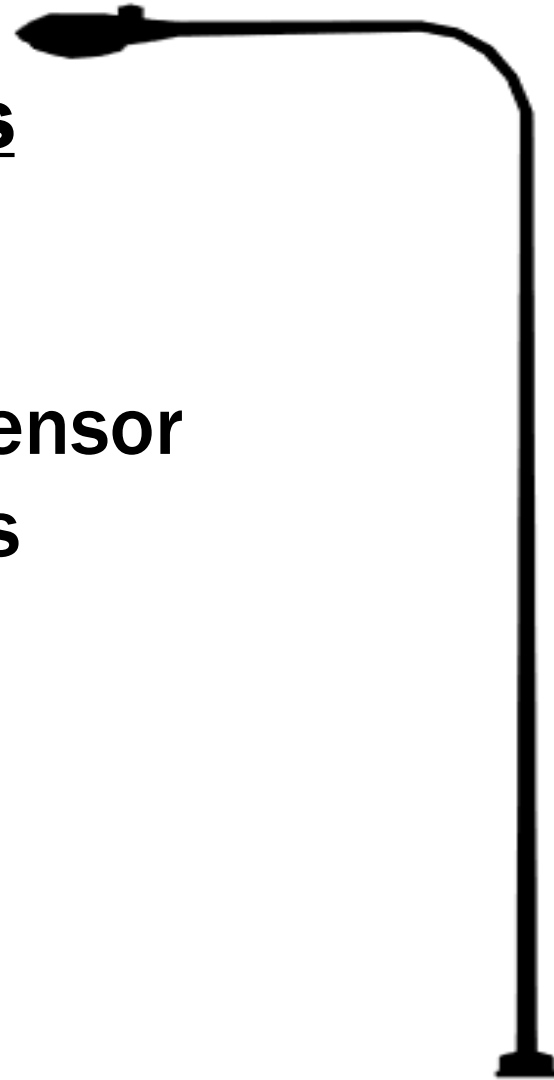
Broadband Strategy

STREETLIGHT

Light/Safety

Properties

- Height
- Power
- Light Sensor
- Lumens
- Density

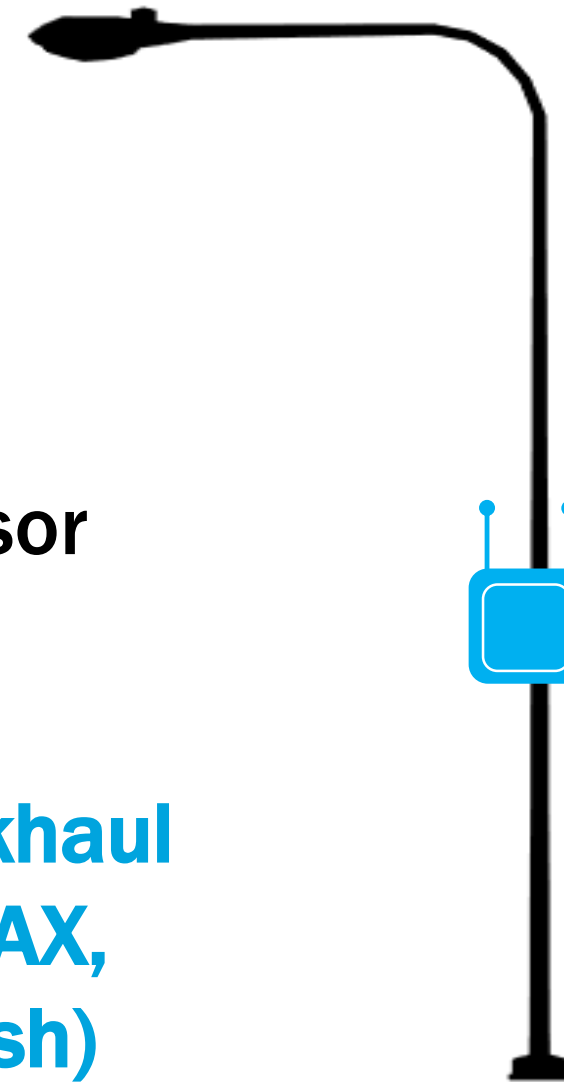


SMALL CELLS

Broadband Digital Infrastructure

Properties

- Height
- Power
- Light Sensor
- Lumens
- Density
- **Data Backhaul (Fiber, COAX, Radio mesh)**

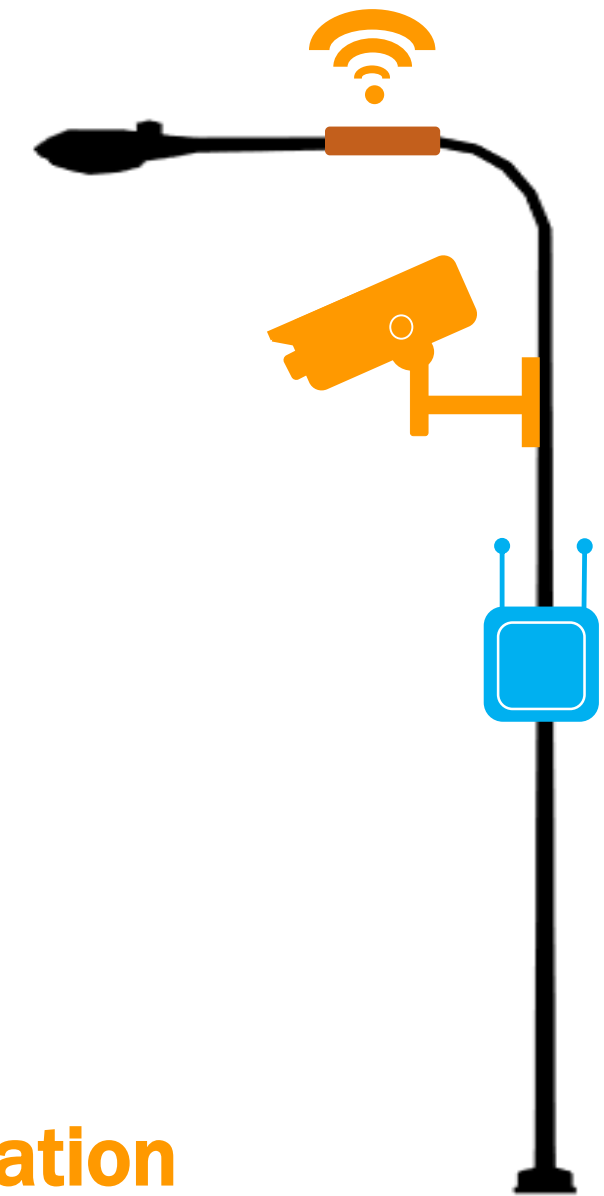


INTERNET OF THINGS

Smart Cities

Properties

- Height
- Power
- Light Sensor
- Lumens
- Density
- **Data Backhaul**
- **Sensors**
- **Cameras**
- **2-way Communication**
- **Banner Advertising**



Maturity:

Mature

Emerging

Extremely Immature

Possible Action:

Proceed w/ LED Light Replacement Only

Re-examine in Broadband Strategy

Seek to Understand with Knight IoT Grant



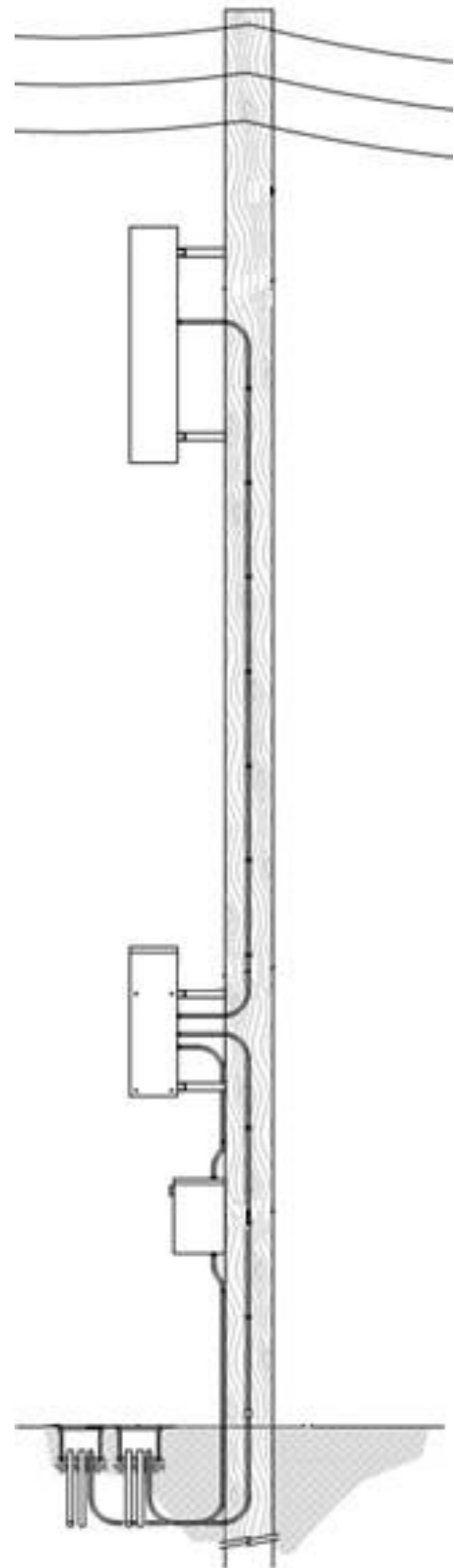
Smart Street lighting

- **GOAL: 100% LED streetlight by 2020**
- OUC working to retrofit 20,000+ streetlights to LED
 - 12,480 currently retrofitted
- Exploring test of new “Smart Streetlights” in Downtown
 - LED technology
 - Video surveillance
 - Environmental monitoring
 - Traffic analytics
 - Wi-fi / DAS systems
 - Gun shot detection



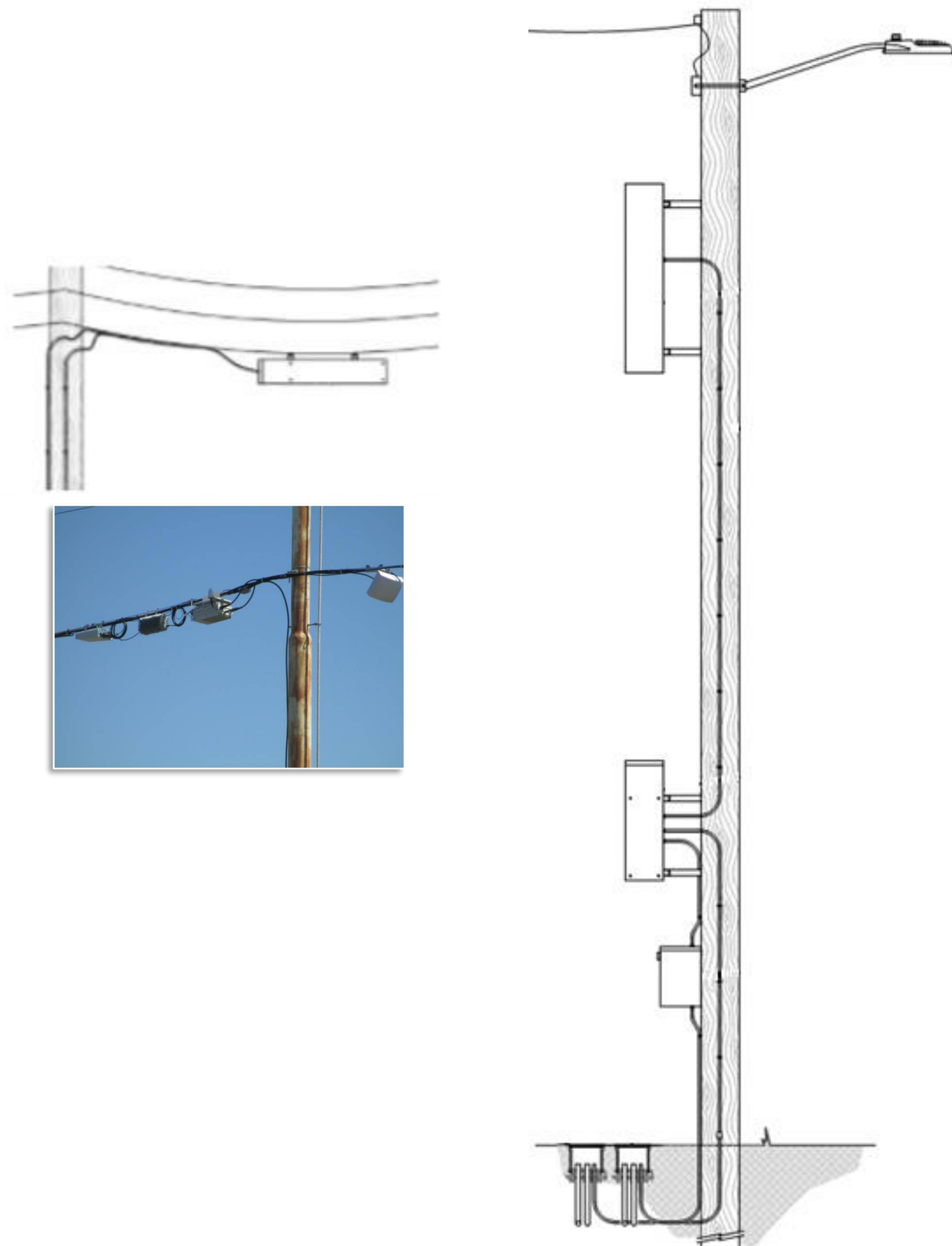
Small Cellular Deployment Types in Denver ROW

1 



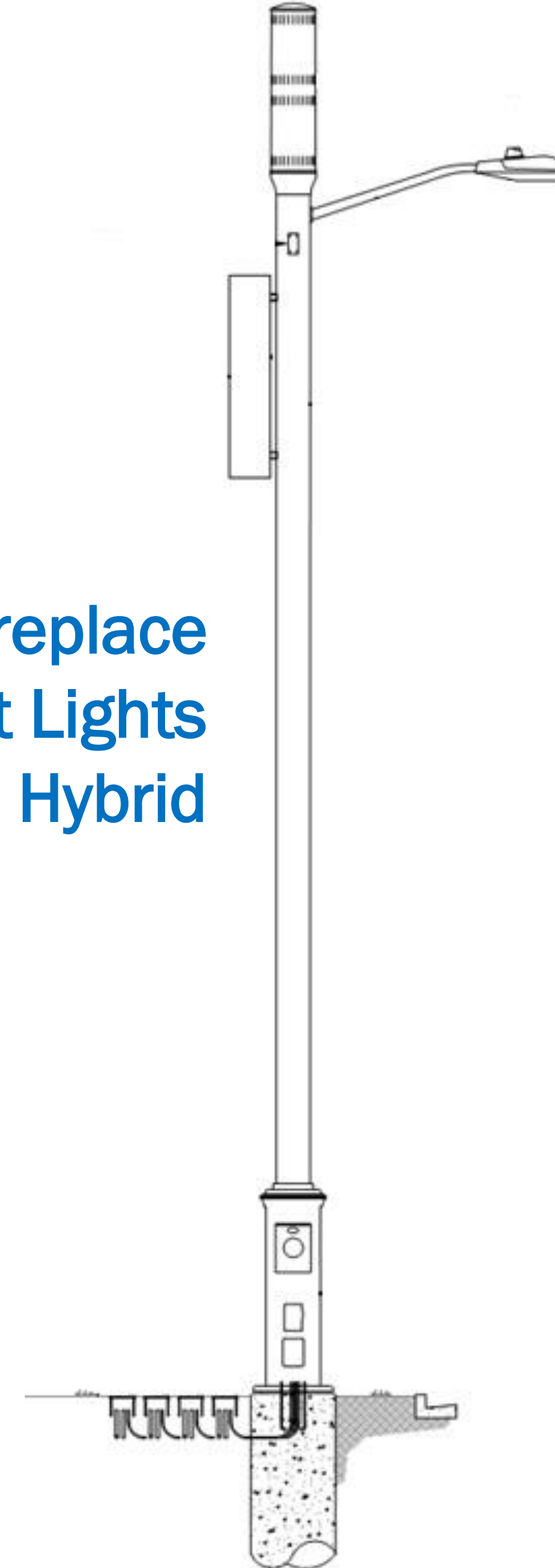
Onto or between
Xcel Utility Poles

2 



Onto Xcel Wood
Street Lights

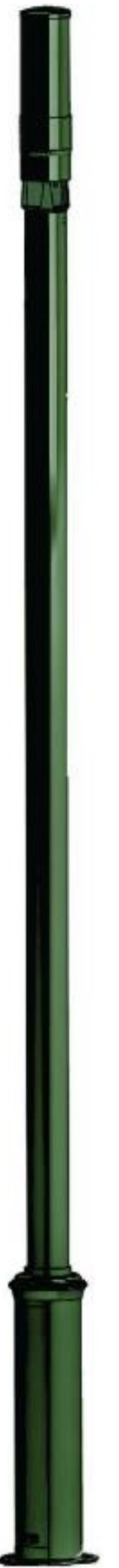
3 



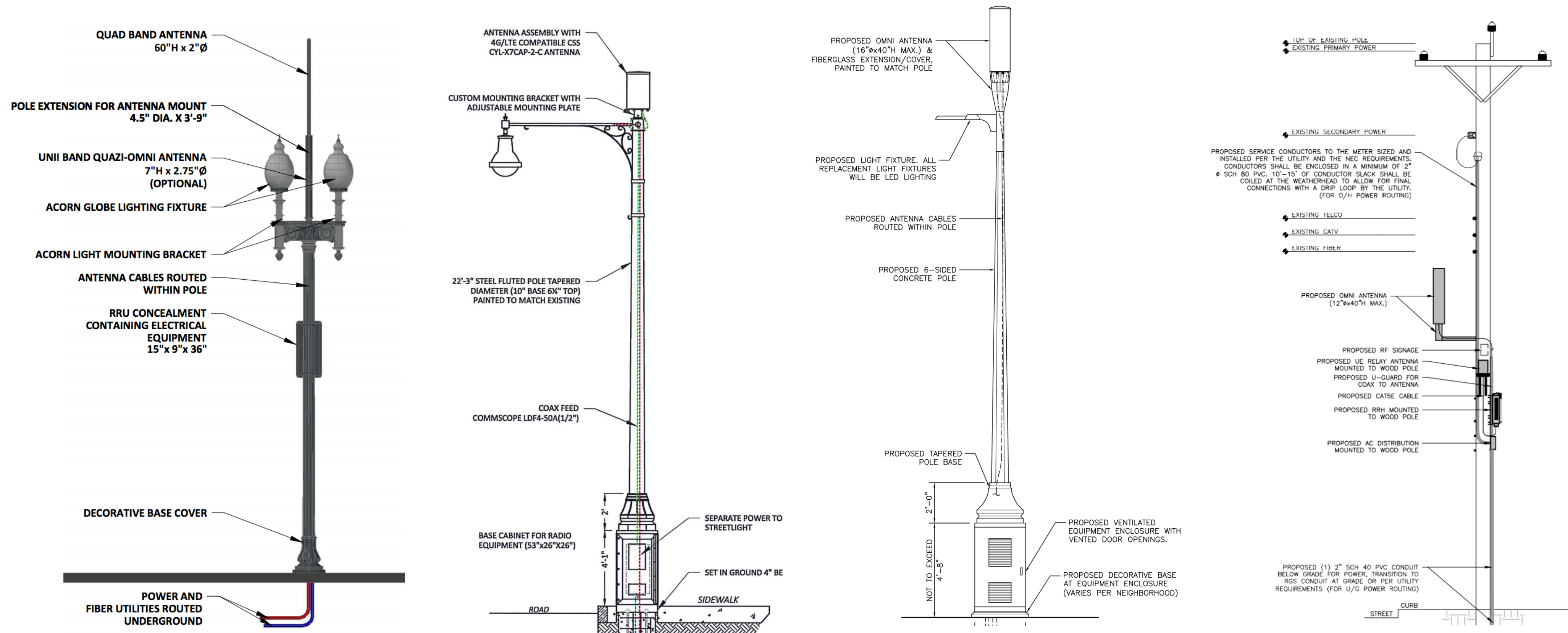
Remove & replace
Xcel Street Lights
with Hybrid

4 

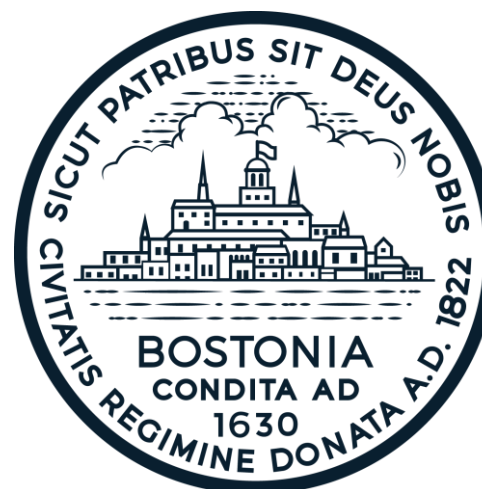
(Private)
Permitted
Freestanding
Antenna



COOPERATIVE DESIGN PROCESS



- *City and Licensees develop designs for replacement lights together*
- *Heavy focus on aesthetics, concealment, and historic character*
- *Once approved, design can be used by any licensee*



Public Works has created Design Guidelines and a custom Permit process to address:



April 2018

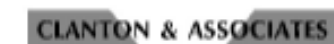
- ❑ Public-facing review process including Districts, City Departments, Neighborhood Orgs
- ❑ Policy for co-location first
- ❑ Notification of adjacent property owner
- ❑ Restricting new pole density through min **250'** spacing
- ❑ Restricting placement (along parks, historic & residential frontages)
- ❑ Restricting placement in front of residential & valuable sight lines
- ❑ Requiring camouflage and concealment
- ❑ Limiting height and equipment size
- ❑ Opportunity to coordinate fiber conduit



The City and County of Denver
Public Works Department
Jon Reynolds, Engineering Supervisor



Jacobs Engineering Group
Mike Butters, Project Manger



LIGHTING DESIGN AND ENGINEERING

Clanton & Associates:
Nancy Clanton, CEO
Dane Sanders, Principal
Arnie Kuczkowski, Engineer II - Lighting



Aero Wireless Group:
Jim Lockwood, CEO
Mike Hoganson, Chief Operating Officer

5G Momentum

- **\$275 billion opportunity***
- **3 million new jobs**
- **\$500 billion boost to GDP**
- **100 x more antenna locations**



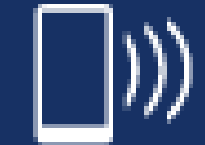
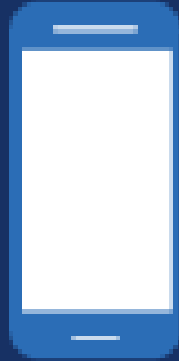
1G



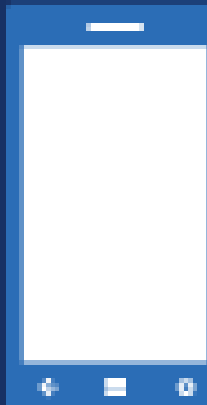
2G



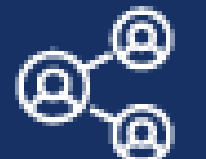
3G



4G



5G



How Low Can It Go?

Average price per Mbps



Source: FCC's "Twentieth Wireless Competition Report"

A night cityscape with a network overlay of white arcs and Wi-Fi symbols. The word "Connectedness" is written in large white letters across the center. The background shows a dense urban area with many lit-up buildings and a highway with light trails.

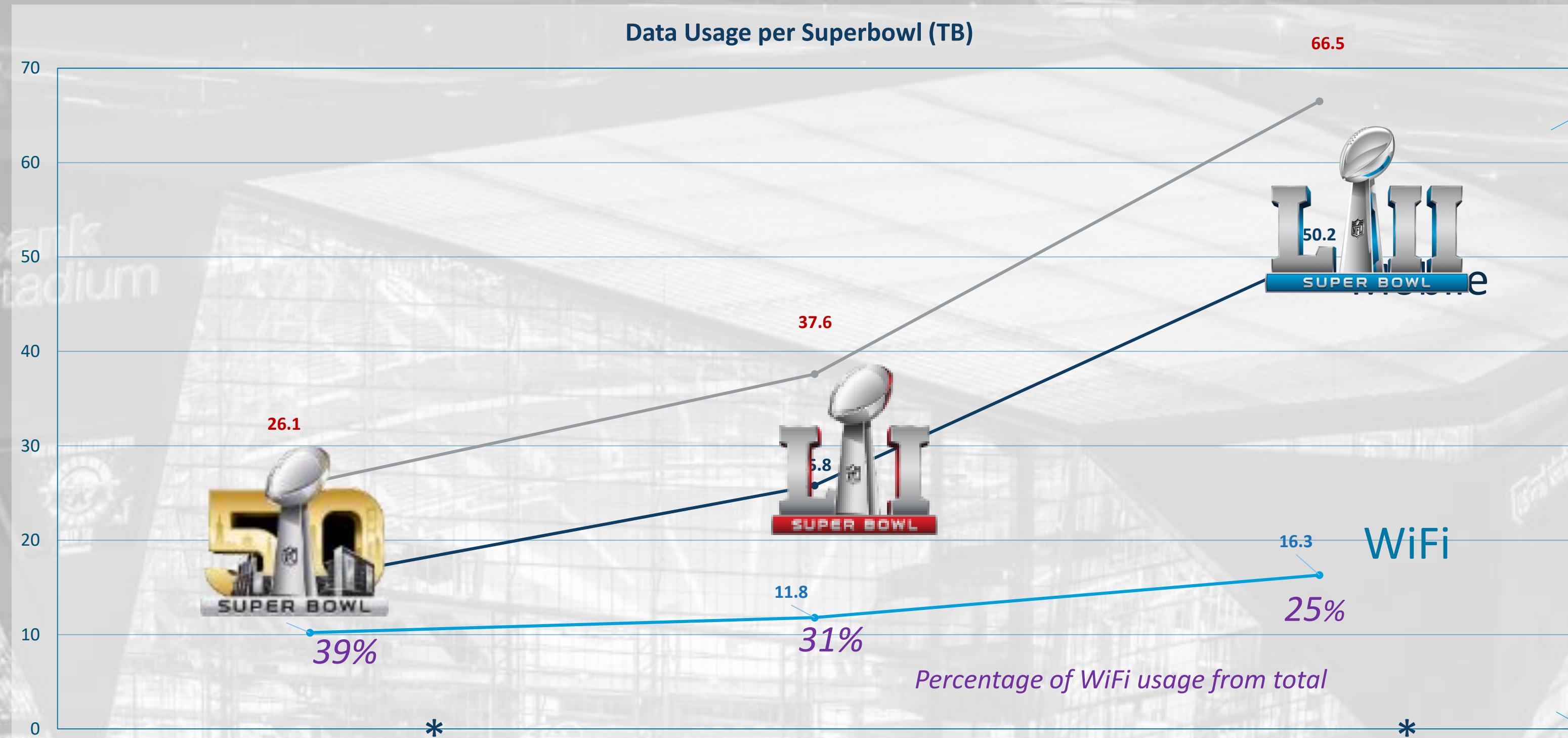
Connectedness

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Mobile/Wireless Bandwidth Demand



x17



* JMA Wireless in-building solutions used for mobile traffic

SOURCES:

- Data usage at Super Bowl 52 grows 48% as social media use skyrockets <https://www.techrepublic.com/article/data-usage-at-super-bowl-52-grew-48-as-social-media-use-skyrockets/>
- Super Bowl 51 makes digital history with record-breaking data usage <https://www.techrepublic.com/article/super-bowl-51-makes-digital-history-with-record-breaking-data-usage/>
- AT&T, Verizon and Sprint see a combined 50.2 TB of cellular traffic for Super Bowl 52 <https://www.mobilesportsreport.com/2018/02/verizon-sees-18-8-tb-of-cellular-data-used-at-super-bowl-52/>
- Super Bowl fans use a record 10TB of data on Levi's Stadium WiFi network, up 63% from 2015 <https://www.geekwire.com/2016/super-bowl-data-usage/>



Office Buildings

Industrial

Suburbs

Public Areas

Major Venues

Transportation Systems

Private Campus

Metro Area Neutral Host

Challenges



Digital Literacy

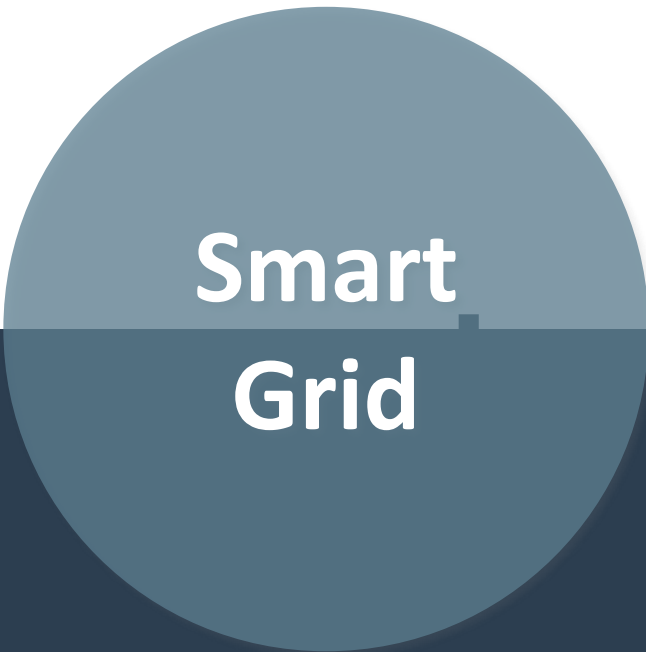


Aging infrastructure



Lack of access for low income communities

Smart Cities need smart infrastructure



Smart
Grid

Energy Efficiency

EPB in Chattanooga built out a fiber network to reliably manage its energy and electrical systems



Smart
Health

Healthier Cities

Hiawatha Broadband in Minnesota piloting project to use its fiber as a platform for home monitoring of patients with dementia



Sensor
Network

Civic IoT

US Ignite and cities around the U.S. (and the world) are developing a smart city app store predicated on big bandwidth



Smart
Mobility

Safer Streets

Verizon and the City of Boston are using sensors and advanced traffic signal controls to measure traffic, improve safety



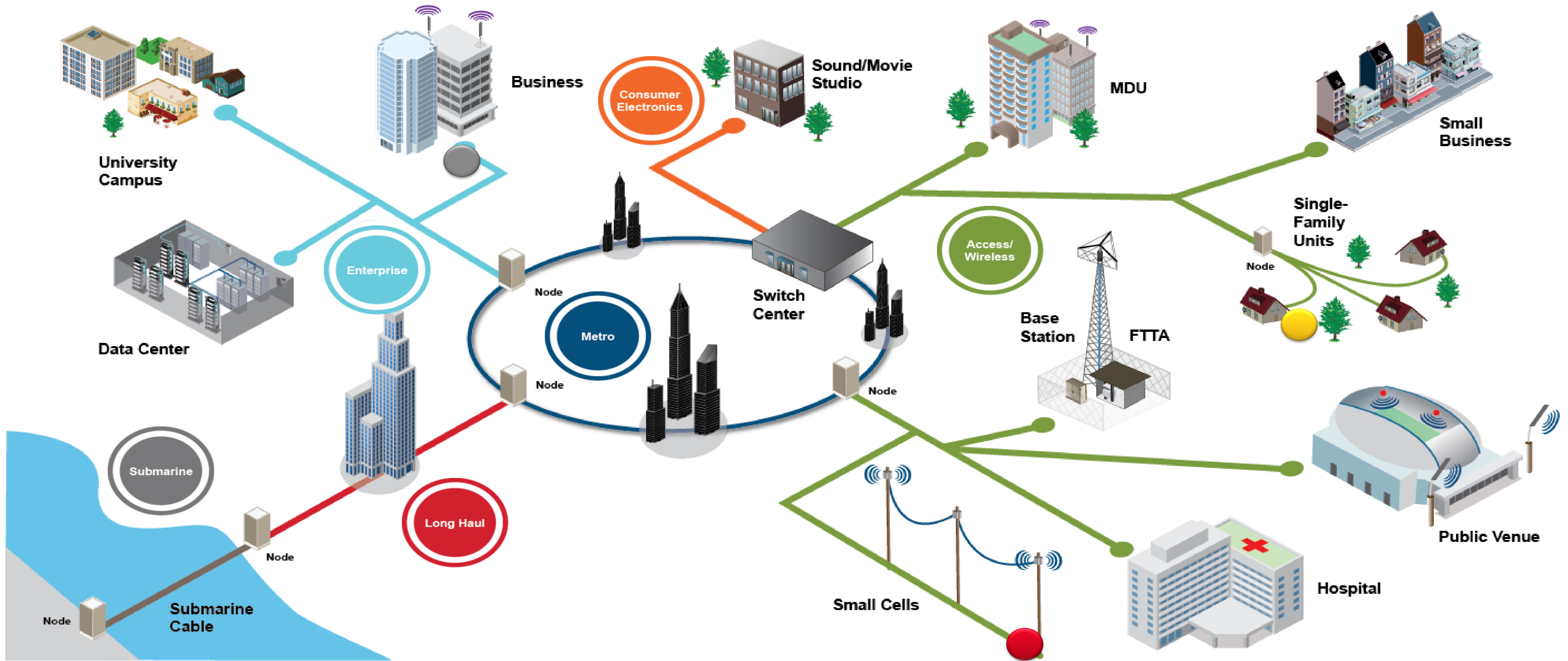
City
Wi-Fi

Connected Community

Santa Monica City Net provides fiber-supported Wi-Fi to its residents in public places



Fiber is Moving Deeper into the Network





SAN FRANCISCO
DEPARTMENT OF
TECHNOLOGY

Fiber for San Francisco Internet for All

Date RFQ Issued:	January 31, 2018
Pre-Submittal Conference:	February 12, 2018 (10:00 a.m. PST) View livestream: http://sfgovtv.org/youtube_live
Deadline for Respondent Team Written Questions or Requests for Clarification:	March 2, 2018
Respondent Team Submittals Due:	March 26, 2018
Issue Notice of Shortlist of Respondent Teams Selected for Oral Interviews:	April 9, 2018
Oral Interview with Selected Respondent Teams:	Week of April 16, 2018
Issue Notice of Qualified Bidders:	April 30, 2018



DenseNetworks.com

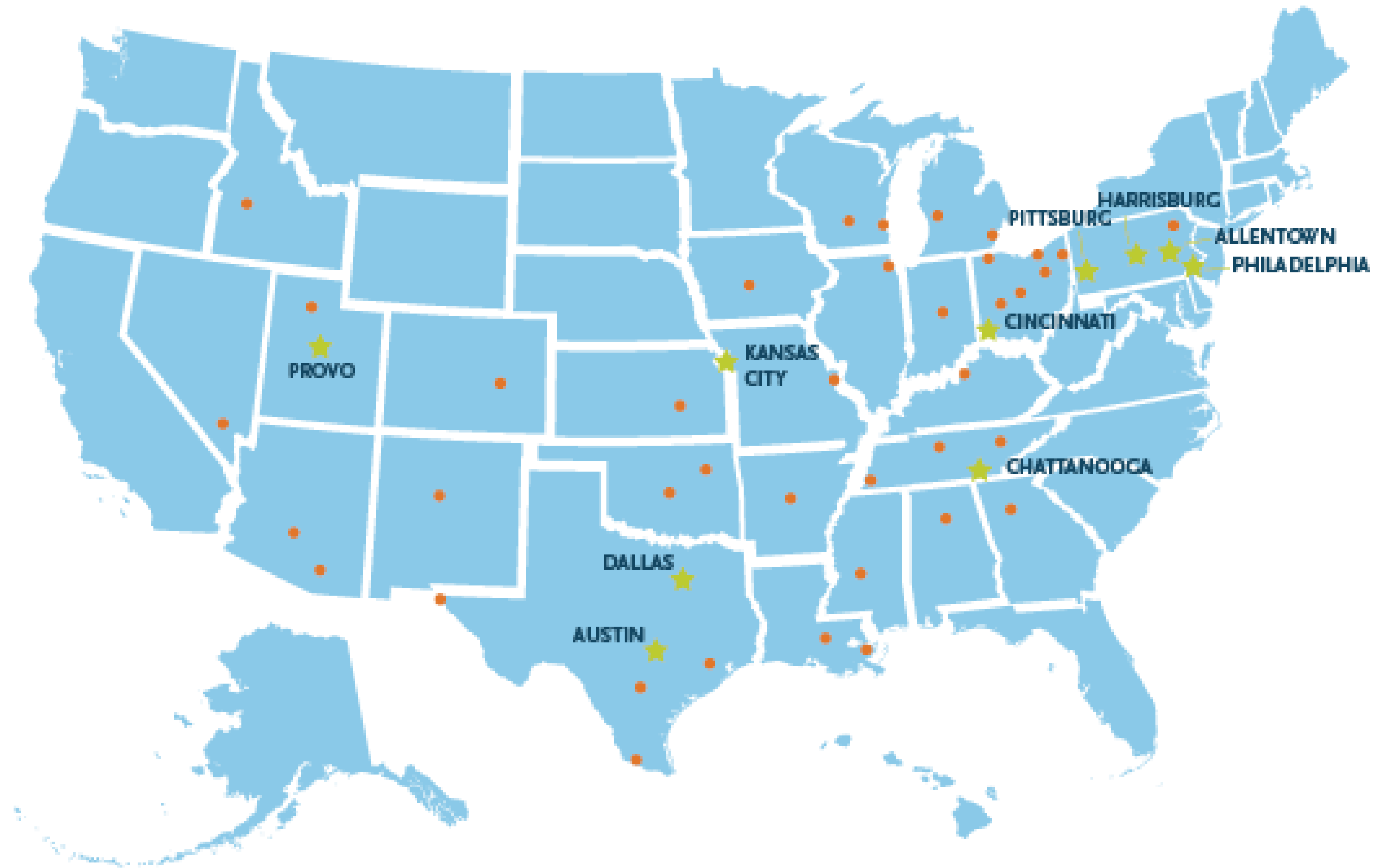
*Dates are subject to change.

Economic Development: Fiber's Killer App

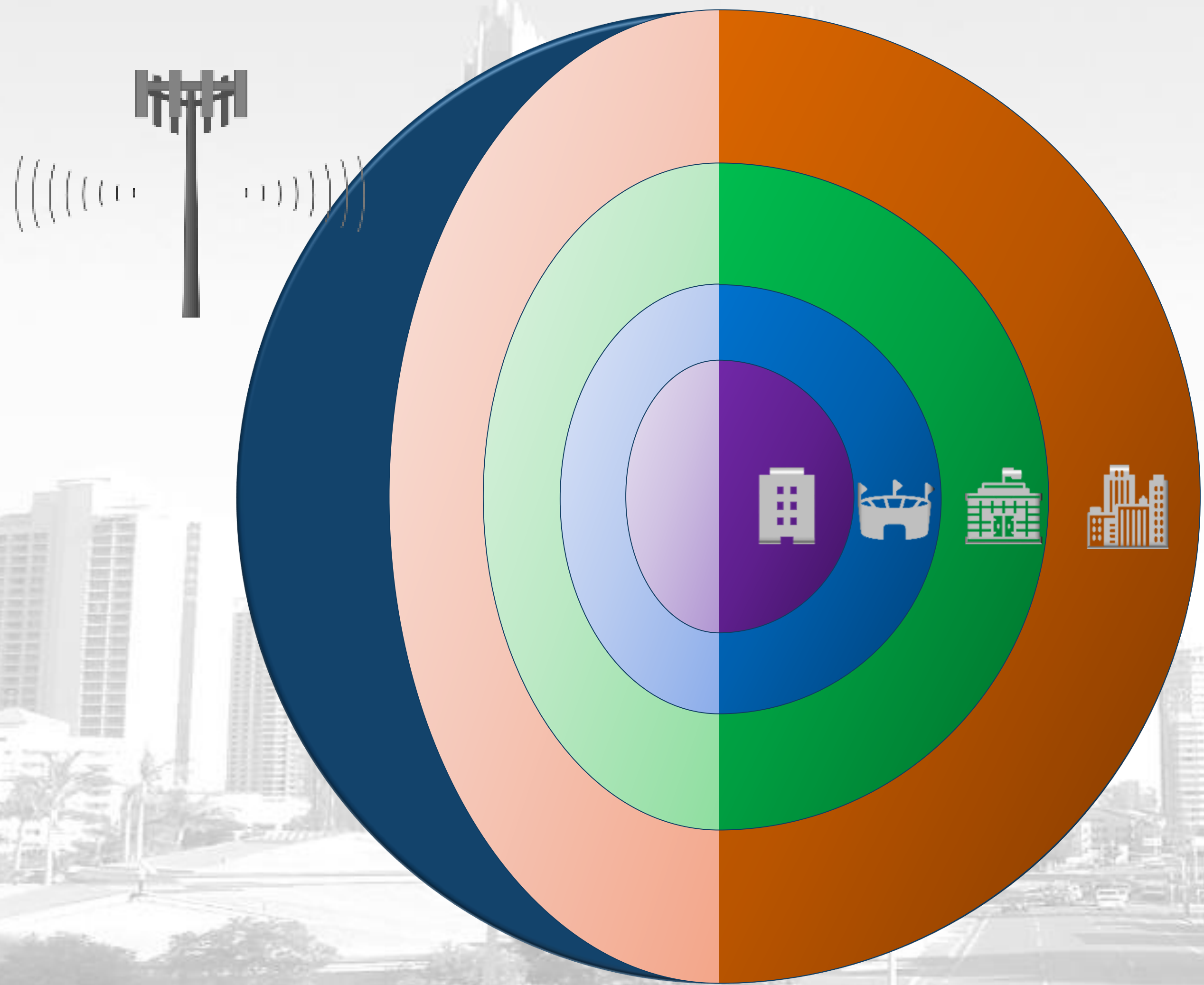
Ten Year Gross Metropolitan Product:
64% Better For FTTH Cities

Ten Year Job Impact:
72% Better For FTTH Cities

Better Year New Business Formation:
46% Better For FTTH Cities



Mobile Convergence



CITY

Densification



CAMPUS

Coverage



VENUE

Capacity



BUILDING

All of the above

Hurricane IRMA – Early September 2017

- In FL **3,973 of 14,730** out (27.4%) with 6 counties >50%, 2 counties >80%.
- In PR & USVI **497 of 1,850** (26.9%) out with
 - St Johns 9/10 out
 - St Thomas 44/57 out
 - St Croix 9/40 out



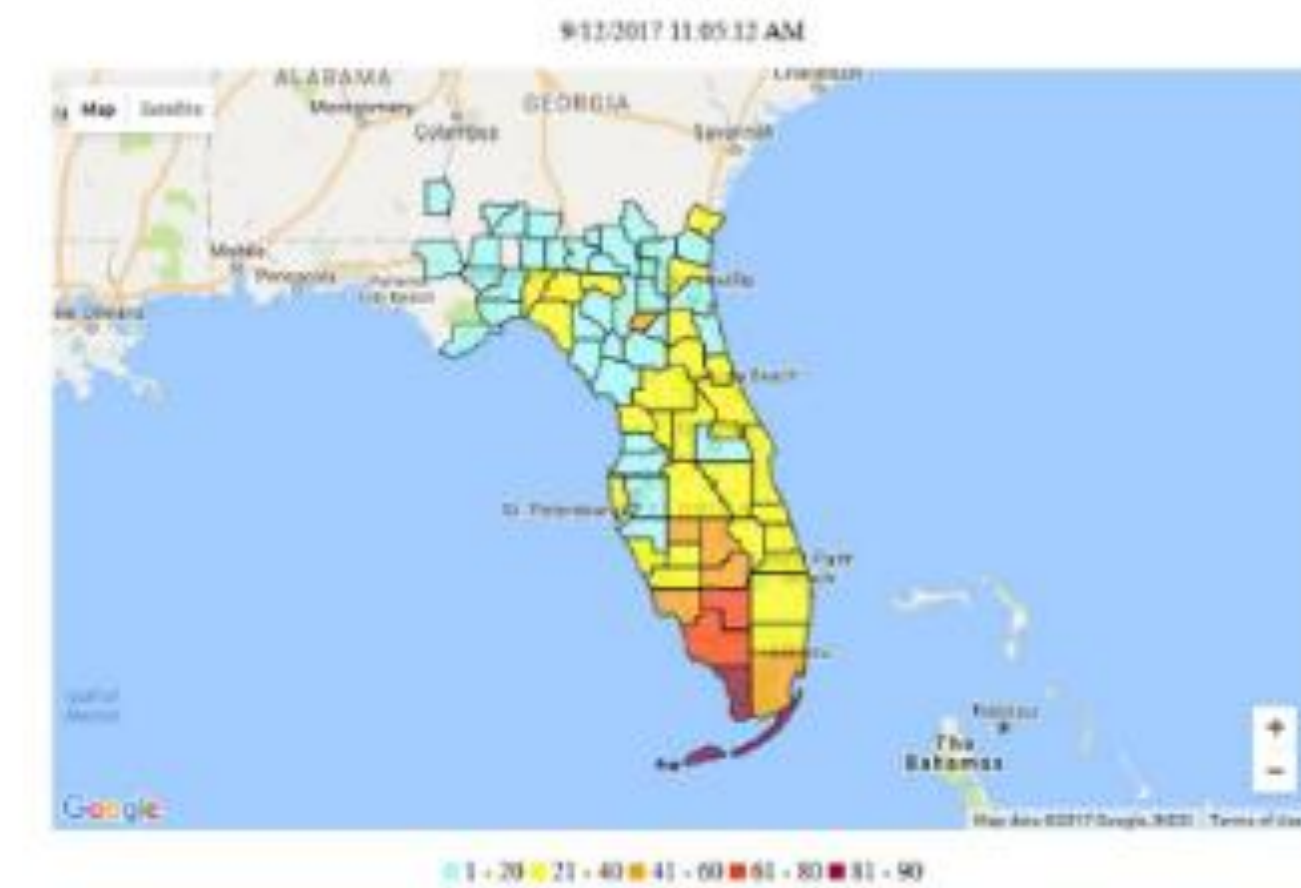
Florida:

Percent Cell Sites Out-of-Service By County



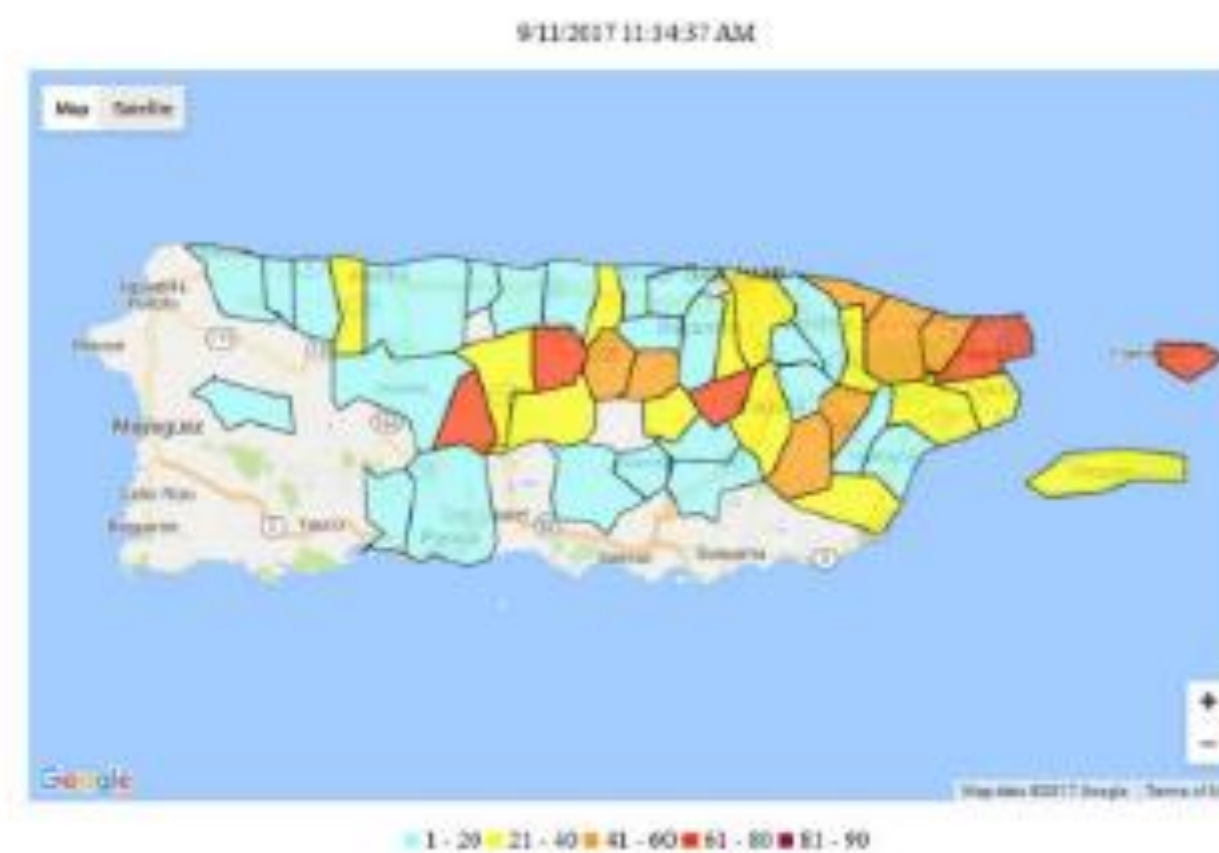
Alabama, Florida, and Georgia:

Percent Cell Sites Out-of-Service By County

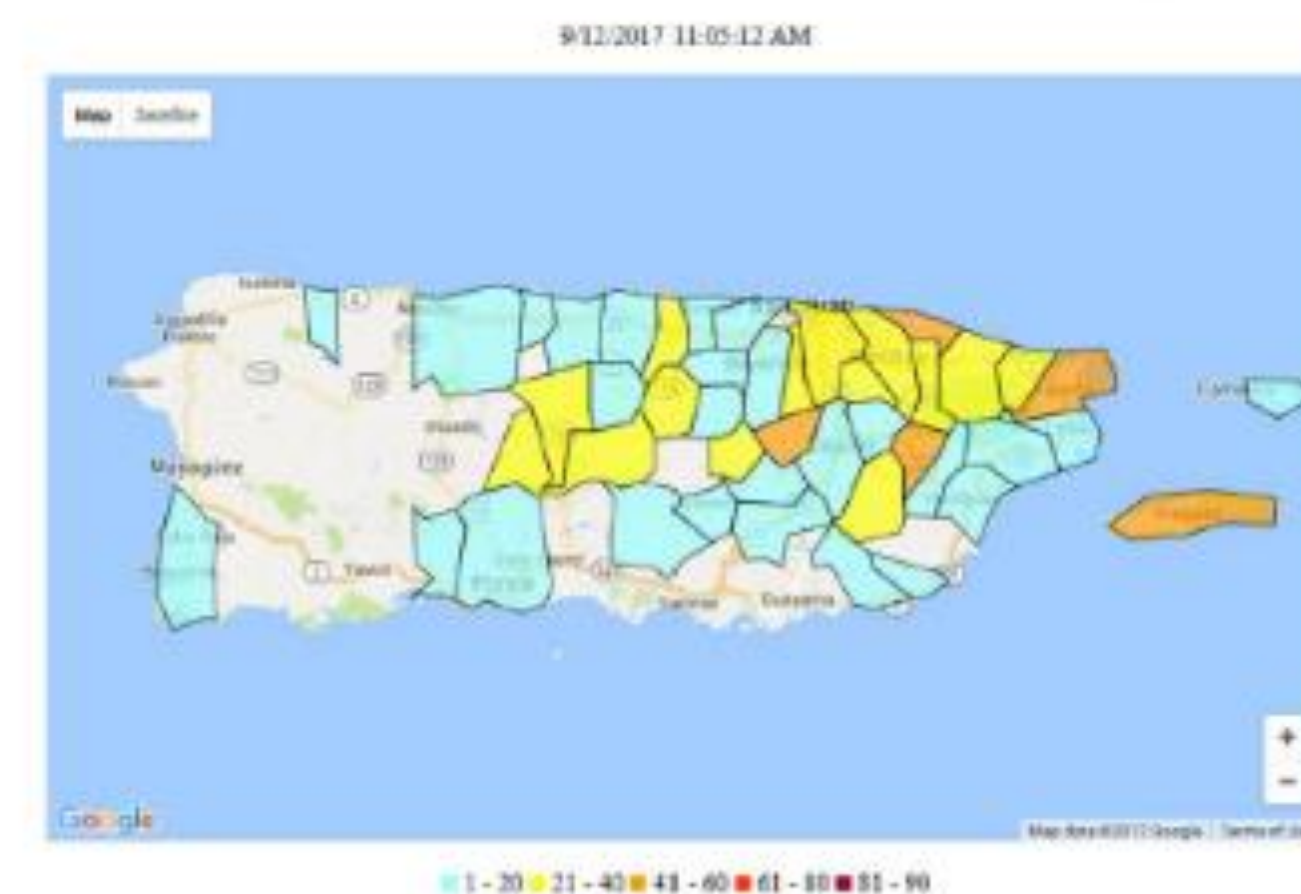


Puerto Rico:

Percent Cell Sites Out-of-Service By County



Percent Cell Sites Out-of-Service By County



Current State:
Baltimore City
Information
Technology



Decentralized IT Operations
No standard City-wide IT policies
and practices

IT Budget
City of Baltimore invests proportionally
less on IT than most of its peers

IT Staffing
City has less than half staff needed
to properly support IT functions

Change the IT Culture and
Improve
Customer Service



One IT Enterprise

Centralize various IT operations and functions to reduce cost, improve efficiency and streamline operations

Human Capital Investment

Improve training and IT professional staffing levels

Governance & Administration

Establish a structure that promotes cross-agency collaboration, strategic alignment, and continuous change for IT initiatives

DevOps

Integrate software development to strengthen enterprise IT operations and service delivery

Support and Secure
Critical IT Operations
and Infrastructure



Cloud Services

Utilize cloud services to rapidly deploy platforms and software without the need to build physical infrastructure

Data Telecommunications

Invest in next-generation network infrastructure to connect the City with high-volume, high-velocity data communications

Enterprise Resource Planning (ERP) modernization

Procure a modern and integrated system to streamline the complexities of the ERP landscape

Build IT Partnerships and
Increase Community
Engagement Around Technology



Data and Analytics Hub

Expand the City's capacity to combine data residing in different sources and provide users with the ability to access, use, and benefit from the data

IOT-Enabled Smart City

Deploy new technology that improves the quality of life and service delivery for all city residents, businesses and visitors

Baltimore Tech Center

Create a space for people to view and experience immersive technology environments

P3 Partnerships

Partner with external stakeholders to leverage technology resources for the betterment of all city residents and businesses

VISION

Over the next decade engage all City departments, businesses and citizens to design, build and implement technology that creates a safe, thriving and smart city.



The Baltimore City Office of Information & Technology will provide sustainable infrastructure and technology to support and enhance City departments, communities, businesses, and mayoral goals.

MISSION

Technology Megatrends



Smart City Initiatives



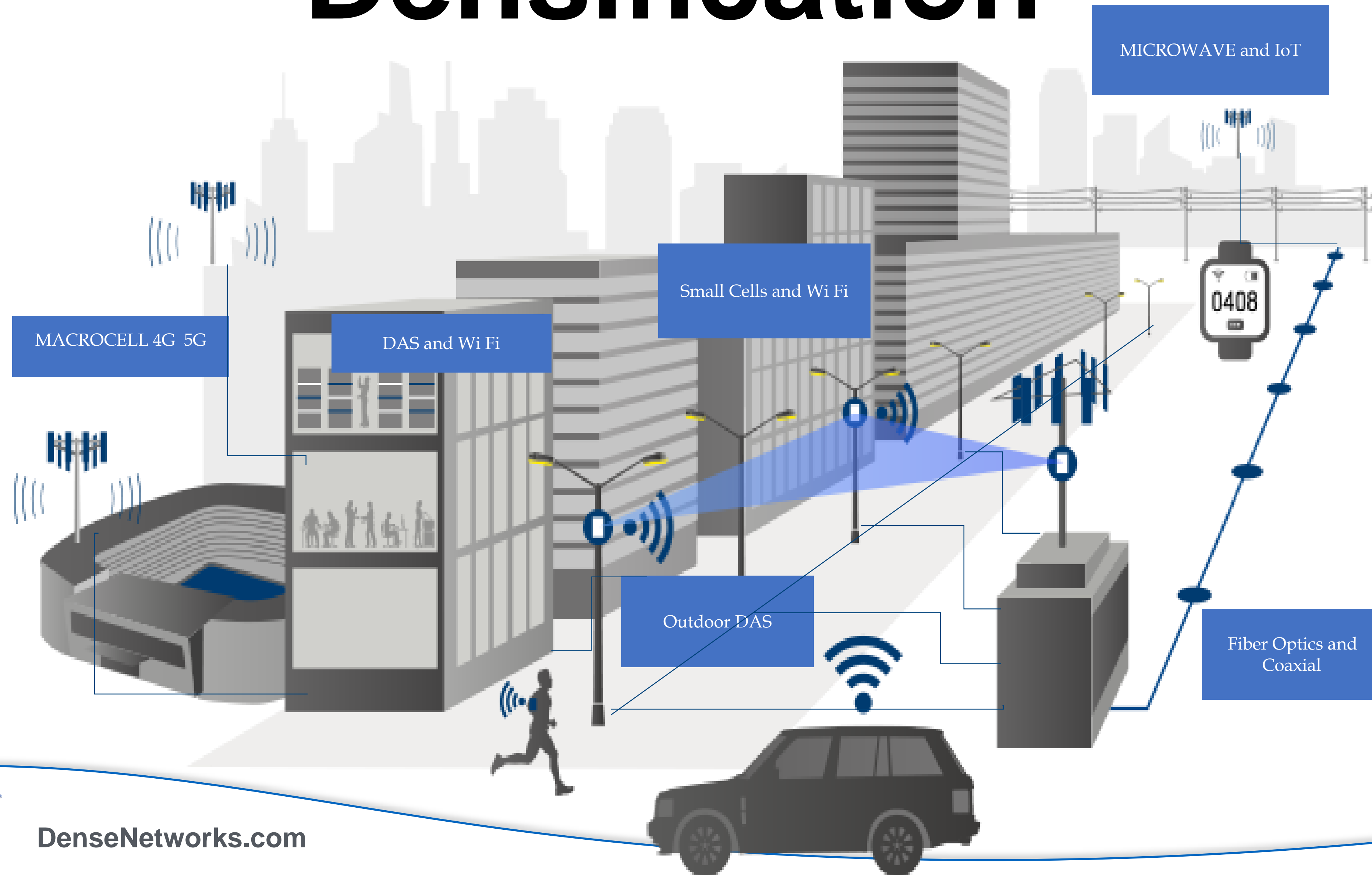
LED Conversions



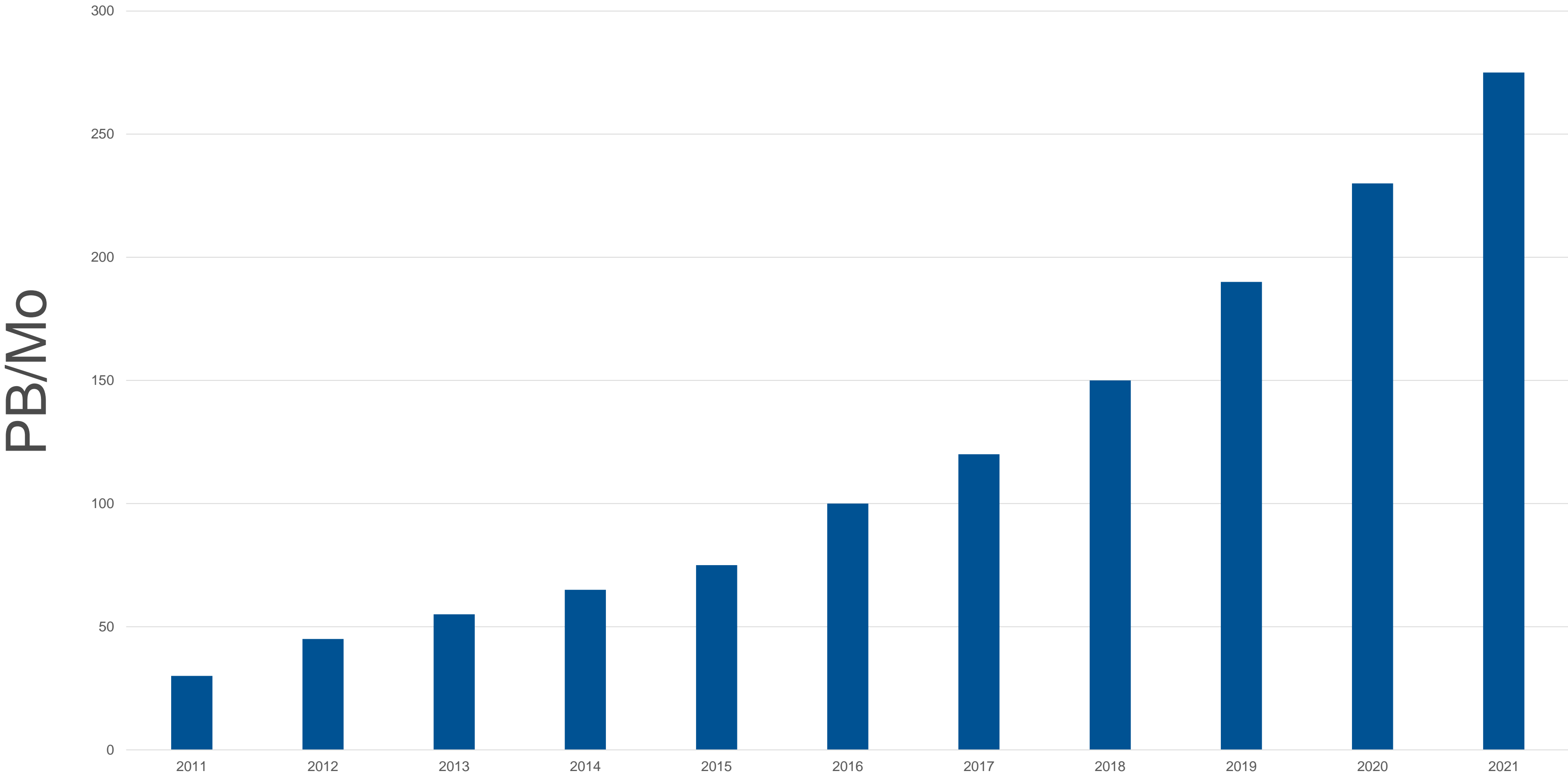
Network Densification

These megatrends are shaping the wireless infrastructure landscape in U.S. cities

Densification



Global IP traffic is growing at an exponential rate



82%
of IP traffic will be
video by 2021

Of all IP traffic:
50% WiFi
30% Fixed
20% Mobile

Source: Cisco, VNI. 2017

1G

1980s

Analog Voice

2G

1990s

Digital Voice
SMS

.1 Mbps

3G

2000s

Rudimentary
Data

.1 – 8 Mbps

4G

2010s

Video
Internet

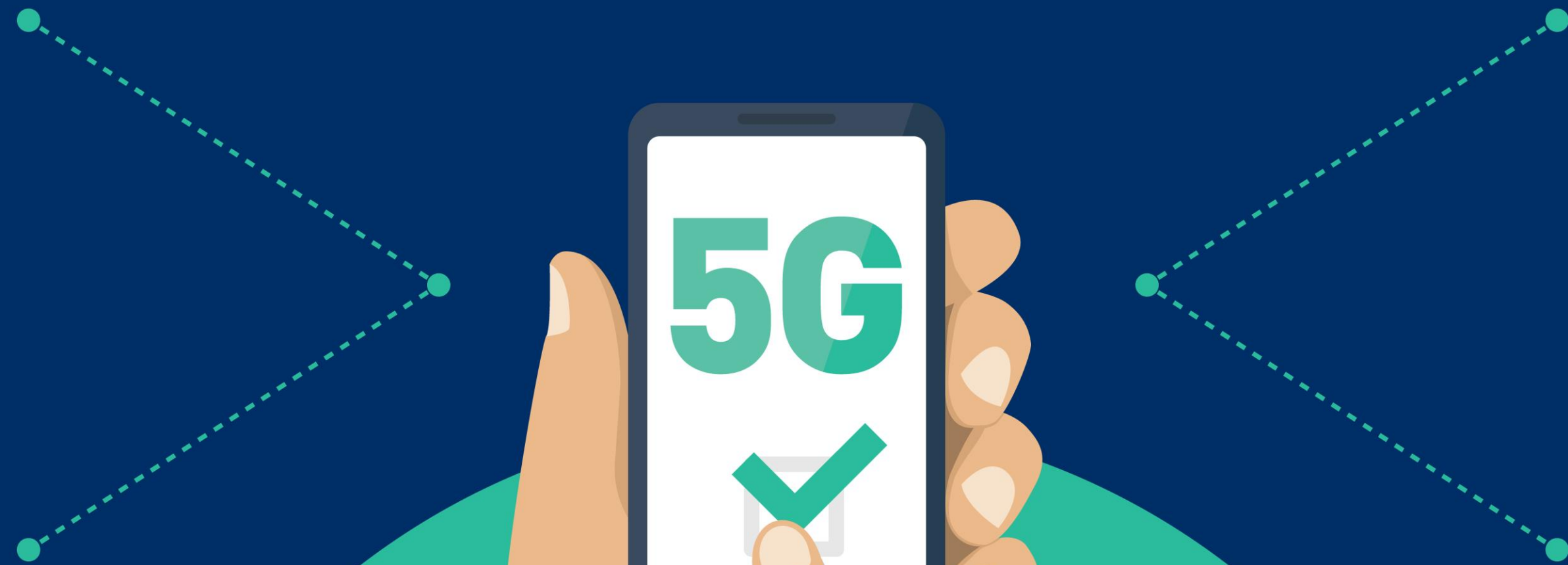
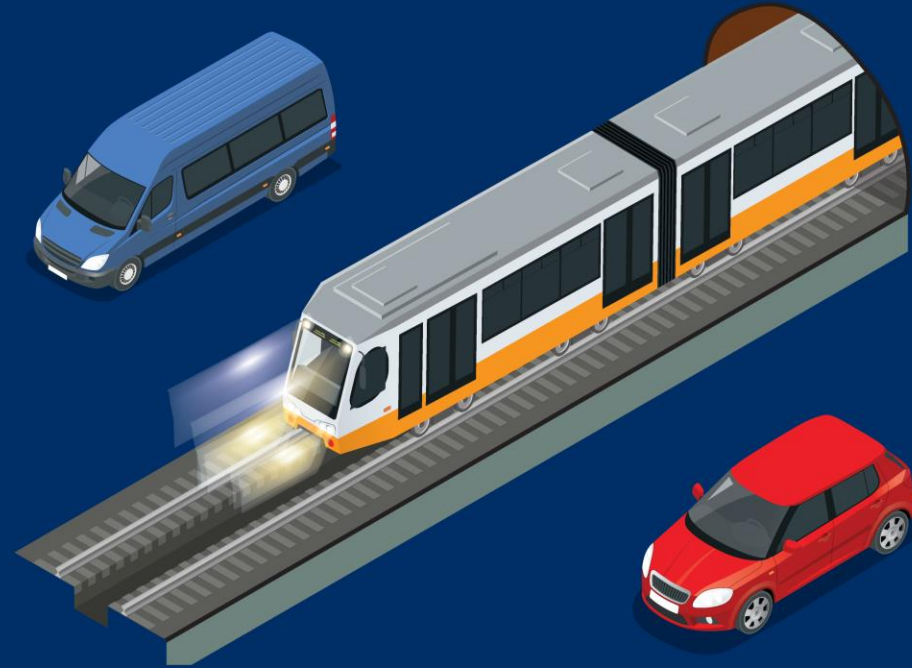
15 Mbps

5G

2020s

UHD Video
IoT

1 – 10 Gbps

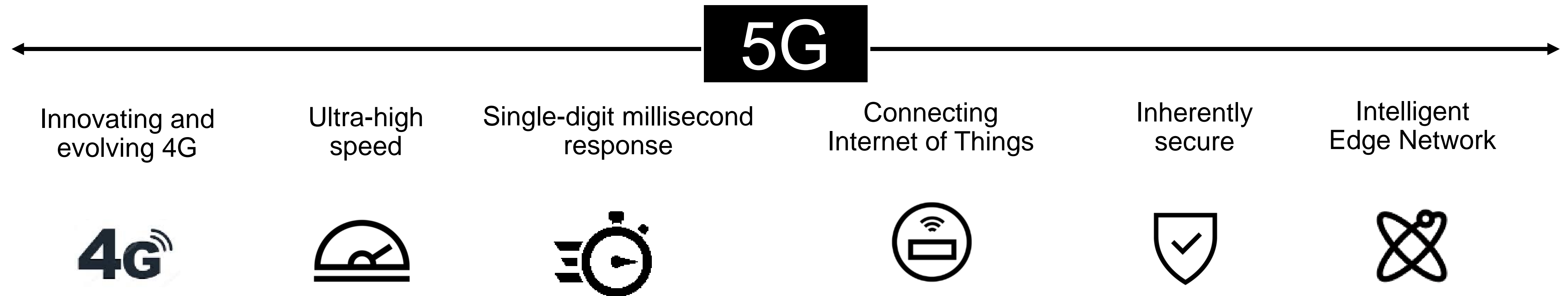


Announced 5G Cities

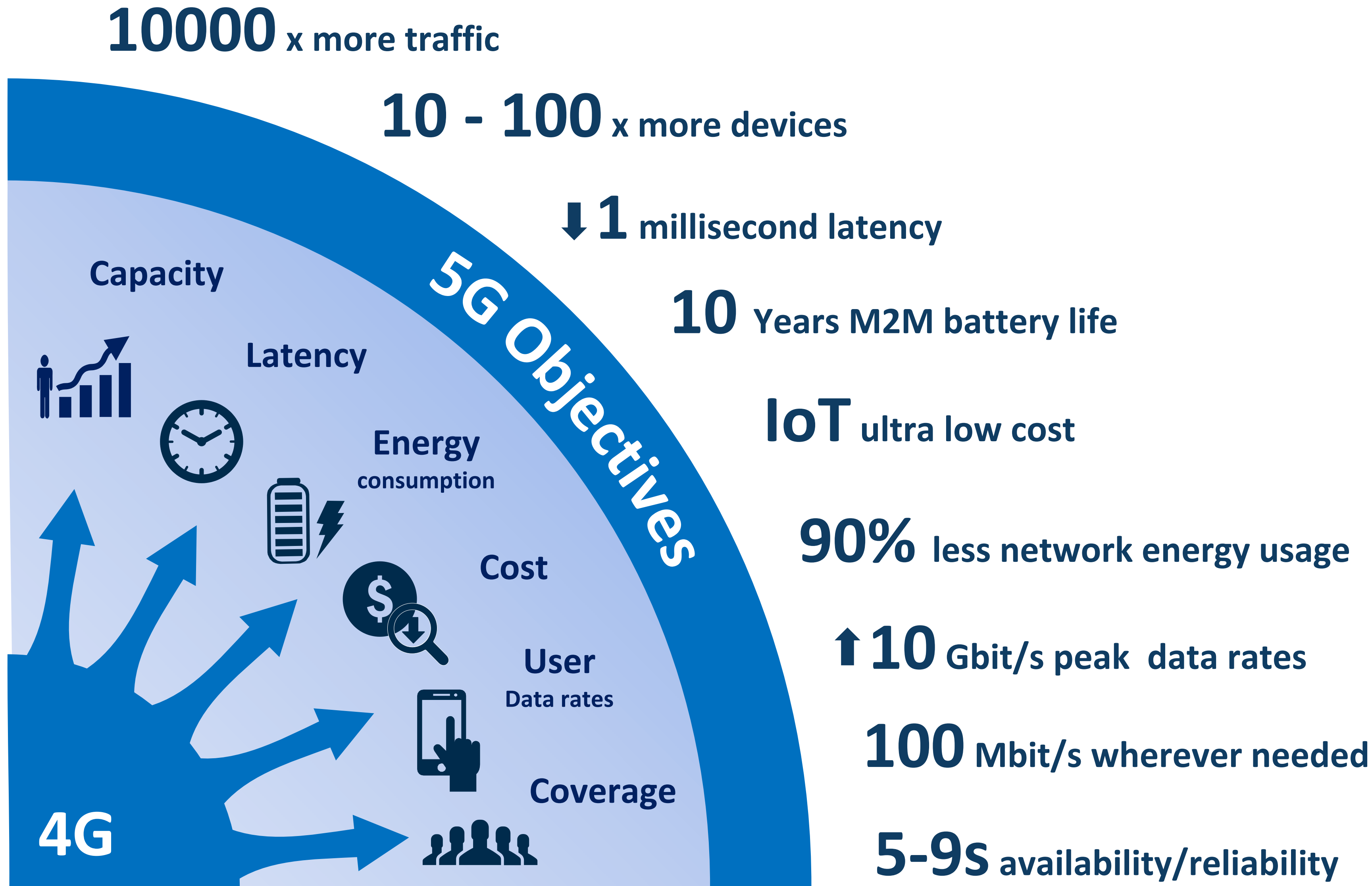


5G: The future is closer than you think.

- Verizon rolls out 5G in Houston, Indianapolis, Los Angeles & Sacramento
- Verizon and Nokia complete first over-the-air data transmission on a commercial 5G NR network
- Verizon with Erickson and Qualcomm, completed the first end-to-end call on a commercial 5G NR Network
- 5G Home, our exciting alternative to traditional cable & internet, is officially open for business



5G Objectives



5G Use Cases

Enhanced Mobile Broadband

High data rate

 4K/8K UHD

 Hologram



 VR/AR (Virtual/Augmented Reality)



Demanding conditions

Broadband Access in Dense Areas



Massive hot spots / Smart office

High-speed Mobility



Moving hot spots / High-speed train

Low Latency Services

Ultra-high reliability/low latency

 Tactile Internet



 Remote-control robot/machines



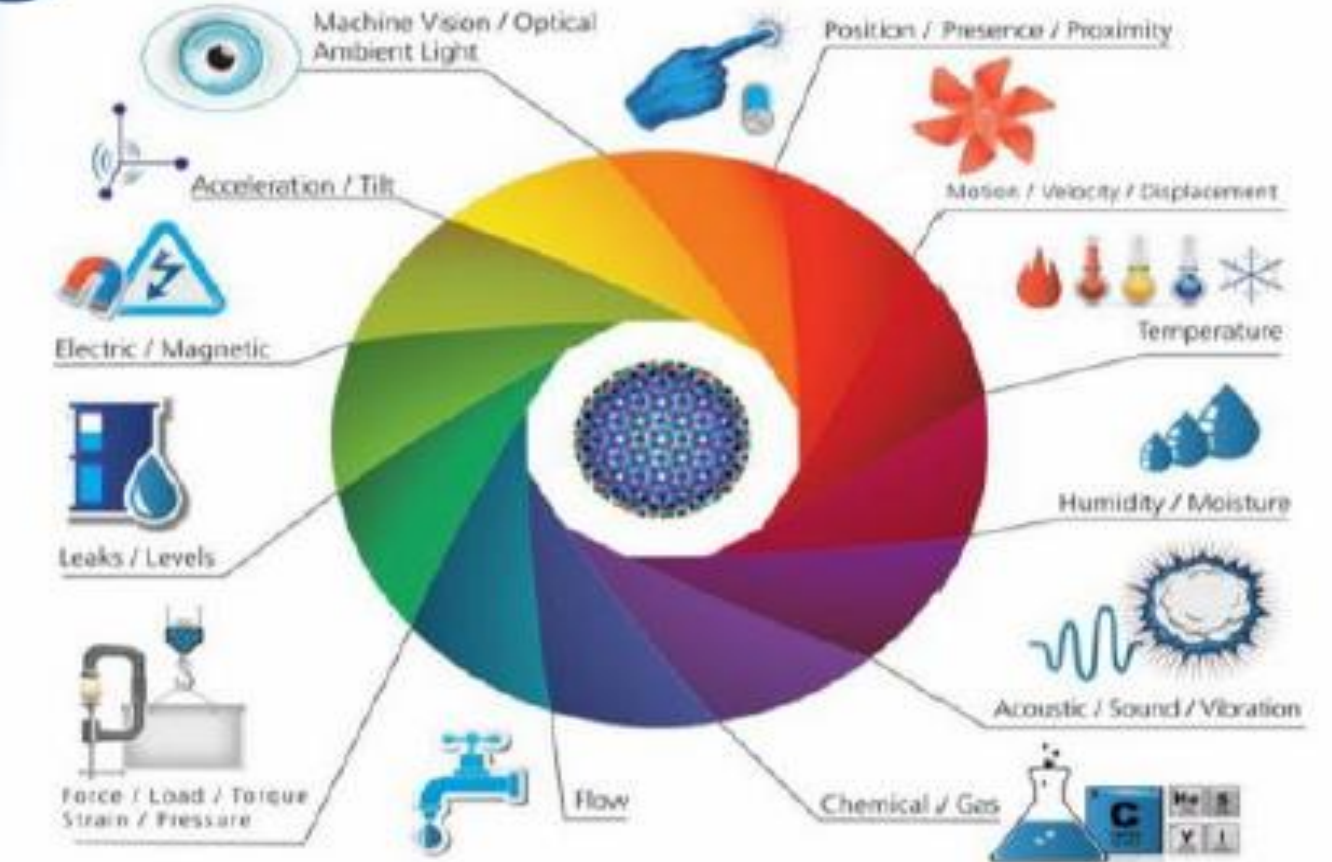
 Connected cars (V2X)



Massive Internet of Things

Massive connectivity

 Remote sensors/actuators



 Smart city-home

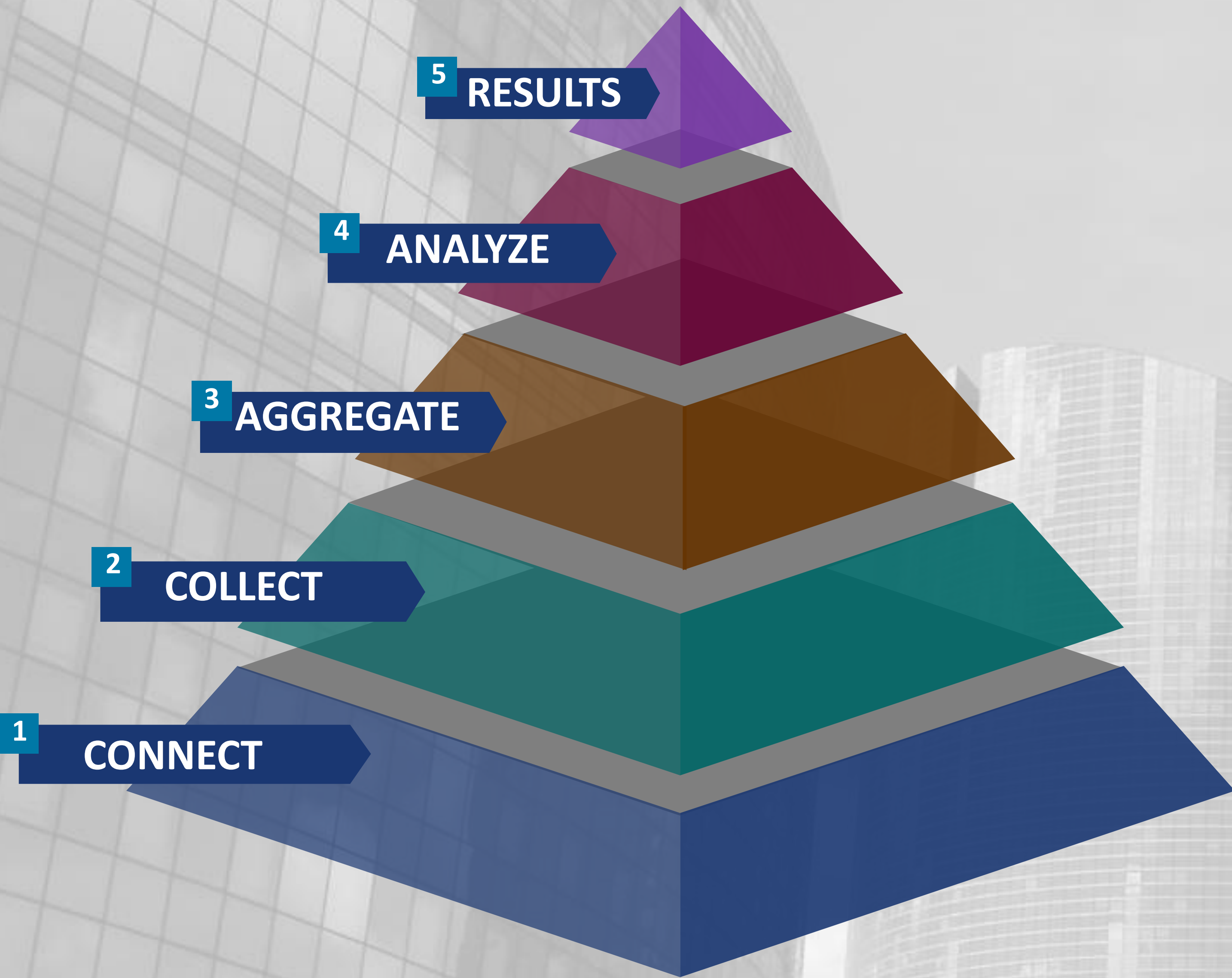


 IoT 5G IoT



Source: 5G Vision and Enabling Technologies

Building Smart City Infrastructure



USERS & CONSUMERS



Transform user and customer experience with engaging, enhanced and autonomous services

ANALYTICS & INTELLIGENCE



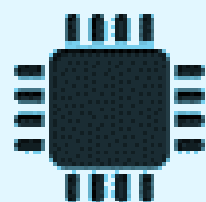
Transform data into insight, action and knowledge. Integrate into business and operational processes.

DATA FLOW & DEVICE CONTROL



Collect data and manage devices on the network. Use edge computing and gateways prior to sending to the cloud.

DEVICES & SENSORS



Deploy devices and sensors to measure existing and new data sets. Inventory assets that are not measured today.

CONNECTIVITY & ACCESS



Build a network foundation for connectivity and access for more bandwidth, device types & mobility.

Making the Technology Disappear



10ft
Link NYC



14ft
Verizon LQD



14ft
Citi Bike



15ft Bus
Shelter

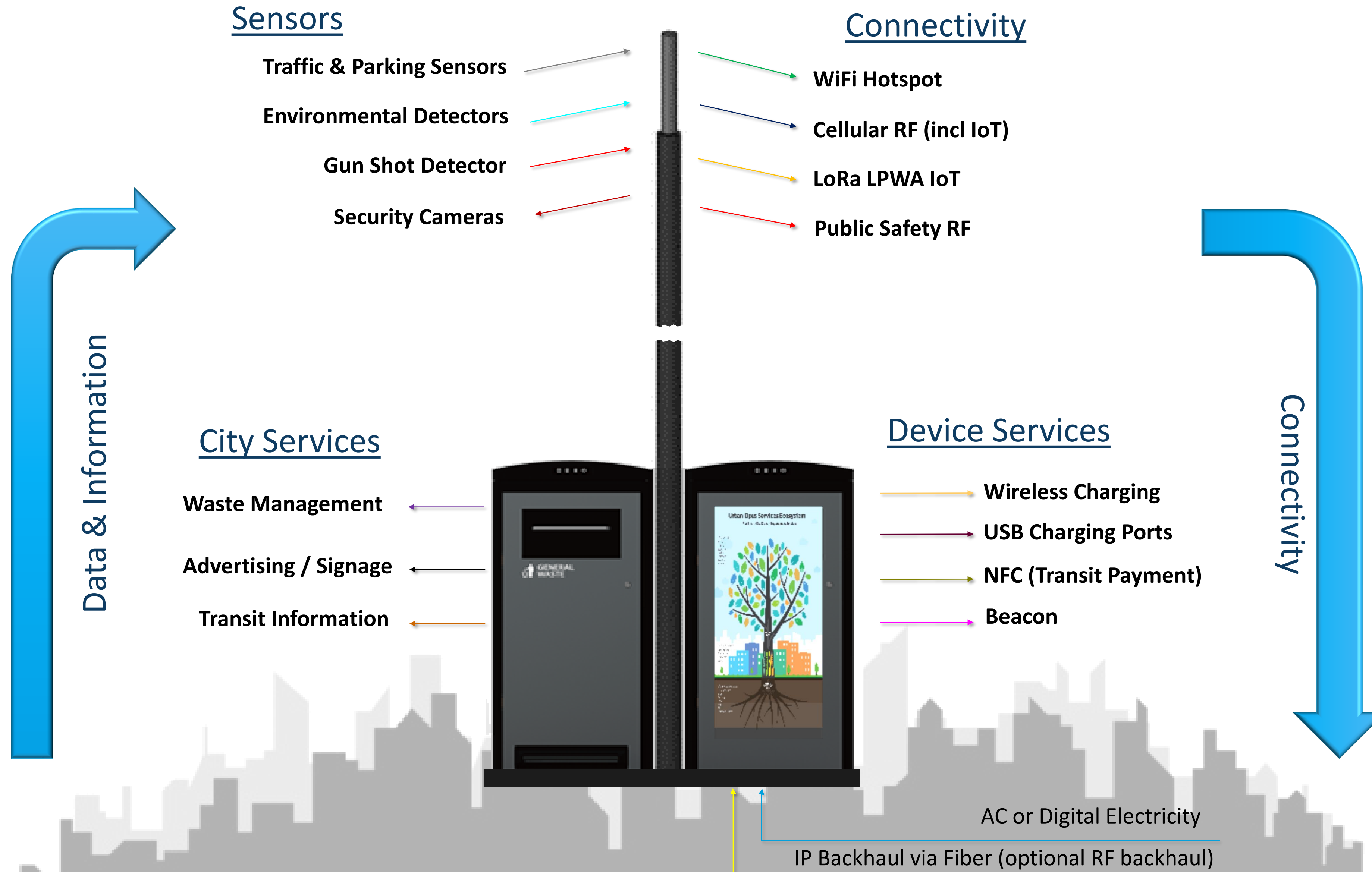


20.5ft
News Stand



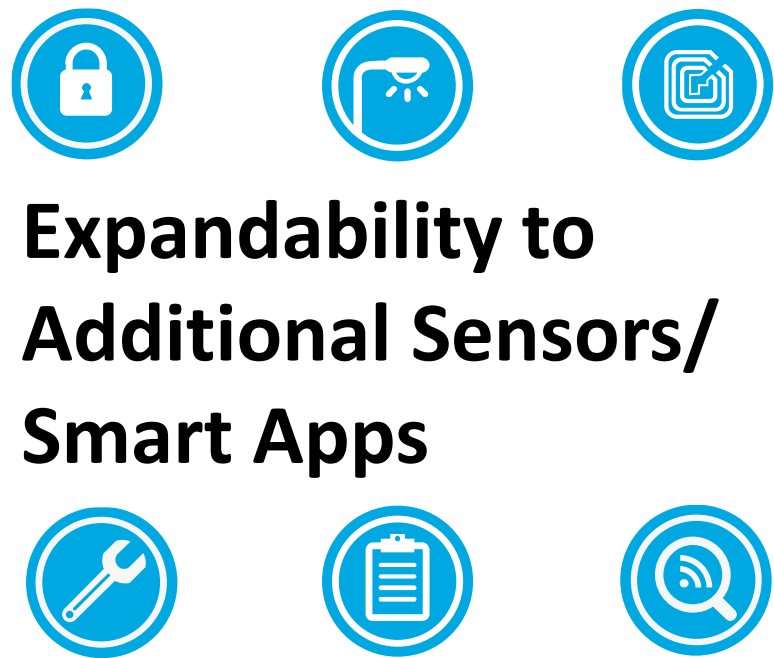
30ft
Smart Pole

Edge of the Smart City



Light Pole as Smart Venue Information Hub

Smart Lighting



Expandability to
Additional Sensors/
Smart Apps

Wi-Fi Connectivity



One Network, No
New Poles or
Trenching

Smart Parking



Smart Traffic



Video Surveillance



Multi-phase strategy, with public-private collaboration

Phase 1. City/county and other public sector facilities

Business case is internal savings, efficiencies, Smart City

Phase 2. Key economic development targets

Business case is economic development

Phase 3. Platform for last mile deployment

Business case is economic development, private sector opportunity, service improvement

Platform is public infrastructure, optimized to enable the Smart City, with private opportunity for commercial service

How to
move
forward?



Smart Cities invest in smart infrastructure like fiber

According to 2018 research from RVA, LLC:

Fiber Cities are more likely to be Smart Cities

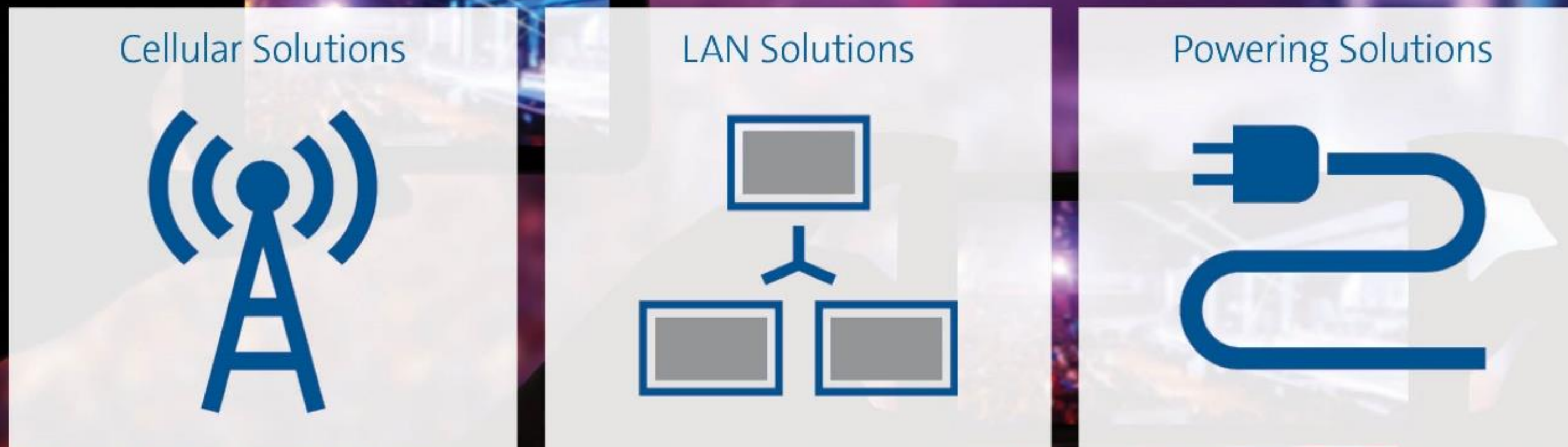
- Cities with fiber have, on average, **37% more deployed small cells** and just **over 35% more smart city applications**
- **33% of cities without fiber** report small cell activity, versus **60% of cities with fiber** to the residence.



Corning in-building network solutions provide a future-ready platform at less cost



Corning's In-Building Network Solutions



Corning's In-building Solutions

- Lower first-installed cost
- Reduced future upgrade costs
- Virtually **unlimited** bandwidth
- Optimized space utilization
- Low latency
- **Scalable** and **intelligent**

Tomorrow's network, today



“You can’t have smart cities with dumb buildings”

James Carlini, Author

Location, Location, Connectivity

“You can’t have smart buildings with dumb infrastructure”

Mike Collado, Marketing Director

Corning

Easter morning 1900: 5th Ave, New York City. Spot the automobile.

Disruption can happen very fast...



Source: US National Archives.

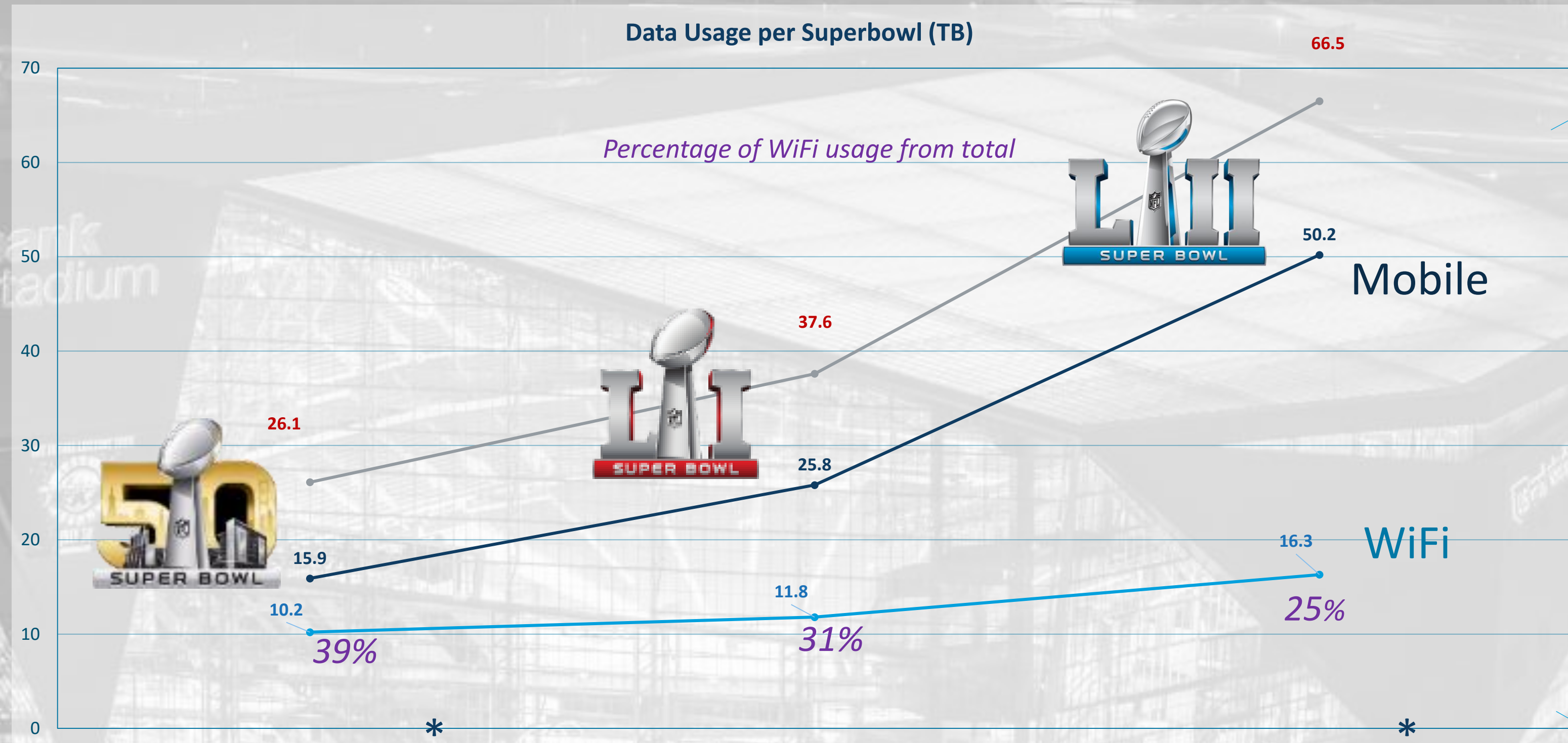
**Easter morning 1913: 5th Ave, New York City.
Spot the horse.**

Disruption can happen very fast...



Source: George Grantham Bain Collection.

Mobile/Wireless Bandwidth Demand



x17



* JMA Wireless in-building solutions used for mobile traffic

- SOURCES:
- Data usage at Super Bowl 52 grows 48% as social media use skyrockets <https://www.techrepublic.com/article/data-usage-at-super-bowl-52-grew-48-as-social-media-use-skyrockets/>
 - Super Bowl 51 makes digital history with record-breaking data usage <https://www.techrepublic.com/article/super-bowl-51-makes-digital-history-with-record-breaking-data-usage/>
 - AT&T, Verizon and Sprint see a combined 50.2 TB of cellular traffic for Super Bowl 52 <https://www.mobilesportsreport.com/2018/02/verizon-sees-18-8-tb-of-cellular-data-used-at-super-bowl-52/>
 - Super Bowl fans use a record 10TB of data on Levi's Stadium WiFi network, up 63% from 2015 <https://www.geekwire.com/2016/super-bowl-data-usage/>



Capacity

Coverage

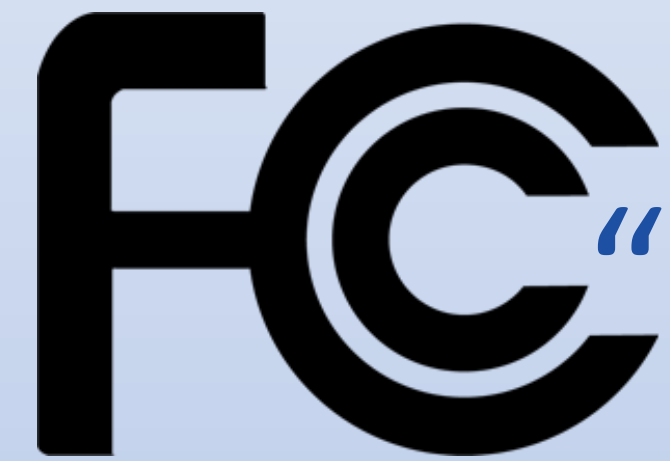
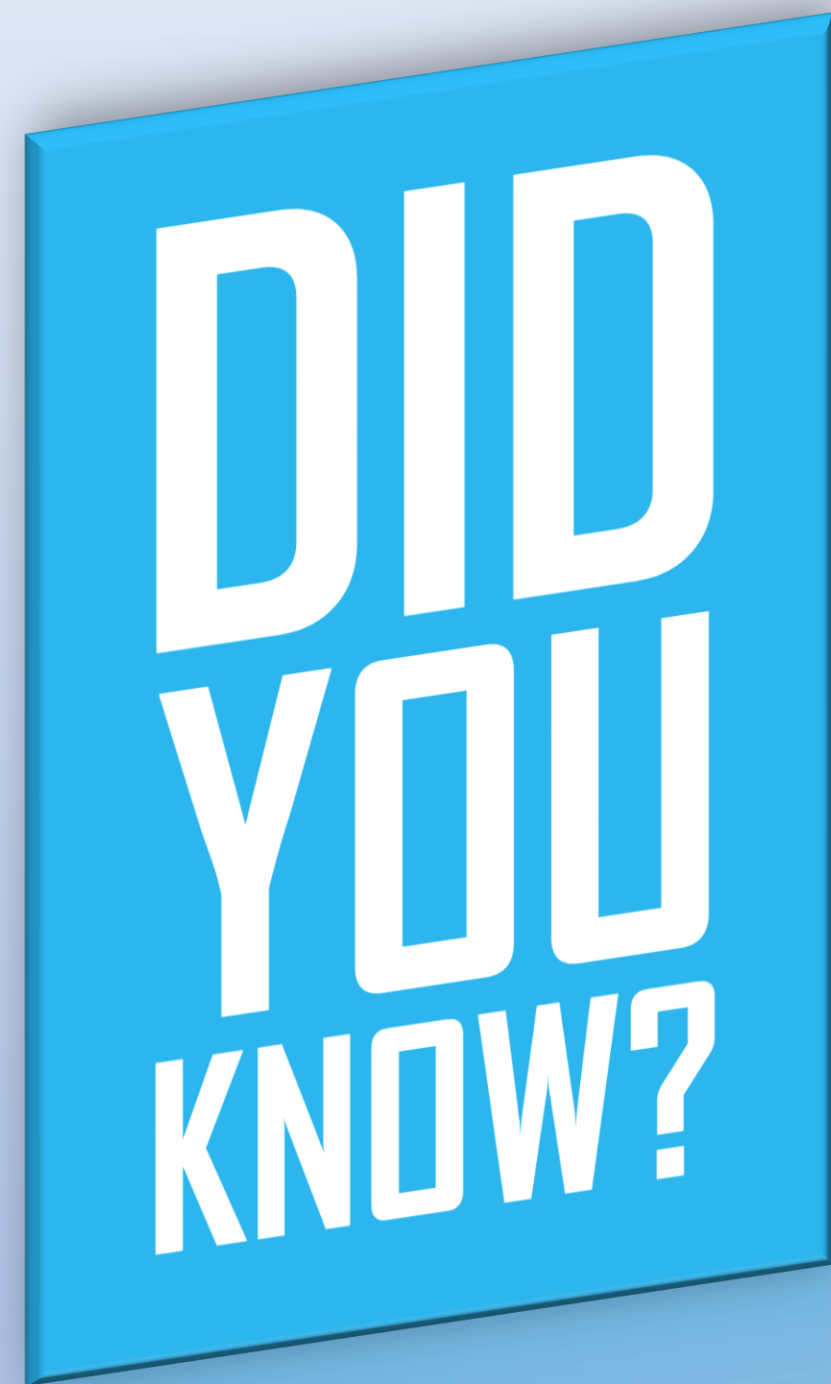


Bandwidth

ENTER

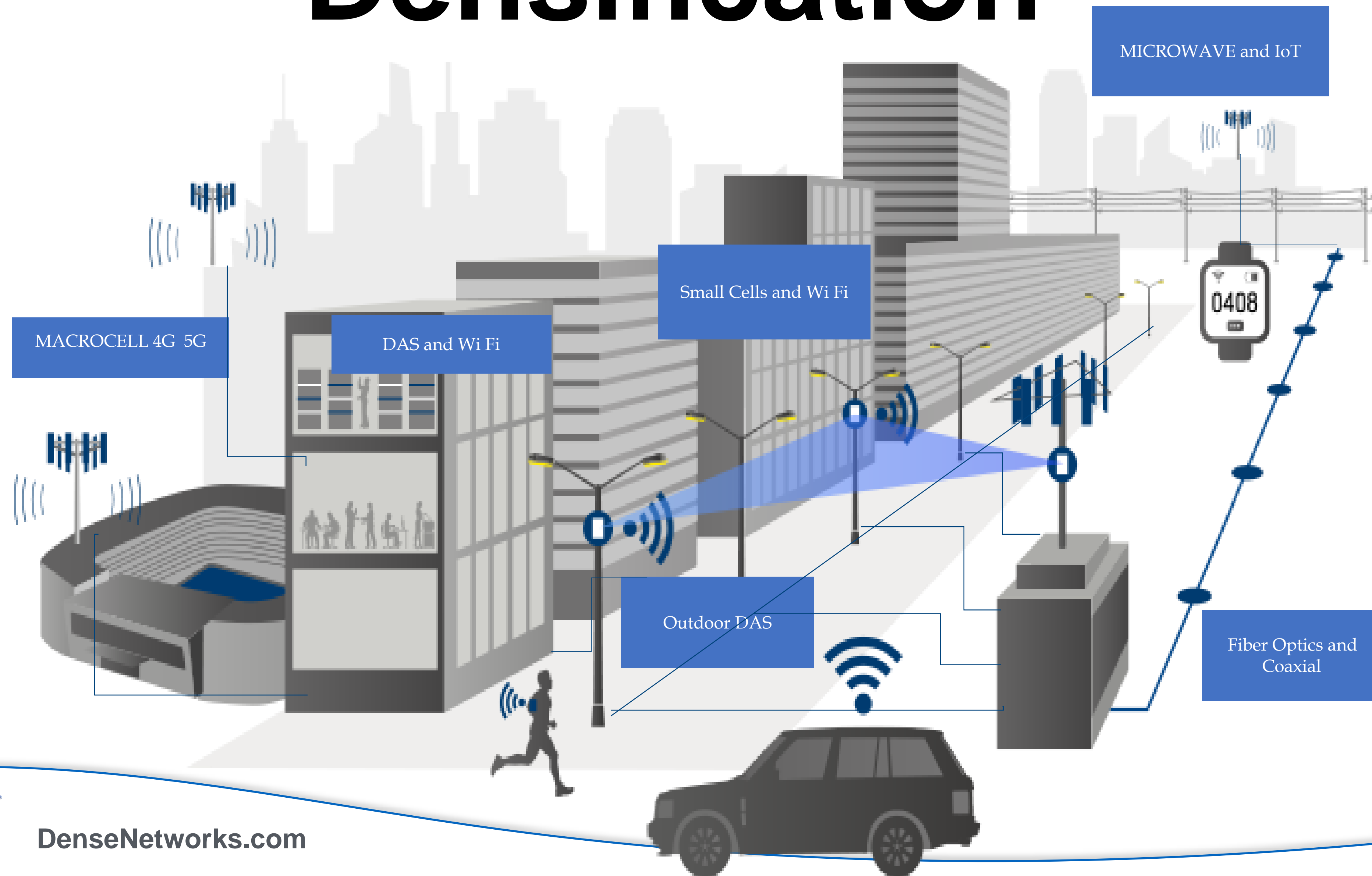
[click here for more information](#)

Driver: NG911 Location Accuracy



“The FCC estimates that a one minute improvement in 9-1-1 dispatch time could save 10,000 lives each year”

Densification



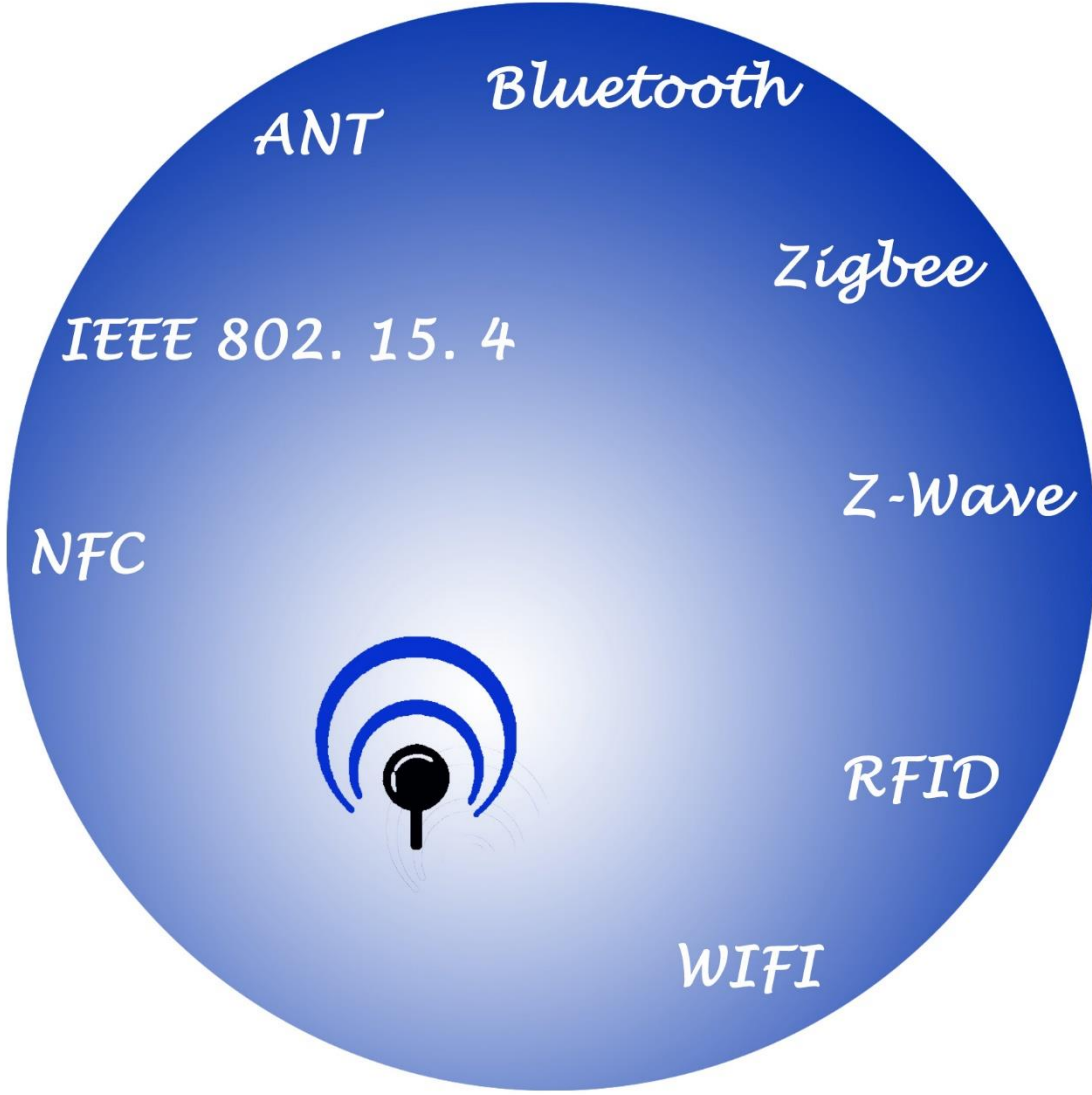
A Tidal Wave of Antennas



Significant opportunity exists to evolve to a *shared* infrastructure model in urban centers

How Many Networks?

Capacity, Coverage, Compliance



Interesting WiFi Facts

1. Beginning at the end of 2013, there were more mobile devices than people on earth. – SAP

2. Wi-Fi speeds have increased significantly with each release.

11a / 54Mbps / 1999

11n / 450Mbps / 2009

11ac-wave1 / 1.3Gbps / 2012

11ac wave2 / 3.47 Gbps / 2013

11ax 5G Wifi / 6+ Gbps / 2018?

1. Wi-Fi / mobile data consumption is 44% higher on screens 4.5” and larger. – NPD

2. 75% of people say 1 week without Wi-Fi would leave them grumpier than 1 week without coffee. – Iconic Displays

3. Most businesses are planning to increase Wi-Fi capacity by at least 20% in 2018. – Infonetics

4. 75% of the increase is to support mobile devices and BYOD users. – HP

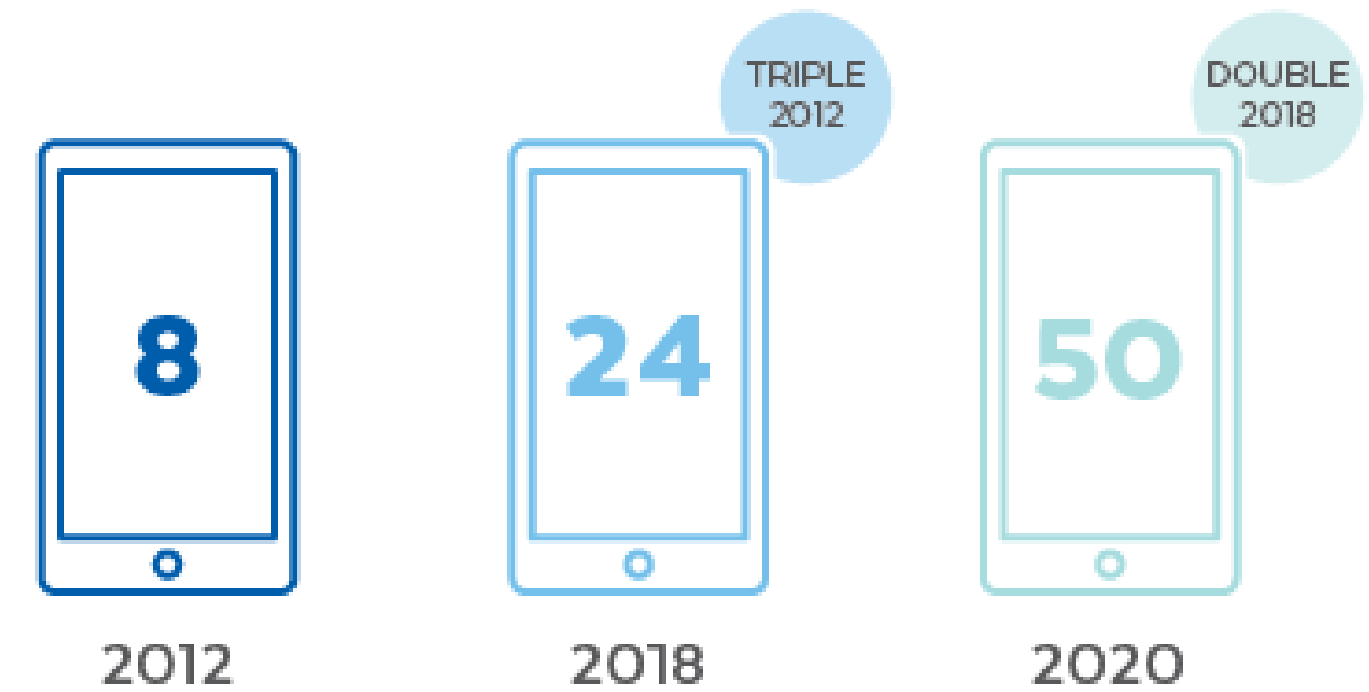
5. 2/3 of enterprises allow their employees to bring their own devices into the enterprise today. – Infonetics

6. 38% of 2-year-olds use mobile devices. – Common Sense Media

7. Average age for first cell phone is now 13. – SAP

8. Smartphone users spend an average of 60 minutes a day. iPhone users average 90 minutes a day. – Experian

DEVICES PER HOUSEHOLD

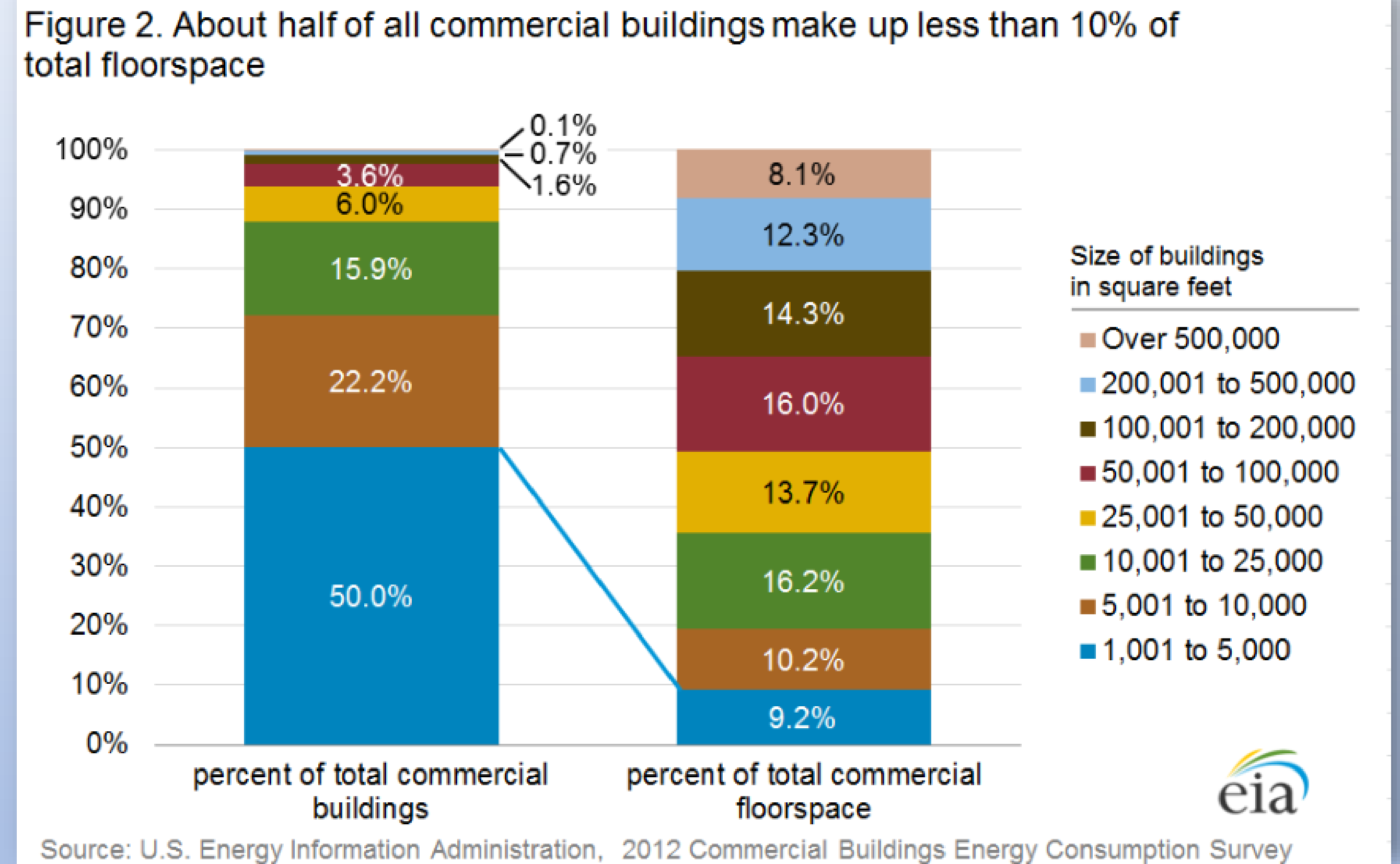


DAS



In-Building Public Safety – US Market Size

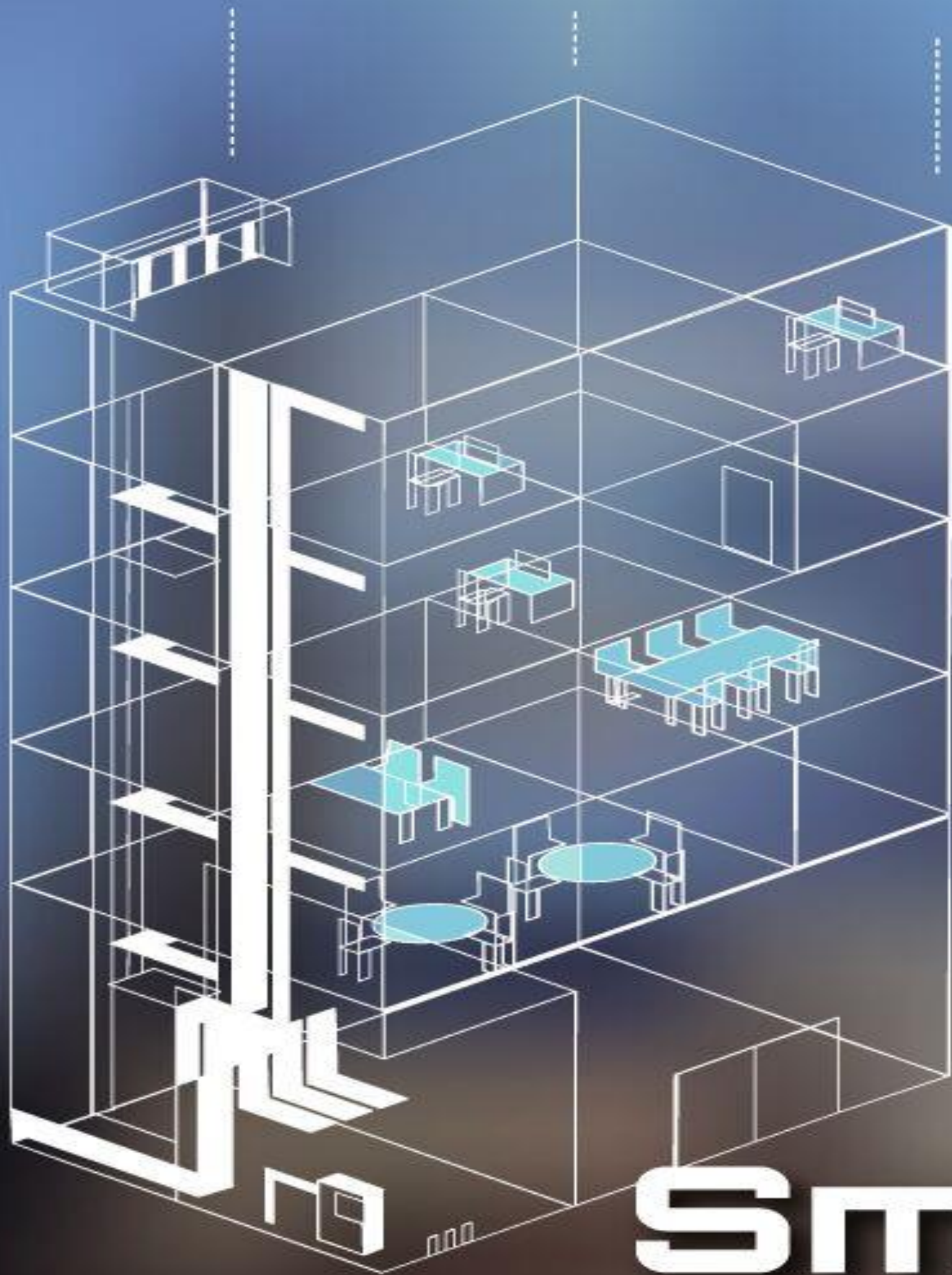
- 5.6 million commercial buildings in the United States in 2012
- 87 billion square feet of floorspace
- 14% increase in the number of buildings and a 21% increase in floorspace since 2003



Source:
Commercial Buildings Energy
Consumption Survey (CBECS)



BUILDING MANAGEMENT SYSTEM



Smart Buildings

55 Water Street - Lower Manhattan

- The largest commercial office building in New York; second largest in the U.S.
- 72 stories; 4 million square feet.
- Approximately 30K people traffic through the building Monday through Friday.
- DAS consists of 32 high-power units located around the towers, combined with 1K interior antennas in the ceilings.
 - 9K feet of single-mode fiber optic cable to connect the remotes.
 - 110K feet of coaxial cable to connect the remote antenna units.
 - Access Points installed in lobby and two outdoor parks.



Improve Wifi Network Capacity With 802.11ax

An estimated 8.4 billion devices are connected to the Internet right now. That's higher than [the world's population](#). A goal of the wireless industry has been to provide cable/wired equivalency for bandwidth and reliability.

802.11ac Wave 2 is only the beginning

Continued utilization of MU MIMO Technologies, Additional Modulation Techniques, and More Powerful Chipsets continue to fuel our thirst for bandwidth.

802.11ax (5G Wifi) and 5G NR (New Radio)

- **Expanded Capacity**

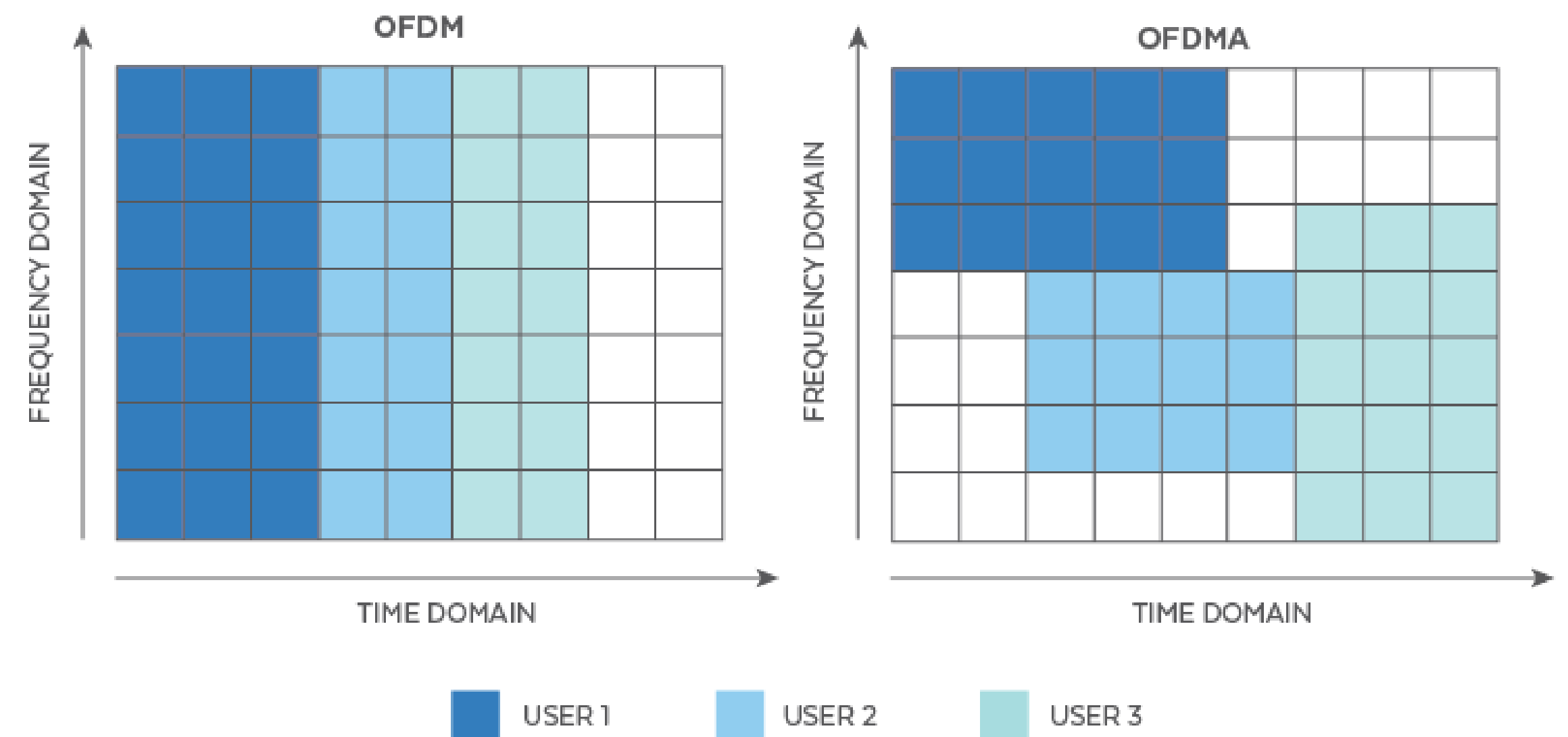
Expanded capacity through use of subcarrier waves and additional streams

- **Higher speeds**

Speeding up things up to 4x faster through 160 MHz channels

- **Less battery drain**

Using micro-sleep mode to preserve battery life



New York Subway

- The largest in-building DAS network in the world covering all NYC underground stations with expansions into the tunnels.
- Serves 282 underground stations.
- Design, built, operate entire network from 5 base station hotels to 160 miles of carrier grade fiber optic cable.
- Integrated Access Points throughout each station.
- Privately funded with a license that extends to 2038 and covers all current & future commercial cellular wireless bands as well as unlicensed WiFi bands.
- Supports Transit Apps, Public Safety and Security requirements for Federal, State and City agencies.

Objectives

- Resilient, fault-tolerant
- Leverage fiber for future assets
 - Street infrastructure
 - Buildings
- Ubiquitous WiFi
 - APPs to promote transit
 - Ad-based
- Support NYC Transit Operations

Challenges

- Heat
- Equipment size and orientation
- A lot of RF
- 24x7 Rail Ops with Express Track (only system in the world)
 - 22 Lines
 - 5.7 million daily riders
- Multiple agencies involved
- Cost



Design

- Double Star Topology
 - Base Station Hotels to Stations
 - Primary Station Hub to multiple nodes in each station
- Fiber-To-The-Edge
 - (XG Ready)
 - Each station capable of well over 100Gbps
- Integration of CMRS, WiFi and PSR

Benefits

- Integrated solution a cost-effective means to solve multiple communications objectives
- Carrier Off-Loading due to network densification
- Happier customers - NYCT and CMRS
- Public Safety
 - See Something, Say Something
 - Wayside Blue Light System
- Improved communication with customers

Driver: FirstNet Internet of Life-Saving Things (IoLST)*

*Slide Source: FirstNet Presentation to IACP – Philadelphia, October 2017

Personal Devices
Fitbit, health monitors, insulin pumps, heart monitors, health apps, PulsePoint



Buildings
burglar/fire alarms, video surveillance, intrusion detection etc.



Vehicles
telematics, cars, trucks, UAS/UAV, watercraft



Responders
body-worn video, dashcam video, SCBA, bomb robots, biomonitors, wearables



EMS Devices, Apps
AED, portable EKG, EPCR, ER tech



Control & Analysis systems, software