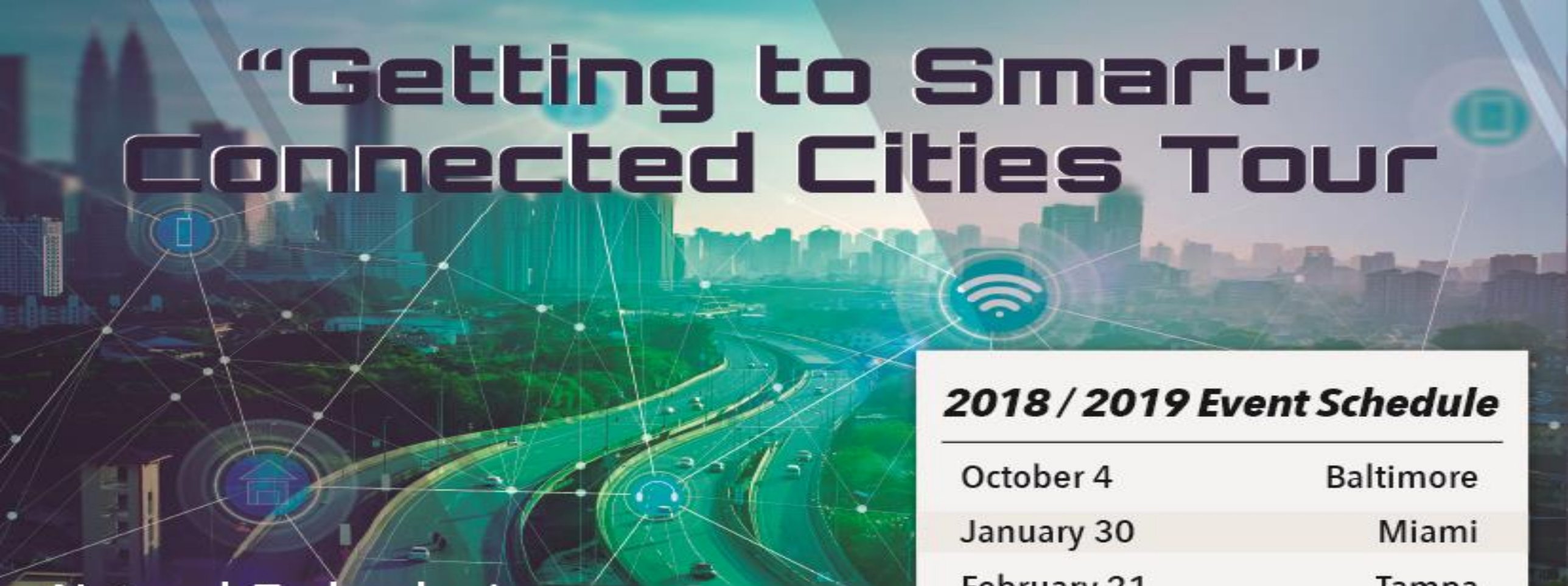
"Getting to Smart" Connected Cities Tour



Network Technologies:
4G/5G, IoT, Fiber, Small Cell and Wi Fi
Transforming how Society Connects.

Be part of the Solution
www.densenetworks.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

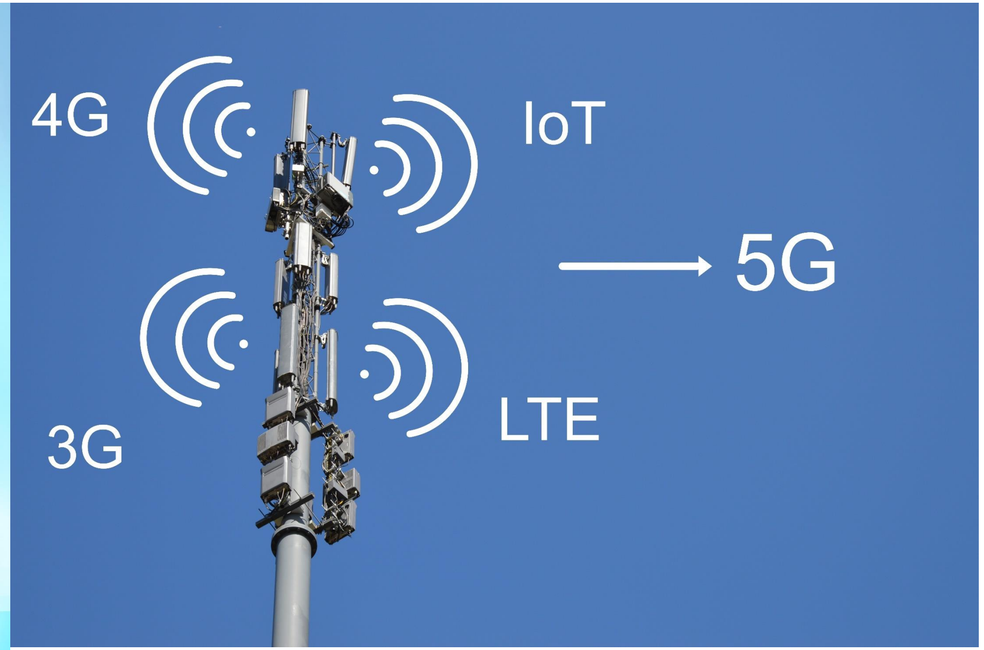

The UN predicts Global Population Growth
Greater than 30% by 2050
The Majority will be in Cities

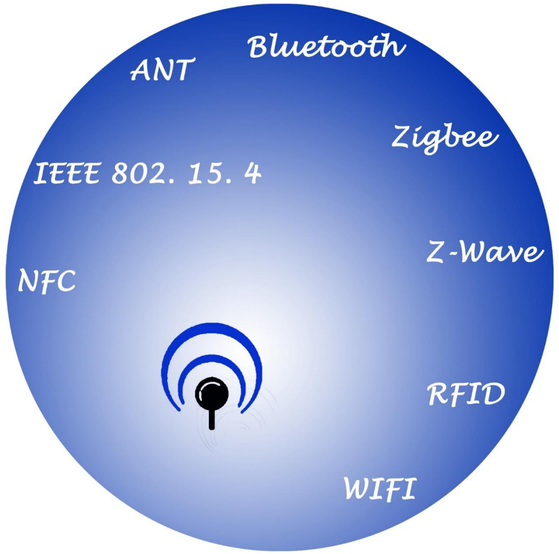

ALWAYS ON


Connected City
Smart City

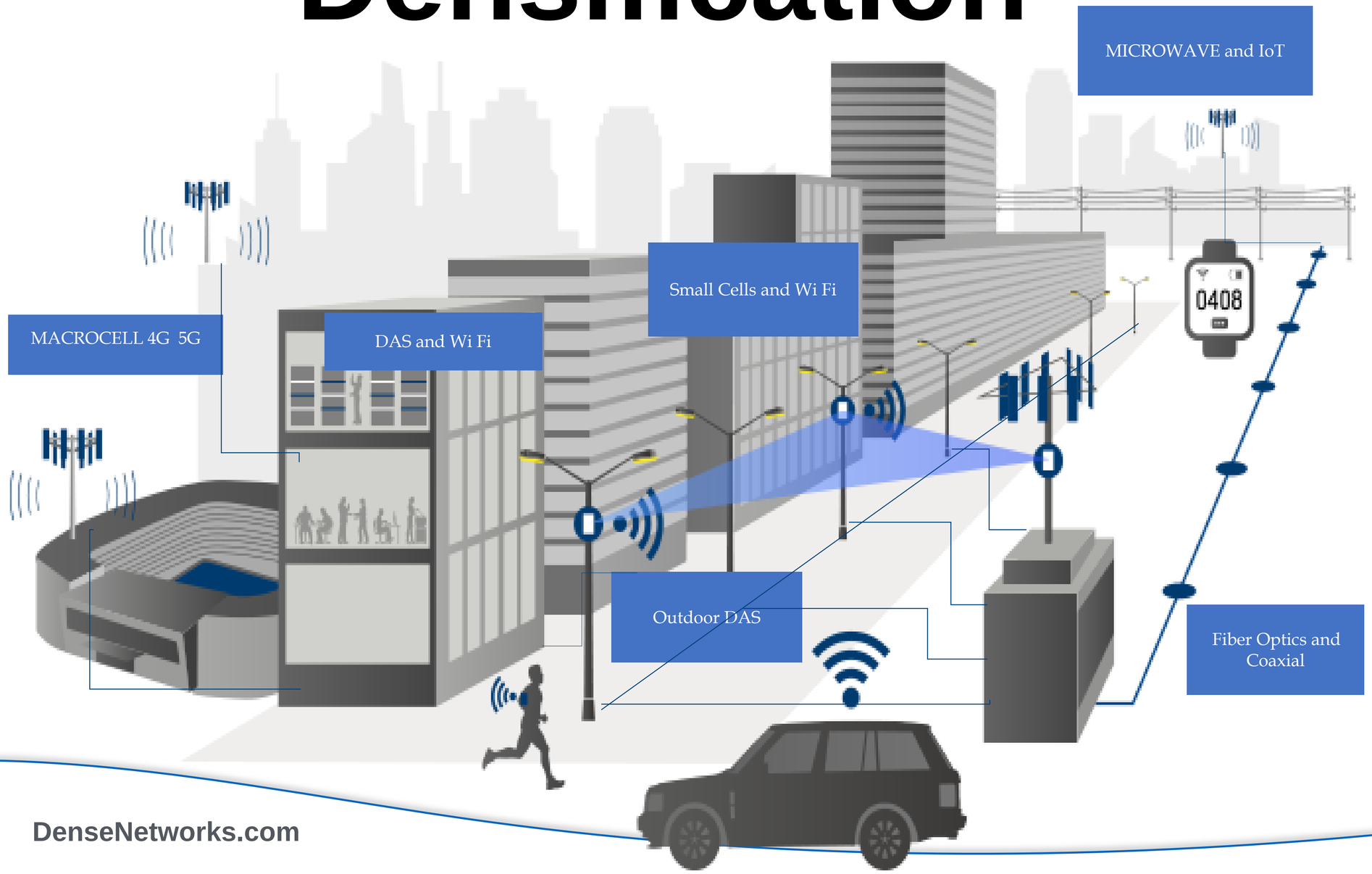
How Many Networks?

Capacity, Coverage, Compliance

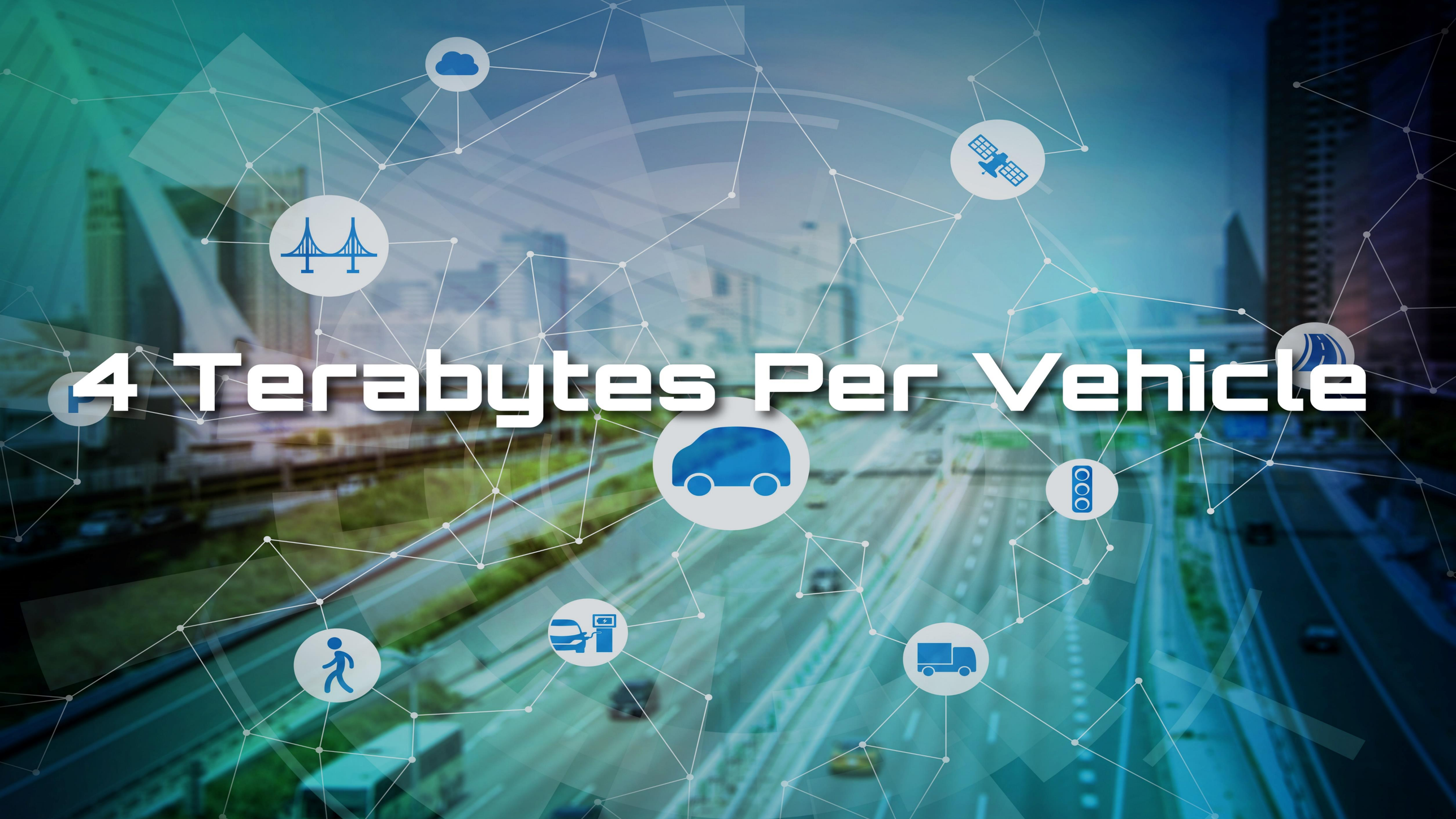




Densification

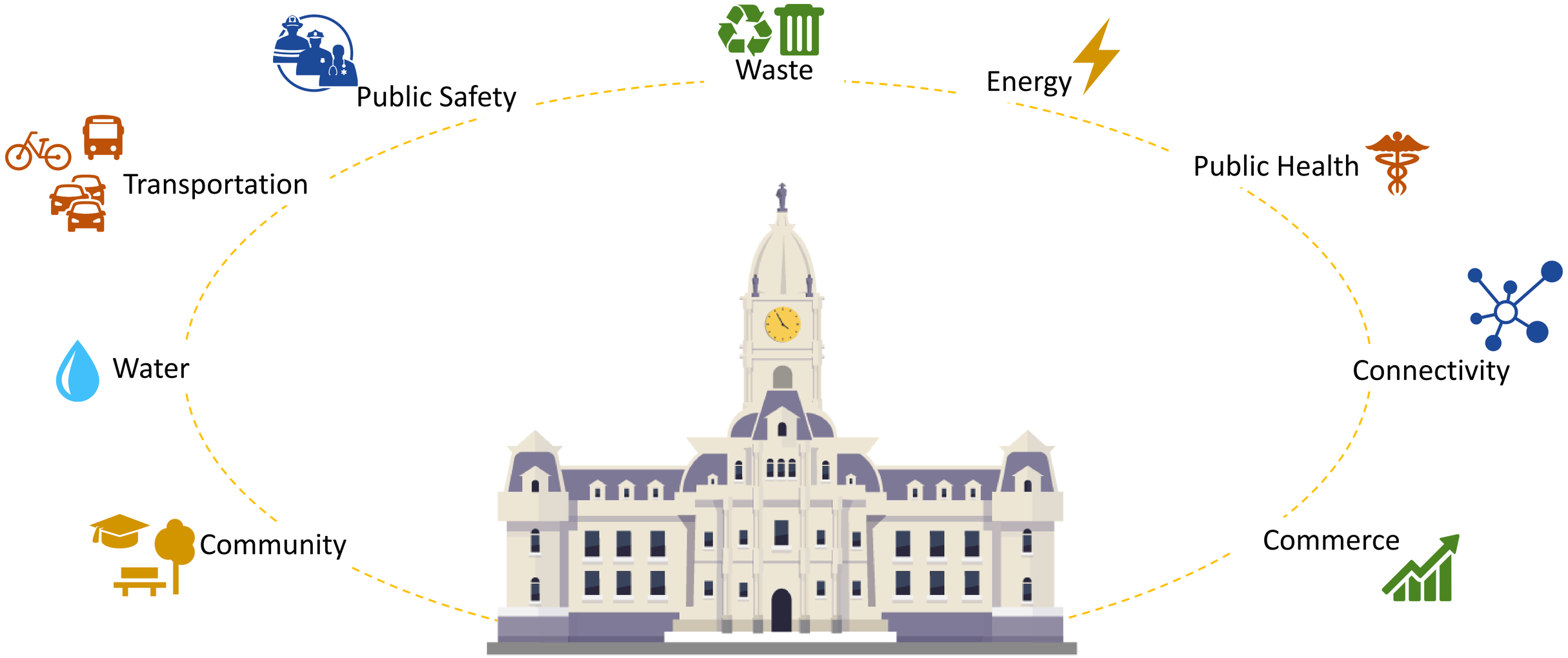



Autonomous
P
Connected

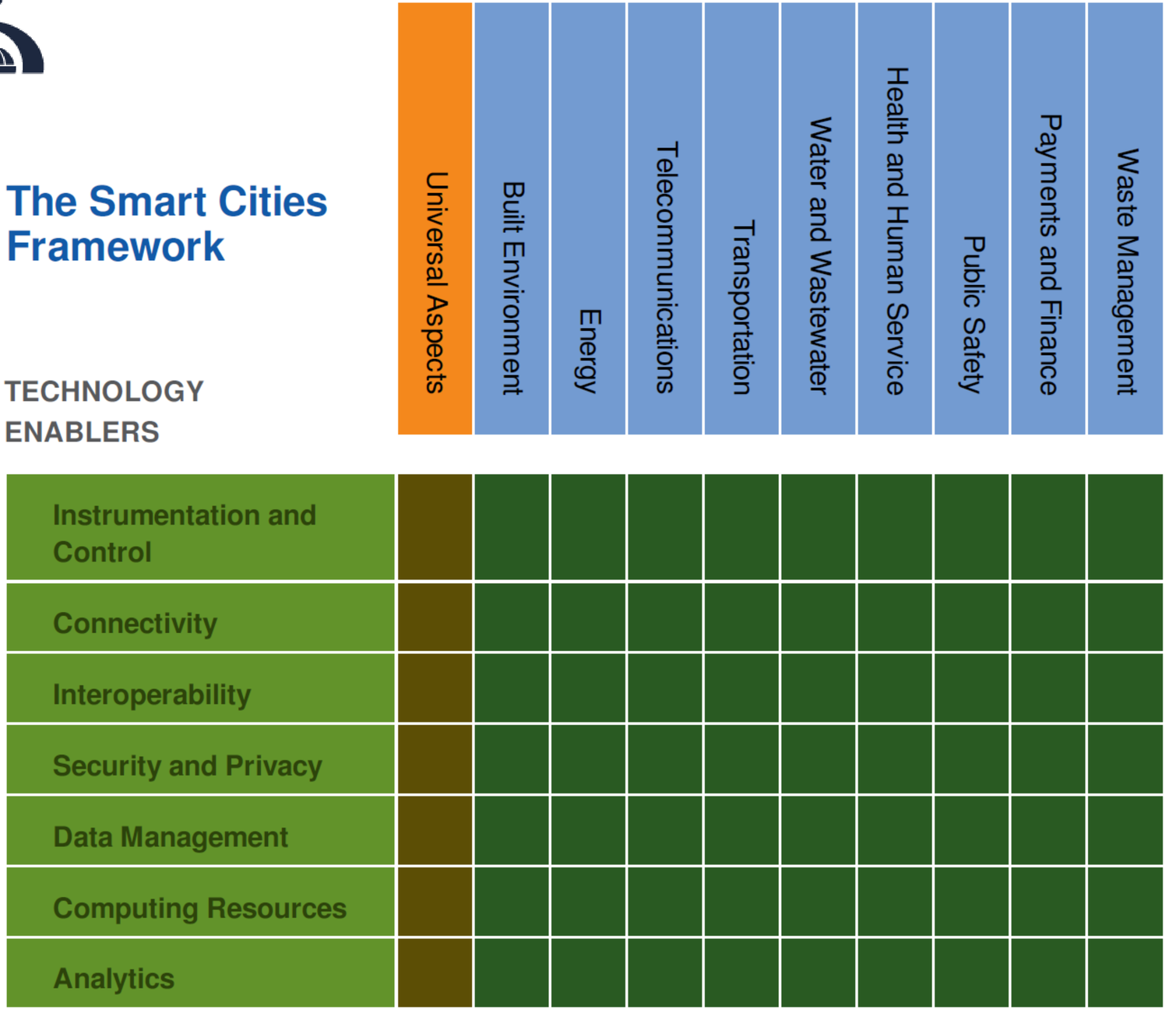

4 Terabytes Per Vehicle

The Big Picture

Smart Collaboration > Improved Efficiency > Faster Response > Better Service

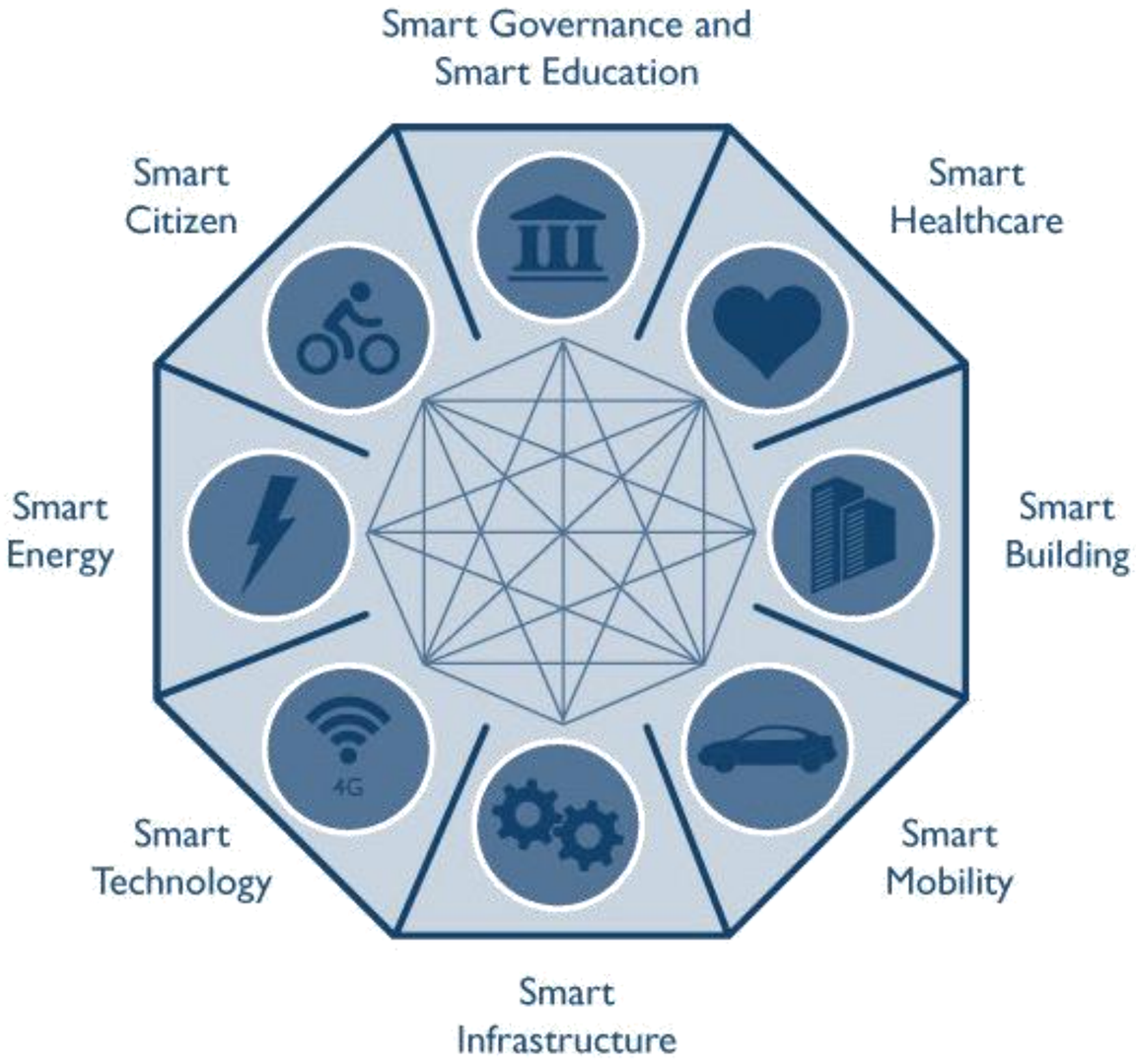


The Smart Cities Framework



How Does Orlando Define Smart City?

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



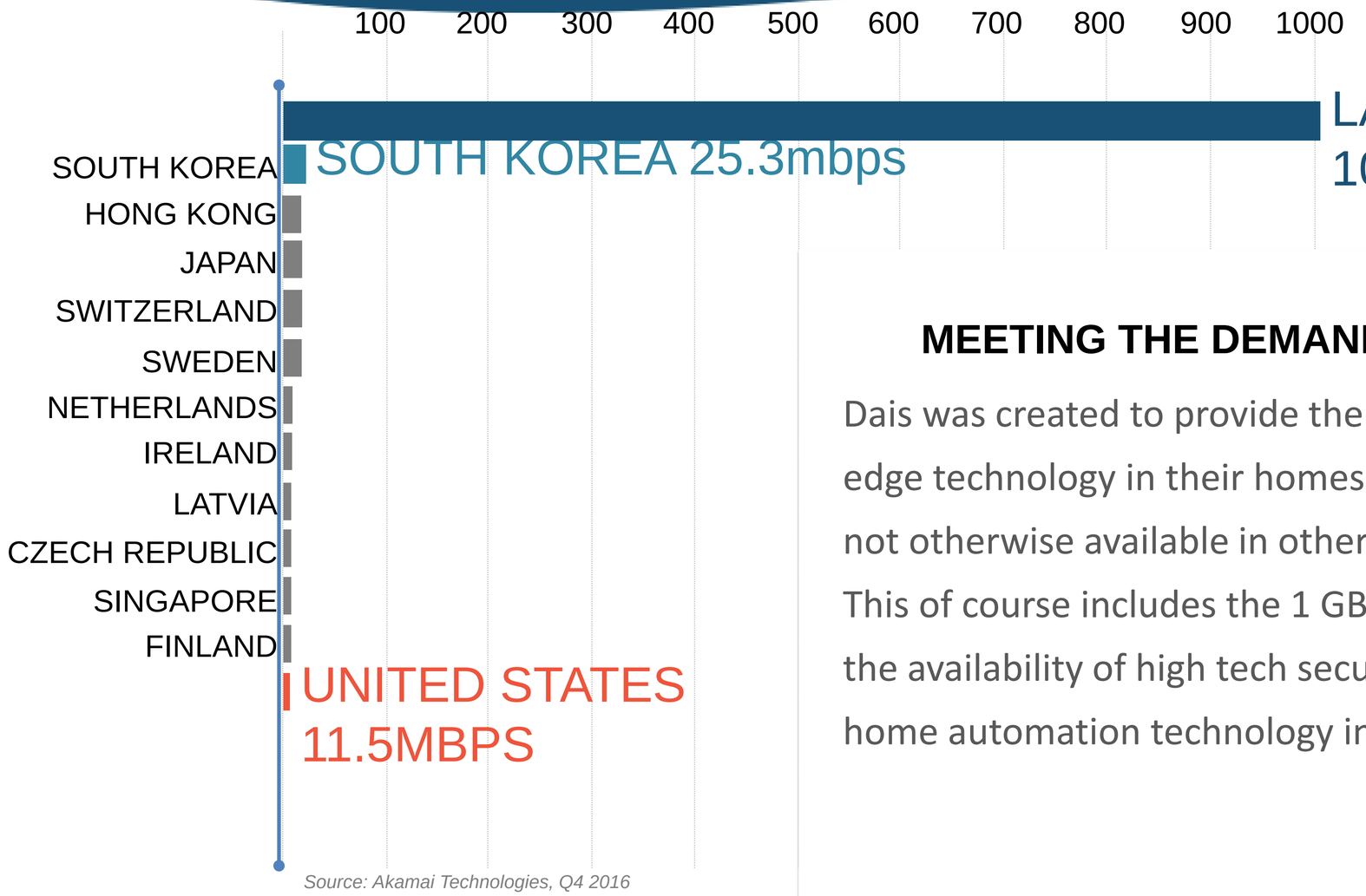
WELCOME TO LAKE NONA

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

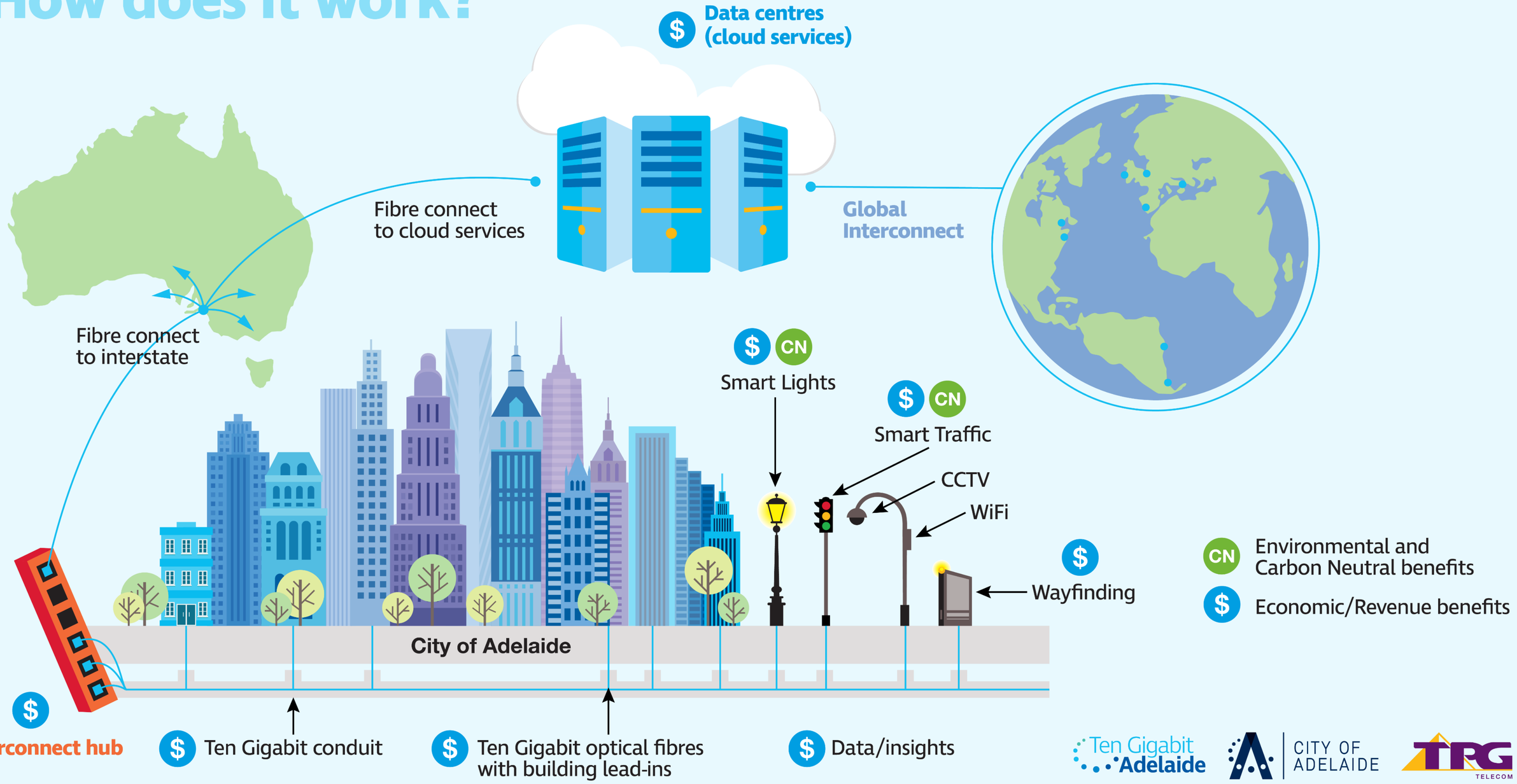
Dais was created to provide the residents of Lake Nona with cutting-edge technology in their homes -- something special and exciting, and not otherwise available in other premier Orlando neighborhoods. This of course includes the 1 GBPS internet connection It also includes the availability of high tech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

dais

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?



Ten Gigabit Adelaide

CITY OF ADELAIDE

TPG TELECOM
OFFICIAL NETWORK PROVIDER

Broadband Strategy

Hybrid Approach – 80% results for 20% effort

	Government-led	Hybrid model (Recommended)	Market-led
			
Summary	Cities building full fiber networks is expensive, complex, and risky **Too Risky**	Cities that welcome private investment with appropriate guidance are most successful **Just Right**	Cities with laissez faire broadband stagnate as cable-telecom duopolies **Too Ineffective**
Key Takeaways	• 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	• Seattle leveraged streamlined policies to drive competition and massive fiber buildout • NYC used franchise agreements to drive fiber build-out	• Broadband speed and price cluster to the bottom of the peer set • No substantial competition in any market-led city
Potential costs	**Very high.** City-owned fiber-to-the-premise would cost $800M+.	**Moderate.** Working with carriers could cost $50-250M based on build types.	**Very low or none.** City relies on private sector investment.
Results	Peers show **90%+ fiber build-out.**	Peers show **55-70% fiber build-out.**	Peers show **0-5% fiber build-out.**

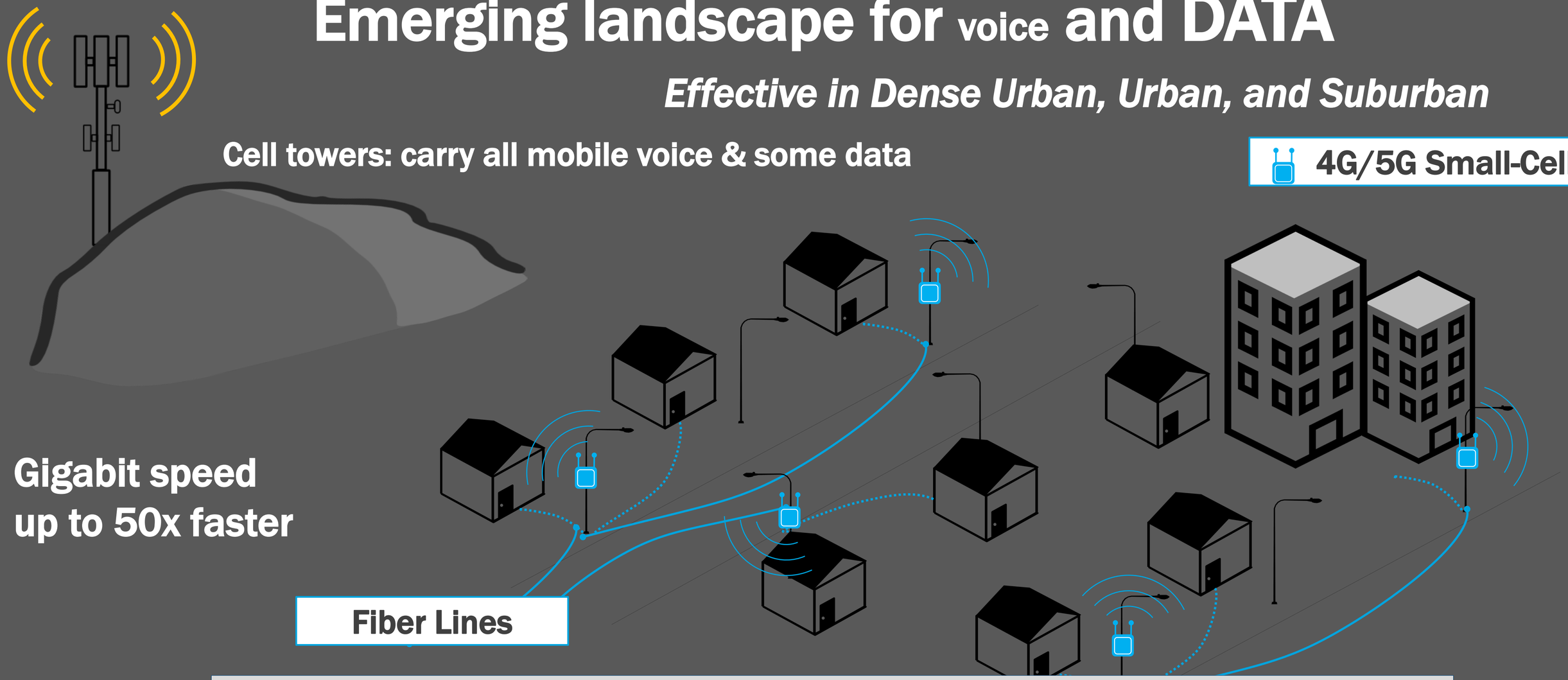
Broadband Strategy

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

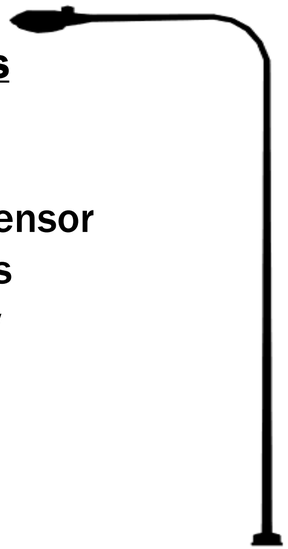
Fiber Lines

Light pole is most valuable asset for broadband

Broadband Strategy

STREETLIGHT

Light/Safety

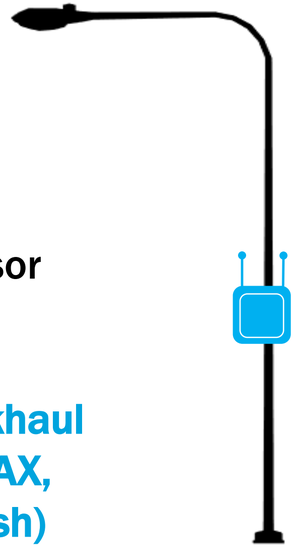


Properties

- Height
- Power
- Light Sensor
- Lumens
- Density

SMALL CELLs

Broadband Digital Infrastructure

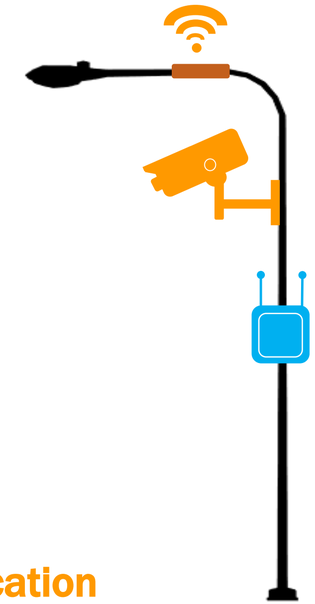


Properties

- 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

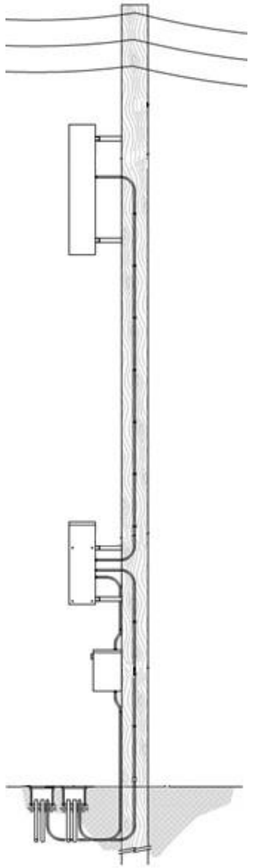
- **GOAL: 100% LED streetlight by 2020**

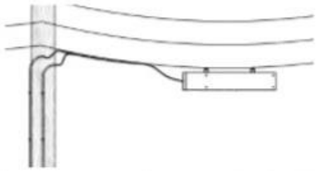
- OUC working to retrofit 20,000+ streetlights to LED
  - 12,480 currently retrofitted

- 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

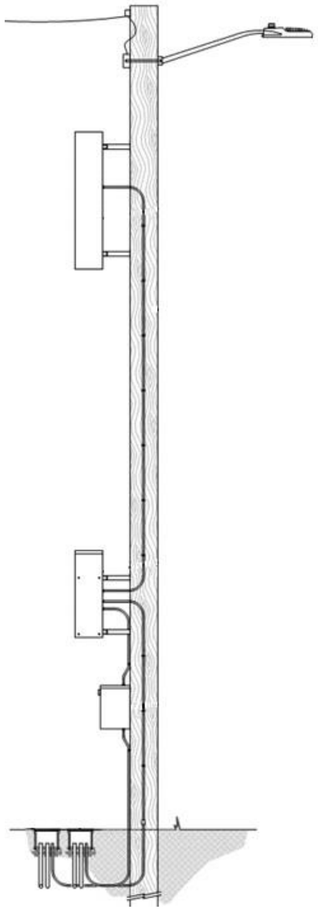
1





Onto or between
Xcel Utility Poles

2



Onto Xcel Wood
Street Lights

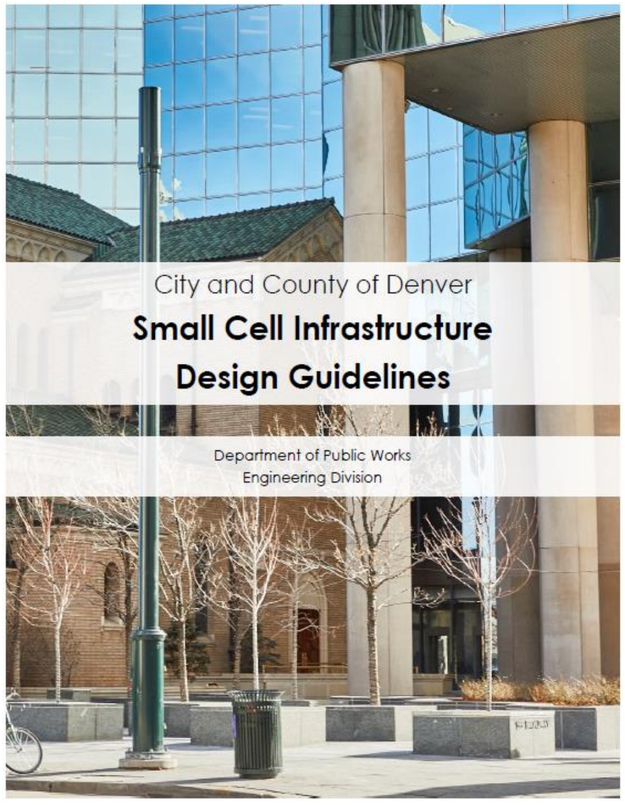
3

Remove & replace
Xcel Street Lights
with Hybrid

4

(Private)
Permitted
Freestanding
Antenna

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



- 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

DENVER THE MILE HIGH CITY

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

JACOBS

Jacobs Engineering Group
Mike Butters, Project Manger

CLANTON & ASSOCIATES
LIGHTING DESIGN AND ENGINEERING

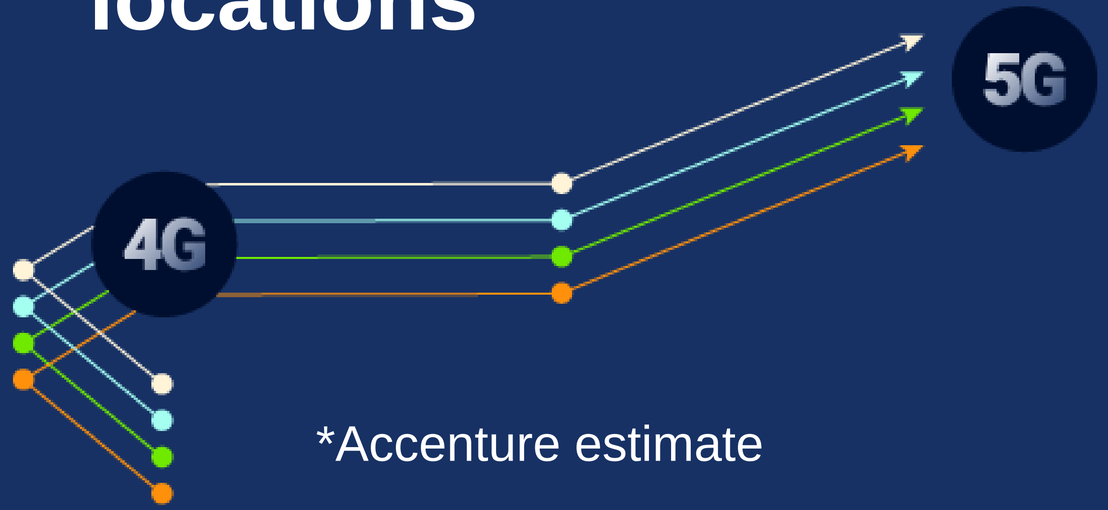
Clanton & Associates:
Nancy Clanton, CEO
Dane Sanders, Principal
Annie Kuczkowski, Engineer II - Lighting

Aero *Wireless Group*

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

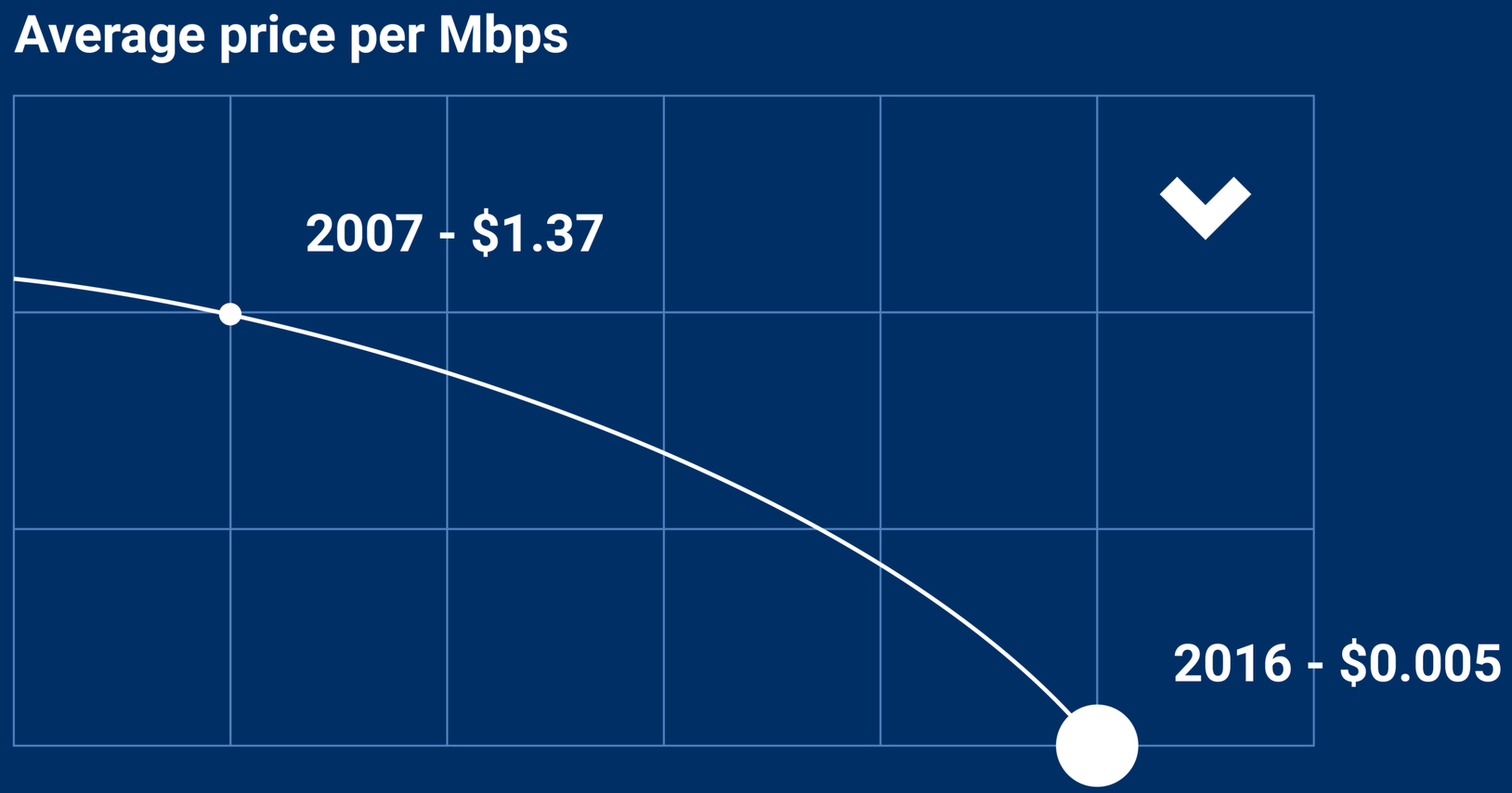
5G Momentum

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



*Accenture estimate

How Low Can It Go?



Source: FCC’s “Twentieth Wireless Competition Report”


Connectedness

Technology Megatrends

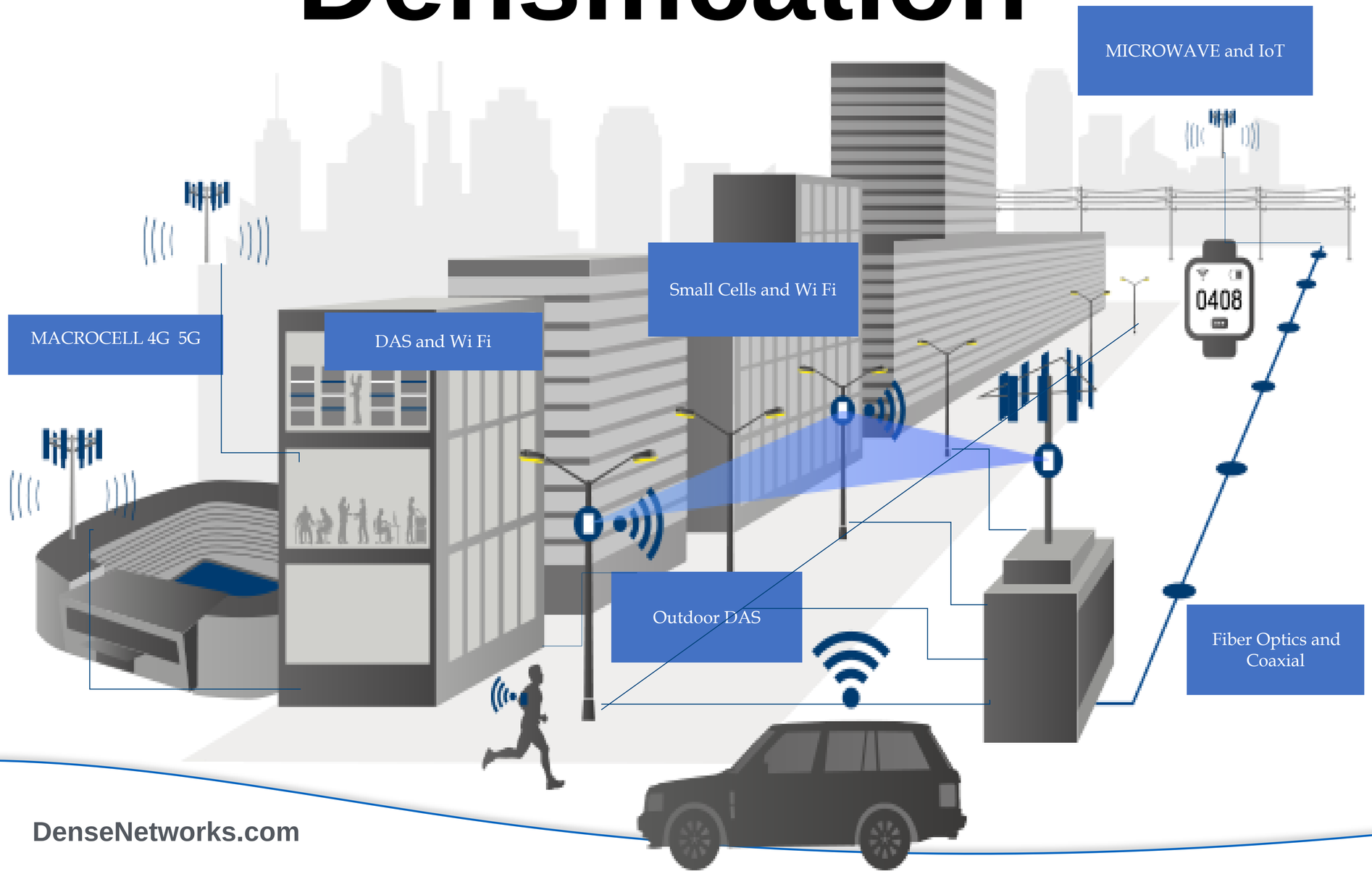
Smart City Initiatives

LED Conversions

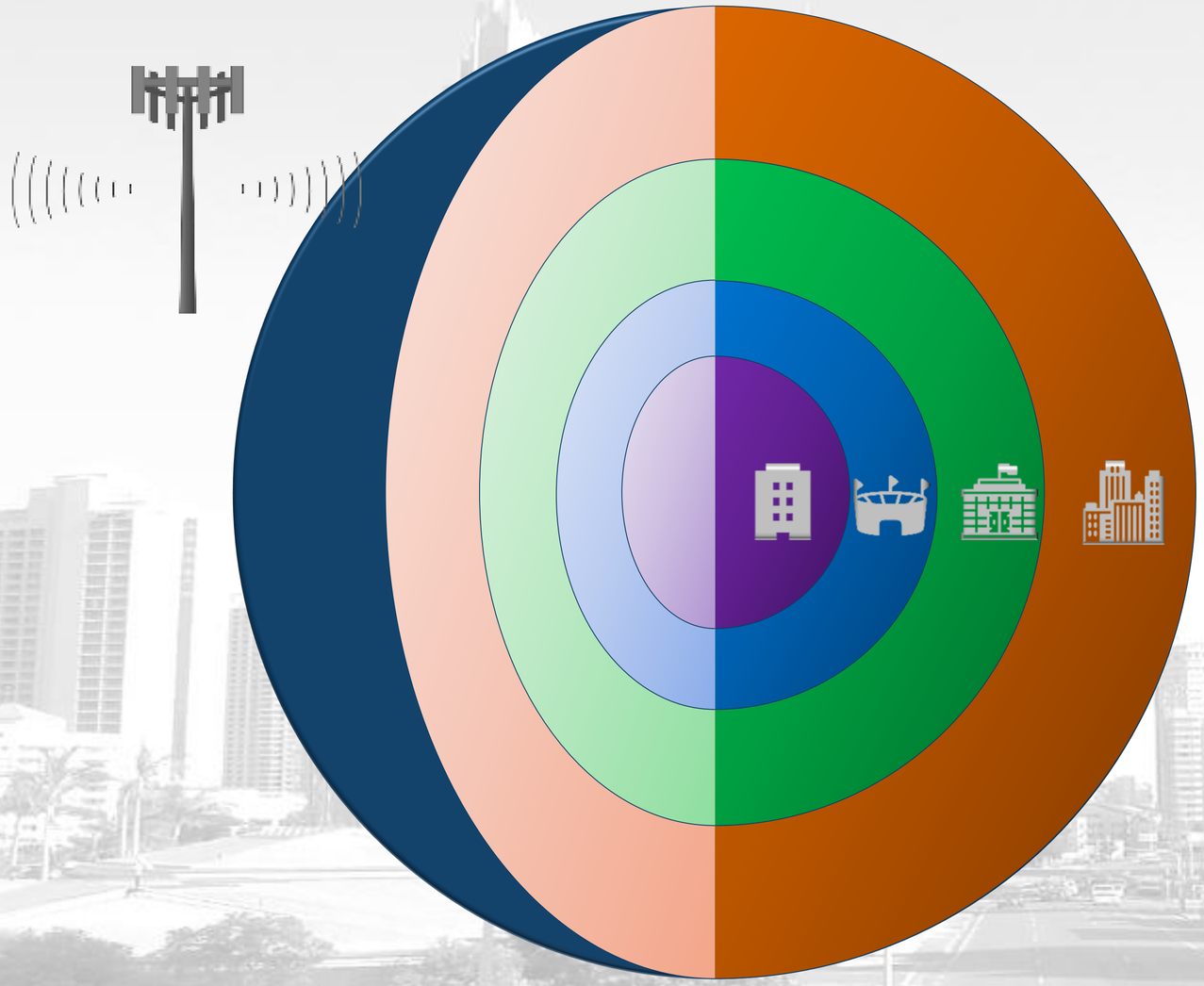
Network Densification

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

Densification



Mobile Convergence



CITY

Densification

CAMPUS

Coverage

VENUE

Capacity

BUILDING

All of the above

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

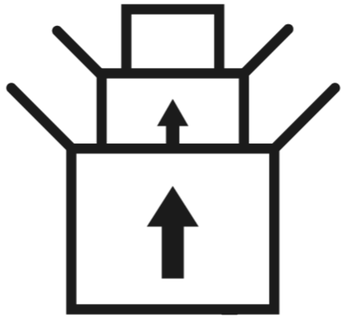
Business case is economic development, private sector opportunity, service improvement

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

WHAT'S NEXT

PREPARING FOR 5G

Program will adapt to new technology and deployment models



INCREASED DEPLOYMENT

Pace of deployments expected to increase to meet wireless data demand

REGULATORY RISK

Federal or state policy could undermine successful structure of program

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

Innovating and evolving 4G

Ultra-high speed

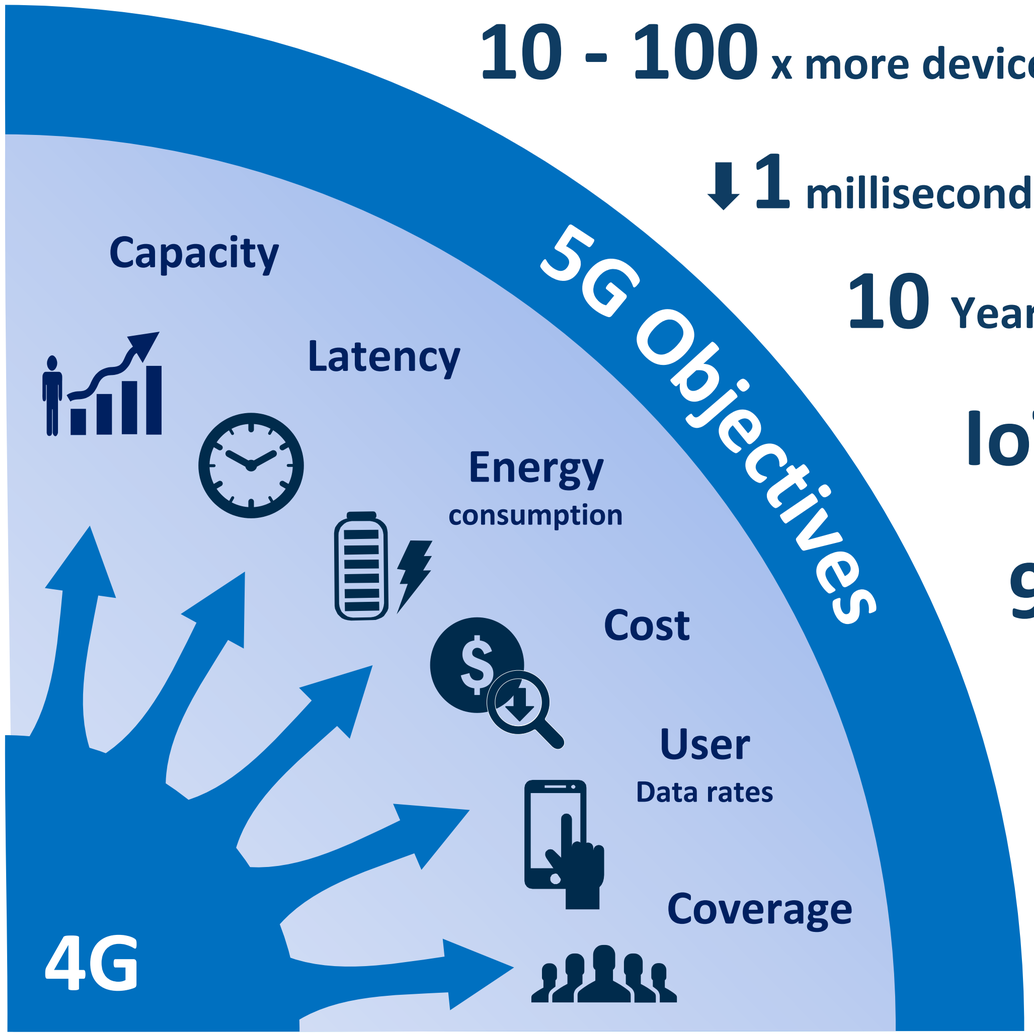
Single-digit millisecond response

Connecting Internet of Things

Inherently secure

Intelligent Edge Network

5G Objectives



10000 x more traffic

10 - 100 x more devices

⬇**1** millisecond latency

10 Years M2M battery life

IoT ultra low cost

90% less network energy usage

⬆**10** Gbit/s peak data rates

100 Mbit/s wherever needed

5-9s availability/reliability

CITY GOALS

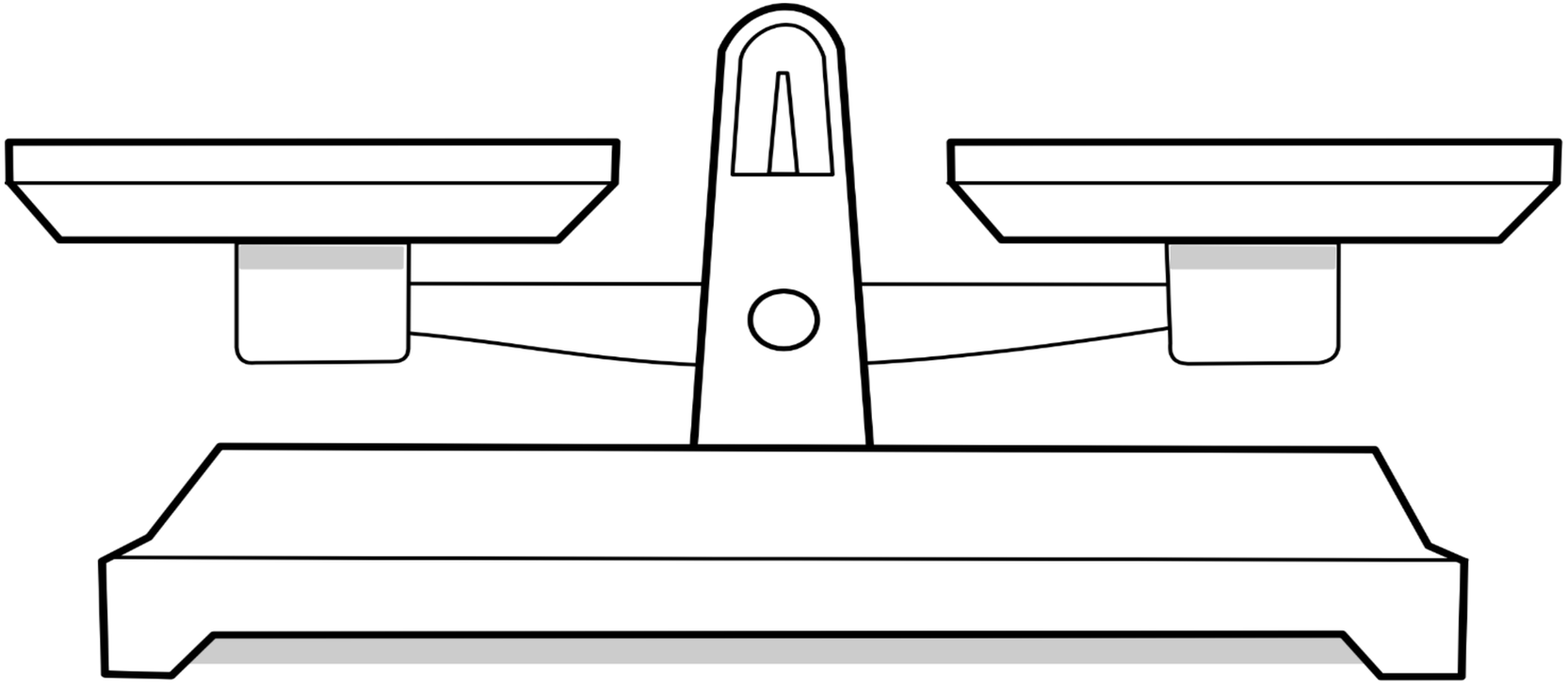
- *Minimize aesthetic impacts*
- *Encourage competition in wireless market*
- *Community awareness / comfort*
- *Fair compensation for use of public asset*

INDUSTRY GOALS

- *Fast and predictable approvals*
- *Large volume of installations*
- *Manageable community process*
- *Appropriate pricing models for carriers and neutral hosts*

SHARED GOALS

- *Great wireless service in every neighborhood*
- *Avoid community concerns with deployment*



A Tidal Wave of Antennas

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

Making the Technology Disappear

10ft
Link NYC

14ft
Verizon LQD

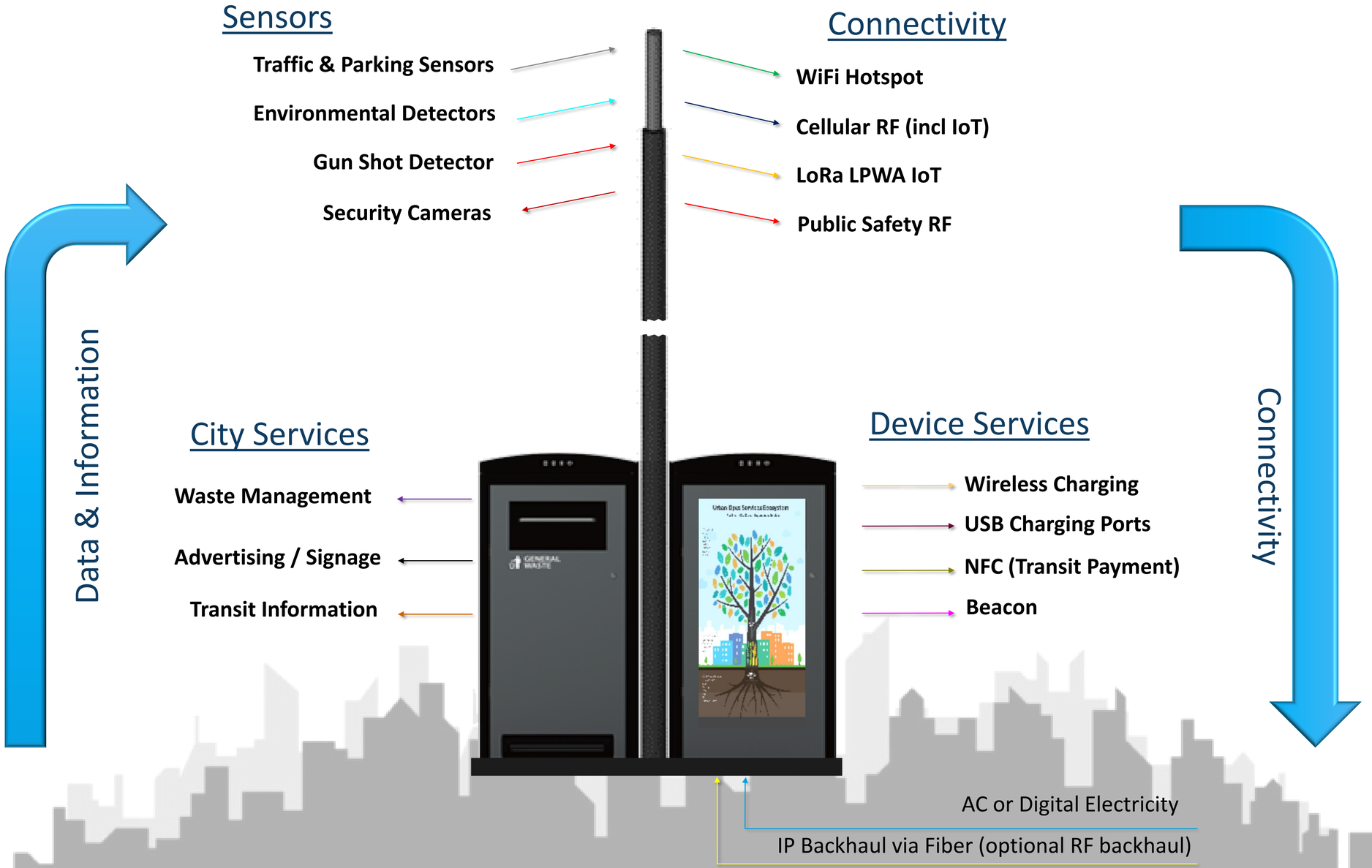
14ft
Citi Bike

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

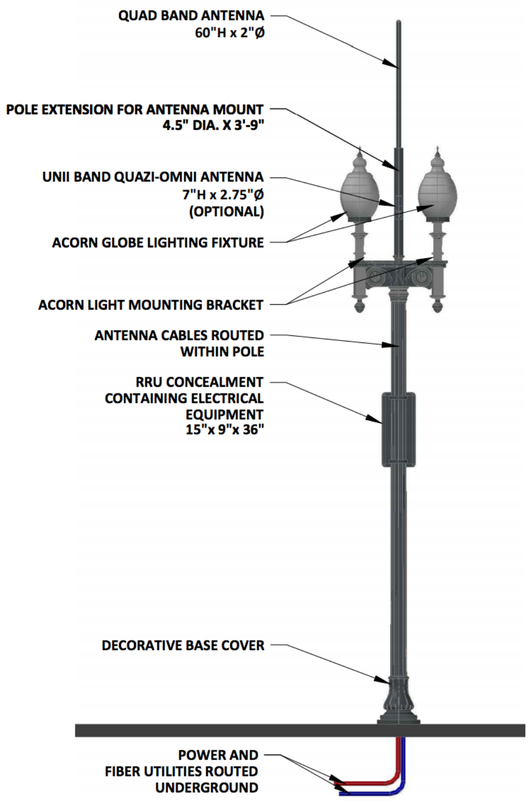
Smart Parking

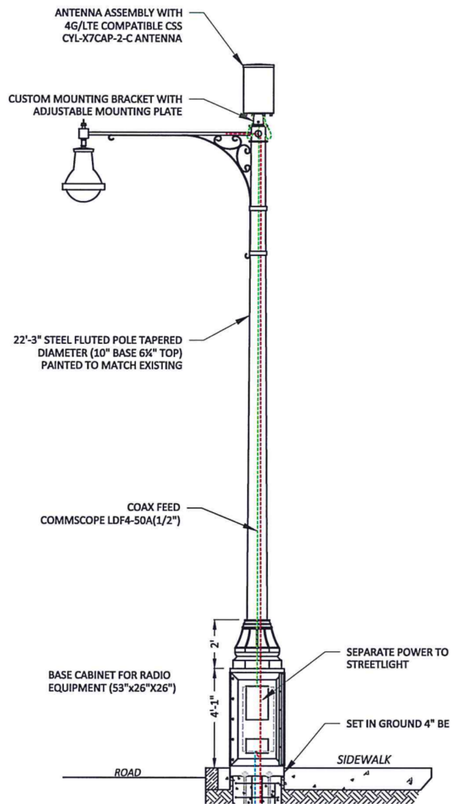
Smart Traffic

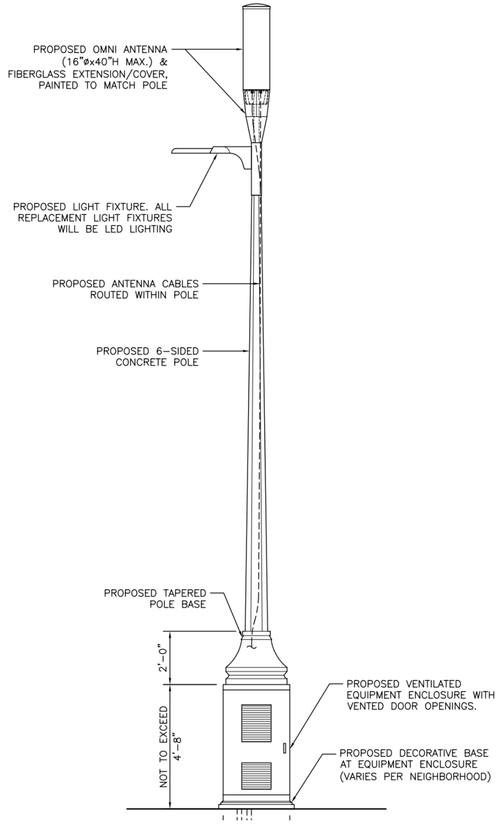
Video Surveillance

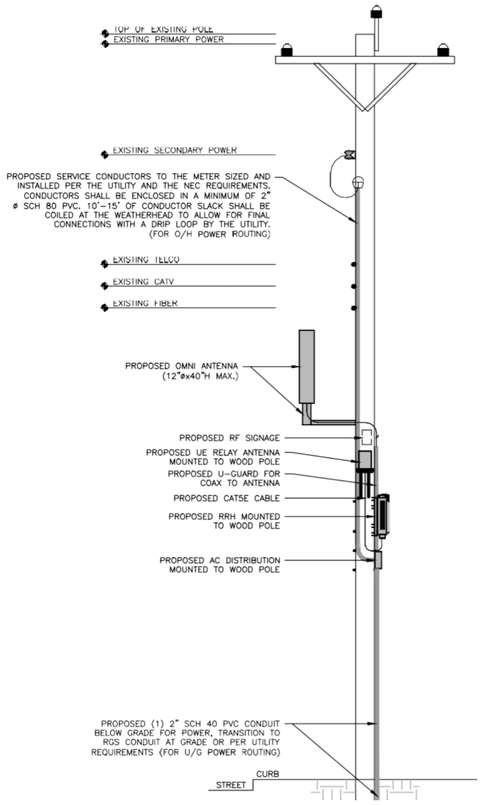
verizon

COOPERATIVE DESIGN PROCESS





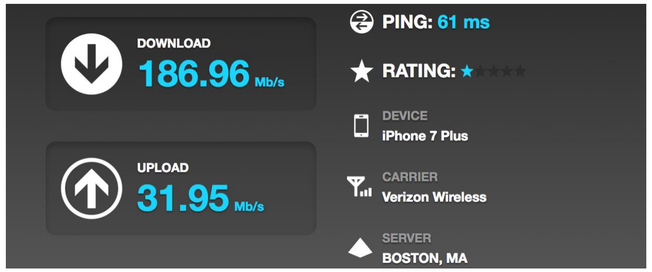




- *City and Licensees develop designs for replacement lights together*
- *Heavy focus on aesthetics, concealment, and historic character*
- *Once approved, design can be used by any licensee*

RESULTS (OCTOBER 2017)

- *>800 approved or installed, 314 in process*
- ***90% approved within 10 business days, 100% within 28 business days***
- *Improved wireless service*



- *Funding for digital equity programs and hotspot lending*
- *Positive relationship between City and licensees*

Smart Pole – Use Cases

Dense Urban
i.e., CBDs

Venues / Events
i.e., arenas, resorts

Suburban
i.e., PUDs

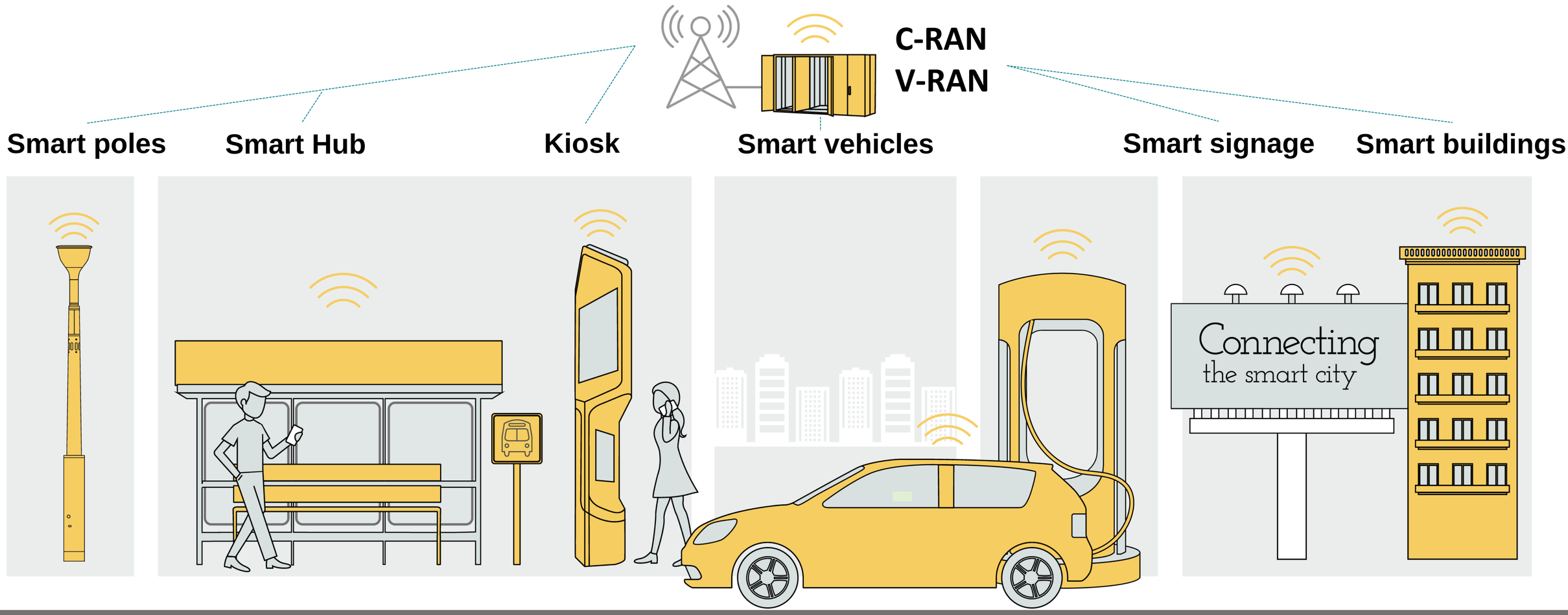
Parks / Historic
i.e., aesthetically - sensitive environs

Capacity-Driven

Coverage-Driven

Smart pole use cases extend *beyond* urban centers

Enabling the Connected City



Shared wireless infrastructure facilitates a connected city

Metro Area Neutral Host

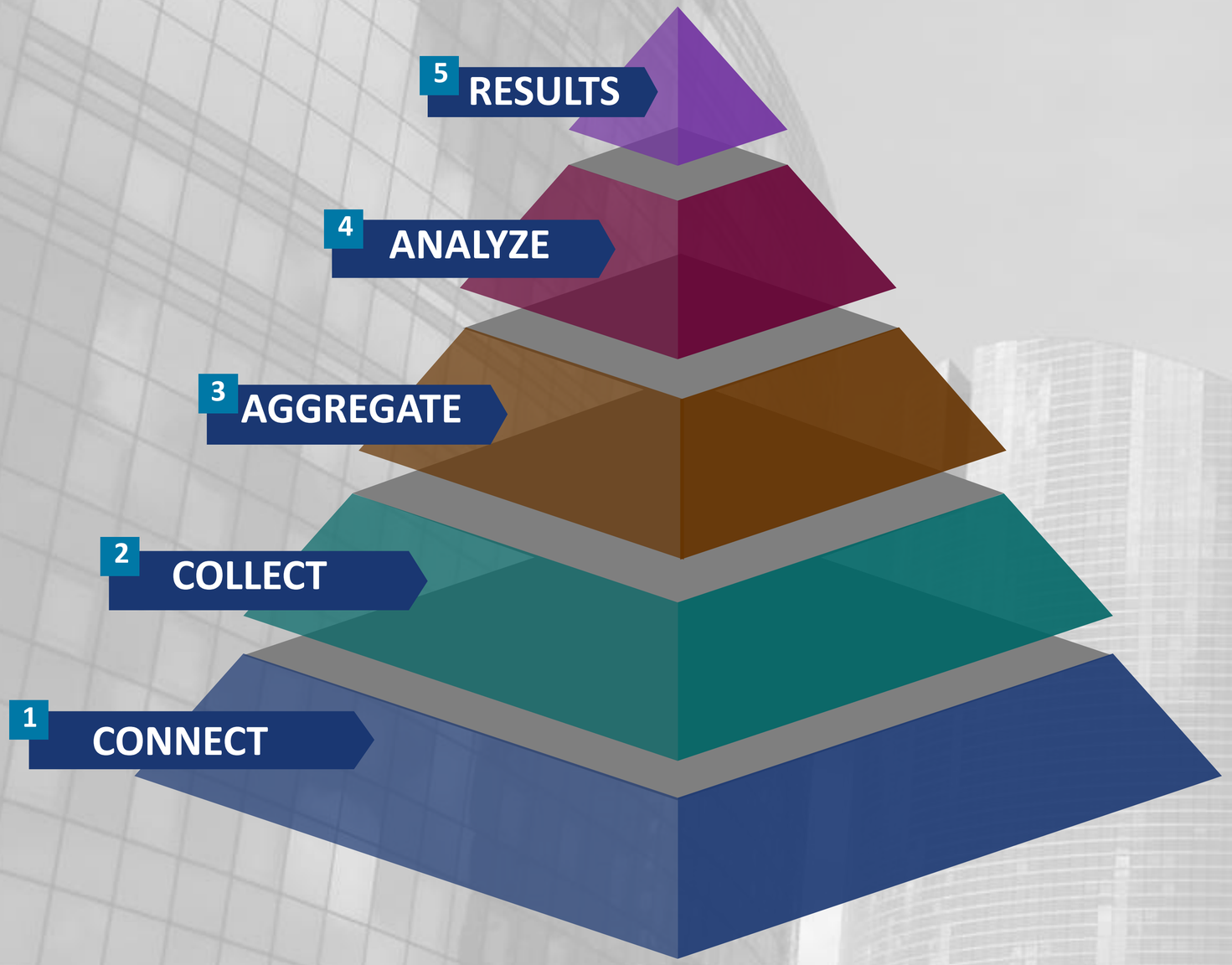
SAN FRANCISCO
DEPARTMENT OF
TECHNOLOGY

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

*Dates are subject to change.

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.

JMA WIRELESS

Integrated Smart Communities

Intelligent Lighting

Public Safety

Intelligent Traffic Management

Traffic Data Services

Parking Optimization

Intersection Safety Analytics

Smart City Hub

Network densification

Connectivity

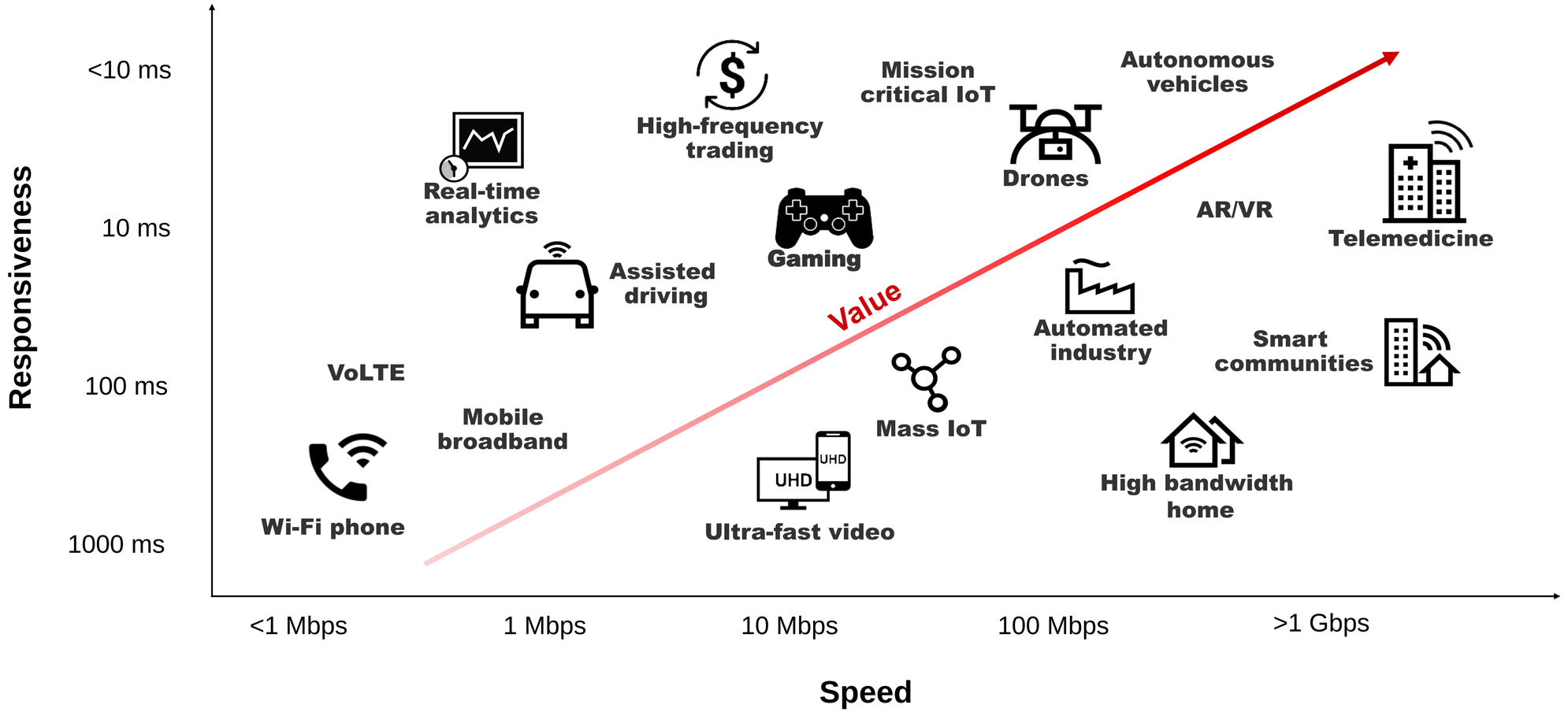
Fiber Small cell 4G/5G/Wi-Fi

One Fiber

Improving sustainability and efficiency | Reducing crime and increasing security | Enhancing citizen experience

verizon

Transform your business in ways never before imagined.

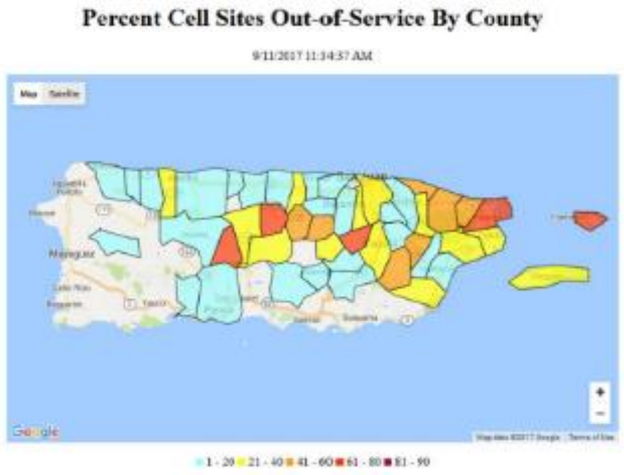


Hurricane IRMA – Early September 2017

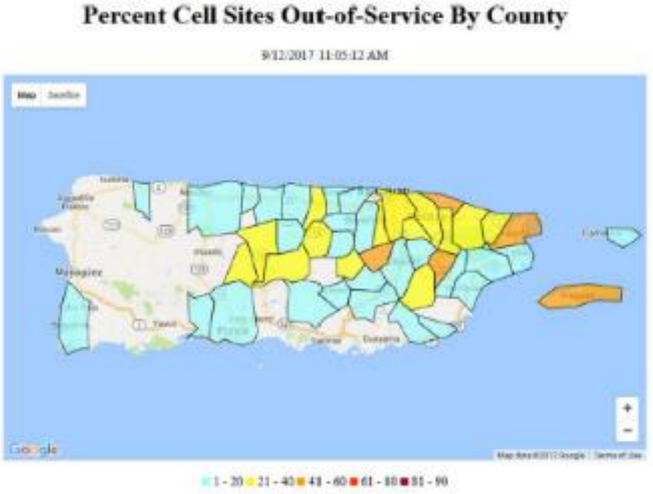
- In FL **3,973 of 14,730** out (27.4%) with 6 counties >50%, 2 counties >80%.
- In PR & USVI **497 of 1,850** (26.9%) out with
  - St Johns 9/10 out
  - St Thomas 44/57 out
  - St Croix 9/40 out

Florida:

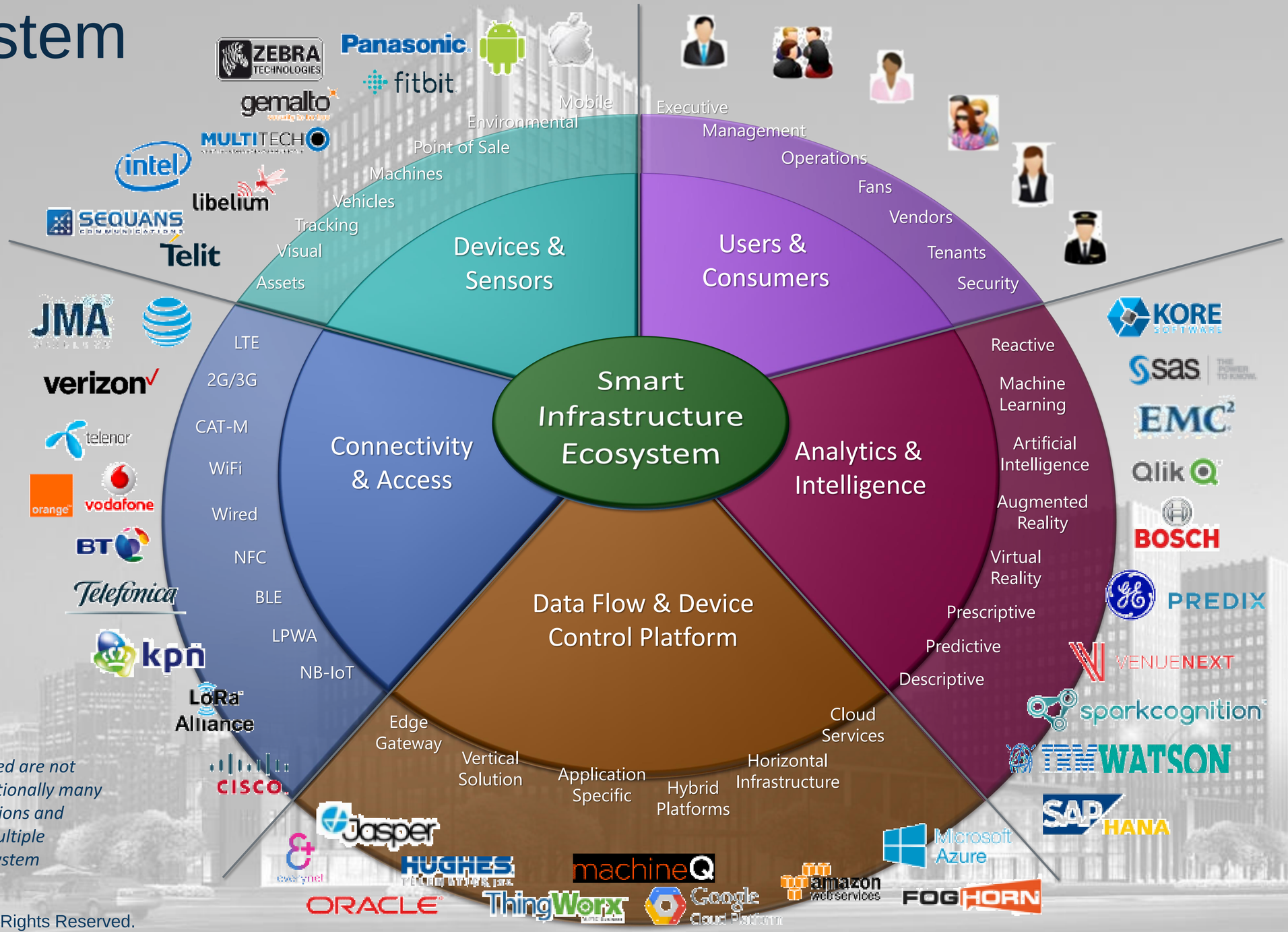
Alabama, Florida, and Georgia:



Puerto Rico:



Ecosystem



NOTE: Companies listed are not comprehensive. Additionally many companies have solutions and products that span multiple segments of the ecosystem

Verizon Smart Communities

Disruption can happen very fast…

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

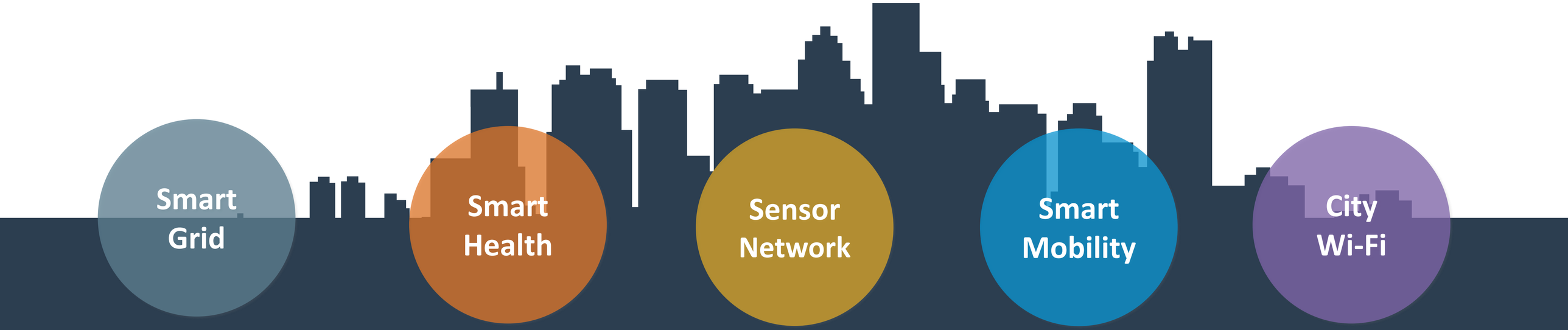
Source: US National Archives.

Disruption can happen very fast...

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

Source: George Grantham Bain Collection.

Smart Cities need smart infrastructure



Smart Grid

Smart Health

Sensor Network

Smart Mobility

City Wi-Fi

Energy Efficiency

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

Healthier Cities

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

Civic IoT

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

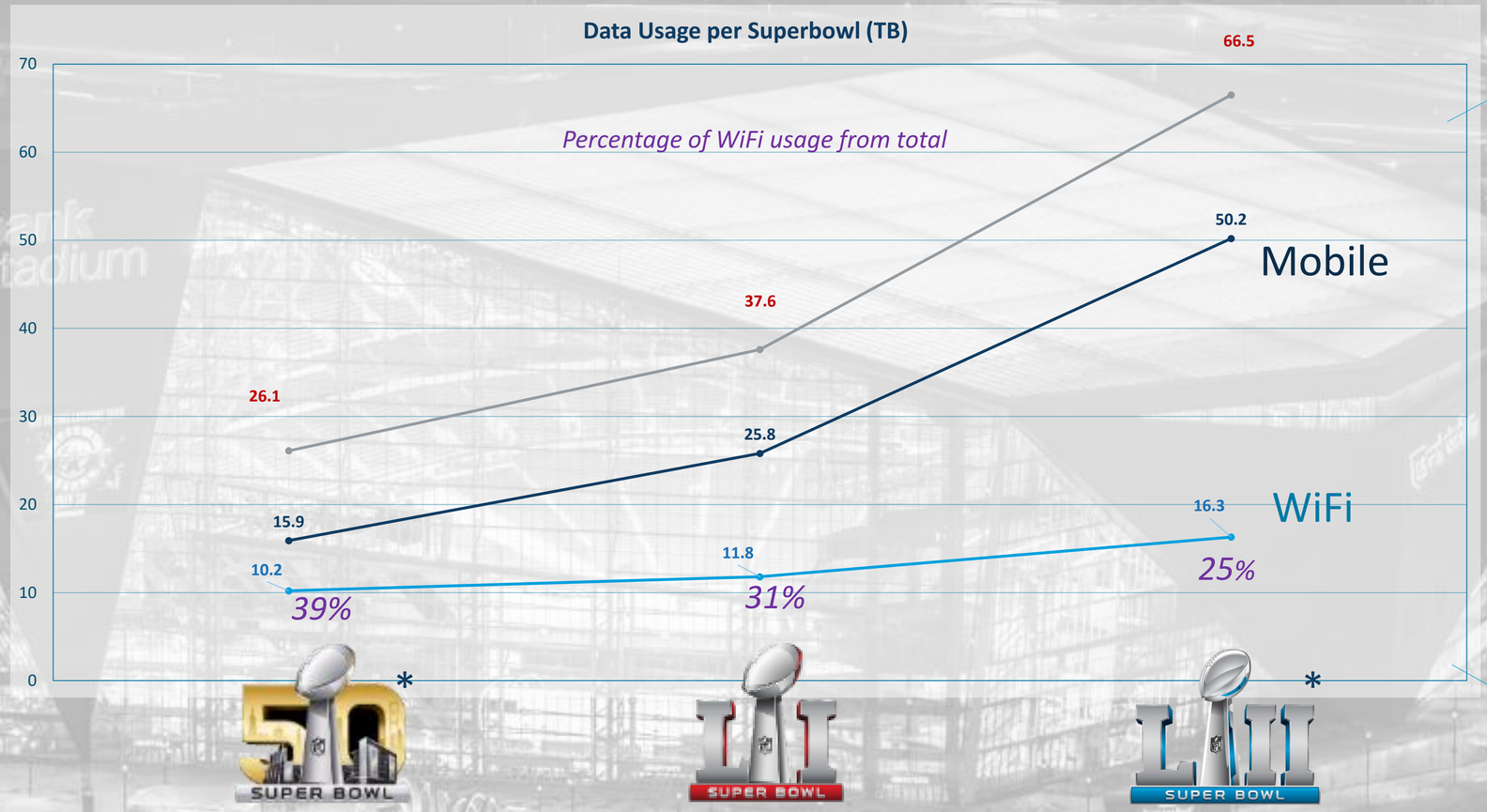
Safer Streets

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

Connected Community

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

Mobile/Wireless Bandwidth Demand

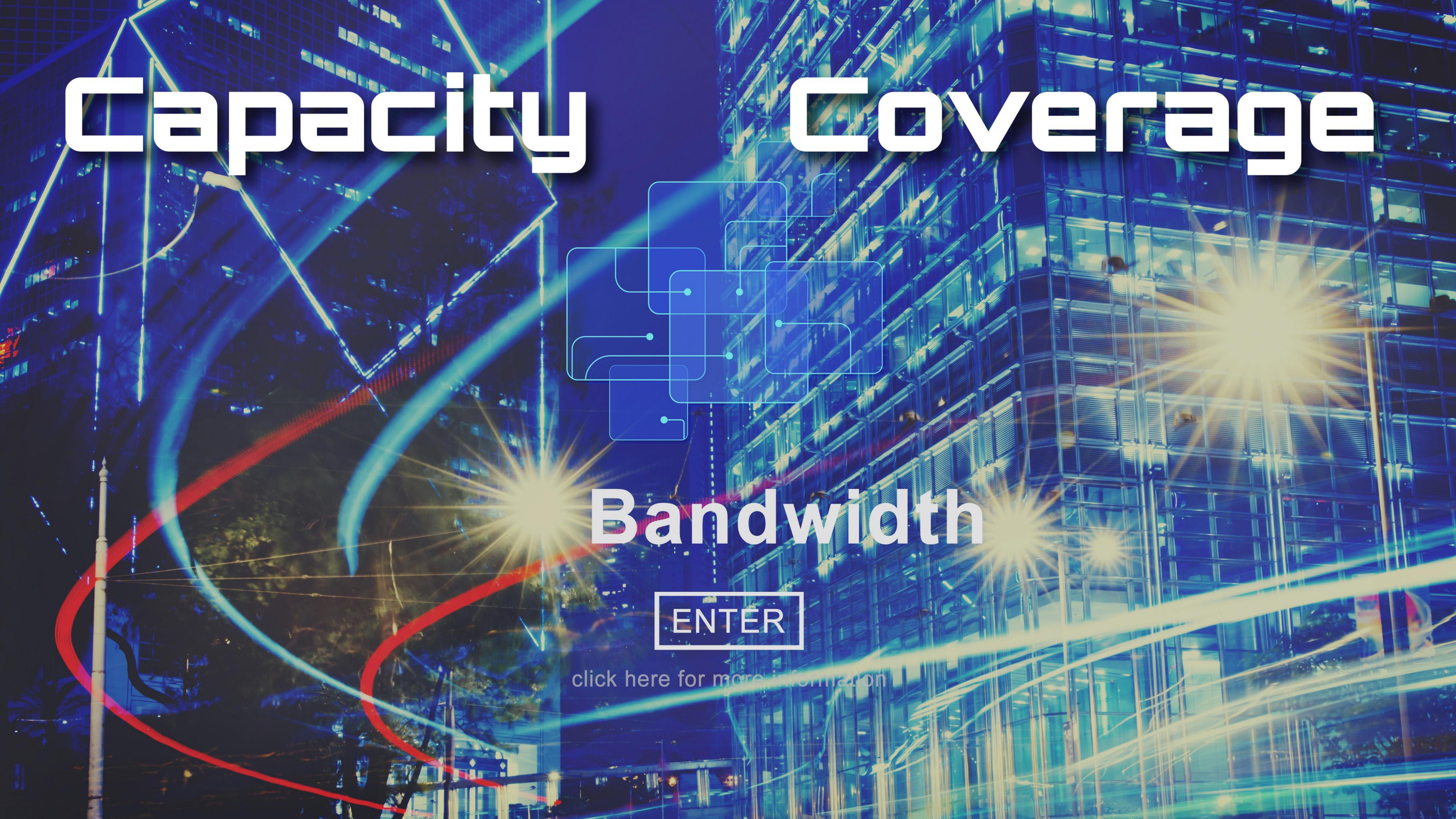


x17

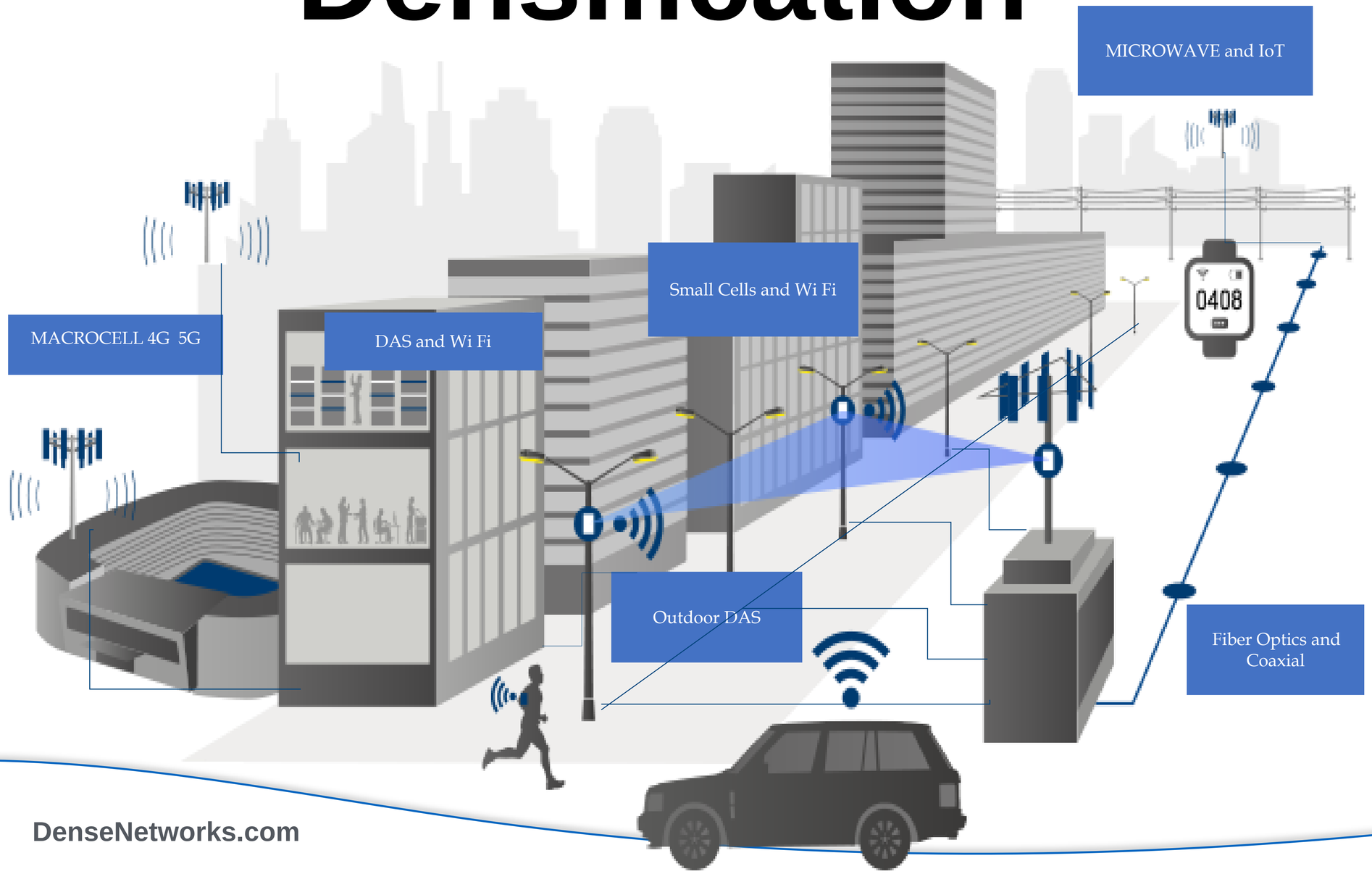
** JMA Wireless in-building solutions used for mobile traffic*

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

Densification



Smart Cities invest in smart infrastructure like fiber

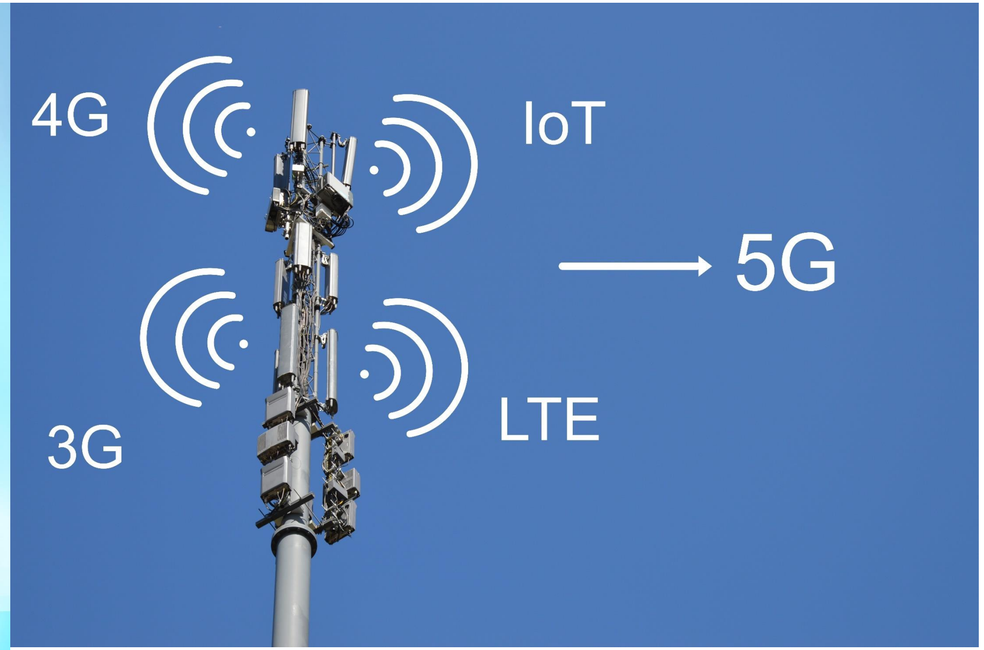
According to 2018 research from RVA, LLC:

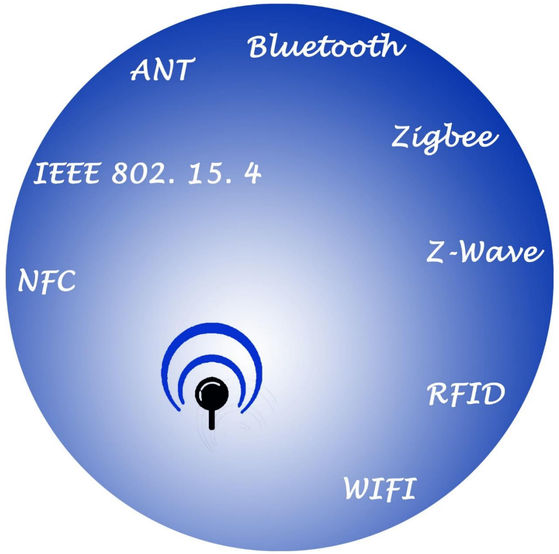
Fiber Cities are more likely to be Smart Cities

- 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.

How Many Networks?

Capacity, Coverage, Compliance

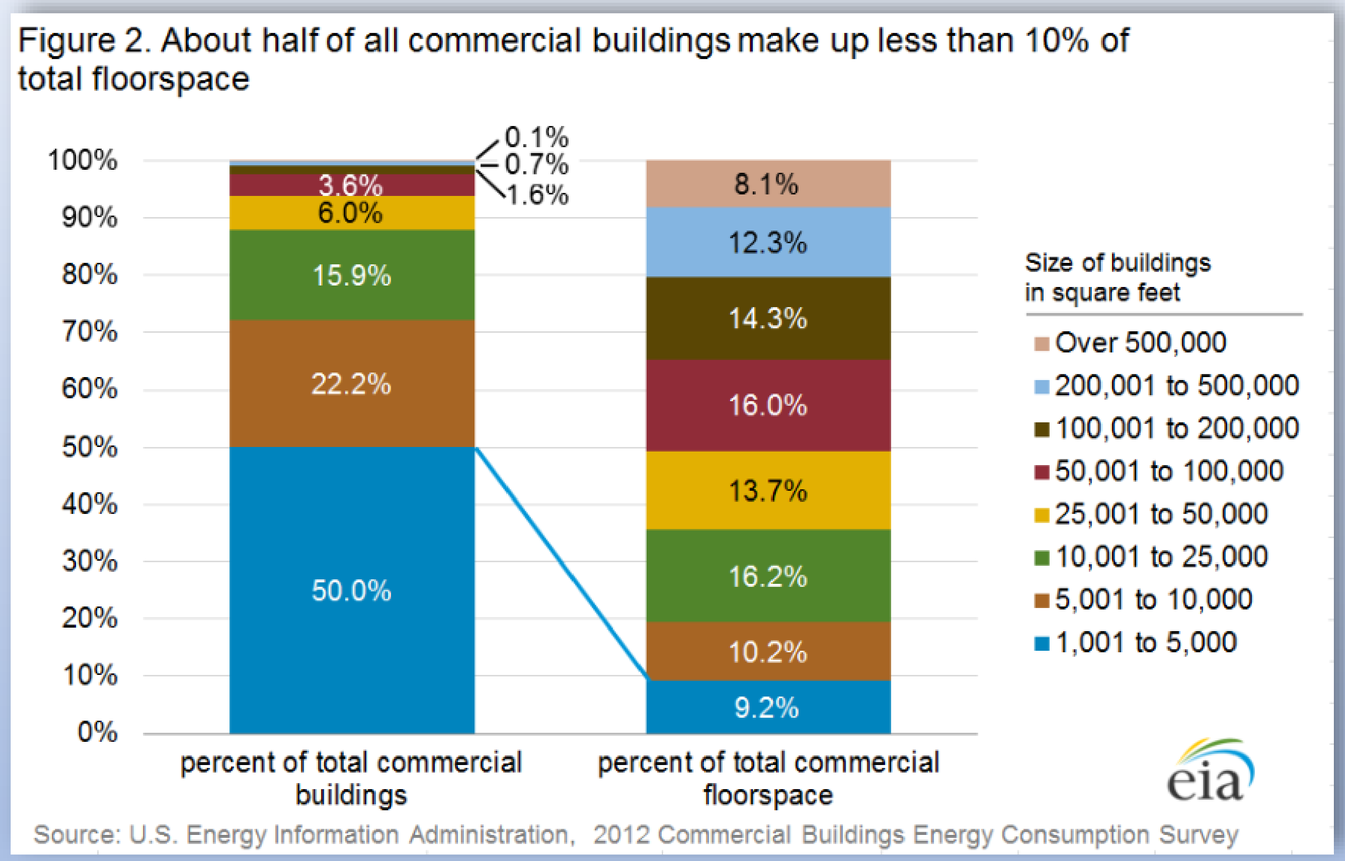




DAS

In-Building Public Safety – US Market Size

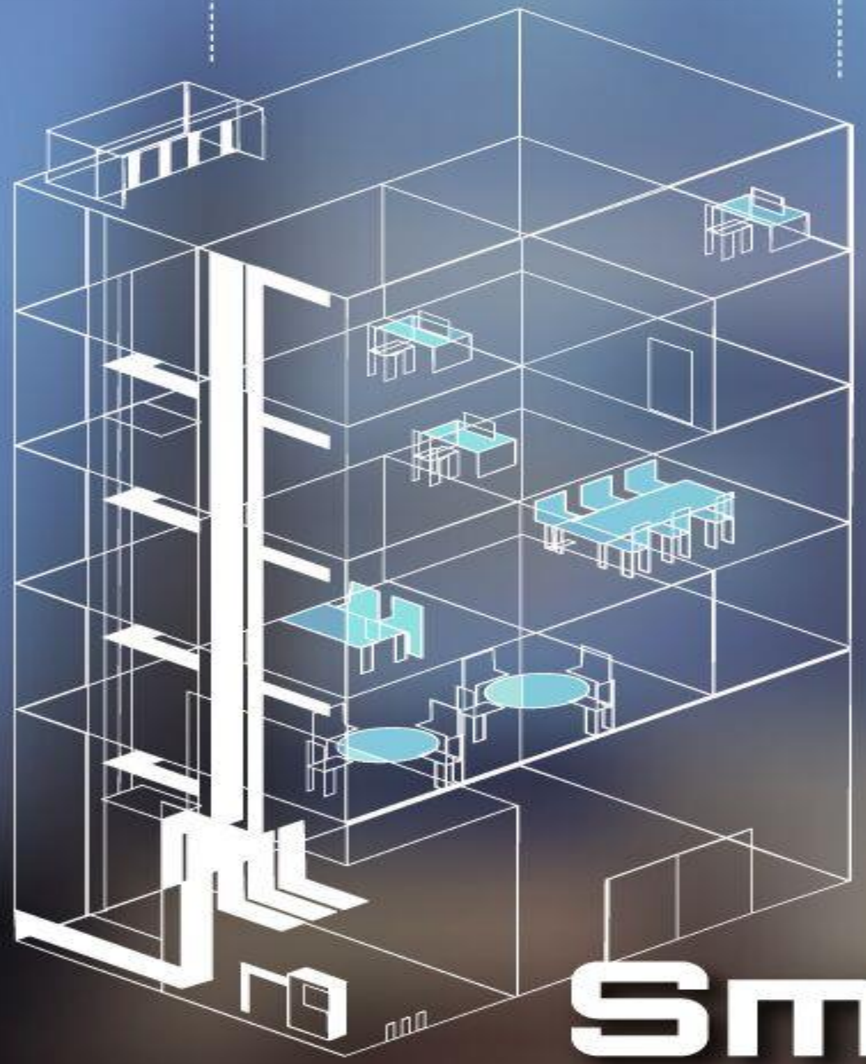
- 5.6 million commercial buildings in the United States in 2012
- 87 billion square feet of floorspace
- 14% increase in the number of buildings and a 21% increase in floorspace since 2003



Source:
Commercial Buildings Energy Consumption Survey (CBECS)

eia Independent Statistics & Analysis U.S. Energy Information Administration

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.

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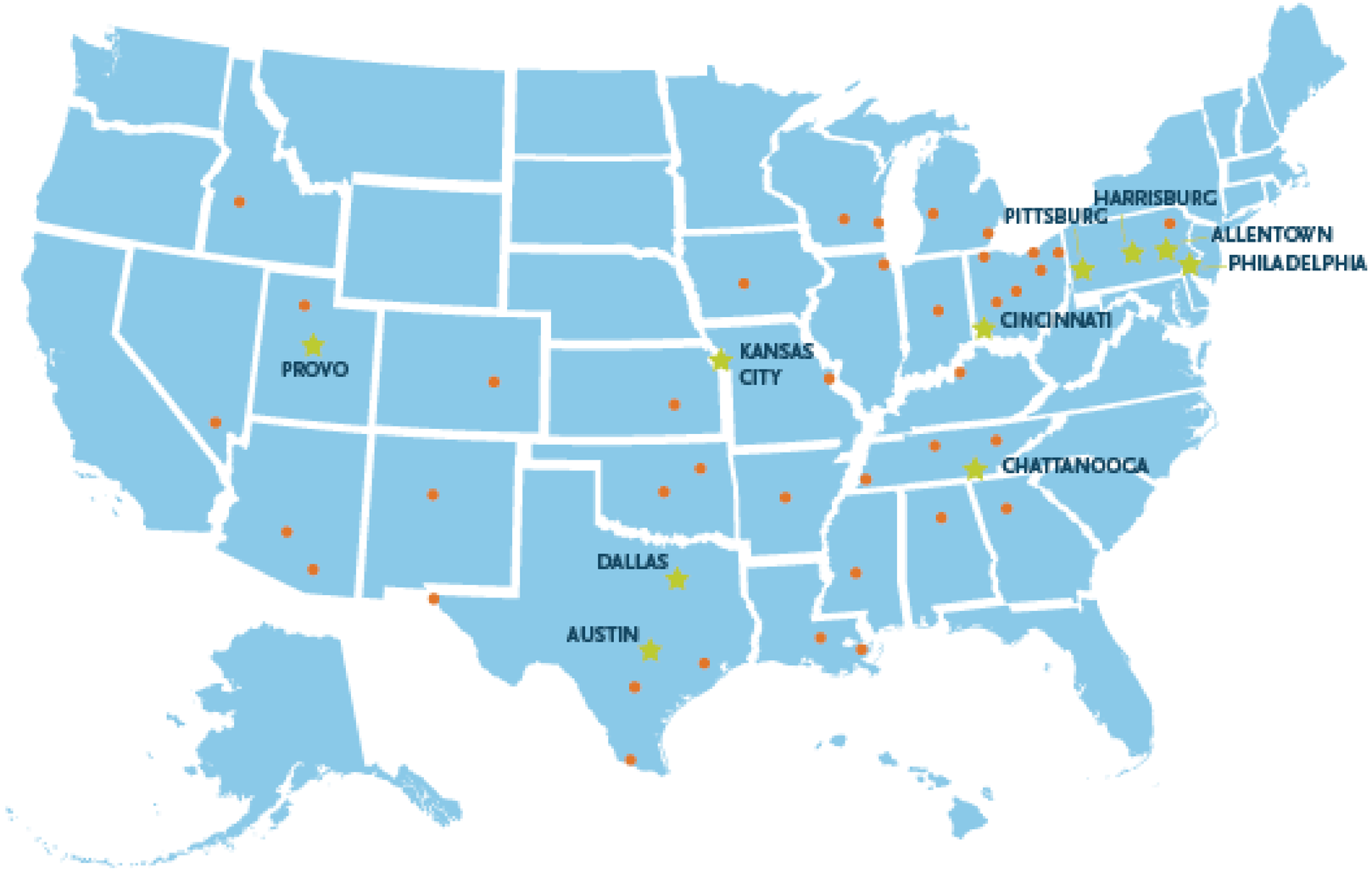
Economic Development: Fiber's Killer App

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

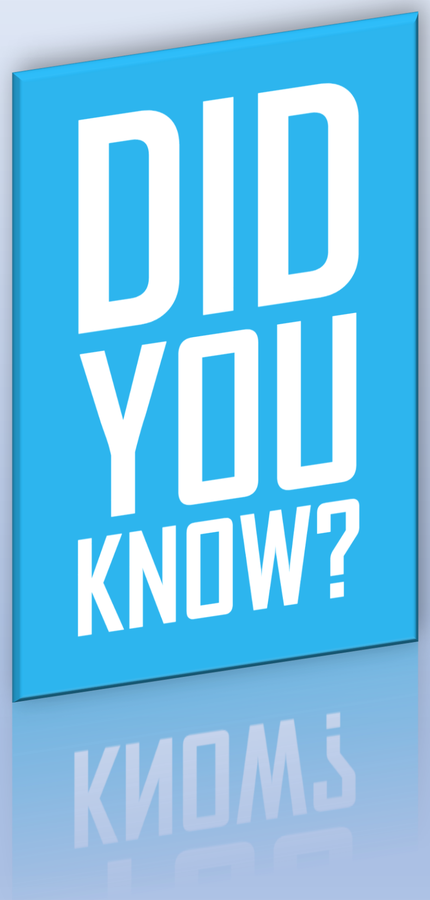
Ten Year Job Impact:
72% Better For FTTH Cities

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



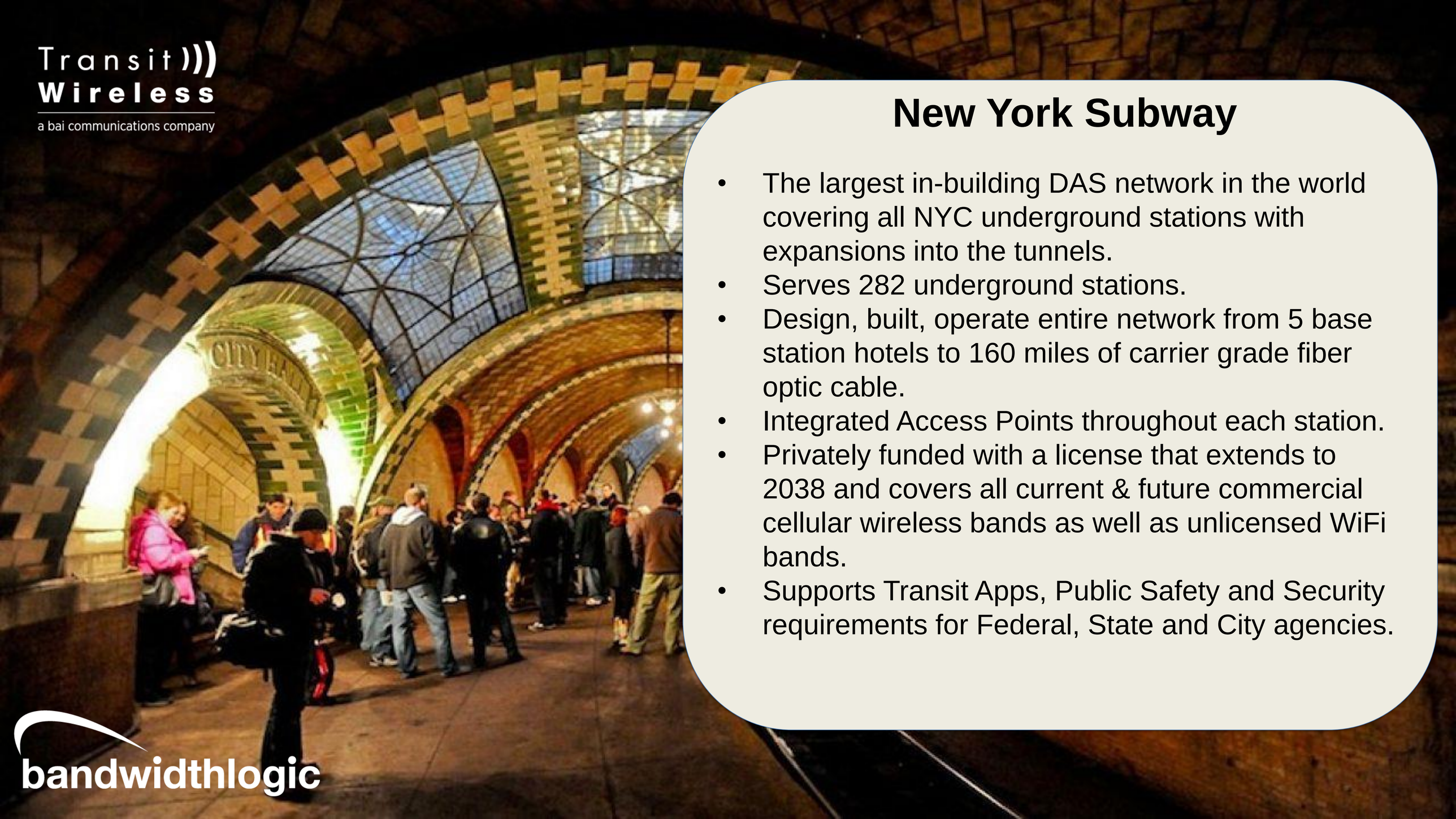

HOSPITAL
5G

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"

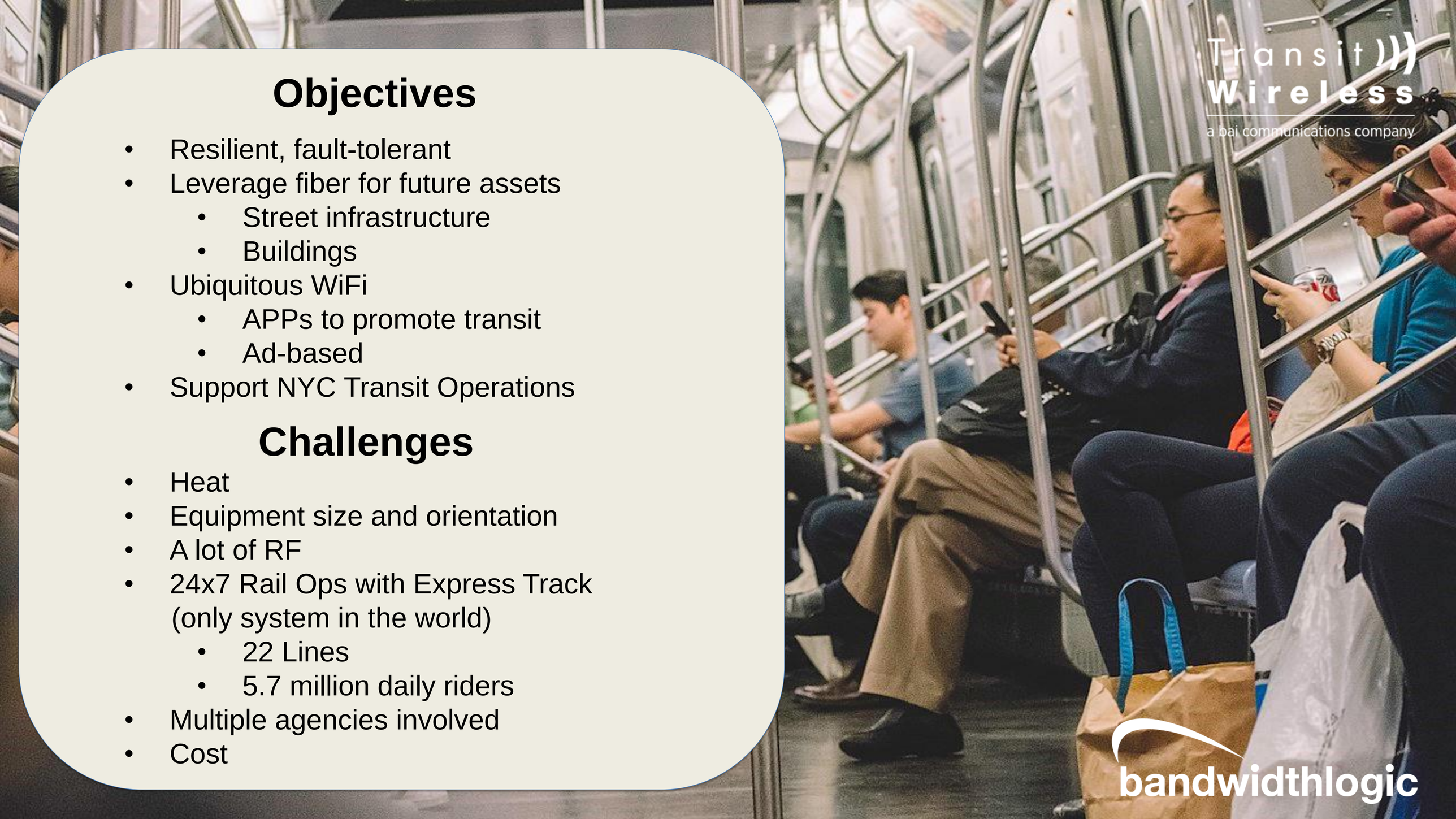
Transit Wireless
a bai communications company



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.

bandwidthlogic



Transit Wireless
a bai communications company

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

bandwidthlogic

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 100Gbs
- 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

FirstNet™
(and other networks)

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

Control & Analysis
systems, software

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

The Data Center Industry Ecosystem

Micro Edge Data Centers expand the Industry to the edge and enable in-market colocation