# Path to 5G

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Roadmapping Connectivity

4G to 5G Evolution

What, When, Where?

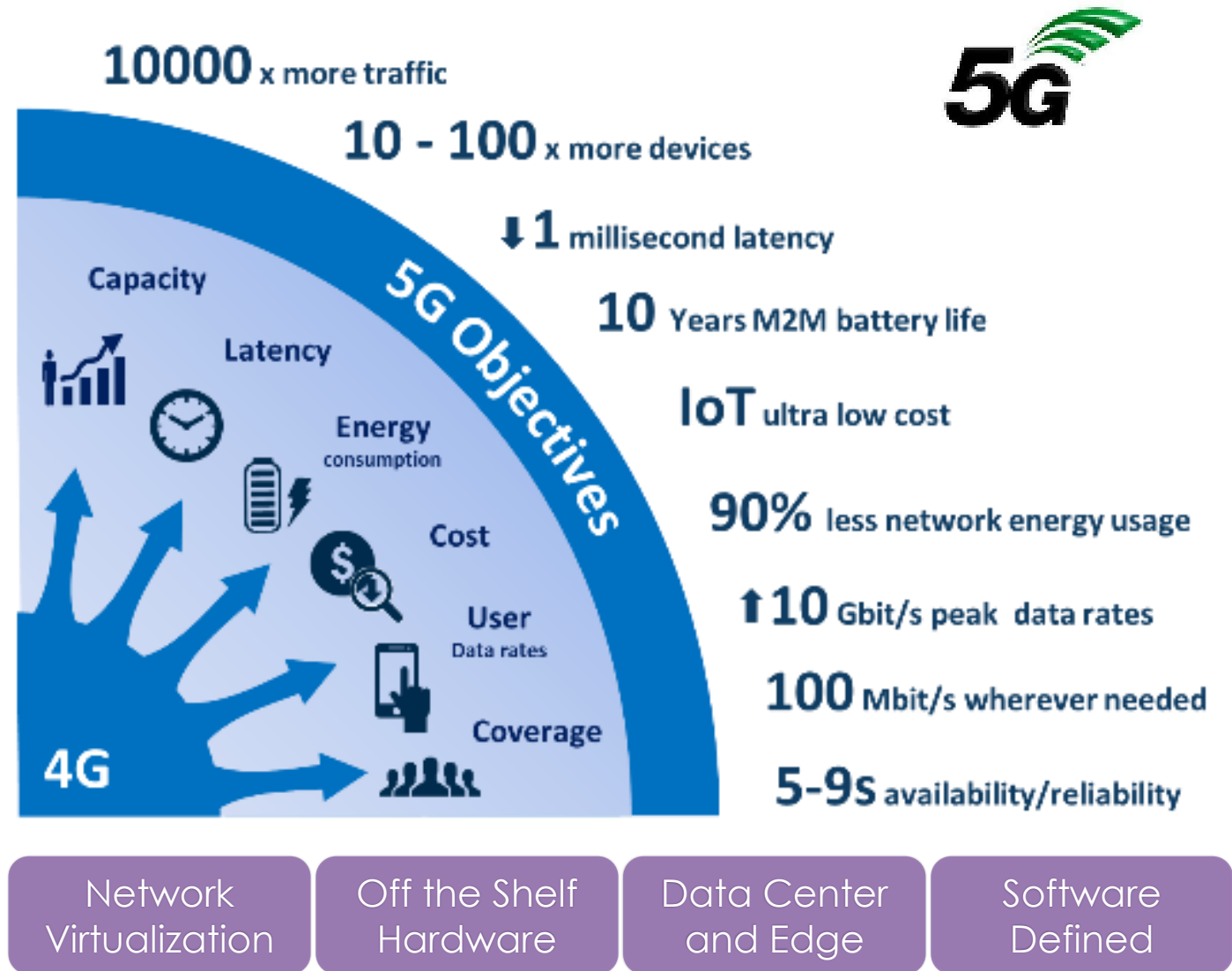# 5G Goals and Opportunity

- 5G Goals breakdown boundaries and constraints of 4G

- Most goals are backward compatible to 4G to some extent

- 5G is by design interoperable with 4G and other connectivity

- Goals can enable solutions, applications and opportunity but are "trapped" until both networks available and users deploy.
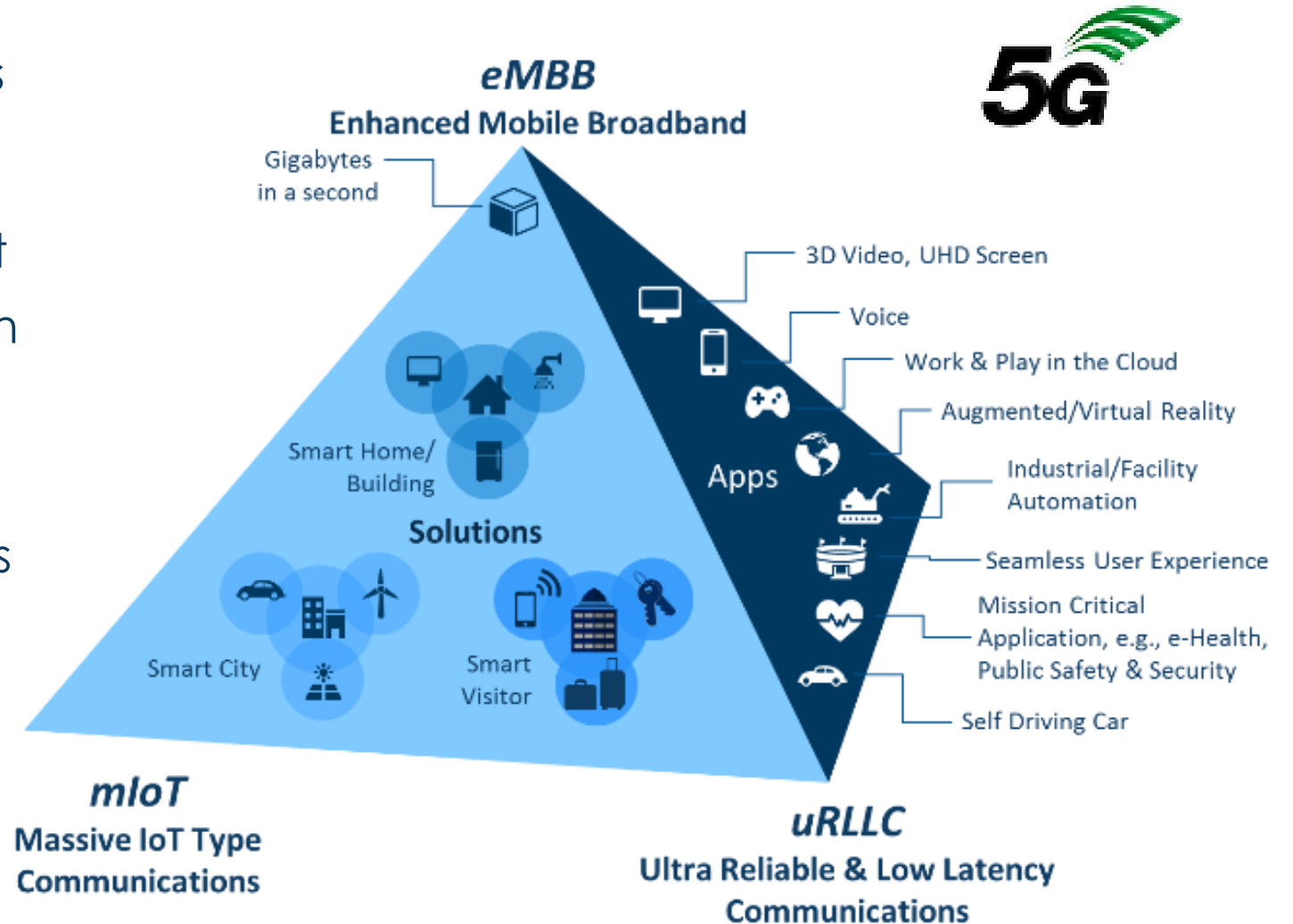
5G Objectives

- User vs. Edge vs. Core
- Not just about speed and scale
  - Energy/Power
  - Availability/Reliability
  - Cost
  - Ease of Deployment
- Different users will value different objectives
- Builds on 4G infrastructure

- Other technology and business shifts are concurrently happening

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

5G Objectives

Capacity

Latency

Energy consumption

Cost

User Data rates

Coverage

4G

| Network Virtualization | Off the Shelf Hardware | Data Center and Edge | Software Defined |

Smart City Network Densification

4G LTE

Coverage
Capacity
Basic IoT

5G

Enhanced Broadband
Massive IoT
Mission Critical Latency
Higher Availability
Differentiated Services
Energy Efficiency

5G 5G 5G 5G 5G 5G 5G 5G 5G 5G 5G

4G **4G** **4G** **4G**

Macro Network Macro Network Macro Network
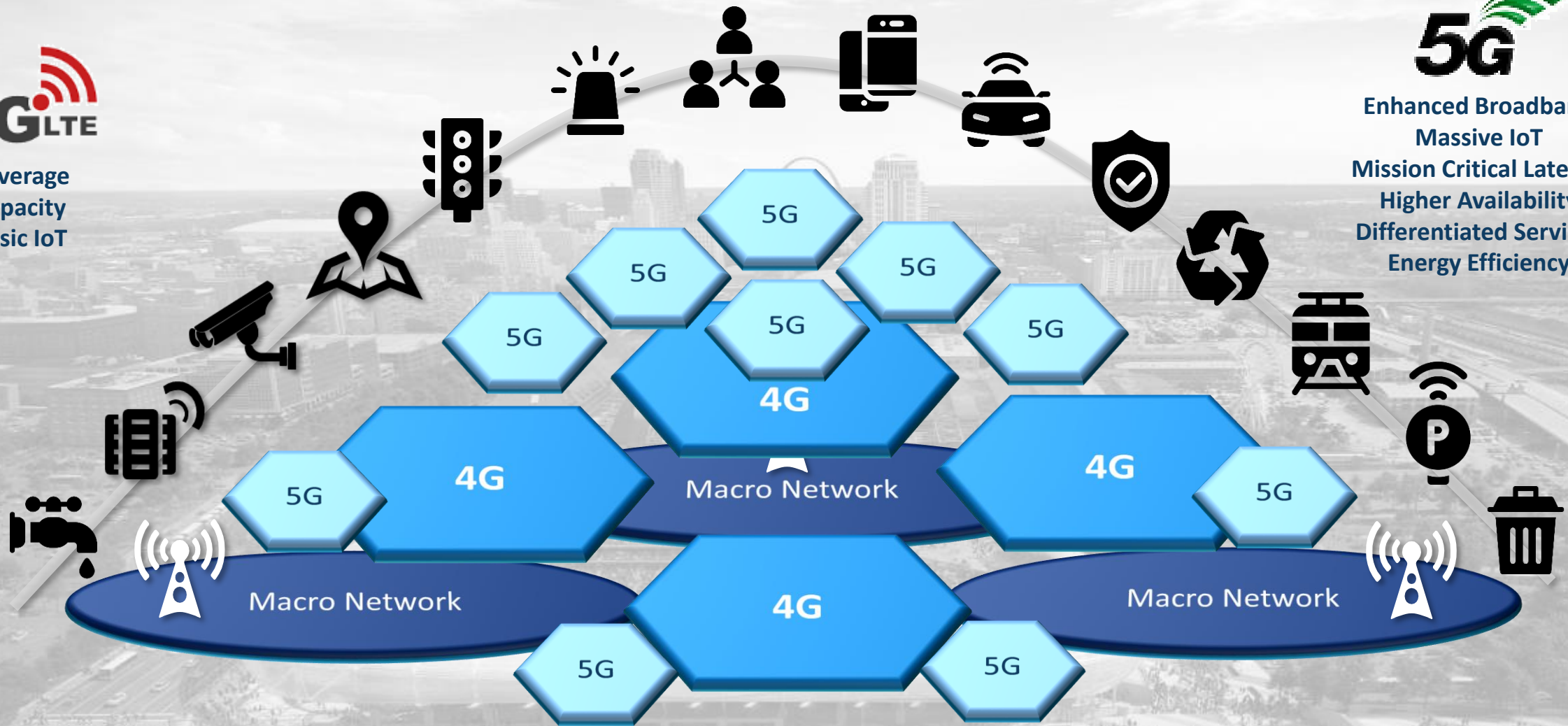
5G Technology Basket

"Its all good but you don't have to eat everything!"

Spectrum: Expanded, Shared, Dynamic, mmWave

Topology: Distributed, User & Control Separation

Antennas: Massive MIMO, Beam Forming

Edge Computing: Applications, APIs
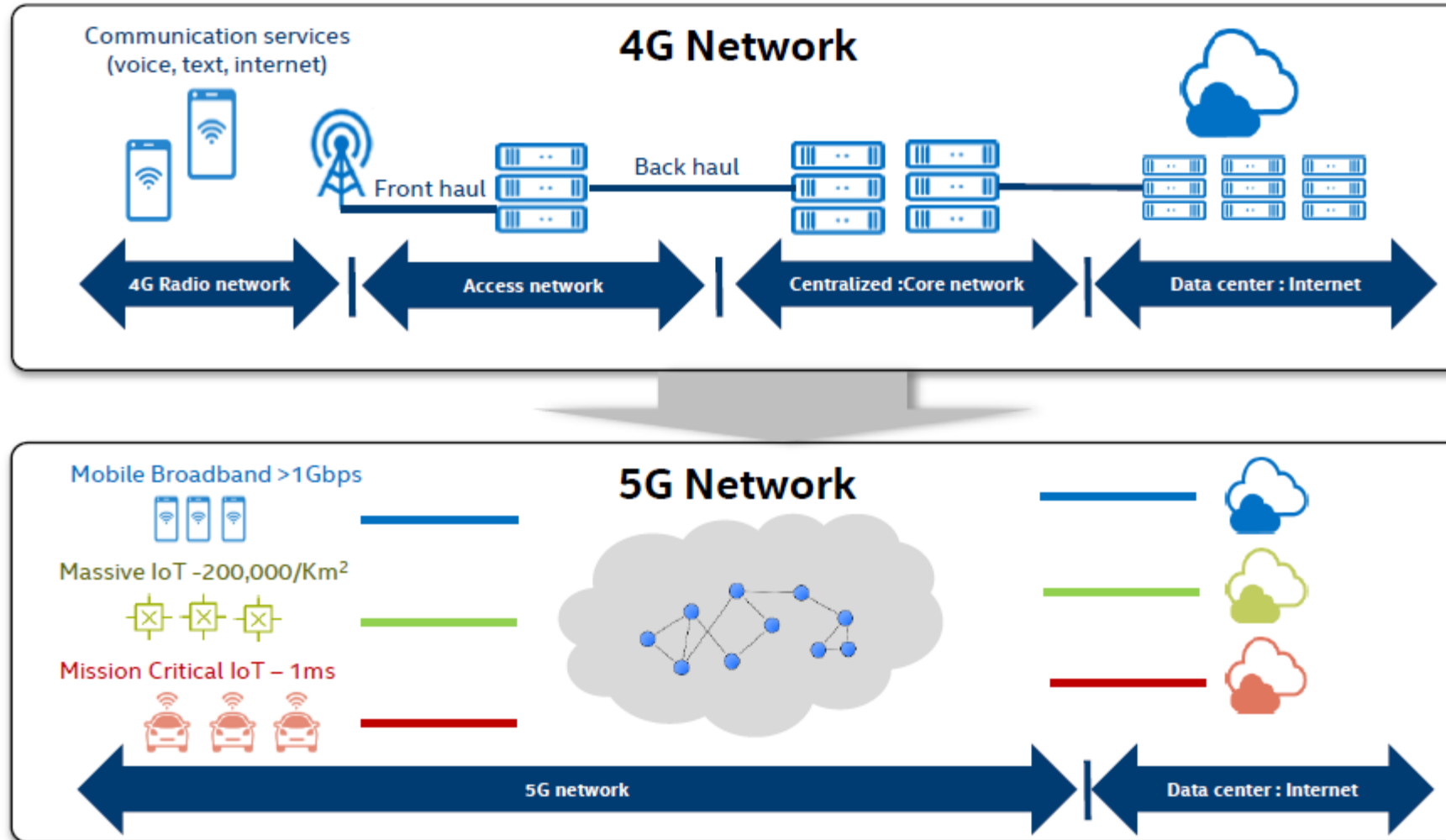
Security: Authentication, Privacy

Radio: New Radio (NR), Software, Micro Cells

IoT: Low Power, Low Latency, NB-IoT, CAT-M

Network: Slicing, Virtualization, SDN, SON, COTS

Interoperability: Path from 4G (NSA), Coexist with 4G (SA)

5G

JMA
WIRELESS

Transition to Multi-dimensional Networks
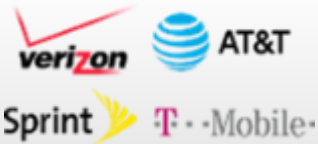

Graphic: Intel

Spectrum Diversity on the Path to 5G

Mobile Cellular

- Multiple Carriers -
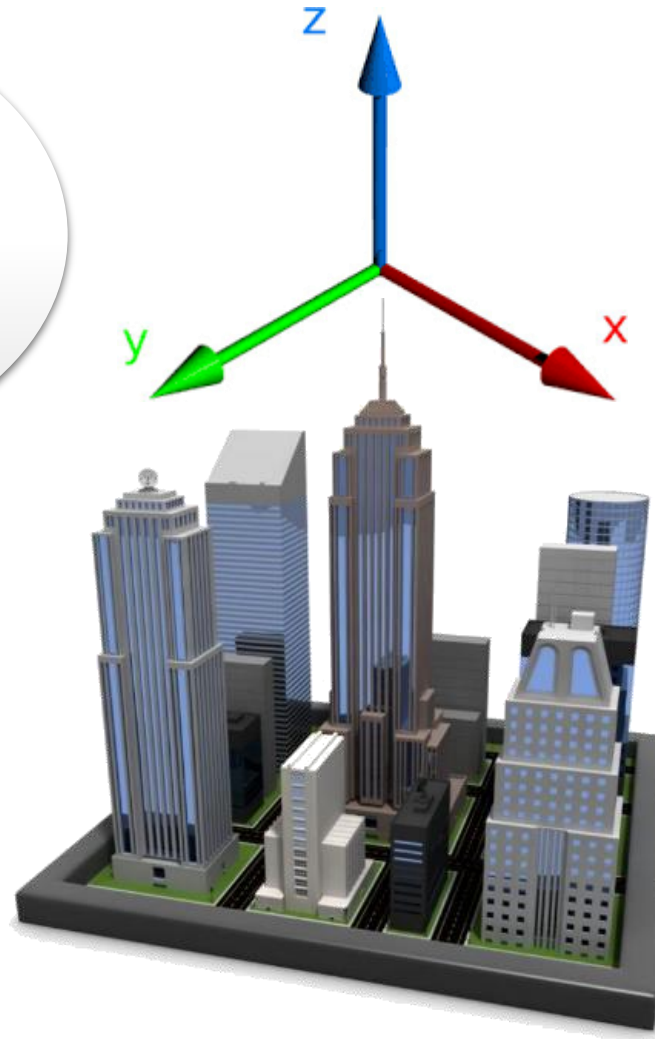
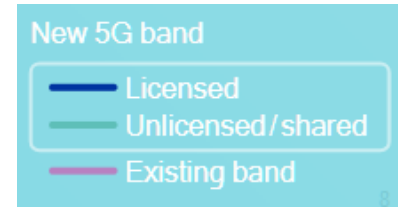**Shared & Unlicensed**

- CBRS, 5G, LAA, WiFi -

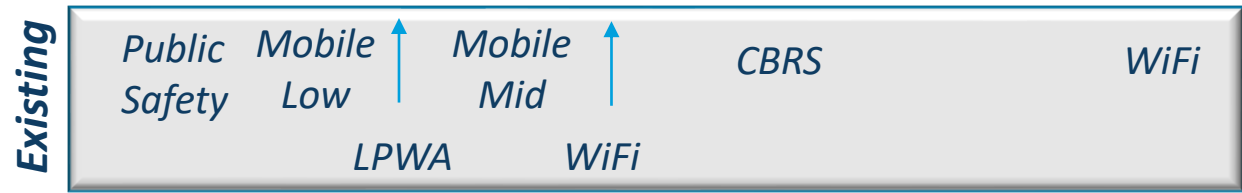**Public Safety**

- FirstNet, LMR -

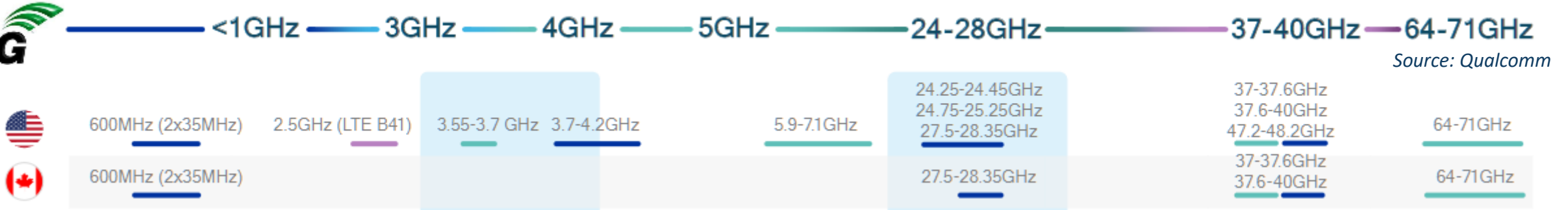**Internet of Things**

- NB-IoT, CAT-M, LoRa -
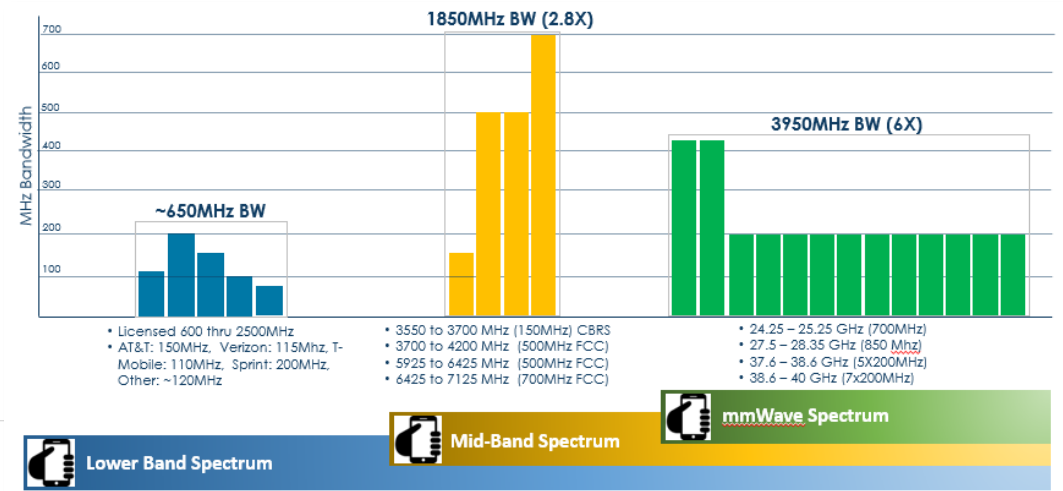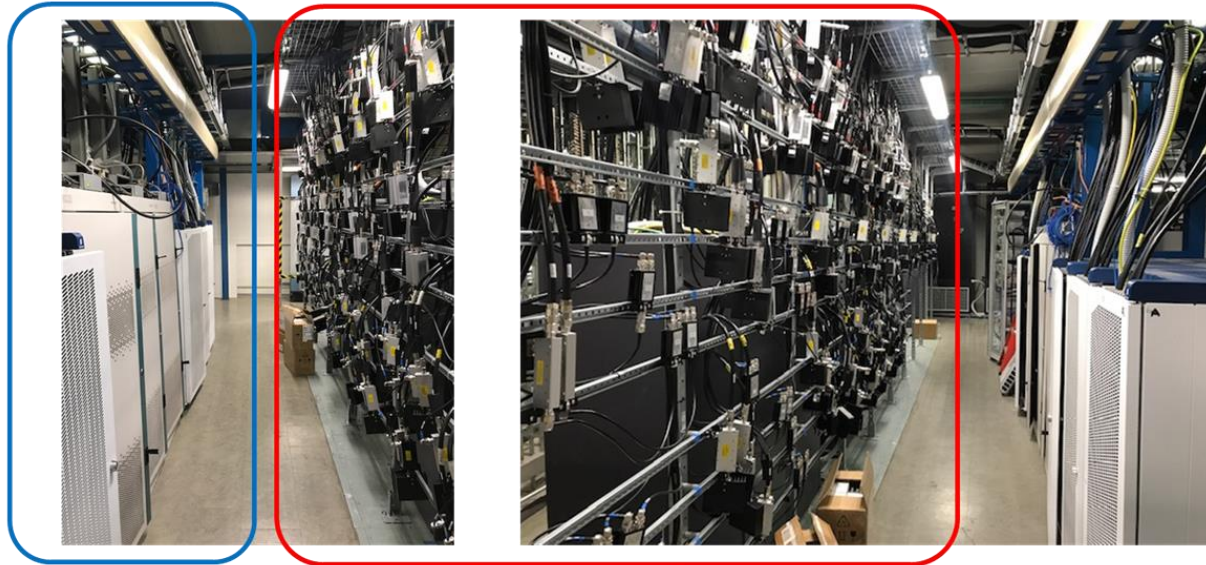
Spectrum Utilization: Today to 5G

Source: Qualcomm

Impact of the 5G Evolution

6x eNB Racks   Entire wall of coax + couplers + attenuators
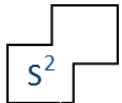
Post upgrade

XRAN

1/2 Rack BBU Servers   1x Rack for POIs

Fit in more places and reduce site costs

-95%

Footprint

Deploy faster with less resources

-70%

Time to Deploy

Reduce ancillary equipment and energy

-75%

Power & Cooling

Utilize assets more often, in more places

+70%

RAN Utilization
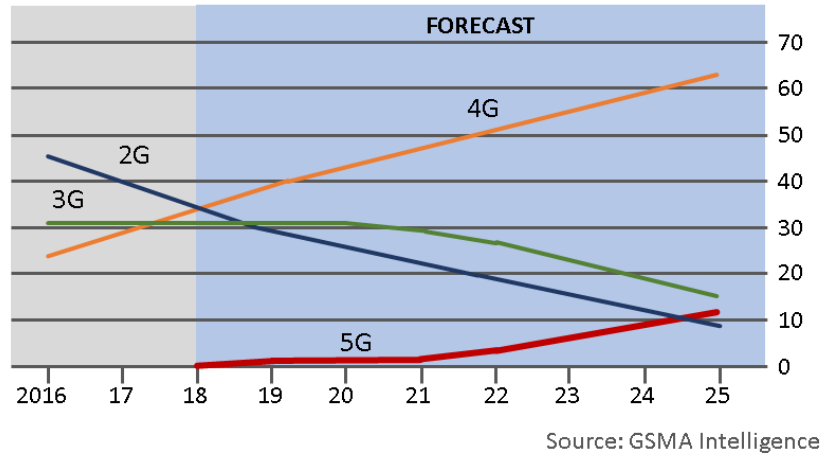
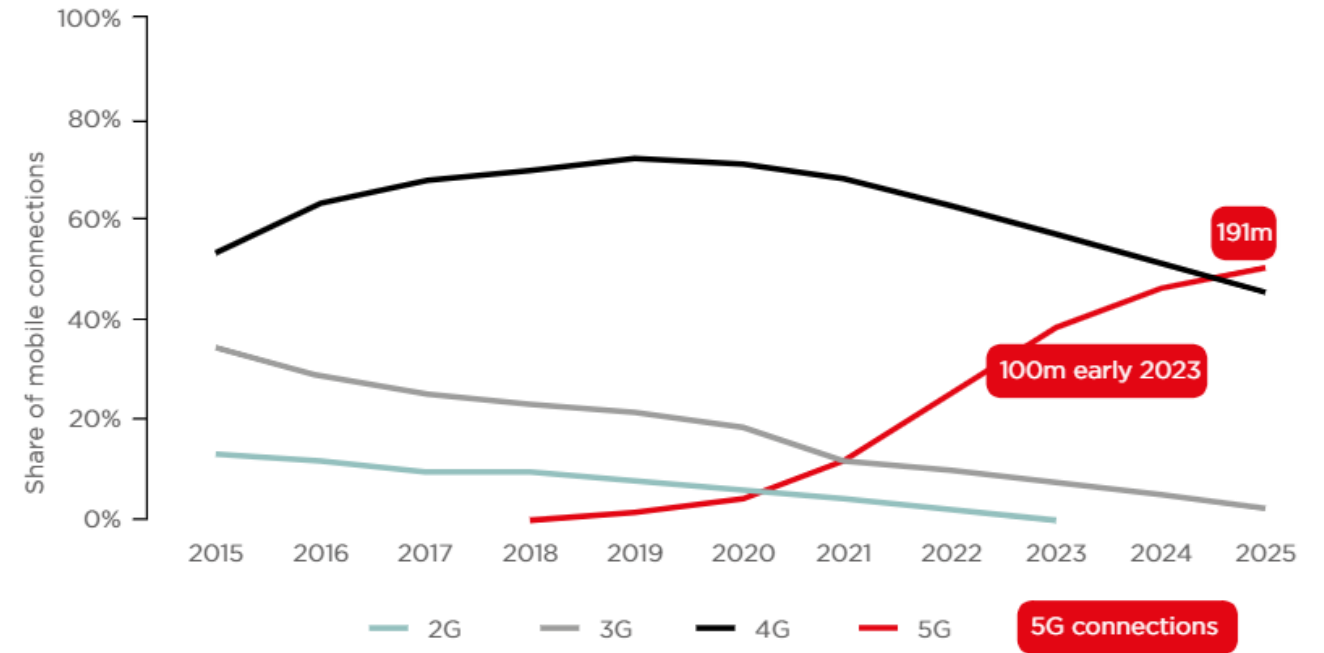*Costs less to purchase and operate*

-55%

10 Year TCO

5G Rollout

Mobile connections by network technology
Worldwide, % of connections

FORECAST

4G
2G
3G
5G

2016 17 18 19 20 21 22 23 24 25

Source: GSMA Intelligence

- ## 10/20 rule
  - ### 10 years between "Gs"
  - ### 20 years until that G peaks in deployment
- ## US a leading adopter

US mobile connections by technology, excluding cellular IoT

Share of mobile connections

100%
80%
60%
40%
20%
0%

2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025

191m

100m early 2023

— 2G   — 3G   — 4G   — 5G   **5G connections**

Source: GSMA Intelligence

Connectivity Dependence – 4G World

Connectivity Dependence – 5G World

Smart Grid

Smart Health

Smart Enterprise

Smart Water

Smart City

Autonomous and Connected Vehicle

Lifeline systems

COMMUNICATIONS/IT

Lack of power put 95% of cellular sites out of service.

ENERGY

Lack of transportation limited the fuel supply for generators to restore communications.

Transportation damage led to closed ports unable to accept fuel shipments, while the ability to move goods and people was disrupted by losses in power.

Without power for pumps, drinking water was unavailable and wastewater systems overflowed.

TRANSPORTATION

Washed out roads limited access to repair water infrastructure.

WATER

And without those lifeline systems:

Many heathcare facilities were not open, and people were unable to travel to those that were.
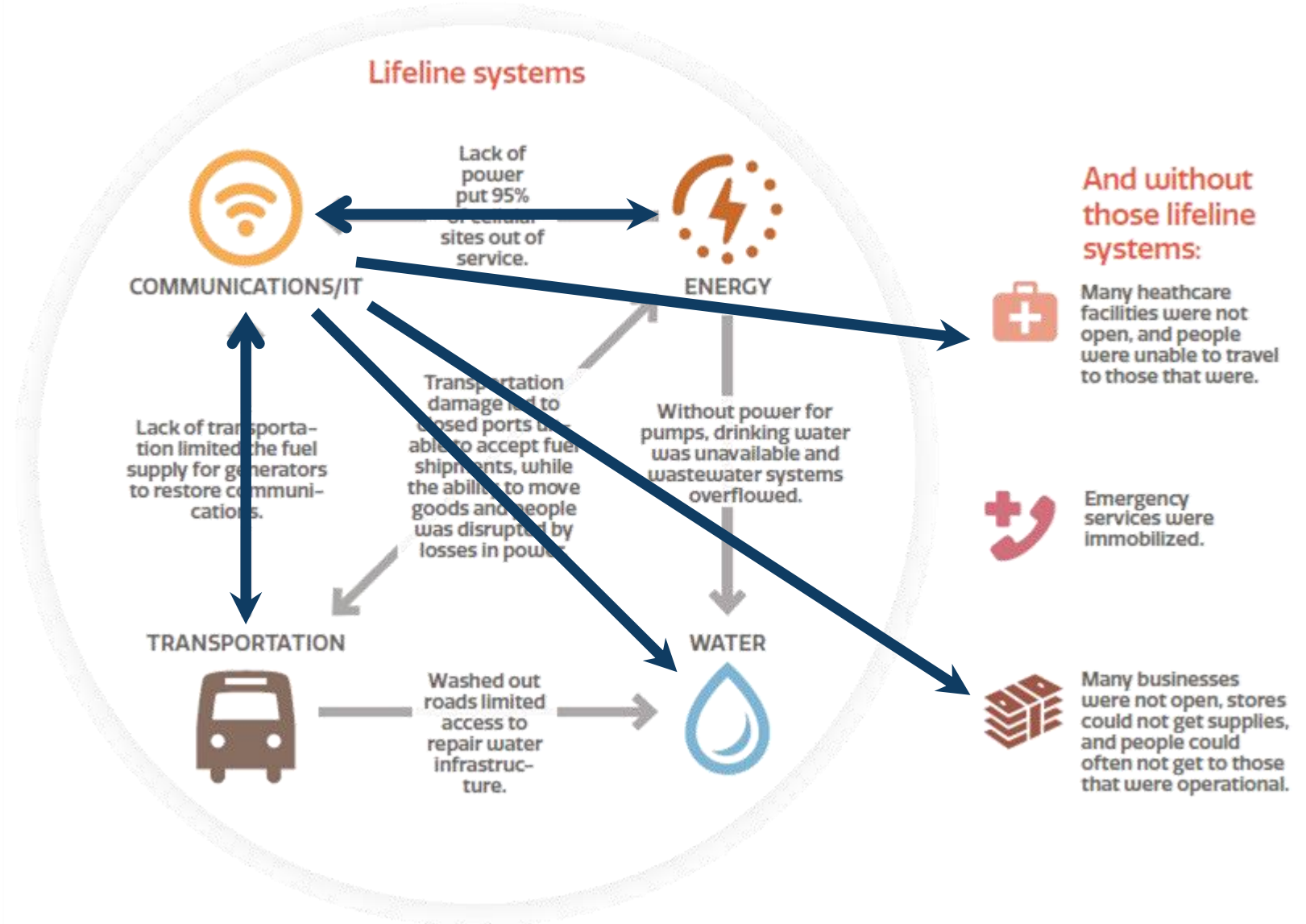
Emergency services were immobilized.

Many businesses were not open, stores could not get supplies, and people could often not get to those that were operational.

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THANK YOU