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5G/LTE: A Game Changer for Electric Utilities?

Presented by:

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Topics for Our Discussion Today

1. *What is 5G/LTE?*
   - Overview of the technologies
   - Overview of the application potential for utilities
2. *Why could 5G/LTE be a game changer for utilities?*
3. *What are some of the implications and considerations that utilities must consider?*
4. *What are CESI and EnerNex doing to further define the options and potential synergies?*
5. *Questions and Answers*

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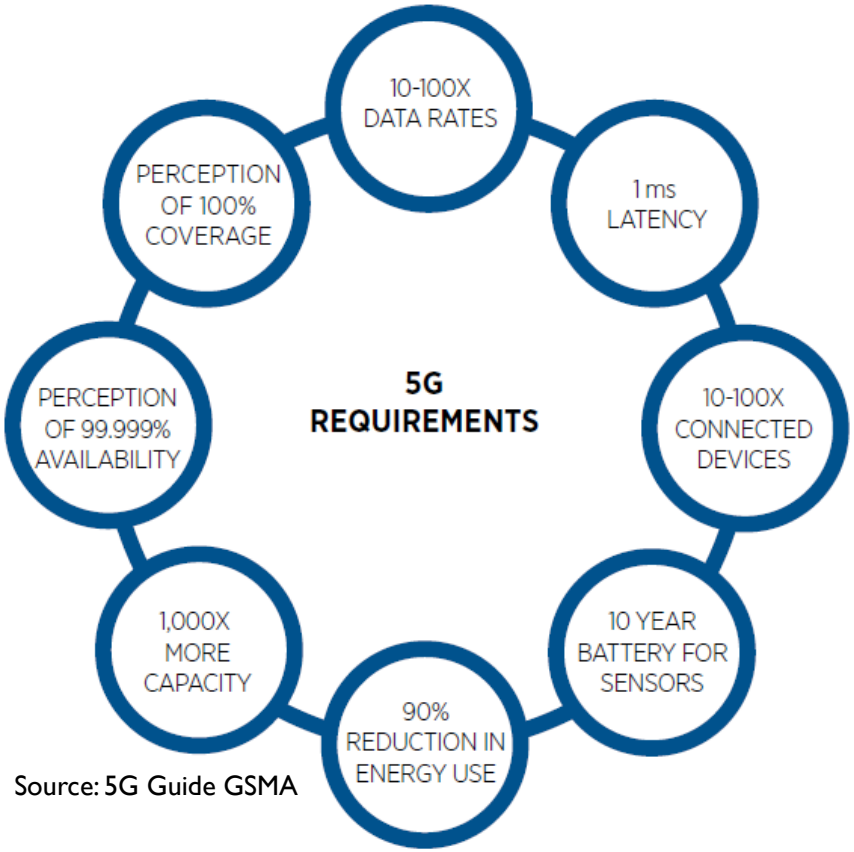
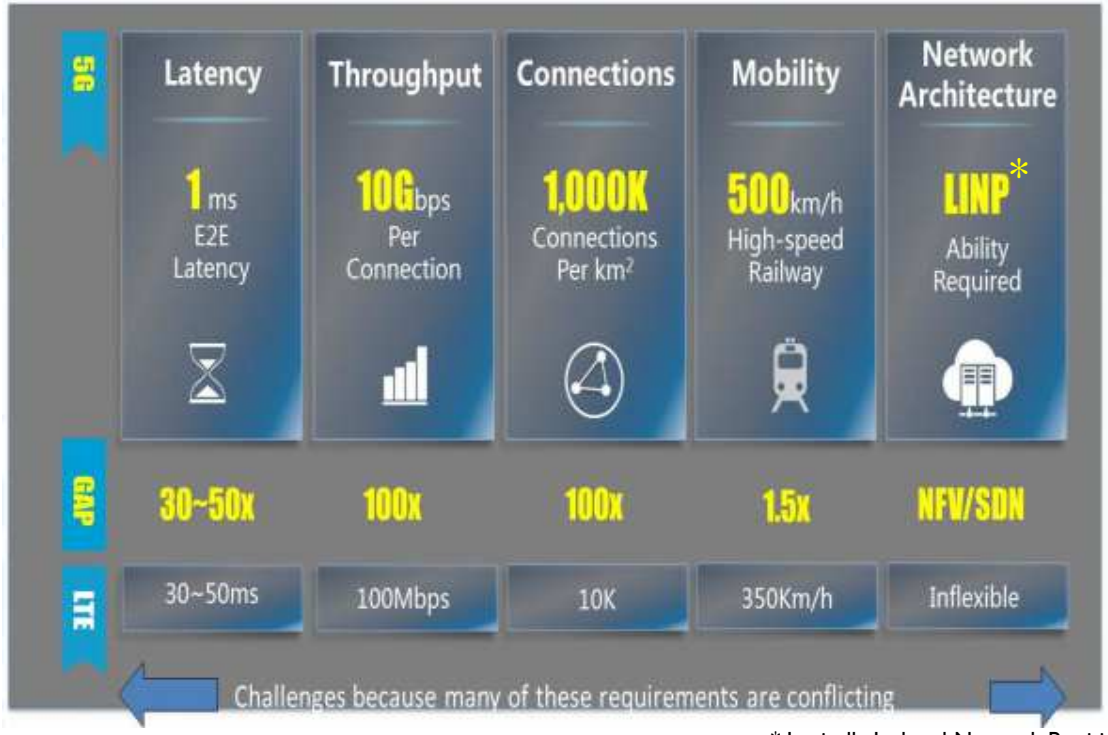
1. What is 5G/LTE?

International Mobile Telecommunications-2020 (IMT-2020 Standard) 5G Requirements

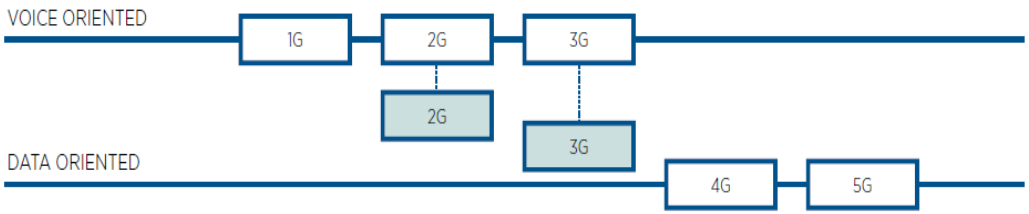


Source: 5G Guide GSMA



* Logically Isolated Network Partitions

4G AND 5G ARE BASED ON THE SAME TECHNOLOGY PHILOSOPHY



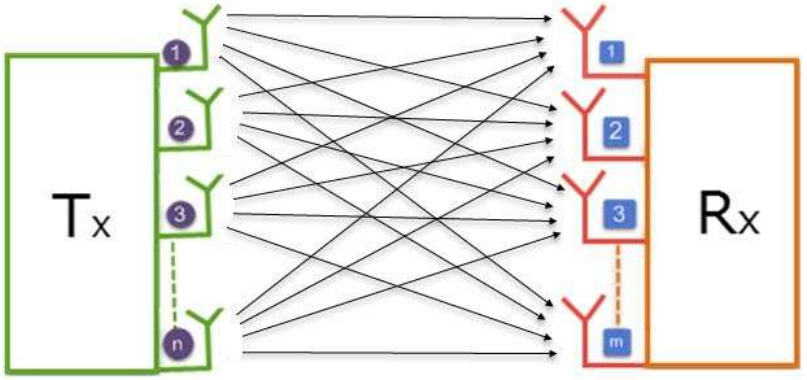
Source: 5G Guide GSMA

Some of the Key Technology Innovations to Meet these Requirements

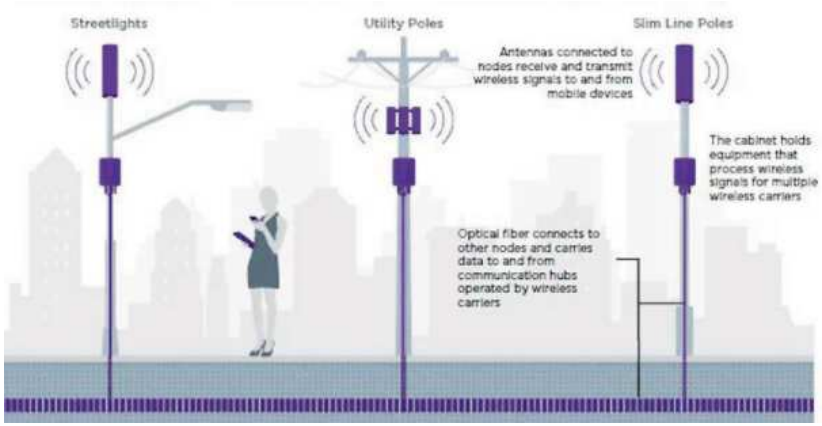
New Spectrum – Higher Frequency Bands – expanded bandwidth

Source: Qualcomm

MIMO Multiple Inputs Multiple Outputs

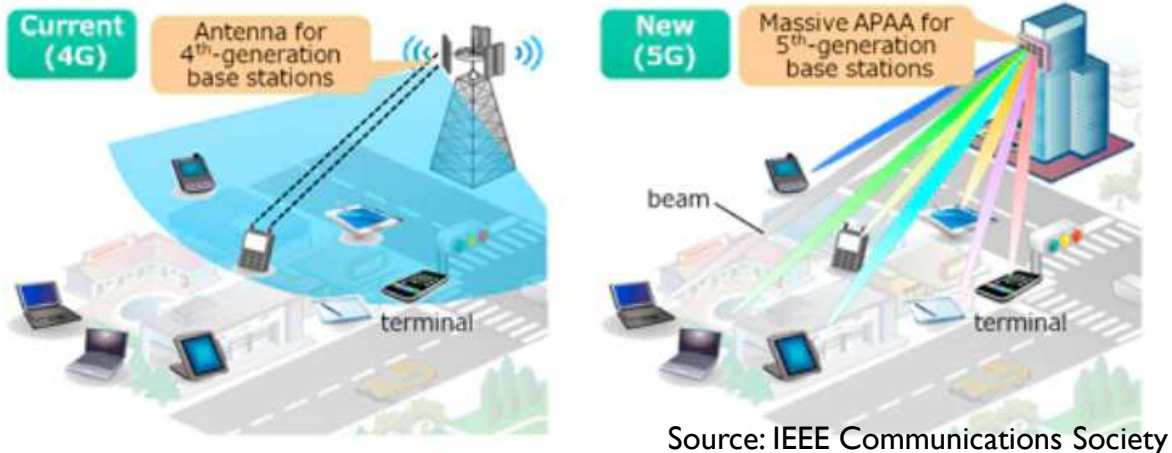


Small Cells



Source: Crown Castle

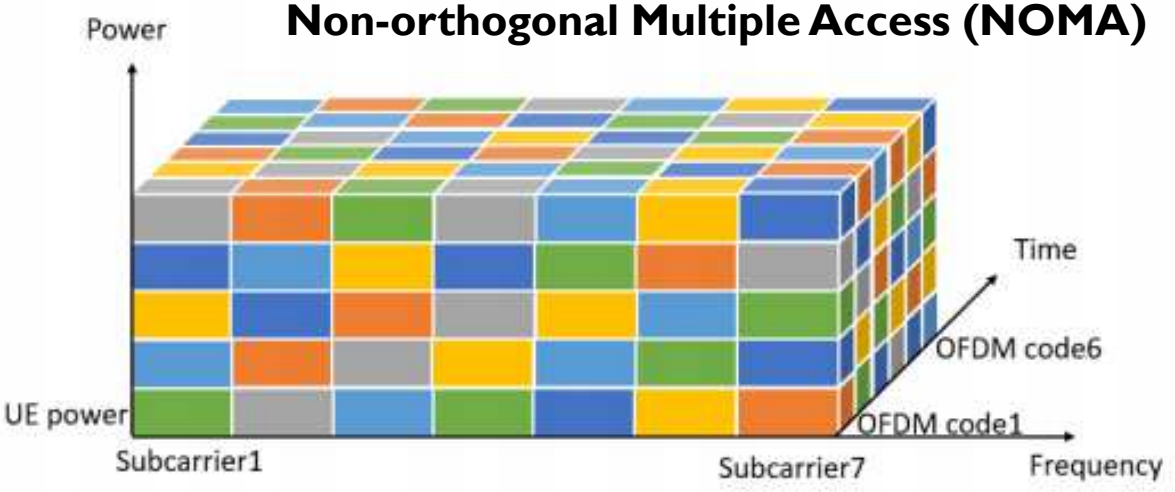
Beamforming



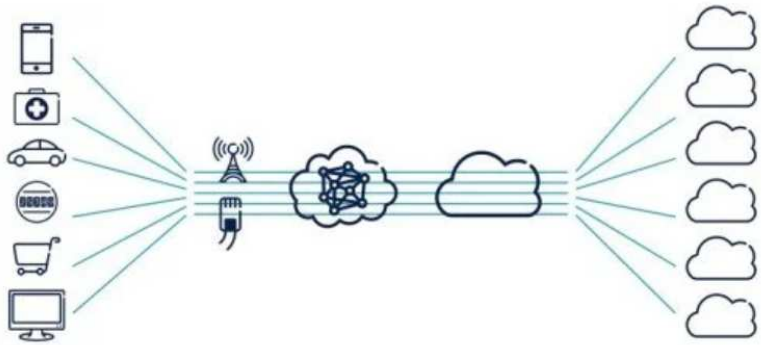
Source: IEEE Communications Society

Some of the Key Technology Innovations to Meet these Requirements

Non-orthogonal Multiple Access (NOMA)



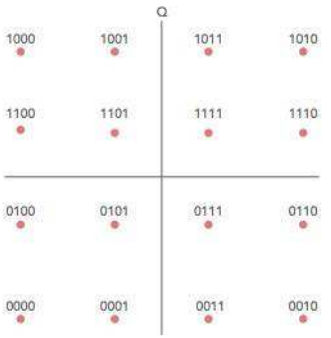
Network Slicing (NFV/SDN)



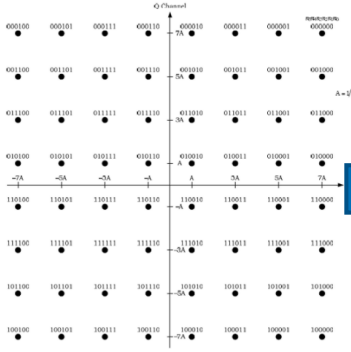
Source: Inside5G

Realization of Higher Data Compression

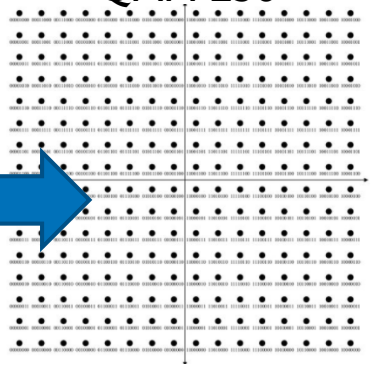
QAM 16



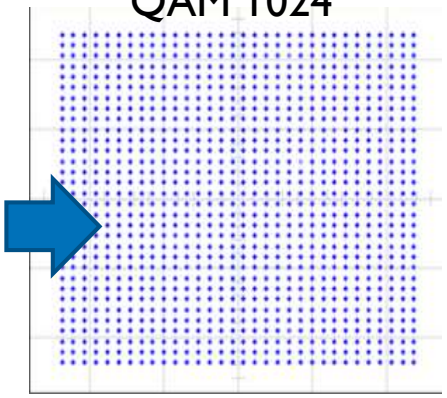
QAM 64



QAM 256



QAM 1024



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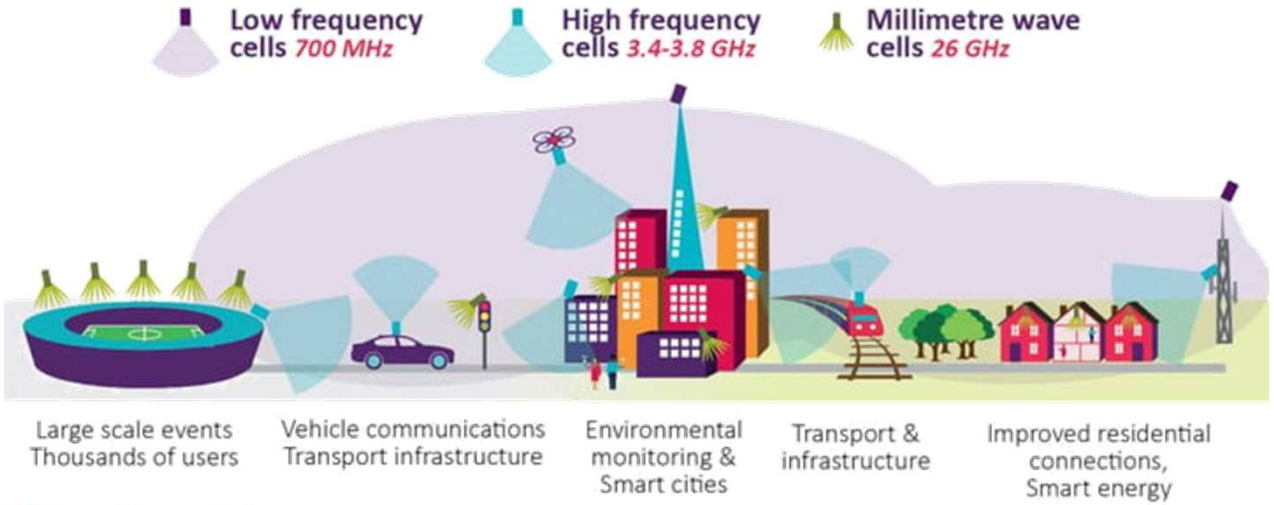
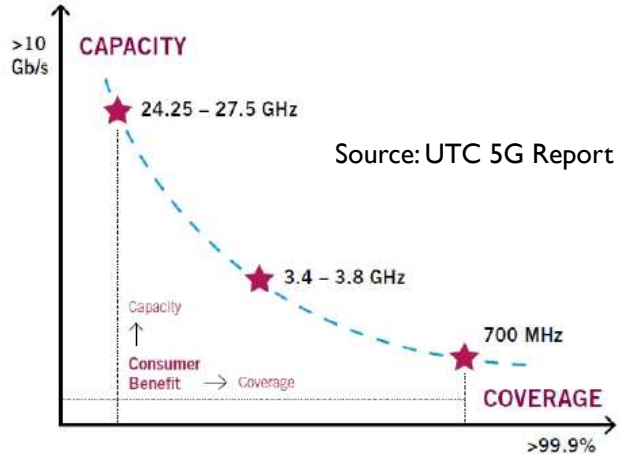
Technology Overview

- *U.S. 5G Spectrum bands*
  - Low-band: 600MHz; 800 MHz; 900MHz – wide coverage, rural in-building
  - Mid-band: 2.5 GHz; 3.5GHz, 3.7-4.2GHz above UHF carry large data suited for small antenna
  - High (millimeter band) 24GHz, 28GHz; 37GHz, 39GHz, 47GHz
    - Millimeter band Characteristics:Very High Bandwidth very poor penetration (line of sight)
    - Targeted areas: Dense population/ fixed wireless/ broadband wired service replacement – small cells



Source: Cable Free



Source: UTC 5G Report

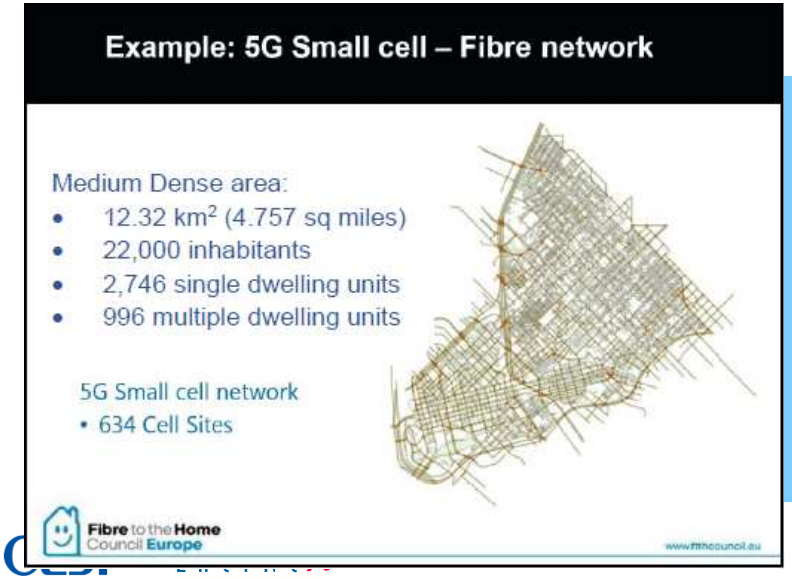
Verizon and AT&T are focused on rolling out mmWave 5 G
T-Mobile (Sprint) focused on rolling out low-band

Speed Comparison

Generation	2G	3G	3G HSPA+	4 G	4G LTE-A	5G
Max Speed	0.3 Mbps	7.2 Mbps	42 Mbps	150 Mbps	300 M – 1Gbps	1-10 Gbps
Average Speed*	0.1 Mbps	5 Mbps	5 Mbps	10 Mbps	15-50 Mbps	50 Mps and up

*Average speed is dependent on many factors such as network density, topology congestion and spectrum allocations

Although 5G will be able to deliver higher speeds, the main difference end-users will notice will be the extra-low latency on 5G compared to 3G or 4G — this will open up new applications in the Internet of Things space.



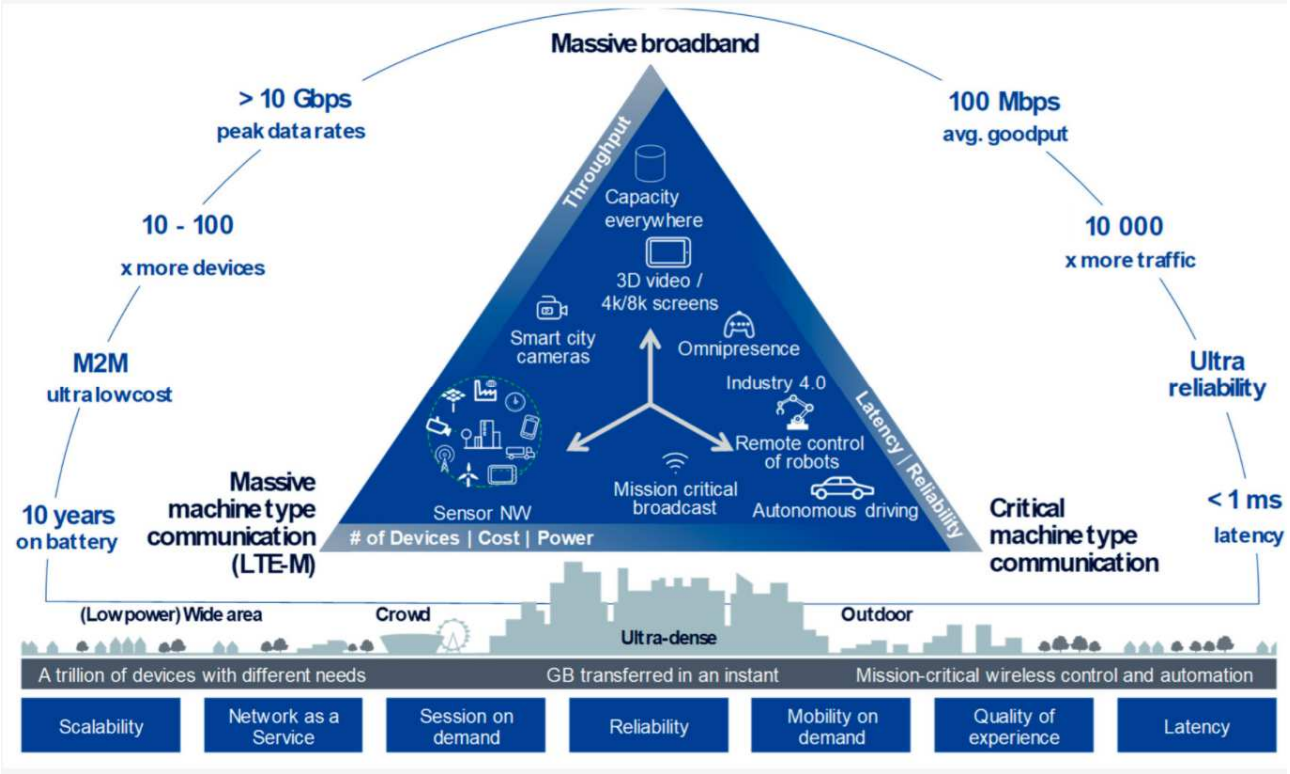
High-data rate 5G networks using millimeter wave technology will require much denser infrastructure – dense networks of small cells, an order of magnitude greater than currently. This presents enormous challenges in finding sites, powering the base stations and backhauling the data.
The backhaul will have to be either in-band wireless or dense fiber, or a combination of the two. The Fibre to the Home Council in Europe has developed models as shown to illustrate the densification of wireless networks required for 5G with 634 base station sites required in the relatively small geographic area depicted and the consequential need for dense fiber backhaul.

Source: UTC 5G Cutting through the Hype

Flavors of 5G

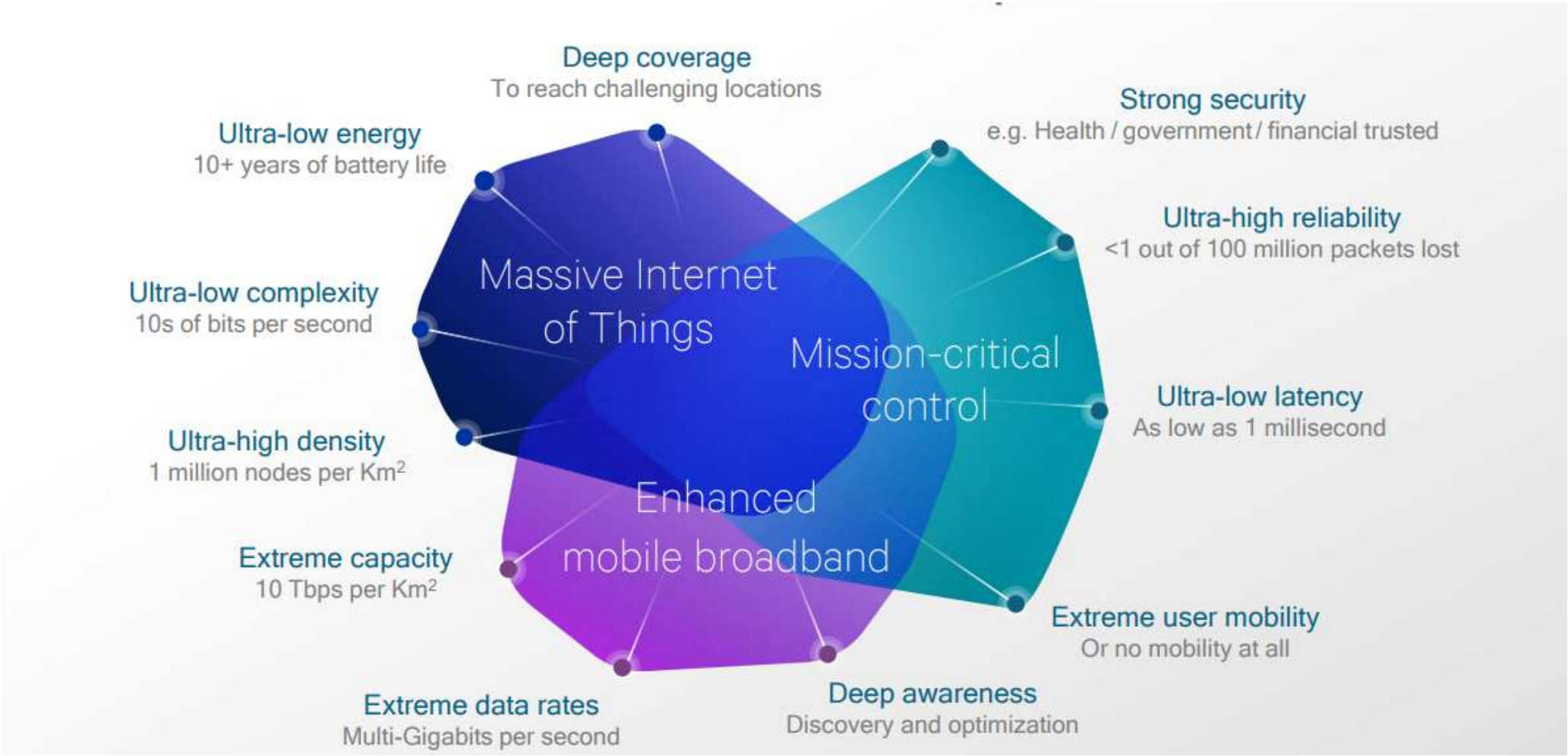
Enhanced Mobile Broadband (eMBB)	Ultra-Reliable and Low Latency (URLLC)	Massive Machine-Type Communication (mMTC)
All data, all the time 2 billion people on social media	Ultra-high reliability Ultra-responsive	30 billion "things" connected Low cost, low energy
500 km/h mobility 10-20 Gbps peak data rates	<1 ms air interface latency 5 ms end-to-end latency 99.9999% reliable 50 kbps – 10 Mbps	105 to 106 devices per km2 1-100 kbps per device 10-year battery life

Source: Keysight Technologies ABC of 5G



Source: J. Varga, A. Hilt, C. Rotter and G. Járó, "Providing Ultra-Reliable Low Latency Services for 5G with Unattended Datacenters,"

5G Application Areas



Source: Qualcomm

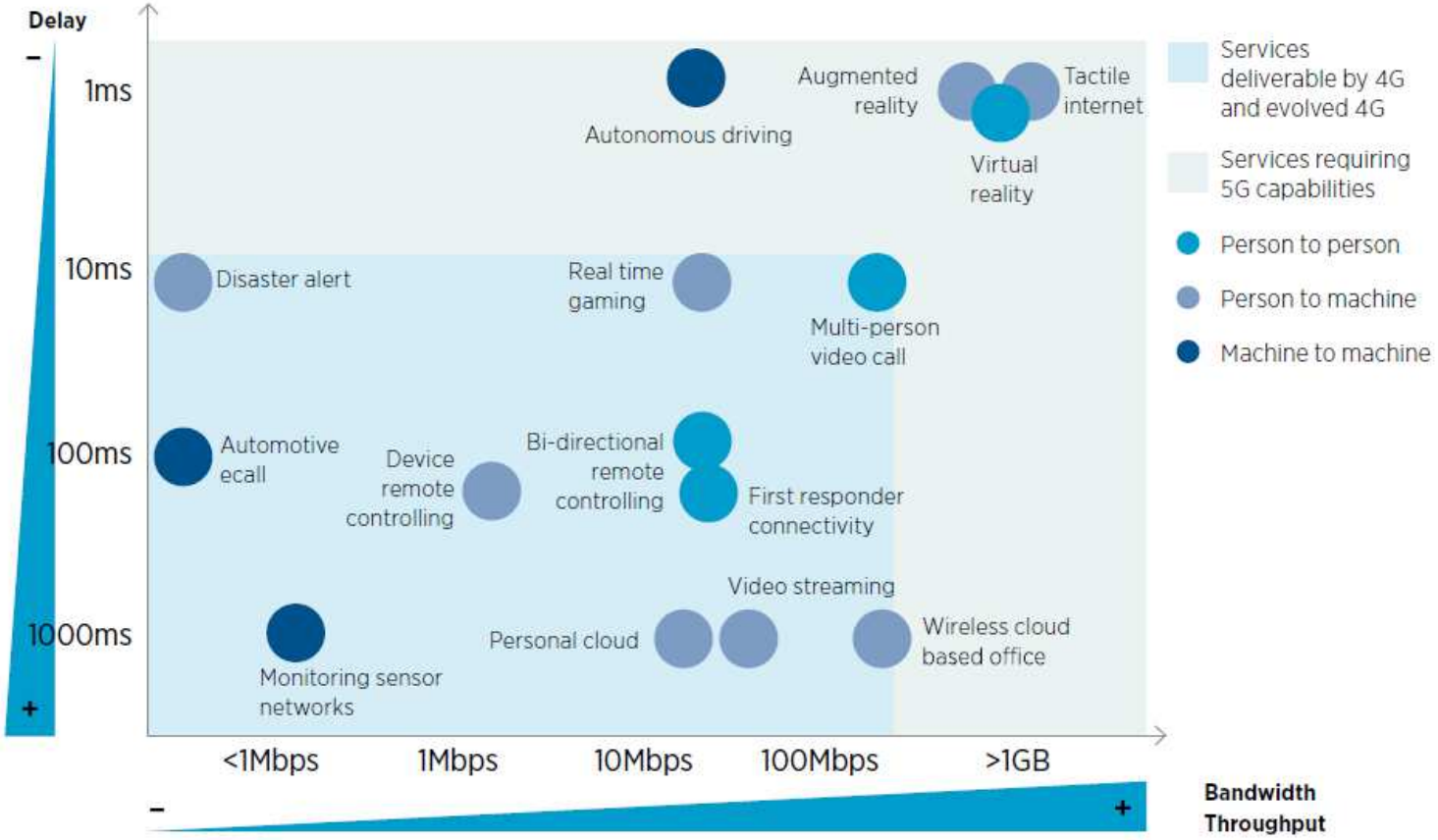
5G General Purpose Use Cases

- Improved Broadband
- Autonomous Vehicles
- Public Safety & Infrastructure
- Remote Device Control
- Healthcare
- Internet of Things (IoT)

- Below 1 GHz Longer Range IoT
- 1GHz to 6 GHz wider band low latency
- Above 6 GHz extreme bandwidth, shorter range

FIGURE 1.2.4

5G WILL SUPPORT LOW LATENCY AND HIGH THROUGHPUT SERVICES



Source: Thales 5 G networks

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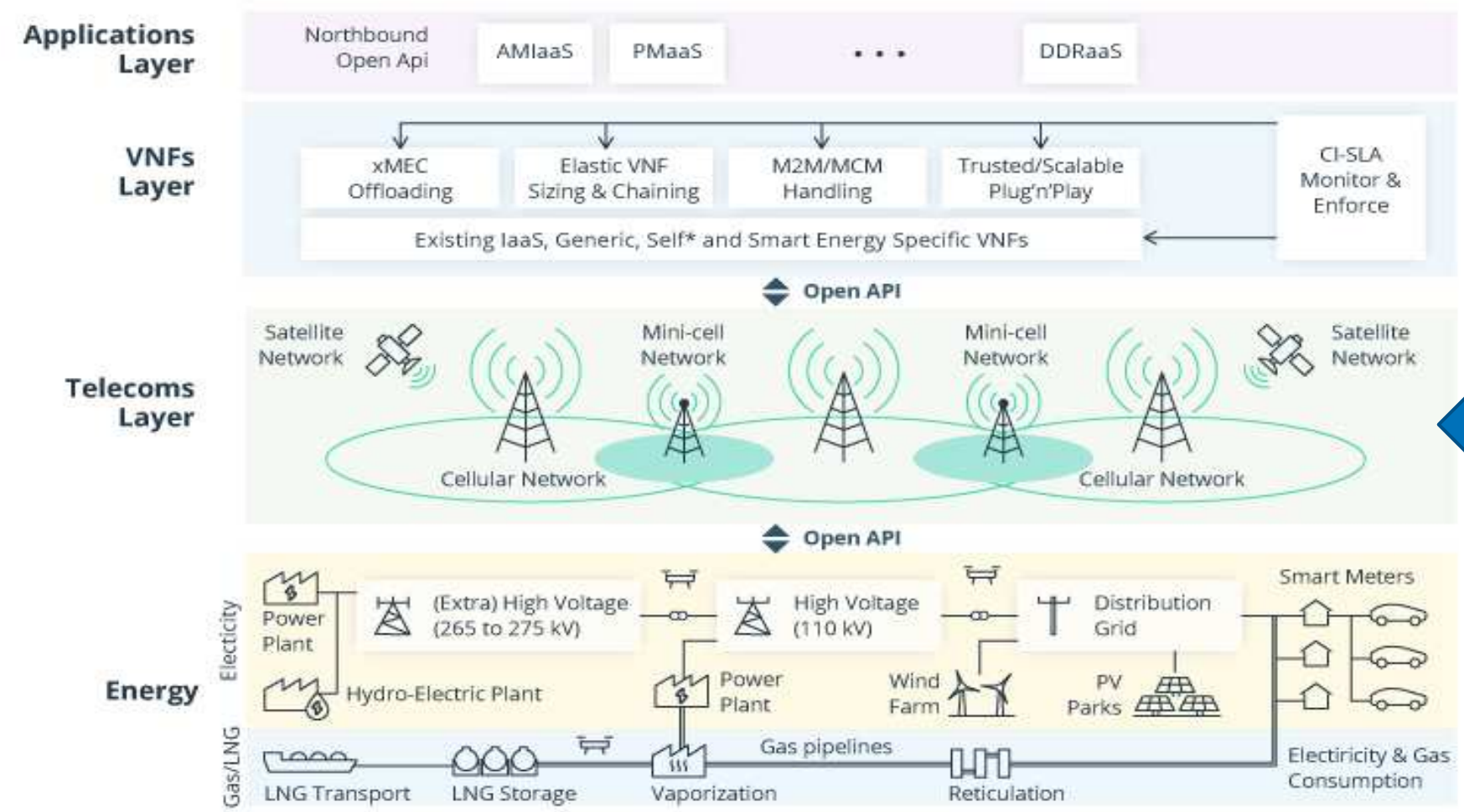
2. Why 5G Could Be A Game Changer for Utilities?

- *Potential Applications*

A Smarter Grid Enabled by Improved Telecommunications



Growth of Communications Options and Functionality

Source: Smart Grid: a demanding use case for 5G Technologies – White paper EE Department University of Applied Science of Central Greece

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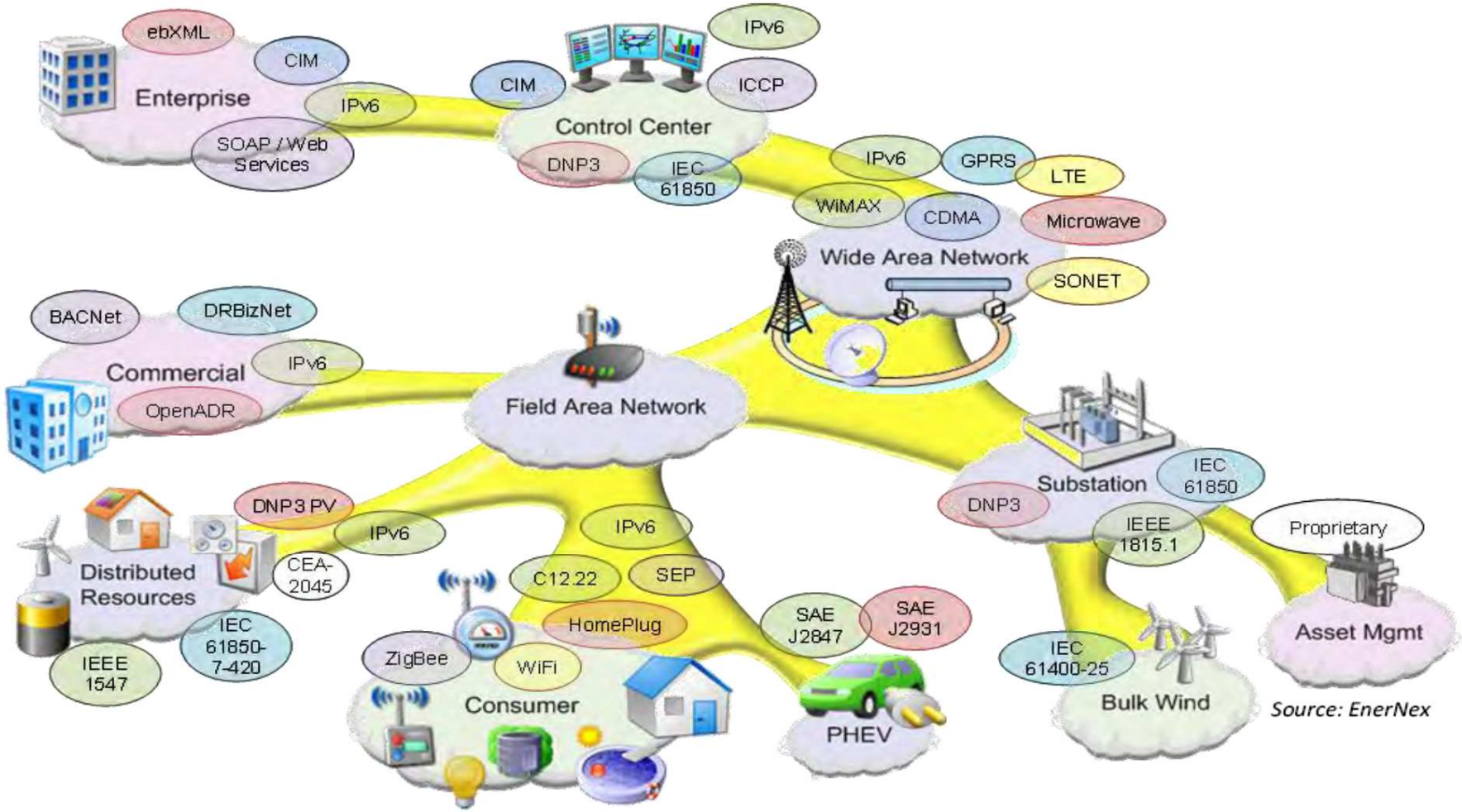
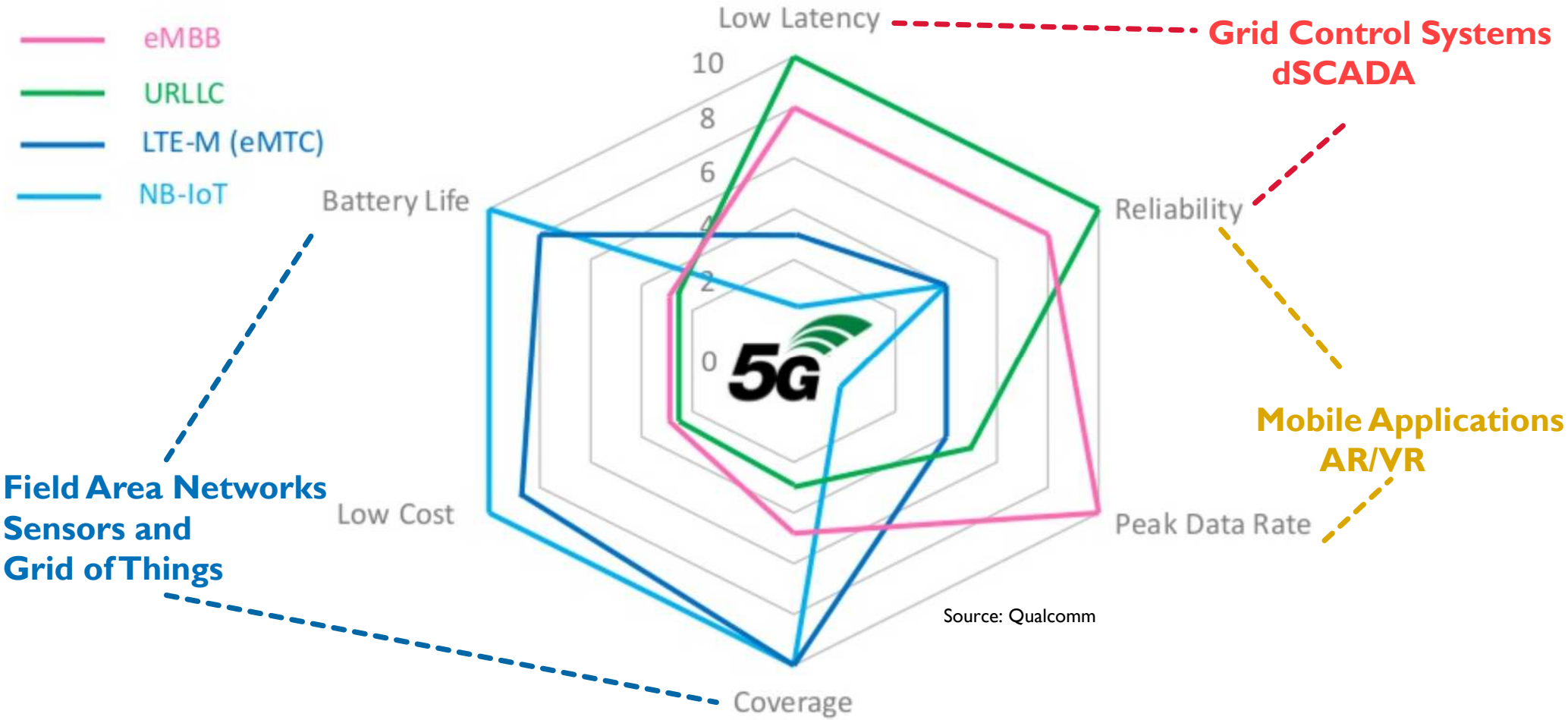
Communications Networks in the Utility Environment



Mapping of 5G Capabilities to Utility Application Areas



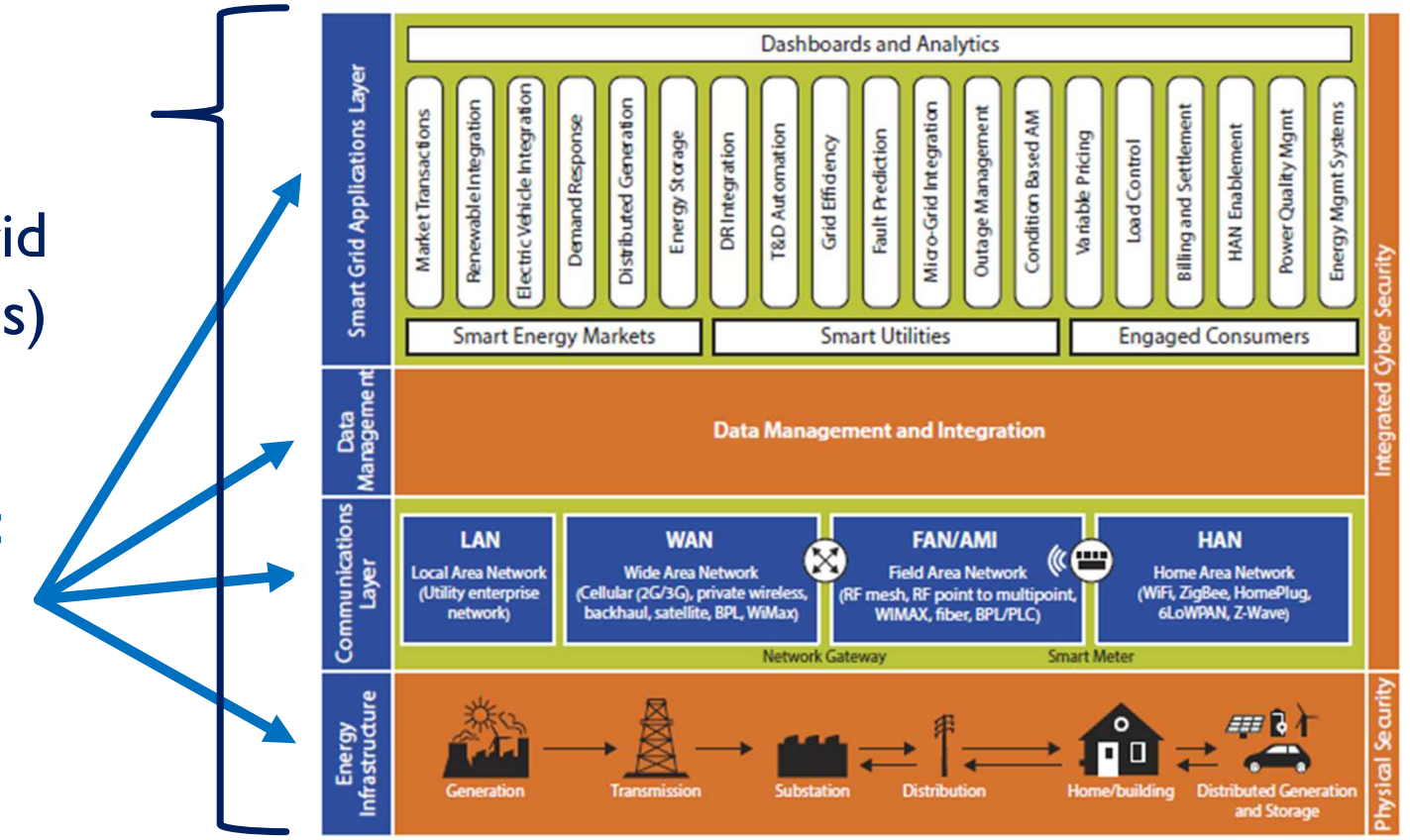
Source: Qualcomm

Edge Sensors, Communications, Data Management and Application Integration

Directional Alignment
(Comprehensive Grid Modernization Focus)

Topical Alignment
(Grid Modernization Component Focus)

Grid Modernization Components



Source: Adapted from Pacific Gas & Electric

Low Power Wide Area (LPWA) technologies

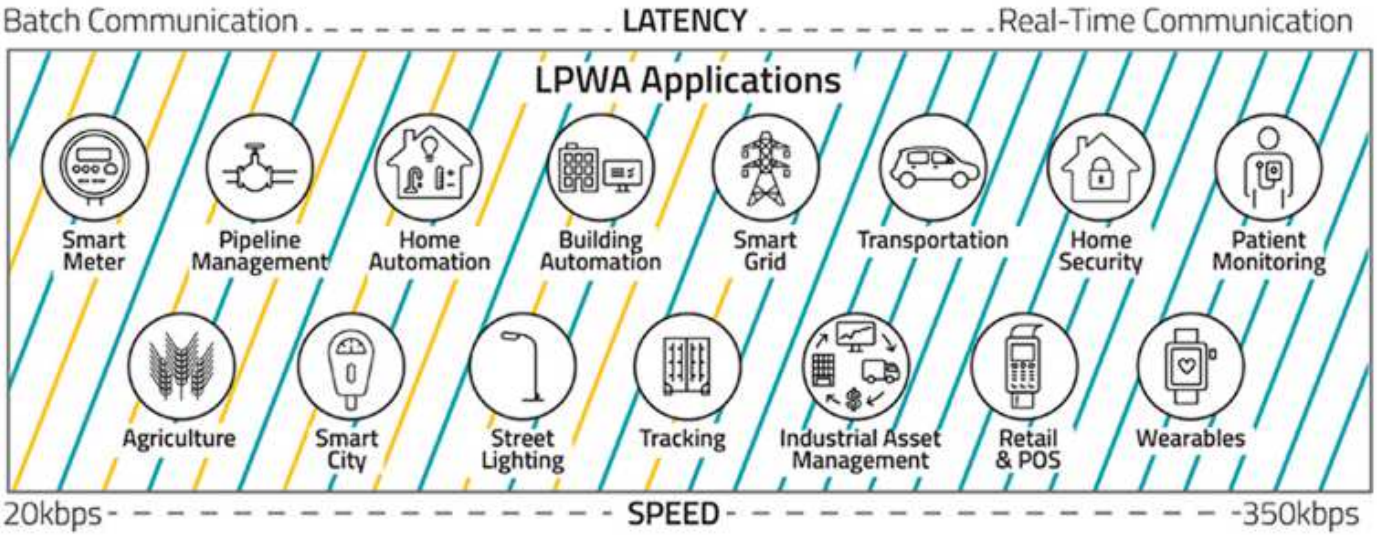
Attribute	CAT-M1 (LTE-M)	CAT-NB1 (NB-IoT)
Voice Capability	Yes	No
Mobility	Full	Partial
Data Rate	375 kbps	20-65 kbps
Latency	Fast (~same as LTE)	Medium

NB-IoT 5G ready

- Focused on very low data rates
- Ideal for simpler static sensor applications

LTE-M / eMTC / Cat-M 5G ready

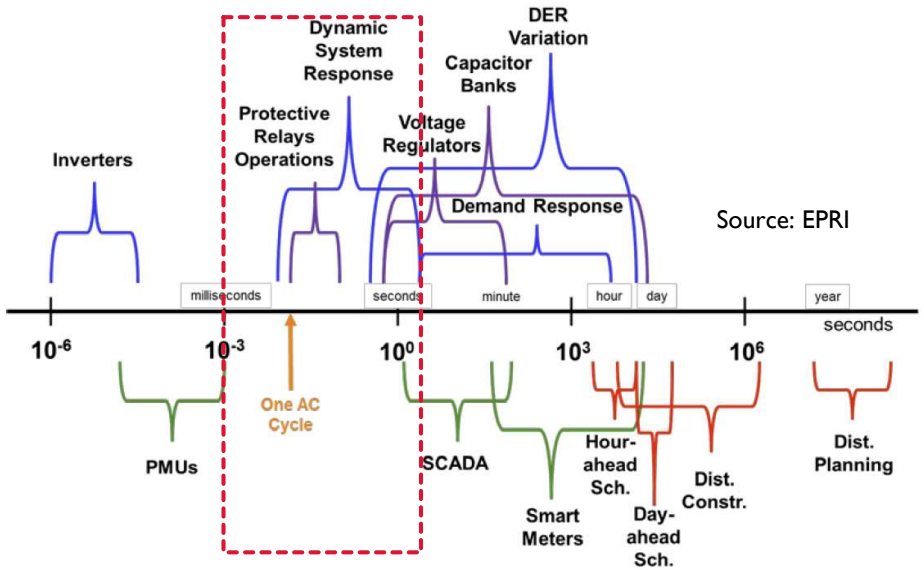
- Highest bandwidth of any LPWA technology
- Ideal for fixed and mobile applications



Source: Ericsson

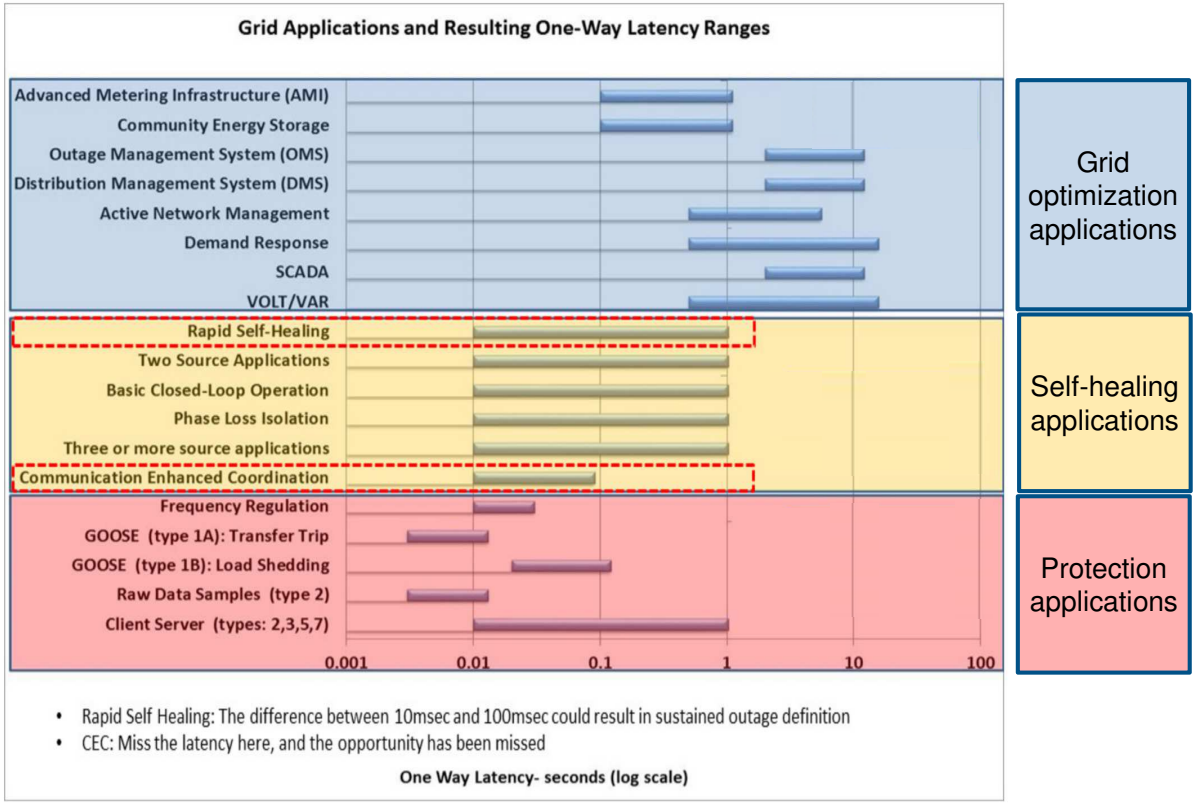
Low Latency - SCADA and Distribution Control Systems

All grid devices are not the same and require different communications parameters - one of the key considerations is latency (i.e., data transmission speed/timing)



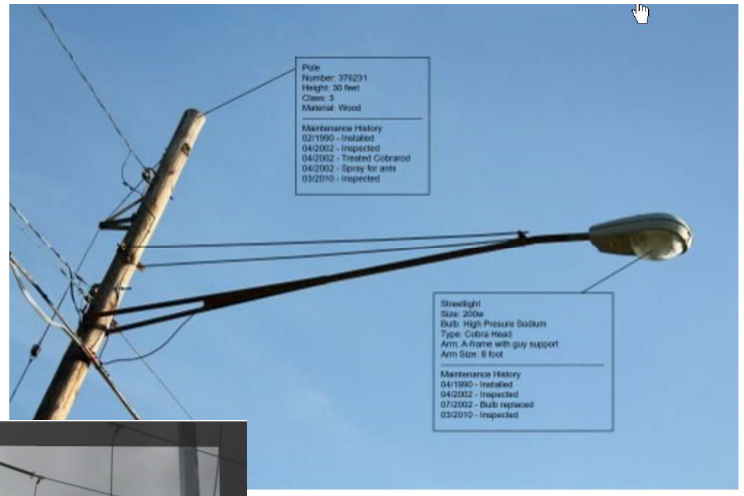
Source: EPRI

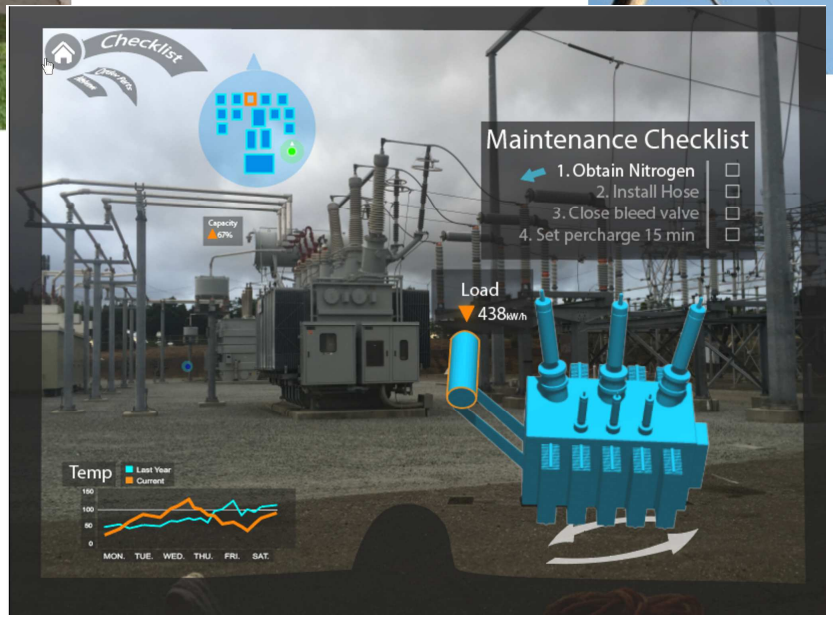
Purple = Traditional Devices
Green = Traditional Distribution Measurement Devices
Blue = DER & DR Devices
Red = Planning



Source: Adapted from S&C Electric CIGRE paper

High Bandwidth - Augmented/Virtual Reality AR/VR





High Bandwidth- Unmanned Aerial Vehicles

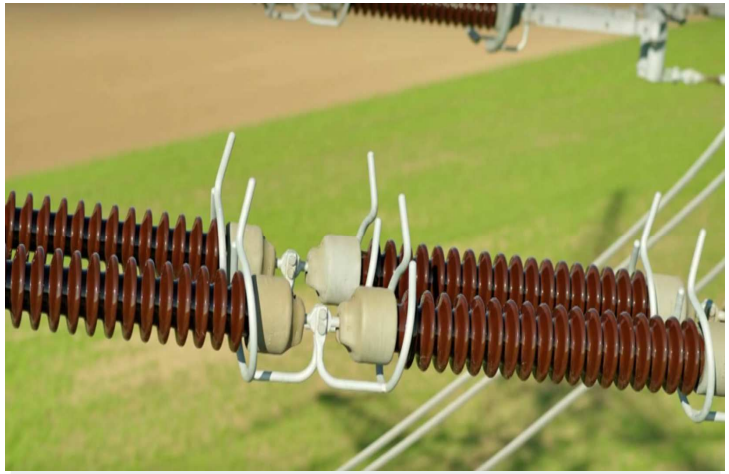


Photo courtesy of San Diego Gas & Electric Co.

Using drones to inspect power lines will save time and money, say San Diego Gas & Electric officials.

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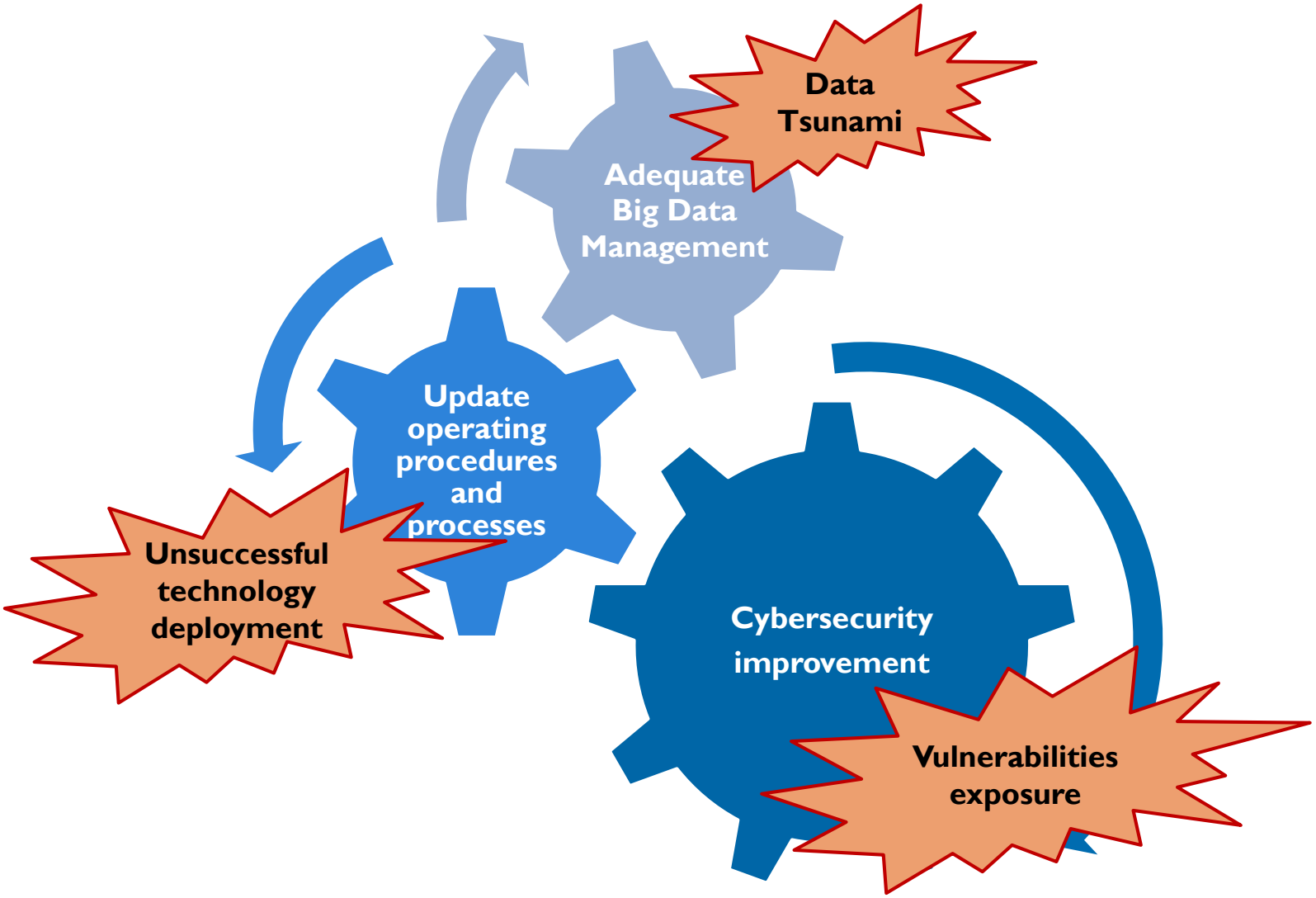
3. What are some of the implications and considerations that utilities must consider?

Main Implications Coming From 5G Introduction



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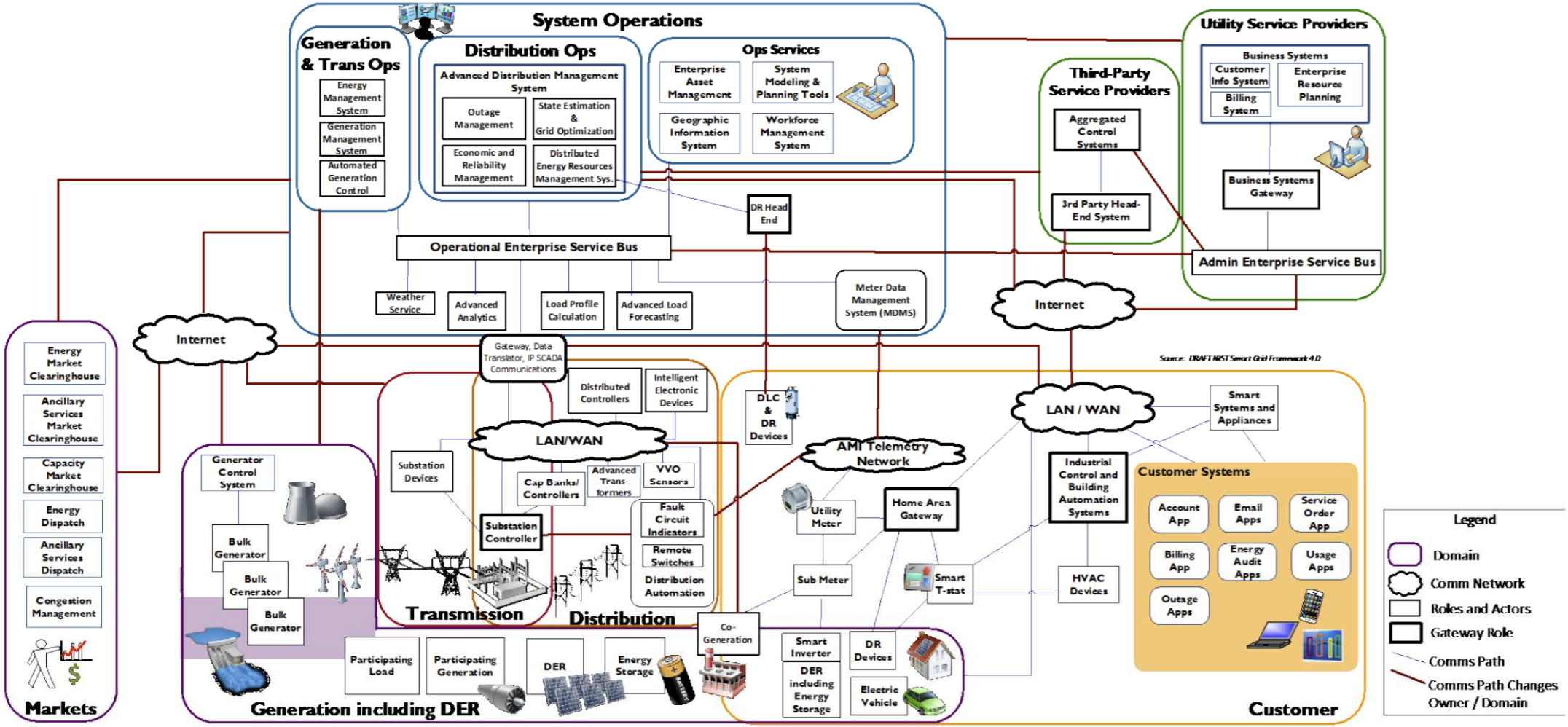
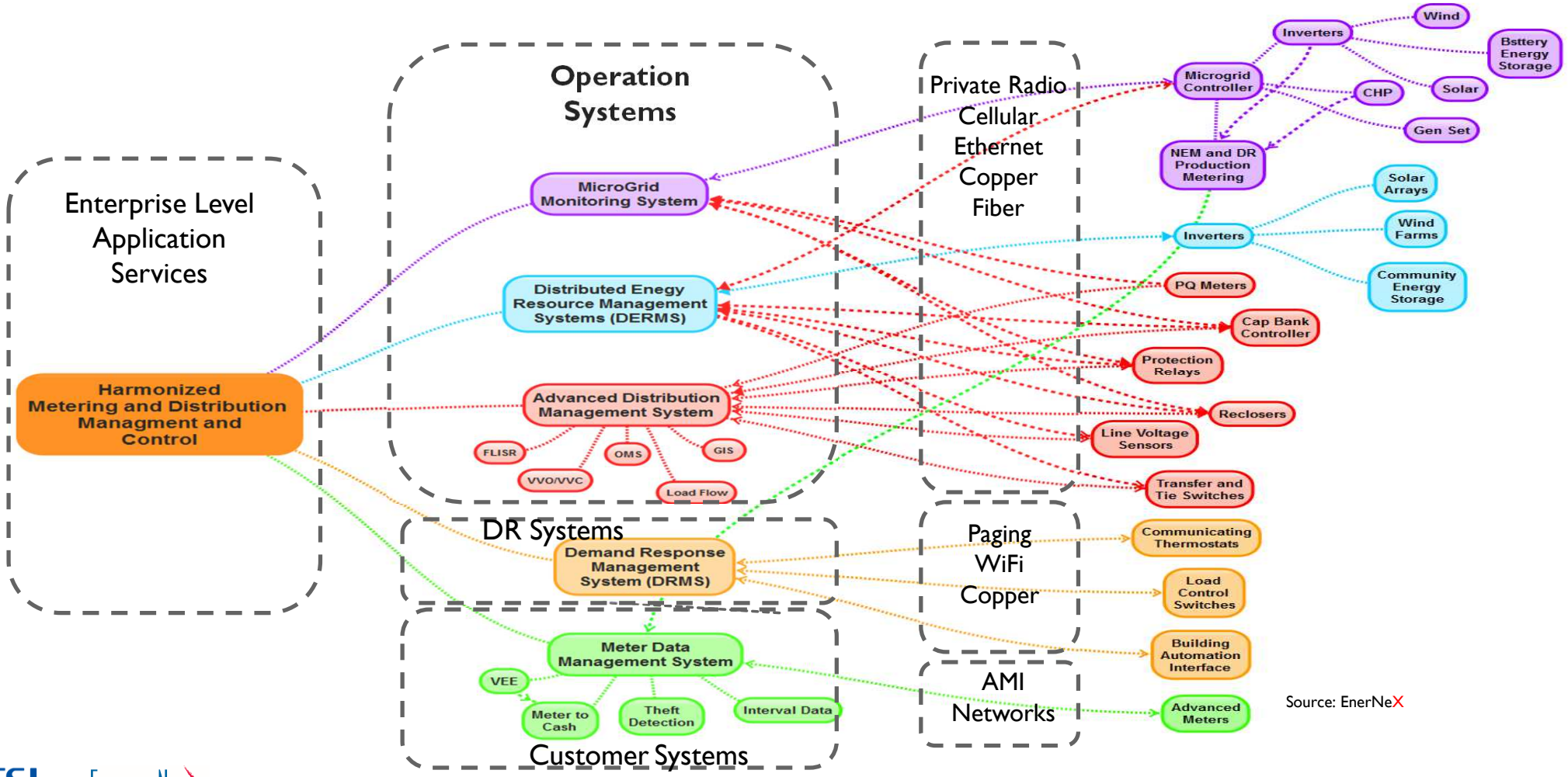
NIST Smart Grid Logical Model V4.0 – High-DER Communications



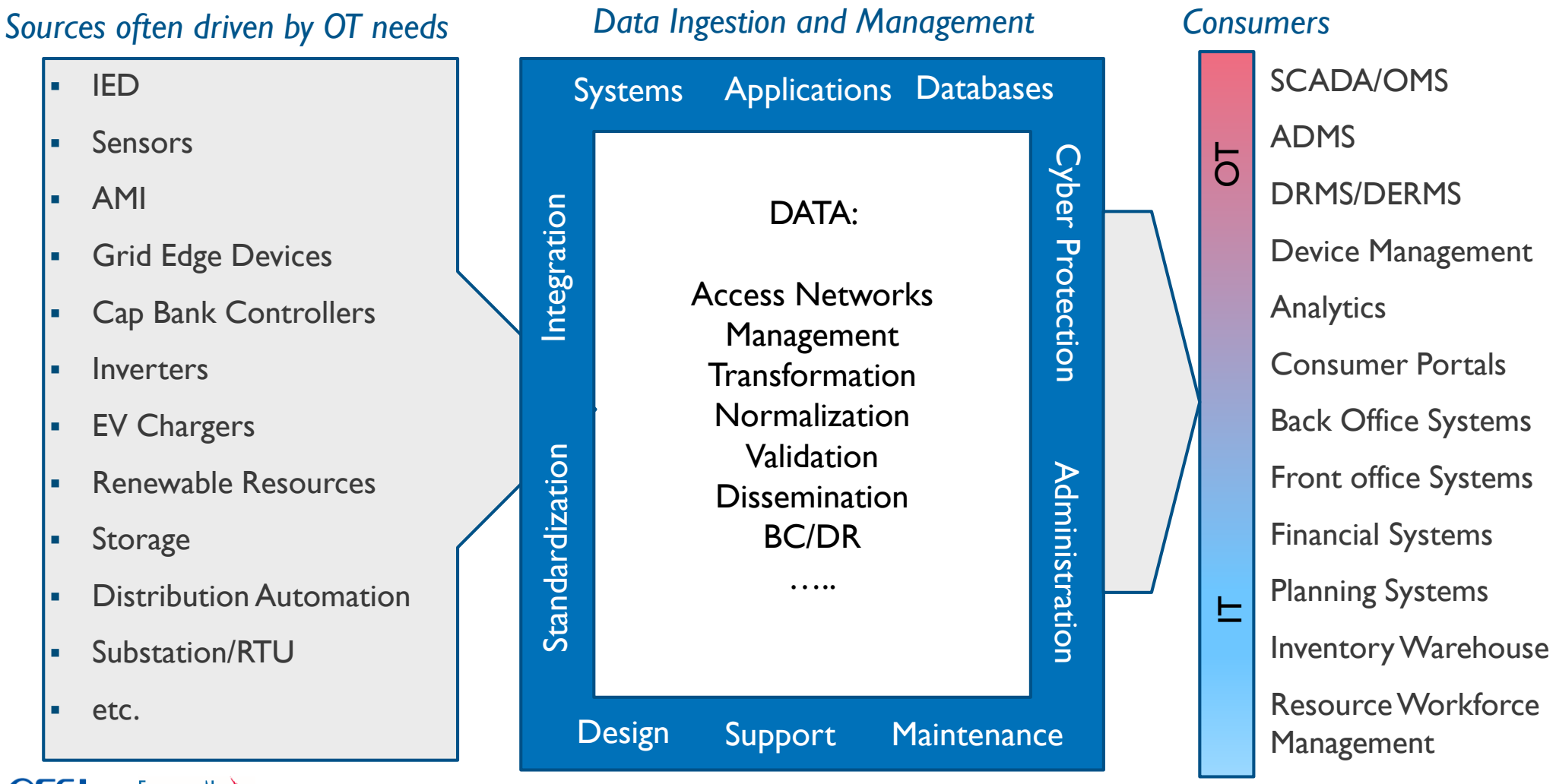
Source: NIST

Alignment of sensors, telecommunications networks and system ingestion

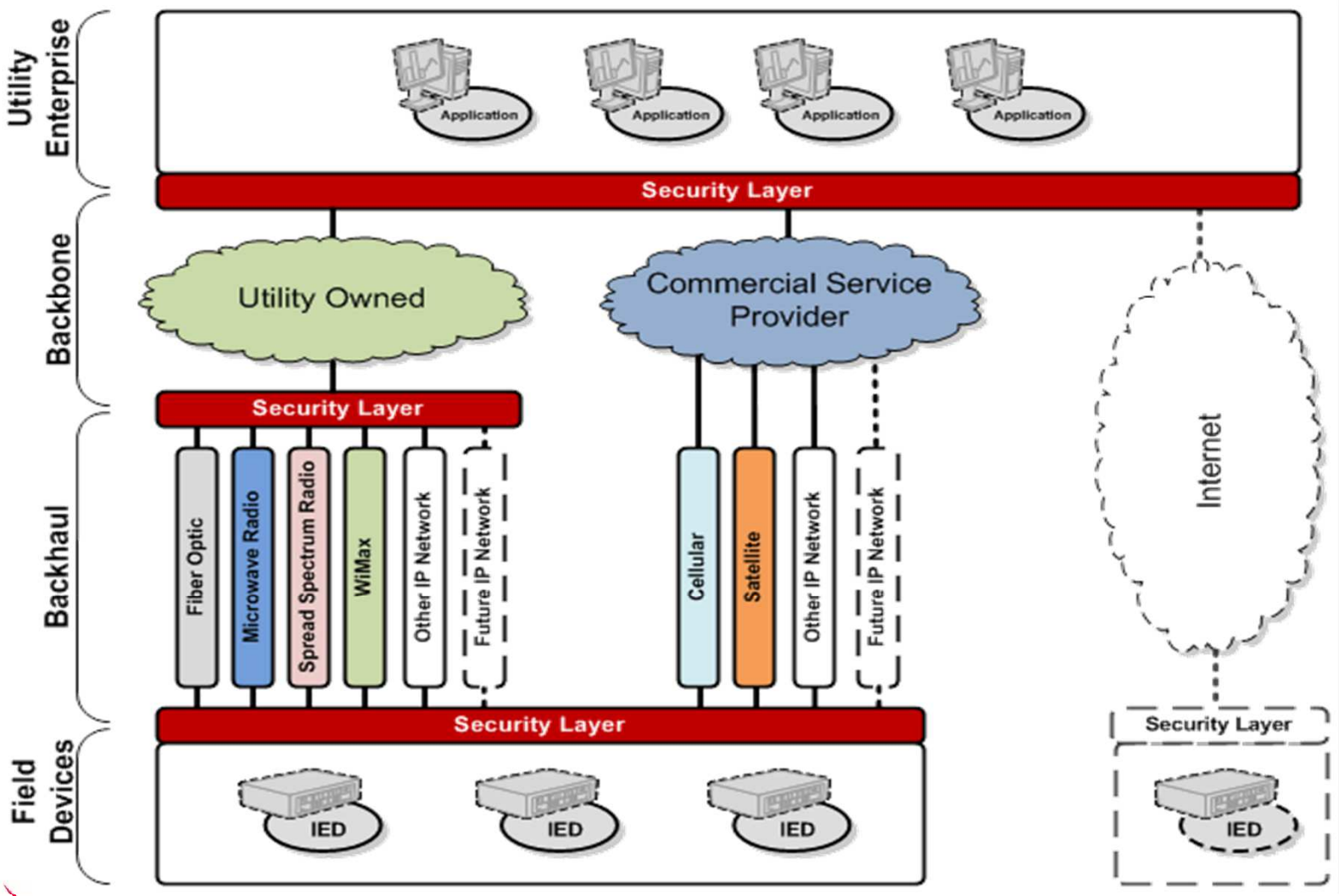


Source: EnerNeX

OT/IT Bridging the Divide

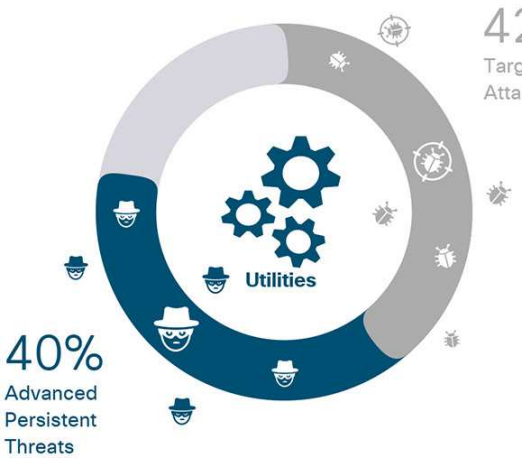


Trust Layers



Source: EnerNex

Cyber Context and Challenges



Source: CISCO 2017 – Security Capabilities Benchmark Study

New Technologies and Devices

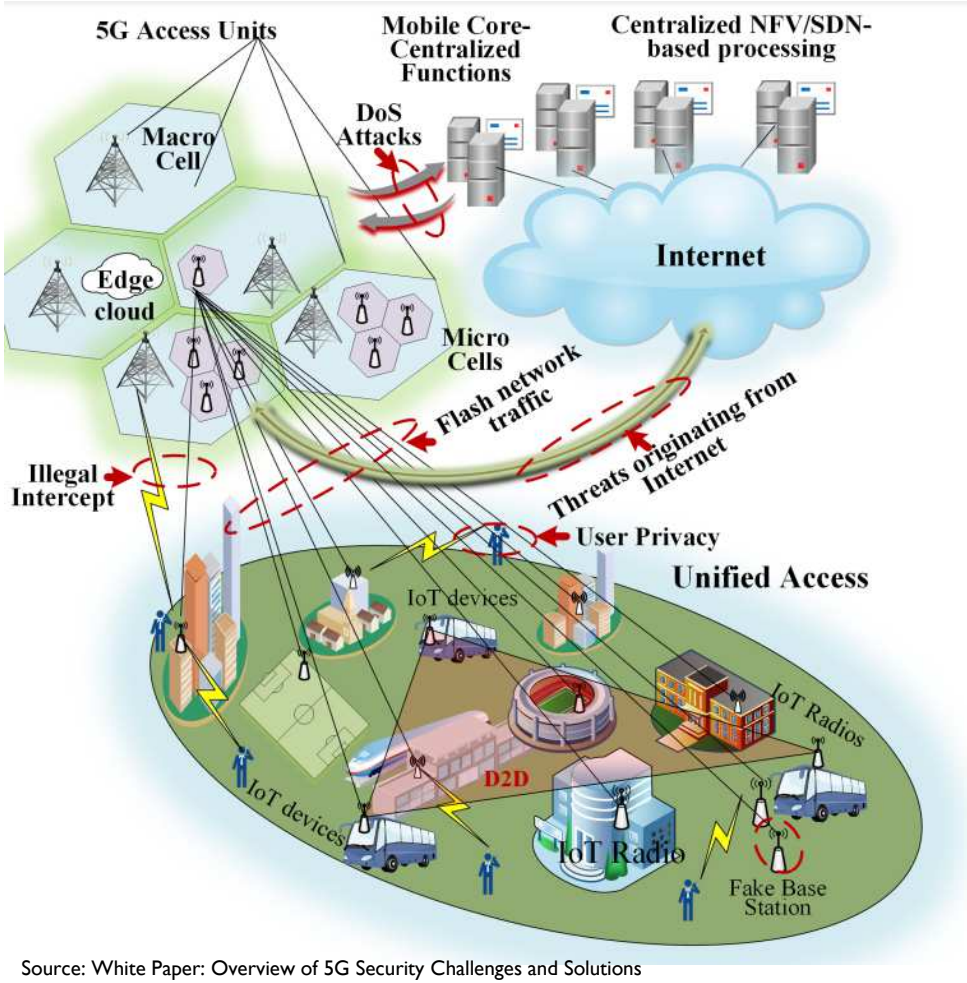
- **New Risks,** strictly connected to the new technology:
  - Enlarged **exposure surface**
  - Number of **connected devices** and **shared** network **resources**
- **Increased likelihood of existing threats**

"Security by Design" principle: if security is not projected from the beginning surely there will be problems

Large majority of industrial equipment are based on legacy infrastructure

Cybersecurity implementation and update are needed

Cyber Risks and Threat Vectors



Source: White Paper: Overview of 5G Security Challenges and Solutions
Ijaz Ahmad, Tanesh Kumar, Madhusanka Liyanage, Jude Okwuibe, Mika Ylianttila, Andrei Gurto
IEEE Communications March 2018

Flash network traffic: High number of end-user devices and IoT.

Security of radio interfaces: Radio interface encryption keys sent over insecure channels.

User plane integrity: No cryptographic integrity protection for the user data plane.

Mandated security in the network: Service-driven constraints on the security architecture leading to the optional use of security measures.

Roaming security: User-security parameters are not updated with roaming from one operator network to another, leading to security compromises with roaming.

Denial of Service (DoS) attacks on the infrastructure: Visible nature of network control elements, and unencrypted control channels.

Signaling storms: Distributed control systems requiring coordination, e.g. Non-Access Stratum (NAS) layer of Third Generation Partnership Project (3GPP) protocols.

DoS attacks on end-user devices: No security measures for operating systems, applications, and configuration data on user devices.

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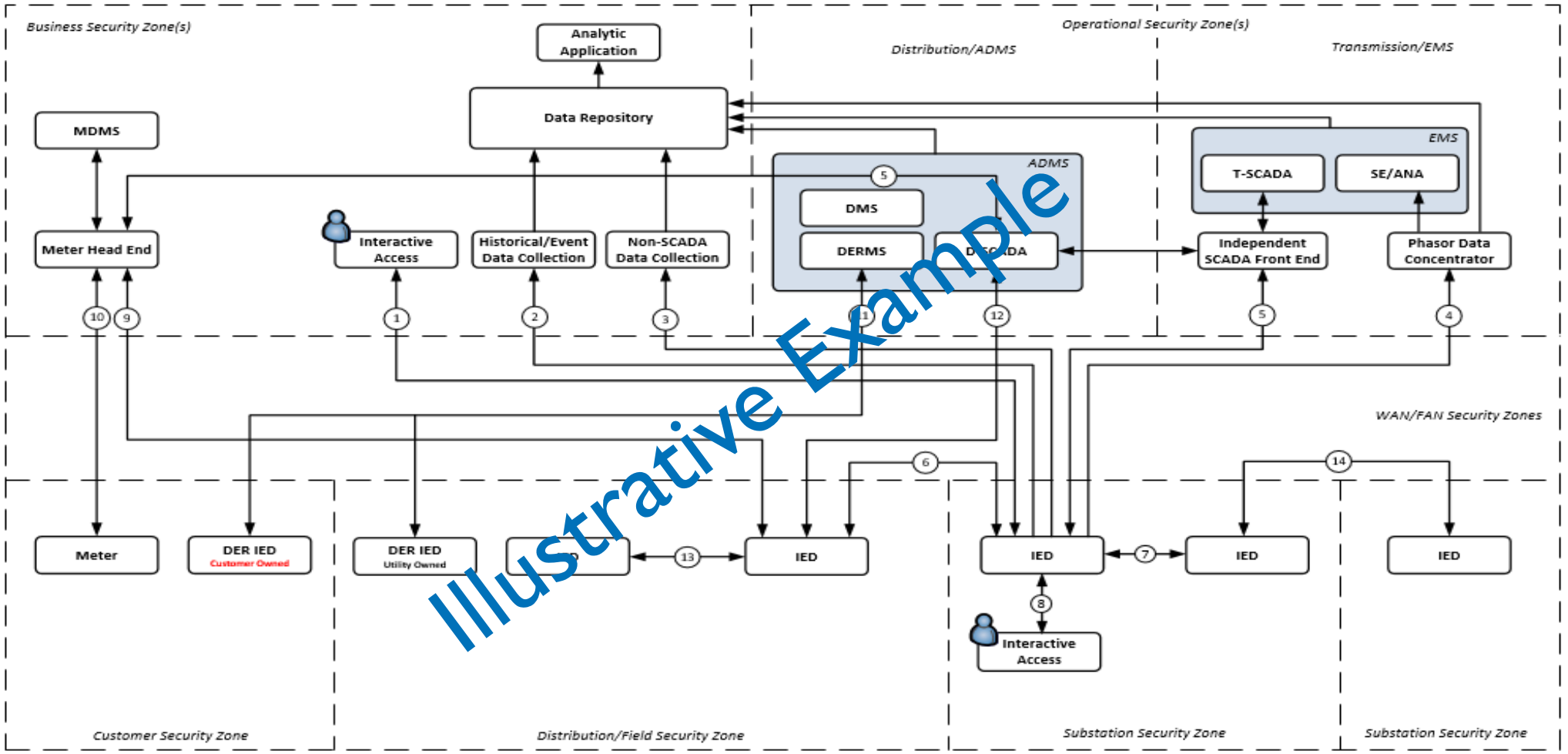
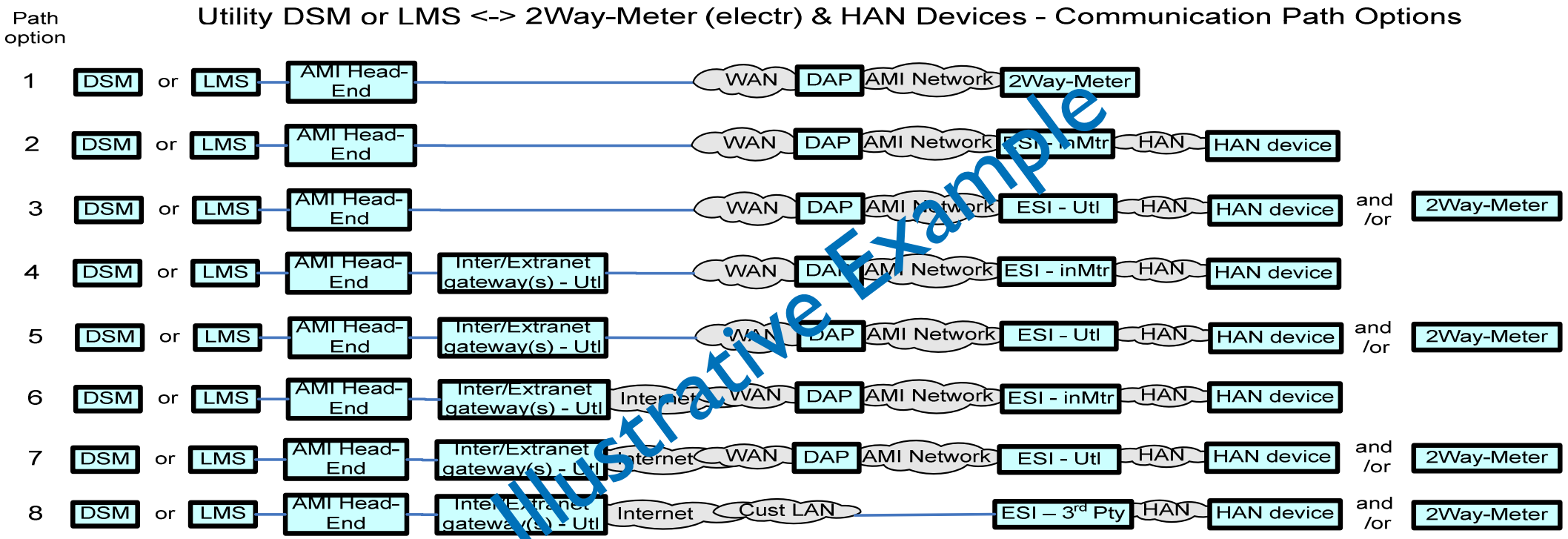
5. What are CESI and EnerNex doing to further define the options and potential synergies?

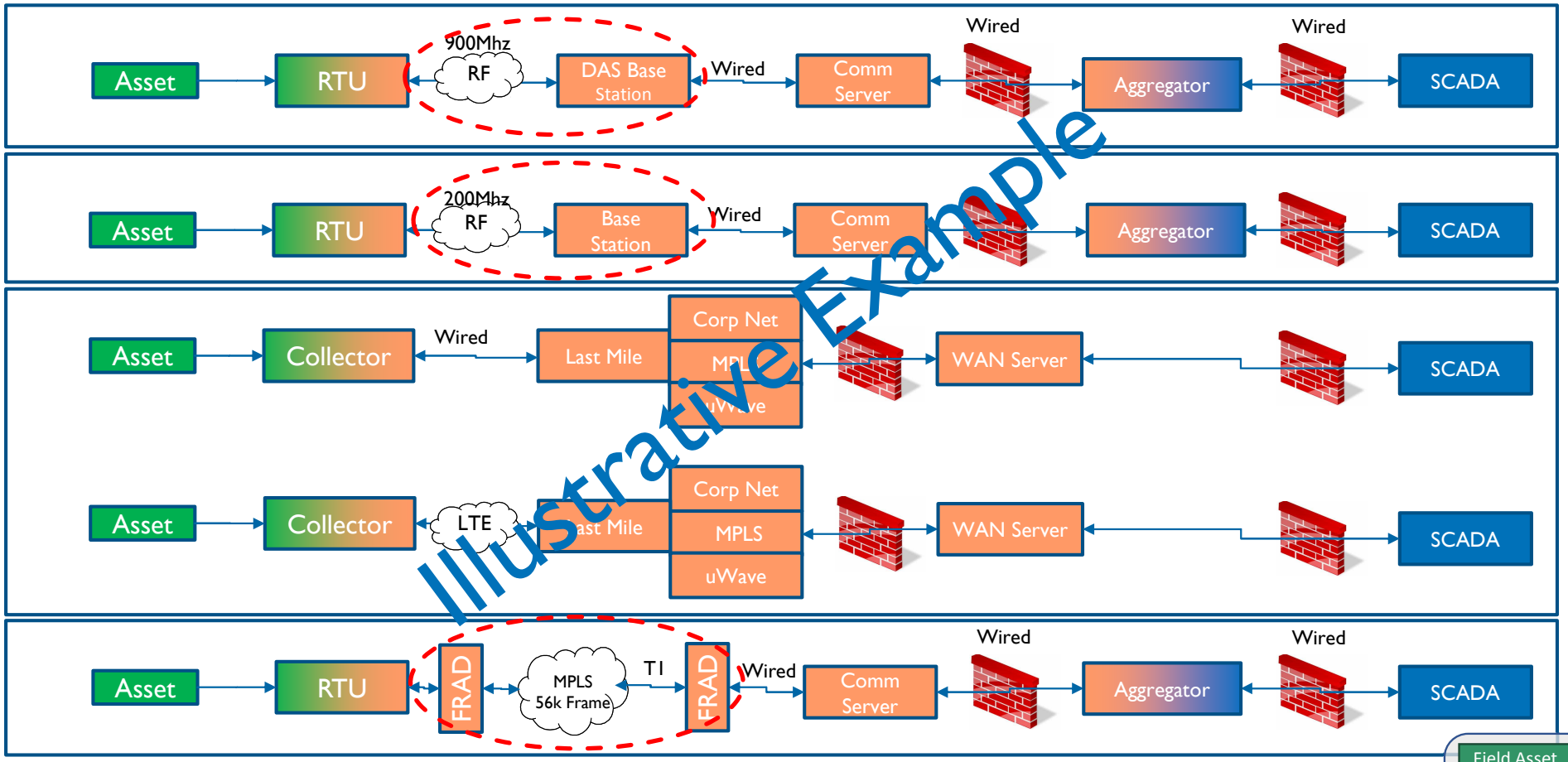
Enterprise Level Pathway Tracing



Sensor Pathway Mapping



Asset, Communications and Target Mapping



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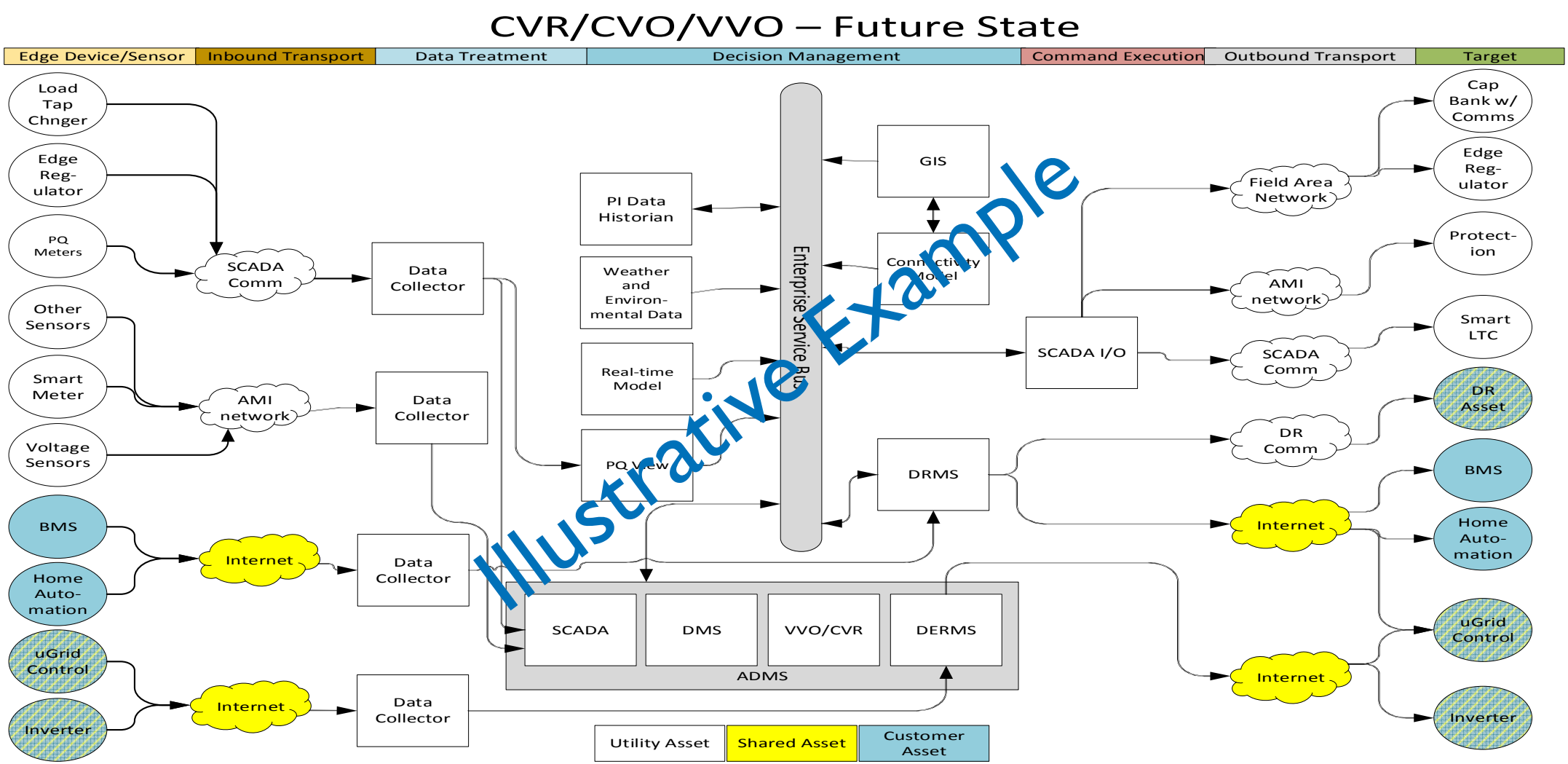
Application Decomposition: Sensors, Telecommunication Network and Systems Mapping



Cyber Trust Level Assessment

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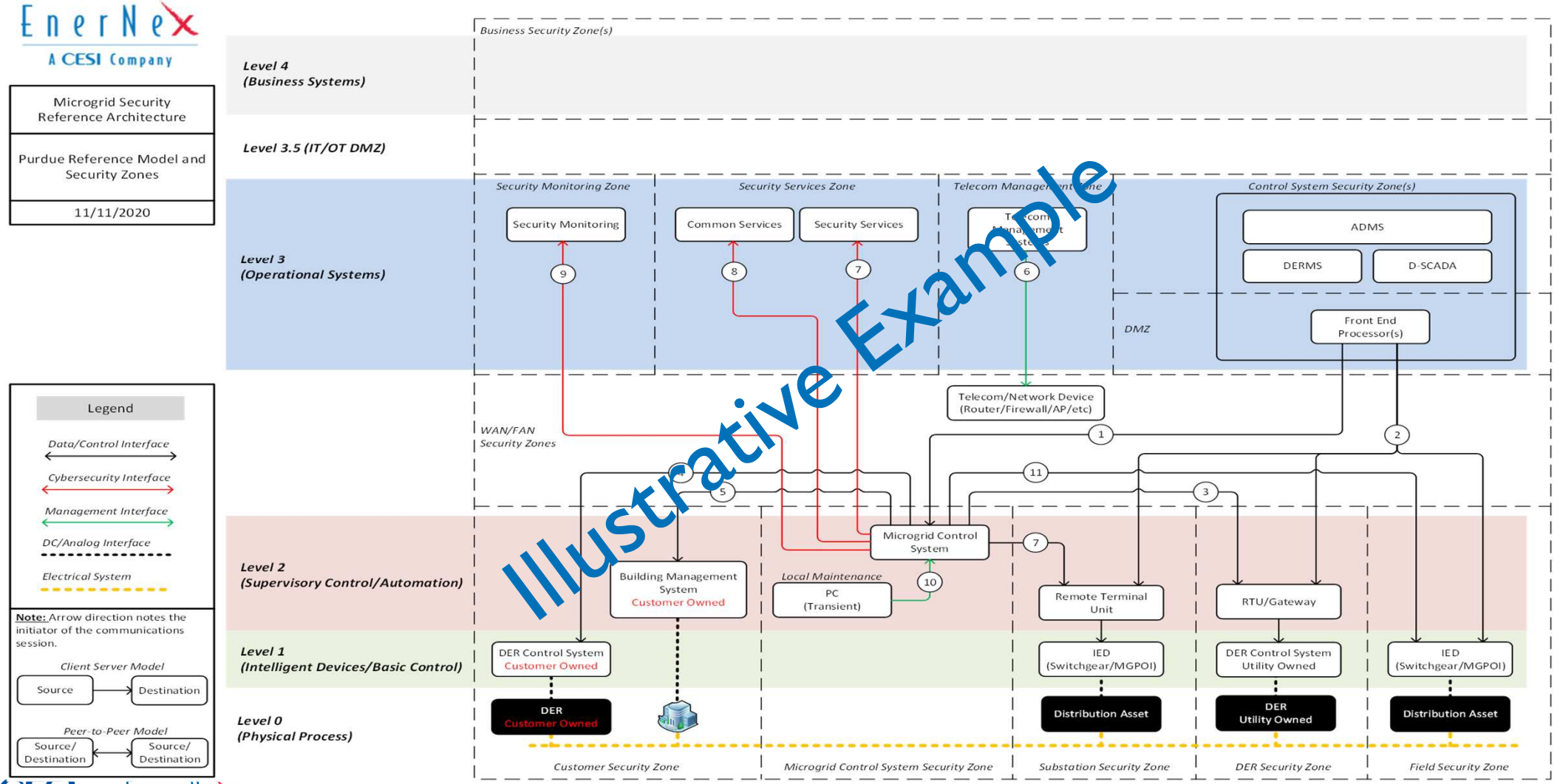
Microgrid Security Reference Architecture

Purdue Reference Model and Security Zones

11/11/2020



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Physical Siting Issues with Small Cells – Survey and Study on Behalf of DSTAR*

Installing the necessary equipment on utility poles requires getting clearance from utility companies, cities, and towns. But this has been a mixed bag in various jurisdictions. So much so that the FCC has established new rules to reduce federal regulatory impediments to deploying the small-cells, including limits on the use fees that cities and towns can charge wireless carriers and a timeline to approve or disapprove small-cell siting applications.

* GE Consulting: DSTAR (Distribution System Testing Application and Research)

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Q&A

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Thank you for attending! Keep in touch.

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