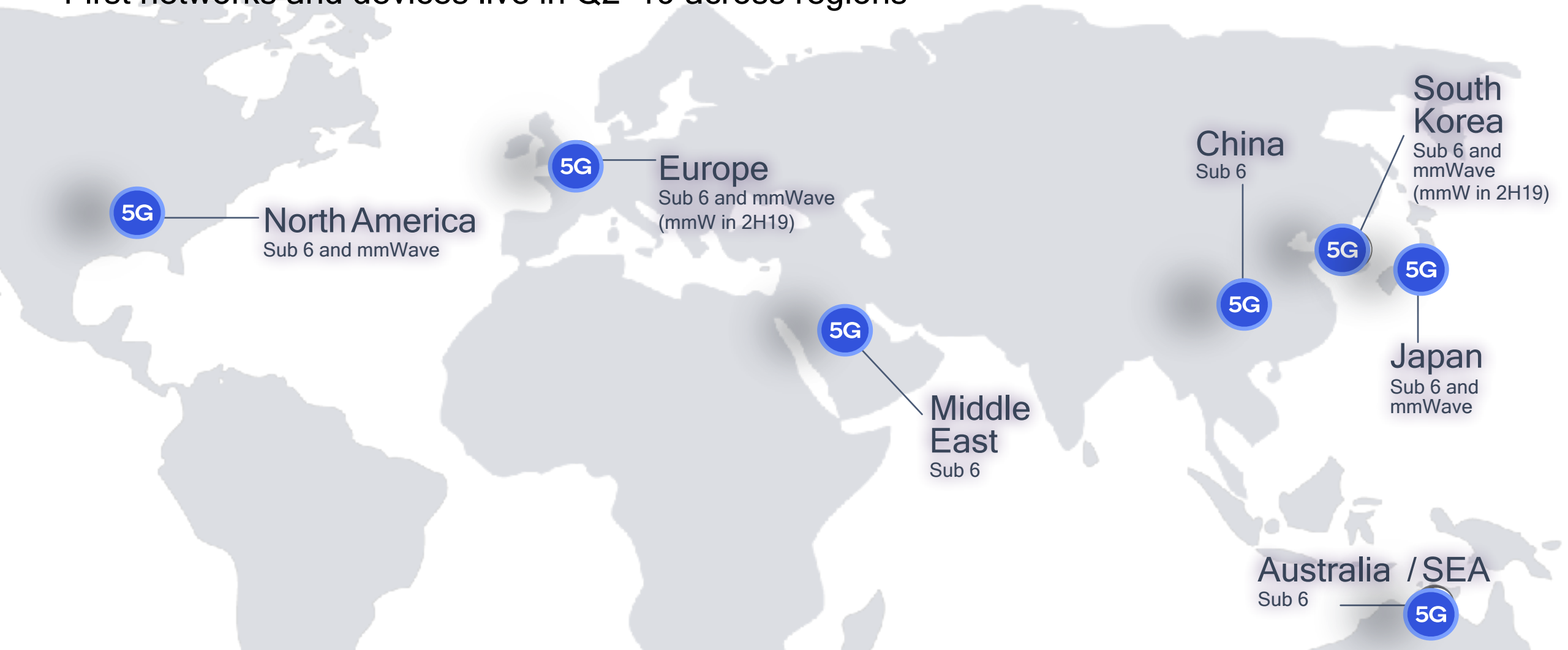

Qualcomm
June 6, 2019
Robotics Summit & Expo
@Dev Singh
How 5G Will Usher in a New Generation of Connected Robots
Dev Singh
Director, Business Development
Head of Robotics, Drones & Intelligent Machines
Qualcomm Technologies, Inc.
5G

2019 is the Year of 5G

First networks and devices live in Q2 ’19 across regions

5G Networks and Smartphones - a Commercial Reality in 2019

First networks and devices live in Q2 ’19 across regions



5G roll-out happening faster than 4G

Source: IHS Report Jan '19, Qualcomm Technologies data

Year 1 announcements underscore tremendous momentum with 5G

Lenovo
Z6 Pro 5G

LG
V50 ThinQ 5G

Motorola
moto z³ + 5G
moto mod

Nubia
Mini 5G

OnePlus
7 Pro 5G

OPPO
Reno 5G

Samsung
Galaxy S10 5G

Samsung
Galaxy Fold

Xiaomi
Mi MIX 5G

ZTE
Axon 10 Pro 5G

Askey
5G CPE

HTC
5G Hub

Inseego
MiFi 5G NR

Netgear
Nighthawk 5G

WNC
5G mobile hotspot

WNC
5G Outdoor CPE

Quectel
5G modules

Sierra Wireless
5G M.2 module

Telit
5G modules

The device ecosystem is delivering 5G

75+ 5G devices in development

5G Is Far More Than Just Mobile

To meet an extreme variation of 5G NR requirements

Mission-critical services

Cellular Vehicle-to-Everything (C-V2X)

Drone communications | Private Networks

Ultra Reliable Low Latency Comms (URLLC)

Enhanced mobile broadband

Spectrum sharing | Flexible slot-based framework

Scalable OFDM | Massive MIMO | Mobile mmWave

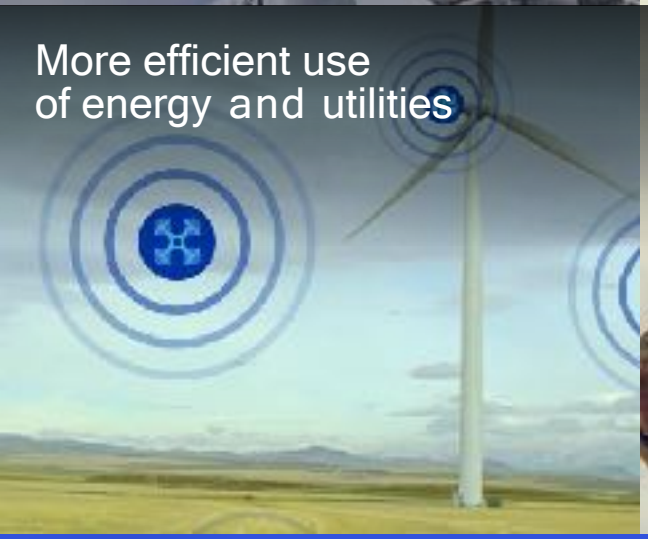
Dual Connectivity | Advanced channel coding | VR/XR

Massive Internet of Things

Enhanced power save modes

Deeper coverage | Grant-free UL

Narrow bandwidth | Efficient signaling



5G

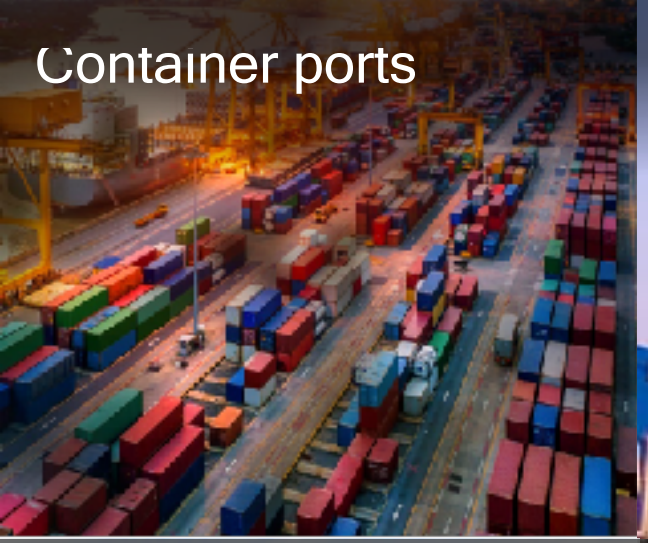
5G will expand the mobile ecosystem to new industries

*The 5G Economy, an independent study from IHS Markit, Penn Schoen Berland and Berkeley Research Group, commissioned by Qualcomm

Powering the digital economy

>$12 Trillion

In goods and services by 2035*



>$5 Trillion[1]

Global economic output in 2035 enabled by 5G in the following five categories

Manufacturing	Transport	Construction	Utilities	Mining
$3,364B	$659B	$742B	$273B	$249B

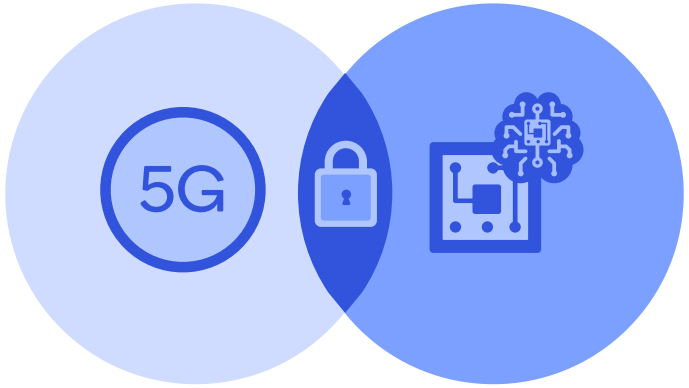
1. “The 5G economy: How 5G technology will contribute to the global economy” by IHS Economics / IHS Technology

5G takes Industry 4.0 to the next level

Single futureproof 5G network

Scalable capacity and reliability

Flexibility with wireless Ethernet

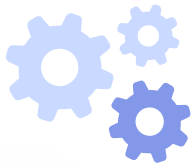


Connectivity | Security | Compute

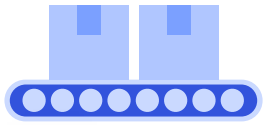
On-device processing and sensing

CV and AI for autonomous machines

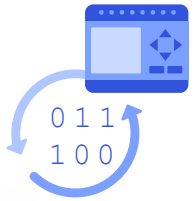
Edge services and data privacy



Industry 1.0
Mechanization



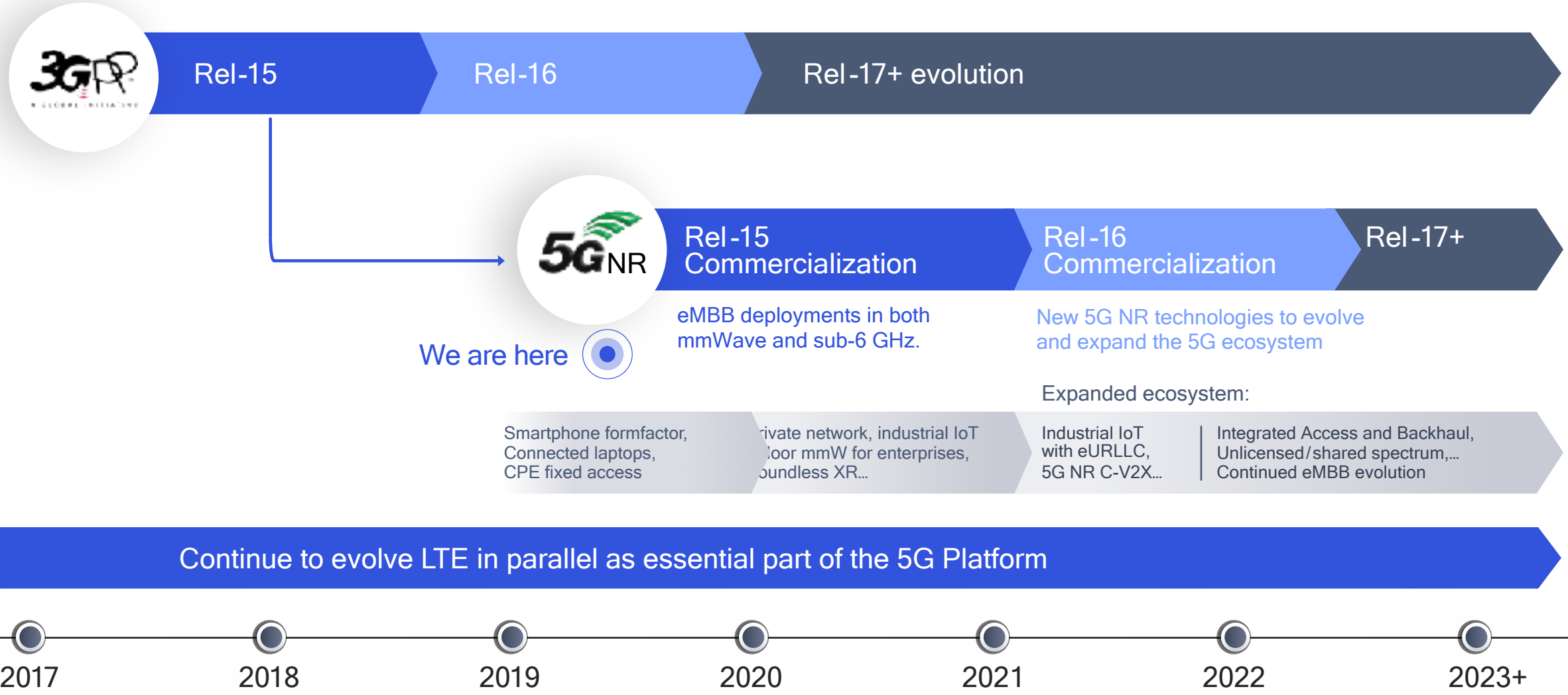
Industry 2.0
Electrification

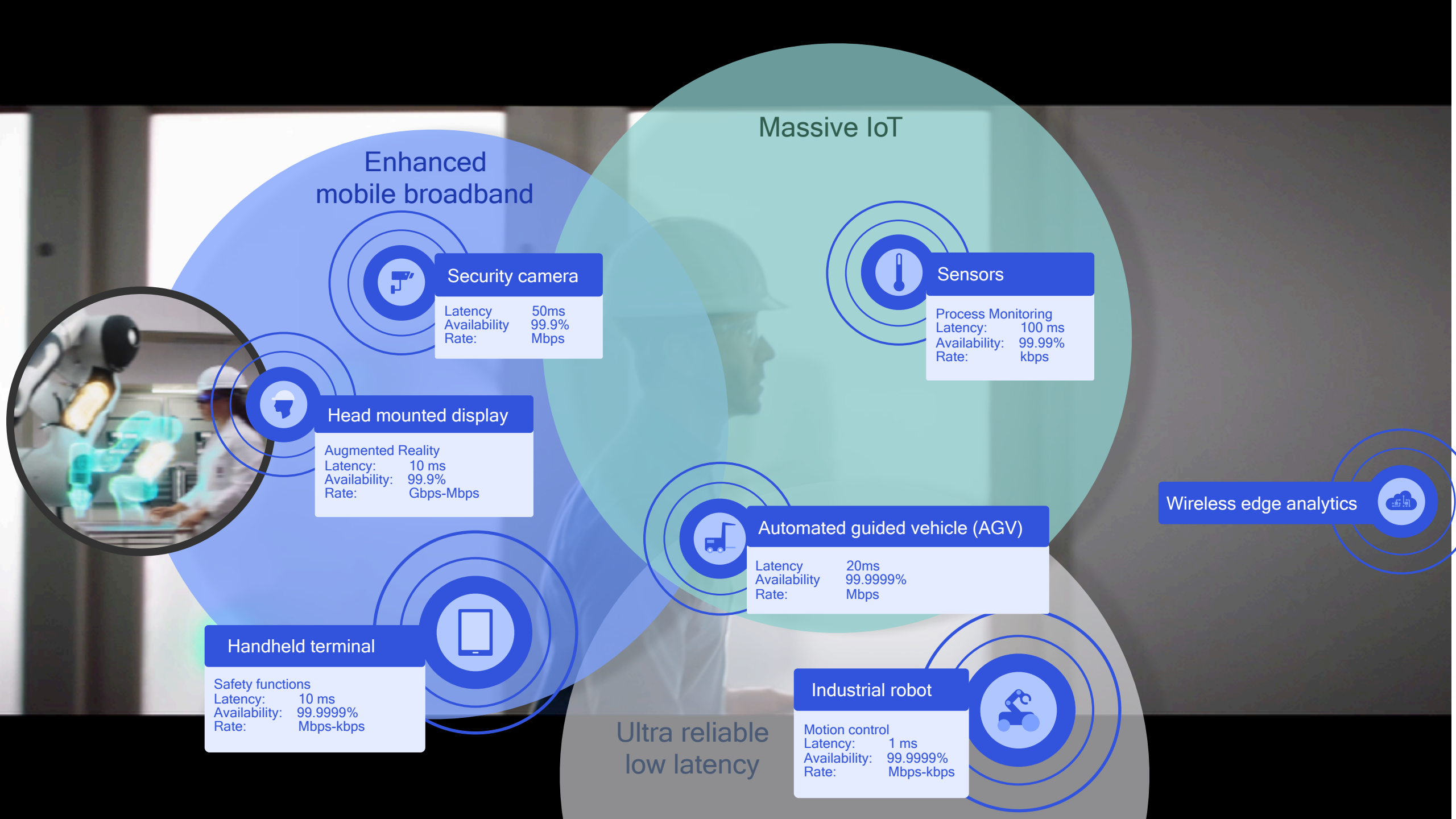


Industry 3.0
Digitalization

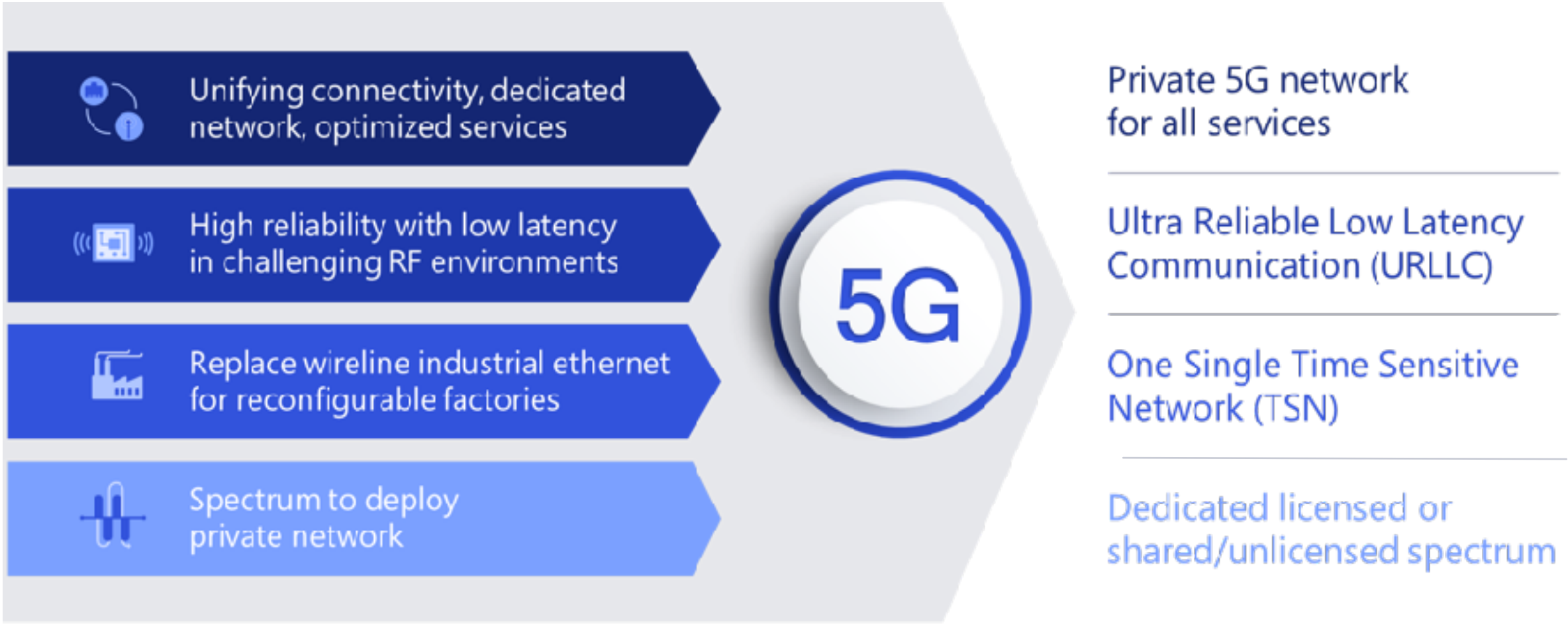
Industry 4.0
5G Connectivity

Driving the 5G roadmap and ecosystem expansion




Enhanced mobile broadband
Massive IoT
Security camera
Latency 50ms
Availability 99.9%
Rate: Mbps
Sensors
Process Monitoring
Latency: 100 ms
Availability: 99.99%
Rate: kbps
Head mounted display
Augmented Reality
Latency: 10 ms
Availability: 99.9%
Rate: Gbps-Mbps
Automated guided vehicle (AGV)
Latency 20ms
Availability 99.9999%
Rate: Mbps
Wireless edge analytics
Handheld terminal
Safety functions
Latency: 10 ms
Availability: 99.9999%
Rate: Mbps-kbps
Industrial robot
Motion control
Latency: 1 ms
Availability: 99.9999%
Rate: Mbps-kbps
Ultra reliable low latency

5G NR supports many industrial IoT use cases today; 3GPP Rel-16 brings additional capabilities

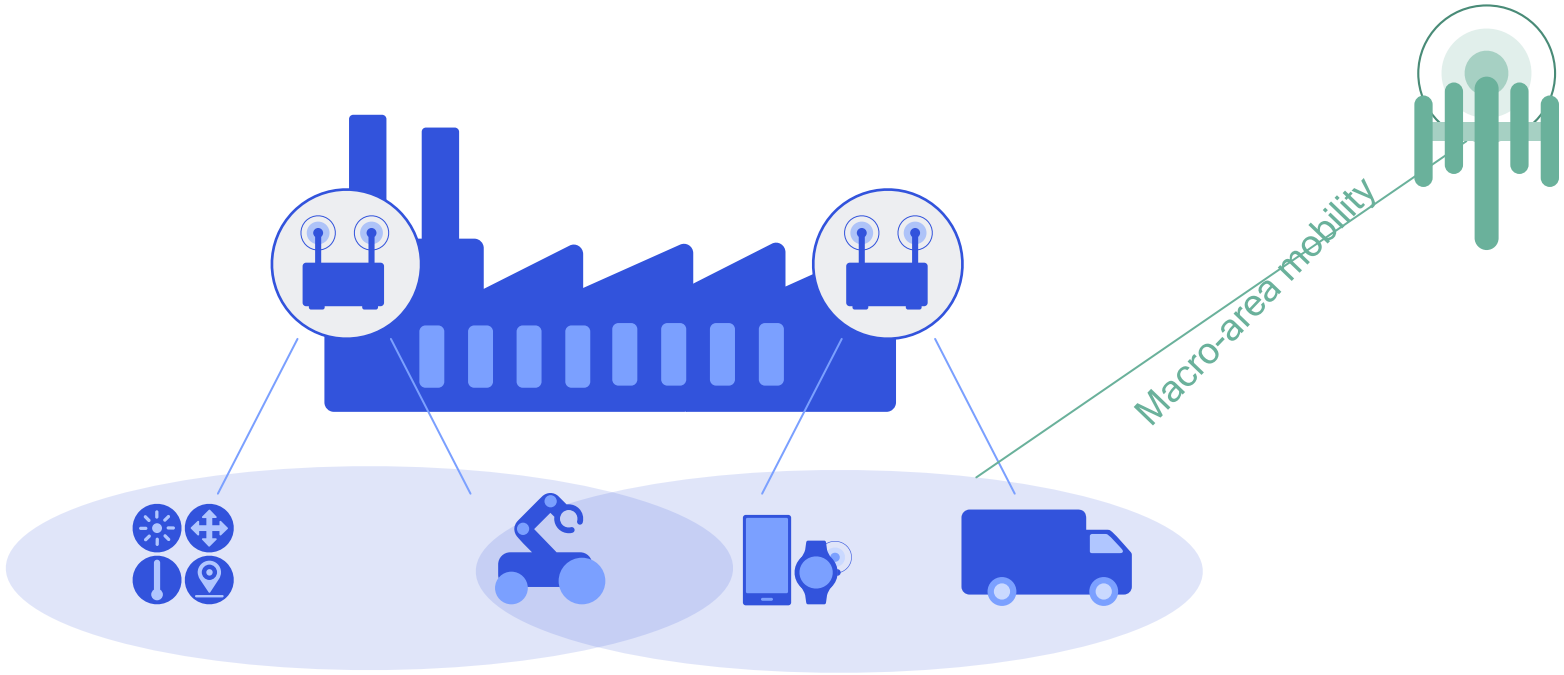


Designing 5G to meet industrial IoT requirements

Private networks

(non-public networks)

Private 5G networks for Industrial IoT use cases



Private network[1]

Optimized

Tailored for industrial applications, e.g., QoS, latency

Dedicated

Local network, easy to deploy, independently manage

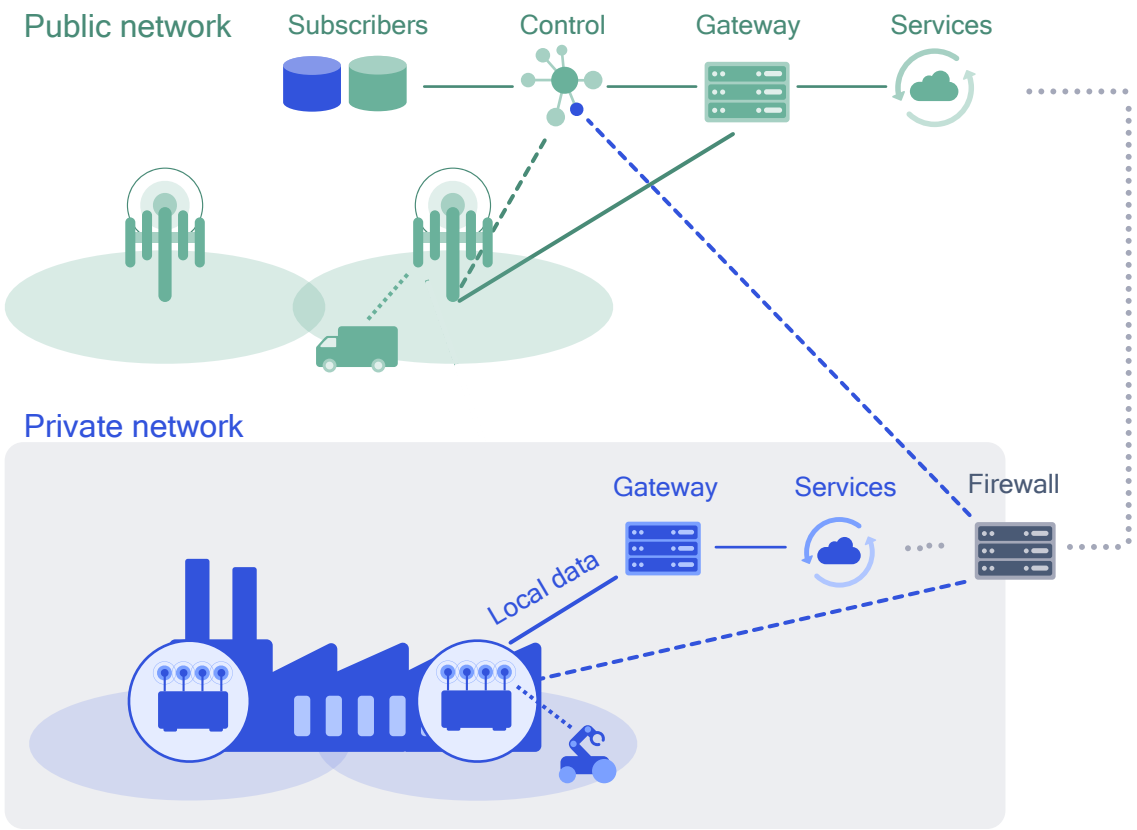
Secure

Cellular grade security and keeping sensitive data local

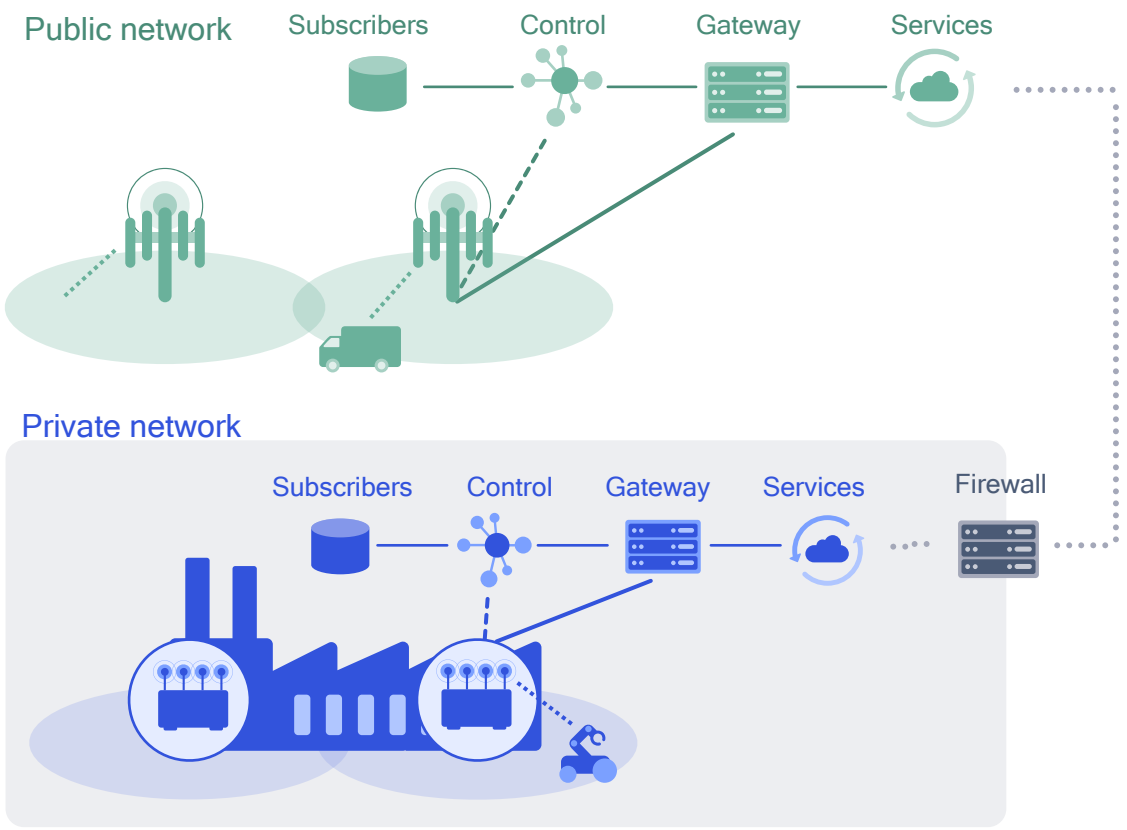
Optimizing private LTE for Industrial IoT today → New opportunities and scalability with 5G NR capabilities → 3GPP roadmap with regular releases providing new features

1. Also referred to as non-public network (NPN)

Integrated private network[1]



Independent private network



1. There are different levels of integration of public and private network architectures, e.g., shared RAN, shared control plane, shared user plane. This example shows shared control plane.

Multiple private network architectures for flexible deployments

Spectrum for private 5G networks

Multiple spectrum options for Private 5G NR networks

Licensed spectrum owned by mobile network operators

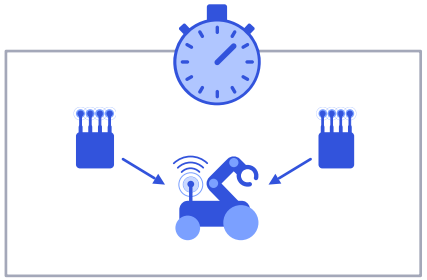
Operators can allocate spectrum in a specific area for industrial IoT (e.g., mines)

Dedicated spectrum with optional synchronized sharing

In some region's spectrum is dedicated for industrial IoT use (e.g., 3.7GHz Germany).

Unlicensed spectrum with asynchronous sharing

NR-U with asynchronous sharing can be used for private 5G networks that do not require eURLLC



Unlicensed spectrum with synchronized sharing

Synchronized sharing can provide significant capacity gains and eURLLC

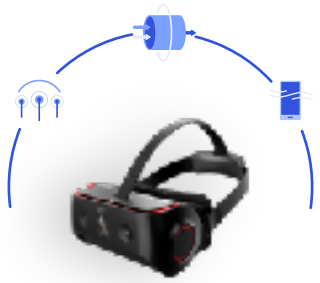
5G NR in unlicensed spectrum (NR-U) part of 3GPP R16

For wide range of deployments – also opportunity for new sharing paradigms

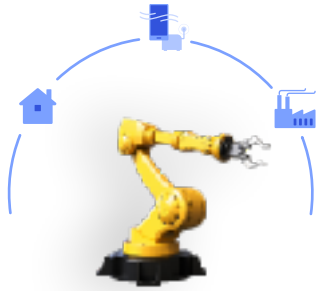
Asynchronized sharing

Evolutionary path: existing coexistence rules in unlicensed spectrum

LAA NR-U



Stand-alone NR-U



5G

Synchronized sharing

Revolutionary path: new rules for time synchronized sharing in unlicensed and shared spectrum

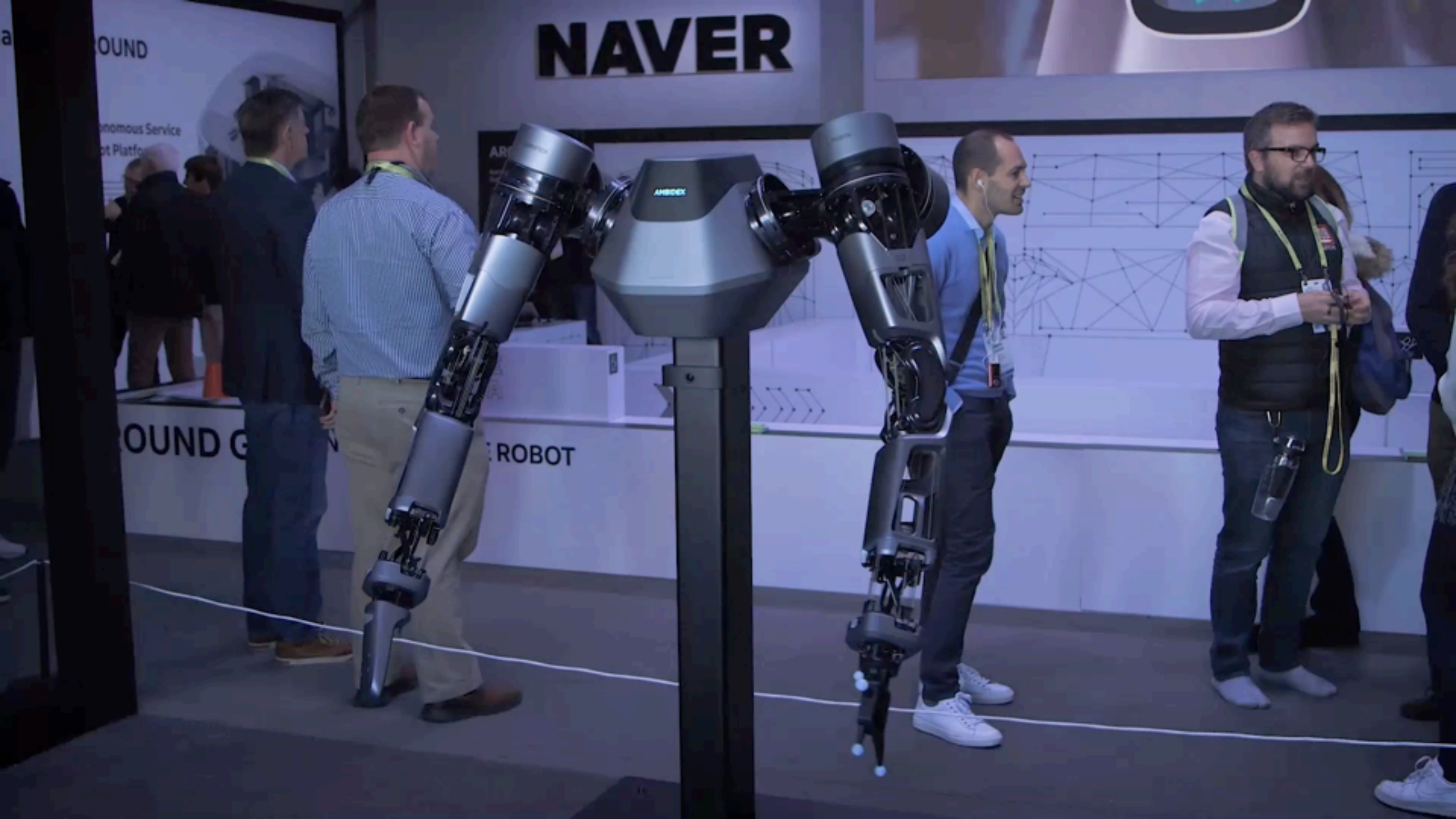
Time synchronization

Provides great potential to share spectrum more efficiently

- 5G CoMP
- Predictable sharing
- Spatial sharing

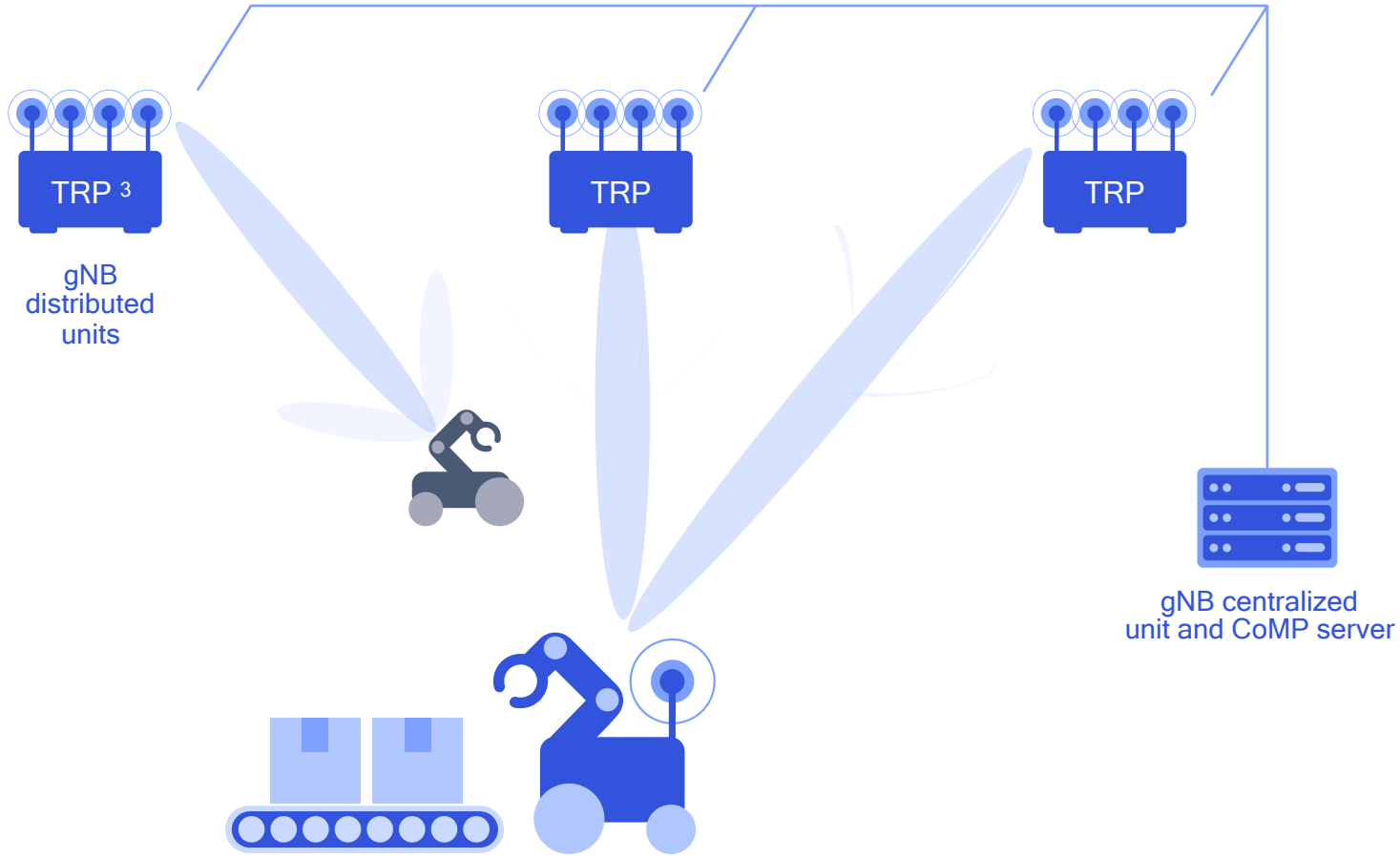
eURLLC

Enhanced ultra-reliable low latency communication


NAVER
AMBIDEX

5G CoMP achieves ultra-reliability

Spatial diversity for eURLLC[1] to reach 99.9999% reliability[2]



Coordinated Multi Point (CoMP) creates spatial diversity with redundant communication paths

- Other diversity methods such as frequency and time diversity are not sufficient for URLLC
- CoMP is facilitated by denser deployment of small cells with high bandwidth backhaul

1. Enhanced ultra-reliable low latency communication; 2. A performance requirements for communication service availability in 3GPP TS 22.104;
3. Transmission/Reception Point

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Ultra-Reliable 5G NR for Industrial IoT

Coordinated Multi-Point (CoMP) OFF

Restart

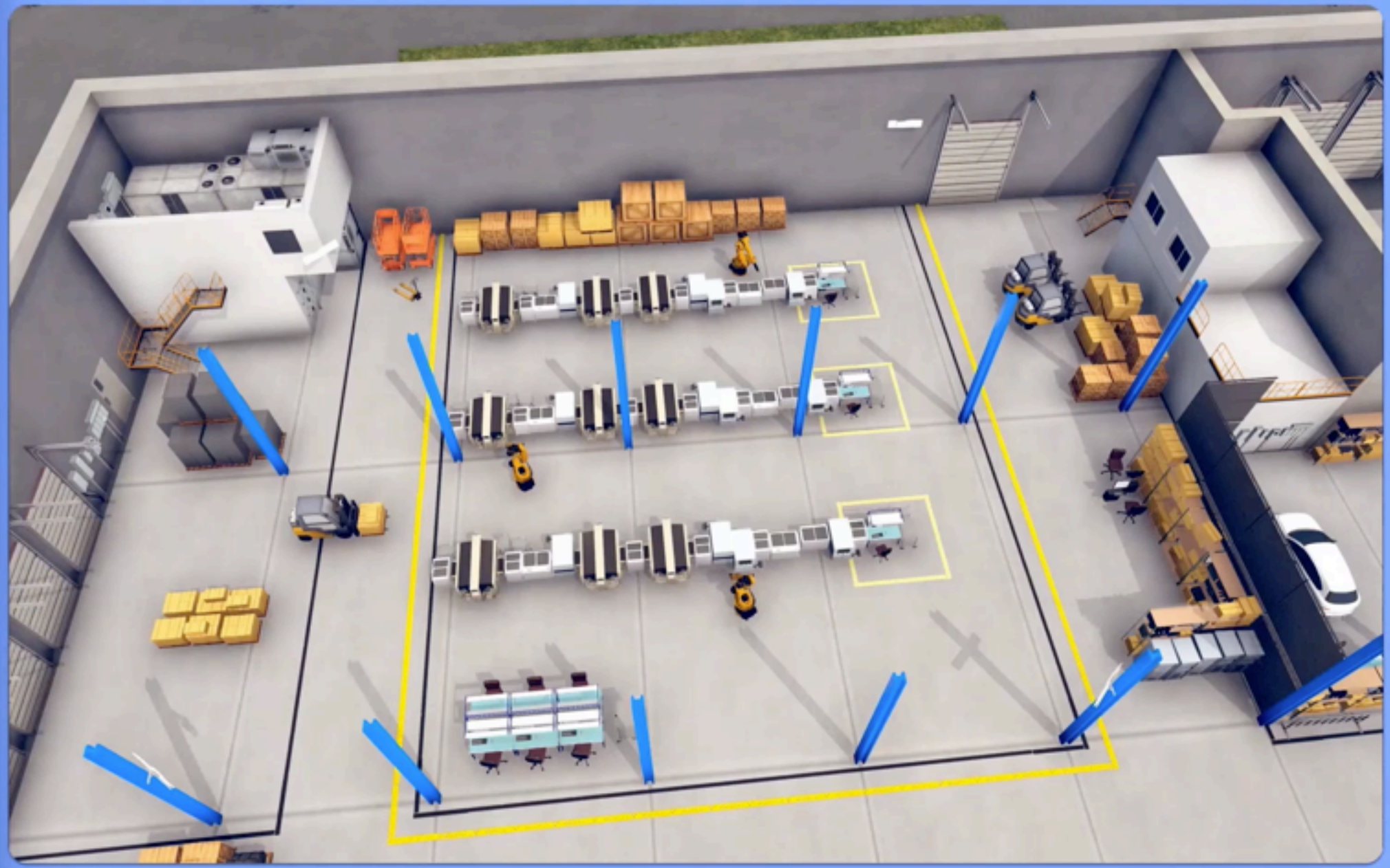
Loop

Demo Introduction

Demo Results

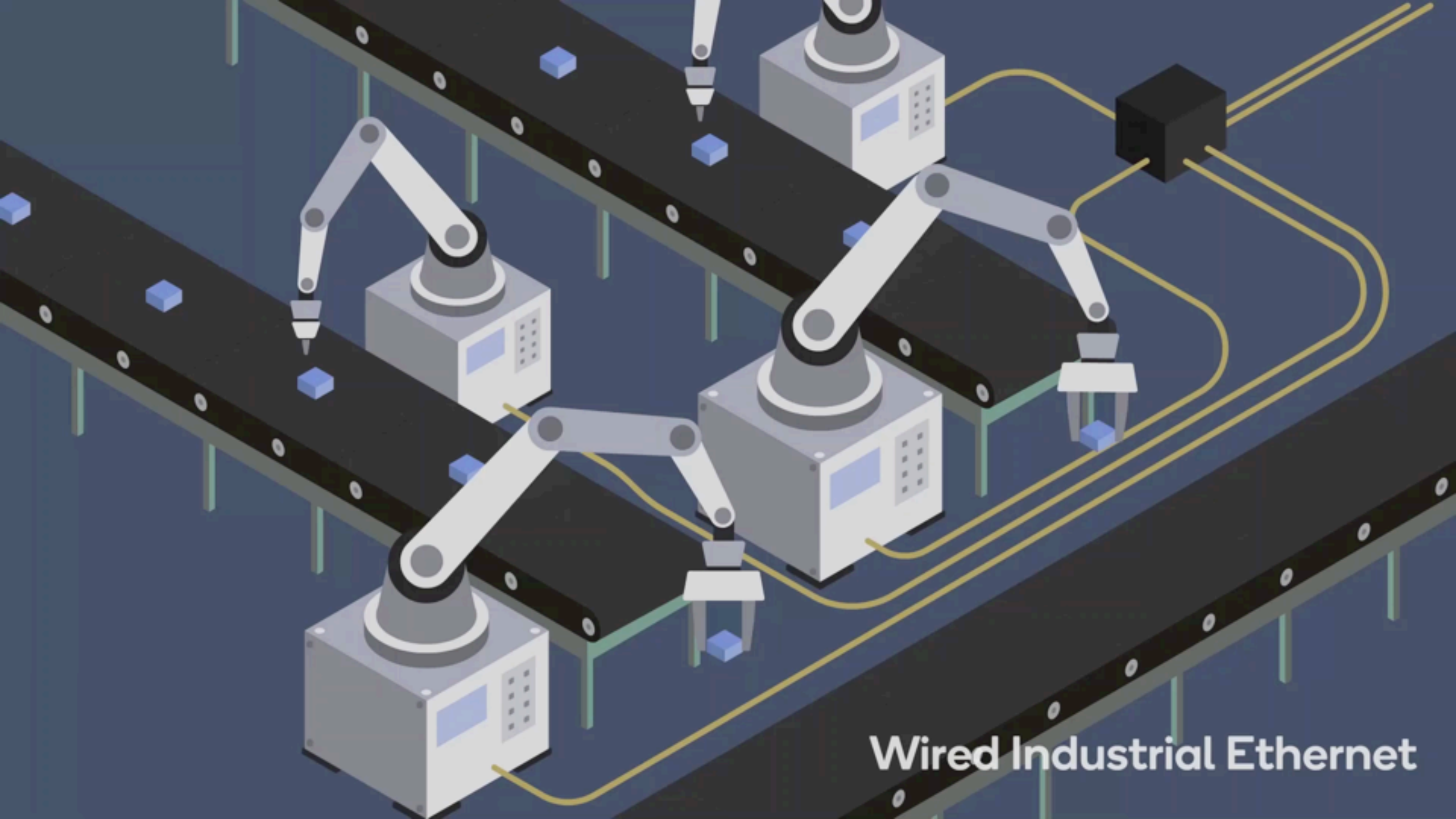
Demo Summary

Videos

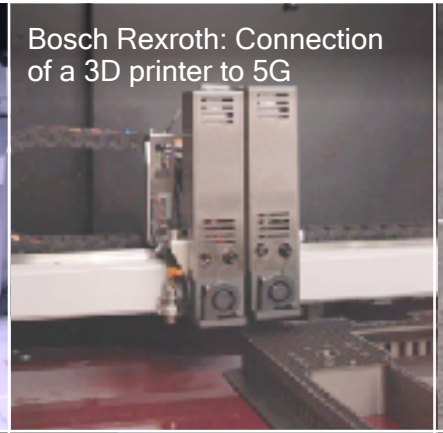


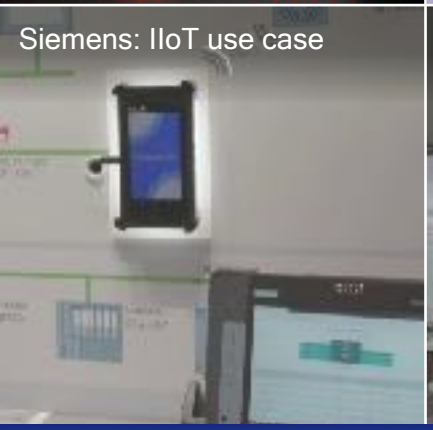
TSN

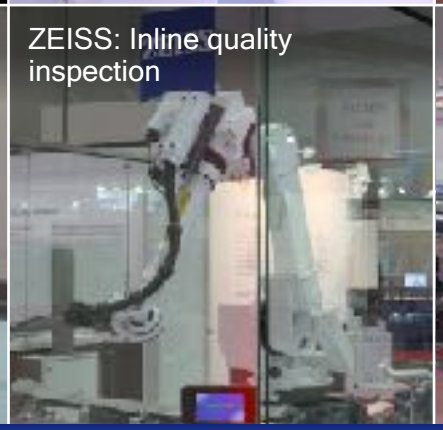
Time Sensitive Networking– a collection of IEEE 802.1Q standards

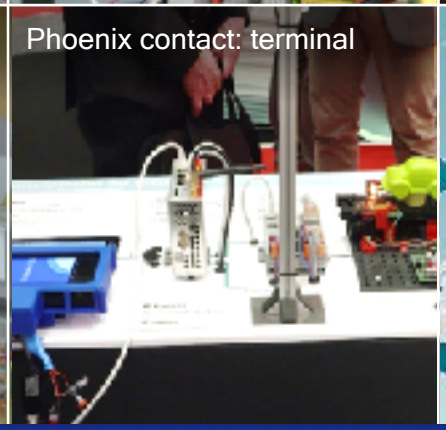

Wired Industrial Ethernet

Strong industry collaboration around 5G Industrial IoT









Kickstarted 5G for Industrial IoT with 10+ live ecosystem demonstrations at Hannover Messe 2019 based on Rel-15

Research collaboration with Bosch announced Feb. 2019

5G Alliance for Connected Industries and Automation (5G-ACIA)–advancing 5G for the industrial domain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