# Maximizing the Impact of Research Through Standardization: SDOs plans for the future

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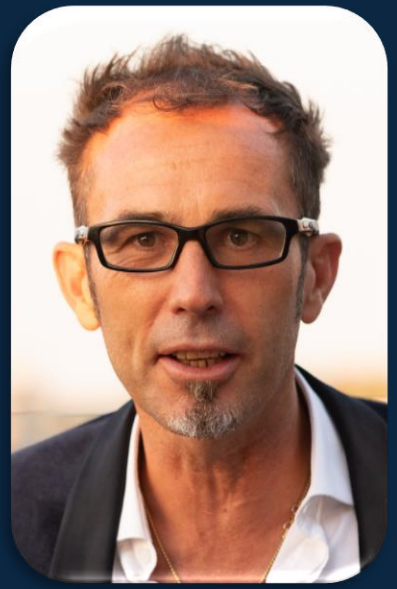


# Presenter


Dr. Thomas Stockhammer
Senior Director, Technical Standards
Qualcomm Europe, Inc., IEEE Fellow

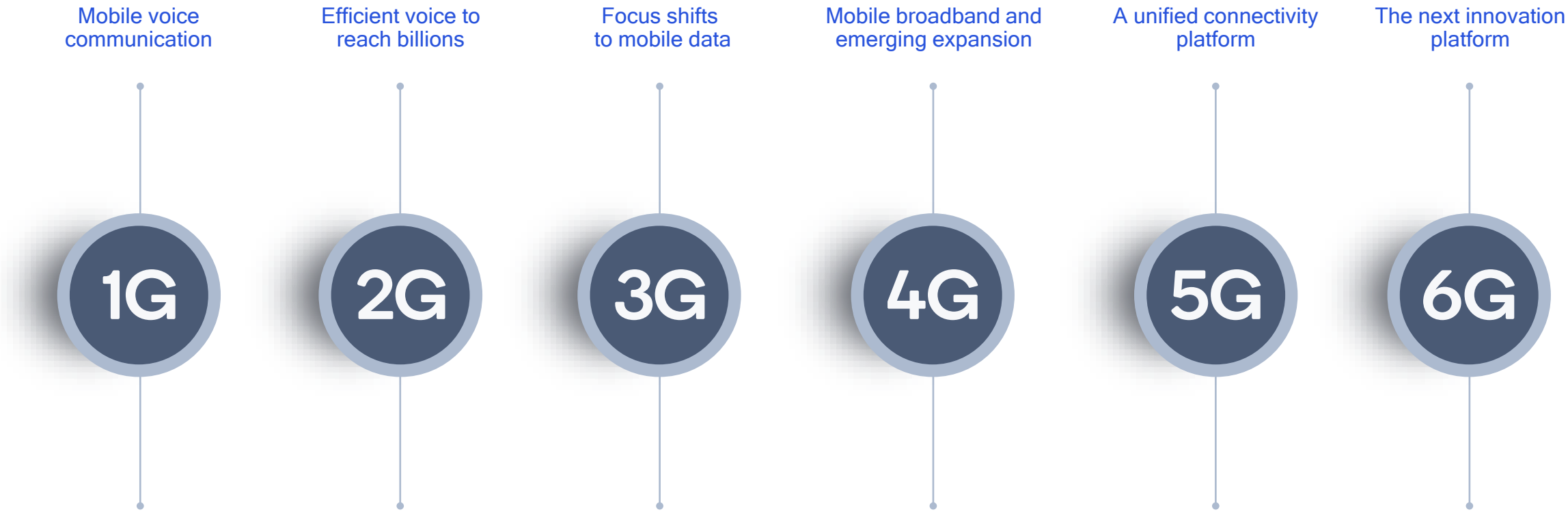

Leading and driving among others

- DVB: 5G TF, DVB-I
- MPEG: MPEG-I, CMAF and DASH
- 3GPP: XR over 5G, 5G Video, 5GMS
- DASH-IF: Interop WG, Test
- ETSI & 5G-MAG: 5G Broadcast and 5GMS
- CTA WAVE: CMAF Device PB, Test
- Metaverse Standards Forum: Chair, Board

# About this talk

1. Cellular standards
2. 6G Requirements and Design Vectors
3. The XR/Metaverse example

# Mobile has made a leap every ~10 years



# The telecom industry is based on technology standards

Technology standardization is key for an openly competitive ecosystem

## Ensuring inter-vendor system interoperability

Vendors design and manufacture products adhering to standards, so products from one vendor can work seamlessly with ones from another – a cornerstone of global roaming

## Spurring transparent and fair industry competition

Standards are available to anyone who wishes to access them; in many cases, they are free to download on the Internet (e.g., cellular standards at www.3gpp.org)

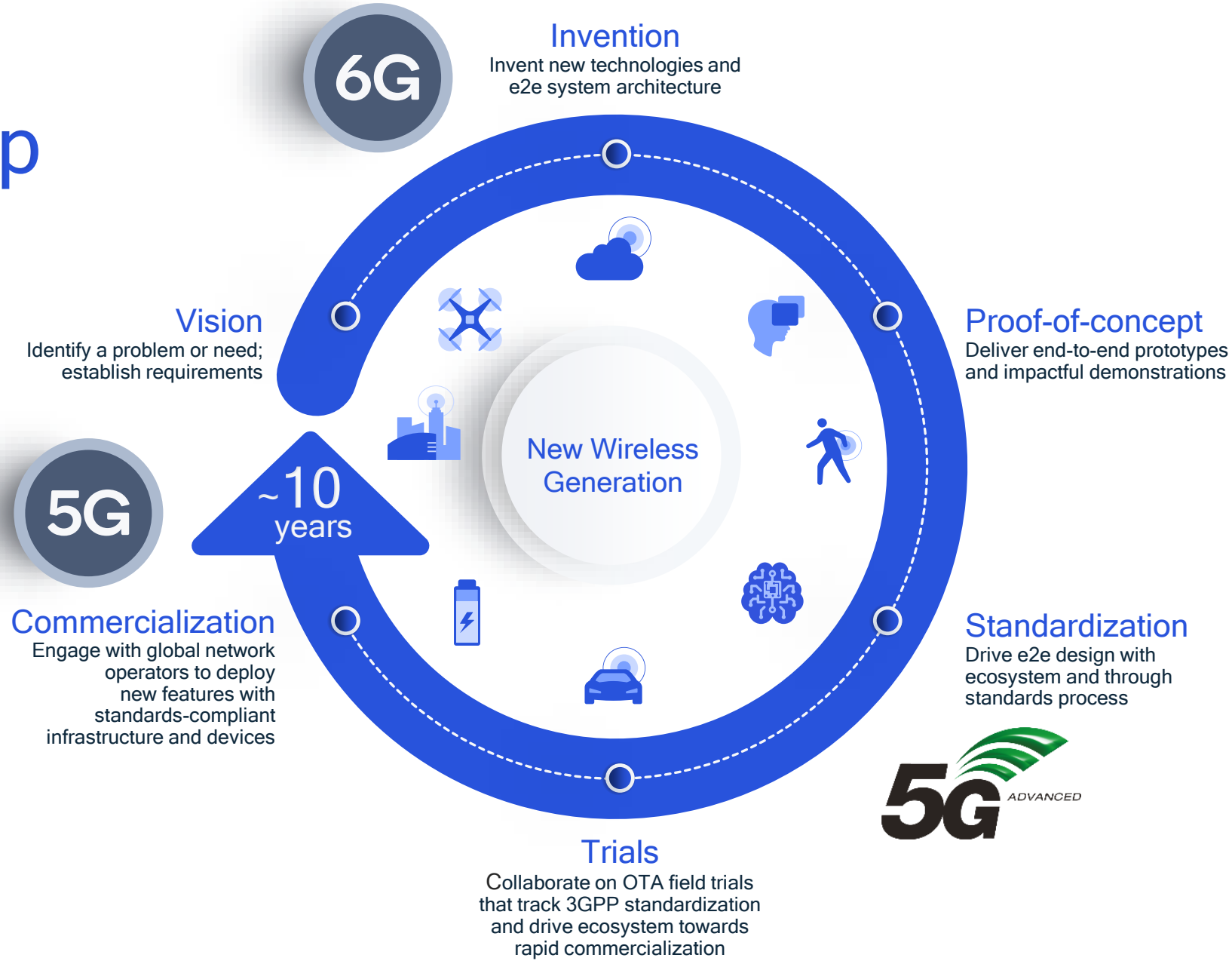


## Standards are essential for commercializing new technologies

Inventions from early R&D need to be first standardized, e.g., 5G NR in 3GPP, before productization

# Foundation to “G” leadership is technology leadership

Early R&D and technology inventions essential to leading ecosystem forward



# Cellular innovation:
# a vibrant, decades-old tree

## The Trunk
Foundational innovations – without these 5G fundamentally wouldn't work.

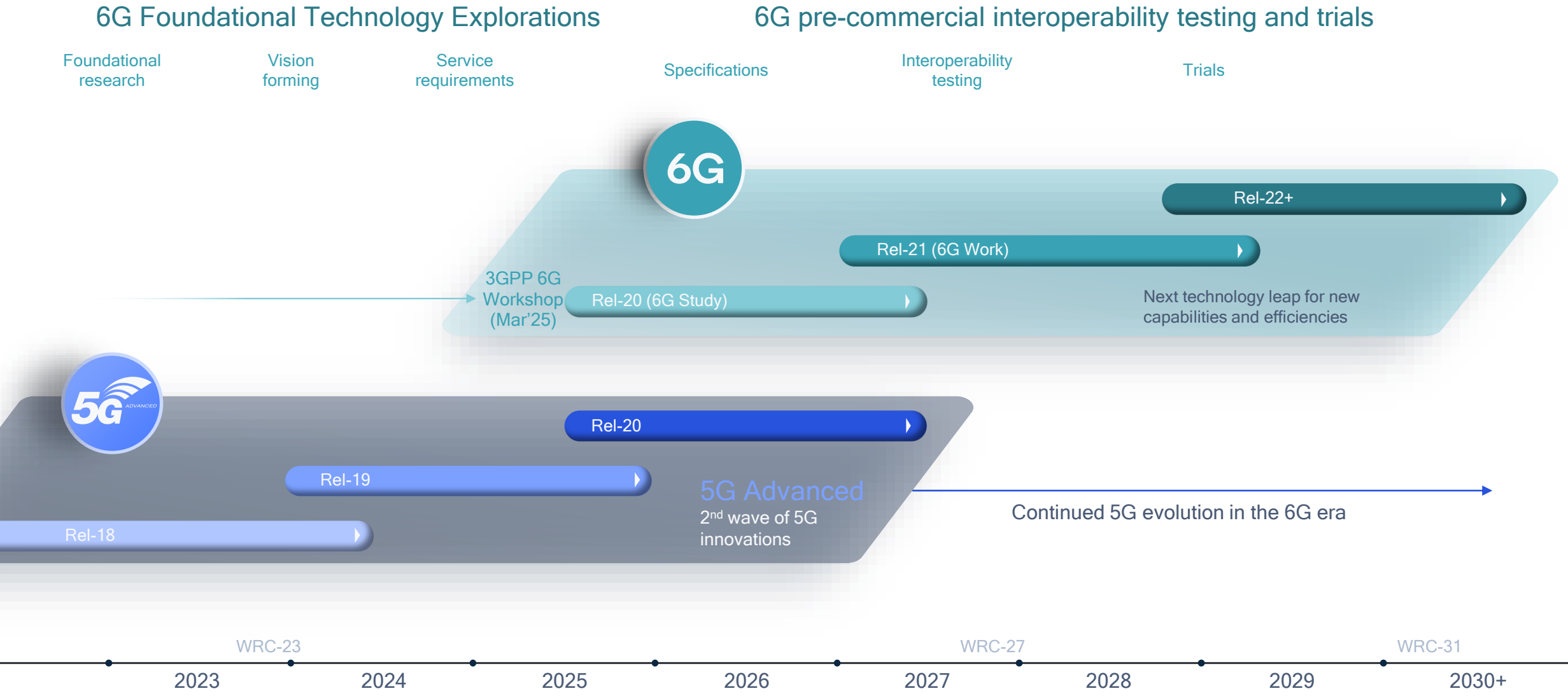
## The Branches
Key innovations that allow 5G to expand and extend into new use cases.

## The Leaves
Innovations that are plentiful, but less impactful compared to the system they are built on.



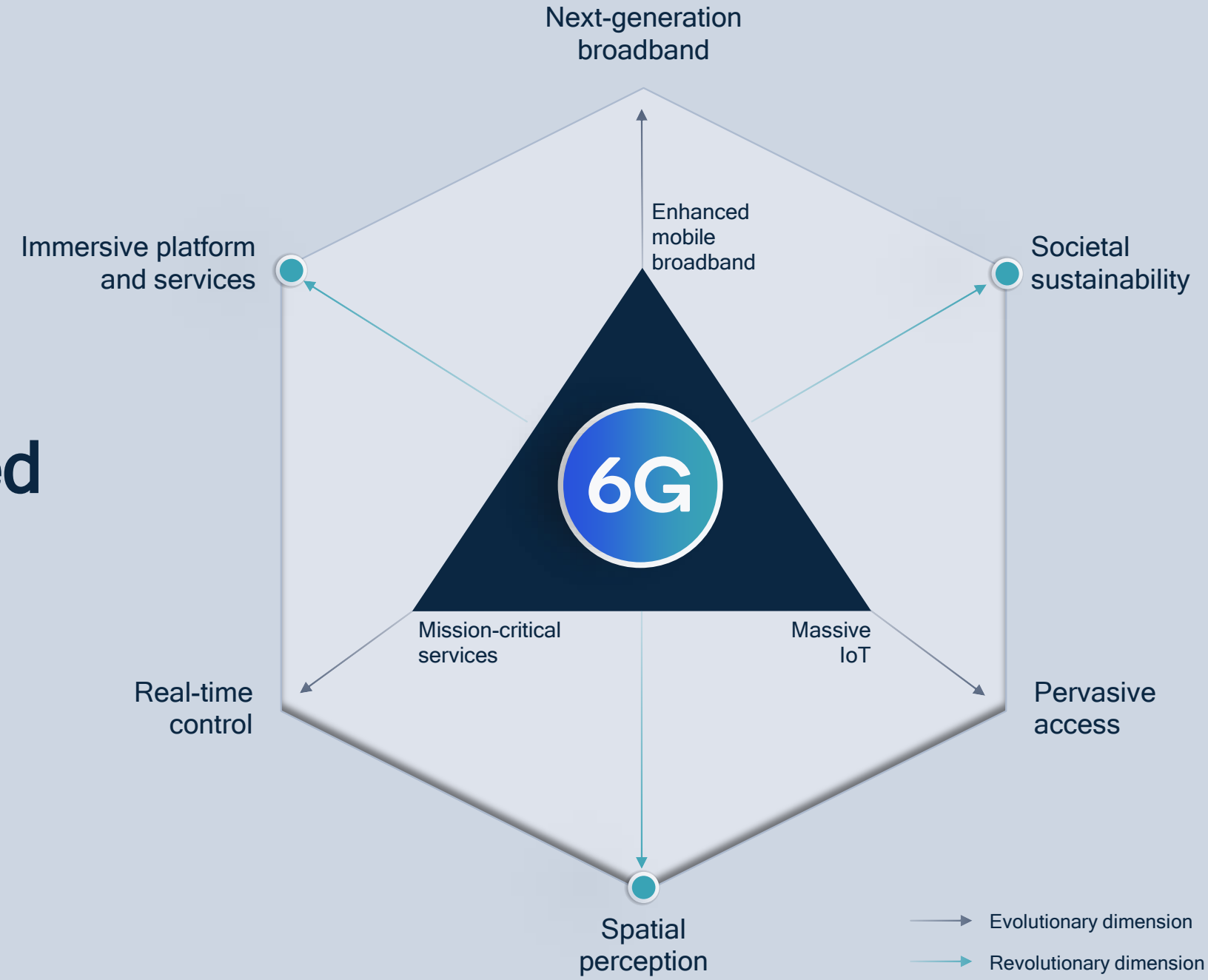

# Not all innovations are equal

# Leading the 5G Advanced evolution towards 6G



A smarter wireless platform to

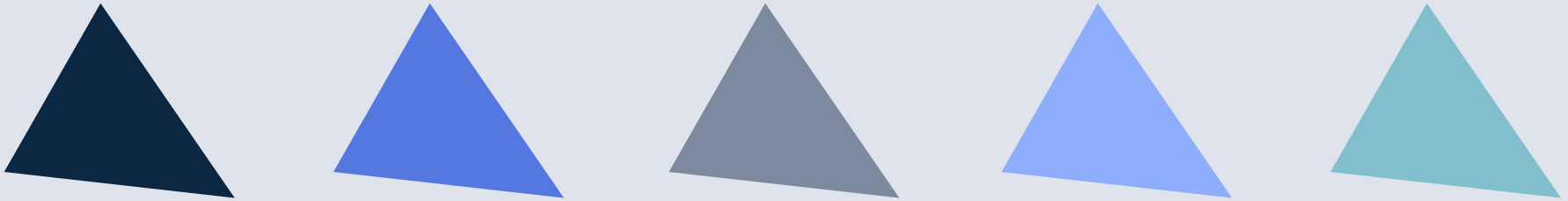
# support enhanced services and new use cases



A smarter wireless platform with

# new capabilities that expand beyond communication

# System design targets for expanded 6G capabilities



| Key Performance Indicators | Communication | AI & compute | System resiliency | Integrated sensing | Green network |
|---|---|---|---|---|---|
| | Capacity | Inference accuracy | Confidentiality | Range | Network energy efficiency |
| | Data rate | Model transfer latency | Integrity | Confidence level | Network carbon intensity |
| | Mobility | AI service roundtrip time | Availability | Sensing accuracy | Carbon neutrality |
| | Coverage | Compute capacity | Mean time to detect / resolve / contain | Resolution | ECO rating |
| | Connection density | Scalability / adaptability | ... | Latency | Battery requirement |
| | ... | ... | | ... | ... |

## 6G will be designed to meet enhanced traditional communication requirements as well as KPIs for new capabilities

Key longer-term research vectors

# enabling the path towards 6G

Key longer-term research vectors

# enabling the path towards 6G

## AI-native E2E communications

Data-driven communication and network design, with joint training, model sharing and distributed inference across networks and devices

## Scalable network architecture

Disaggregation and virtualization at the connected intelligent edge, use of advanced topologies to address growing demand

## Expanding into new spectrum bands

Expanding to THz, wide-area expansion to higher bands, new spectrum sharing paradigm, dynamic coordination with environmental awareness

## Air interface innovations

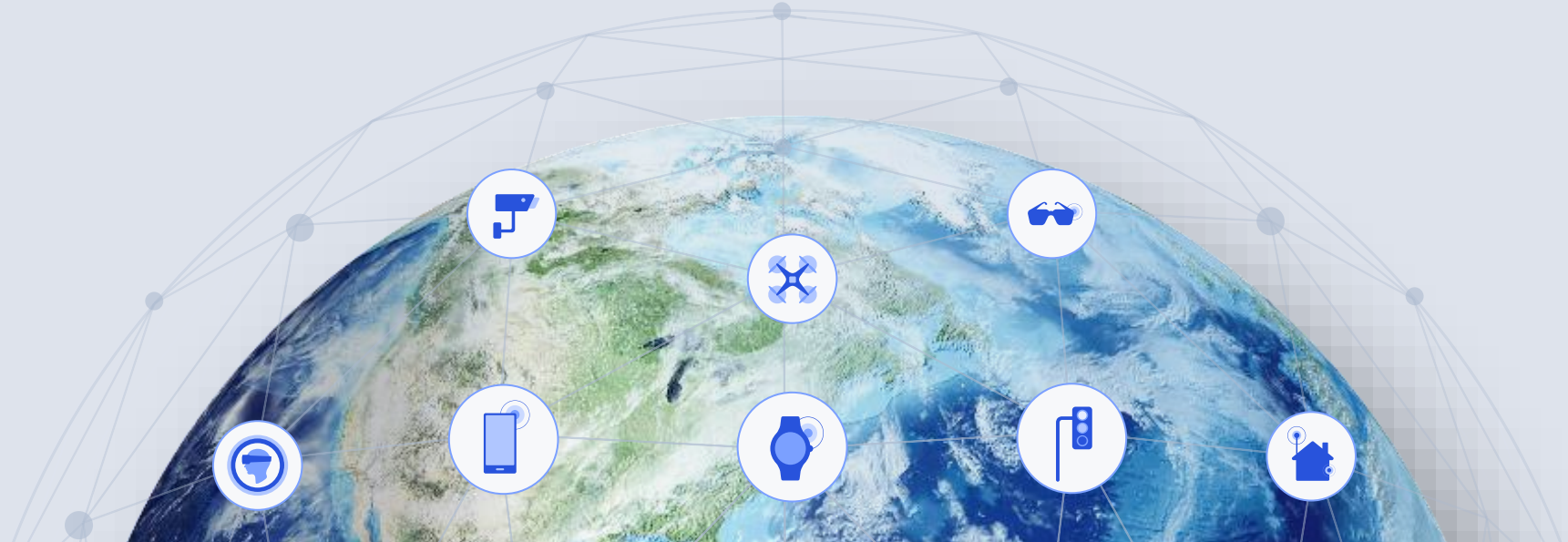
Evolution of duplexing schemes, Giga-MIMO, mmWave evolution, reconfigurable intelligent surfaces, non-terrestrial communications, waveform/coding for MHz to THz, system energy efficiency

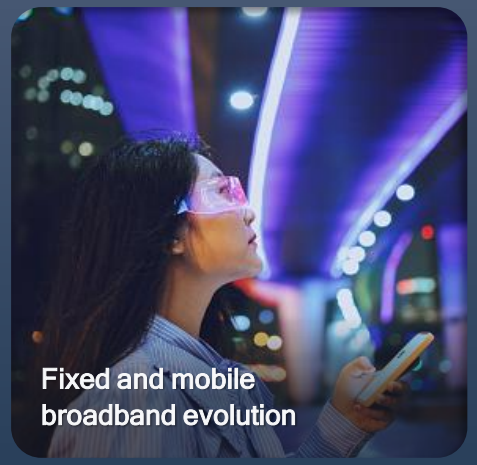
## Merging of worlds

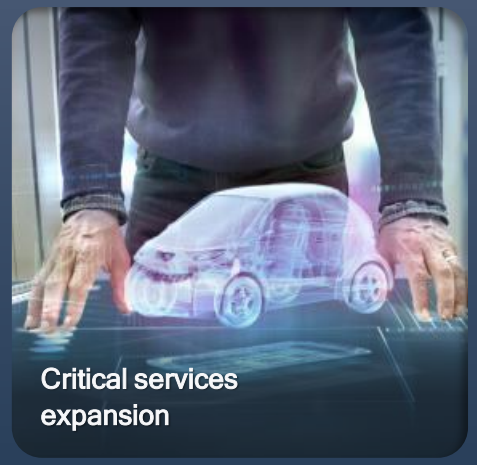
Physical, digital, virtual, immersive interactions taking human augmentation to next level via ubiquitous, low-power joint communication and sensing

## Communications resiliency

Multifaceted trust and configurable security, post quantum security, robust networks tolerant to failures and attacks

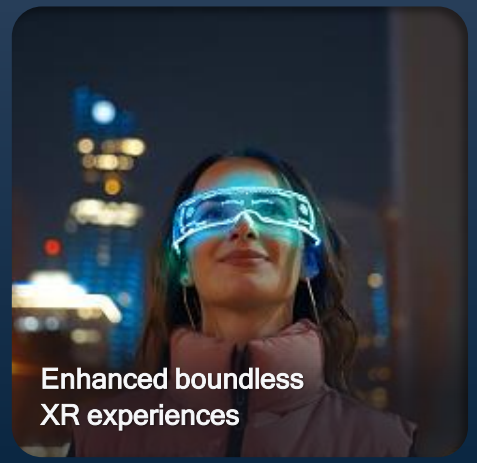




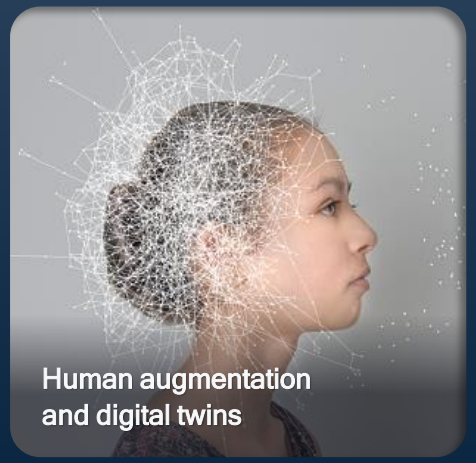













6G

# Propelling next-level experiences and innovative use cases in the new era of the connected intelligent edge for 2030 and beyond

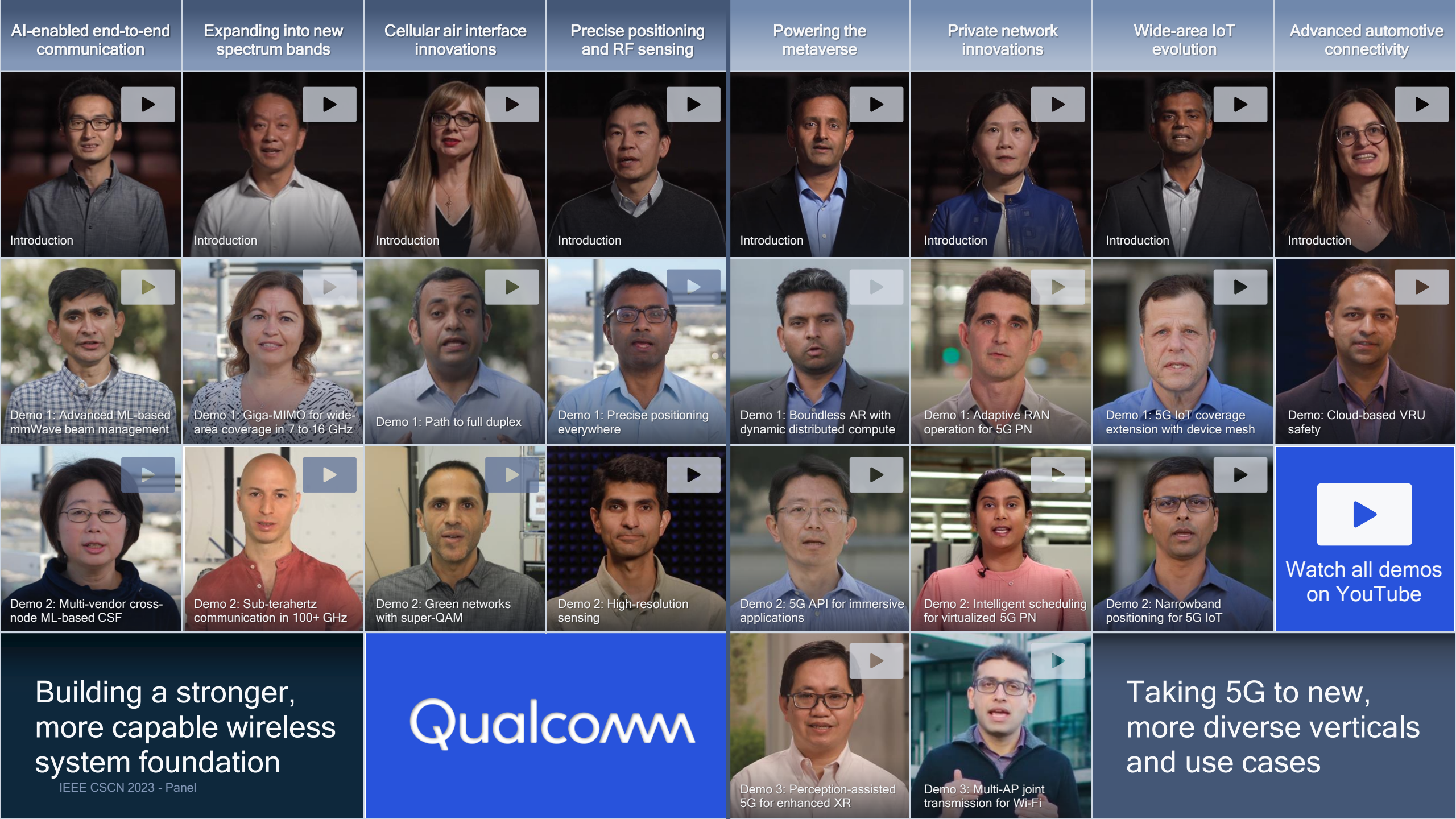
# Continued technology evolution on the path to 6G

Building a stronger, more capable wireless system foundation

Taking 5G to new, more diverse verticals and use cases


5G ADVANCED

6G


AI-enabled end-to-end communication
Expanding into new spectrum bands
Cellular air interface innovations
Precise positioning and RF sensing
Powering the metaverse
Private network innovations
Wide-area IoT evolution
Advanced automotive connectivity
Introduction
Introduction
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Introduction
Demo 1: Advanced ML-based mmWave beam management
Demo 1: Giga-MIMO for wide-area coverage in 7 to 16 GHz
Demo 1: Path to full duplex
Demo 1: Precise positioning everywhere
Demo 1: Boundless AR with dynamic distributed compute
Demo 1: Adaptive RAN operation for 5G PN
Demo 1: 5G IoT coverage extension with device mesh
Demo: Cloud-based VRU safety
Demo 2: Multi-vendor cross-node ML-based CSF
Demo 2: Sub-terahertz communication in 100+ GHz
Demo 2: Green networks with super-QAM
Demo 2: High-resolution sensing
Demo 2: 5G API for immersive applications
Demo 2: Intelligent scheduling for virtualized 5G PN
Demo 2: Narrowband positioning for 5G IoT
Watch all demos on YouTube
Building a stronger, more capable wireless system foundation
IEEE CSCN 2023 - Panel
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Demo 3: Perception-assisted 5G for enhanced XR
Demo 3: Multi-AP joint transmission for Wi-Fi
Taking 5G to new, more diverse verticals and use cases

# 6G XR requirements fueled by digital twins and spatial compute

Digital twins digitize the complex physical world in the metaverse

Spatial compute enables immersive interaction with 3D digital content

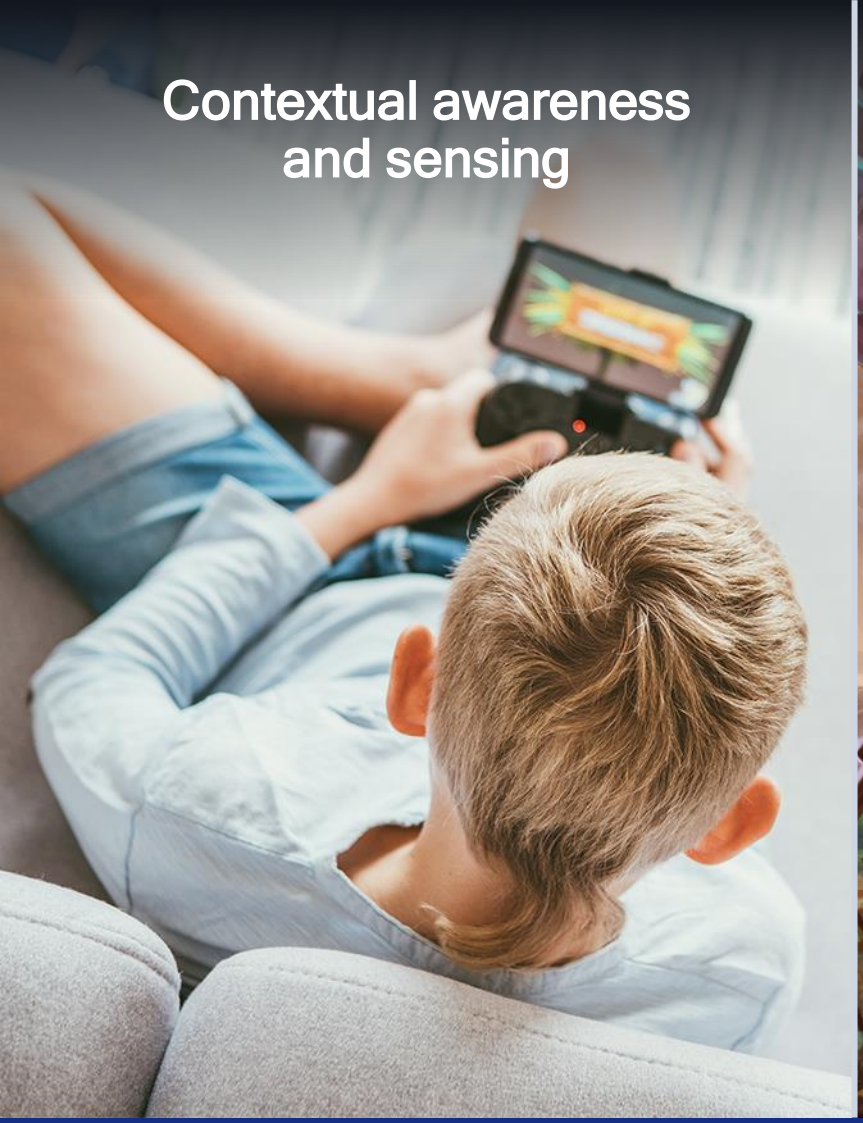


100x network capacity

0.1-10 Gbps per user

Use multiple frequency bands

(sub-THz, mmW, sub 7GHz, 7-24GHz, unlicensed, shared spectrum)






# Technologies & Standards for the Metaverse: XR, AI, 5G

# AR/VR/AI Work Flow

## Simultaneous Complex Processing for Seamless AR/VR Experience

3 **Recognize and understand images** for symbolic information

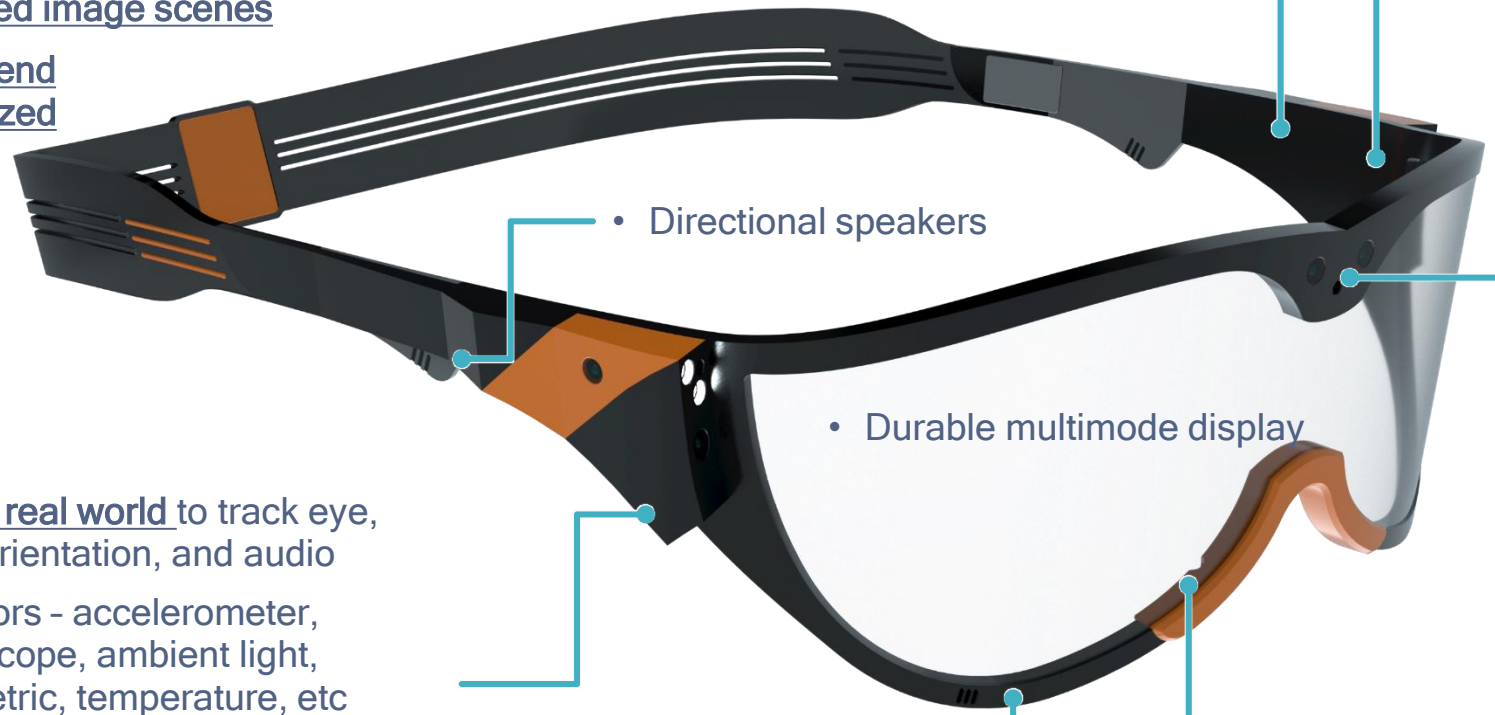
- Highly efficient and lower power CV processing

5 **Overlay virtual objects/data with real or virtually created image scenes**

6 **Recommend personalized actions**

4 **Collect virtual contents and data** from cloud network

- Multimode connectivity (4G, 5G, Wifi)
- GPS for location information
- Coding compression
- Video transport



- Directional speakers
- Durable multimode display

1 **Sense the real world** to track eye, position, orientation, and audio

- Sensors – accelerometer, gyroscope, ambient light, biometric, temperature, etc
- Multiple audio microphones
- Eye tracking cameras

2 **See the world around** you by collecting and monitoring visual images for depth info, object detection, face detection

- Cameras with fisheye and telephoto lenses
- Depth sensing camera (TOF, Structured Light, etc)
- Optoelectronic night vision and thermal imaging sensors

# Open and Global Standards for the Metaverse

Metaverse STANDARDS FORUM™

3GPP A GLOBAL INITIATIVE

MPEG

KHRONOS GROUP

- XR Architectures
- XR Split Rendering
- Tethered AR Glass
- XR Conferencing
- IVAS Speech Codec
- XR Traffic QoS, Power Savings, Capacity Enhancement

- XR System: Scene Description
- Coding/Compression for CGC/3D content
- Haptics, Audio, Video
- Coding for Machines

Vulkan

OpenXR™

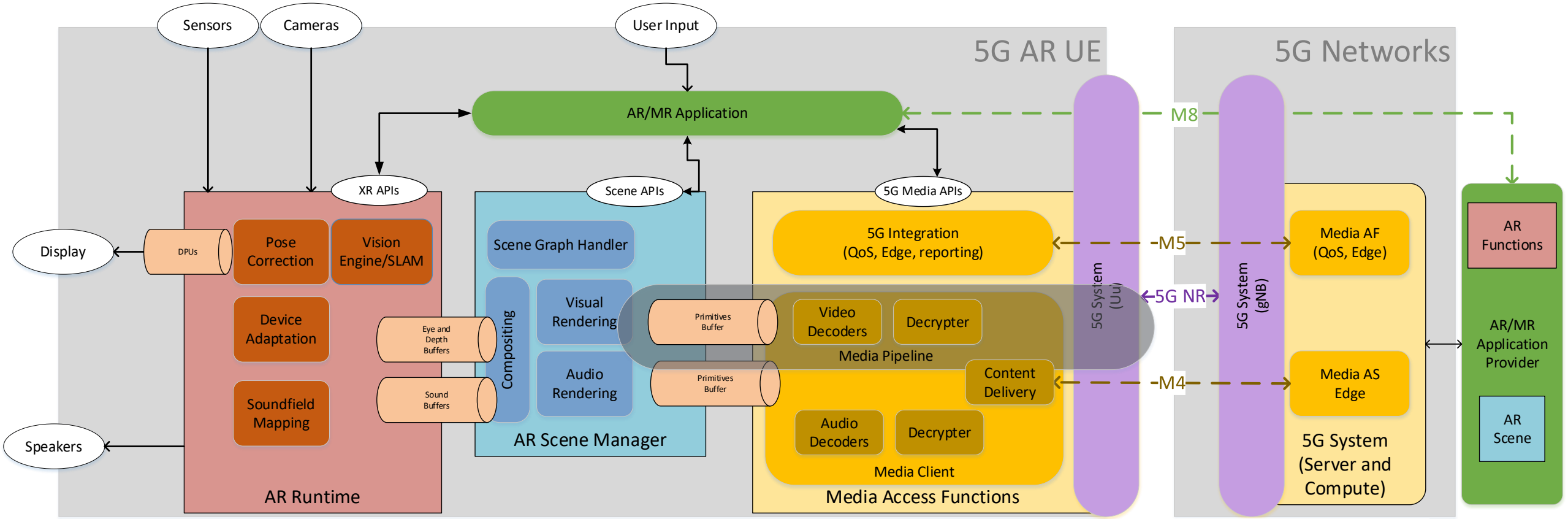
glTF™


QC driving or contributing

Additional selected organizations

# XR Standards – Optimizations, Systems and Workflows

Formalizing architectures, workflows and APIs for highest quality and lowest power consumption



# Thank you

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