

# On the path to 6G: Driving advanced wireless technology evolution

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Vice President, Engineering  
Qualcomm India



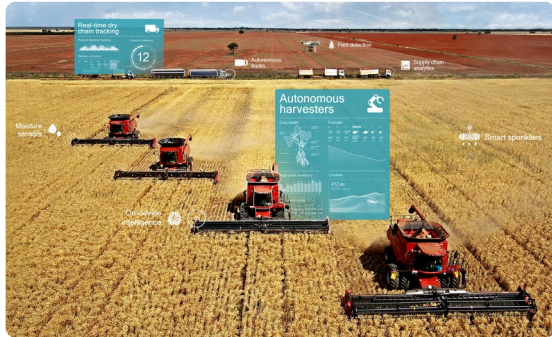


# 5G is expanding the mobile ecosystem to new industries

Powering the digital economy

# \$13.1 Trillion

in global economic value by 2035\*



### Precision agriculture

\$416B



### Construction and mining

\$984B



### Digitized education

\$264B



### Connected healthcare

\$1,083B



### Richer mobile experiences

\$2,224B



### Smart manufacturing

\$4,771B



### Intelligent retail

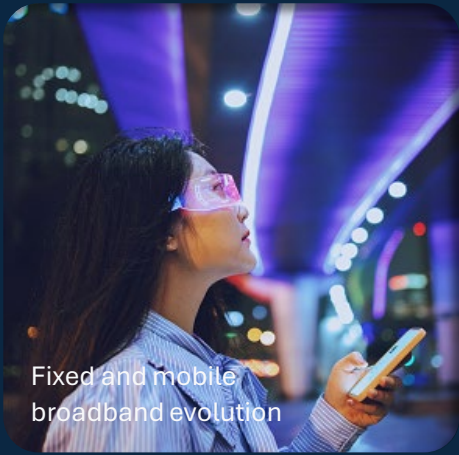
\$1,144B



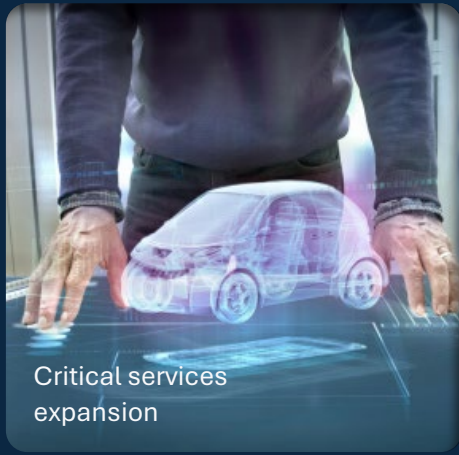
### Smart city

\$2,213B

\* The 5G Economy in a Post-COVID-19 Era – an independent study from IHS Markit, commissioned by Qualcomm Technologies, Inc.



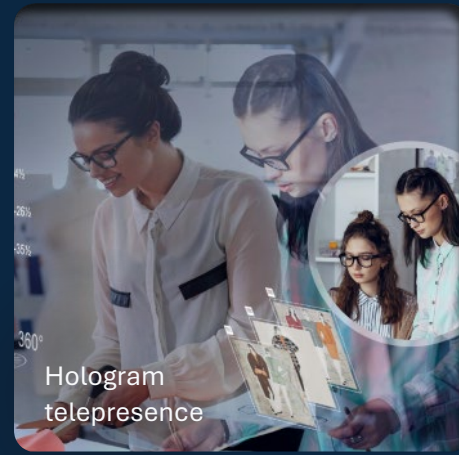
Fixed and mobile  
broadband evolution



Critical services  
expansion



Collaborative robots, real-  
time command and control



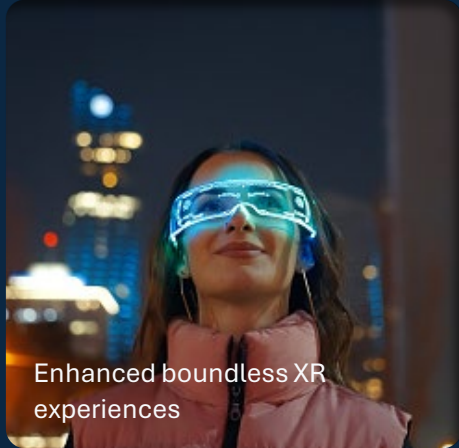
Hologram  
telepresence



Ultra-wide area to  
micro connectivity



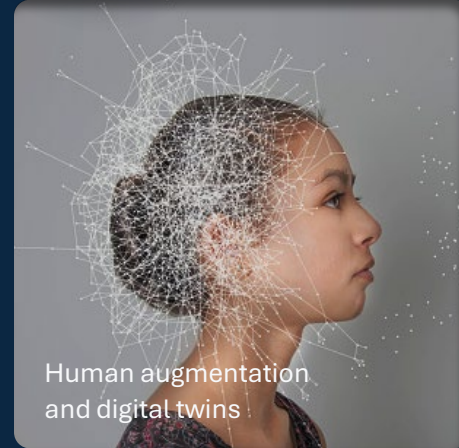
Smarter  
verticals



Enhanced boundless XR  
experiences



Wireless sensor  
fusion



Human augmentation  
and digital twins



Unknown future  
use cases



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

# Generative AI is transformational

A platform for a broad set of applications

- Search
- Content generation
- Productivity
- Coding

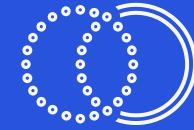
Disruptive to the current status quo

Productivity increase — creates content in seconds

A large potential revenue opportunity



ChatGPT is the **fastest-growing** consumer application in history<sup>1</sup>



**Over 11,000** generative AI ChatGPT plugins available<sup>2</sup>



Generative AI is estimated to add **\$2.6T-\$4.4T** in economic benefits<sup>3</sup>



Generative AI market value at **\$44.89B**, expected to be **\$66B** by end of 2024<sup>4</sup>



**95%** of customer interactions may involve AI by 2025<sup>5</sup>

1: <https://www.statista.com/chart/29174/time-to-one-million-users/>;

2: <https://theresanaiforthat.com/> (as of February 2024)

3: <https://www.mckinsey.com/mgi/overview/in-the-news/ai-could-increase-corporate-profits-by-4-trillion-a-year-according-to-new-research>

4: Statista 5: <https://www.accenture.com/us-en/services/applied-intelligence/solutions-ai-customer-engagement>

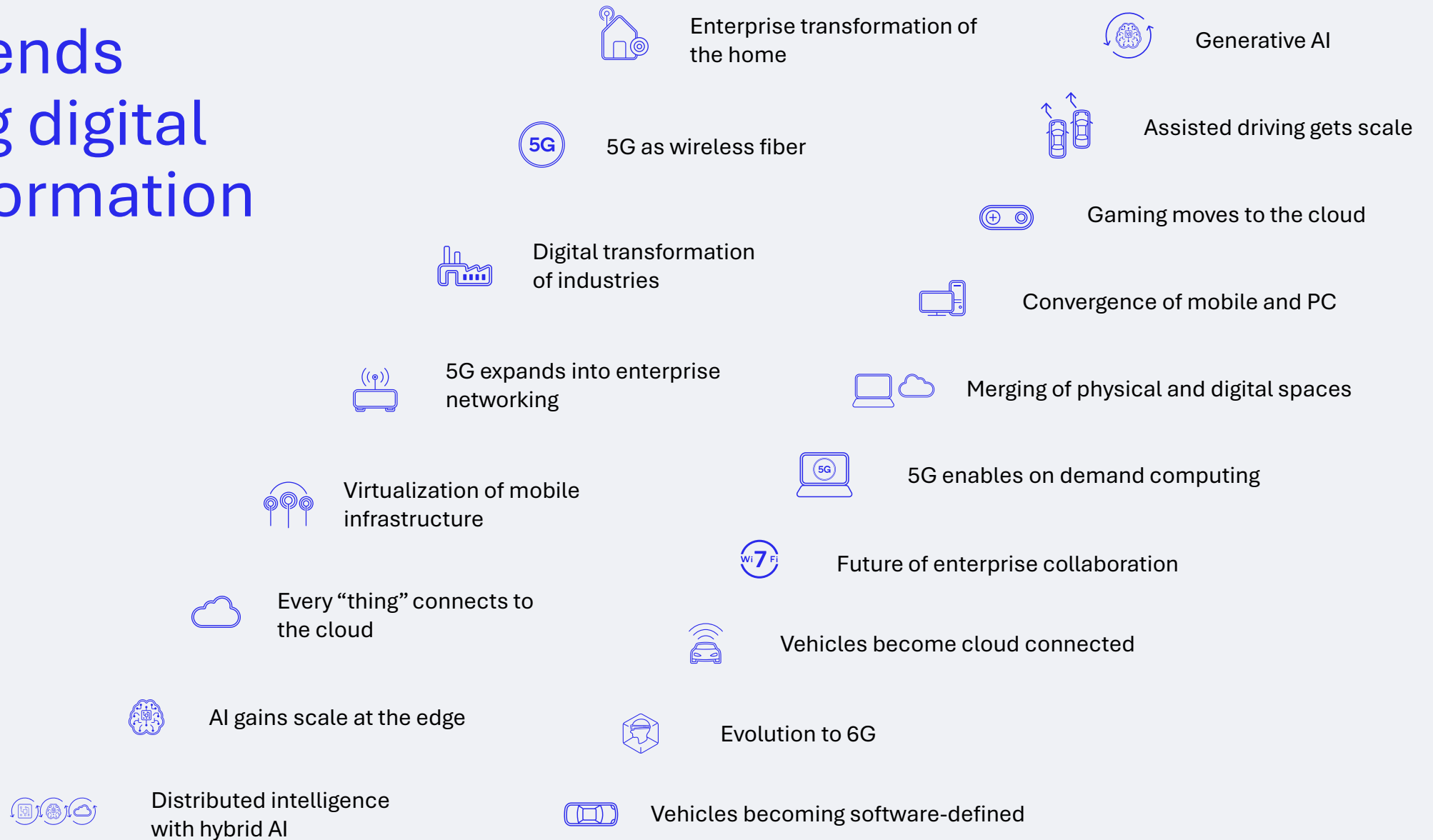
# On-device & hybrid AI are critical for Gen AI to scale

## Benefits

- Cost
- Energy
- Reliability, performance, and latency
- Privacy and security
- Personalization



# Key trends driving digital transformation





# Inventing the technologies shaping the digital future

**\$90+ billion**

in cumulative R&D

**140,000+**

patents, patent applications



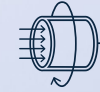
Power management



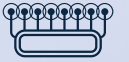
Location



Security



Carrier aggregation



Massive MIMO



Fingerprint



Sensors



Gesture



Multimedia



Imaging



Computer vision



RFFE



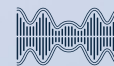
5G technology



AI



C-V2X



Envelope tracking



mmWave



Bluetooth



Wi-Fi



Modules



CPU



DSP



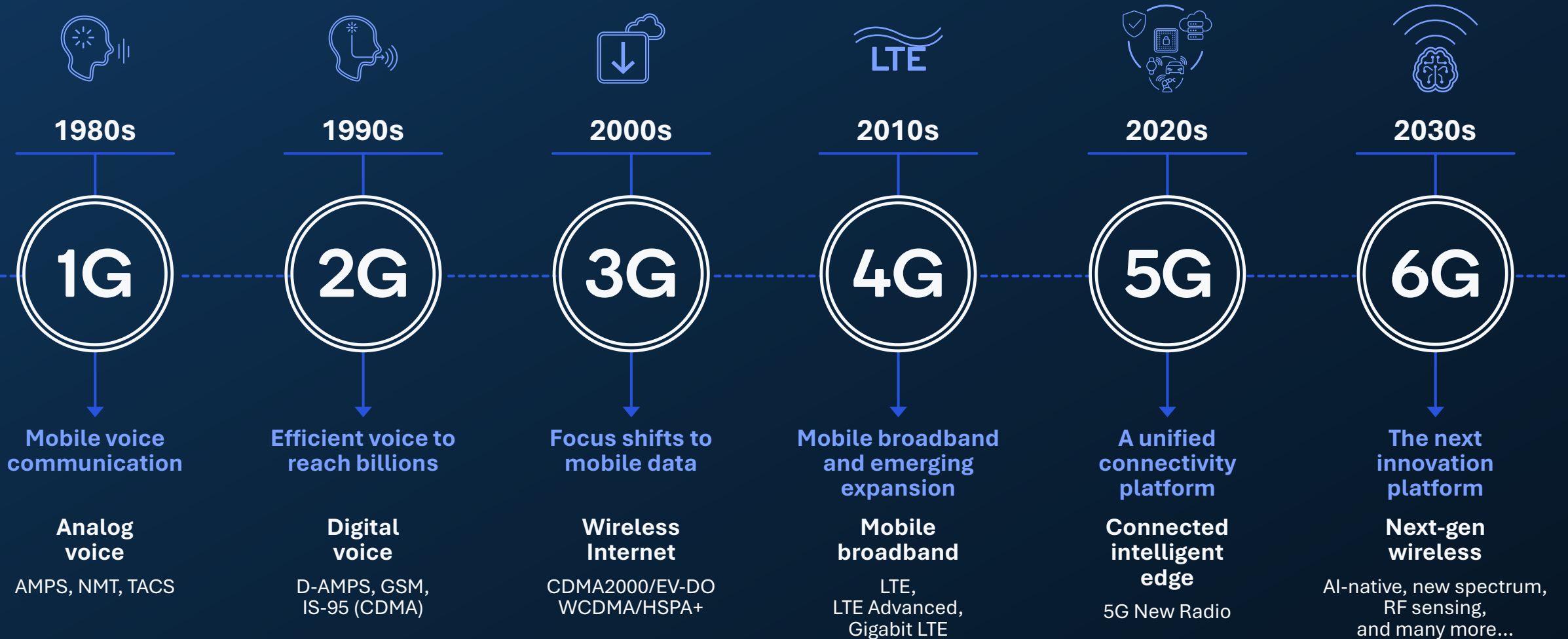
GPU



Advanced channel coding



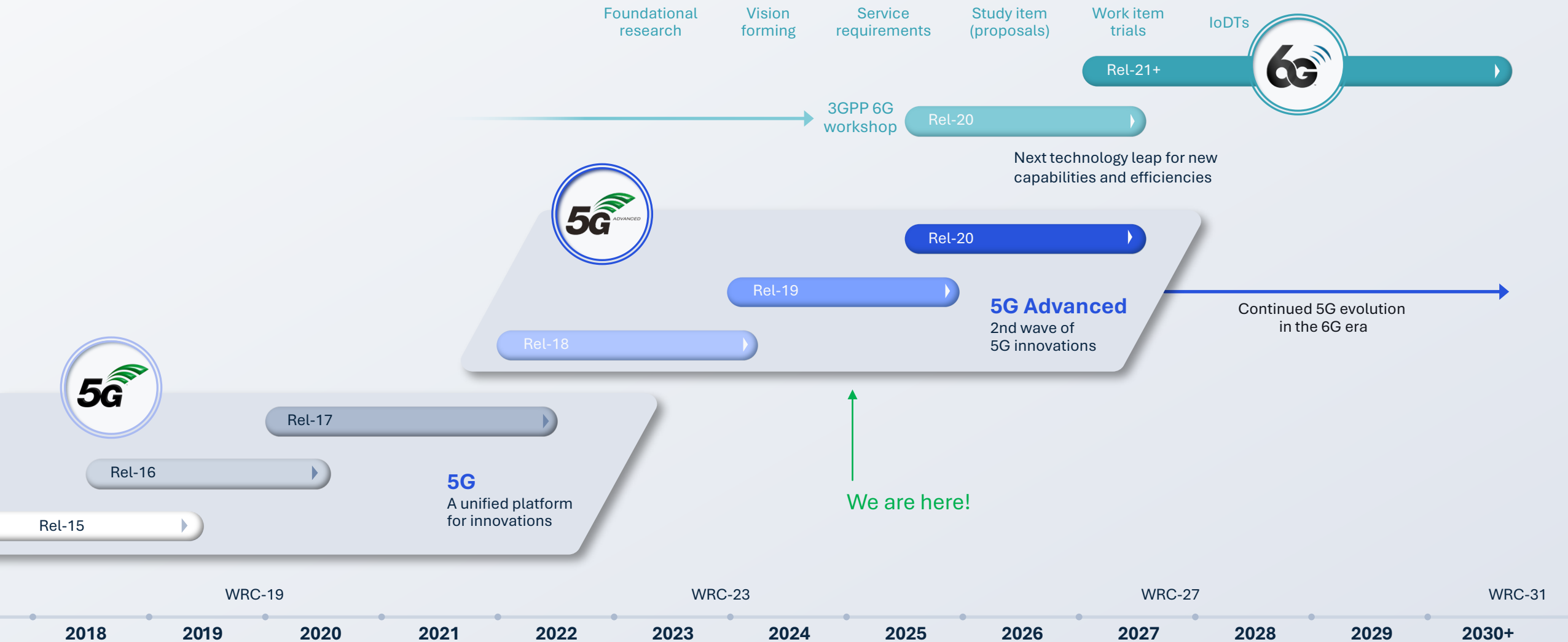
Voice recognition



Mobile has made a leap every ~10 years



# Leading the 5G Advanced evolution toward 6G



# Rich Evolution of 5G

## Rel 15

Established 5G NR technology foundation

5G

- eMBB — enhanced mobile broadband services
- 5G core network and enhanced E2E security
- Sub-6 GHz with massive MIMO
- Advanced channel coding
- 5G broadcast
- In-band eMTC/NB-IoT and 5G Core

- Scalable OFDM-based air interface
- Mobile mmWave
- Flexible framework
- LTE integration
- Private Networks, SON

## Rel 16

Expanding to new use cases and industries

~1.5–2 years between releases

- Mission-critical services with eURLLC (e.g., 5G NR IIoT)
- Positioning across use cases
- eMBB evolution - improved power, mobility, more

- 5G NR Cellular V2X
- Better coverage with IAB, uplink MIMO
- 5G NR in unlicensed spectrum
- IAB integrated access/ backhaul

## Rel 17

Continued expansion and enhancements

- Enhanced DL/UL MIMO, multiple transmission points
- NR-Light Reduced Capability (RedCap) for low-complexity IoT
- More capable, flexible IAB
- Unlicensed spectrum across all use-cases
- New spectrum above 52.6 GHz

- Centimeter accuracy IIoT with mmWave
- Expand sidelink for V2X reliability, P2V, IoT relay
- Enhancements to 5G NR Industrial IoT
- Non-terrestrial network (i.e., satellites)
- Rel-15 deployment learning, eMBB enhancements, XR, others

## Rel 18

New wave of 5G innovations in the decade-long 5G evolution

5G Advanced

- Further eMBB enhancements
- Full-duplex MIMO
- Extended Reality (XR)
- Smart repeaters for coverage expansion
- Automotive and NR V2X enhancements

- Non-terrestrial network enhancements
- 5G NR-Light expansion for IoT and more
- AI/ML data-driven designs
- Broadcast enhancements
- Sidelink in unlicensed spectrum

## Rel 19

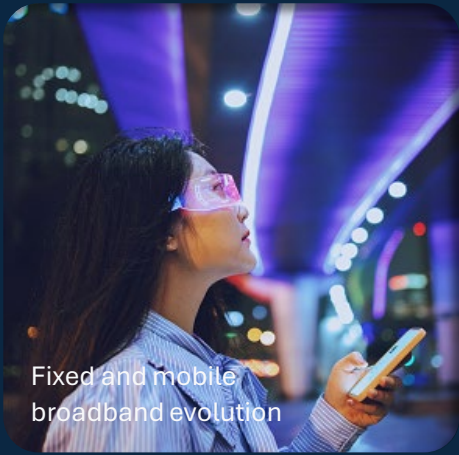
Realizing the full potential of 5G and bridging to 6G

- Continued MIMO, mobility
- Advanced topology
- Wireless AI
- Device and network energy savings
- Ambient IoT

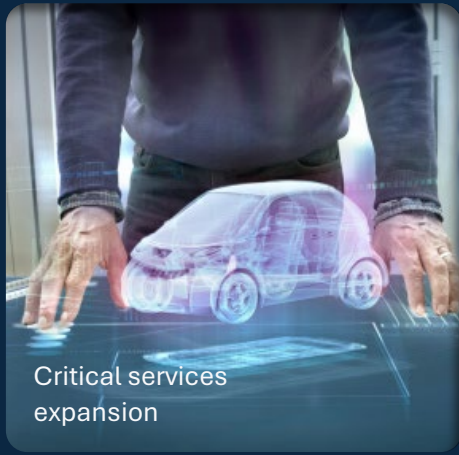
- XR evolution
- Enhanced NTN
- Duplex evolution
- Higher midband spectrum
- Integrated sensing and communications

## Rel 20

## Rel 21+



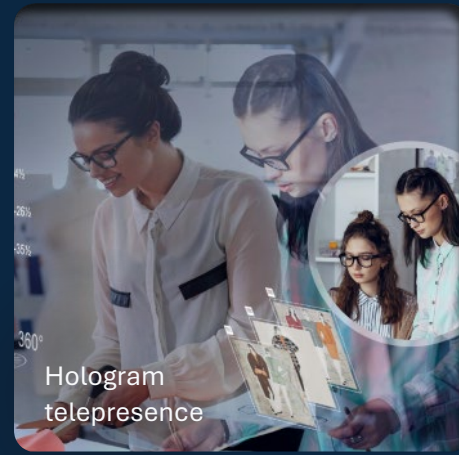
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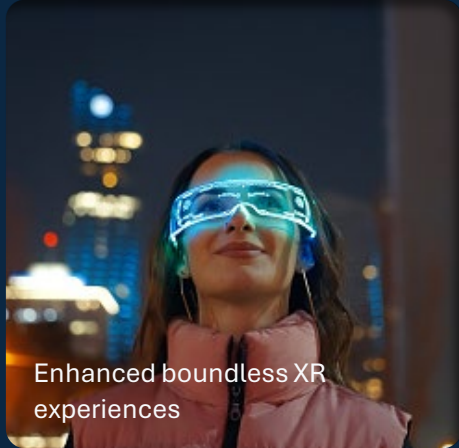
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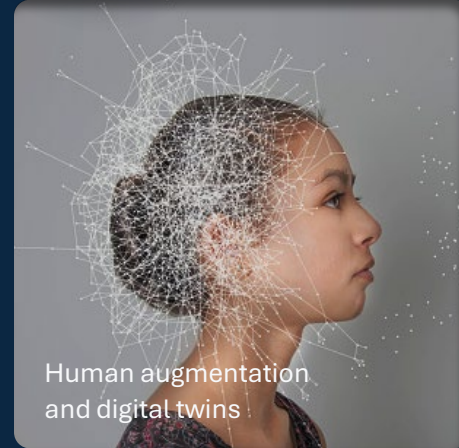
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verticals



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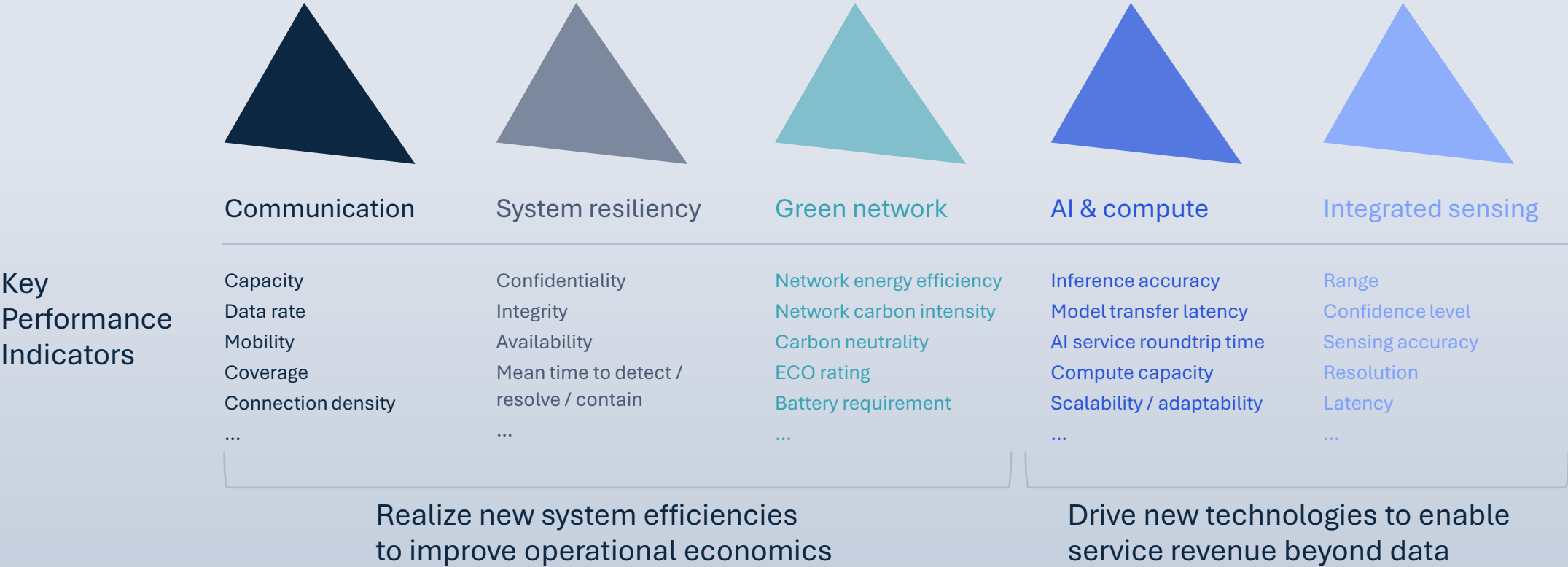
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A smarter wireless platform with

# new capabilities that expand beyond communication



# System design targets for expanded 6G capabilities



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



## 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



# Where are we in the cellular innovation cycle?

## 5G

Ramping volume and expanding to new use case

## 5G Advanced

Embarking on the 2<sup>nd</sup> phase of 5G innovations

## 6G

Aligning on vision, foundational research, and timeline



# Thank you

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