

What new opportunities will the evolution to 5G Advanced bring?

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Leading wireless innovation for more than 35 years

Digitized mobile
communications



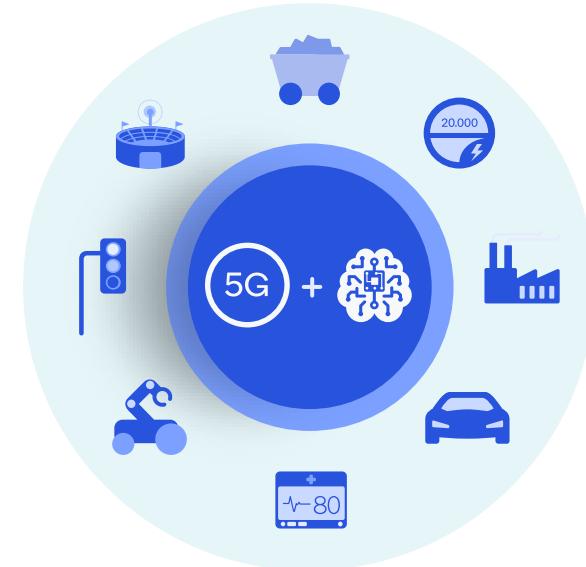
Analog to digital

Redefined computing



Desktop to smartphones

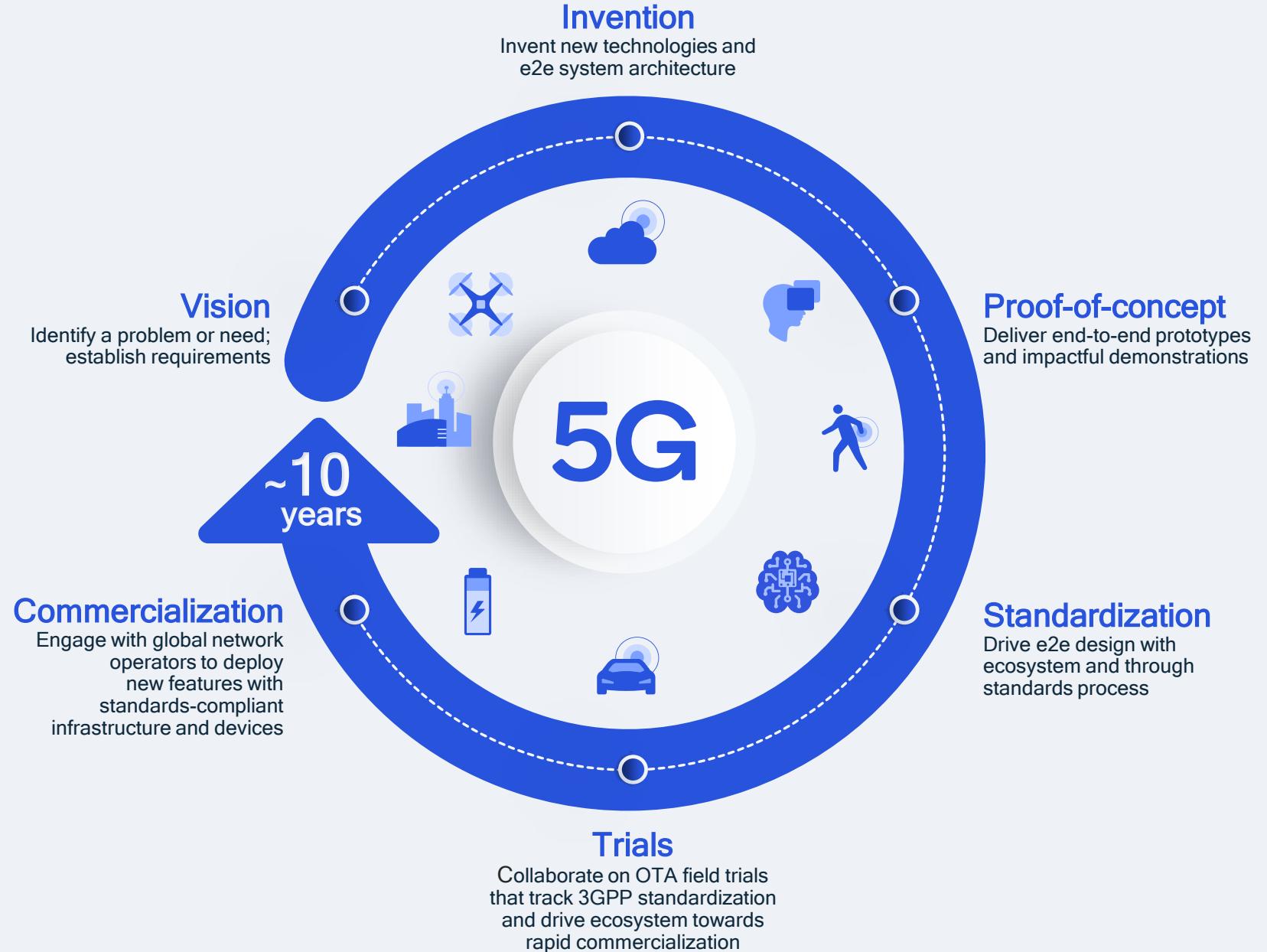
Transforming
industries



Connecting virtually everything

Foundation to 5G leadership is technology leadership

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



5G Accelerating Globally

225+

Operators with
5G commercially
deployed

275+

Additional
operators
investing in 5G

1B+

5G connections
by 2023 – 2 years
faster than 4G

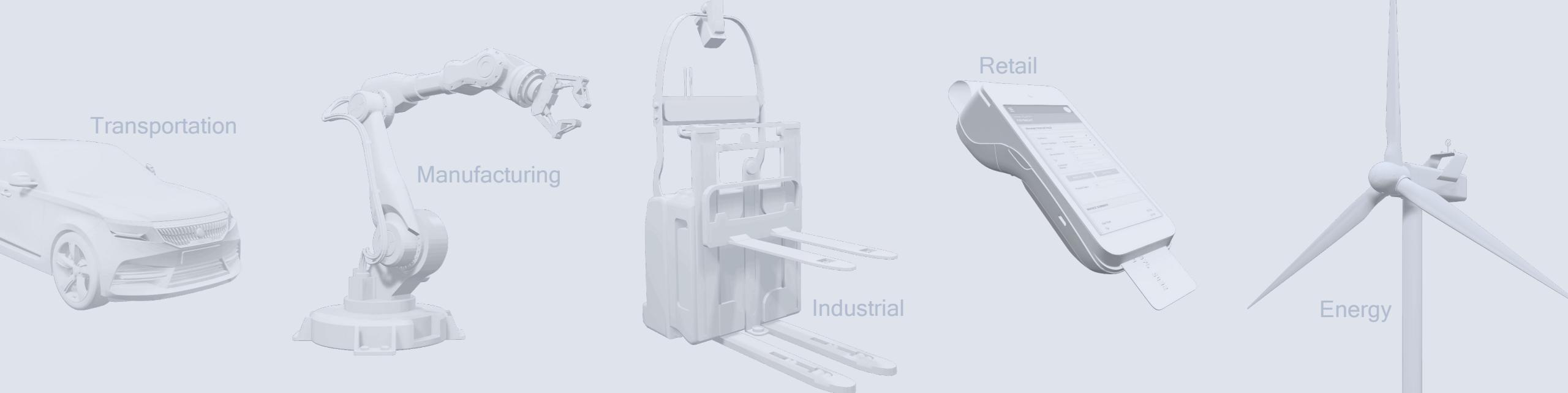
5B+

5G smartphones
to ship between
2020 and 2025

1,490+

5G designs
launched or in
development





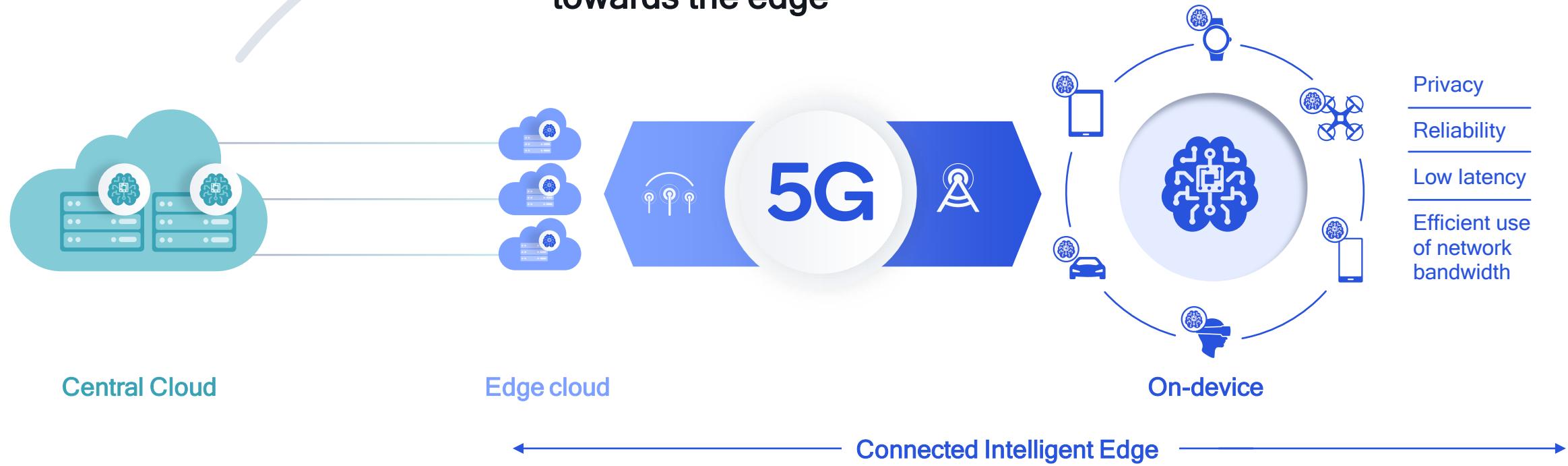
Driving digital transformation across industries

5G will enable \$13.1 Trillion in global sales activity in 2035



Source: The 5G Economy, an independent study from IHS Markit,
commissioned by Qualcomm Technologies, Inc., November 2020

To efficiently scale,
AI processing is expanding
towards the edge

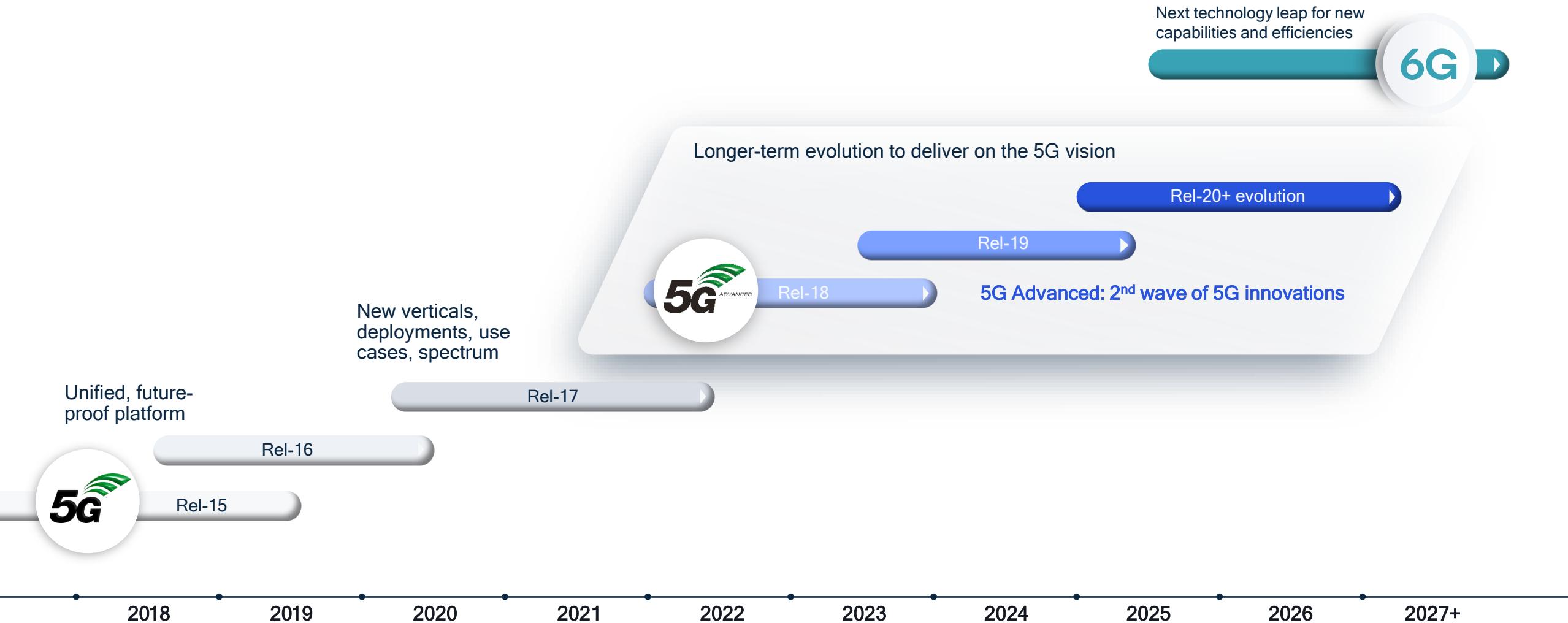


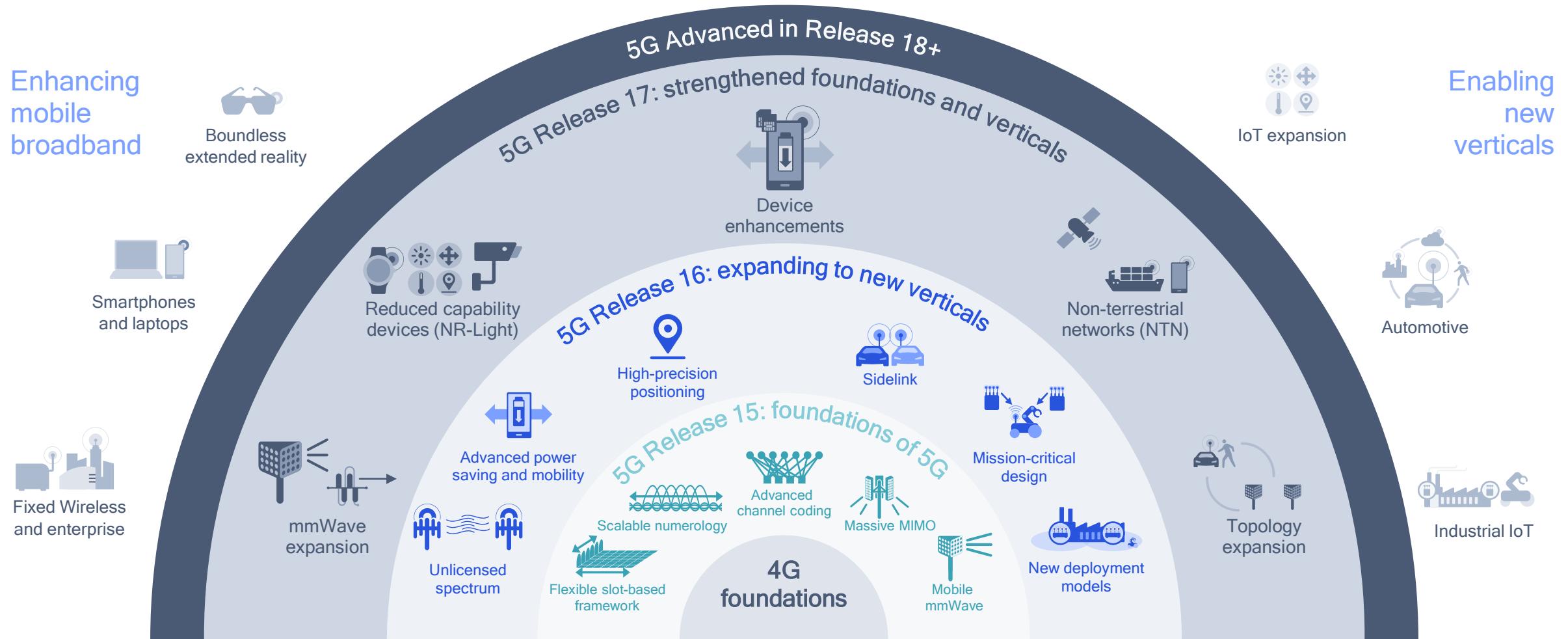
Qualcomm is leading the realization
of the Connected Intelligent Edge

Convergence of:
Wireless connectivity
Efficient computing
Distributed AI

Unleashing massive amount
of data to fuel our digital future

Driving 5G Advanced for a full decade of 5G technology evolution



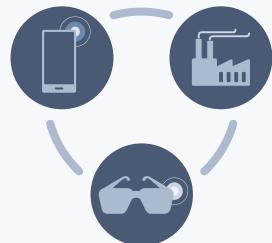


Our innovations expand the foundation of 5G

Foundational Qualcomm innovations lead 3GPP Releases 15, 16 and 17

Driving a balanced 5G Advanced evolution across key technology areas

Mobile broadband evolution and further vertical expansion



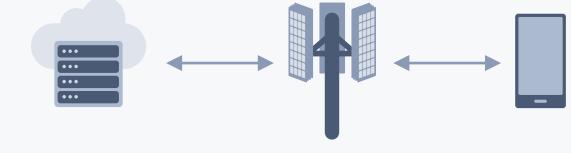
Deliver enhanced mobile broadband experiences and extend 5G's reach into new use cases

Immediate commercial needs and longer-term 5G vision



Drive new value in commercialization efforts and fully realize 5G's potential with future deployments

New and enhanced devices and network evolution



Focus on the end-to-end technology evolution of the 5G system to bring new levels of performance

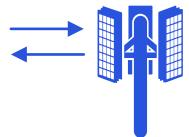
Release 18 starts the 5G Advanced evolution and it prepares for new and enhanced features coming in subsequent releases



Release 18

3GPP Release 18 sets off the 5G Advanced Evolution

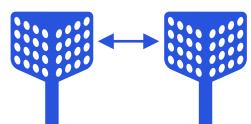
Strengthen the end-to-end
5G system foundation



Advanced
DL/UL MIMO



Enhanced
mobility



Mobile IAB,
smart repeater



Evolved
duplexing



AI/ML data-driven
designs



Green
networks

Proliferate 5G to virtually
all devices and use cases



Boundless
extended reality



NR-Light (RedCap)
evolution



Expanded
sidelink



Expanded
positioning



Drones & expanded
satellites comm.



Multicast & other
enhancements



5G AI

Working together
across the connected
intelligent edge



Source: RP-213599 (AI/ML for NR Air Interface),
RP-213602 (AI/ML for NG-RAN)

1 Quality of Experience; 2 Channel State Information

5G NR Release 18 Scope

AI/ML-enabled air interface design



Use cases

Enhanced CSI² feedback, beam management, and positioning accuracy



AI/ML models

Collaboration models, life cycle management, and algorithms



Evaluation methodology

Existing 3GPP framework and field data to assess performance and identify KPIs



Impact assessment

Spec changes needed to support identified use cases, covering multiple aspects

AI/ML framework for next-gen RAN



Network optimization

Data collection and signaling support for energy saving, load balancing, mobility optimization



Future study

New use cases (e.g., AI/ML for slicing, QoE¹), network functionality and interface procedures

5G Advanced evolution will expand wireless ML to the end-to-end system across RAN, device, and air interface



Network architecture enhancements

ML to run over different HW/SW and future RAN function split to improve flexibility and efficiency



AI/ML procedure enhancements

Model management, training (e.g., federated and reinforced learning), and inference



Data management enhancements

ML data storage/access, data registration/discovery, and data request/subscription



New and expanded use cases

Traffic/mobility prediction, optimized coverage/capacity, massive MIMO, SON, CSI, beam management, ...



Snapdragon® Platforms and Reference Designs

Snapdragon XR1 Mobile Platform



Snapdragon 5G XR2 Mobile Platform



\$100M
Snapdragon
Metaverse
Fund



Staggering UE packet arrivals at gNodeB

Improves scheduling more users

QoS and delay-aware schedulers

Use Packet Delay Budget (PDB) information to improve UE and flow multiplexing

Release 18 capacity enhancement proposals

HARQ enhancements

Improved ACK feedback to optimize retransmissions.

SPS/CG enhancements

Improvements to DCI signaling efficiencies

UL skipping with gNB notification

Network coding

Outer coding between PDCP and RLC layers to improve reliability and reduced latency

Further improving XR experience with
5G Advanced



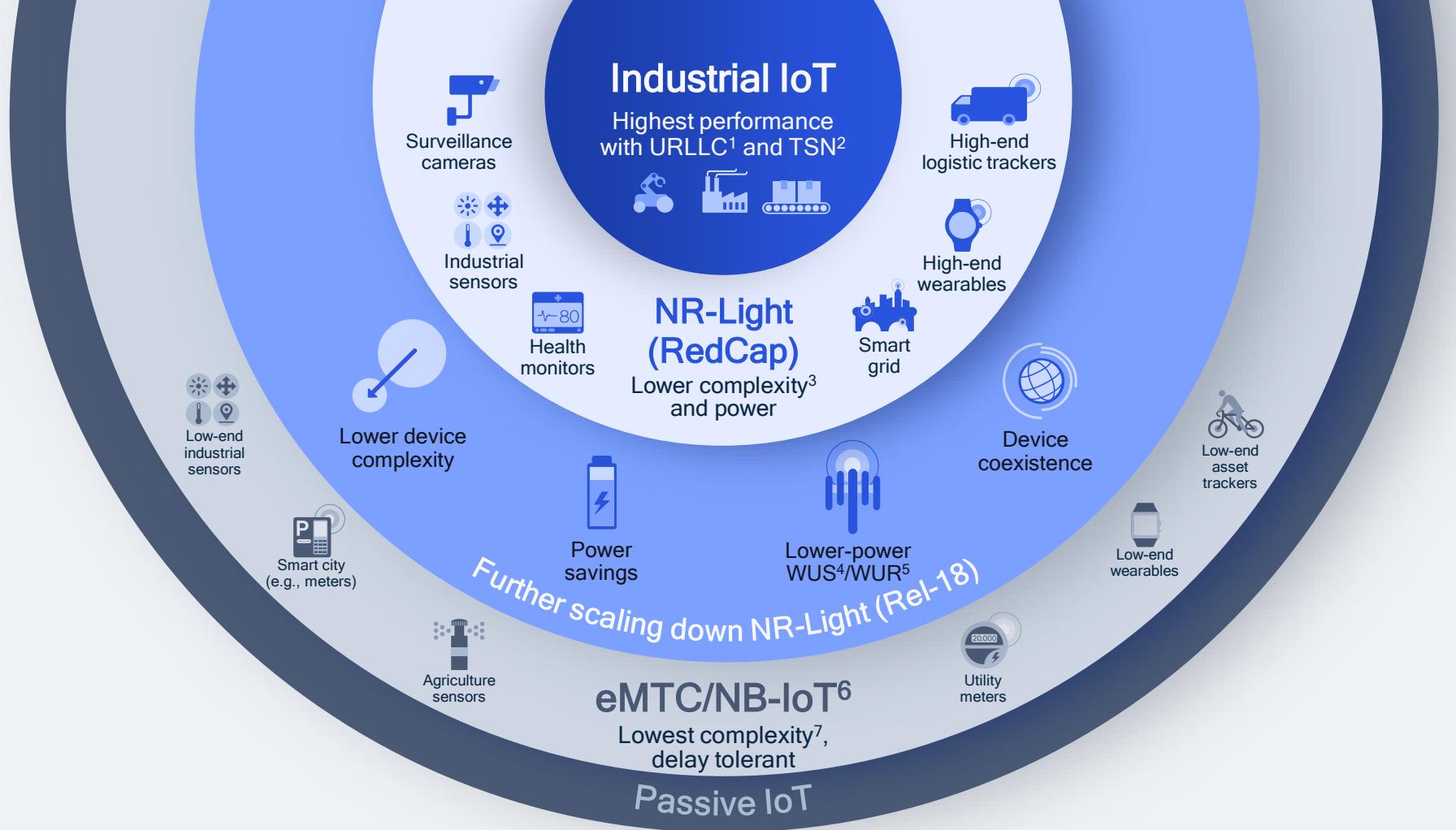
Supporting diverse IoT devices and services



Consumer IoT



Industrial IoT



5G NR: A unified, scalable air interface allowing coexistence of a wide range of 5G device classes

1 Ultra-reliable low-latency communication; 2 Time sensitive networking; 3 Data rate of 150 Mbps DL / 50 Mbps UL, latency of 10-30 ms, 10-3 to 10-5 reliability, coverage MCL of 143 dB; 4 Wakeup signal; 5 Wakeup receiver; 6 Also including satellite access; 7 Data rate of 1Mbps, MCL of 155.7 dB (eMTC) and 164 dB (NB-IoT)



Pushing forward with the 5G positioning technologies



Indoor navigation



Vehicular nav.



Public safety



Drone tracking



Geofencing



User insights



AGV tracking



Asset tracking



Fleet management



XR optimization

Release 16 Establishing foundation

Achieving accuracy of 3m/10m (indoor/outdoor) for 80% of time

Supporting RTT¹, AoA/AoD², TDOA³, single-cell positioning

Including new evaluation scenarios, i.e., industrial IoT

Release 17 Enhancing performance

5G Positioning Evolution

Meeting centimeter-level absolute accuracy requirement of down to 0.3m

Reducing positioning latency to as low as 10 ms

Scaling to higher capacity for millions of simultaneous devices (e.g., IoT, automotive)



5G Advanced in Release 18+

Improving performance, expanding to new devices and deployments

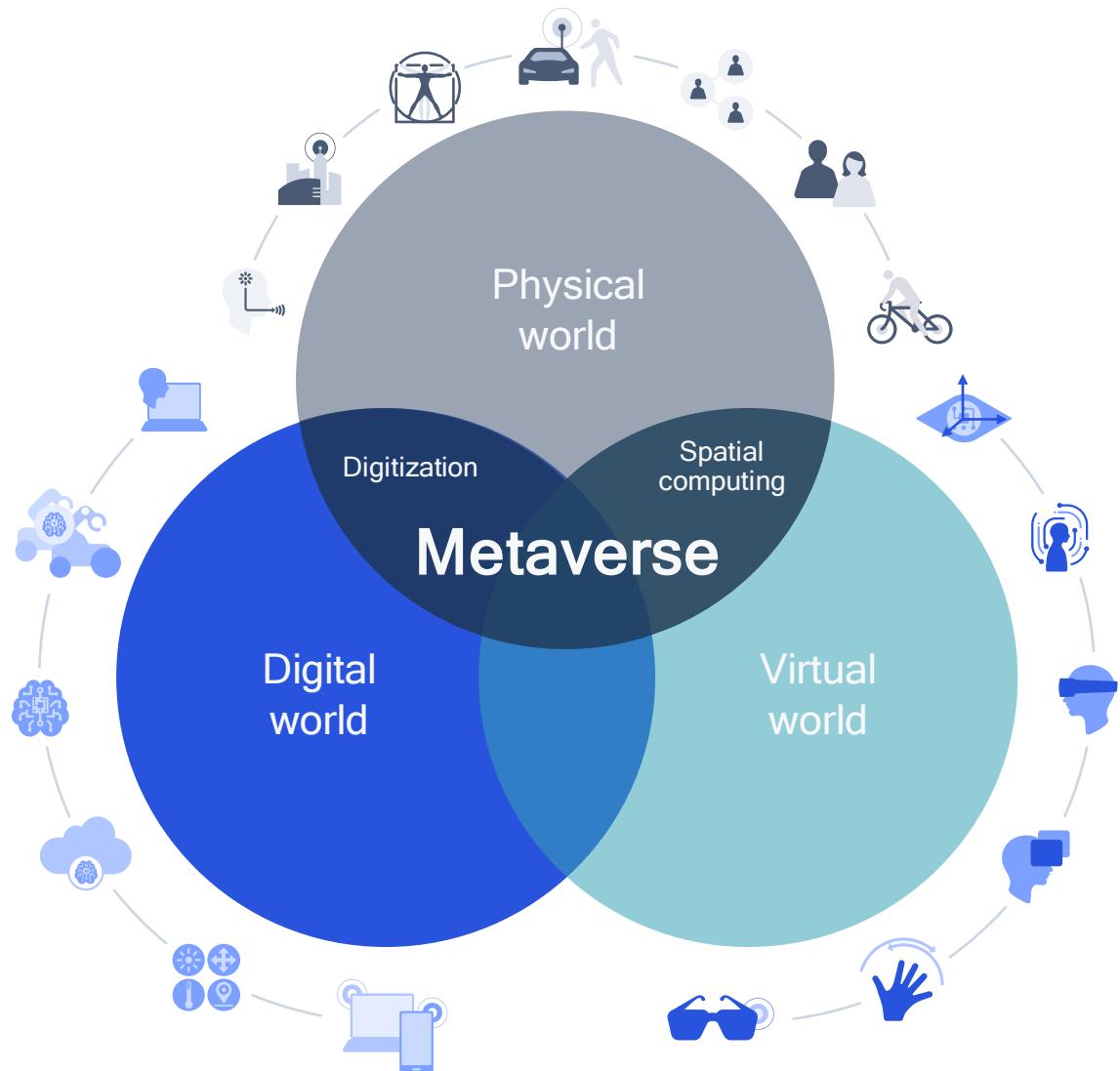
Sidelink positioning and ranging

Defining reference signals, measurements, procedures for out-of-range, absolute and relative (e.g., ranging) sidelink positioning

Improved positioning performance

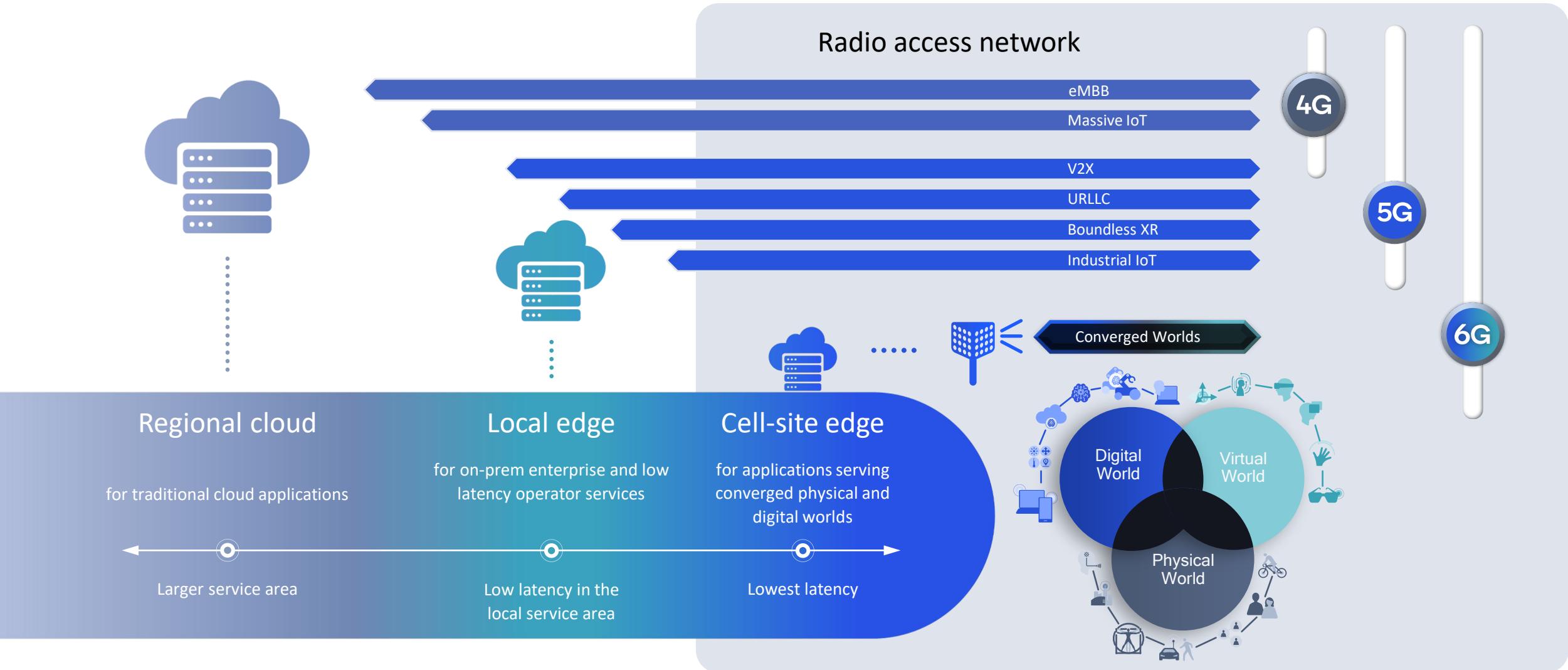
Specifying higher layer solutions for RAT⁴ dependent positioning techniques, accuracy improvement based on PRS/SRS⁵ bandwidth aggregation, carrier phase measurements, and positioning accuracy in heavy NLOS⁶ with AI/ML





New interface opportunities through
Merging worlds
The
New human interface

Serving more diverse requirements with an evolving topology



Building the wireless system of the next decade and beyond

Driving the continued evolution of wireless and adjacent technologies

Advanced RF

Even higher bands, faster switching, improved PA efficiency



Compute topology

Virtualization, containerization for end-to-end system in cloud, edge, device



Extreme RAN disaggregation

Horizontal and vertical ecosystems, richer mix of new vendors



Machine learning / AI

Distributed / federated learning, network automation and optimization



Silicon / material technology

Faster and more efficient baseband processing, meta-surfaces



Power management

More efficient battery charging, energy storage, energy harvesting



Human interface

More immersive experiences (e.g., XR evolution), biological implants



Multimedia and display

Higher resolution, richer color, lower latency, 3D holography



Fueling next-gen devices and use-cases



Extreme evolution of XR experiences



Increasing role of smarter verticals



Future markets and services not yet fully known today



Design goals and performance vectors

Capacity

Data rate

Coverage

Latency

Reliability

Security

Spectral efficiency

Mobility

Energy efficiency

Connection density

Cost efficiency

User experience

Intelligence

Scalability

Ease of onboarding

Positioning capability

And others...

Key research vectors enabling the path towards 6G



AI/ML powered E2E communications

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



Spectrum expansion & sharing

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



New radio designs

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



Scalable network architecture

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



Communications resiliency

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

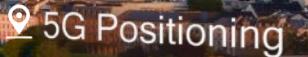


Leading the 5G Advanced technology evolution on the path to 6G

Creating new value across applications



5G



5G Positioning



Advanced MIMO



Mobile mmWave



Green Networks



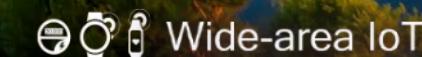
Industrial 5G Networks
Industrial Precise Positioning



Automotive



AI-enabled Air Interface



Wide-area IoT



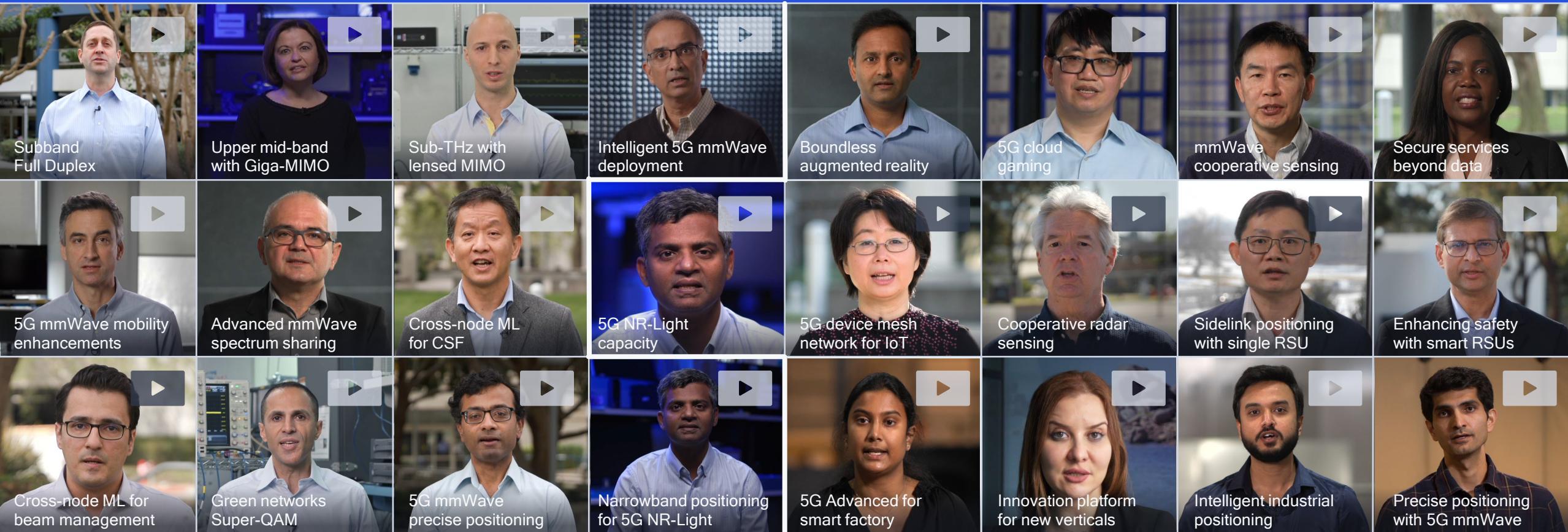
Enabling the Metaverse



Driving the 5G evolution with our advanced R&D demonstrations



Watch all on
YouTube



Foundational Air Interface Innovations

Expansion to New Applications

Innovating to pave the path to 6G

A unified connectivity fabric for this decade

Continued evolution

5G

Rel-15
eMBB focus

Rel-16 and 17 expanding
to new industries



Rel-18, 19, 20 and beyond
Continued 5G proliferation

6G

Strong 5G momentum sets
stage for global expansion

Next technology leap
for new capabilities
and efficiencies

Historically 10 years
between generations

Thank you



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