3GPP Release 17:
Completing the first phase of the 5G evolution

To bring new system capabilities and expand 5G
to new devices, applications, and deployment

5G Accelerating Globally

205+
Operators with 5G commercially deployed

280+
Additional operators investing in 5G

750M+
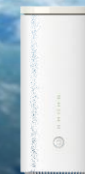5G smartphones to ship in 2022

1B+
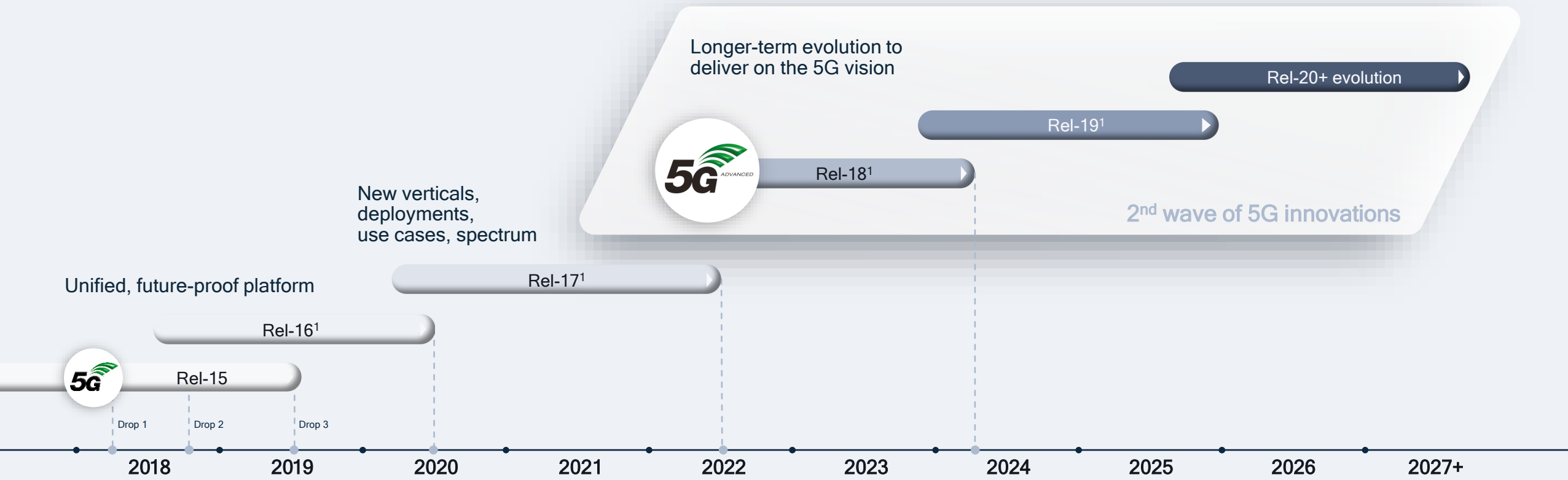5G connections by 2023 – 2 years faster than 4G

5B+
5G smartphones to ship between 2020 and 2025

1275+
5G designs launched or in development

Driving the 5G technology evolution in the new decade

Longer-term evolution to deliver on the 5G vision

Rel-20+ evolution

Rel-19[1]

5G ADVANCED

Rel-18[1]

New verticals, deployments, use cases, spectrum

2nd wave of 5G innovations

Unified, future-proof platform

Rel-17[1]

Rel-16[1]

5G

Rel-15

Drop 1   Drop 2   Drop 3

2018   2019   2020   2021   2022   2023   2024   2025   2026   2027+

Rel-15 eMBB focus
- 5G NR foundation
- Sub-7 and mmWave
- Scalable & forward compatible
- Basic URLLC support
- mMTC via eMTC & NB-IoT

Rel-16 industry expansion
- Unlicensed spectrum (NR-U)
- Enhanced URLLC
- New functionalities: Sidelink (NR V2X), Positioning
- 5G broadcast
- eMTC/NB-IoT with 5G core
- Topology: IAB
- eMBB enh: MIMO, device power, CA/DC, mobility

Rel-17 continued expansion
- mmWave extended to 71GHz
- Lower complexity "NR-Light" (RedCap)
- Non-terrestrial communication (satellites): NR NTN and NTN IoT
- Improved IIoT, positioning, V2X
- Enhanced IAB, RF repeaters

Rel-18+ 5G-Advanced
- Next set of 5G releases (i.e., 18, 19, 20, …)
- Rel-18 scope decided in Dec '21
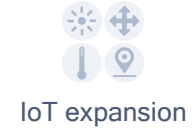- Rel-18 study/work to start in Q2-2022

1. 3GPP start date indicates approval of study package (study item->work item->specifications), previous release continues beyond start of next release with functional freezes and ASN.1

3

Enhancing mobile broadband

Enabling new verticals

5G Advanced in Release 18+

5G Release 17: strengthened foundations and verticals

5G Release 16: expanding to new verticals

5G Release 15: foundations of 5G

Boundless extended reality

IoT expansion

Smartphones and laptops

Automotive

Device enhancements

Reduced capability devices (NR-Light)

Non-terrestrial networks (NTN)

High-precision positioning

Sidelink

Mission-critical design

Advanced power saving and mobility

Advanced channel coding

Massive MIMO

mmWave expansion

Scalable numerology

Fixed Wireless and enterprise

Unlicensed spectrum
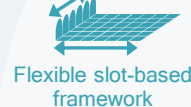
Flexible slot-based framework

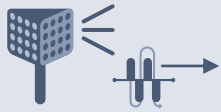4G foundations

Mobile mmWave

New deployment models

Topology expansion

Industrial IoT

Our innovations expand the foundation of 5G

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

Qualcomm innovation leadership in 3GPP Release 17

mmWave expansion

For more capacity, new use cases and deployments

Licensed and unlicensed spectrum operations in 52.6-71 GHz

Reduced capability devices (NR-Light)

For expanded IoT: wearables, sensors, surveillance cameras

Lower complexity devices with 20 / 100 MHz max bandwidth in sub-7 / mmWave with 1 or 2 Rx antennas

Device enhancements

For enhanced device user experience and performance

More antennas, higher throughput, battery life, mobility, coverage, positioning accuracy, multi-SIM

Non-terrestrial networks (NTN)

For ubiquitous coverage and expanded use cases

Satellite communications for mobile devices and IoT, leveraging 5G NR framework

Topology expansion

For more efficient deployments, public safety, and others

Enhanced IAB, repeater, C-V2X with vulnerable road users

Early R&D investments

Cutting-edge prototypes

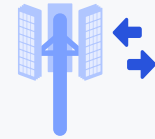**Fundamental contributions to 3GPP**

![5G logo]

3GPP Release 17

A key 5G milestone: 3GPP Release 17 Completion

Functional freeze in March 2022 and ASN.1 freeze expected in June 2022

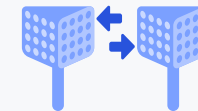## New and enhanced 5G system capabilities

Further enhanced massive MIMO

Coverage enhancements

Device power savings

Spectrum expansion (60 GHz)

Enhanced IAB and RF repeater

Further enhanced URLLC, private networks, others…

Expansion to new 5G devices and applications

Sidelink expansion

Broadcast/ multicast expansion

NR-Light (RedCap), enhanced mIoT

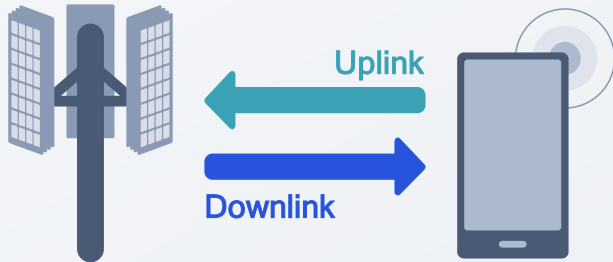Non-terrestrial networks (NTN)

Enhanced precise positioning

Boundless XR study, others…

Strengthen the end-to-end 5G system foundation

Further enhancing 5G mobile broadband and expanded use cases

Further enhancing 5G massive MIMO performance

Focus areas for Release 17 Work Item

Enhanced multi-beam operation

- Unified TCI[1] framework in DL/UL[2] to reduce latency and overhead
- UL beam selection for multi-panel devices
- More efficient L1/L2[3] intra-and inter-cell mobility

SRS[7] improvements

- More flexible triggering of aperiodic SRS and DCI[8] overhead reduction
- SRS switching for up to 8 antennas
- Improved SRS reliability such as repetitions and time bundling

Enhanced multi-TRP[4] deployment

- Improved reliability for DL control, UL control and data channels
- QCL[5] for inter-cell multi-TRP reusing L1/L2 mobility measurements
- Beam management for multi-panel Rx
- High-speed SFN[6] enhancements

CSI[9] measurement & reporting

- DL/UL reciprocity of angle and delay for FDD[10]
- More dynamic channel/interference hypotheses for non-coherent joint transmission

Improving 5G uplink coverage

Targeting urban and rural deployments using sub-7 GHz and mmWave, also applies to satellites (NTN[1]) communication

5G
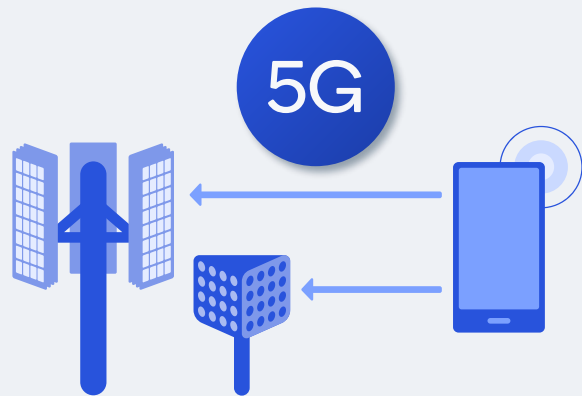
Coverage enhancements Work Item
3GPP Release 17

Uplink data channel (PUSCH[2]) enhancements
Increasing the maximum numbers of repetitions, supporting transport block processing over multiple slots, and enabling joint channel estimation across multiple transmissions and frequency hopping

Uplink control channel (PUCCH[3]) enhancements
Supporting dynamic repetitions for better reliability, DMRS[4] bundling across repetitions based on similar mechanisms for enabling joint channel estimation for PUSCH

Message 3 enhancements
Supporting Type A PUSCH repetitions for capability signaling, barring, and early indication

Further enhancing device power efficiency

For idle/inactive mode

Techniques to reduce unnecessary device paging reception (false alarms) without impacting legacy devices

Providing potential TRS[1]/CSI-RS[2] to devices in idle/inactive mode with minimized system overhead impact

Supporting PDCCH[3]-based permanent equipment identifier (PEI)

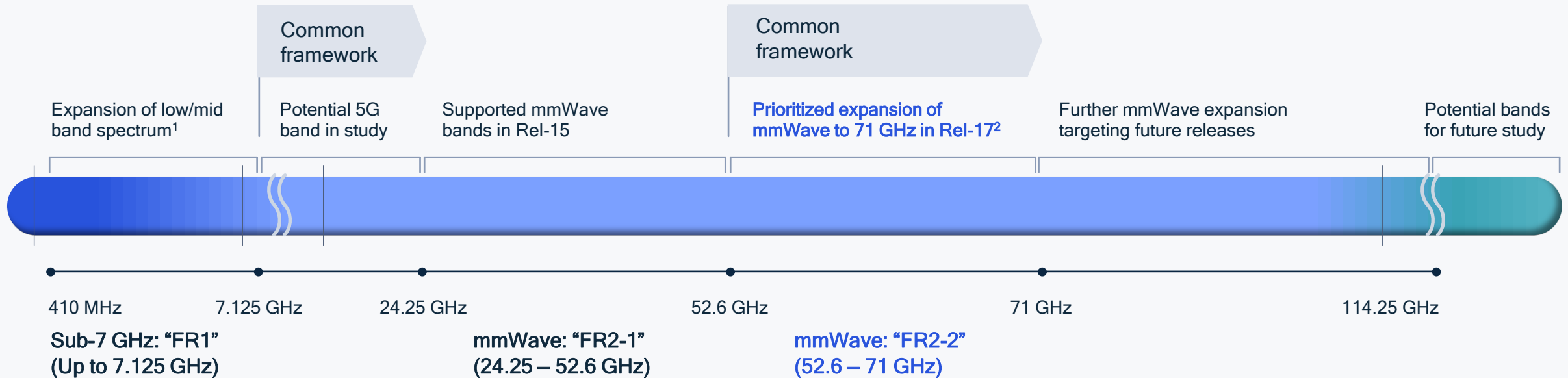### Rel-17 power saving enhancements

Building on Rel-16 device power saving design

For connected mode

Extending to Rel-16 DCI[4]-based power saving adaptation for an active BWP[5], including PDCCH monitoring skipping during C-DRX[6]

Relaxing device measurement for RLM[7] and/or BFD[8] for low mobility devices with short DRX[9] cycle

Scaling 5G NR design to support 60 GHz unlicensed band

Common framework		Common framework	

| Expansion of low/mid band spectrum[1] | Potential 5G band in study | Supported mmWave bands in Rel-15 | Prioritized expansion of mmWave to 71 GHz in Rel-17[2] | Further mmWave expansion targeting future releases | Potential bands for future study |

410 MHz　　　7.125 GHz　　　24.25 GHz　　　52.6 GHz　　　71 GHz　　　114.25 GHz

Sub-7 GHz: "FR1"
(Up to 7.125 GHz)

mmWave: "FR2-1"
(24.25 – 52.6 GHz)

mmWave: "FR2-2"
(52.6 – 71 GHz)

Design Principles

SCS[3] for control/data channels

Leveraging existing design of 120 kHz, and scaling to wider numerology of 480 kHz and 960 kHz

SSB[4] numerology

Supporting 120 kHz (480 kHz optional) for initial access, 120 kHz (480 kHz, 960 kHz optional) for non-initial access, and 64 SSB beams

Channel access mechanisms

Supporting flexible deployment in unlicensed spectrum utilizing LBT[5], directional LBT, or no LBT

Beam management

Reusing designs based on existing mmWave frequency range (FR2-1) established in Release 15 and 16

Further enhancing ultra-reliable, low-latency communications

Release 17 Work Item targeting to meet more stringent requirements of Industry 4.0 applications

Enhanced physical layer feedback

- Improved device feedback for HARQ-ACK[1]
- New mechanism triggered aperiodic CSI[2] and SRS[3] for more accurate MCS[4] selection
- Improved reliability with uplink control[5] on two carriers
- Subband CQI[6] with more granularity

Improved compatibility for unlicensed spectrum

- Supporting device-initiated COT[7] for FBE[8]
- Harmonizing uplink configured-grant enhancements in Rel-16 NR-U[9] and URLLC[10] to be applicable for unlicensed spectrum

Intra-device multiplexing and prioritization

- Handling low-priority traffic on eMBB without impacting data flow in case of URLLC concurrency
- Parallel PUCCH and PUSCH[11] transmissions on different component carriers for inter-band CA[12]
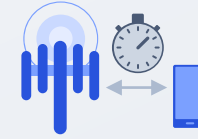
Enhanced time synchronization

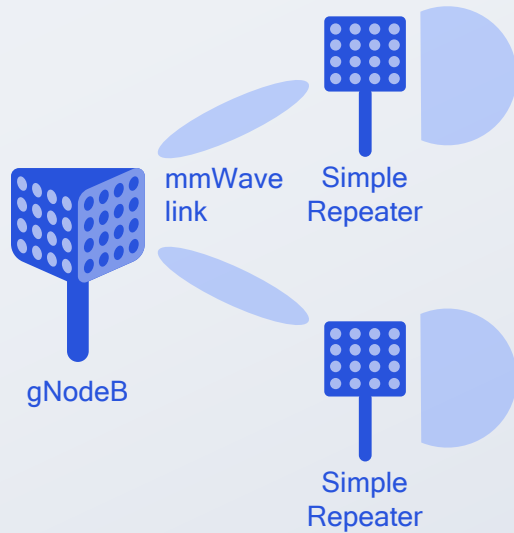Supporting uplink RTT[13]-based method for TSN[14] and improved propagation delay compensation

Network enhancements

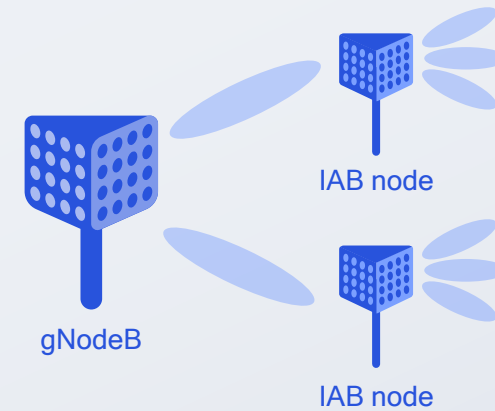Based on new QoS[15] related parameters such as survival time, burst spread

RF Repeaters

Introduced RF repeaters (without adaptive beamforming) that can operate in sub-7 GHz (FDD/TDD) and mmWave, leveraging IAB and LTE repeaters work; "Smart" network-controlled repeater in Rel-18

Integrated Access & Backhaul (IAB)

Enhanced Rel-16 IAB design by adding support for simultaneous Tx and Rx (spatially separated full duplex), inter-donor migration / handover, and multi-hop efficiency enhancements
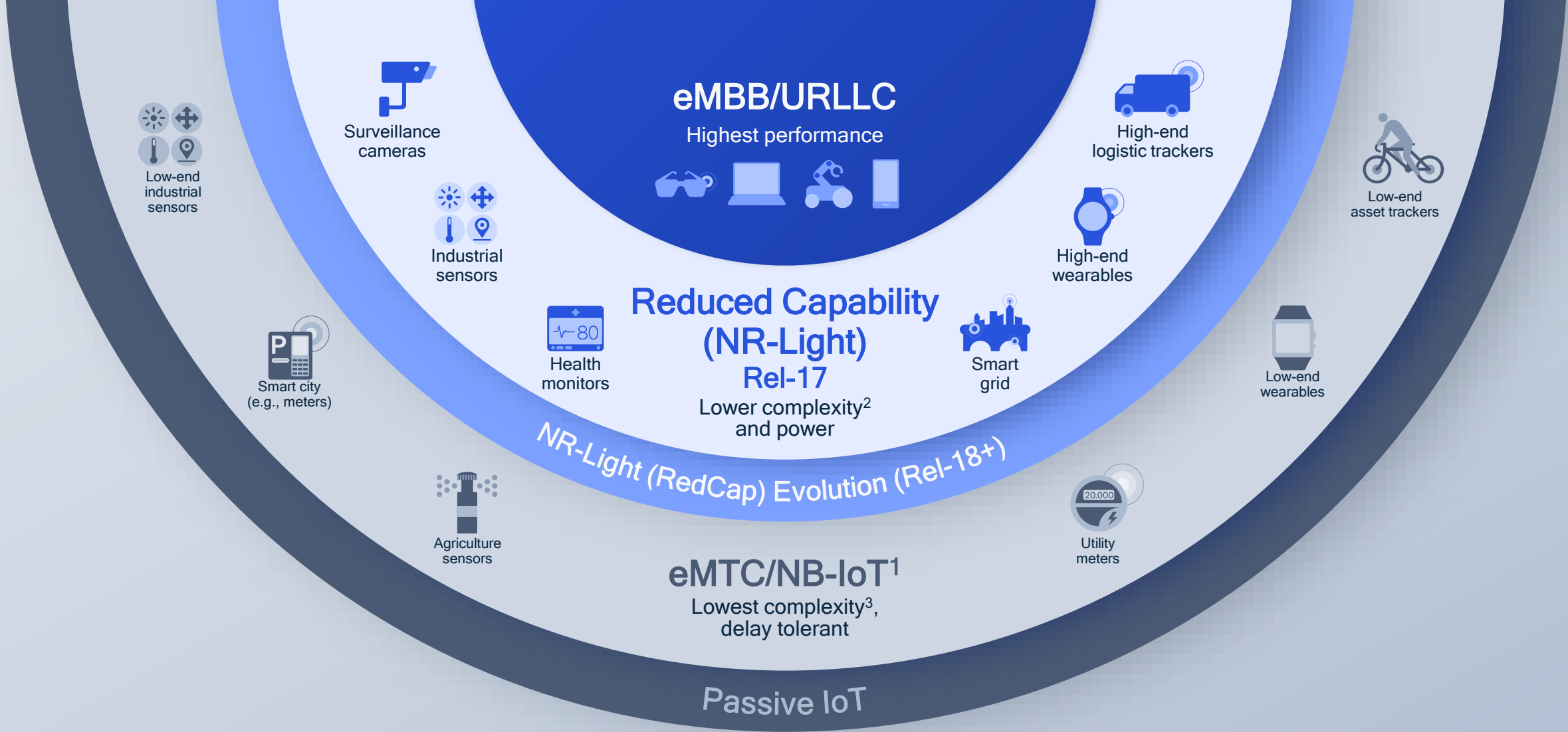
Efficiently expand 5G mmWave coverage

New mmWave infrastructure options introduced as part of Release 17

Proliferate 5G to virtually all devices and use cases

Continued expansion to new device types and tiers — fulfilling the 5G vision

5G

eMBB/URLLC

Highest performance

Surveillance cameras

Low-end industrial sensors

Industrial sensors

Health monitors

Reduced Capability (NR-Light) Rel-17

Lower complexity[2] and power

Smart grid

High-end logistic trackers

High-end wearables

Low-end asset trackers

Low-end wearables

Smart city (e.g., meters)

NR-Light (RedCap) Evolution (Rel-18+)

Agriculture sensors

eMTC/NB-IoT[1]

Lowest complexity[3], delay tolerant

Utility meters

Passive IoT

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

Scaling down 5G NR for lower complexity IoT devices

Continued 5G massive IoT evolution with eMTC/NB-IoT

Release 17 Work Item enhancements

5G Massive IoT Data Rates

Higher data rates supported by NR-Light (RedCap), LTE Cat-1, …

- eMTC
- NB-IoT

Maximum throughput

	Rel-13 Baseline	Rel-13/14/15 Enhancements	Rel-17 Enhancements
eMTC	300 kbps	588 kbps	1.2 Mbps
NB-IoT	28 kbps	127 kbps	254 kbps
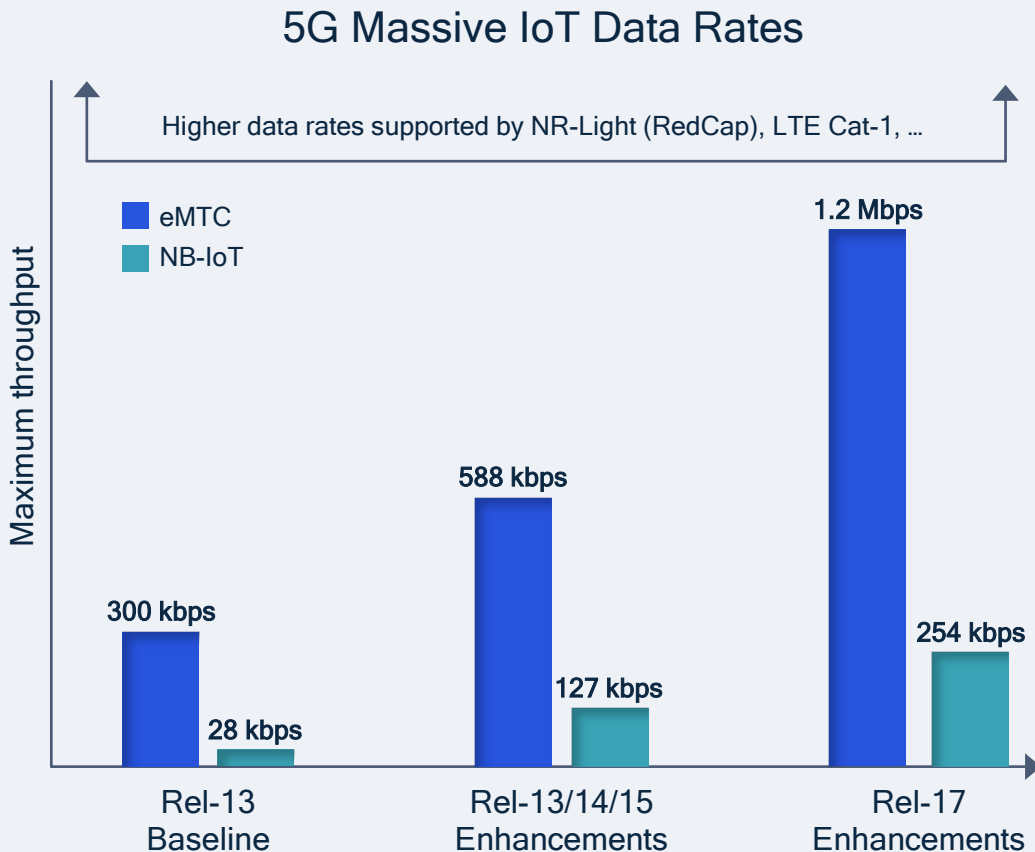
Source: RP-211340 (Additional enhancements for NB-IoT and LTE-MTC)
1 Transport Block Size; 2 Hybrid Automatic Repeat Request; 3 Frequency Division Duplex;
4 Physical Uplink Shared Channel; 5 Physical Resource Block; 6 Radio Link Failure

eMTC enhancements

Supporting larger TBS[1] sizes and 14 HARQ[2] processes to increase data rate for half-duplex FDD[3] devices

Supporting power boosting for devices with PUSCH[4] sub-PRB[5] resource allocation

Adding an optional device capability to support a maximum DL TBS of 1,736 bits for half-duplex FDD devices

NB-IoT enhancements

Supporting 16-QAM for UL and DL unicast, increasing in maximum TBS sizes for DL compared to Rel-16 NB-IoT and extended channel quality reporting

Reducing the time taken to recover from RLF[6], with new signaling for neighbor cell measurements and triggering

Introducing carrier selection based on coverage level and associated carrier specific configurations

5G NR for NTN
Complementing terrestrial networks in underserved areas

LEO, GEO, HAPS, air-to-ground communications
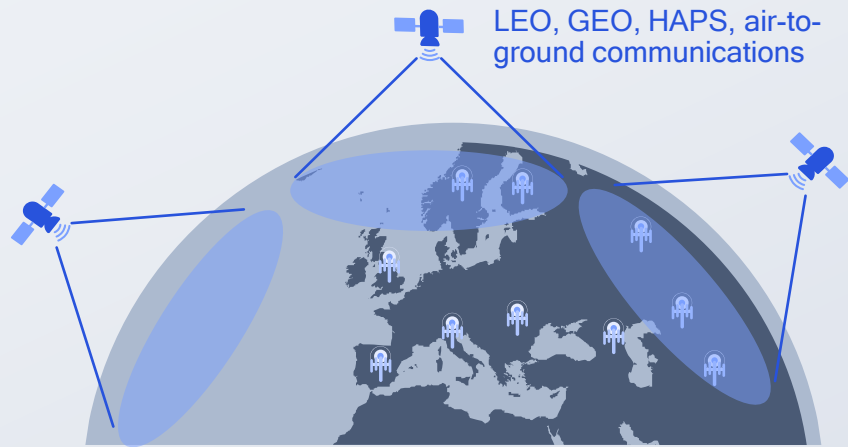
Supporting satellites backhaul communication for CPEs and direct link to handhelds (e.g., smartphones) for low data rate services

Utilizing sub-7 GHz S-band with additional bands added in the future (e.g., 10+ GHz in Rel-18 proposed)

5G IoT for NTN
### Expanding addressable market for the 5G massive IoT

LEO, GEO, PC3/PC5 satellites with intermittent access link

Supporting diverse use cases, including transportation, utilities (e.g., solar, oil/gas), farming, mining, environmental monitoring

Utilizing sub-7 GHz band for both eMTC and NB-IoT, with LTE EPC[1] only in standalone network

Release 17 establishes 5G NR support for satellites communication

Release 17 Work Item expands sidelink to new use cases
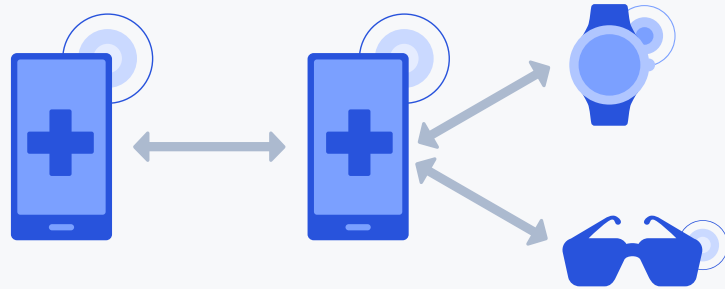
Release 17 Sidelink Enhancements

For public safety, IoT,
commercial use cases
and beyond

Updated sidelink evaluation methodology

Reusing existing evaluation assumption and performance metric[1],
based on feedback from car manufacturers

Improved resource allocation

Reducing device latency, power consumption, and improving reliability (e.g., half
duplex, collision detection indication, control forwarding, inter-device coordination)

Power saving enhancements

Defining sidelink DRX for broadcast, groupcast, unicast, and power-efficient
resource selection for devices

New sidelink frequency bands

Ensuring sidelink and network communication coexistence in the same
and adjacent channels in licensed spectrum

Geographic confinement

Limiting sidelink operations to be within a predetermined area for a given
frequency range in non-ITS[2] bands

Sidelink relay

L2/L3 device to network relay for coverage extension,
Follow-up work Item for device-to-device relay in scope for Release 18

5G positioning evolution

5G positioning evolution in Release 18+

Improving performance, expanding to new devices and deployments

Release 17

Enhancing capability and performance for a wide range of use cases[4]

Centimeter-level accuracy

Meeting accuracy requirements for commercial use cases (<1m) and IIoT (<0.2m within 100ms)
- Mitigating device and base station Rx/Tx timing delays
- Improving accuracy for UL AoA and DL-AoD positioning
- Enhancing information reporting for multipath & NLOS[5] mitigation

Reduced positioning latency

Optimizing positioning latency to as low as 10ms, related to the request / response of location, device measurement time and gaps

Improved efficiency

Scaling to higher capacity by supporting device positioning in inactive state and on-demand PRS[6], triggered by network or device

GNSS[7] enhancements

Improve the performance and efficiency for 5G positioning with assistance information from GNSS, supporting GNSS positioning integrity determination, BeiDou positioning signals (BDS B2a and B3I), and NavIC[8] for 5G NR

Release 16

Establishing foundation

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

Supporting RTT[1], AoA/AoD[2], TDOA[3], single-cell positioning

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

Pushing forward with the 5G positioning technologies

Optimizing 5G NR for Boundless XR experiences

Release 17 Study Item for XR over 5G NR – Work Item in scope for Release 18

Edge Cloud

5G NR
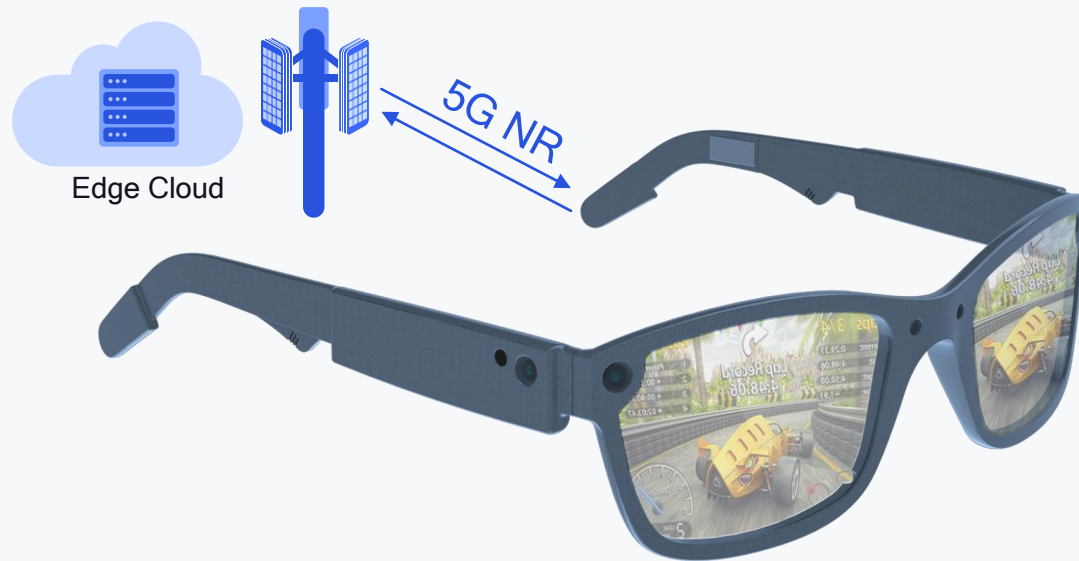
Use cases in scope

| Distributed computing | Split rendering | Viewpoint dependent streaming |

| Conversational XR | Cloud gaming |

Traffic requirement

Identifying requirements for use cases in scope, such as roundtrip time, one-way packet delay budget, and packet error rate, taking different upper layer assumptions into consideration

Evaluation methodology

Assessing XR (including VR, AR) and cloud gaming performance along with identification of KPIs for relevant deployment scenarios

Performance evaluation

Carrying out characterization of XR system performance based on agreed upon evaluation methodologies

UHF[1] broadcast frequencies

Adding support for 6/7/8 MHz carrier bandwidths[2] to support UHF bands

CMAF[3]-based streaming ecosystem
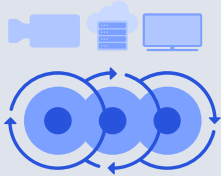
Targeting low-latency broadcast distribution and 5G media streaming
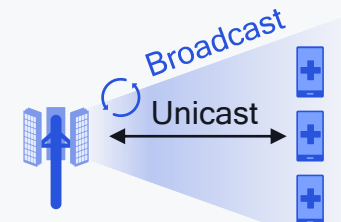
Simultaneous broadcast + unicast
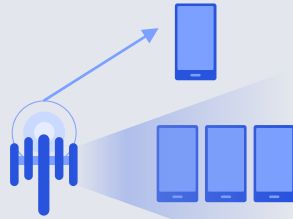
Optimizing modem resource usage and enabling fast broadcast service discovery
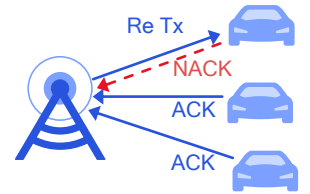
Multicast operation for 5G NR
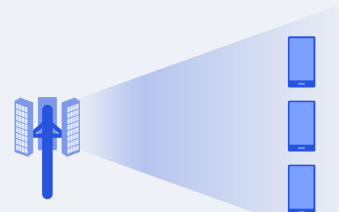
Supporting group scheduling, mobility, DRX[4], reception in idle and transparent SFN[5]

Broadcast and unicast dynamic switching

Enabling dynamic switching between unicast & broadcast (e.g., for public safety use cases)

Improved robustness and efficiency

Supporting uplink HARQ[6] feedback and retransmissions for link adaptation and reliability

5G Standalone Broadcast (Rel-17) ⟶   5G Mixed-mode Multicast (Rel-17)

Continue to evolve the end-to-end design for 5G broadcast

DSS[1] enhancements

Enable PDCCH[2] cross-carrier scheduling from a SCell[3] to a P(S)cell[4] in sub-7 GHz

Enhanced multi-radio DC[5]

Support efficient activation/de-activation of one SCG[6] and SCells, and conditional PSCell change/addition

Multi-SIM[7]

Support dual-standby, 1 active and 1 idle SIM, device-indicating network switch, and SIM from different MNOs[8]

Higher-order modulation

Support 1024-QAM for downlink and 256-QAM for sub-7 GHz uplink communication

Small data transmission

Allow uplink data in inactive mode (in either 2-step or 4-step RACH[9]) with defined small data request message

High-speed train

Optimize 5G support for high-speed trains for both sub-7 GHz and mmWave

5G

Other RAN projects in 3GPP Release 17
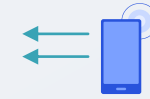
Uplink data compression

Utilize LTE procedure as baseline for 5G NR Standalone mode only

Enhanced data collection

Add new data categories for SON/MDT[10] (mobility, energy saving, capacity, coverage, …), and for RAN AI (use cases, types of input/output)

RAN[11] slicing

Support slice-based cell reselection, RACH configuration, service continuity, enforcement of slice maximum bit rate

Enhanced private network

Access to standalone private networks using credentials from a different entity, IMS voice, emergency services.

Quality of experience

Enable measurement collection in Standalone mode with mobility continuity and per-slice support.

User-plane integrity protection

Strengthen 5G security with integrity protection for user-plane in addition to control-plane using 5G NR PDCP[12]

How will 5G Advanced bring us a step closer to 6G?

Continued evolution towards 6G

Leading the 5G Advanced technology evolution on the path to 6G
Creating new value across applications

5G

Mobile mmWave

5G Positioning

Advanced MIMO

Green Networks

Industrial 5G Networks
Industrial Precise Positioning
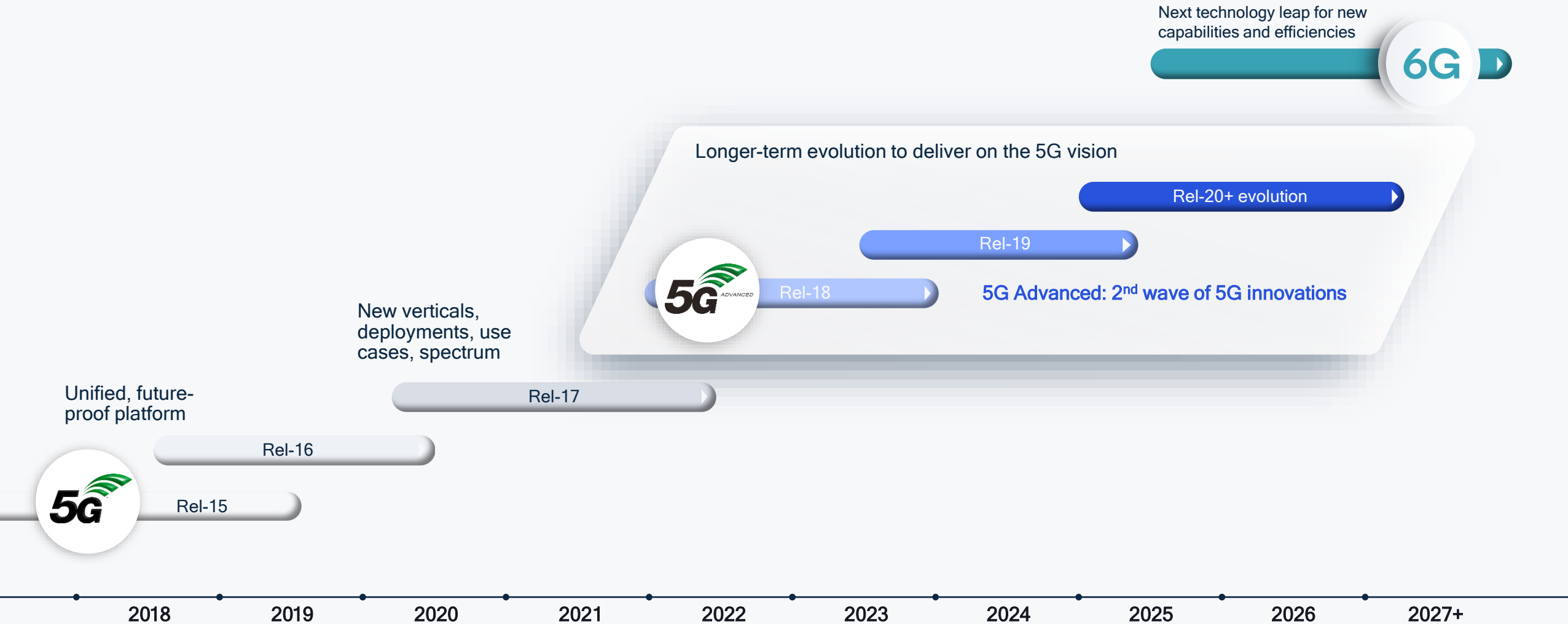
AI-enabled Air Interface

Automotive

Enabling the Metaverse

Wide-area IoT

Driving the 5G Advanced technology evolution in the new decade

Next technology leap for new capabilities and efficiencies

6G

Longer-term evolution to deliver on the 5G vision

Rel-20+ evolution

Rel-19

Rel-18

5G Advanced: 2nd wave of 5G innovations

New verticals, deployments, use cases, spectrum

Rel-17

Unified, future-proof platform

Rel-16

Rel-15

| 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027+ |

Driving a balanced 5G evolution across key technology areas

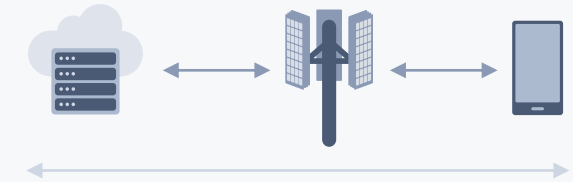## Mobile broadband evolution vs. further vertical expansion
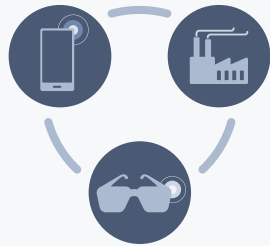
Deliver enhanced mobile broadband experiences and extend 5G's reach into new use cases

Immediate commercial needs vs. longer-term 5G vision

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

New and enhanced devices vs. network evolution

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

Release 18 scope takes into consideration of the 5G Advanced evolution in Release 18, 19, and beyond (i.e., many Study Items defined to set up for Work Items in later releases)
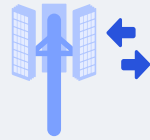
5G ADVANCED

Release 18

3GPP Release 18 sets off the 5G Advanced Evolution

Approved package has a wide range of projects – nominal work to start in Q2 2022
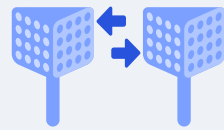
Strengthen the end-to-end 5G system foundation

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

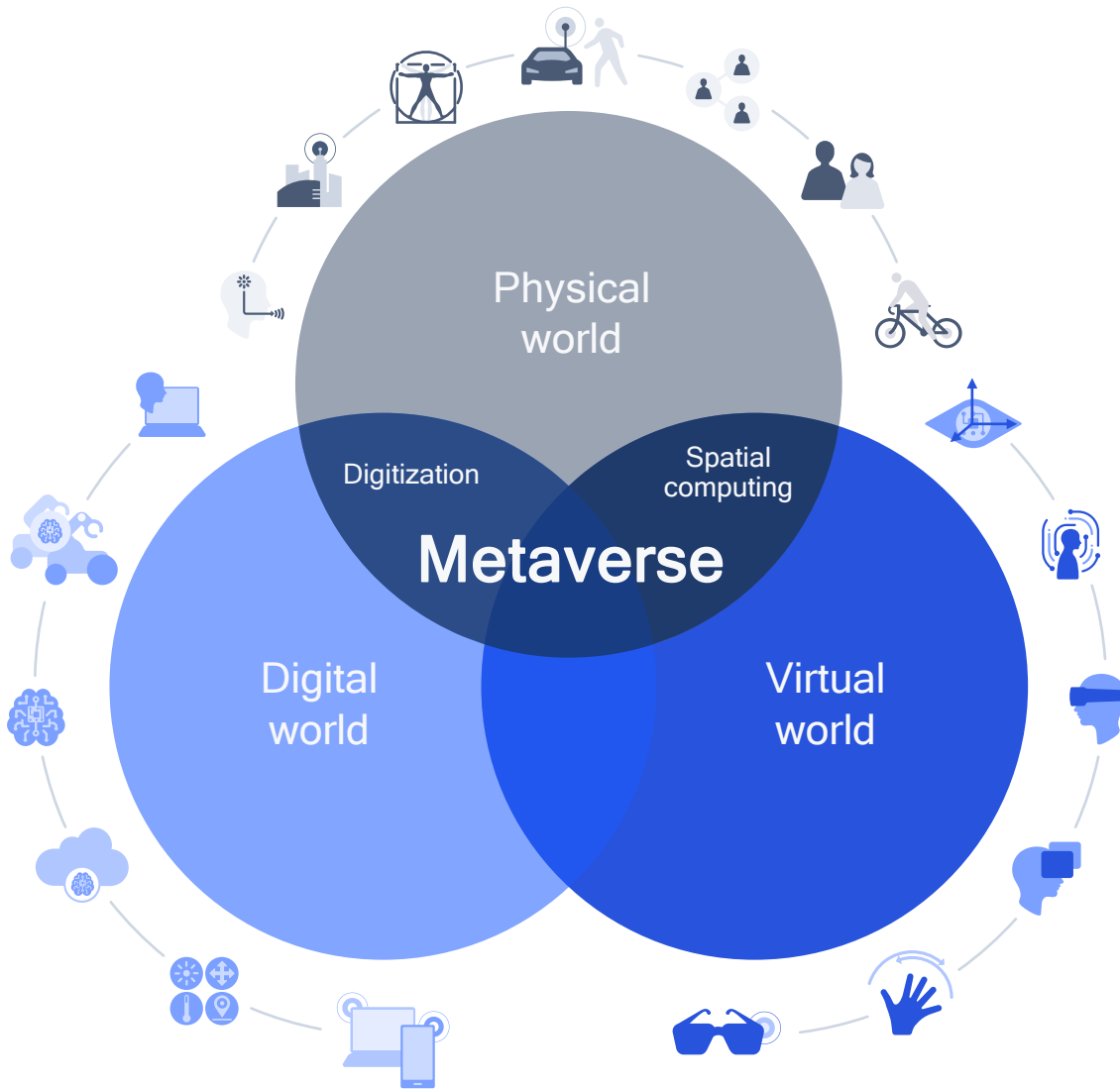NR-Light (RedCap) evolution

Expanded sidelink

Expanded positioning

Drones & expanded satellites comm.

Multicast & other enhancements

Physical world

Digital world

Virtual world

Digitization

Spatial computing

Metaverse

Ubiquitous, low-power sensing and monitoring with near real-time actions

Immersive interactions take human augmentation to the next level

New interface opportunities through

Merging worlds

The

New human interface

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

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6G
Design goals & performance vectors

Capacity	Latency	Spectral efficiency	User experience	Ease of onboarding
Data rate	Reliability	Mobility	Security	Scalability	Intelligence	Cost efficiency
Coverage	Energy efficiency	Connection density	Positioning capability	And others…

Innovating to pave the path to 6G

A unified connectivity
fabric for this decade

Next technology leap
for new capabilities
and efficiencies

Continued evolution

5G

Rel-15
eMBB focus

Rel-16 and 17 expanding
to new industries

5G ADVANCED

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

6G

**Strong 5G momentum sets
stage for global expansion**

Historically 10 years
between generations

Thank you