Qualcomm

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# Scaling 5G to new frontiers with NR-Light

Release 17 Reduced Capability efficiently expands 5G into lower-complexity IoT devices and services

# 5G will expand 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.
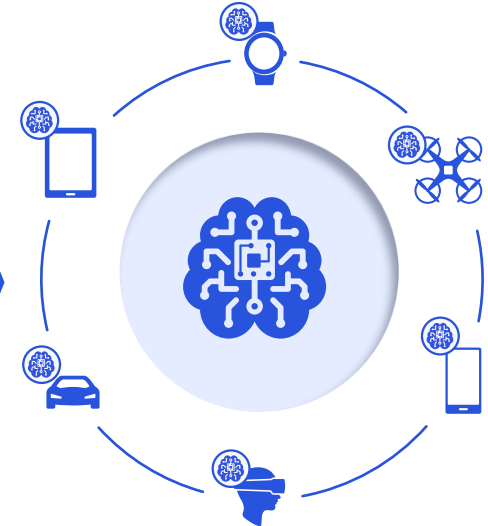
2

To efficiently scale,
AI processing is expanding
towards the edge

**5G**

Privacy

Reliability

Low latency

Efficient use
of network
bandwidth

Central Cloud

Edge cloud

On-device

Connected Intelligent Edge

Qualcomm is leading the realization
of the Connected Intelligent Edge

Convergence of:

Wireless connectivity

Efficient computing

Distributed AI

Unleashing massive amount
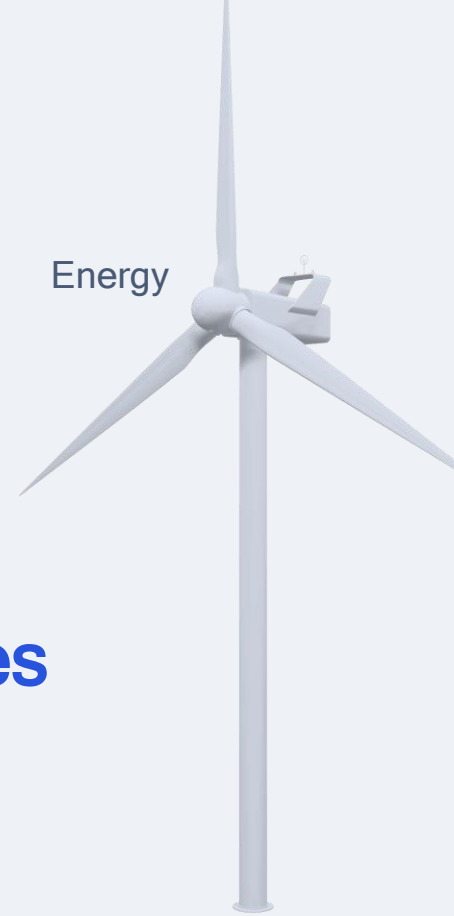of data to fuel our digital future

Transportation

Manufacturing

Industrial

Retail

Energy

# 5G connects a wide range of intelligent edge devices

A unified platform for enhanced mobile broadband, mission-critical control, massive IoT devices, and everything in between

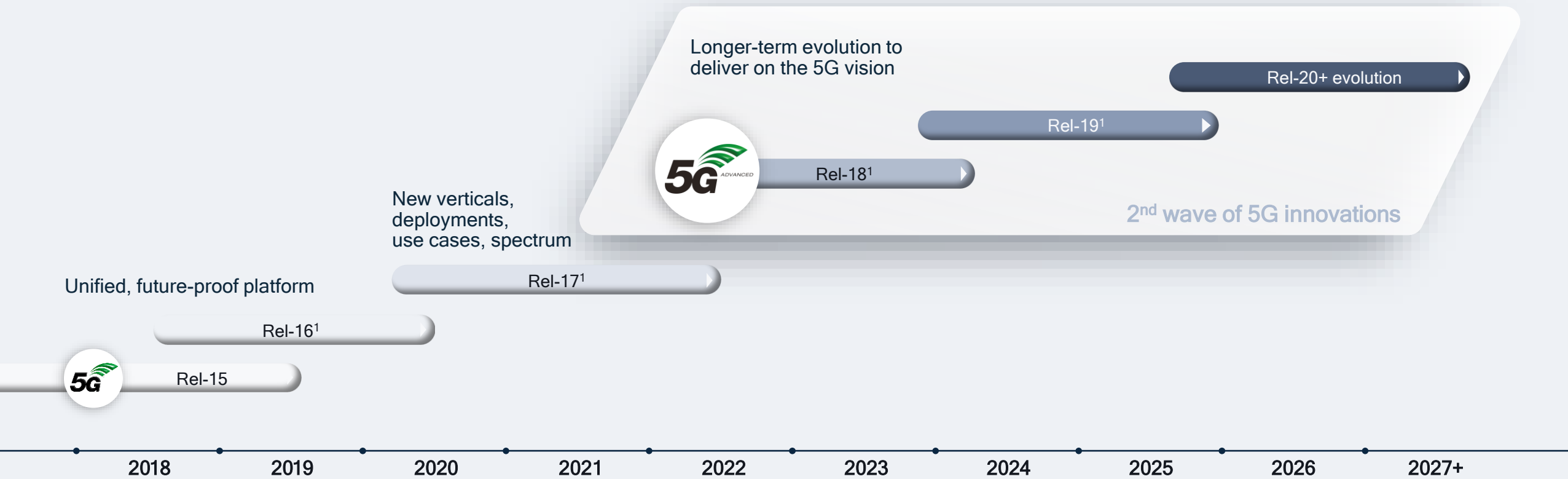Agriculture

Public safety

Smart cities

Healthcare

Entertainment

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

Longer-term evolution to deliver on the 5G vision

Rel-20+ evolution

Rel-19[1]

Rel-18[1]

2nd wave of 5G innovations

New verticals, deployments, use cases, spectrum

Rel-17[1]

Unified, future-proof platform

Rel-16[1]

Rel-15

| 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)
- IIoT with enhanced URLLC
- Integrated access/backhaul
- Sidelink (NR V2X), positioning
- Private network
- 5G broadcast
- eMTC/NB-IoT w/ 5G core
- Enhanced MIMO, device power, CA/DC, mobility

## Rel-17 continued expansion

- **NR-Light** (RedCap)
- mmWave extension to 71GHz
- Non-terrestrial communication (satellites):
- Improved IIoT, positioning, V2X
- Enhanced IAB, RF repeaters

## Rel-18+ 5G-Advanced

- **NR-Light** evolution
- Full duplex
- Wireless AI/ML
- Boundless XR
- Green networks

# 5G NR-Light accelerates the growth of the Connected Intelligent Edge

Ushering the next wave of 5G expansion with new designs and use cases

**eMBB/URLLC**
Highest performance

Surveillance cameras

Industrial sensors

High-end logistic trackers

High-end wearables

Low-end industrial sensors

Health monitors

Smart grid

Low-end asset trackers

**NR-Light (RedCap)**
Rel-17 Lower complexity[2] and power

Smart city (e.g., meters)

*NR-Light evolution (Rel-18+)*

Low-end wearables

Agriculture sensors

Utility meters

**eMTC/NB-IoT[1]**
Lowest complexity,[3] delay tolerant

Passive IoT

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

# Bridging the 5G IoT capability and complexity gap with NR-Light

Expanding the 5G universe to connect more tiers of devices and services

| | LATENCY | THROUGHPUT | DENSITY | COMPLEXITY | BATTERY LIFE | |
|---|---|---|---|---|---|---|
| **Mission-critical IoT** (with TSN, URLLC, and precise positioning) | Low | High | Low | High | Reference | High-performance |
| **NR-Light** (RedCap) | | | | | | |
| **5G massive IoT** (i.e., eMTC, NB-IoT) | High | Low | High | Low | Long | Low-complexity |

# NR-Light will fuel device ecosystem expansion in diverse 5G deployments



**Smart cities**

Smart grid
Real-time asset tracking
Environmental sensors

**Indoor enterprises**

Boundless AR
Asset monitoring
Smart display

**Industrial IoT**

Industrial sensors
IoT gateway
Surveillance cameras

**Consumers**

High-end wearables
Health monitors
Broadband access (e.g., tablets)

# 5G NR-Light can power the smart city of our future

Smart UHD surveillance

Asset tracking (e.g., packages)

Smart grid fault sensors

Real-time parking status and video monitoring

Smart city command center

Smart utility meter

## Green energy smart grid

Windmill smart grid adjustments

**475** MW
Transferring power to city

Daily consumption

423.1 m | 418.4
425.8
415.3
425.7
422.8
465.9
419.2
472.9

Monthly consumption

77 | 65 | 76 | 84 | 86 | 79 | 83 | 88 | 91
34 | 52

May Jun Jul Aug Oct Nov Dec Jan Feb Mar Apr May

### City energy transfer level

City block one

City block two

City block three

Predictive maintenance sensors

## Firefighter vital and location tracking

First responders onsite at the fire

Firefighter temperature exposure

**1,212**
Surrounding fire area temperature

Time in current temperature
**1.65** hrs
Recommended time remaining
**4.5** hrs

Firefighter Location

Firefighter vitals

93 Hbm
Normal

102°
Body temp. normal

87 mm Hg
Oxygen normal

25 mm Hg
Carbon dioxide level

Environmental sensors

# Driving the next industrial revolution with flexible manufacturing

NR-Light can optimize cost structures for robust industrial IoT

On-premise edge analytics and data storage

5G private network

5G private network

Smart UHD surveillance

Process monitoring sensors

**AR guided belt repair**

Conveyor belt repair steps

Performance

Maintenence schedule

Arm lubricants          8.5

Capacity

124 Hours until maintenance

**Robot #018**
Digital twin

5G cloud connection

Production metrics          Transfer speed

8.5          **2.3** Gbps

Performance

77  34  65  62  76  84  86  79  82  100  88  91

HMI interface

Wireless modular equipment

Predictive maintenance

Boundless augmented reality

Health sensors

Smart clothing

Location tracking

Smart watches

Fitness trackers
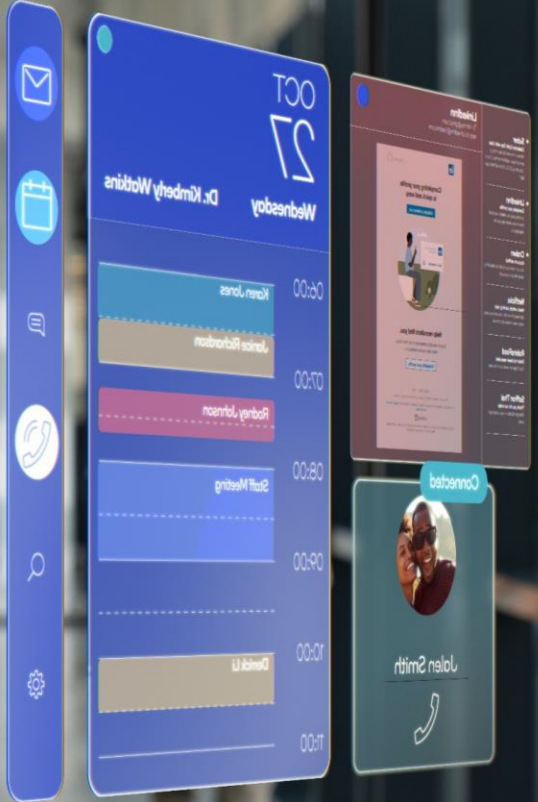
Powering next-generation indoor enterprise wearable devices

# Future-proof new mid-tier IoT designs with 5G NR-Light

|  | LTE Cat-1bis | LTE Cat-4 | 5G NR-Light (Rel-17) |
|---|---|---|---|
| Bandwidth | 20 MHz | 20 MHz | 20 MHz (sub-7 GHz) |
| DL/UL peak data rate | 10/5 Mbps | 150/50 Mbps | 150/50 Mbps or higher |
| Duplexing | FD-FDD, TDD | FD-FDD, TDD | HD-FDD, FD-FDD, TDD |
| Tx/Rx chain | 1 Tx, 1 Rx | 1 Tx, 2 Rx | 1 or 2 Tx, 1 or 2 Rx |
| DL/UL MIMO layer | 1/1 | 2/1 | 1 or 2/1 |
| Maximum coupling loss | 140 dB | 144 dB | 140 dB |

5G Core

5G RAN

5G Devices

eMBB   Mi-Cr   mIoT   NR-Light

Unified 5G platform for all use cases can simplify system management and security
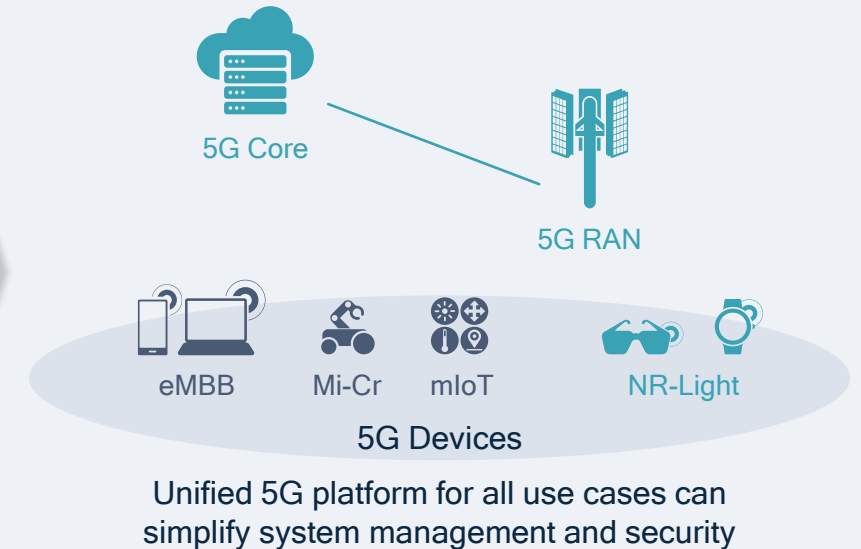
5G NR-Light can deliver higher throughput, lower latency, longer battery life, and an optimized cost structure

# 5G NR-Light
# is an integral part of the
# 5G roadmap and evolution

Continued evolution to expand IoT capabilities in 5G Advanced and beyond

# A unified 5G platform for all services

Continued 5G evolution to meet future IoT needs
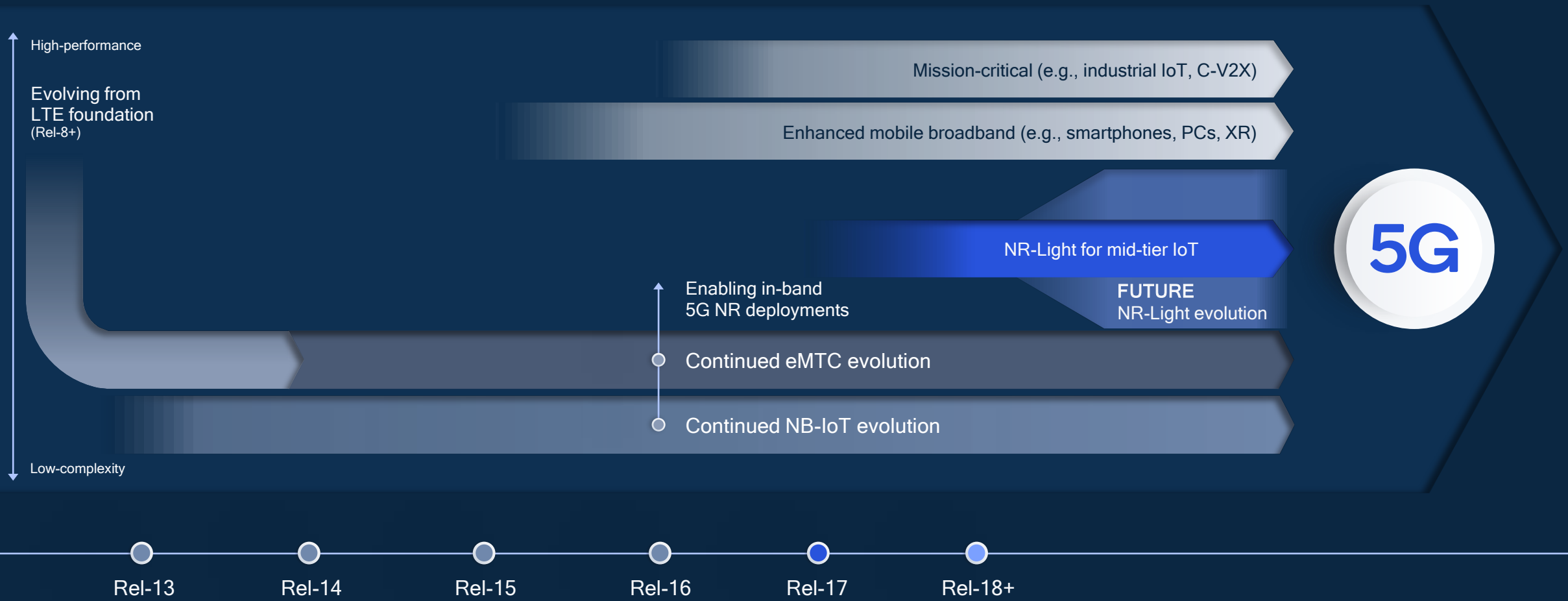
High-performance

Evolving from
LTE foundation
(Rel-8+)

Mission-critical (e.g., industrial IoT, C-V2X)

Enhanced mobile broadband (e.g., smartphones, PCs, XR)

NR-Light for mid-tier IoT

**5G**

Enabling in-band
5G NR deployments

**FUTURE**
NR-Light evolution

Continued eMTC evolution

Continued NB-IoT evolution

Low-complexity

Rel-13    Rel-14    Rel-15    Rel-16    Rel-17    Rel-18+

## 5G NR
# Technology Foundation

Scaling down 5G NR for lower complexity IoT devices

Lower device complexity

Reduced power consumption

# Reduced Capability

(NR-Light) Release 17

Coverage optimization

Increased network efficiency and flexibility

Narrower bandwidths
(20 MHz in sub-7, 100 MHz in mmWave)
Fewer receive antennas (1 or 2 Rx)
Half duplex

Lower transmit power
Enhanced power saving modes
Limited mobility and handovers

Repetition and bundling
Lower order modulation
(256-QAM optional)

Optimized resource management
5G NR service coexistence
Deployment flexibility
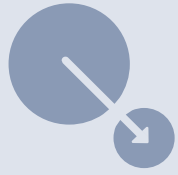
# Scaling 5G NR device complexity to address mid-tier IoT requirements

### Maximum Bandwidth

Supporting up to 20 MHz in sub-7 GHz and 100 MHz in mmWave on a single carrier, with no carrier aggregation and dual connectivity

### Minimum RX Chain

Reducing the number of Rx branches to 1 for sub-7 GHz frequencies, with an option to support 2 Rx

### Maximum DL MIMO Layers

Supporting rank-1 (single layer) for devices with single Rx chain, and rank-2 for devices with 2 Rx

### Maximum Modulation

Relaxing requirements to support up to 64-QAM for downlink and uplink, with 256-QAM optional

### Duplex Mode

Adding Type-A half duplex support in FDD bands to enable simplified RF design

### Upper Layer Capability

Lowering device memory requirements with e.g., reduced DRB[1], SN[2], field length, and others

# Enhancing power efficiency for 5G NR-Light devices

Key enhancements to address battery-powered IoT devices

## Release 17 power-saving features for 5G NR-Light

### Enhanced low-power mode

Extending maximum enhanced discontinued reception (eDRX) for idle mode to 10485.76s (10.24s for inactive mode, 2.56s minimum for both), supporting longer time window, and lower device transmit power

### Limited mobility and handovers

Relaxing radio resource management (RRM) measurements for stationary devices (e.g., fixed industrial sensors), with more flexible configuration by the network

### Other power saving features

Including various 5G NR enhancements up to Rel-17, such as bandwidth part (BWP) adaptation, cross-slot scheduling, wakeup signal (WUS), paging early indication (PEI), and others

# Improving 5G network efficiency and deployment flexibility

## Optimized resource management

5G NR-Light devices are supported with early indication, identified when establishing connection, to potentially apply charging differentiation, support specialized policies (e.g., for IoT) and access restrictions (e.g., for IoT services).
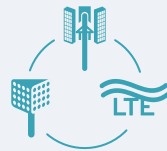
## 5G NR service coexistence

5G system can support 5G NR-Light devices in the same frequency band as other services (e.g., smartphones), even when they are utilizing wider bandwidths than the maximum bandwidth allowed by NR-Light (i.e., 20 MHz sub-7 GHz, 100 MHz mmWave).

## Deployment flexibility

5G NR-Light can be deployed in all 5G frequency bands, including unlicensed bands (e.g., 5 and 6 GHz), as well as support features related to 5G services such as positioning and 5G NR V2X.

# Optimizing network coverage for 5G NR-Light

Compensating for loss of coverage due to reduced device complexity (i.e., 1x Rx)

## For downlink coverage

Transport block size (TBS) scaling

Lower modulation and coding scheme (MCS)

Higher control channel element (CCE) aggregation level

## For uplink coverage

Enhancement for uplink data channel repetition (up to 32)

Transport block processing over multi-slot uplink data channel

Inter-slot frequency hopping and repetition

Dynamic indication of uplink control channel repetition

Enhancement of channel estimation with demodulation reference channel (DMRS) bundling
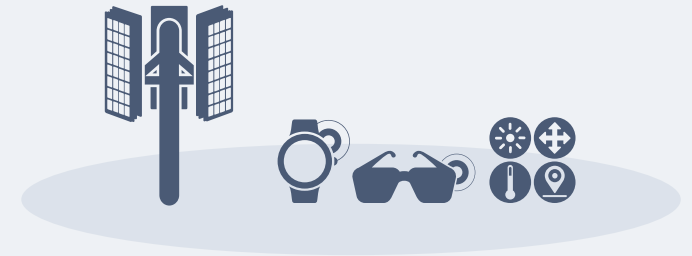
# Evolving 5G NR-Light to support new device capabilities

## 5G NR-Light Evolution in Rel-18 and beyond

Building on Rel-17 design foundation

### Positioning

Rel-18 will set performance requirements, evaluating performance for Rel-17 positioning procedures, and identifying potential enhancements

Rel-18+ can further enhance M-RTT[1], DL-AoD[2], UL-AoA[3], DL-TDoA[4] positioning, and broadcast of assistance data

### Sidelink

Rel-18 can support unlicensed spectrum operations for sidelink, including for 5G NR-Light devices

Rel-18+ can support coverage extension for 5G NR-Light devices based on direct PC5 connection, extending to multi-hop communications

[1] Multiple Roundtrip Time; [2] Downlink Angle of Departure;
[3] Uplink Angle of Arrival; [4] Downlink Time Difference of Arrival

Qualcomm innovations drive key 5G technologies, including NR-Light and its evolution in 5G Advanced

Enhancing mobile broadband

Enabling new verticals

Boundless extended reality

IoT expansion

Smartphones and laptops

Automotive

Fixed Wireless and enterprise

Industrial IoT

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

Device enhancements
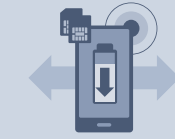
Reduced capability devices (NR-Light)

Non-terrestrial networks (NTN)

High-precision positioning

Sidelink

Mission-critical design

Advanced power saving and mobility
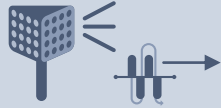
mmWave expansion

Unlicensed spectrum

Scalable numerology

Advanced channel coding
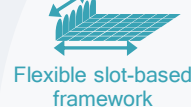
Massive MIMO

Flexible slot-based framework

4G foundations

Mobile mmWave

New deployment models

Topology expansion

# Our innovations expand the foundation of 5G

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

# 5G NR-Light

**Initial access and mobility management**

**Optimized resource allocation**

**Seamless device coexistence**

**Extended battery life**

**Complexity and cost reduction**

- Early identification of NR-Light devices for service provisioning and network compatibility
- Simplified initial access and mobility management procedures
- NR-Light device profile with optimized network resource allocation for coverage, capacity and power consumption
- Delivering quality of service across different device categories coexisting in a 5G network
- IoT-specific power optimization techniques for extended battery life
- Matching device capabilities to service requirements to reduce complexity and cost

# Qualcomm led the design of key elements of 5G NR-Light
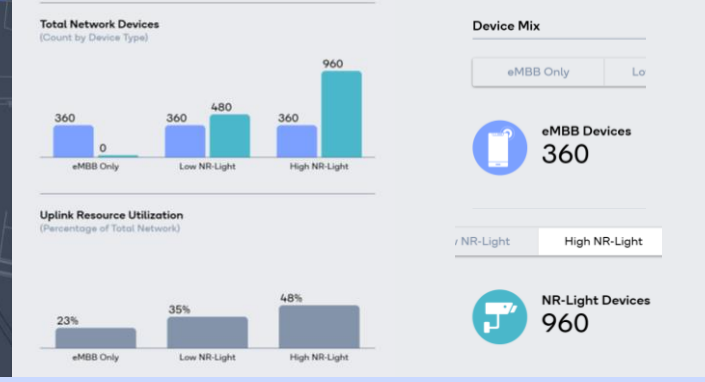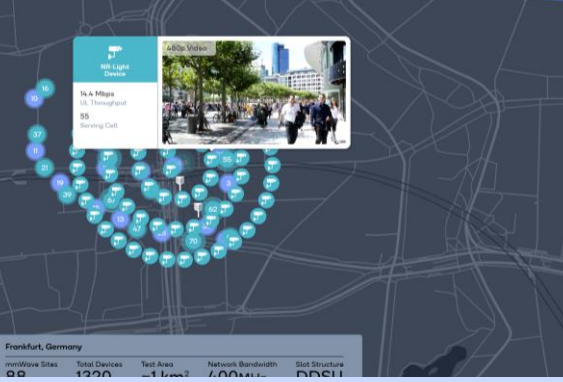
**Sub-7 GHz Capacity**
Release 17 | System simulation

Demonstrating system capacity and performance impact with NR-Light devices (i.e., 20 MHz bandwidth) coexisting with eMBB devices (e.g., smartphones)

**mmWave Capacity**
Release 17 | System simulation

Showcasing overall capacity tradeoffs between NR-Light (e.g., surveillance cameras) and traditional eMBB, in Frankfurt, Germany

**Narrowband Positioning**
Release 18+ | System simulation

Supporting scalable, low-power positioning with future NR-Light devices (i.e., with 5 MHz bandwidth), based on DL angle-of-departure (AoD) technique

**Multi-hop Relay Coverage Expansion**
Release 18+ | Over-the-air testing

Utilizing sidelink communication to extend coverage for NR-Light IoT, enabling cost-efficient connectivity for multiple devices through a single wide-area connection

**Qualcomm**

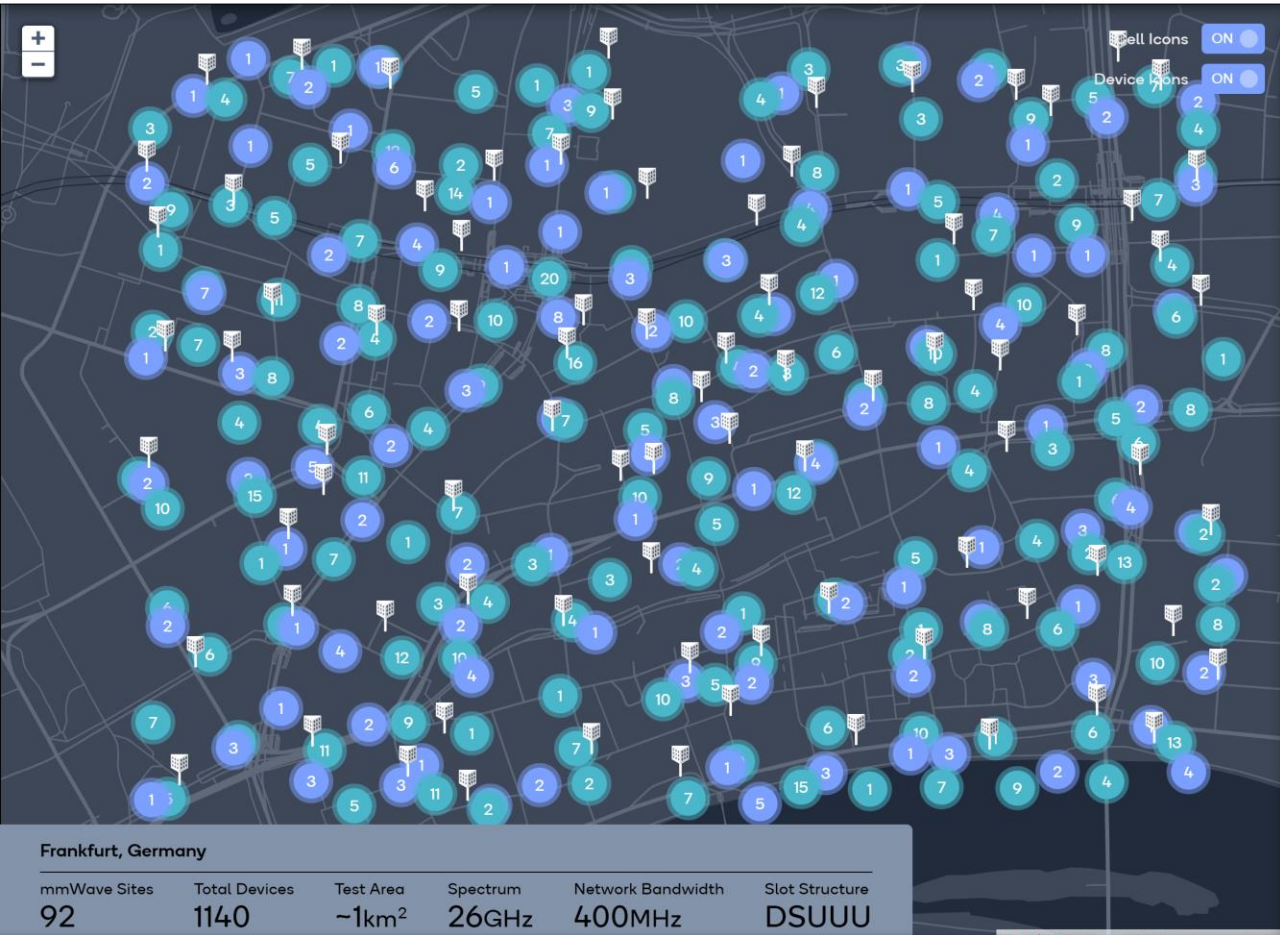# Showcasing 5G NR-Light's new capabilities, improved efficiency, and technology evolution

Qualcomm

**Advanced wide-area technologies**
⌄ | 5G NR-Light (RedCap) capacity

Device mix per cell
○ 4 eMBB
● 4 eMBB + 40 NR-Light

| Network information | | NR-Light device information | |
|---|---|---|---|
| Spectrum | 2.6 GHz | Antenna elements | 1 |
| Bandwidth | 100 MHz | Bandwidth | 20 MHz |
| Layout | 21-cell urban macro | Traffic bit rate | 100 kbps |

eMBB devices
- Smartphones
- Laptops
- Fixed wireless access

Rel 17 NR-Light (RedCap)
- High-end wearables
- High-end industrial sensors

▶ NR-Light overview

gNodeB

gNodeB

**eMBB user perceived throughput**
Mbps
■ 4 eMBB
■ 4 eMBB + 40 NR-Light

| | 5%-ile UPT | 50%-ile UPT | 95%-ile UPT |
|---|---|---|---|
| 4 eMBB | 168 | 533 | 1,170 |
| 4 eMBB + 40 NR-Light | 136 | 403 | 1,037 |

**gNB resource utilization**
Percent
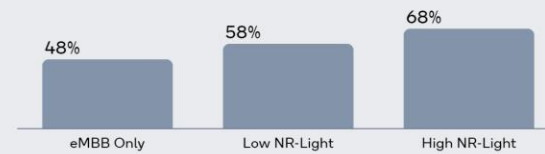
| 4 eMBB | 4 eMBB + 40 NR-Light |
|---|---|
| 21.0% | 30.6% |

5G NR-Light devices utilize narrower bandwidth and can be more efficient for certain use cases (e.g., wearables, sensors, etc.), allowing the network to support a large number of devices with small impact to overall network performance

## Sub-7 GHz Capacity

Release 17
System simulation

# 5G NR-Light can seamlessly coexist with wide-area eMBB devices with minimal impact to system performance and capacity
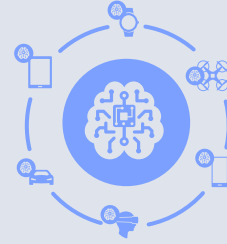
mmWave
Capacity

Release 17
System simulation

5G NR-Light can seamlessly coexist with wide-area eMBB
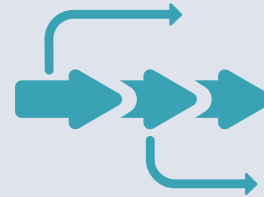devices with minimal impact to system performance and capacity

# Proliferating 5G to new device tiers with NR-Light

**3GPP Release 17 and beyond**

5G NR-Light accelerates the growth of the Connected Intelligent Edge with new use cases

5G NR-Light bridges the 5G IoT complexity gap and it is an integral part of the 5G roadmap

Qualcoww

We are the innovator behind key 5G technologies, including NR-Light and its evolution in 5G Advanced

# Thank you

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