GSMA

# Advancing the 5G Era

## Benefits and Opportunity of 5G-Advanced

SEPTEMBER 2022

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# 1. Executive Summary

1.0

# Executive Summary

**The second phase of the 3GPP 5G standardisation process, 5G-Advanced brings a new wave of wireless innovations that will push technology boundaries in three broad directions (see graphic):**

This document focuses primarily on 3GPP Rel-18 - the inaugural release of 5G-Advanced. Initial work on Rel-18 in 3GPP started in 2022 (just before the finalisation of Rel-17), targeting commercialisation from 2024 onwards. As it evolves, 5G-Advanced will play an important role bridging from 5G to 6G with new features previously not standardised in 3GPP.

5G ADVANCED
RELEASE 18

## PERFORMANCE IMPROVEMENTS

- Advanced DL/UL MIMO
- Enhanced multi-carrier operation & Enhanced mobility
- Enhanced sidelink, sidelink relay enhancement and UE aggregation
- Mobile integrated access/backhaul (IAB), network-controlled repeaters
- Evolved duplexing
- Time Sensitive Communication

## BETTER MANAGEMENT AND GREATER EFFICIENCY

- AI/ML data-driven designs
- Operation & Maintenance Architecture and Management Functions
- Autonomous Networks

## ENHANCEMENT FOR SPECIFIC USE CASES

- Edge computing
- Expanded positioning
- Extended Reality (XR)
- RedCap Evolution
- Drones & enhanced satellite connectivity
- Multicast
- NR<5MHz & Additional spectrum bands
- Personal IoT Network
- Vehicle mounted relay
- Non public networks
- Enhanced support for IoT, industrial IoT and URLLC
- Mission-critical services

5G-Advanced will provide all kinds of smart connectivity, including services that focus on uplink communication and connect people moving at high velocities, such as those on trains and on planes. 5G-Advanced will also efficiently support highly immersive and interactive applications, which will be widely deployed in the entertainment, training and education sectors.

At the same time, 5G-Advanced will further strengthen support for low cost, low power-devices, such as industrial wireless sensors, smart watches and smart eyewear, together with bandwidths below 5 MHz. It will also support time-sensitive networks, timing-as-a-service, precise network-based positioning and enhance positioning based on the Global Navigation Satellite System.

In addition, 5G-Advanced will support uncrewed aerial vehicles, as well as non-terrestrial networks (such as those provided by satellites) with full seamless interworking with terrestrial networks. 5G-Advanced will also harness artificial intelligence and machine learning to enable efficient network configuration, operation and optimisation in a sustainable way.

Over time, 5G-Advanced could evolve to support integrated sensing and communication, ambient IoT, tactile and multi-modality communication services, mobile Metaverse services and networks of service robots with ambient intelligence.

In summary, 5G-Advanced will serve a wide variety of industries with different ecosystems, different needs and different regulatory environments. The GSMA is encouraging and facilitating cross-industry collaboration to fully explore the use cases for the capabilities of 5G-Advanced.

# 2. Introduction

2.0

# Introduction

## Generational changes in mobile tech and why the evolution[1] to 5G-Advanced is important

**Mobile technology has shaped our industries and lives for the past 40 years. In 2021, mobile technologies and services generated 5% of global GDP, equivalent to US$4.5 trillion of economic value added[2]. The mobile ecosystem also supported approximately 26 million jobs (directly and indirectly) and made a substantial contribution to the funding of the public sector, with almost US$500 billion raised through taxes on the sector.**

By 2025, mobile telecoms' economic contribution is set to grow by more than US$400 billion (to approach US$5 trillion per annum[3]) as countries around the world increasingly benefit from the improvements in productivity and efficiency brought about by the increased take-up of mobile services.

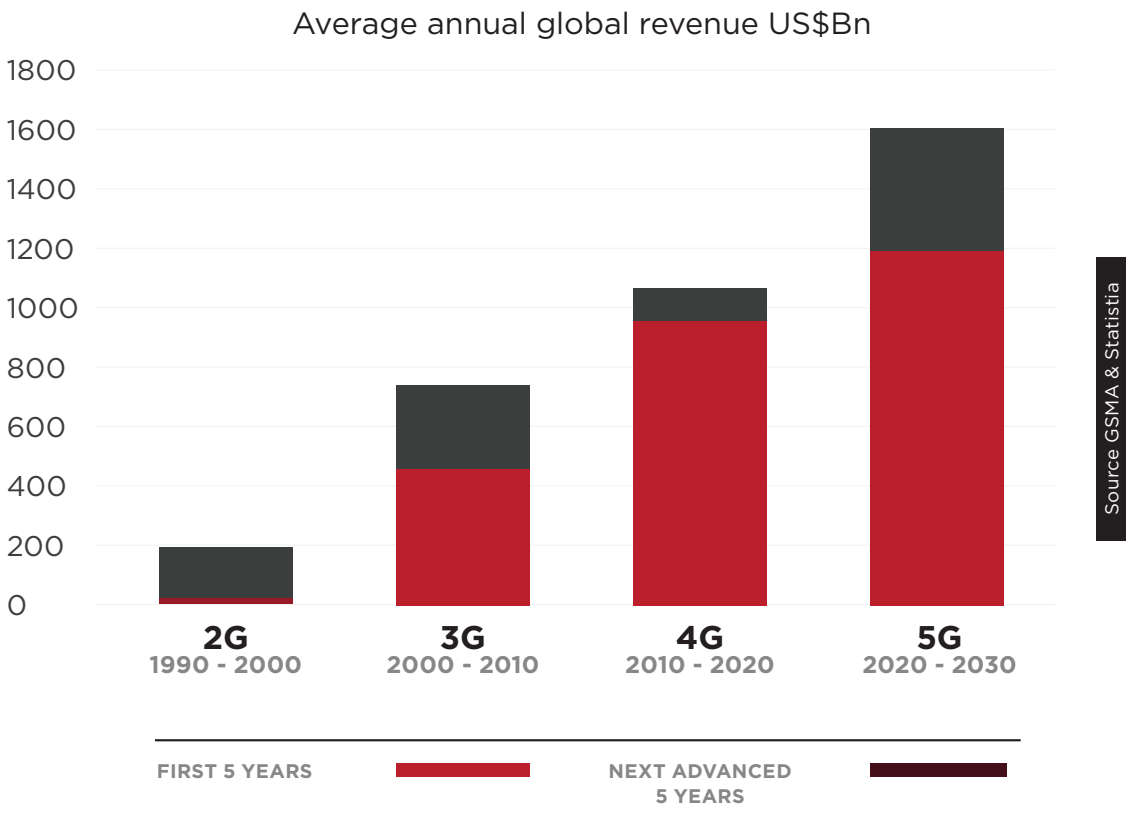
The mobile telecommunications technology revolution started with 1G in the 1980s and continued with 2G in the 1990s, 3G in the 2000s, 4G in the 2010s and now 5G in the 2020s. The table below shows the core proposition for each generation and how the technology evolved during its lifetime.


[1] The term Advanced is generally used to indicate the second half of each generation evolution, i.e 2.5G, 3.5G and 4.5G
[2] https://www.gsma.com/mobileeconomy/wp-content/uploads/2022/02/280222-The-Mobile-Economy-2022.pdf
[3] https://www.gsma.com/mobileeconomy/wp-content/uploads/2022/02/280222-The-Mobile-Economy-2022.pdf

| | CORE PROPOSITION | HOW THE TECHNOLOGY EVOLVED |
|---|---|---|
| **1G** | Enabled voice communications for the mass market on sub 1GHz spectrum, but based primarily on regional solutions with very limited interoperability. | Limited national and international roaming across networks. Some advanced 1G systems had short message capability. |
| **2G** | Supported voice and text-based SMS communication and circuit switched data on sub 2GHz spectrum. Connected one billion phones with the first global standard for mobile communication. | New digital techniques were employed to gain spectral efficiency. GPRS (2.5G) and (EDGE 2.75G) provided a more advanced and faster packet data connectivity than the cellular digital packet data (CDPD) techniques used in earlier generations. |
| **3G** | Supported voice, text and data communications on sub 3GHz spectrum. Connected three billion handsets. | CDMA2000 3X and HSPDA (3.5G) improved the data connectivity downlink to 1Mbps and HSUPA/HSPA (3.75G) improved uplink to 0.5Mbps, facilitating demand for USB data dongles and the first smartphones. |
| **4G** | Packet data (IP) optimised mobile architecture network based on Sub 3GHz spectrum, with data rate of 150Mbps DL and 50 Mbps UL. | LTE-Advanced and LTE-Advanced Pro introduced significant increases in capacity and speed with carrier aggregation, 4x4 MIMO, 256 QAM, with data rates up to 1Gbps, expanding into other industries through support for IoT, C-V2X, LTE-M, UAVs, NB-IoT, providing billions of new connection opportunities. |
| **5G** | New Radio, disaggregated NG-RAN, and Service Based Core Network Architecture. Increase on frequency bands to support frequency range 1 and frequency range 2. With data rate support more than 1Gbps | 5G-Advanced is designed to bring enhancements on mobility, global connectivity with non-terrestrial networks, uplink and multicast at lower latency, sub decimetre positioning accuracy, enhancements for extended reality and time sensitive communication. There will be further support for IoT verticals with RedCap and sidelink enhancements. 5G-Advanced will also deliver increased sustainability through the use of AI/ML data-driven designs to improve user experience and enhance network operations. |

Each of these generations saw continued advancements during the decade in which they were deployed, improving the generational technology to meet new demands and needs.

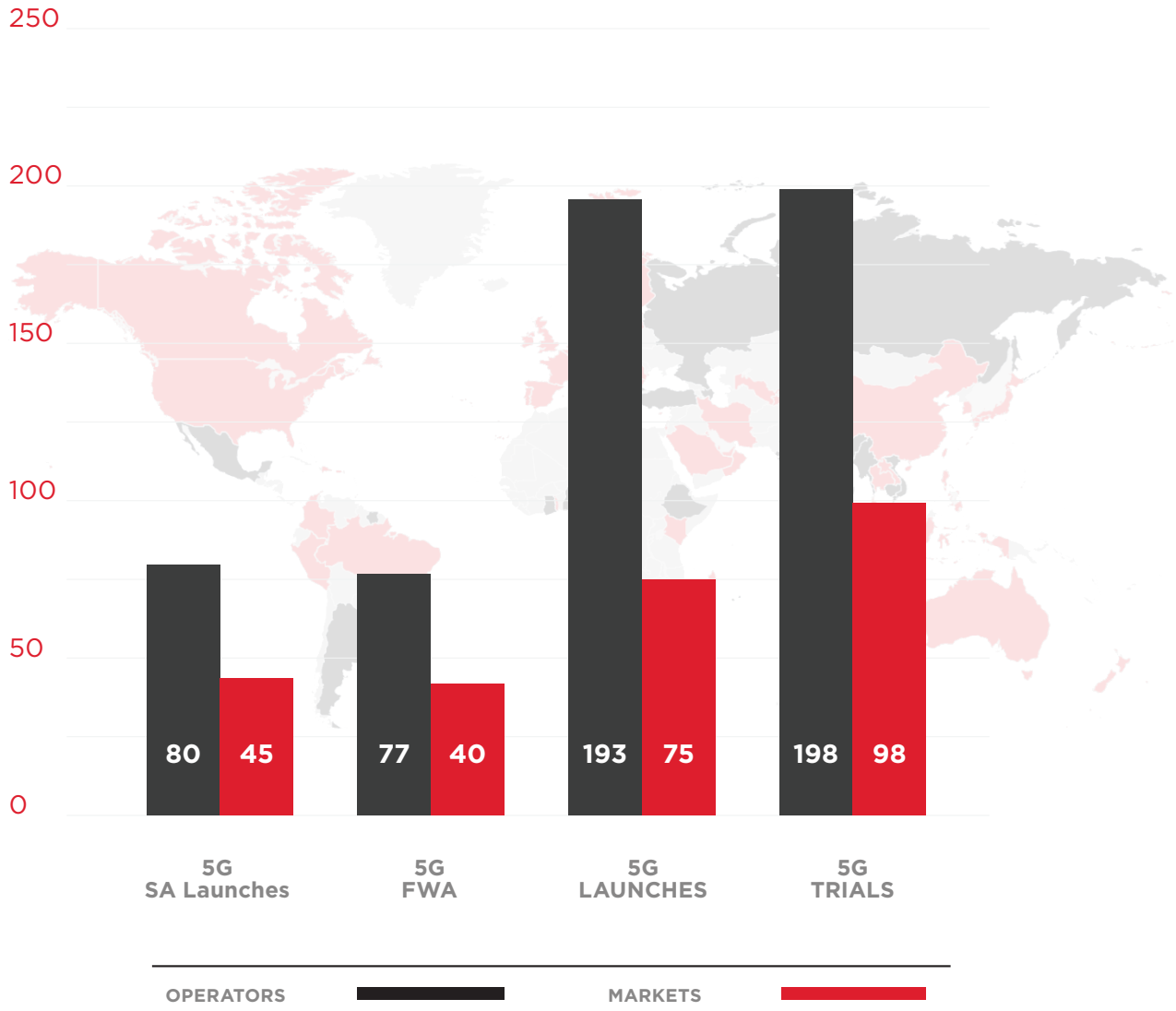
**FIGURE 1:** Average annual revenue globally for all operators




LTE-Advanced, for example, improved peak and average data rates enabling content and internet service providers to create further value in the industry, and penetrate new markets that now rely on 3GPP-defined communication technology. Furthermore, 5G-Advanced has the opportunity to reach additional vertical sectors, provide users with an enhanced human-centred technology experience (e.g. with extended reality or XR), and enable improved global mobility. It could also serve the unconnected by harnessing new technology approaches, such as network repeaters, IAB (integrated access/backhaul), high altitude platform systems (HAPS) and satellite connectivity. The use of AI/ML-based systems to optimise the network configuration and operation will also help 5G-Advanced to minimise energy consumption and pave the way to a sustainable future.

Within two years of standardization, 5G has been launched in 50% of countries worldwide, covering 26.2% of the global population. This is the fastest deployed technology to date: 5G is on course to serve two billion connections by 2025, which would make it the fastest adopted 3GPP technology generation.

**FIGURE 2:** 5G global launches and trials



# 2.1 3GPP 5G-Advanced timeline

**Marking the second phase of the 3GPP 5G standardisation process, 5G-Advanced brings a new wave of wireless technology innovations. It is designed to push technology boundaries in two broad directions:**

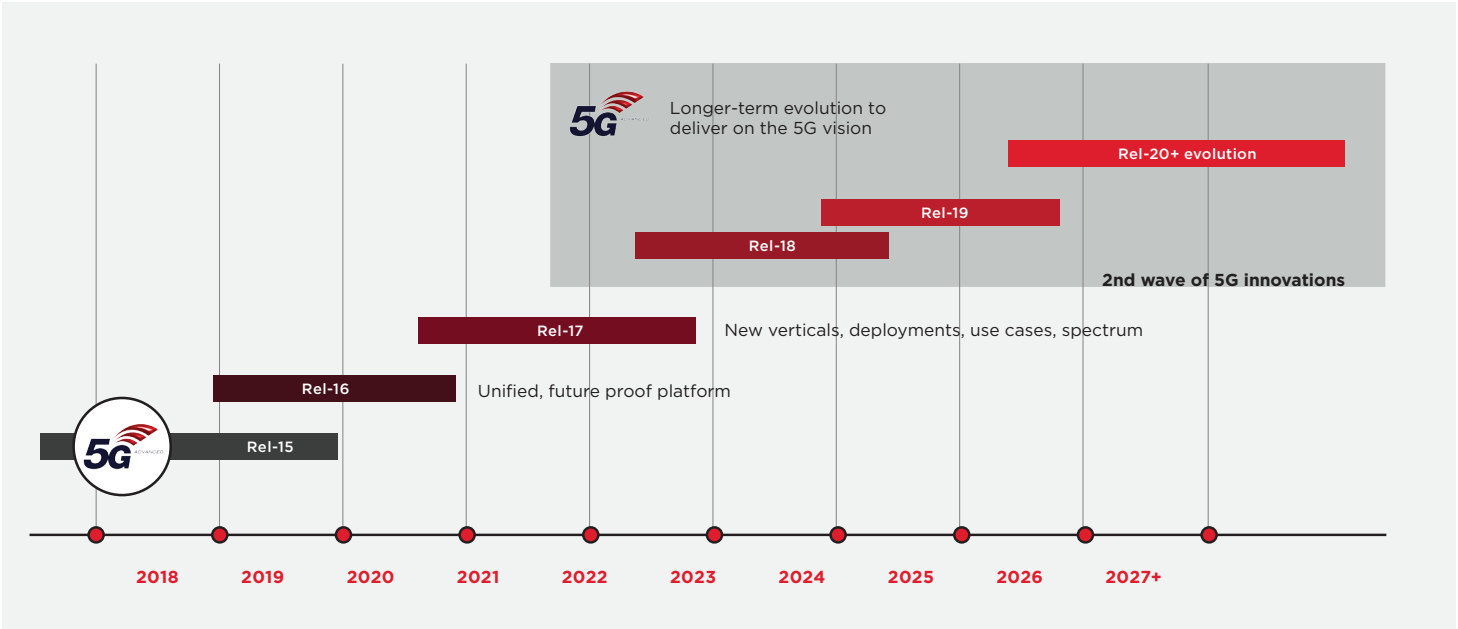
1. To strengthen the 5G system foundation by further improving speed, global coverage, mobility, power efficiency and more,
2. Support new use cases, as well as to proliferate 5G to virtually all devices and deployments involving connectivity.

3GPP Rel-18 is the inaugural standard release of 5G-Advanced, which will continue to evolve beyond Rel-18. It is designed to give application developers entirely new capabilities to deliver services to large segments of the population regardless of their location.

**This document is primarily focused on Release 18 features. Additional opportunities beyond Rel-18 are also briefly summarised.**

Initial work on Rel-18 in 3GPP started in 2022 (right before the finalisation of Rel-17), targeting commercialisation from 2024 onwards (see chart).

**FIGURE 3:** 5G global launches and trials



# 3. 5G-Advanced Industry Value

3.0

# 5G-Advanced Industry Value

## 3.1 Building on 5G use cases

**5G is designed to connect and transform society. From the start in Rel-15, 5G has addressed three main usage scenarios: enhanced mobile broadband (eMBB), massive machine-type communication (mMTC) and ultra-reliable and low latency communications (URLLC) in line with the ITU IMT-2020 requirements.**

5G can deliver eMBB, thanks to its support for high bandwidth in new 5G spectrum, and low latency, due to its new radio and core network architectures. Rel-16 and Rel-17 bring support for new features and additional frequency bands that further expand 5G's eMBB capabilities. Together, these capabilities take the eMBB support for entertainment, education, and media production services to new levels.

5G provides support for mMTC use cases that require massive numbers of low power and low cost devices that can operate under the most challenging coverage conditions. It can be used to provide latency-tolerant services for smart meters, sensors and actuators, characterised by small and infrequent data transfers. These are typical 5G mMTC usage scenarios that employ 3GPP LTE-M and NB-IoT solutions, for which co-channel compatibility with NR is ensured.

URLLC is designed to provide high reliability and low latency connections for services in various vertical industries, such as autonomous driving, logistics, and healthcare. Rel-16 and Rel-17 extend the application of URLLC into industrial environments to support Industrial Internet of Things (IIoT), and automation in manufacturing, process industries, mining, and smart electric grid applications.

Beyond the three main use case families, 5G brings support for additional services, such as intelligent transportation systems (ITS) using NR-V2X for advanced use cases, public safety, and the Future Railway Mobile Communication System (FRMCS).

# 3.2 New opportunity use cases

**In future, people's lives and industrial production will go digital in the most fundamental way, generating massive amounts of data that will be distributed over 5G-Advanced networks. 5G-Advanced will evolve to provide all sorts of smart connectivity, including services that mainly entail uplink communication, smart transportation, smart city applications, and entertainment services.**

The support for mobility is a cornerstone of cellular communications. In 5G, the work to facilitate efficient mobility with seamless service continuity has accelerated, and will accelerate further in 5G-Advanced. 5G-Advanced will also address high speed connectivity use cases and ensure the user experience isn't affected by the user's velocity. Mobile use cases in the automotive and public transport domains, such as connectivity on high-speed trains and inflight connectivity provided by air-to-ground networks, will benefit from these advances.

There is strong interest in highly interactive applications, such as virtual reality (VR), augmented reality (AR) and extended reality (XR). Thanks to its support for high data rates, low latencies, and seamless mobility, 5G-Advanced will efficiently provide support for these and other immersive experience services.

Rel-17 already caters for energy- and cost-efficient 5G NR IoT connectivity through the introduction of the reduced capability (RedCap) user equipment category. RedCap will evolve in 5G-Advanced to further strengthen support for cost-efficient devices and/or power-sensitive applications, such as industrial wireless sensor networks (IWSN), and smart watches, smart eyewear and other wearables. 5G-Advanced will also provide further support for utilities and public safety use cases by addressing operation in dedicated frequency bands and support channel bandwidths below 5 MHz. Other applications will address the specific needs of vertical sectors with regard to time-sensitive networks (TSN), timing-as-a-service, precise network-based positioning and improved integrity of positioning based on the Global Navigation Satellite System (GNSS).

In addition, 5G-Advanced will provide communications support for uncrewed aerial vehicles (UAVs), as well as satellites or HAPS operating as non-terrestrial networks (NTN) with full seamless interworking with terrestrial networks. UAVs will offer new types of smart transportation solutions, while satellite and HAPS connectivity are a good complement to terrestrial connectivity for maritime industry, IoT use cases and other applications, and for filling coverage gaps.

**FIGURE 4:** 5G-Advanced capabilities and the use case families they support


5G-Advanced will also harness artificial intelligence and machine learning (AI/ML) to enable efficient network configuration, operation and optimisation in a sustainable way, thereby improving the user experience, while minimising the energy consumption of networks. AI/ML will be instrumental in the evolution of the network and as an enabler of autonomous networks for an always-connected and sustainable future.

In summary, 5G-Advanced will both enhance existing commercial 5G networks and open up new markets by enabling new B2B business models.

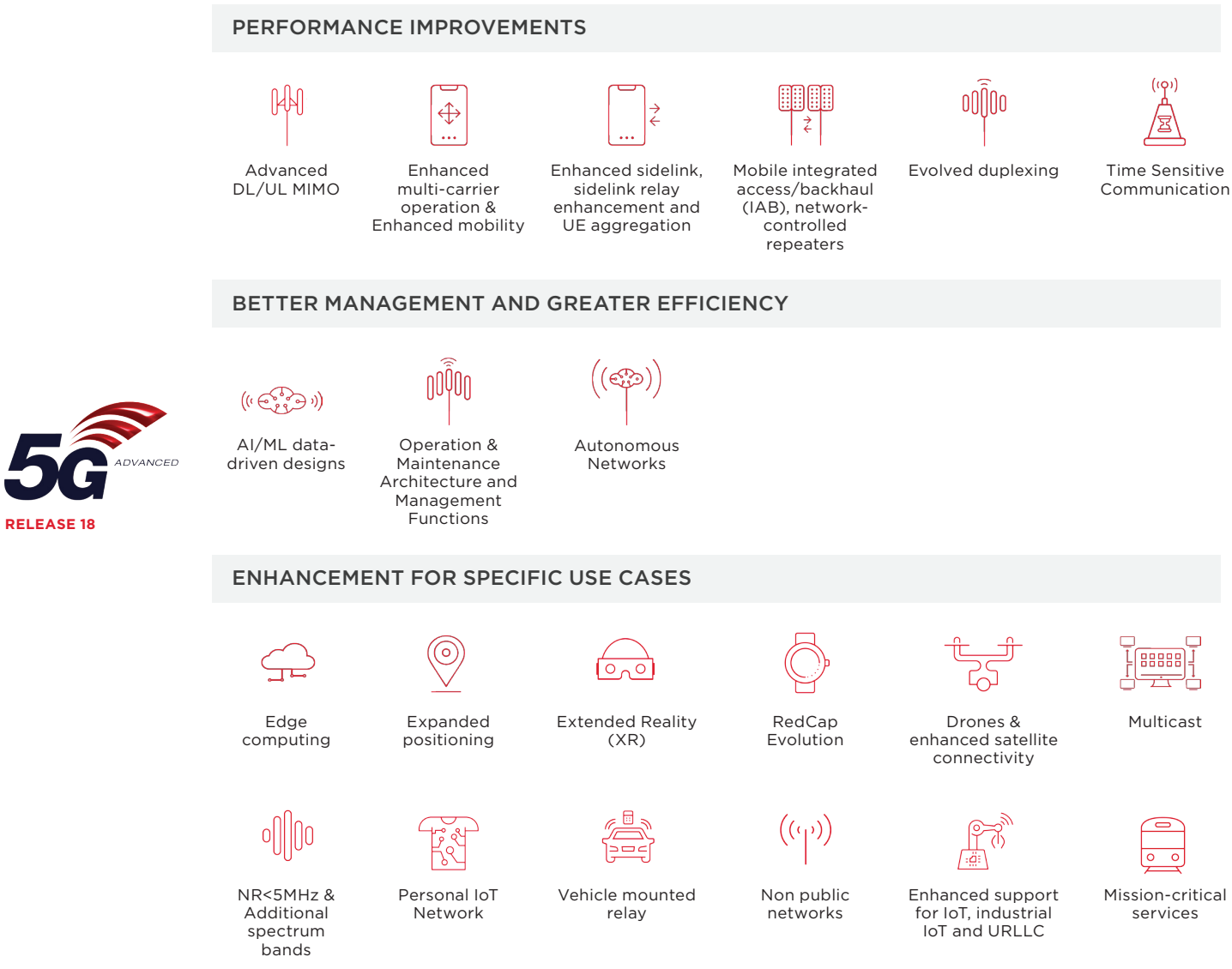
# 4. 5G-Advanced Technical Progress

4.0

# 5G-Advanced Technical Progress

**5G-Advanced will play an important role bridging from 5G to 6G with new features previously not standardised in 3GPP. Figure 5 shows some of the features being developed in Rel-18.**

**FIGURE 5:** Release 18 of 3GPP will support a raft of new capabilities as part of 5G-Advanced



**BELOW IS A SUMMARY OF THE NEW CAPABILITIES SHOWN IN FIGURE 5.**

## 4.1 Performance improvements

**MIMO evolution for downlink and uplink:**

Enhanced 5G massive MIMO performance and efficiency by delivering improved throughput, coverage, power consumption, reliability, and support for more device antennas for a wide range of use cases. Multi-panel antenna allow for optimised link performance and beam flexibility.

**Enhanced multi-carrier operation:**

Enhanced scheduling through single downlink control information (DCI) for multi-carrier operation to minimize control channel overhead. There is also the potential to further enhance other channels and signals for efficient multi-carrier operation. Moreover, uplink transmitter switching enables user equipment with a restriction on simultaneous uplink transmission to support more spectrum bands.

**Enhanced mobility:**

Improved service perception for mobile devices operating in sub-7 GHz and mmWave bands by supporting lower handover latency and improved robustness through lower layer mechanisms (i.e., layer 1 and 2 based inter-cell mobility), and more seamless carrier aggregation and dual connectivity operations.

**Mobile integrated access/ backhaul (IAB) and network-controlled repeaters:**

Expanded capability for IAB on cars/trains to extend 5G coverage in sub-7 GHz and mmWave deployments for users inside and outside the vehicles. Introduction of network-controlled repeaters with traffic awareness and beamforming capability via side control information in TDD spectrum for cost-effective coverage improvements at high frequency bands.

**Evolution of duplex operation:**

Introduction of non-overlapping sub-band full duplex that can improve network efficiency, latency, and coverage in TDD deployments. This is especially critical for low latency application in unpaired spectrum in the industrial environment, while also minimising interference.

**Enhanced sidelink:**

building upon the C-V2X and Rel-17 foundation to expand into new spectrum types and bands (i.e., unlicensed bands and mmWave).

**Sidelink relay enhancements and UE Aggregation:**

Enhanced service continuity and multi-path support of sidelink relay for V2X, public safety, and commercial use cases, mainly consisting of link-reliability.

**Time-sensitive communication (TSC) enhancement:**

Extended TSC framework to support deterministic networks with time-sensitive features that guarantee almost zero packet loss rates and bounded latency. TSC enhancement will support industrial automation use cases, industrial machine-to-machine communication and smart grids, and also allow the provision of new time-critical synchronised services.

# 4.2 **Better management and greater efficiency**

**AI/ML data-driven designs and services:**

Expanded AI/ML framework to optimise network energy saving, load balancing and mobility with enhanced data collection and signalling support. AI/ML techniques could improve support of air interface functions, such as channel state information (CSI) feedback, beam management, and positioning, all based on a standardised framework for ML model provisioning and training. In the system architecture area, AI/ML services and transmissions will be enabled to support model distribution, transfer and training for various applications, such as enhanced support for monitoring of network resource utilisation and exposure to user equipment/authorised third parties. This approach will also enhance application AI/ML traffic transport, quality of service (QoS) and policy enhancements and federated learning operations.

**Autonomous networks:**

Enabling a telecommunications system (including both the management system and the network) that can run itself with minimal to no human intervention via step by step approach. Enablers for autonomous networks include self-organising network technology, management data analytics, intent-driven management and closed loop service level specification (SLS) assurance. AI/ML capabilities will be employed as enablers and applicable for multiple autonomous network levels. 5G-Advanced will also introduce enhancements on analytics for 5G network functions (NFs) to support their decision making. In Rel-18, there are new work/study items enhancement of autonomous network levels and evaluation, for AI/ML management, enhanced intent-driven management services, and self-configuration of RAN network elements, which will introduce more intelligence and automation in networks towards higher autonomous network level.

**Operation and maintenance architecture:**

Service based management architecture (SBMA) including network slicing was introduced in Rel-15 giving enhanced flexibility to the operations and maintenance functionality. In Rel-18, there are new work/study items for enhancement of SBMA and network slicing, such as enhancements to network slicing provisioning rules, management aspects of network slice management capability exposure and intent-driven management for network slicing.

**Management functions:**

3GPP SA5 specifies the management part of RAN features to support their configuration and to follow up on their performance. In Rel-18, there are new work/study items for enhancement of QoE measurement collection, and further enhancements of management of trace/minimisation of drive test (MDT).

# 4.3 Enhancements for specific use cases

**Edge computing:**

Edge computing has been supported by 5G since Rel-15 and additional support was added in Rel-17 including discovery and re-discovery of edge application services, and edge relocation. 5G-Advanced may also support emerging industry requirements including support for collection of UEs, access to edge hosting environment in a visited public land mobile network (VPLMN) and other improvements.

**Extended Reality (XR):**

A Rel-17 study characterised XR traffic models and evaluated how 5G NR supports XR applications. The next step is to define the KPIs and QoS requirements, as well as support application awareness and power and capacity enhancements tailored specifically for improved support of XR experiences over 5G, including for the Metaverse. Furthermore, there may also be enhancements for active queue management and QoS mechanisms to take into account the characteristics of XR, as well as adaptation of the application to the network status to provide a better quality of experience.

**Further RedCap evolution to support user equipment complexity reduction:**

Expanded NR platform for reduced capability devices to further scale the data rate and enhance low-power modes, while maintaining coexistence with Rel-17 RedCap and other 5G NR devices. The reduction in device complexity should result in lower priced devices across the industry.

**NR support for dedicated spectrum less than 5 MHz for FR1:**

Aims at identifying and specifying changes to NR to operate in spectrum allocations from 3 MHz to less than 5 MHz. Those can be used for utilities operating in narrow spectrum allocations and concurrent operation of FRMCS and GSM-R and effectively lead to migration from GSM-R systems towards FRMCS in the rail and utilities sectors.

**Enhanced positioning:**

Enhanced performance (e.g., accuracy, integrity, efficiency at cm level) for positioning/ranging, including assessing techniques, such as bandwidth aggregation and carrier phase measurements, as well as defining performance requirements for sidelink and RedCap positioning. Further enhancements will better support fine-granular control of positioning, restrictions, latency, power saving and analytics.

**Support for drones (UAVs) and enhanced satellite connectivity:**

Introduction of defined drone communications with 5G NR, leveraging the LTE Rel-14 drone study/work items, defining measurement reporting and signalling design; extending 5G NR satellite support into new bands in FR2, improving coverage and mobility targeting voice support over satellite for regular smartphone form factors, including initial device mobility. Enhancements to the satellite backhauling connection for 5G systems are also being considered.

### Multicast enhancements:

Enhanced 5G mixed-mode multicast, such as supporting multicast reception in inactive/idle mode and better system efficiency for multicast reception in RAN sharing scenarios.

### Non-public networks (NPNs):

Support for NPNs was introduced in 5G with basic functions and then enhanced to enable wider cooperation between different networks/different entities to provide access for user equipment with no native credentials. In 5G-Advanced, enhancements will be investigated to support equivalent standalone NPNs, mobility between NPNs and non-3GPP access for standalone NPN services as well as localised services - networks offering specific services in a specific area and/or time.

### Enhanced support for IoT, industrial IoT and URLLC:

In use cases requiring small and infrequent data packet transmissions, the battery lifetime for user equipment can be extended by removing the need to execute the whole session setup procedure. The small data transmission feature will enable the sending of data packets and signalling messages, extending battery lifetime.

### Personal IoT network:

Work to explore how types of IoT devices placed around the body, scattered in the home or in an office/factory environment can leverage 5G services despite their physical constraints or limited capabilities.

### Vehicle mounted relays:

Potential architecture and system level enhancements for 5G systems to support the operation of base station relays, possibly mounted on vehicles, using NR for wireless access toward the user equipment and for wireless self-backhauling toward the 5G core.

### Mission-critical services:

In Rel-18, 3GPP will enable multicast and broadcast communications over 5G for mission-critical services. There are plans to satisfy the remaining interconnection and migration needs for railways, through enhancements to mission-critical push-to-talk, video and data in the common functional architecture.

## 4.4 Other enhancements to end-to-end network architecture, configuration and operation

**Several other Rel-18 projects (beyond the ones discussed above) aim to provide additional improvements to the 5G system, including:**

- Enhancements to dynamic spectrum sharing (DSS),
- Multi-(U)SIM,
- In-device coexistence,
- Quality of experience,
- Carrier aggregation,
- Self-organising network/minimisation of drive test (SON/MDT),
- Policies for user equipment route selection in VPLMN,
- Minimisation of the service interruption,
- Usage of the 5G system to act as a backup time synchronisation service for other applications,
- Evolution of the IMS multimedia telephony service for the next generation real time communication services
- In the area of fixed-mobile convergence (FMC), access traffic steering, switch and splitting will be enhanced, for example, by different traffic load-balancing modes and additional transport protocols, and the extension of proximity services.
- Group management, exposure and communication enhancements

## 4.5 Additional spectrum bands under consideration

**5G-Advanced will work across all spectrum bands. Regulators are considering making additional spectrum bands available for 5G within the 5G-Advanced timeframe. For example:**

- APT 600 (which complements n71/US600) supports 617-698 MHz: Improving the coverage of 5G deployments with a spectrum band that complements APT 700 band with excellent wide area coverage suitable for urban, rural, and suburban areas with high in-building penetration.
- CEPT is harmonising technical conditions for active antenna system (AAS) deployment in band n40 (2.3 GHz).
- CEPT is harmonising technical conditions for band n259 (40.5-43.5GHz) in Europe.
- NR band n104 has now been specified as licensed band covering 6425-7125 MHz by 3GPP, followed by 5925-7125 MHz also for licensed operation.

## 4.6 Security and privacy

**The security and privacy features of 5G-Advanced build on the high security and privacy requirements of 5G. Moreover, the security and privacy features of 5G will be extended to the new features developed under 5G-Advanced. For example, the security and privacy related to AI, ML and network automation are being studied under Rel-18. The other main pillar of 5G-Advanced security and privacy work is the ongoing extension of 5G security and privacy features to the evolved threat landscape resulting from virtualised deployments.**

# 5. 5G-Advanced Blueprint for Corporate Social Responsibility/ Sustainability

5.0

# 5G-Advanced Blueprint for Corporate Social Responsibility / Sustainability

***Climate change is the most urgent global issue that we face today and is one which will impact generations to come. Delaying or limiting decarbonisation efforts will be disastrous for society and will limit our ability to transition to a low carbon economy. Transitioning within the necessary timeframe will require the use of technologies that enable rapid emission reductions.***

*This is where the mobile sector has a key role to play. By increasing connectivity, improving efficiency, and impacting behaviour change, mobile network enabled technologies are helping avoid emissions.*

*The total annual emissions of the mobile sector are approximately 220 MtCO2e, which is about 0.4% of total global emissions. Compared to the global carbon footprint of mobile networks themselves, the level of avoided emissions enabled by mobile communications technologies is 10 times greater – a tenfold positive impact.*

*Digitisation is expected to disrupt all parts of the economy over the next decade and, if sufficient policy and investment is received, has the potential to be a key driver of low carbon development.*

*A similar 2015 report, with a European and North American scope, concluded that mobile technologies had a 5:1 enablement ratio compared to the footprint of the industry. Published four years later, this report has seen a doubling in enablement savings, to 10:1. By 2025, estimates based on projections of smartphone users and increases in number of IoT connections could result in a further doubling of the avoided emissions enabled by mobile technologies.*[4]

[4] Source: GSMA Carbon paper: https://www.gsma.com/betterfuture/resources/the-enablement-effect

In 3GPP, a study item has been approved to increase network energy savings as energy consumption is a key part of operators' OPEX. There is a need to study and develop a network energy consumption model especially for base station KPIs and an evaluation methodology and to identify and study network energy savings techniques in targeted deployment scenarios. The goal would be to investigate how to achieve more efficient operation dynamically and/or semi-statically and finer granularity adaptation of transmissions (for example, methods to optimise common signals such as SSBs and SIB1). It could also study one or more network energy saving techniques in time, frequency, spatial, and power domains, with potential support/feedback from user equipment, potential user equipment assistance information, and information exchange/coordination over network interfaces. AI/ML could play a vital role in achieving the required minimisations in terms of consumed energy.

5G-Advanced will introduce technologies that either enable greater efficiencies of the wireless system, thereby allowing reductions in power consumption (e.g., advanced downlink/uplink MIMO, enhanced multi-carrier operation, enhanced mobility, AI/ML data-driven designs), or enable further digitisation of the economy which is necessary to continue increasing the mobile technology enablement ratio (e.g., extended reality, further RedCap UE complexity r eduction evolution).

With 5G-Advanced, 3GPP has started to target development of new solutions helping to reach the UN Sustainable Development Goals (SDGs), also known as the Global Goals, which were adopted by the United Nations in 2015 as a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity.

# 6. Future Opportunities

6.0

# Future Opportunities

**The industry is discussing emerging use cases and services that could be enabled by future development of 5G-Advanced. These include:**

- **Integrated sensing and communication:** Investigating sensing capabilities provided by the same 5G NR wireless communication system and infrastructure as used for communication.
- **Ambient IoT:** an IoT service with an IoT device powered by energy harvesting, being either battery-less or with limited energy storage capability. This would enable communication with IoT devices without a conventional power source and avoid the need for manual recharging or replacing.
- **Tactile and multi-modality communication services:** including identification of network KPIs on latency, reliability and data rate to satisfy the multi-modal user experience, and potential network assistance for coordinated transmission of multiple modal representations.
- **Mobile Metaverse services:** Investigating support of interactive XR media shared among multiple users in a single location and identification of users and other digital representations of entities. Study acquisition, use and exposure of local information to enable Metaverse services.
- **Network of service robots with ambient intelligence:** identifying efficient communications service and cooperative operation for a group of service robots, including the capability to handling on-demand high priority events, and the timely delivery of information/data between multiple service robots for large-scale group operation scenarios.

# 7. Industry and Ecosystem Collaboration

7.0

# Industry and Ecosystem Collaboration

**Mobile networks were initially designed to provide basic person-to-person communication services. However, since 2.5G, they have also supported machine-to-machine communications, which benefits from a globally available solution. With subsequent cellular generations, more and more industries have been using mobile technologies to solve some of their challenges in a more efficient, scalable and cost-effective way.**

Some of the most prominent examples are trackers used in logistics, smart metering, connected and autonomous vehicles, and, more recently, applications in robotics. A huge number of industries are utilising mobile services: payments and finance, utility, health, transport (railway, cars, aviation, maritime), agriculture, logistics, manufacturing, gaming, entertainment, public safety, etc. Such industries have different ecosystems, with different needs and different regulatory environments.
As it is impossible for the mobile ecosystem to be fully aware of these differences, there is a need for cross-industry collaboration to fully explore the use cases for the capabilities of 5G-Advanced described in the previous sections of the document.

## 7.1 Considerations

**Operators will use 5G-Advanced for improved service offering, better utilisation of spectrum and network assets while minimizing the energy consumption required to deliver communication services in the 2020s, with an ever-increasing demand for data volume and global connections.**

5G-Advanced is primarily focusing on use cases for entertainment, industrial automation, utilities and transport in the automotive, aviation, railways, maritime domains. Some industries, such as transport, are already actively engaging in global standards, while others are more bound to national or regional constraints.

At the beginning of the 5G era, the automotive and the telco industry came together and created the 5G Automotive Association (5GAA) to develop end-to-end solutions for future mobility. More recently, the 5G Alliance for Connected Industries and Automation (5G-ACIA) is focusing on the Industry 4.0 use cases for the development of 5G and 5G-Advanced. Clearly these sectors already understood the need of cooperation and to work together to provide a collective view of a realistic evolution of the mobile technology.

In contrast, other industries operate in a more traditional fashion, where individual companies will approach a mobile operator to solve a particular challenge. Also, associations representing a particular industry are actively engaging with 3GPP, either by being a Market Representation Partner (MRP) or by means of liaisons. The number of 3GPP MRPs is growing, but it is still limited to few industries.

The GSMA is also playing a role in engaging with some selected sectors, such as **automotive**, **aviation**, **manufacturing** and **fintech**. Other GSMA activities are more horizontal, such as the 5G IoT Strategy Group, focusing on mMTC, and the **Operator Platform Group**, looking at exposing capabilities to customers and developers. The GSMA has also an operator-only group focusing on 3GPP related topics of relevance for mobile operators (**GSMA 3GPPOP**); which is reporting to the Technology Group. As one of the MRP of 3GPP, the GSMA conveys the mobile industry perspective on standards, while also helping to convey some joint-industry views from the communities that are active.

The industries that have not yet expressed an interest to join include entertainment, immersive experience and gaming, and the GSMA is considering ways to engage with these industry participants.

## 7.2 How to get involved

**Each of the activities and groups within GSMA is supporting the conversation on 5G-Advanced. Although they have slightly different governance and openness to participation policies, all GSMA members should seek to engage and actively participate in those groups.**

# Appendix

| ACRONYM/TERM | DESCRIPTION |
|---|---|
| 3GPP | 3rd Generation Partnership Program |
| 5GAA | 5G Automotive Association |
| 5G-ACIA | 5G Alliance for Connected Industries and Automation |
| AAS | Active antenna system or advanced antenna system |
| AI | Artificial intelligence |
| APT | Asia-Pacific Telecommunity |
| CDMA | Code division multiple access |
| CDPD | Cellular digital packet data |
| CEPT | European Conference of Postal and Telecommunications Administrations |
| CSI | Channel state information |
| CSR | Corporate social responsibility |
| C-V2X | Cellular vehicle to everything |
| DCI | Downlink control information |
| DetNet | Deterministic networks |
| DL | Down link |
| DSS | Dynamic spectrum sharing |

| ACRONYM/TERM | DESCRIPTION |
|---|---|
| EDGE | Enhanced data rates for GSM evolution |
| eMBB | Enhanced mobile broadband |
| FR1 | Frequency range 1 (consist of 5G bands in the Sub-6GHz) |
| FR2 | Frequency range 2 (consist of 5G bands in the mmWave above 24 GHz) |
| FRMCS | Future Railway Mobile Communication System |
| FWA | Fixed wireless access |
| GDP | Gross domestic product |
| GNSS | Global Navigation Satellite System |
| GPRS | General packet radio service |
| GSM-R | GSM railway |
| HAPS | High altitude platform systems |
| HSPA | High-speed packet access |
| HSPDA | High speed downlink packet access |
| HSUPA | High speed uplink packet access |
| IAB | Integrated access backhaul |
| IIoT | Industrial Internet of Things |
| IoT | Internet of Things |
| IP | Internet protocol |
| ITS | Intelligent transportation systems |

| ACRONYM/TERM | DESCRIPTION |
|---|---|
| ITU | International Telecommunication Union |
| IWSN | Industrial wireless sensor networks |
| KPI | Key performance indicator |
| LTE | Long Term Evolution |
| LTE-M | Long Term Evolution for machine type communication |
| Mbps | Megabits per second |
| MDT | Minimisation of drive test |
| MIMO | Multiple input multiple output |
| ML | Machine learning |
| mMTC | Massive machine type communication |
| mmWave | Millimetre waves |
| MRP | Market Representation Partner |
| NB-IoT | Narrowband Internet of Things |
| NG-RAN | Next generation radio access networks |
| NPN | Non public networks |
| NR | New Radio |
| NR-V2X | New Radio - vehicle to everything |
| NTN | Non terrestrial networks |
| OPEX | Operational expenditure |
| QAM | Quadrature amplitude modulation |

| ACRONYM/TERM | DESCRIPTION |
|---|---|
| QoS | Quality of service |
| RedCap | Reduced capability |
| SBMA | Service based management architecture |
| SDG | Sustainable development goals |
| SIB1 | System information block type 1 |
| Sidelink | Indicates the direct communication between user equipment without the intervention of a base station |
| SLS | Service level specification |
| SMS | Short message service |
| SON | Self-organising networks |
| SSB | Synchronization signal block |
| TDD | Time division duplex |
| TSC | Time sensitive communication |
| TSN | Time sensitive networks |
| UAV | Uncrewed aerial vehicle |
| UE | User equipment |
| UL | Uplink |
| URLLC | Ultra reliable low latency communication |
| USB | Universal serial bus |
| V2X | Vehicle to everything |
| XR | Extended reality |

# About the GSMA

The GSMA is a global organisation unifying the mobile ecosystem to discover, develop and deliver innovation foundational to positive business environments and societal change. Our vision is to unlock the full power of connectivity so that people, industry, and society thrive. Representing mobile operators and organisations across the mobile ecosystem and adjacent industries, the GSMA delivers for its members across three broad pillars: Connectivity for Good, Industry Services and Solutions, and Outreach. This activity includes advancing policy, tackling today's biggest societal challenges, underpinning the technology and interoperability that make mobile work, and providing the world's largest platform to convene the mobile ecosystem at the MWC and M360 series of events.

We invite you to find out more at **gsma.com**.

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