5G-Advanced

Shaping the future of operator services

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GSMA™

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Executive summary

1.0

This paper explains how 5G-Advanced technologies will extend the coverage, enhance the mobility and improve the speed and power efficiency of 5G, creating new value for both mobile operators and their customers. As a result, 5G-Advanced will help mobile operators better monetise their investments in 5G.

More than half the operator respondents in a recent GSMA Intelligence survey said they plan to deploy 5G-Advanced during the year after commercial equipment becomes available in 2025. Following the first wave of deployments in 2026, 5G-Advanced promises to transform every aspect of the services mobile operators provide to their customers, opening up new opportunities for business and strategic partnerships, and helping them to remain competitive in an increasingly complex environment.

Based on 3GPP Release 18, 5G-Advanced will enable mobile operators to provide data-driven, intelligent network solutions. For example, they will be able to better tailor connectivity to deliver specific services and use cases, such as autonomous vehicles, industrial automation, metaverse and extended reality (XR) applications. At the same time, greater power efficiency will strengthen support for industrial wireless sensor networks, smart watches, smart eyewear and other wearables.

The technology will also support full seamless interworking between non-terrestrial and terrestrial networks, while extending the Internet of Things (IoT) into new areas, in part by connecting devices that lack their own power source. Ambient IoT technologies could make asset monitoring, for example, much more economic, while dramatically increasing the efficiency of warehouse stocktaking and other industrial processes.

5G-Advanced networks will even be able to sense and precisely locate objects, enabling operators and their customers to potentially create dynamic 3D maps of the real world. As a result, enterprises will be able to create dynamic digital twins of their facilities, giving them the ability to monitor and fine-tune operational processes in real-time.

For consumers, 5G-Advanced will bring about a major improvement in the uplink, as well as providing an increase in capacity and reducing latency. In the GSMA Intelligence survey, respondents identified an improved uplink performance as the most important technological advance. Some 77% of the respondents said that 5G-Advanced will also trigger the broader exposure of application programming interfaces (APIs), providing developers with a cost-effective and straightforward means through which to access specific network capabilities, such as positioning or a configurable uplink.

The GSMA asked major equipment vendors to provide examples of how 5G-Advanced will create value for mobile operators and their customers. In a series of interviews, vendors highlighted how 5G-Advanced will:

- Enable a step-change in network capacity and flexibility, giving operators much more scope to tailor 5G connectivity to the needs of an individual enterprise or a single application.

- Use new spectrum and extremely large antenna array to provide fixed wireless access (FWA) connectivity capable of bringing 10 Gbps throughput to homes and businesses.
- Deliver much greater automation, AI-driven analytics and programmability, enabling enterprises to track and monitor the enormous variety of assets used in different industry sectors.
- Coordinate artificial intelligence (AI) in the network, the device and the cloud/edge to optimise the available connectivity for demanding applications, such as image recognition and conversations with automated personal assistants.
- Employ integrated sensing and communication (ISAC) and reconfigurable intelligent surfaces (RIS) equipment to provide the capacity to enable large numbers of people to enjoy reliable connectivity at major events, such as the Asian Games and the Olympics.

Initial deployments of 5G-Advanced in 2026 are likely to be focused on addressing the specific needs of specific enterprises and industries, with broader nationwide rollouts later in the decade. As they have been the first to adopt standalone 5G networks, operators in developed markets, notably East Asia, North America and parts of the Middle East, are likely to be the first to harness 5G-Advanced technologies.

The GSMA 5G transformation hub features case studies illustrating how the latest 5G technologies are being deployed and creating new value for organisations and their customers. The hub will be updated with 5G-Advanced case studies over time.

Introduction

2.0

The next step in the development of cellular technologies, 5G-Advanced refers to a suite of technologies that will be introduced with Release 18 of the 3GPP standards. Release 18 is due to be finalised in June 2024, paving the way for vendors to start supplying commercial solutions to mobile network operators for deployment in late 2025 onwards. Following the first major wave of deployments in 2026, 5G-Advanced capabilities promise to transform every aspect of the services mobile network operators (MNOs) provide for their customers.

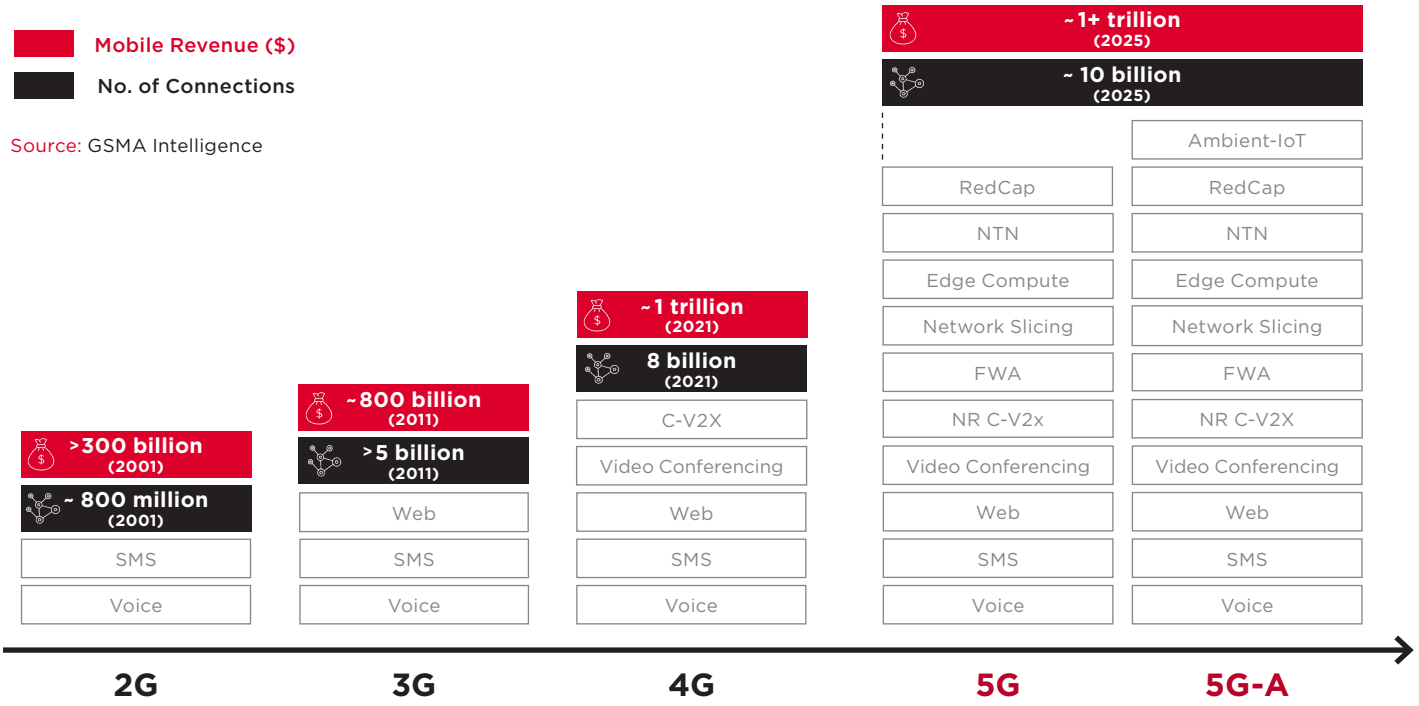
This paper explores how and why 5G-Advanced technologies will create value for both mobile operators and their customers. It draws on research by GSMA Intelligence and the expertise of the GSMA's technologists, supplemented by interviews with leading 5G equipment vendors. The paper is intended to provide readers with clear and compelling examples of how 5G-Advanced technologies will support various use cases in the consumer and business markets, including asset tracking, anomaly detection, event management, conversational AI (artificial intelligence) and fixed wireless access.

Equipment vendors envision that 5G-Advanced technologies will enable mobile operators to connect tens of billions of devices, appliances, machines and vehicles, as well as smartphones, tablets and laptops (see Figure 1), while opening up new revenue streams.

Figure 1

5G-Advanced is the next step in the development of cellular technologies*

* Not an exhaustive list of technologies

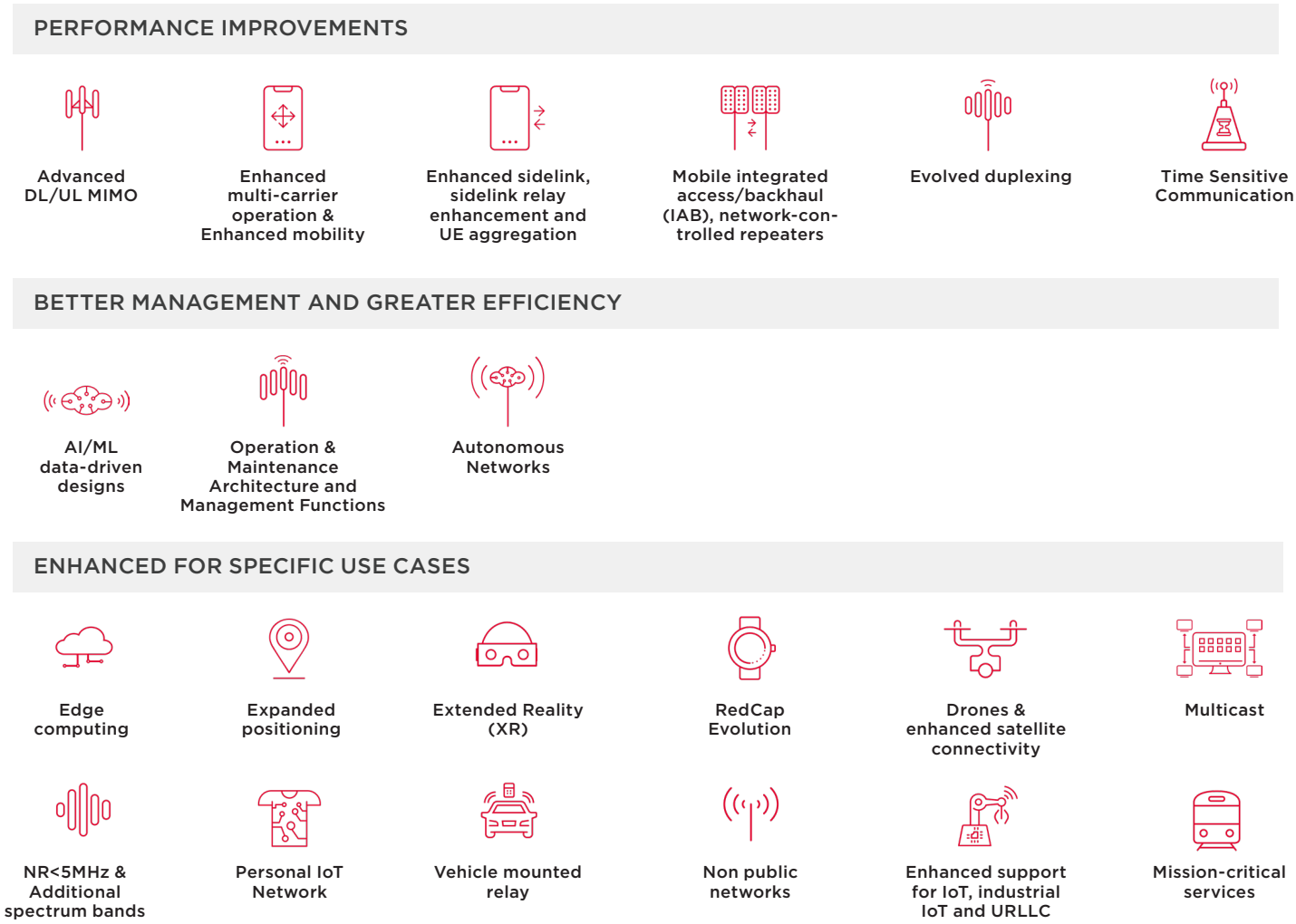


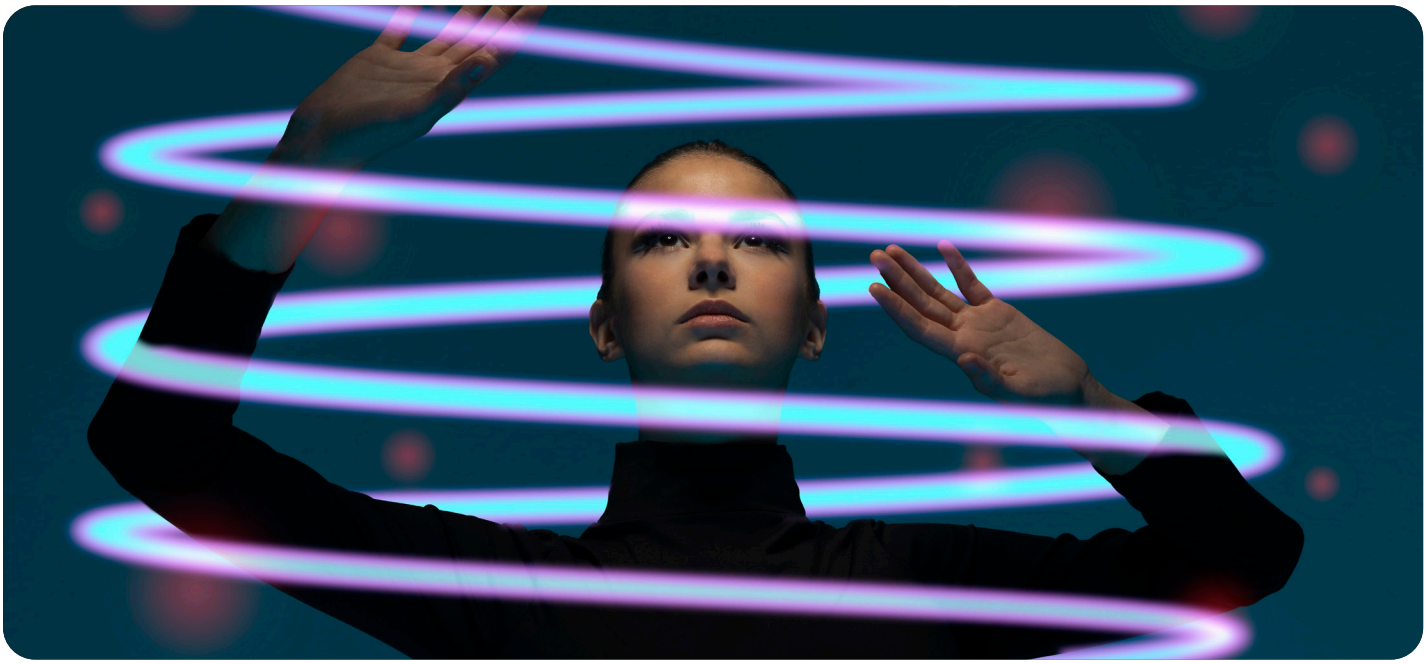
5G-Advanced encompasses an array of wireless technology innovations that promise to strengthen the 5G system foundation by maximising coverage, enhancing mobility and improving speed and power efficiency. Broadly speaking, 5G-Advanced will push technology boundaries in three directions (see Figure 2):

1. Performance improvements through enhancements to existing technologies, such as MIMO (multiple input, multiple output) antenna and multi-carrier operation, and harnessing new technologies, such as non-overlapping sub-band full duplex to improve network efficiency, latency, and coverage in deployments using TDD (time division duplexing) spectrum. At the same time, 5G-Advanced will support "deterministic" networks with time-sensitive features that guarantee almost zero packet loss rates and bounded latency. The predictability and reliability of enhanced time-sensitive communications will position cellular networks to support industrial automation use cases, industrial machine-to-machine communication and smart grids, and also allow the provision of new time-critical synchronised services (see Figure 2).

Figure 2

5G-Advanced combines performance improvements, greater efficiency and support for specific use cases





2. Better management and greater efficiency through artificial intelligence data-driven designs and autonomous networks. In particular, AI will enable network operation and maintenance to be highly automated, ensuring potential faults are identified and addressed before they can impact the end-user experience.

3. Support for specific use cases, such as edge computing, drones and enhanced satellite connectivity, and enhanced support for IoT technology. 5G-Advanced will enable operators to provide enterprises and consumers with connectivity that is carefully tailored to specific use cases, rather than having to adapt generic connectivity as they do today.

Business benefits of 5G-Advanced

3.0

5G-Advanced will help mobile operators monetise their previous investments in 5G. In particular, it will give operators the ability to tailor 5G connectivity to deliver specific services, opening up new business and strategic partnerships and enabling operators to remain competitive in an increasingly complex environment.

While today's 5G is centred on enabling the basics of connectivity – wide-area coverage, capacity, solution reliability – 5G-Advanced is designed to enable mobile operators to provide data-driven, intelligent network solutions.

Just as 4G enabled the growth of social networks, app stores and the collaborative economy, 5G-Advanced is designed to enable the creation of new business models and support new use cases across the economy. It could, for example, enable connected autonomous vehicles, industrial automation, metaverse and extended reality (XR) services, while supporting highly immersive and interactive applications in the entertainment, training and education sectors.

Increased power efficiency will strengthen support for cost-efficient devices and/or power-sensitive applications, such as industrial wireless sensor networks, smart watches, smart eyewear and other wearables. Meanwhile, interactive applications, such as virtual reality, augmented reality and extended reality, will benefit from 5G-Advanced's support for high data rates, low latencies and seamless mobility.

In the transport domain, 5G-Advanced will help to overcome connectivity issues by ensuring a user's experience isn't affected when on a high-speed train or plane. The technology will also provide communications support for uncrewed aerial vehicles (UAVs), satellites and HAPS (high altitude platforms) operating as non-terrestrial networks with full seamless interworking with terrestrial networks. In turn, UAVs will offer new types of smart transportation solutions, while satellite and HAPS connectivity are a good complement to terrestrial connectivity for the maritime industry, IoT (Internet of Things) use cases and to fill coverage gaps.

3.1 Major expansion of the IoT

Indeed, 5G-Advanced will provide enhanced support for a wide range of IoT, industrial IoT, and ultra-reliable low latency communications. "The connectivity will be more predictable, as operators will be able to dynamically change the performance of the network to deliver QoS (quality of service)," explains Barbara Pareglio, Senior Technical Director, Smart Mobility Lead at the GSMA. "Network slicing will allow for quality, priority and pay-as-you-use scenarios, where you buy a temporary upgrade to your connectivity."

5G-Advanced will also bring out the full potential of a streamlined form of connectivity called 5G RedCap (reduced capability), which allows the connected devices to be significantly simpler and less power-hungry. With 5G RedCap, it should be cost-effective for both enterprises and consumers to connect many more devices to cellular networks.

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, side link support and narrow band positioning.

"Ambient/passive IoT (which don't require devices to have their own batteries) will open up a completely new set of opportunities for IoT," adds Barbara Pareglio. "However, the ultimate impact and success of these technologies will depend on the development of robust business models." As the rollout of 5G-Advanced develops, ambient IoT technologies could make asset monitoring, for example, much more economic, while dramatically increasing the efficiency of warehouse stocktaking and other industrial processes.

3.2 New sensing and location-based services

Unlike their predecessors, 5G-Advanced networks will be able to sense objects, enabling operators and their customers to potentially create dynamic 3D maps of the real world. "Sensing will be towards the end of 5G, rather than in the short-term, but it will open up a lot of opportunity around security and safety and applications in the sky," adds Barbara Pareglio. "The networks will be able to detect any objects."

At the same time, 5G-Advanced networks will be able to provide precise positioning information for connected devices, independent of GPS or other satellite-based positioning systems. These capabilities will make it much easier for enterprises to create dynamic digital twins of their facilities, giving them the ability to monitor and fine-tune operational processes in real-time.

3.3 Opening up to developers

While the exact models and features that will make it to market remain to be seen, industry collaboration, such as GSMA Open Gateway, will unlock opportunities in the 5G enterprise market. By working together on a framework of common network application programmable interfaces (APIs), mobile operators and hyper-scalers will help create new business opportunities in partnership with third-party application developers and vendors.

3.4 Public and private networks work together

Given that 5G-Advanced will serve a wide variety of industries with different ecosystems and enable a plethora of new business models, 5G-Advanced is likely to boost the penetration of private networks in vertical markets, particularly in the manufacturing, financial services and transportation sectors. "Most of the impact will be B2B or B2B2C," concludes Barbara Pareglio. "Enterprises will value the flexibility and the manageability afforded by 5G-Advanced. There will be many hybrid deployments of public/private 5G."

For consumers, 5G-Advanced will bring about a major improvement in the uplink, as well as providing an increase in capacity and reducing latency, making FWA (fixed wireless access) services even more competitive with fixed-line alternatives.

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

> Ambient/passive IoT (which don't require devices to have their own batteries) will open up a completely new set of opportunities for IoT
>
> **Barbara Pareglio** - Senior Technical Director, Smart Mobility Lead at the GSMA

Market trends and overview

4.0

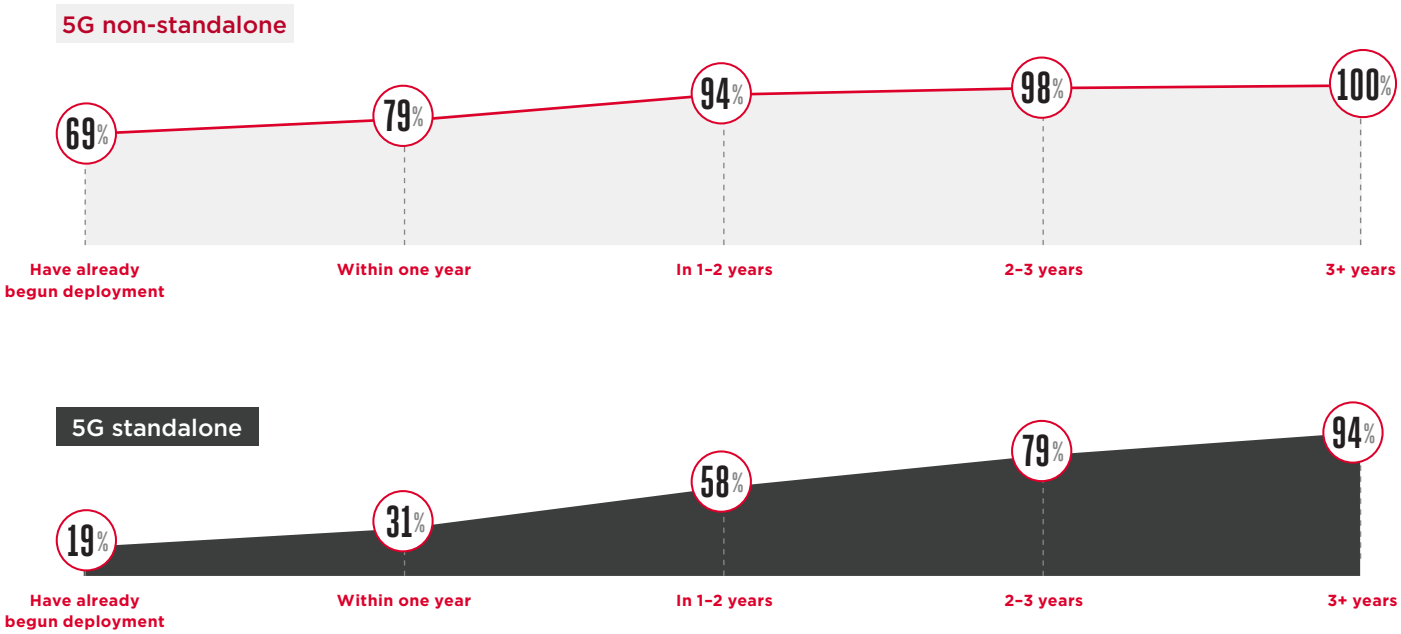
One of the key stepping stones to 5G-Advanced is the deployment of standalone 5G networks, which use cloud native technologies to be more agile, versatile and scalable than their predecessors. A standalone 5G core network is a prerequisite for network slicing, for example, which enables a mobile operator to dedicate a "slice" of network resources to a specific customer or application.

Today, most 5G networks are non standalone, in the sense that they use a 4G core network, together with 5G radios. However, in 2024, many mobile operators around the world will begin deploying standalone 5G networks, according to the GSMA Intelligence Network Transformation survey, published in November 2023. In that survey, 19% of respondents said they have already begun deployment of 5G standalone, while 31% said they will begin within one year (see Figure 3).

The operators that deploy 5G standalone first are likely to lead the progression to 5G-Advanced. "You need 5G standalone to take advantage of 5G-Advanced," notes Barbara Pareglio, Senior Technical Director, Smart Mobility Lead at the GSMA. European operators are lagging behind their counterparts in East Asia and North America in this respect, but they may be emboldened by an upturn in 5G ARPU (average revenue per user) in those markets that have standalone 5G in place, adds Barbara Pareglio.

Figure 3

5G deployment timing: standalone versus non-standalone



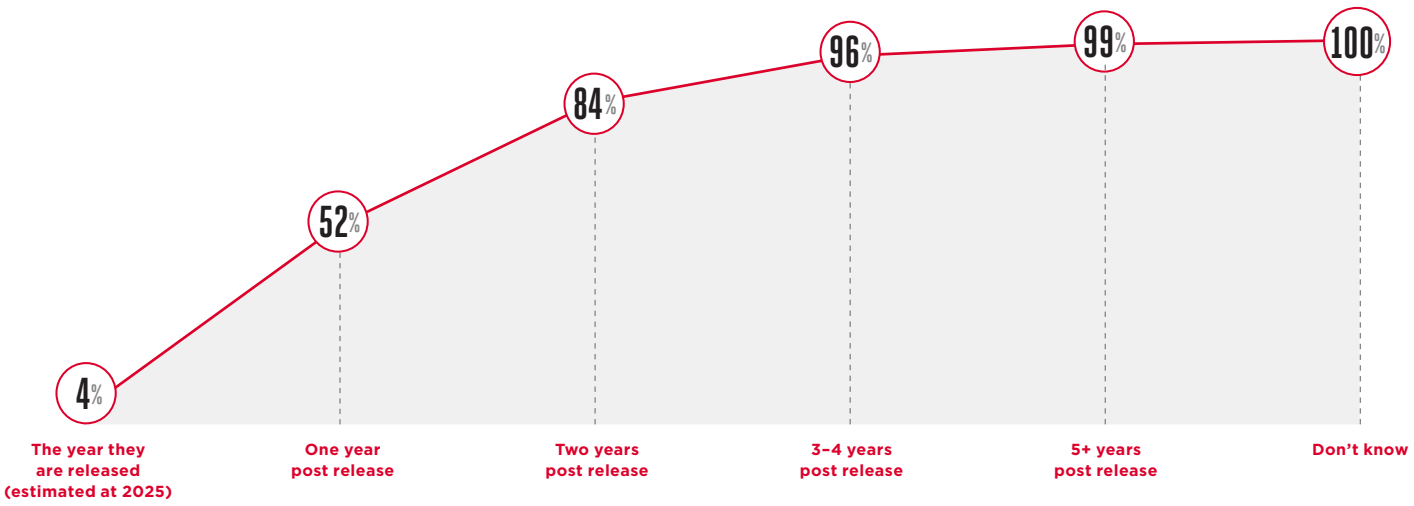
Source: GSMA Intelligence Operators in Focus: Network Transformation Survey 2023

The widespread rollout of 5G standalone networks in 2024 and 2025 is likely to be followed by the first major wave of 5G-Advanced deployments in 2026. More than half the respondents in the GSMA Intelligence survey said they plan to deploy 5G-Advanced one year after commercial equipment becomes available (see Figure 4), which is likely to be in 2025.

However, that doesn't mean these operators will deploy the technologies throughout their networks – the geographic coverage and scale of deployments is likely to be driven in part by demand from local businesses (see previous section).

Figure 4

How long after commercial availability do mobile operators expect to deploy 5G-Advanced?

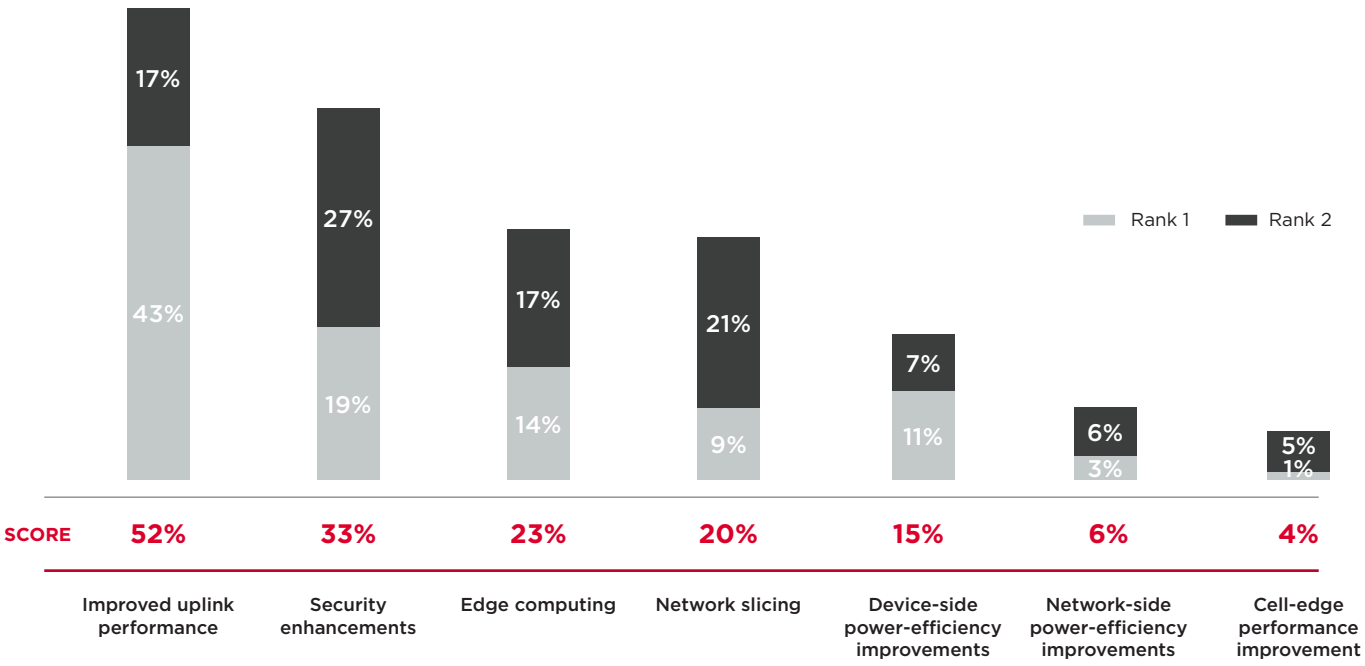


Source: GSMA Intelligence Operators in Focus: Network Transformation Survey 2023

As they look ahead to 5G-Advanced, the survey respondents identified an improved uplink performance as the most important technological advance, followed by security enhancements and edge computing (see Figure 5). The focus on the uplink reflects the growing demand for video calls, live streaming and augmented reality applications, which require the connected device to transmit live images from its camera.

Figure 5

Which 5G-Advanced technological features are most important (top two choices ranked)?



Source: GSMA Intelligence Operators in Focus: Network Transformation Survey 2023

However, the respondents in the GSMA Intelligence survey identified multi-cast services and low-cost IoT as key use cases for 5G-Advanced technologies (see Figure 6). That suggests that operators are particularly interested in harnessing the efficiency gains offered by 5G-Advanced, which will enable them to offer customers better value connectivity.

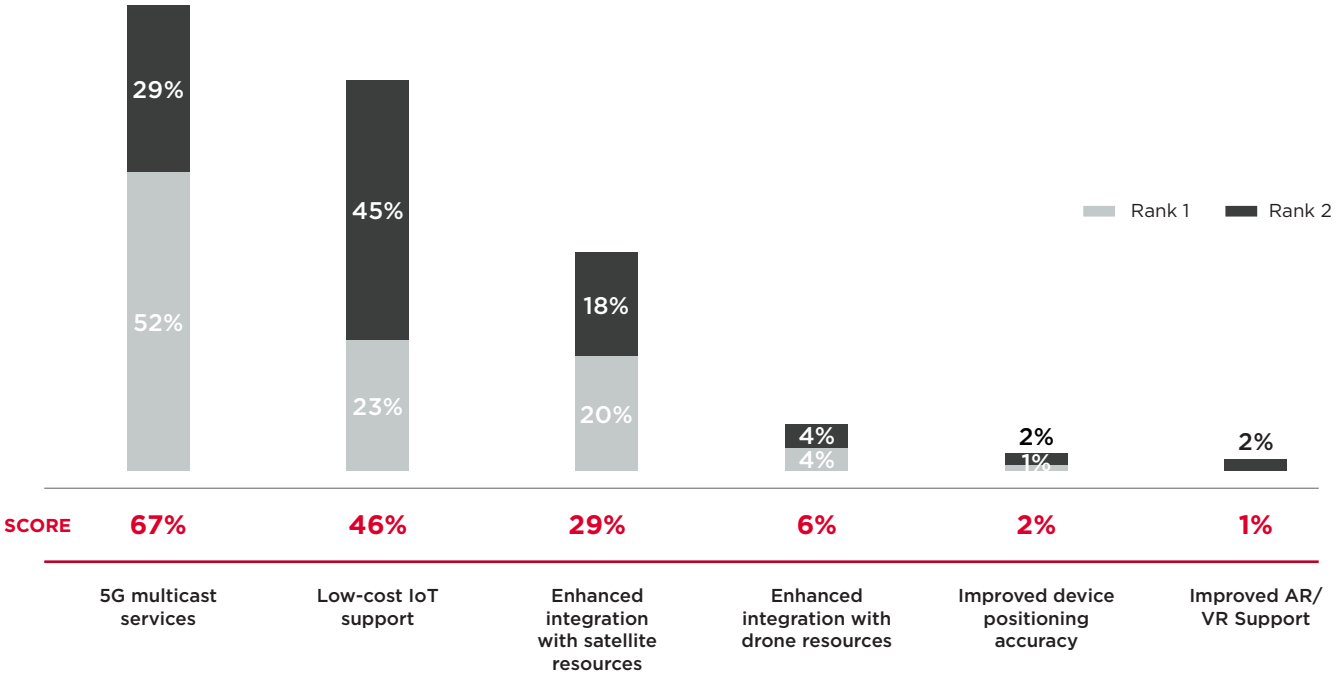
5G-Advanced will support mixed-mode multicast with key features, such as multicast reception in inactive/idle mode and better system efficiency for multicast reception in RAN (radio access network) sharing scenarios. In the IoT domain, 5G-Advanced networks will be able to connect devices that lack their own power source, as well as refining 5G RedCap (reduced capability), which offers a low cost version of 5G connectivity.

By contrast, the GSMA Intelligence survey found that improved support for device positioning accuracy and extended reality (AR/VR) services is a relatively low priority (see Figure 6). That finding probably reflects the fact that most mobile network operators are under pressure from investors to concentrate on increasing efficiency, rather than experimenting with new service propositions.

More than three quarters (77%) of the respondents in the GSMA Intelligence survey said that 5G-Advanced will be a trigger for broader exposure of application programming interfaces (APIs). APIs potentially provide a cost-effective and straightforward means through which app developers can access specific network capabilities, such as positioning or a configurable uplink.

Figure 6

Which 5G use cases and applications are most important (top two choices ranked)?



Source: GSMA Intelligence Operators in Focus: Network Transformation Survey 2023

In summary, the GSMA Intelligence survey revealed that mobile operators are particularly interested in the ways in which 5G-Advanced can increase the efficiency of their networks and enable them to cost-effectively support many more connected devices. These imperatives could drive initial adoption of 5G-Advanced, paving the way for operators to open up new service propositions (as discussed in the next section) in the second half of the decade.

As the next section of this paper indicates, operators in China and the Middle East are likely to be among the earliest exponents of 5G-Advanced's ability to boost network performance. In these markets, 5G is already playing a central role in delivering high-speed connectivity to large numbers of devices, driving demand for more capacity, lower latency and high levels of reliability.

Vendor perspectives

5.0

In a series of interviews, the GSMA asked major equipment vendors to provide examples of how 5G-Advanced will create value for mobile operators and their customers. These examples are summarised in this section.

5.1 Ericsson – providing customised connectivity

Today, mobile operators largely sell generic connectivity, differentiated only by speed. But with 5G-Advanced networks, they will be able to offer far more customised propositions. Crucially, 5G-Advanced technologies will bring about a step-change in both capacity and flexibility, giving operators much more scope to tailor the connectivity to the needs of an individual enterprise or a single application. For example, operators will be able to offer connectivity with a specific latency, additional security or very precise positioning accuracy.

"5G-Advanced will enable us to increase the number of values that we can monetise," explains Dr. Sibel Tombaz, Head of Product Line Cloud & Purpose-built 5G RAN at Ericsson. For example, a consumer attending a concert may wish to temporarily purchase a better uplink so they can live stream video to their friends or an executive working from home may wish to pay for a guaranteed consistent throughput speed that will ensure they can always have crystal clear video calls.

Meanwhile, broadcasters might pay for a premium for an assured uplink that would enable them to use as 5G network to capture live images from a location where a news event is unfolding. For some applications, latency can also be a key metric. "You don't necessarily need low latency, you need consistent latency for connected glasses, AR devices or for a cloud gaming application," adds Sibel Tombaz.

"All of this needs to be visible. With 5G, there's a certain observability, which we don't have in 4G networks."

With 5G-Advanced, operators could also monetise other network capabilities, notably their ability to increase 5G based position accuracy indoors. Using the cellular network to locate assets can help automate and optimise enterprise processes, for example, warehouse logistics, locating equipment in hospitals, autonomous vehicle tracking, and monitoring vehicles and equipment in high-risk environments like mines.

> You don't necessarily need low latency, you need consistent latency for connected glasses, AR devices or for a cloud gaming application. All of this needs to be visible. With 5G, there's a certain observability, which we don't have in 4G networks

Sibel Tombaz - Head of Product Line 5G Radio Access Network at Ericsson.

5.12 Enabling service level agreements

Ericsson is already building adaptability and customisation into its product portfolio on the journey toward programmable RAN, thereby enabling mobile operators to configure network resources to provide a specific throughput and latency to a specific user. “There are already functionalities to ensure that service level agreements (SLAs) and the required throughput, latency and other KPIs can be met per slice,” says Sibel Tombaz. “In 4G we just optimise the KPI per se. But now, in the same cell, I can actually change how the adaptation works for a FWA user compared to a cloud gaming user.”

The next step is to enable mobile operators to monetise these capabilities. Rather than negotiating individually with different enterprises, operators could establish application programming interfaces (APIs) that third party developers can use to harness specific network capabilities in return for a fee. “We believe that APIs are a great way to do this because they enable operators to scale, much, much faster: they don’t need to go and talk to different use cases, different enterprises separately,” notes Sibel Tombaz.

At the same time, she believes operators will need to make much greater use of automation to make it practical to provide customers with tailored connectivity. “We are going from a single use case - mobile broadband - that anyone can get best-effort, to suddenly a network that has hundreds of different virtual networks, different use cases, even the same device can have multiple slices,” Sibel Tombaz explains.

With 5G-Advanced, networks should be sufficiently automated to enable operators to handle this complexity and ensure they can deliver on individual SLAs. “We strongly believe that automation is actually an enabler of monetisation,” concludes Sibel Tombaz.

> We are going from a single use case - mobile broadband - that anyone can get best-effort, to suddenly a network that has hundreds of different virtual networks, different use cases, even the same device can have multiple slices

Sibel Tombaz - Head of Product Line 5G Radio Access Network at Ericsson.

5.2 **Huawei –** turbocharging fixed wireless access

In many markets around the world, 5G fixed wireless access (FWA) service is bringing broadband to homes and businesses. In the UAE, for example, mobile operator du (part of the Emirates Integrated Telecommunications Company) was providing FWA to more than 240,000 customers in September 2023, a tenfold increase on September 2022.

At the 2023 Global Mobile Broadband Forum in October, du and Huawei unveiled a 5G-Advanced demonstration "villa" - an archetype for a future smart home connected by networks capable of 10 Gbps. The villa was designed to show how Huawei's FWA² solution, enabled by 5G-Advanced technologies, can support cutting-edge services, such as naked-eye 3D and extended reality (XR). Huawei's FWA² portfolio includes FWA Pro for ultrafast connectivity, FWA Lite for cost-effective connectivity, and FWA Biz for highly reliable connectivity.

FWA Pro, for example, is designed to support multiple device connections, including smart wearables, smart home devices, smart surveillance devices, virtual games, multi-people 3D calls and panoramic videos. It employs TDD multi-band multi-channel ELAA (extremely large antenna array) to enable 5G networks to boost TDD coverage and energy efficiency. Huawei says its 128T MetaAAU, which integrates over 500 antenna elements, can work with multidimensional high-resolution beam algorithms to improve the customer experience by 50%.

Fahad Al Hassawi, the CEO of du, commented: "From the beginning of the 5G era, fixed wireless access has been a transformative catalyst, empowering us to deliver cutting-edge solutions to our valued customers. ...With the introduction of FWA², we are poised to redefine the boundaries of user experience, offering our subscribers unparalleled internet connectivity indoors."

John Gao, President of Huawei's 5G-A Domain, added: "5G-A supports a deterministic user experience and ensures low latency for XR and cloud-based services. It will provide an immersive user experience for multiple people in a family scenario."

> 5G-A supports a deterministic user experience and ensures low latency for XR and cloud-based services. It will provide an immersive user experience for multiple people in a family scenario
>
> **John Gao** - President of Huawei's 5G-A Domain

By 2024, Huawei anticipates the average household in the UAE will have four devices using a FWA connection simultaneously, while 10% of households may be using 10 devices simultaneously, meaning they will need throughput of at least 500 Mbps. By enabling the network to support several very demanding services simultaneously within a single household, Huawei's FWA^2 solution could provide du's customers with more immersive experiences. Huawei notes that regular online gamers, for example, may be prepared to pay a premium for a consistently low latency of about 20 ms, which would ensure their Internet connection is sufficiently responsive for them to be competitive. "5G-A will enhance the connectivity capability of operators, serving as a primary digital enabler in the UAE," Saleem Alblooshi, CTO of du, said. "du has already rolled out a diverse strategy offering a broad array of services to our customers, including cloud, digital wallet, and Wi-Fi. We hope to further collaborate with Huawei, leveraging its cutting-edge technologies and industry-leading solutions through this journey."

Demand for FWA will vary considerably between different markets. In countries with limited fixed line networks, adoption of FWA is likely to be higher than in those countries with extensive fibre-to-the-home (FTTH) networks. Another key factor is the size of the rental market – tenants tend to gravitate towards FWA services because they are easy and quick to deploy. The local geography, the broadband strategy of the government and local planning regulations can also be major influences on the connectivity options available to households.

GSMA Intelligence expects global 5G FWA connections to reach 40 million by the end of 2025, with the majority in developed countries, such as the US. It says that 5G mmWave FWA is cost-effective versus FTTH when deploying the latter requires the building of new underground or overground infrastructure: the cost savings can reach 65% in rural towns, 45% in suburban areas and 40% in urban areas.

5.3 **Nokia –** enabling asset tracking and anomaly detection

Across the economy, all kinds of organisations need to both track their assets and detect any anomalies. While a range of technologies are used for such purposes today, 5G-Advanced could make it feasible and cost-effective to track and monitor vast numbers of assets and in a much more systematic way.

As they will combine automation, AI-driven analytics and programmability, 5G-Advanced networks will be well-suited to supporting these use cases, according to Nokia. These three capabilities will enable the networks to track and monitor the enormous variety of assets used in different industry sectors, explains Jitin Bhandari, CTO of Cloud and Network Services at Nokia. "The ecosystem of endpoints is very diverse," he notes. "If you walk into a mine, there are different kind of earth movers and big heavy machines. If you walk in into a retail warehouse, you are talking about a lot of robotic arms and if you are talking about an agriculture farm, you have the emergence of drones with very powerful capabilities."

To support a drone performing surveillance, for example, a 5G-Advanced network could dynamically upgrade the connectivity as soon as the drone detects an anomaly and begins streaming high resolution video to an image recognition system or a human operator. For example, the network could switch from transferring 60 Kbps to 200 Mbps for a few minutes and then go back to 60 kbps. "That requires a high degree of agility in the network to give that drone device what it needs when it needs it," notes Jitin Bhandari.

Nokia envisions that application developers will be able to configure the network to deliver this kind of bandwidth boost using a single application programming interface (API), that disguises the complexity of the radio, the core, the back end servers and other architectural elements.

Nokia also envisions that AI-driven analytics will be built into the edge of the 5G-Advanced network so that an image recognition system can instantly determine the nature of the anomaly and provide the drone with further instructions. By offloading the data analytics to an edge platform, the drone won't need to consume as much power, saving battery life for actually flying.

5.31 Potential to be deployed right across the economy

Nokia says it has already built prototypes of such systems in its labs, using drones and cameras. The same principles could be used to enable a wide range of robots and sensors, including fixed cameras, to track assets and detect anomalies.

> The ecosystem of endpoints is very diverse. If you walk into a mine, there are different kind of earth movers and big heavy machines. If you walk in into a retail warehouse, you are talking about a lot of robotic arms and if you are talking about an agriculture farm, you have the emergence of drones with very powerful capabilities

Jitin Bhandari - CTO of Cloud and Network Services at Nokia

"If we do this right, bottom up, which means we build the networks on these three paradigms, we will be touching hundreds, even thousands, of industries, because this is where the scale would be needed," says Jitin Bhandari.

Nokia is building the three enablers - automation, AI-driven analytics and programmability – into its commercial products and solutions. "We have got a few customers where we are actually exploring and deploying some of these capabilities for a business construct to a network construct transition," says Jitin Bhandari. As well as developing AI-driven analytics, Nokia has launched its Network-As-Code platform to expose "simple personas of networks" that will make them easy for developers to programme.

The pace at which these technologies are being deployed by mobile operators will depend in part on how fast they can go cloud-native. "Everything has to be standalone (SA)," says Jitin Bhandari. "A half baked cake is not edible and that's where we are at today. But we are seeing operators who have done 5G SA deployments and have done cloudification of 5G radios and 5G SA core. They have started building automation and analytics around it and started building concepts of programmability, but those operators are a handful right now."

To really pursue this opportunity, operators will have to make sustained investments in automation, AI-driven analytics and programmability. "We keep drooling over hyperscalers and what a fantastic network infrastructure they have and how dynamic, how AI-driven, how automated that is, and every network operator aspires to be a hyperscaler," adds Jitin Bhandari. "And you have to realise that they have been investing in autonomous operations and analytics for the last decade."

If we do this right, bottom up, which means we build the networks on these three paradigms, we will be touching hundreds, even thousands, of industries, because this is where the scale would be needed

Jitin Bhandari - CTO of Cloud and Network Services at Nokia

5.4 **Qualcomm –** enabling and employing artificial intelligence

For mobile networks, artificial intelligence (AI) is becoming both a major application and a key enabler. Straightforward access to AI tools while on the move is going to require very responsive and reliable 5G networks. At the same time, AI is also set to play a major role in improving the performance of the network and optimising the way in which computing power on the device and in the cloud work together.

That's the view of Qualcomm, which is exploring how device-based AI can work with network-based AI to provide the end-user with the connectivity they need, when they need it. Qualcomm believes that wireless networks and devices need to become "AI-native" in the sense that they will continually optimise themselves to improve the performance of the overall system.

A key use case for these networks will be enabling people to get an immediate response from a cloud-based AI system to everyday questions, such as where is the nearest pharmacy or what am I looking at? Demand for such applications is set to rise as svelte connected glasses and other wearable devices arrive on the market. For example, start-up Humane has just launched a small wearable broach with a built-in cellular connection that enables the end-user to query a remote AI-based assistant. Specifically designed for interacting with large language models, the Humane AI Pin is likely to be followed by other similar wearable devices that rely on audio as the primary interface.

For such systems to be compelling, they need to respond quickly – a delay of several seconds will be unacceptable. "We will want conversational response times," notes Sunil Patil, vice president of product management at Qualcomm.

How fast an answer comes through will depend on the performance of the device, the network and the AI system running in the cloud (or at the edge of the network). With 5G-Advanced, Qualcomm anticipates that the network and the device will use AI models to optimise the available connectivity for such applications. For example, in cases where an individual is talking to an AI system about the video feed being captured by their connected glasses, the AI model will look to minimise the latency and maximise the uplink between the wearable and the network.

5.41 Dynamically optimising the available connectivity

An end-to-end AI system, spanning the core network, the radio access network and the device, could dynamically optimise the available connectivity to meet the requirements of a specific application. "Today it is very static," notes Sunil Patil. "But we could have different models for different types of applications and use cases, where the network and the device are interoperating and that will form the basis for the next G."

With 5G-Advanced, AI will also be able to optimise the performance of various components within the network. It could support beam management and precise positioning, for example, so that 5G mmWave and MIMO antenna can be orientated to use RIS (reconfigurable intelligent surfaces) to connect a device that is not in their line of sight. Qualcomm anticipates that AI will also be used to improve spectral efficiency through the use of channel feedback mechanisms that continually monitor and fine-tune the performance of the radios.

"In the classical design, you design for what you believe is the worst case scenario," explains Sunil Patil. "You cannot predict how it's going to behave in the field. But if there is enough data, you can do better beam management and improve robustness and overall higher throughput performance." Qualcomm has already introduced AI-based beam management into 5G mmWave devices and is exploring how it can help reduce power consumption by minimising the time spent looking for beams.

With 5G-Advanced, these optimisation technologies could work together to ensure people can enjoy responsive connectivity and have fluent conversations with an automated personal assistant, even in crowded urban environments or transport hubs.

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>
> **Sunil Patil** - Vice President of Product Management at Qualcomm

5.5 ZTE – making major events manageable and profitable

Hosting large-scale sporting events, such as the Asian Games and the Olympics, can be challenging. As they attract so many spectators, such events can require major investments in infrastructure, which can be very expensive for the host city. By significantly improving network performance and operational efficiency, ZTE believes 5G-Advanced technologies could help cities cope with a major influx of visitors.

At the 19th Asian Games in Hangzhou, China Telecom Zhejiang and ZTE verified several 5G-Advanced technologies, such as RIS (reconfigurable intelligent surfaces) and ISAC (integrated sensing and communication). A new multi-antenna technology derived from electromagnetic metamaterials, RIS is designed to optimise base station signal propagation and beam control, thereby improving 5G signal quality and base station coverage.

Together with ZTE, China Telecom Zhejiang completed commercial RIS verification in the Asian Games Village, achieving 10 Gbps network coverage in former blind spots, such as underground garages and stores. The measured data showed that, after RIS was deployed, the device downlink rate increased sixfold and the uplink throughput by 20 times, while RIS deployment costs just one tenth of the cost of deploying small cells, according to Hans Neff, senior director, CTO Group at ZTE. When a user moves, the dynamic RIS reflection beam can accurately track them in real time, with stable signal strength and throughput, he adds.

ISAC is designed to equip base stations with radar-like perception capabilities, effectively sensing drones, people, vehicles, and objects. China Telecom Zhejiang and ZTE jointly verified low-altitude drone control using a single ISAC AAU (active antenna unit) device in the Asian Games Village. In the verification, the perception distance of AAU based on the 5G-Advanced network reached 1,000 metres, with distance precision at the sub-meter level, according to ZTE. “The AAU can sense the flight path of a drone in real time, and alert when the drone flies close to a warning area, thereby greatly ensuring low-altitude safety at the Asian Games,” adds Hans Neff.

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5.51 Digital twin enables efficient network operations

The upgraded connectivity helped the organisers of the Asian Games to monitor what was happening at the venues in near real-time. ZTE provided a digital twin to act as a comprehensive control system for the event and enable China Telecom and China Unicom to optimise the performance of their joint network. Updated every five minutes, this dynamic 3D model was designed to provide the operators with a continuous and very detailed view of the network's performance, enabling them to allocate resources as efficiently as possible. ZTE says the digital twin's monitoring and control capabilities enabled the two operators to achieve a connection rate of 99.82% during the event, which attracted 600,000 4G/5G users.

ZTE and Zhejiang Telecom also used the Asian Games to test 1.6 GHz ultra-wide-bandwidth 5G-Advanced equipment. Deployed along the Qiantang River, this equipment delivered downlink peak rates in excess of 11 Gbps, according to ZTE. A 5G-Advanced backhaul system and small cell base station were deployed on the river's cruise ship to address spectrum interference and signal attenuation issues, and provide a seamless live streaming experience.

Meanwhile, in the badminton stadium, 10 Gbps 5G-Advance connectivity was used to connect 20 4K high-definition cameras, situated around the courts, together with a VR camera next to the net to give the referee's perspective. As a result, every moment of play could be frozen and played back in 360 degrees, enabling the audience to see more details of the game, and the referees to make more accurate judgment calls.

"The Asian Games was a good test of the 5G-Advanced technologies and we can expect more verifications in 2024," concludes Hans Neff.

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Future outlook

6.0

Initial deployments of 5G-Advanced in 2025/2026 are likely to be focused on addressing the specific needs of specific enterprises and industries, with broader nationwide rollouts following later in the decade. As with previous cellular technologies, developed markets, notably East Asia, North America and parts of the Middle East, are set to lead the way.

By 2026, 5G-Advanced will be the state-of-the-art in wireless connectivity, paving the way for the deployment of 6G in the 2030s. As with previous generations, it is expected that the roll out of 6G will be gradual, so 5G-Advanced will play an important role in bridging from 5G to 6G. Many of the 5G-Advanced technology components and innovations will be viewed as precursors to 6G building blocks. Artificial intelligence is likely to play a particularly important role in the fully data-driven architecture of 6G and the intelligent network platform of the future. While some mobile operators may jump directly to 6G, the foundations for the majority will be through 5G-Advanced.

Although 6G applications are yet to be defined, they will almost certainly build on some of the key capabilities of 5G-Advanced, such as sensing, integration of terrestrial and non-terrestrial networks, passive IoT and highly-configurable connectivity. In particular, extended reality (XR) applications, which will gradually evolve into immersive communication for human-machine interaction, are likely to benefit from the further performance improvements delivered by 6G. To be really compelling, XR applications will need very responsive high resolution graphics delivered at very high frame rates. Meeting those requirements will depend on very robust and reliable high-capacity connectivity.

GSMA

About this whitepaper

About GSMA

The GSMA is a global mobile industry association that represents the interests of mobile operators worldwide, uniting more than 750 operators with almost 300 companies in the broader mobile ecosystem, including handset and device makers, and software companies. The GSMA also holds the industry-leading events such as MWC (in Barcelona, Shanghai and Los Angeles) and the Mobile 360 Series.

GSMA Foundry is the go-to place for cross-industry collaboration and business development, where GSMA members and industry players come together to rapidly develop real-world solutions to industry challenges, nurture new ideas through initial commercial trials and scale proven solutions at a regional and global level to forge our digital future.

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