GSMA Intelligence

The 5G-Advanced era: the importance of 5G's evolution for the mobile core

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GSMA

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www.gsmaintelligence.com

info@gsmaintelligence.com

Author

Peter Jarich, Head of GSMA Intelligence

Contents

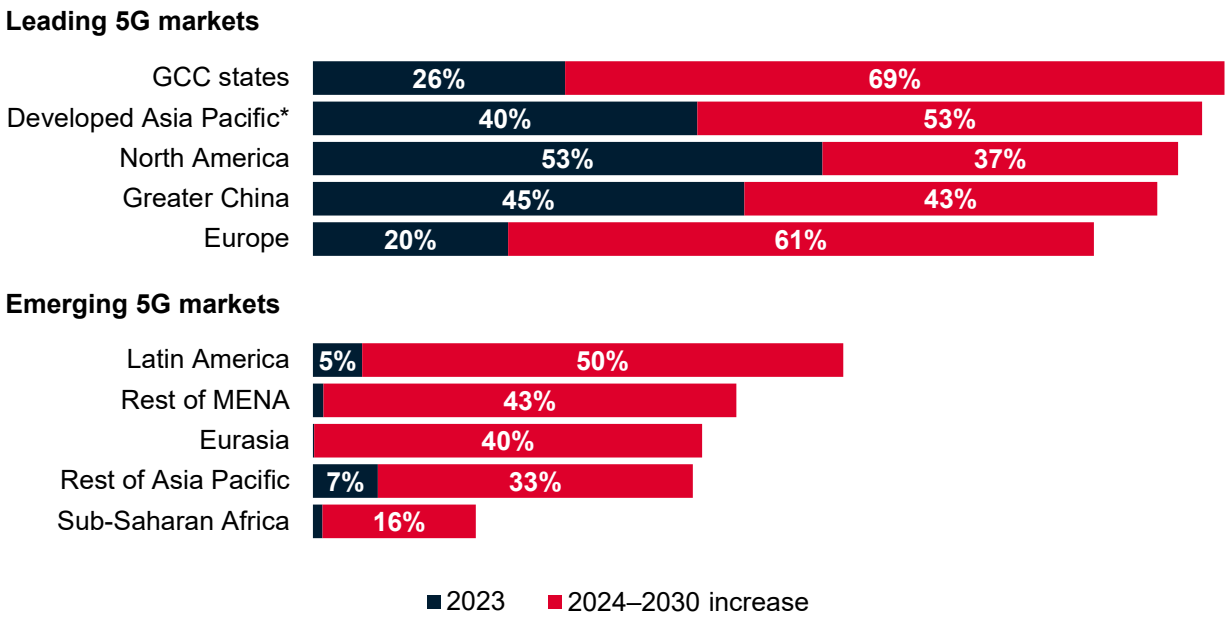
Executive summary **4**
1. 5G's evolution and the mobile core **6**
2. The need to think beyond standards evolutions **9**
3. Service trends that will impact the way core networks are built **13**
Media escalation 13
Media diversification 15
5G B2B 16
Service demands and demanding services 18
4. How an evolved 5G core will be impacted by service trends **20**
Boosted performance 20
Extended distribution 22
Ensured determinism 24
Native intelligence 25

Executive summary

We are at an undeniably pivotal time for 5G growth and uptake. On the path to 2 billion connections before the end of 2024, 5G is forecast to exceed the combined number of 2G and 3G connections by the middle of 2024 – an incredible accomplishment. Beyond simply reaching new users and enhanced scale, 5G will also connect with new industries and new use cases, and support will scale up in markets that have yet to launch the technology. This trajectory will continue through the medium term to 2030, when 5G will have commercially launched in 225 markets, compared to 109 markets at the end of 2023.

Figure 1: 5G adoption globally
Percentage of total connections

Source: GSMA Intelligence



* Australia, Japan, New Zealand, Singapore and South Korea

Despite its success, it is well acknowledged that 5G has yet to deliver on some of its foundational promises. Many of today's 5G eMBB services could be delivered by 4G networks. Meanwhile, new and innovative 5G use cases are still evolving and 5G monetisation remains a work in progress for many operators. This explains the intense interest in 5G's evolution. For some operators, this equates to a focus on 5G-Advanced and for others it means executing on new 5G capabilities such as the use of mmWave spectrum and 5G standalone (SA).

Of course, evolving today's 5G services and networks (i.e. bringing the 5G-Advanced era to life) will require new investments. More importantly, it will require the right investments. New RAN capabilities will be needed, including new antenna capabilities, reduced capabilities (RedCap), passive IoT, extended use of mmWave and improved uplink performance, among many other advancements. These are all well documented and the focus of extensive R&D, so we can expect these to be addressed; the RAN is an operator's top capex priority and always a focus.

Core network investment and innovation, however, is just as critical – if not more so. The mobile core, after all, enables and secures the services that are delivered to users via the RAN. It is responsible for supporting operator strategies around 5G monetisation along with simply meeting end-user requirements. To this end, we need to recognise what will impact mobile networks in the near and medium terms, and what this will mean for the evolution of the mobile core.

It's best to think about these evolutions in terms of service demands and their impact on core network capabilities. While end users will continue to consume more and more media, the formats will be increasingly diverse. Meanwhile, operators will continue to focus on B2B services as a critical 5G revenue upside. Across both the media and B2B service landscapes, however, the content and application requirements will become ever more demanding – unless key performance metrics are met, the services and applications will simply fail to work. Against this backdrop, the required core network capabilities follow logically. Performance of core network solutions will need to be boosted – increased user scale, increased upstream and downstream bandwidth, latency improvements, application and security scale – and distributing core network assets closer to the network edge will become an important component of meeting user requirements. And where service and application operations will be dependent on tight performance criteria, the core network will need to support deterministic networking, ensuring the right resources are available and orchestrated in line with requirements. Finally, pulling this all together will require an evolution from today's automation solutions to real intelligence across service, network and operations domains.

Table 1: 5G-Advanced era drivers and mobile core requirements

Source: GSMA Intelligence

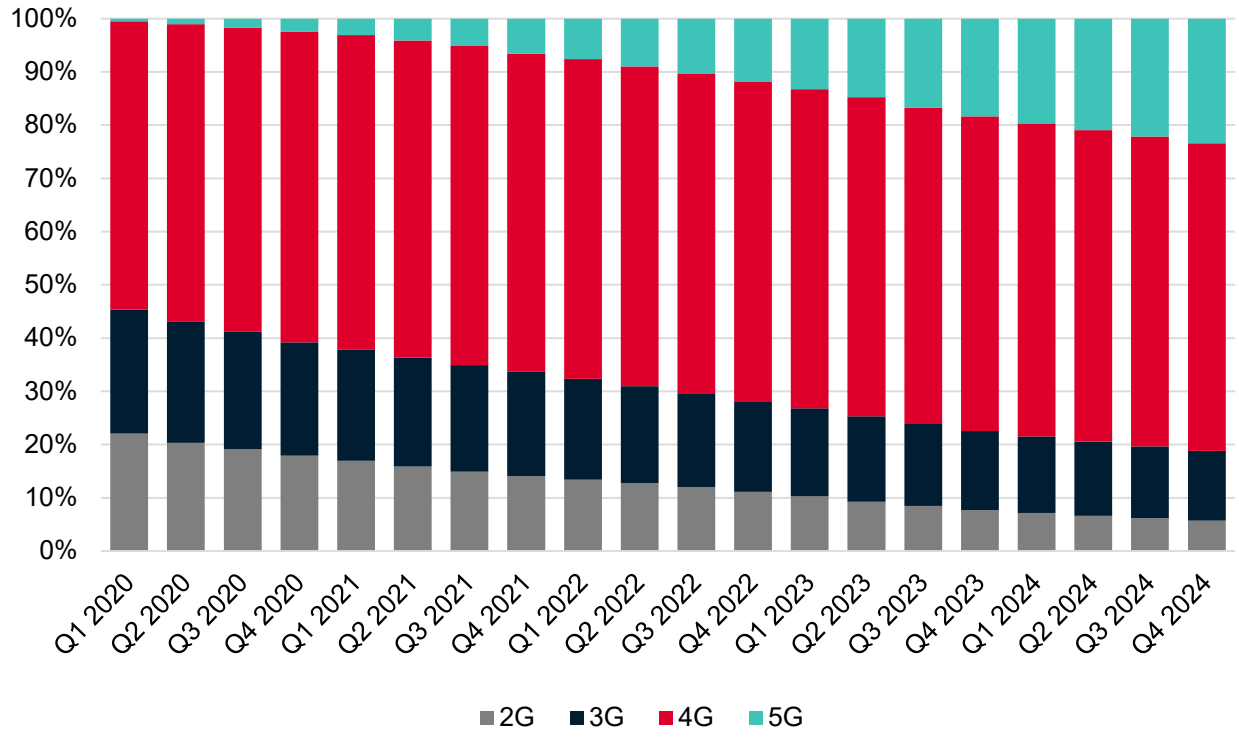
Service trends	Core requirements
Growing media usage	Boosted performance
Media diversity	Enhanced distribution
B2B service focus	Enhanced determinism
Demanding requirements	Native intelligence

1. 5G's evolution and the mobile core

2024 will mark the sixth anniversary of 5G services. By all accounts, the growth story has been remarkable: at the end of 2023, there were 1.6 billion 5G connections, commercial 5G service launches by 332 operators in 116 markets and 5G spectrum allocations in more than 95 markets. 2020 began with 5G representing less than 1% of global connections, but by the end of 2023 the number of 5G connections outnumbered that of 2G or 3G – and by the middle of 2024 it will outnumber 2G and 3G combined (see Figure 2).

Figure 2: Mobile adoption by share of technology
Percentage of total connections

Source: GSMA Intelligence

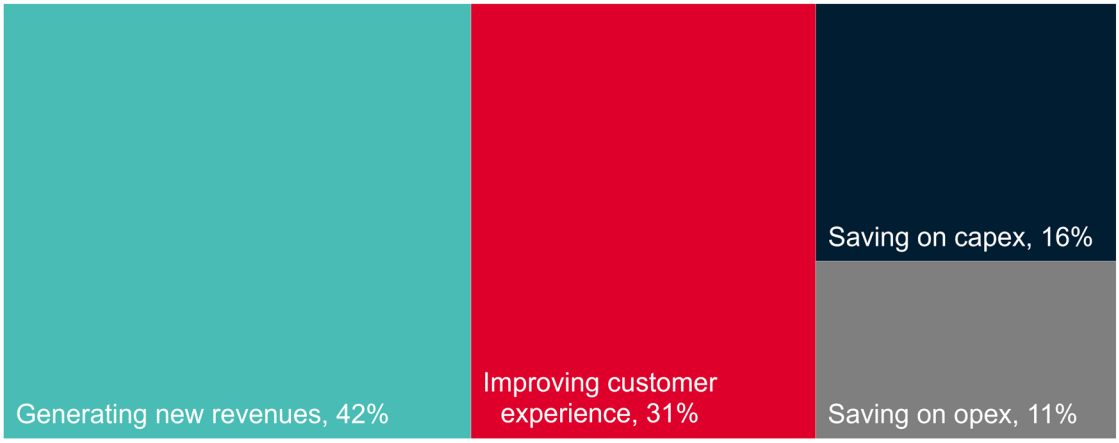


However, 5G has yet to fully deliver on one of its fundamental objectives: operator revenue growth and diversification. While some operators have seen an ARPU uplift following the introduction of 5G, global ARPU grew by less than 6% between the start of 2020 and the end of 2023, which is roughly on par with global price inflation in 2023. Meanwhile, and not surprisingly, operators continue to focus on business growth – driven by new revenues and improved user experience – as the core objective of their network transformation strategies, including 5G rollout strategies.

As a result, the next iteration of 5G, 5G-Advanced, is increasingly capturing operator attention as operators continue their search for new revenue streams and greater customer engagement.

Figure 3: How do operators measure network transformation strategy success?
Percentage of operators

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

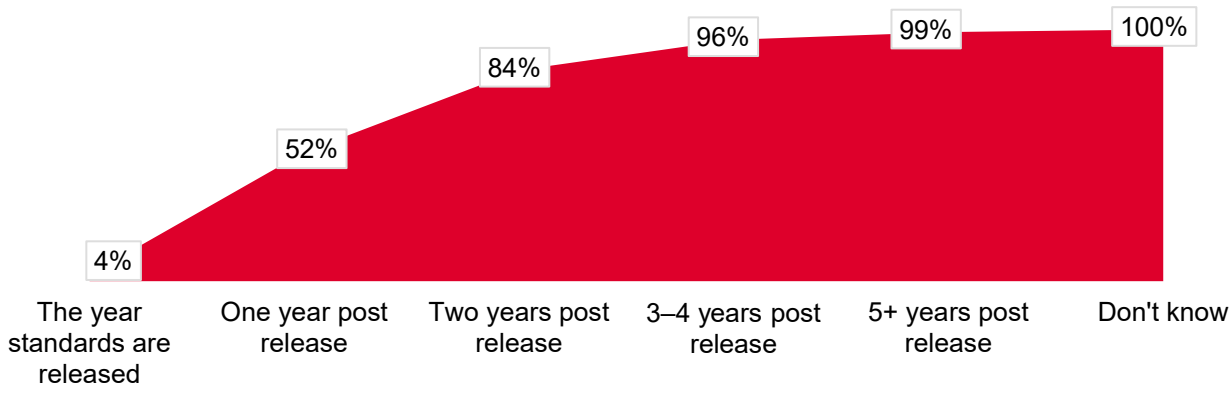


As part of the 3GPP's 5G standards, beginning with Release 18, 5G-Advanced will become part of the 5G era. And while new technologies don't necessarily ensure an uptick in revenues or customer engagement, 5G-Advanced is attempting to address this on multiple fronts: improved uplink performance to support new services; improved network capacity to support more services; low-cost IoT support thanks to RedCap; and integrated device sensing and positioning for new enterprise use cases. In short, 5G-Advanced delivers capabilities that should allow operators to extend today's 5G use cases and capture new opportunities which aren't currently possible.

Technology capabilities aside, operator interest in 5G-Advanced commercialisation is building. Most operators expect to roll out 5G-Advanced after two years of commercial solutions being available (see Figure 4), suggesting that the technology could be globally mainstream by 2027. This is likely an optimistic timeline though, as the actual timing of 5G-Advanced deployment will depend on monetisable use cases along with solution availability. Regardless, aggressive 5G-Advanced deployment plans signal an intense interest in the technology if nothing else.

Figure 4: When do operators plan to deploy 5G-Advanced?
Percentage of operators (cumulative)

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



5G-Advanced deployments will touch upon myriad parts of a telco's operations. New services will need to be developed and launched, new categories of devices will need to be sourced and supported and marketing campaigns will need to be created in order to drive visibility around the network upgrades. Ultimately, however, 5G-Advanced represents a network upgrade. As such, 5G-Advanced deployment and monetisation will begin with network infrastructure upgrades, including significant core network enhancements, which deserve special attention.

Why focus on the mobile core?

Traditionally, in any mobile network upgrade cycle, the RAN captures the most attention. This is understandable since the RAN maintains a direct touchpoint with end users and represents the largest capex component for many operators given the need to deliver solid coverage and capacity. Additionally, RAN innovation is often responsible for network efficiency or performance improvements.

The core connects RAN assets to networks and applications powering end-user services. This means that any given node in the core touches many more people than a single base station or even a region of base stations. It also means that the core needs to be network- and service-aware while also taking on the responsibility of securing end-user services. And, of course, it needs to be reliable, operating with little margin for downtime.

As we look to forecast the impact of 5G's evolution on the mobile core, we need to consider network capabilities and architectures, which imply specific network requirements. In particular, we look at service trends, including ever more demanding use cases, and the growing volume of increasingly diverse media, combined with the renewed focus on B2B services. These realities will lead to new requirements, including:

- core network performance enhancements to address new traffic and use cases
- greater core network deployment distribution to support traffic and use-case requirements
- deterministic performance support and embedded intelligence to manage the new era of 5G services and network infrastructure.

2. The need to think beyond standards evolutions

The development and rollout of fractional technology generations has been a reality since the early days of cellular networks. Initial GSM networks set the stage for EDGE, which was often referred to as 2.5G. UMTS, in turn, brought about 3.5G HSPA networks and services. And the impressive capabilities of initial 4G networks were extended with the advent of LTE-Advanced, carrying a 4.5G moniker.

The rationale for these upgrades has been fairly straightforward. Foundational network capabilities drive new user requirements, starting users on a path from which their wants and needs, and subsequently their usage of mobile networks and services, evolves. Initial technology rollouts may not be able to meet all the use cases originally planned for and so need to evolve as well. Operators, of course, know that each technology generation will be followed by another and, while waiting for that to materialise, expect some of the R&D for a new generation to trickle down to prior generations. We can expect to see the same dynamic play out with 5G.

End-user requirements and mobile use cases continue to advance. But at the same time, some initial 5G promises (e.g. deep penetration of enterprise verticals) have yet to materialise and may require new innovations to move forward. When asked about 6G, the majority of operators said they expect 6G R&D will be used to improve today's 5G networks (see Figure 5). In the meantime, standards evolutions set a clear timeline for the evolution of 5G. Beginning with 3GPP Release 18, 5G-Advanced represents that evolution.

Figure 5: Will 6G R&D efforts be used to improve 5G networks and solutions prior to 6G's launch?
Percentage of operators

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

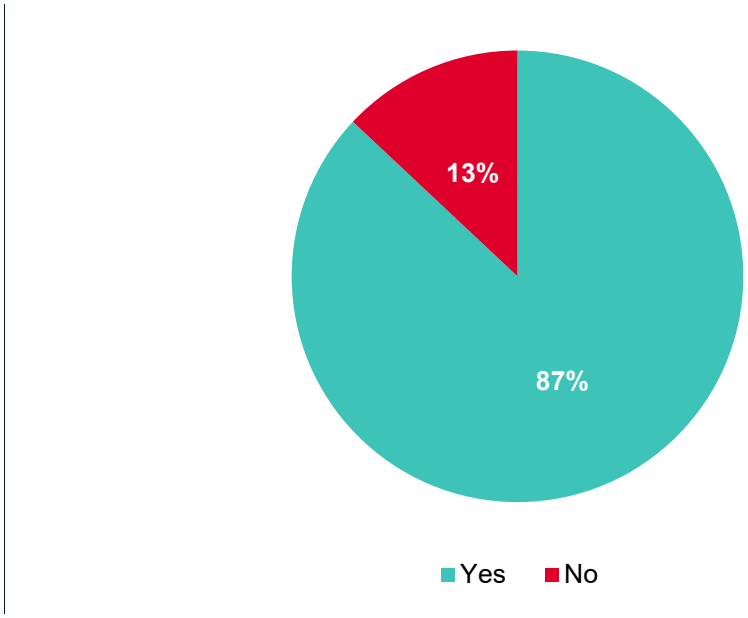
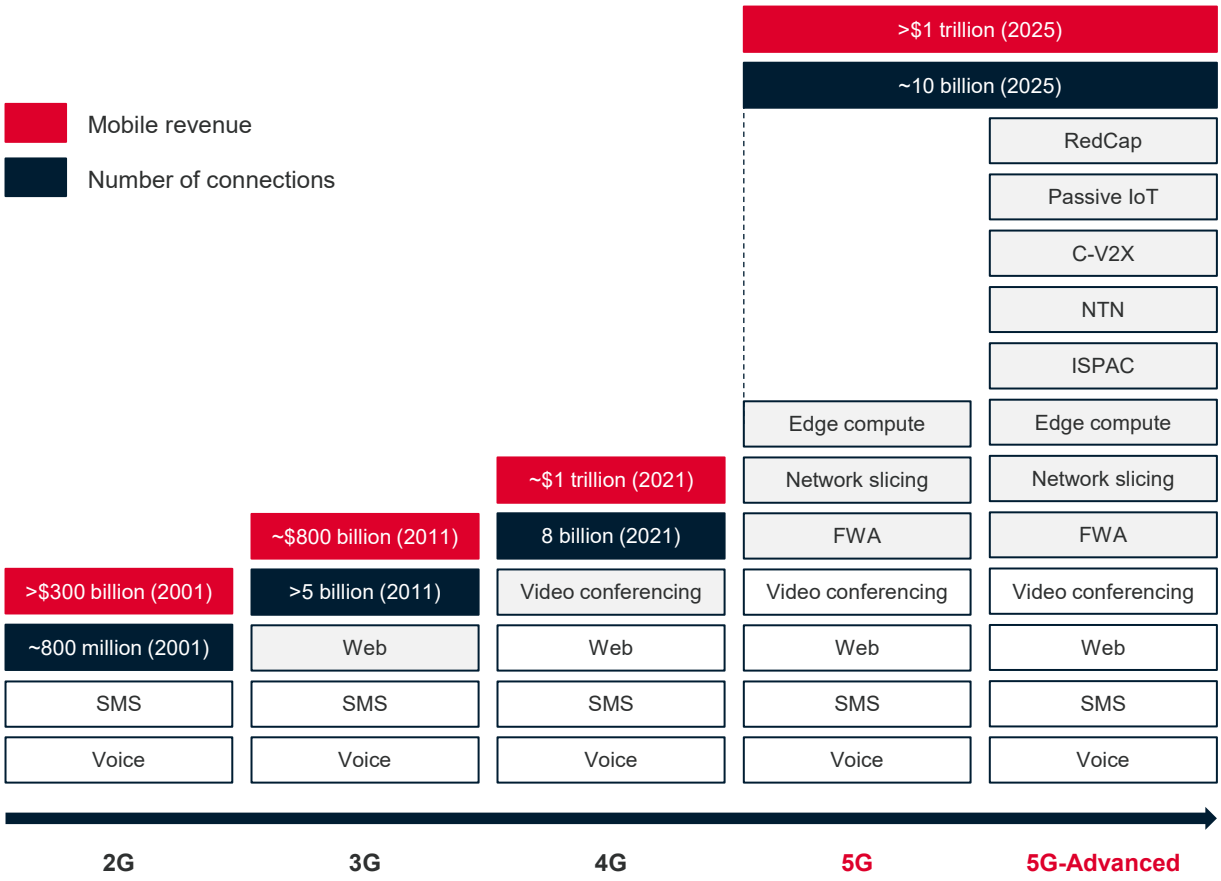


Figure 6: 5G-Advanced is the next step in the development of cellular technologies

Source: GSMA Intelligence



Note: List of technologies is not exhaustive

5G-Advanced marketing and messaging gained momentum in 2022 as the shape of the standard came into view and technology suppliers began vying for 5G-Advanced mindshare. As with every set of 3GPP standards and specifications, 5G-Advanced will include myriad features and capabilities – some major innovations, some more incremental. As highlighted in a GSMA report,[1] what 5G-Advanced will deliver can be grouped into three areas:

- **Performance improvements:** Advanced UL/DL MIMO, enhanced multi-carrier operations, enhanced mobility, sidelink relay support, integrated access and backhaul, evolved duplexing, time-sensitive communications.
- **Management and efficiency:** AI/machine-learning-driven designs, autonomous networks, operation and maintenance architecture and management functions.
- **Use-case enhancement:** Edge compute, positioning, extended reality, RedCap IoT, drone and satellite connectivity, multicast, personal IoT networks, vehicle-mounted relays, non-public networks, mission-critical and URLLC services, and 5G new calling.

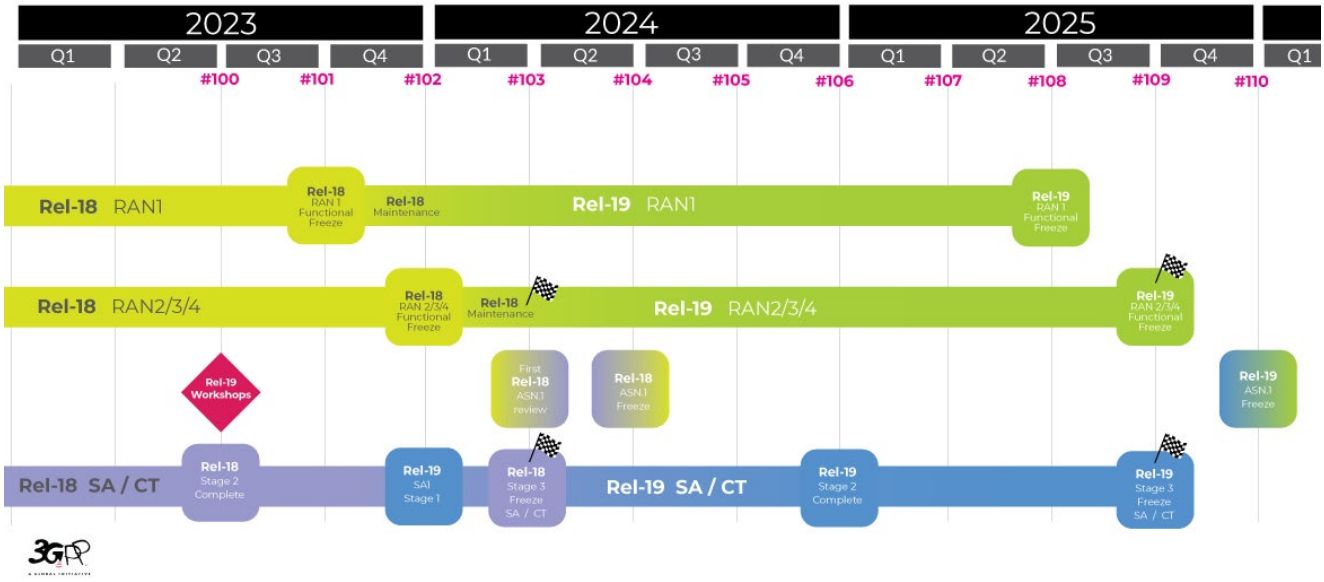
[1] 5G-Advanced: Shaping the future of operator services, GSMA, 2024

And yet, for all the (well-deserved) attention, the broader narrative of 5G's evolution is about more than just 5G-Advanced itself – it's something we might think of as the '5G-Advanced era'.

5G-Advanced represents an evolution of 5G, signified by a new set of 3GPP standards beginning with 3GPP Release 18. It has a specific meaning, including a specific set of capabilities, driven by the 3GPP's timelines. Operators, however, are looking to these technologies not just because of the standards they include (i.e. technology for the sake of technology) but rather as a means of meeting broader goals and requirements.

Figure 7: 3GPP release timelines

Source: 3GPP



For example, while new metaverse applications and satellite integration might attract much attention in 5G-Advanced messaging, the features that operators most value from 5G-Advanced include improved uplink performance and security enhancements, while low-cost IoT ranks as one of the top use cases. 5G-Advanced will certainly support these requirements, but so too can other 5G technologies, some of which are available today and are distinct from any 5G-Advanced specifications.

Table 2: Top three use cases and capabilities of 5G-Advanced

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

Priority use cases	Priority technology capabilities
5G multicast	Improved uplink performance
Low-cost IoT	Security enhancements
Satellite integration	Edge computing

This is a critical distinction. It highlights that whether or not an operator deploys 5G-Advanced they will need to evolve their 5G networks and operations with new capabilities, including:

- new spectrum, including mmWave
- new antenna technologies
- new network architectures, including cloud and edge
- new uses of AI and automation.

In this context, the use of a term such as '5G-Advanced era' makes sense, as near-term 5G network and service innovations will be about more than just 5G-Advanced. We will see plenty of 5G-Advanced innovations and network upgrades rolled out over the next few years. But we will also see a broad set of network upgrades and innovations applied to today's 5G non-standalone and 5G SA networks. And all of these will have implications for how 5G core solutions get planned and built.

3. Service trends that will impact the way core networks are built

Any discussion of network innovations and evolutions must begin with a careful consideration of service realities and future requirements.

It's important to remember that not all network transformation activities are directly in support of end-user services. Many non-service priorities – including capex and opex reduction, improved energy efficiency and improved supply-chain diversity – are involved in network infrastructure decisions. Yet, services and applications remain the most important considerations for how, and when, operators evolve their networks. These services – delivered to consumer or enterprise end users – are the primary way in which operators generate revenues. Networks, in turn, are built in order to support existing services and provide a foundation for the development of new ones. This is why generating new revenues and improving customer experience are the top two network transformation priorities for operators (see Figure 3). It's also why network innovations and evolutions so often link directly to fundamental service and user requirements such as faster speeds, higher capacity and better coverage. This is reflected in the findings from a GSMA Intelligence survey, in which operators were asked about the network capabilities that are most important for enabling consumer and enterprise use cases (see Table 3).

Table 3: Top three network capability priorities for consumer and enterprise use-case support

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

Enterprise services	Consumer services
Improved wide-area coverage	Improved wide-area coverage
Higher network speeds	Higher network speeds
Massive IoT capabilities	Massive IoT capabilities

Moving into the 5G-Advanced era, there are many diverse (and often competing) end-user requirements and service implications for operators to consider. However, several of these dominate and will directly impact how core networks evolve: increased media consumption and media diversity; a renewed focus on B2B services; and support for demanding use cases.

Media escalation

Media – and video specifically – represents the top type of traffic running across mobile networks. According to Sandvine,[2] video accounted for about one third of all mobile network downstream traffic in 2023. With social media applications in second place, however, it's clear that video likely plays an even larger role since much of social media usage centres on video. This is emphasised

[2] 2024 Global Internet Phenomena Report, Sandvine, 2024

by the fact that media- and video-focused apps dominated the list of top 10 apps in terms of mobile traffic volume (see Table 4).

Table 4: Mobile traffic volume by app category and app, 2023

Source: Sandvine

App category	
Video	35%
Social media	31%
Device gaming	7%
File sharing	7%
General web apps	5%
Communication	4%
VPN	2%
Television	1%
Audio	0.9%
Conferencing	0.2%

App	
YouTube	21%
Facebook	18%
Tik Tok	15%
Instagram	7%
Snapchat	7%
Netflix	6%
Disney+	2%
WhatsApp	2%
Telegram	1%
X (formerly Twitter)	1%

All indications suggest that this dominance will not only continue but grow further as video and other forms of media become the norm for what consumers want to consume and how people communicate with one another (particularly within hybrid work settings). This escalating media demand will drive the development of ever-richer content formats (e.g. 4K video, 8K video, glasses-free 3D) to cater to evolving user needs and compete for attention. Mobile network innovation will focus on supporting this traffic, but it's important to recognise the follow-on bandwidth requirements (see Table 5).

Table 5: Media application bandwidth requirements

Source: GSMA Intelligence

8K video	4K video	HD video	Mobile gaming	720p video conferencing	VoLTE call
50 Mbps	25 Mbps	5 Mbps	3–5 Mbps	3 Mbps	50 Kbps

Mobile network implications

- **Higher speeds**: Higher speeds are needed to support the demands of richer, higher-quality, media formats.
- **More capacity**: More capacity is needed to support the added content consumption across the user base.
- **Enhanced uplink**: Enhanced uplink is critical for supporting interactive media at increasingly higher resolutions.

Media diversification

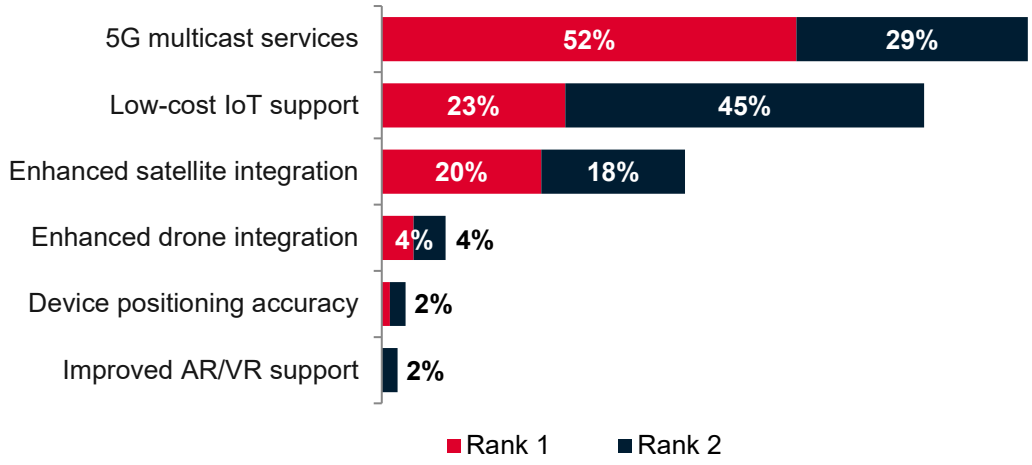
Table 5 highlights that growth in consumption won't simply be more people doing more of the same things; instead, the forms of media consumed will be increasingly diverse.

We can already see this evolution in action. Richer content – 4K video, 8K video, glasses-free 3D and business-critical video conferencing – is beginning to emerge and slowly move into the mainstream. In addition to this, video content is an increasingly important component of messaging and advertising content and there will also be future metaverse use cases. Building on this trend of media consumption diversity, new forms of media consumption will continue to be driven by a number of factors:

- **Networks:** New network capabilities (including 5G and 5G-Advanced) will provide the speeds, capacities and latencies to drive content format innovation.
- **Devices:** New device capabilities (including 5G, 5G-Adanced, processor innovation, form factor innovation and embedded AI) will allow for the consumption of innovative media formats.
- **Competition and innovation:** Efforts to capture end-user attention will require creators and brands to be innovative in the content they develop and deliver.

Figure 8: What is the most important use case for 5G-Advanced?
Percentage of operators

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



Theoretical content innovation might seem too abstract to be meaningful, but we are already seeing operators plan for new forms of content in the 5G-Advanced era. When asked about their top use case for 5G-Advanced, 5G multicast came out on top. We can also expect the intersection of existing content innovation trends, such as 3D content and interactivity, to result in new content categories. Meanwhile, the rise of generative AI as an increasingly mature technology across business and consumer landscapes will drive a greater volume of content along with new forms of content.

Of course, not every operator is the same. Many will not care about 5G multicast and some will find that AR/VR use cases are much more appealing as 5G-Advanced rollouts continue. Regardless, the need to support an increasing amount of increasingly diverse media types is not in question.

Mobile network implications

- **Speeds, capacity and uplink**: Speeds, capacity and uplink are needed to support the demands of new media formats and provide a foundation for richer formats in the future.
- **Media awareness**: The ability to detect use case and application requirements is fundamental to being able to meet the requirements of more diverse media.

5G B2B

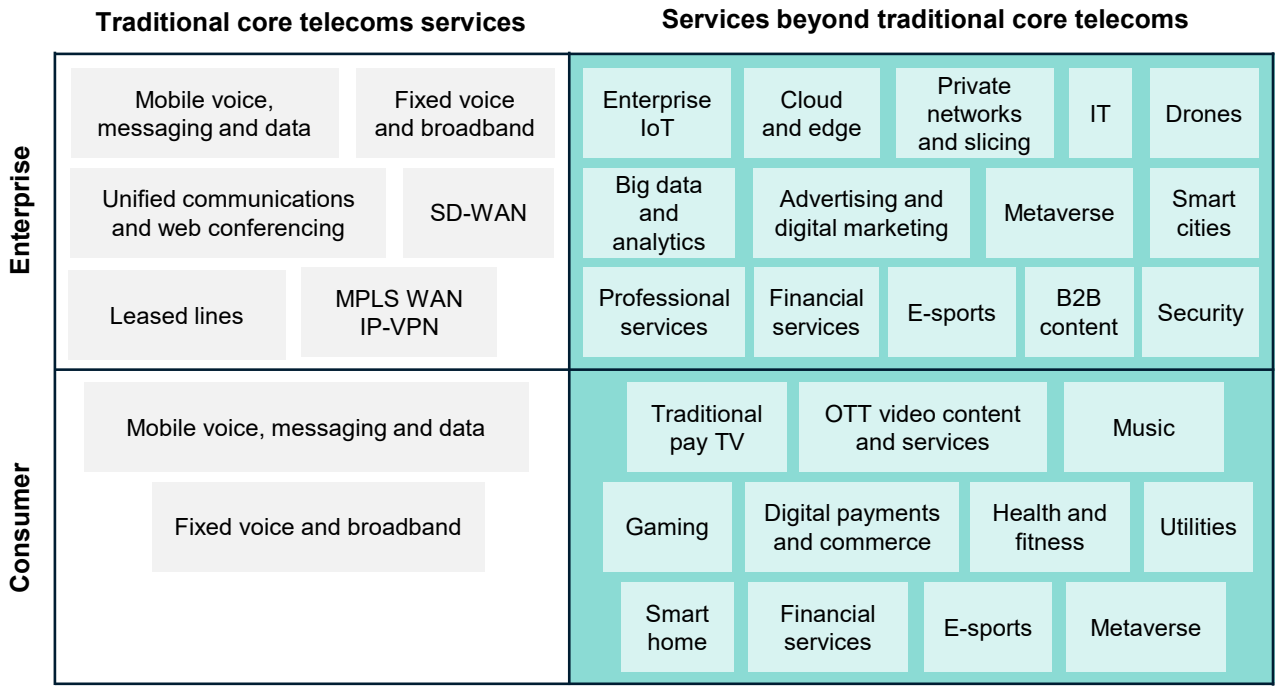
5G's penetration into enterprise verticals remains a work in progress. Efforts to expand the impact (and revenues) of mobile networks beyond their traditional consumer audience will not taper off any time soon.

One of the initial promises of 5G was that it would help operators to diversify their revenue base. Early explanations of 5G use cases highlighted that the technology would be used to support enhanced mobile broadband (eMBB) alongside ultra-reliable, low-latency communications (URLLC) and massive machine-type communications (mMTC). The latter two promised to help operators to meet exacting enterprise application requirements. In the process, this would allow operators to capitalise on the enterprise digital transformation opportunity and help to diversify their revenue base.

There are many diverse services beyond the traditional core business that telecoms operators are expanding into, spanning the consumer and enterprise segments. Enterprise verticals, though, are particularly attractive given the magnitude of the digital transformation opportunity, 5G's ability to support differentiated services in line with specific vertical requirements and the fact that B2B revenues remain a relatively small share of operators' overall revenues.

Figure 9: Segmentation of operator services

Source: GSMA Intelligence

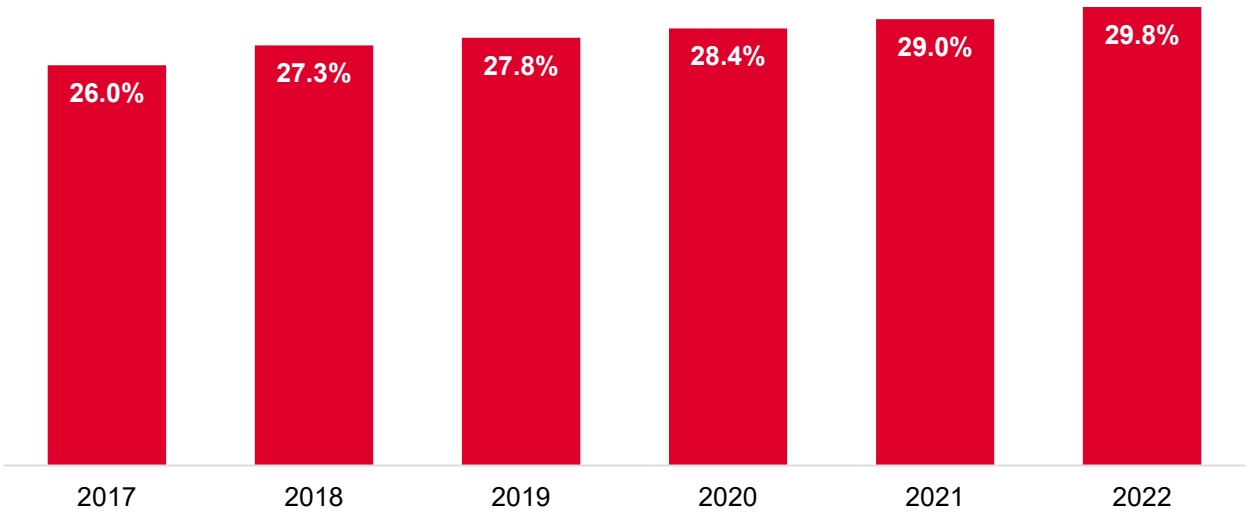


Note: List of technologies is not exhaustive

Progress is being made here, with the top operators having slowly grown their 'beyond core' revenues over much of the past decade. The same holds true for B2B revenues: in 2022, B2B revenues reached an all-time high of nearly 30% of total revenue.

Figure 10: B2B as a share of total revenue among the top 12 operator groups

Source: GSMA Intelligence



Unfortunately, this progress has been slower than many had hoped for, with key components of the 5G B2B story still unfulfilled across many regions. Network slicing is still not commonly offered as a commercial proposition. The same holds true for URLLC. Meanwhile, network functionality exposure via APIs – key for enabling developers to support enterprise requirements by tapping into 5G's capabilities – has only recently begun to gain traction. And 5G SA, a precursor for executing on 5G use cases beyond eMBB, is still not broadly deployed.

But despite uneven progress, B2B service and solution sales will only grow as a focal point for operators. New network capabilities will put operators in a better position to cater to enterprise requirements. The continued rollout of 5G SA and 5G mmWave will be one part of that. 5G-Advanced will bring myriad B2B-focused enhancements, particularly in terms of IoT support, including RedCap IoT, passive IoT, and integrated device sensing and positioning. New device capabilities – always a gating factor on service support – will emerge in order to take advantage of network advancements. Beyond any technology shifts, however, the greatest drivers of a renewed focus on B2B services will be business-oriented. As B2B use cases mature, they will better target real-world market requirements. As 5G spreads into new geographies, new B2B use cases and applications will emerge, expanding the B2B 5G addressable market. As operators continue to focus on revenue growth as their top strategic priority, the enterprise digitalisation opportunity will be too great to ignore.

Mobile network implications

- **Speeds, capacity, uplink and awareness**: In line with the demands of a growing volume of increasingly diverse media traffic, B2B use cases will require network capacity enhancements with an ability for operators to detect use-case requirements on a real-time basis.
- **Latency**: Low latency is not a prerequisite for all enterprise use cases, but it is critical for many of the high-value ones.
- **Security**: The integration of 5G into business processes will only succeed if enterprises know that connectivity is secure; mobile networks will need to deliver on that.

Service demands and demanding services

In addition to the evolution of media consumption and 5G B2B service trajectories, one other service implication is clear: service and use-case requirements will become increasingly demanding, with less tolerance for delivery of sub-par performance.

We have already seen this evolution in service requirements with the introduction of 5G, and even with 4G. In part, this is based on the expectations of users; in many cases, 'best efforts' is no longer sufficient to keep customers satisfied, particularly when an operator is hoping to monetise 5G investments by upselling customers on the newer technology. Working with Qualcomm in 2022, GSMA Intelligence analysed consumer survey data from 4,500 customers across nine countries and saw real proof of how user expectations impact service adoption. When asked about the factors that would drive them to adopt a premium 5G service package, the most important factor for consumers was a simple one: reliable, drop-free connectivity. Compared with broad support for new use cases, the next most important factors all invoke some degree of meeting specific service requirements.

Beyond consumer sentiment, however, it's also true that many increasingly common use cases and applications bring stringent requirements. VoLTE, for example, brings requirements in terms of latency and uplink capacity. Streaming and interactive video simply won't function if connection speeds cannot support resolution requirements. And specialised enterprise use cases may involve any number of specialised service requirements e.g. the security, latency and uplink capacity factors noted earlier, high-speed mobility or powering and reliability/coverage requirements. As mobile connectivity becomes more and more foundational to business operations and everyday digital lives, this trend will only accelerate.

While we highlighted an evolution in use-case requirements earlier, there is an important distinction to make here. The issue is not applications performing poorly when networks cannot support customer needs, but rather applications that can't be monetised because they do not meet customer service-level agreements (SLAs). If operators hope to extract added value from 5G's added capabilities, the customers paying a premium for these capabilities (consumer and enterprise) will need an assurance of delivery.

Mobile network implications

- **All of the above:** Networks that can deliver on the requirements previously noted (higher speeds, uplink capacity, latency, security and service awareness) are foundational to supporting an evolving set of services.
- **Service visibility and assurance**: If operators have any chance of generating 5G revenues based on the promise of supporting specific connectivity metrics, they will need visibility into what they have delivered and be able to share this with customers.
- **Determinism:** Aside from visibility into what an operator has delivered (and can deliver), executing on demand for services attached to demanding specifications will require an ability to engineer services – in an efficient way – with certainty that they will meet those specifications, even in the face of competing demands across diverse user groups.

4. How an evolved 5G core will be impacted by service trends

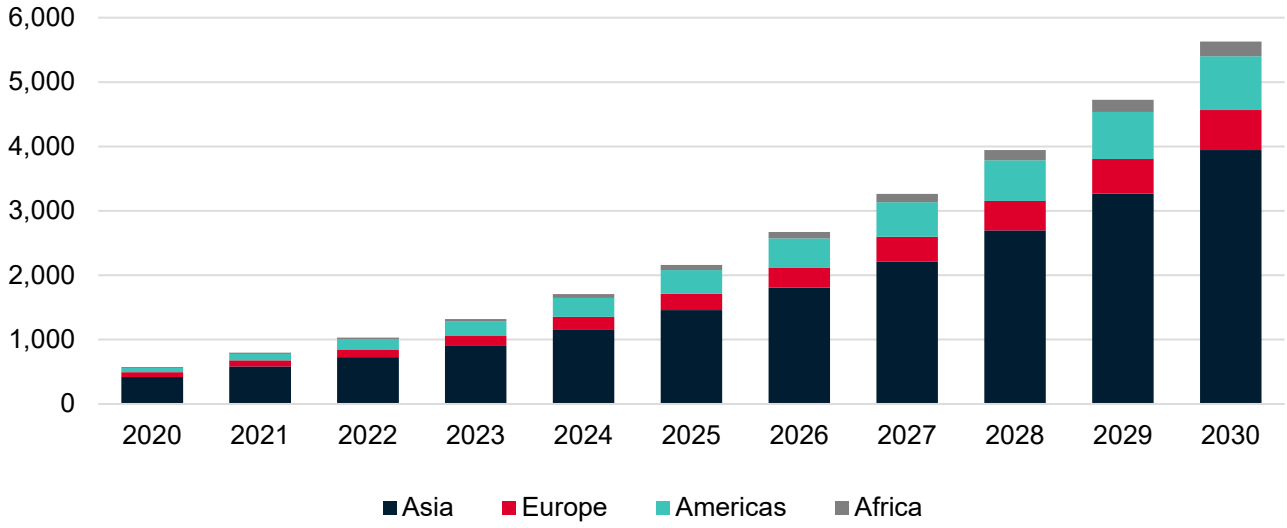
It goes without saying that service trends and user requirements aren't self-fulfilling. Without the right business, network and operational resources in place, the result will be unsatisfied end users, customer churn and missed revenue opportunities. How, then, should we think about the future of the core network against the backdrop of evolving 5G service requirements?

Boosted performance

Even without new applications or 5G-Advanced era use cases, simply bringing more users onto 5G will sustain network upgrade trajectories. In the simplest terms, 5G core networks will need to deal with higher traffic volumes from a broader set of users. This reality is reflected in both mobile data traffic forecasts and IoT connections forecasts.

Figure 11: Mobile data traffic by region, 2020–2030
EB

Source: GSMA Intelligence



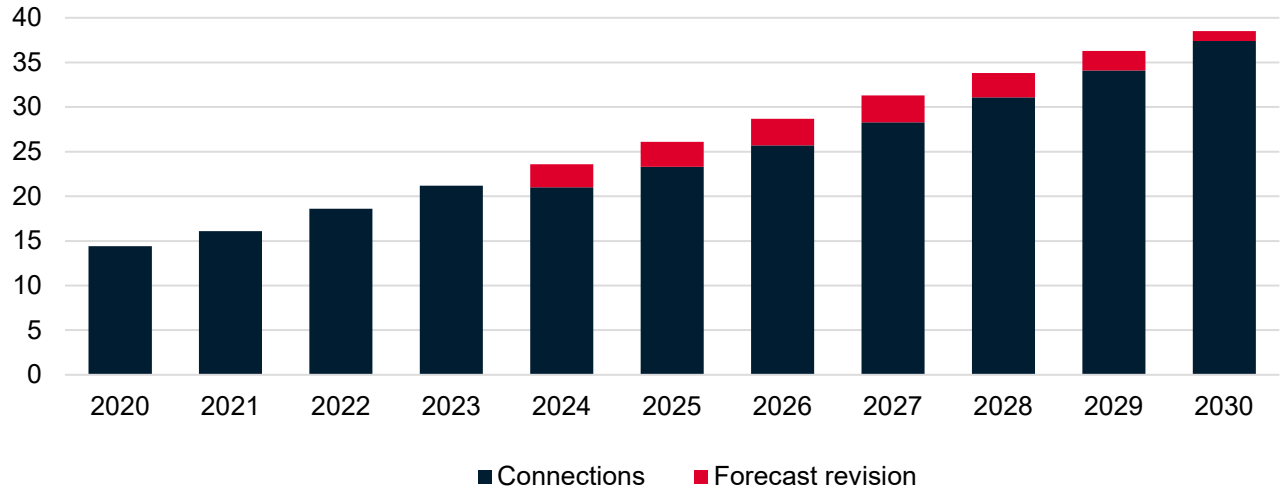
As end users adopt 5G, they will naturally consume more data, whether this is because of an enhanced ability to access higher-bandwidth services or because of tariffs that encourage data usage (e.g. many 5G tariffs include or favour unlimited data usage). This is a large part of the explanation for an expected 10× increase in annual mobile data traffic between 2020 and 2030.

Conversely, IoT connections do not necessarily carry massive data volumes; while some IoT use cases are data-intensive, such as high-definition video analytics, many more derive value from passing small amounts of telemetry, control or signalling data. But the sheer scale of IoT devices will dwarf the number of people on mobile networks, representing an increase in the magnitude of connections that the 5G-Advanced era core will need to support. Furthermore, after a period of overinflated expectations, which drove IoT uptake forecasts down, near-term growth is now estimated to surpass previous expectations: GSMA Intelligence forecasts that the number of IoT

connections in 2024 will likely be 12% higher than originally expected. The future 5G core will therefore not only need to accommodate a growing number of mobile connections, but also an accelerated growth trajectory for the number of IoT connections.

Figure 12: Number of IoT connections, 2020–2030
Billion

Source: GSMA Intelligence



Of course, as discussed earlier, the future will not simply involve more of the same in terms of mobile use cases and traffic. Increased user scale and IoT uptake will indeed drive 5G connections growth to unprecedented levels and this connections growth will also fuel unprecedented levels of data traffic. However, this will all take place within the context of new use cases that will be more demanding in terms of their own requirements: uplink and downlink speeds, uplink and downlink capacity, security and latency. From an evolved 5G core perspective, then, the ability to support tomorrow's users and use cases will depend on boosted performance over today's mobile core in nearly all aspects.

5G-Advanced era core requirements

- **Cloud native**: 5G has made the move to a cloud-native core a necessity. 5G-Advanced era service requirements will only serve to accelerate the value (and importance) of cloud-native technologies in the mobile core.
- **Capacity**: While individual RAN assets touch hundreds of users, core assets touch millions. Mobile core capacity – bidirectional – will need to scale up substantially in order to meet customer requirements going forward.
- **Latency**: Improved 5G airlink latency will be meaningless without a low-latency core.
- **Security**: Securing future 5G services will require device innovations, along with security-focused business processes. Core networks, in turn, will need to be trusted with a robust array of built-in security functionalities.
- **Scalability**: Beyond the need for a 5G-Advanced era mobile core to support boosted capacity, it will need to be able to scale up capacity in a flexible manner. In particular, it should be able to turn up, or wind down, capacity and network functions as service requirements (rapidly) evolve.

Extended distribution

Among the core network requirements noted above, the final one relates to scalability (in terms of capacity and number of users), but more specifically to flexible scalability. Operators will need the ability to scale core capacity up and down as demands evolve. The same need for flexibility also applies to where this capacity resides.

Returning to the earlier discussion of 5G-Advanced era service demands, the trend was richer and more demanding services with a push into the enterprise. This means delivering to specific customer demands when, and where, they are required. Placing workloads where they are required subsequently implies extended network distribution. This builds on today's use of distributed edge computing in support of lower latencies, data security and sovereignty, transport cost savings and energy efficiency.

The value of edge networking in the mobile core is already well understood. As a product area supporting success with B2B sales, edge computing is seen by operators as second only to cloud computing (which increasingly includes distributed functionalities). When operators were asked who they prefer to work with on edge networking, network OEMs came out as the top choice, with nearly twice as many operators choosing network OEMs over the next most popular potential supplier (industrial solution suppliers). This implies that operators view edge networking through the lens of their own networks as an integral part of their core.

Figure 13: Who is your preferred partner for edge networking deployment?
Percentage of operators

Source: GSMA Intelligence Operators in Focus: Enterprise Opportunity Survey 2023

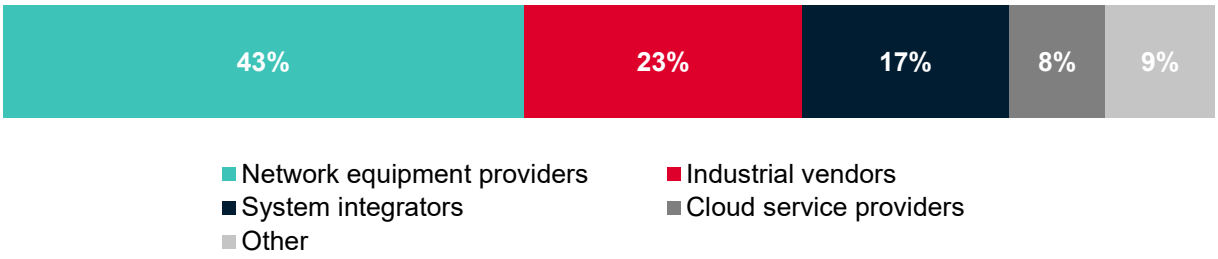
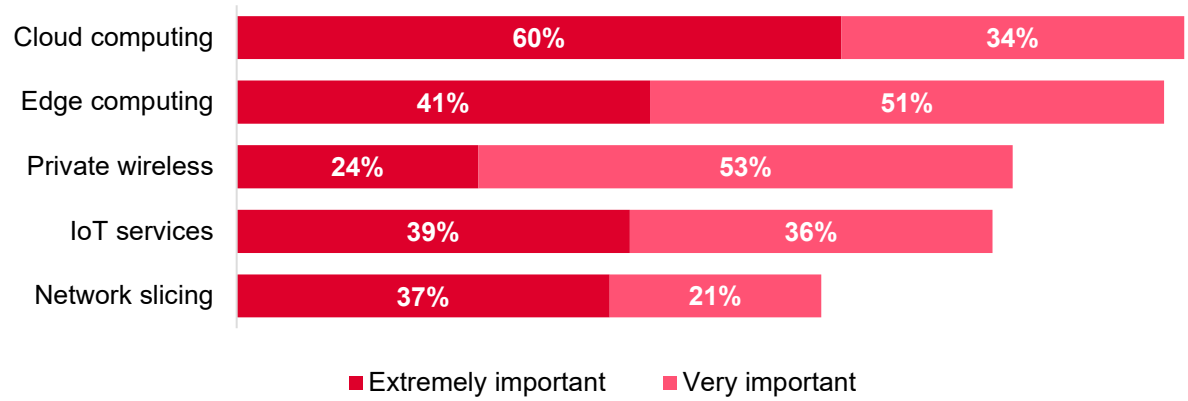


Figure 14: How important is each product area for your B2B sales success?
Percentage of operators

Source: GSMA Intelligence Operators in Focus: Enterprise Opportunity Survey 2023

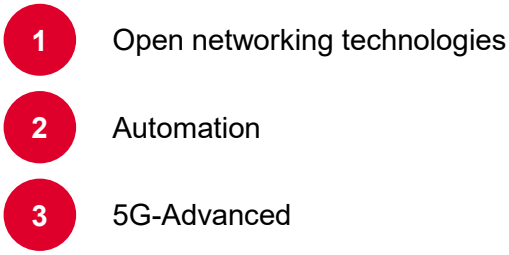


The focus on edge networking as integral to mobile core priorities will only get stronger in the 5G-Advanced era. A number of factors will make a distributed core and edge integration particularly important: more users driving more traffic across different network layers; increasing media volumes that the edge will need to cater to; stricter latency requirements; stricter security requirements; more B2B users and an interest in keeping traffic close to demanding vertical use cases; increased energy efficiency pressures; and a need for the core and edge assets to be integrated into open architectures.

These last two factors deserve additional attention since they represent rather new dynamics. As part of efforts to improve their sustainability profiles, meet net-zero targets and keep energy-related opex in check, operators have been implementing diverse energy-efficiency strategies for several years. Recent GSMA Intelligence research suggests that the use of edge computing (versus processing traffic deeper in the core) can support those efforts thanks to processing and backhaul power savings. At the same time, while sustainability remains a top business priority, the top network technology priority for 2024 is open networking technologies, underscoring the interest in, and need for, the core to be 'open' i.e. interoperable in a multi-vendor framework. As 5G extends to further vertical industries and new use cases supported by myriad suppliers, this is only logical.

Figure 15: Top three technology priorities for operators' network transformation strategy

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



5G-Advanced era core requirements

- **Edge capacity and performance**: Demand for enhanced edge use cases and applications means that operator edge resources will need the same sort of performance boost as the rest of the mobile core. Core network strategies and investments will need to account for this.
- **Edge and cloud**: Edge demand will not come at the expense of cloud demand; both will be needed. More importantly, edge and cloud resources will need to be orchestrated into a multi-cloud solution capable of siting content when and where it's needed.
- **Media-native edge**: The need for application and service awareness in future 5G networks will extend to edge networking deployments, with media deserving much attention. Where edge nodes serve up popular or latency-sensitive media, for example, native media caching and media relay functions will be important for ensuring that the right content can be placed on and delivered from the most appropriate nodes at the right time.
- **Open architectures**: As with native media awareness, open and interoperable 5G edge architectures – multi-cloud and multi-vendor – will support delivery of the right content and connections to the right people at the right time.

Ensured determinism

Building on the 5G-Advanced era service trend of increasingly demanding use-case and application requirements, the core network requirement is clear: support for deterministic networking.

At its simplest, deterministic networking refers to an ability to deliver assured network capabilities and performance criteria based on use-case requirements. This means engineering, or configuring, network performance levels on par with dedicated connections in order to ensure that network performance meets service demands. As Ericsson described in an announcement earlier this year, the objective is delivering differentiated connectivity services by managing conflicting intents to meet the desired business outcomes.

Determinism in telco networks is not a new concept but will become increasingly important in the 5G-Advanced era for a number of reasons:

- **Demanding requirements:** Many mobile services and use cases have specific network performance requirements and limited tolerance for deviating from those requirements. This is not an issue of services performing poorly, but rather not performing at all or not meeting the agreed-upon SLAs.
- **Consumer RoI:** More than simply supporting new services as a part of existing service packages, operators will want to monetise their ability to deliver on exacting requirements. Earlier, we saw that consumers have expressed a willingness to pay for enhanced reliability. Monetising metaverse and gaming applications implies a need to deliver deterministic performance.
- **Enterprise RoI:** More so than consumers, enterprise verticals represent a huge monetisation opportunity if operators can deliver guaranteed, deterministic performance in line with specific application requirements. Enterprises can calculate the value of an application in clear, monetary terms and understand what they would pay for having performance requirements met.

5G was built to help operators monetise new network capabilities by supporting use cases and applications with specific performance requirements. Guaranteeing that those performance requirements are met will be key; unless SLAs can be met, any hopes of monetising network capabilities are misplaced. For example, slicing promises support for multiple virtual networks on top of a 5G infrastructure with each 'slice' configured based on the specific needs of a given customer. But if the resources are not available to accommodate those needs, then the value proposition does not exist. Without being able to offer slicing at scale, performance promises need to be made in a deterministic manner.

5G-Advanced era core requirements

- **Service visibility and network visibility**: Any ability to accurately provision services with a guaranteed level of performance requires a complete and real-time view of the services being delivered (or promised) along with the current state of the network, including resources available. As this touches users and resources across the network, it needs to be driven from the core, connected into billing and operations.
- **End-to-end visibility**: While visibility solutions will be grounded in the core and tied into billing and operations systems, they need to have visibility of the network well beyond the core: indoor and outdoor RAN assets, public and private networks, and

edge and cloud. Where end-user services include all of these assets, any network visibility solution will need to touch them all.

- **Assurance and orchestration**: Ultimately, determinism is tightly linked to service assurance, focused on ensuring services adhere to customer-facing criteria (such as commercially binding SLAs) within the context of network resources. Against the backdrop of myriad new complex 5G services, assurance will need to rely on orchestration that can abstract network complexity and allow policies to be set in business terms which speak to service requirements.

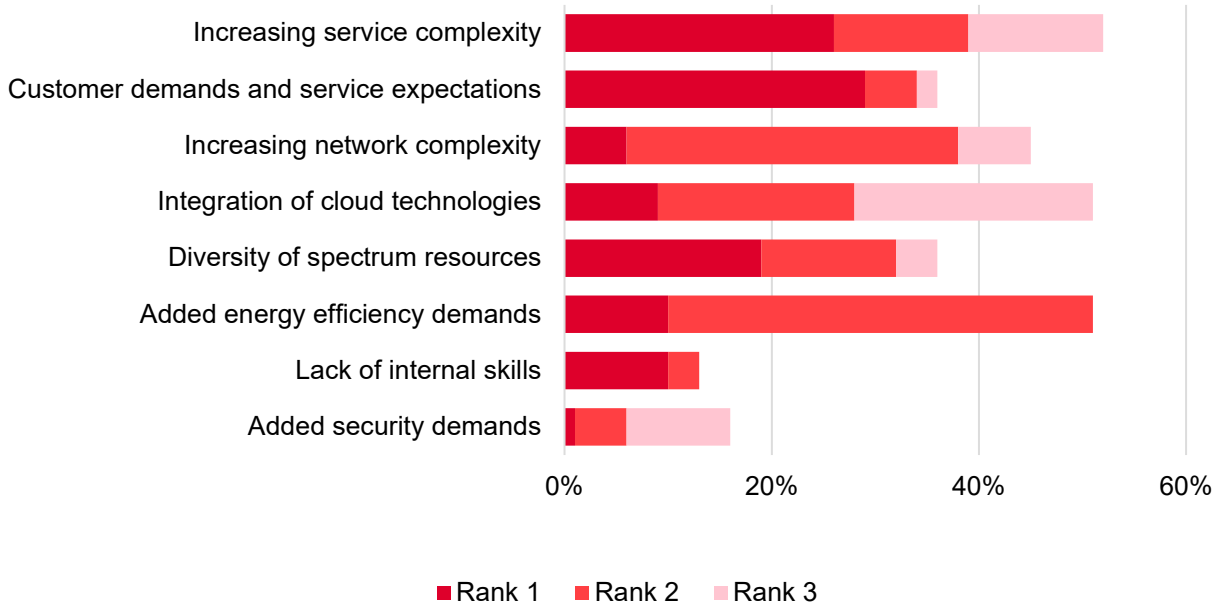
Native intelligence

Service and demand evolutions include increasingly diverse sets of users consuming increasingly diverse types of content with increasingly demanding application and use-case requirements. Core networks will therefore need continued performance enhancements, native support for distributed networking and an ability to deterministically deliver the performance demands attached to a given service or use case. The result of these requirements is added complexity, including more complex network architectures and complex service structures and requirement hierarchies. Core networks, for example, will need to seamlessly support edge and core resources across services that may be more or less latency- and bandwidth-sensitive. Operators will need to continually maintain these increasingly complex networks.

Operators already understand the rise in complexity that they are facing. Increasingly demanding end users, increased service complexity and increased networking complexity comprise the top three drivers for telco network automation.

Figure 16: What are the primary drivers of automation across network assets?
Percentage of operators

Source: GSMA Intelligence Operators in Focus: Automation Survey 2023



While automation can create pre-determined instructions for the performance of repetitive tasks, intelligence is needed to deal with evolving service and network trends. Beyond repetitive tasks, networks need to be able to dynamically make their own decisions – by leveraging AI tools such as machine learning and natural language processing – in order to deal with the inherent complexity in tomorrow's services and networks. Perhaps more importantly, intelligence cannot be siloed, existing only in one domain. To develop, provision, maintain and assure the diverse services that end users want to consume, intelligence will need to span the telco core, touching the network infrastructure, its operations, maintenance and the service resources.

5G-Advanced era core requirements

- **Network intelligence**: As higher-performing and more distributed core infrastructure is deployed, intelligent solutions will be critical for the rollout, placement and management of these new and rapidly evolving resources.
- **Operations intelligence**: After planning and deploying a network, core network operations intelligence becomes critical to deliver on various requirements: ensuring network uptime and reliability; predicting the resources needed in line with (real-time) demands; provisioning those resources, and making decisions about trade-offs, in line with demands and use-case requirements; maintaining network resources and uptime; and doing all of this in a secure manner. Against the backdrop of increasing complexity, none of this will be possible with mere automation.
- **Service intelligence**: Building and operating future 5G core networks will be meaningless unless they connect with and understand the services running over them. Alongside network and operations intelligence, service-level intelligence will make it possible to launch and provision new services, with an informed understanding of network capabilities – all in an efficient manner and against the backdrop of scarce human capital to deliver on these tasks manually.

Looking ahead: the 5G core of tomorrow

Preparing for tomorrow's 5G core requirements might seem like a gargantuan task or outsized investment. But with core networks representing a fraction of RAN capex, the magnitude of the spend should not be the focus of operators. Instead, operators need to consider the undeniable primacy of 5G-Advanced era core network innovation in supporting end-user requirements and operator monetisation opportunities, which need to be a critical part of network strategy.

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