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Ericsson Mobility Report

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Letter from the publisher

5G standalone brings new opportunities

Continued strong uptake of 5G, with around 600 million new subscriptions added globally during 2023, shows that demand for high-performance connectivity remains resilient in the face of ongoing economic challenges and geopolitical unrest in some markets.

The majority of networks deployed so far are 5G non-standalone, but an increasing number of communications service providers are deploying 5G standalone (SA). It offers greater possibilities to support new and more demanding use cases for both consumers and enterprises. Only with standalone architecture can 5G use cases requiring time-bound latency, higher speeds, capacity or benefits from network slicing be achieved. To date, more than 40 service providers have deployed or launched 5G SA in public networks.

5G deployment is far from complete. Further densification of 5G mid-band sites is needed for the full 5G experience. By the end of 2023, it's estimated that 5G mid-band will be deployed in around 30 percent of existing 4G sites globally.

In this edition of the Ericsson Mobility Report, we take a closer look at a large-scale deployment of mid-band 5G SA in India, where the service provider aims to capture the new business opportunities 5G offers for both consumers and enterprises.

The ongoing surge in data traffic remains a strong driver of demand for mobile networks. Most traffic is generated indoors, where people typically spend the majority of their time. There is, however, a growing need to extend 5G mid-band coverage indoors to ensure a comprehensive 5G experience. This edition explores how demand for indoor connectivity drives the need for enhanced network performance.

In the manufacturing industry, wireless connectivity is becoming a key determinant of production-line output, as factory processes cannot withstand intermittent network delays or areas with no coverage. We explore this topic by examining how 5G enables the agility required to support rapid changes and the reallocation of factory resources in modern gigafactories and green steel plants.

I trust that you will find this report engaging and that it offers valuable insights as we navigate the evolving landscape of 5G.

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Forecasts

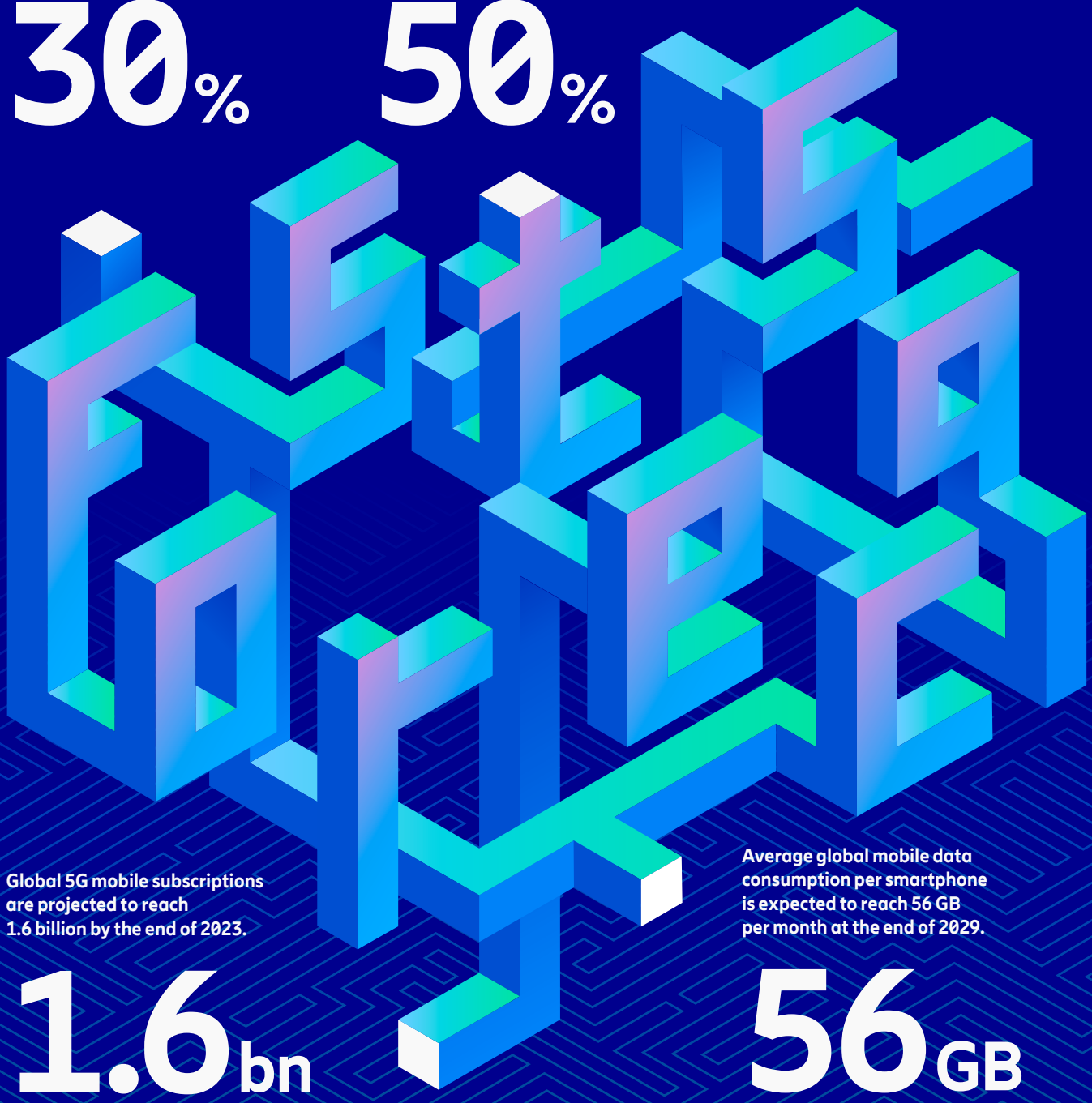
The focus on 5G mid-band is intensifying, with deployments in several regions contributing to global population coverage reaching 40 percent by the end of 2023. 5G subscriptions are rising in every region, including Sub-Saharan Africa, which is the focus of this edition's closer look forecast. Despite this global 5G growth, our forecast exploring sustainability in ICT shows that carbon footprint per subscription has not risen.

5G mid-band coverage outside mainland China has increased from 10 percent in 2022 to around 30 percent at the end of 2023.

30%

Half of all service providers offering Fixed Wireless Access (FWA) now offer the service over 5G.

50%



Global 5G mobile subscriptions are projected to reach 1.6 billion by the end of 2023.

1.6 bn

Average global mobile data consumption per smartphone is expected to reach 56 GB per month at the end of 2029.

56 GB

5G mobile subscriptions to exceed 5.3 billion in 2029

During the third quarter of 2023, 163 million 5G subscriptions were added to make up a total of 1.4 billion.

Service providers continue to deploy 5G despite a weaker global economy and geopolitical uncertainties. Around the world, about 280 service providers have now launched commercial 5G services, and more than 40 have deployed or launched 5G standalone (SA).[1] The most common 5G services launched by service providers for consumers are enhanced mobile broadband (eMBB), Fixed Wireless Access (FWA), gaming and some AR/VR-based services.

North America leading 5G subscription growth

The uptake of 5G subscriptions[2] in North America continues to be strong, and at the end of 2023 the region is expected to have the highest 5G subscription penetration globally at 61 percent. In North East Asia, penetration is anticipated to be 41 percent, followed by the Gulf Cooperation Council (GCC) countries at 34 percent and Western Europe at 25 percent. 5G subscription growth has also been higher than expected in India, and 5G penetration of 11 percent is expected by the end of 2023. Global 5G subscriptions are forecast to reach 1.6 billion by the end of 2023, accounting for 18 percent of all mobile subscriptions.

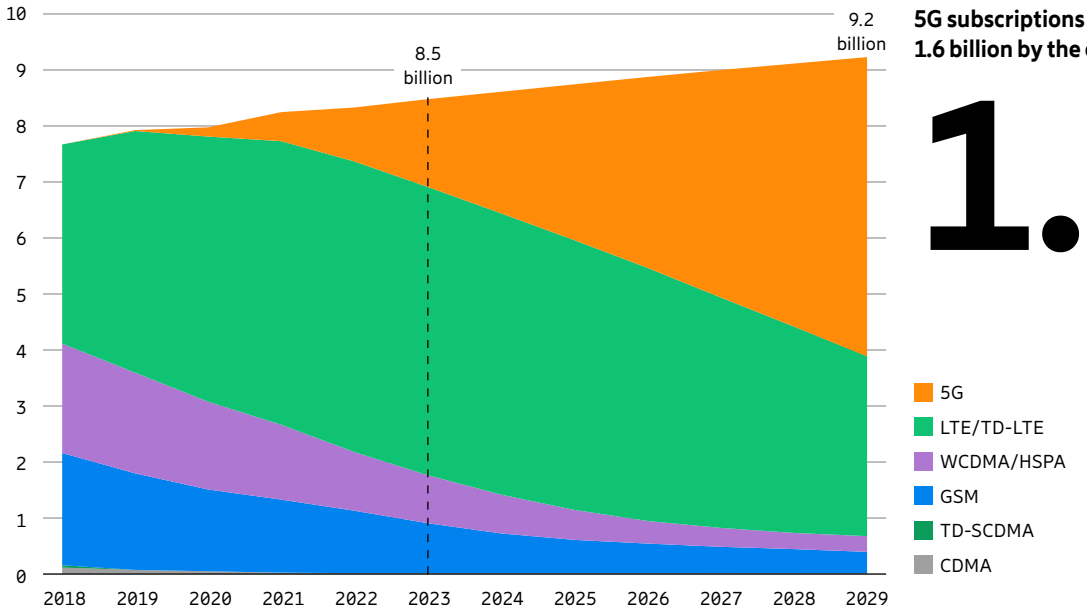
5G will become the dominant mobile access technology by subscription in 2028. Global 5G subscriptions are forecast to exceed 5.3 billion in 2029, making up 58 percent of all mobile subscriptions at that time. It is projected that North America and GCC will have the highest 5G penetration in 2029 at 92 percent, followed by Western Europe at 85 percent.

Subscriptions for 4G increased by 6 million during Q3 2023, totaling 5.2 billion. 4G subscriptions are at their peak, and are now projected to decline to around 3.2 billion by the end of 2029, as subscribers migrate to 5G.

During the third quarter, 3G subscriptions declined by 61 million, while GSM/EDGE-only subscriptions dropped by 55 million and other technologies[3] decreased by about 2 million.

China had the greatest net additions of subscriptions during the quarter with 13 million added, followed by India with 12 million added, and then the US with 3 million added.

Figure 1: Mobile subscriptions by technology (billion)



5G subscriptions are forecast to reach 1.6 billion by the end of 2023.

1.6bn

[1] 1 GSA and Ericsson (November 2023).
[2] A 5G subscription is counted as such when associated with a device that supports New Radio (NR), as specified in 3GPP Release 15, and is connected to a 5G-enabled network.
[3] Mainly CDMA2000 EVDO, TD-SCDMA and Mobile WiMAX.

5G adoption continues, despite weak smartphone market

5G continues to increase its share of the overall smartphone market. 5G devices capable of supporting new network functionalities will enable services beyond mobile broadband.

5G adoption continues

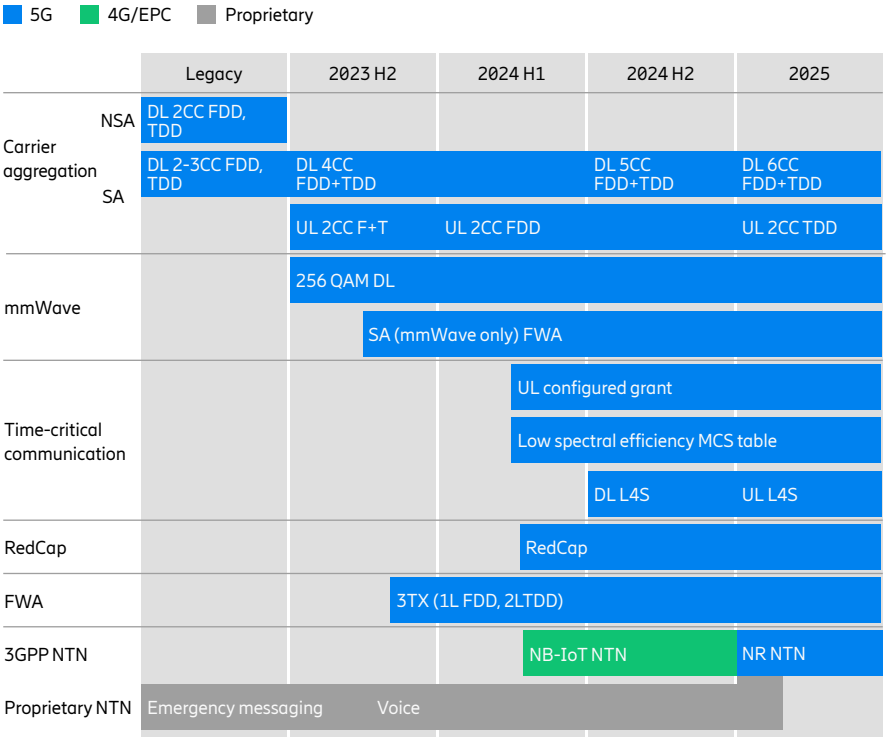
- Smartphone shipments show the first signs of recovery following weak sales in the beginning of 2023, as the decline narrowed to only 1 percent in the third quarter.[1]
- Over 1,000 5G smartphone models have launched in total, with more than 240 so far in 2023.
- 5G's share of shipped smartphones continues to grow and is expected to account for 62 percent in 2023, compared to 57 percent in 2022.[2]
- Foldable device shipments grew by 16 percent year-on-year in the first half of 2023. There are now 10 vendors with foldable smartphone models, and 17 different models launched so far in 2023.
- 5G device market shares could be redistributed in China, as signs of competitive domestic chipset production technology surfaced in the third quarter.
- The move towards XR continues with market movers entering the domain.
- 3GPP-based non-terrestrial network (NTN) technology is expected to achieve the economy of scale needed to drive global adoption of satellite services in cellular devices. This is expected to start with text messaging and low-data-rate services, based on fully integrated system-on-chip (SoC) solutions expected in 2024.

5G SA strengthens its position

5G standalone (SA) is becoming well established. This enables new capabilities such as 5G native voice (Voice over New Radio, or VoNR) and new services like network slicing and user equipment route selection policy (URSP).

- Devices with four-component carrier (4CC) downlink carrier aggregation and uplink carrier aggregation are entering the market, which allows single-user performance on par with or better than non-standalone (NSA) in most markets.
- Smartphone operating systems have introduced support for URSP, targeting both enterprise and consumer use cases. This is expected to boost 5G monetization possibilities.
- SA maturity is an enabler for private networks, either using sub-6 or mmWave spectrum. Since private spectrum is usually limited to a single carrier, NSA is not an option. Recent advances in the device ecosystem have enabled smartphones and tablets as data-only devices.
- New Radio (NR) reduced capability (RedCap) is ready for commercialization. This will enable low-cost devices in 5G SA and open the private networks space for sensors and other IoT devices based on NR (see our RedCap overview for more information, page 19).

Figure 2: 5G technology market readiness



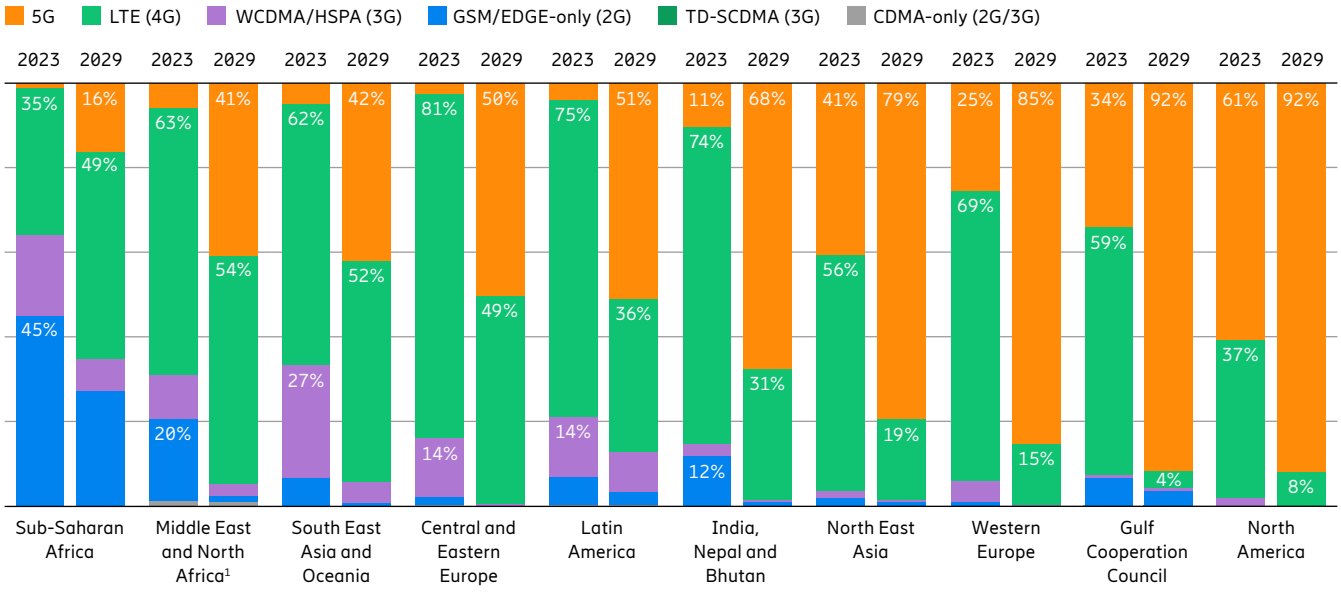
Note: The graph illustrates the availability of network functionality, as well as support in devices.

[1] Source: Canalys.
[2] Source: IDC.

5G subscriptions rising in every region

Uptake is strong in North America, and the region is expected to reach a 5G subscription penetration of 61 percent at the end of 2023. At the same time, 5G penetration in India is expected to reach 11 percent.

Figure 3: Mobile subscriptions by region and technology (percent)



Sub-Saharan Africa

The telecom sector in Sub-Saharan Africa remains resilient, even though the region is facing funding challenges and high inflation. Connectivity has become a basic need for voice and data communications, as well as for enabling services such as banking, which have traditionally had low penetration.

By 2029, 4G subscriptions will account for 49 percent of the total, as access to lower-priced smartphones and data services increases across the region. While 5G will be the fastest-growing subscription type between 2023 and 2029 at 60 percent annually, it will account for 16 percent of mobile subscriptions at the end of this period. Service providers will need to secure additional spectrum capacity or densify coverage in urban areas to preserve user experience, as these congested areas are increasingly reaching maximum capacity.

2G subscriptions will maintain a significant share of total subscriptions at 27 percent. This is mainly due to the region's largely rural population, for whom broadband coverage is limited and smartphone affordability is a challenge.

Service providers in Sub-Saharan Africa are also exploring additional offerings on mobile platforms, such as health, education and e-commerce. As the region with the highest overall subscription growth (3 percent), Sub-Saharan Africa is forecast to have 1.1 billion subscriptions in 2029, out of which 760 million (67 percent) will be smartphone subscriptions.

Middle East and North Africa

Telecom industry growth remains strong in the Middle East and North Africa region, despite economic uncertainty in some countries, with 2.4 percent overall subscription growth forecast between 2023 and 2029. Smartphone subscriptions will also experience strong growth in this period, rising at 5 percent annually (second only to Sub-Saharan Africa).

While 4G subscriptions will account for the bulk of the base, at 54 percent by 2029, 5G subscriptions are projected to register the strongest growth in the period, at 41 percent compounded annually, to account for around 40 percent of total subscriptions by 2029.

Service providers are expected to increasingly push solutions such as mobile financial services – especially in parts of North Africa, where financial inclusion remains a priority – and Fixed Wireless Access (FWA), which shows a discernible growth trend in the region.

[1] All Middle East and North Africa figures include GCC countries.

Gulf Cooperation Council (GCC)
In comparison to the Middle East, North Africa and Sub-Saharan Africa, the subscription base is low in the GCC region, totaling 76 million as of 2023. 5G subscriptions are projected to grow annually by 19 percent over the forecast period. By 2029, over 90 percent of all subscriptions are forecast to be 5G.

Service providers are exploring various ways to monetize their investments in 4G and 5G networks. One way is through services such as machine-to-machine (M2M) or IoT, including fleet management, remote monitoring, health and financial services.

The strong economies in the GCC region are enabling governments to invest in ICT and telecoms as part of ambitious national visions and digitalization programs. Additionally, several smart-city projects are in development or have been proposed, which will utilize 5G network capabilities significantly across various use cases. Network slicing, 5G standalone, and API exposure will be key enablers for service providers to bring incremental revenues from new use cases.

Central and Eastern Europe
Technology adoption and subscription uptake have historically been slower in this region than in Western Europe, with 5G deployment varying by country. This is partly due to slower spectrum allocation processes – for example spectrum auctions in Poland were only completed in October 2023. Conversely, the Czech Republic has seen one of the largest deployments in Central Europe for 5G private networks for industry. It is anticipated that Poland will soon follow, given the country's large manufacturing base and 5G spectrum availability.

4G is currently the dominant technology, and is expected to account for 81 percent of all subscriptions at the end of 2023. Mobile subscription growth has flattened and is expected to be virtually zero in the coming years. However, the migration from 2G/3G to 4G continues to look strong up to 2024. From 2025, 5G is expected to be the only growing subscription type.

During the forecast period, there will continue to be a significant decline in 3G subscriptions, from 14 percent of mobile subscriptions to just 1 percent.

South East Asia and Oceania
5G subscriptions are forecast to reach around 550 million in the region by the end of the forecast period. After the initial investment in 5G infrastructure across the South East Asian markets of Thailand, the Philippines, Singapore and Malaysia, the focus has now shifted to diversifying service offerings for both consumers and enterprises. Enhancing customer experience, expanding network coverage and promoting digital transformations for businesses remain top priorities across the region. In Australia, service providers are focusing on maturing 5G coverage, increasing investments in mmWave technology and exploring satellite solutions for regional connectivity. Additionally, there is an emphasis on enhancing cyber security measures to protect customers and on exploring new growth areas in 5G to expand their offerings to other industries. In countries such as Vietnam and Indonesia, where 5G is limited or yet to be launched, service providers are preparing for 5G and upgrading their 4G networks.

Latin America
4G is still growing and is currently the dominant radio access technology in the region. It is expected to account for 75 percent of all subscriptions at the end of 2023, with around 20 million subscriptions added during the year. However, 3G subscriptions are declining as users migrate to 4G and 5G. Many countries in the region are in the process of auctioning 5G. Uruguay and Argentina concluded these in 2023 and an auction is expected to take place in Peru in 2024.

5G subscription uptake has been slow due to macroeconomic difficulties in the region. Around 28 million 5G subscriptions are expected at the end of 2023. More substantial uptake is anticipated from 2024 onwards. By the end of 2029, 5G will account for 51 percent of all mobile subscriptions.

India, Nepal and Bhutan
India is seeing substantial 5G network deployments from service providers following the launch of 5G services in October 2022. Fast-growing network availability across cities, affordable service plans and the growing availability of 5G smartphones has fueled rapid 5G adoption in the country. 5G subscriptions are expected to reach 130 million in 2023, and are estimated to grow to 860 million by 2029.

Within a year of launching 5G, leading Indian service providers have also introduced 5G FWA services, which are seen as a significant revenue opportunity in the region. 5G subscriptions are estimated to account for 68 percent of mobile subscriptions in the region by the end of 2029.

Meanwhile, 4G continues to be the dominant subscription type driving connectivity and fueling data growth in the region. However, as subscribers migrate to 5G, 4G subscriptions are forecast to decline from 870 million in 2023 to 390 million by 2029. Total mobile subscriptions in the region are estimated to grow to 1.27 billion in 2029.

North East Asia
Service providers in the region have been investing in 5G to improve coverage and capacity, with a focus on indoor coverage. Strong 5G subscription growth continued in 2023, adding an estimated 244 million subscriptions during the year to total 890 million. 5G is the only growing subscription type and is expected to reach 1.8 billion at the end of 2029. The rapid growth of 5G subscriptions, supported by the availability of more 5G device models, has positively impacted service providers' financial performance. Major service providers in leading 5G markets, such as mainland China, Taiwan and South Korea, have reported the positive impact of 5G subscribers on service revenues and ARPU. There is a strong interest in new 5G IoT solutions based on reduced capability (RedCap) in the region. For example, in mainland China, the regulators' plans indicate that nationwide availability and tens of millions of subscriptions are expected by 2025.

Western Europe
Although 5G subscription penetration is behind other developed markets, 5G subscription growth has been strong during the year, rising from 67 million in 2022 to an expected 139 million at the end of 2023. This equals penetration of 25 percent for the region, however, it varies between countries. Markets such as the UK and Finland, which were among the first to launch 5G services, have already achieved relatively high penetration, whereas other markets have lower penetration. 4G is expected to decline in favor of substantially increased 5G subscriptions going forward. 5G subscriptions are anticipated to reach around 480 million at the end of 2029, representing 85 percent penetration at that time.

North America
The addition of mid-band spectrum now enables superior multi-band 5G experiences for many users. In 2023, 5G adoption has continued to grow strongly, and 260 million subscriptions are expected by the year's end. FWA, providing high-speed internet to homes and small businesses, remains the primary technology fueling fixed broadband growth. 5G is also growing in the enterprise segment with wireless WAN to branch office locations and to serve mobile professions. By 2029, around 430 million 5G subscriptions are expected, accounting for 92 percent of mobile subscriptions.

Sub-Saharan Africa: A closer look

Driving forces behind growth include a positive economic outlook and forward-thinking regulatory measures for building out network coverage, meaning the stage is set for the telecom market to thrive in the Sub-Saharan Africa region.

In each edition of the Mobility Report, we take a closer look at the trends in one specific region. This time we are exploring the Sub-Saharan Africa region.

In the face of a global economic slowdown, the economies of Sub-Saharan Africa are set for a period of robust 4 percent short-term growth.[1] Alongside this growth, total mobile subscriptions are projected to rise 3 percent year-on-year for the next 6 years, with a 9 percent increase in 4G subscriptions, indicating a promising market opportunity for service providers. Furthermore, the growing adoption of smartphones, especially affordable devices, is expected to lead to an annual increase of more than 20 percent in data consumption per smartphone throughout this period, from 6.7 GB per month to 23 GB per month.

These projections present numerous opportunities for service providers to support the evolving telecom landscape in Sub-Saharan Africa. The driving forces behind this growth are forward-thinking regulatory measures and substantial investments from both local and international telecom companies.

Catalyzing connectivity: Sub-Saharan Africa's strategic network infrastructure investment

ICT can play a pivotal role in enabling critical climate action, steering African industries toward a low-carbon economic model. Research indicates that ICT solutions have the capacity to reduce global greenhouse gas emissions by up to 15 percent by 2030.[2]

At the same time, in the face of considerable macroeconomic challenges, a number of countries in the Sub-Saharan Africa region are demonstrating a strong commitment to making substantial investments in their network infrastructure. This strategic initiative is driven by the region's demographic advantage of a largely youthful population, alongside a marked surge in demand for enhanced connectivity solutions. As societies increasingly embrace digitalization and the benefits it offers, the pressing need for comprehensive and modernized network systems becomes evident.

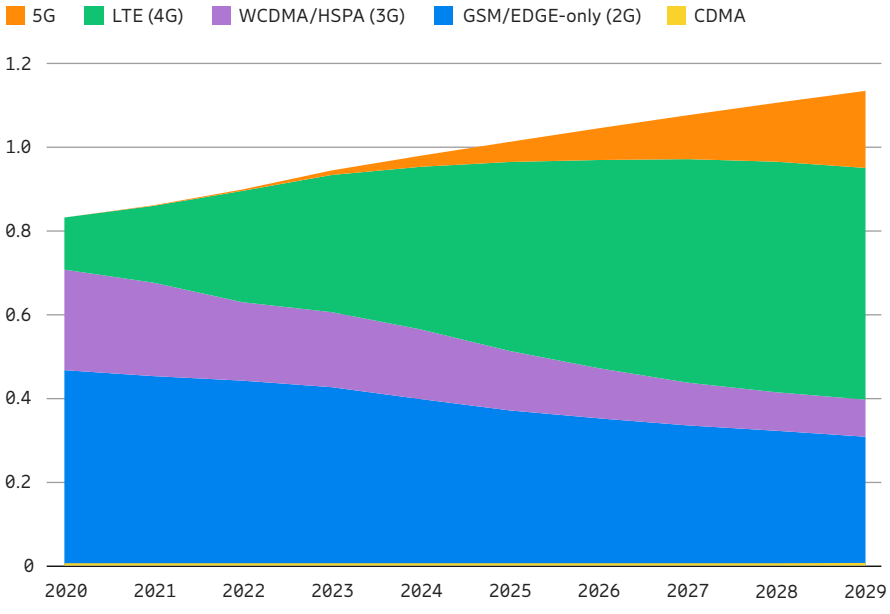
4G is reshaping Sub-Saharan Africa

In the pursuit of modernization and enhanced connectivity, subscribers are constantly migrating toward 4G networks. This trajectory indicates that 4G will be the primary driver for new subscriptions up to the year 2028. By the end of 2029, 4G subscriptions are forecast to account for half of all mobile subscriptions.

This technological shift underscores a pivotal moment in the region's telecom landscape. 4G's prevalence is poised to redefine the way communities engage with digital services, be it for education, commerce, healthcare, or social interactions.

Service providers in Sub-Saharan Africa are evolving into technology companies, integrating mobile money services into their digital portfolios. This shift not only enhances financial inclusion in society but also significantly boosts revenue for service providers, complementing traditional voice and data services. The advantages of the high speeds, improved reliability and efficiency that 4G offers are instrumental in shaping a digitally empowered society.

Figure 4: Sub-Saharan Africa region mobile subscriptions by technology (billion)



[1] IMF, Regional Economic Outlook: Sub-Saharan Africa (October 2023).
[2] Exponential Roadmap (January 2020).

In 2029, 180 million 5G subscriptions are projected in Sub-Saharan Africa.

180m

Strategic spectrum deployment propels 5G expansion

Forward-looking 5G investments in the region are supported by spectrum releases in low- and mid-bands. The bulk of mobile subscribers will remain on 4G networks for several years, and it will be some time before subscribers who have migrated to 5G reach a more considerable proportion. Many African governments and service providers have nonetheless made measurable progress over the past year when it comes to releasing the relevant spectrum resources for launching 5G and activating them on compatible network equipment. More than a dozen countries – which, with the exception of Nigeria, are mostly in Eastern and Southern Africa – now have 5G services available.

Urban areas are increasingly reaching maximum capacity, given the site density and available spectrum, leading to service disruption. To maintain and improve user experience, African service providers could either secure additional spectrum or further densify network coverage.

Many governments, including Kenya and Tanzania, have allowed service providers to reuse their existing spectrum assets, thereby enabling frequency refarming in line with technology neutrality principles. Most also gave service providers access to additional frequencies, especially in the mid-band, in sizable amounts to allow 5G to fully deliver on its promises of higher download speeds. As these frequencies have a limited reach, releasing some low-band frequencies alongside them offers a strategic combination of 5G resources to simultaneously expand capacity and extend coverage. Only a few countries have released frequencies higher than 6 GHz, which are needed for ultra-high performance 5G services. This includes around 80 GHz in the E-Band for high-capacity microwave links to connect towers, which is especially effective in suburban settings where fiber may not yet be available. In 2029, it is anticipated that there will be around 180 million 5G subscriptions in the region, accounting for 16 percent of all mobile subscriptions at that time.

Bridging the digital divide: Challenges and solutions for rural Africa

A substantial segment of the Sub-Saharan Africa population resides in rural areas. This demographic and economic landscape poses a significant challenge in the establishment of profitable macro sites for telecommunication networks, where the ARPU is low. The cost implications of deploying and maintaining infrastructure in these areas often outweigh the potential revenue generation, presenting a formidable financial obstacle to delivering of widespread coverage.

Providing connectivity to rural Africa to enhance digital inclusion calls for innovative solutions and collaborative efforts. An example of this is a tailored radio and transmission solution that is optimized specifically for the needs of rural sites, and can include 100 percent solar and battery power for clean energy and reliability.

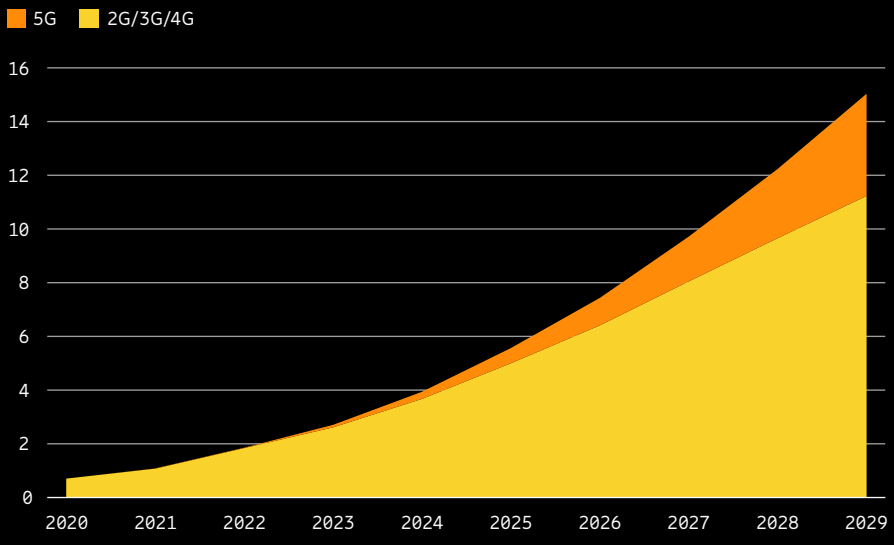
Fixed Wireless Access (FWA) takes center stage

In the quest to meet Africa's increasing broadband demands, FWA emerges as a pivotal technology. While 4G FWA is an initial stepping stone, 5G's potential is increasingly coming to the forefront due to its capability to deliver fiber-like speeds. This advancement complements traditional fixed broadband infrastructure within the region.

Notably, several key African markets, including Angola, South Africa, Nigeria, Kenya, Zambia and Zimbabwe, have already launched 5G FWA services. This shift can be attributed to its cost effectiveness, rapid deployment capabilities and inherent flexibility.

Sub-Saharan Africa has many unconnected households, especially in rural areas, and this digital divide can be effectively and quickly addressed by FWA. It is also a cost-effective solution for bringing digital connectivity to other segments, such as schools, opening a world of access to information and learning.

Figure 5: Sub-Saharan Africa region mobile data traffic (EB per month)



Mobile network data traffic still climbing

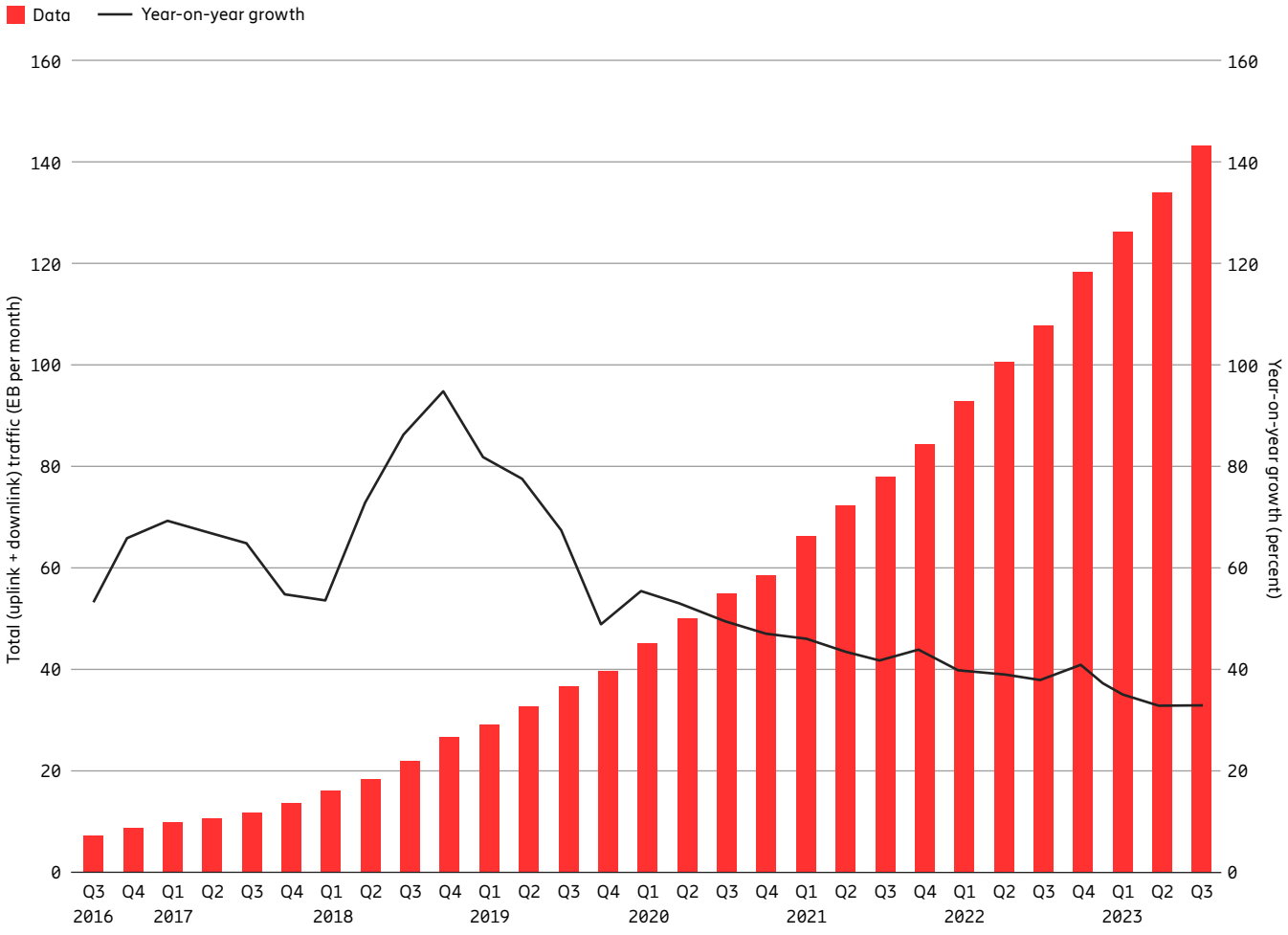
Mobile network data traffic grew 33 percent between Q3 2022 and Q3 2023.

The quarter-on-quarter mobile network data traffic growth between Q2 2023 and Q3 2023 was around 7 percent. Total monthly global mobile network data traffic reached 143 EB.

Long-term traffic growth is being driven by both rising smartphone subscriptions and increasing average data volume per subscription, fueled primarily by increased viewing of video content.

Figure 6 shows the total global monthly network data traffic from Q3 2016 to Q3 2023, along with year-on-year percentage growth for mobile network data traffic.

Figure 6: Global mobile network data traffic and year-on-year growth (EB per month)



Source: Ericsson traffic measurements (Q3 2023).
Note: Mobile network data traffic also includes traffic generated by Fixed Wireless Access services.

Growth in percent falls, while data traffic rises

Yearly mobile data traffic growth rate is expected to slow down until 2029, but the incrementally added traffic is not declining.

Traffic forecast methodology
Forecast traffic growth is based on proprietary data from live network measurements, regulatory data and service providers' reported figures. These data sets are analyzed, modeled and scaled to estimate growth rates on regional and global levels.

FWA traffic is not included in the calculations of mobile data traffic in Figures 7 and 8. For more on data traffic growth, see page 12.

Global mobile data traffic drivers
Mobile data traffic has increased phenomenally in the last 10 years, more than doubling on average every second year. Factors driving data traffic growth in mobile networks include: ever-increasing demand for online digital services, 4G/5G deployments in populous markets, increased network capacity with each new generation of mobile technology, new service introduction, improved quality of experience and affordable service plans for more market segments.

An additional factor driving data traffic growth is subscriber migration. There are still almost 2 billion 2G and 3G subscribers worldwide, with most of them expected to gradually migrate to 4G and 5G over the forecast period. In addition, 5G subscribers consume more data on average than 4G subscribers.

Decreasing year-on-year traffic growth rate, but increasing net additions
Mobile data traffic growth between years can be highly volatile and vary significantly between regions, markets and service providers, depending on local market dynamics. It is forecast to grow 20–30 percent per year for most regions in the next few years, with sub-20 percent growth in the later forecast years. Yearly mobile data traffic growth rate is expected to slow down at different paces in different regions up to 2029 (see Figure 7). However, that does not equal less yearly net added data traffic volume; up to 2027, this is expected to increase, whereafter it will be somewhat flat (see Figure 8).

Predicted mobile data traffic growth up to 2029 includes an assumption that initial uptake of XR-type services, including AR, VR and mixed reality (MR), will happen in the latter part of the forecast period, but its specific contribution is yet to be quantified. However, if adoption is accelerated, data traffic could significantly surpass our current traffic outlook at the end of the forecast period. Service providers continue modernizing their networks to cost-effectively manage increasing traffic volumes, while introducing new services and business models to address a broader market beyond enhanced mobile broadband.

Figure 7: Forecast year-on-year mobile data traffic growth rates by region 2022–2029

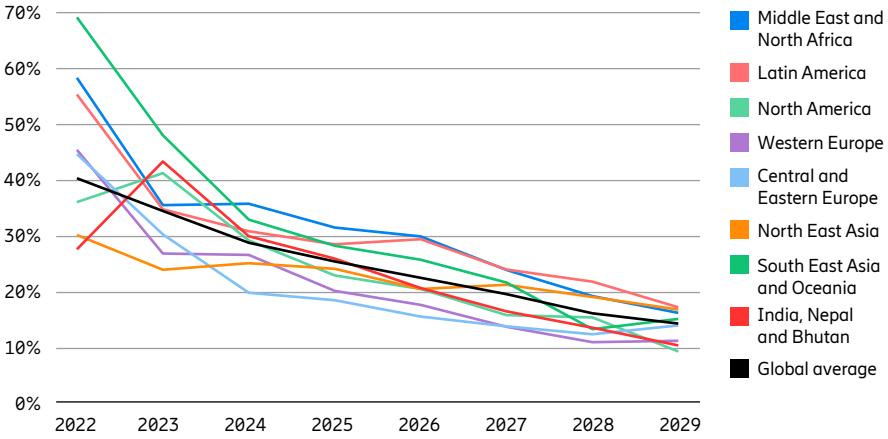
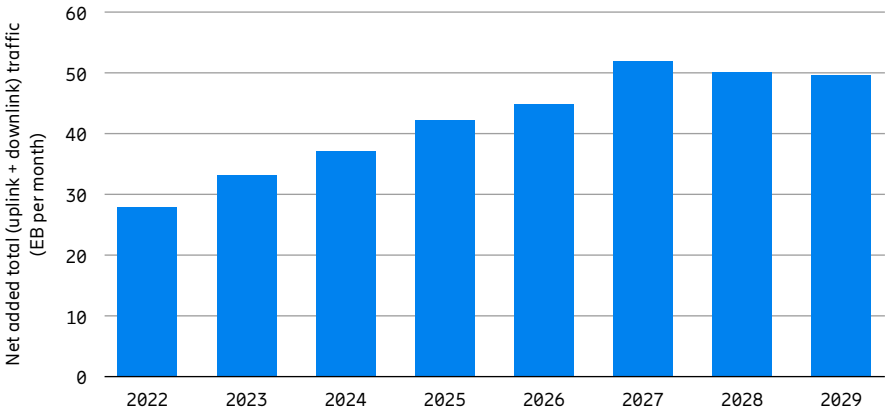


Figure 8: Forecast yearly net added mobile data traffic 2022–2029



Note: Each bar represents the increased traffic volume at end of year, compared to the previous end of year.

5G set to account for 25 percent of mobile data traffic this year

Subscriber migration to 4G and 5G from previous-generation mobile technologies is fueling traffic growth.

Total global mobile data traffic – excluding traffic generated by Fixed Wireless Access (FWA) – is expected to reach 130 EB per month at the end of 2023. This is projected to grow by a factor of around 3 and to reach 403 EB per month in 2029. When FWA is included, total mobile network traffic is anticipated to reach around 160 EB per month at the end of 2023, rising to an expected 563 EB per month by the end of 2029. Predicted traffic growth up to 2029 includes an assumption that an initial uptake of XR-type services, including AR, VR and mixed reality (MR), will happen in the latter part of the forecast period. However, if adoption is stronger than expected, data traffic could increase significantly more than currently anticipated toward the end of the forecast period, particularly in the uplink. At the end of 2023, video traffic is estimated to account for 73 percent of all mobile data traffic.

Populous markets that launch 5G early are likely to lead in terms of traffic growth over the forecast period. 5G's share of mobile data traffic is estimated to be 25 percent at the end of 2023, an increase from 15 percent at the end of 2022. This share is forecast to grow to 76 percent in 2029.

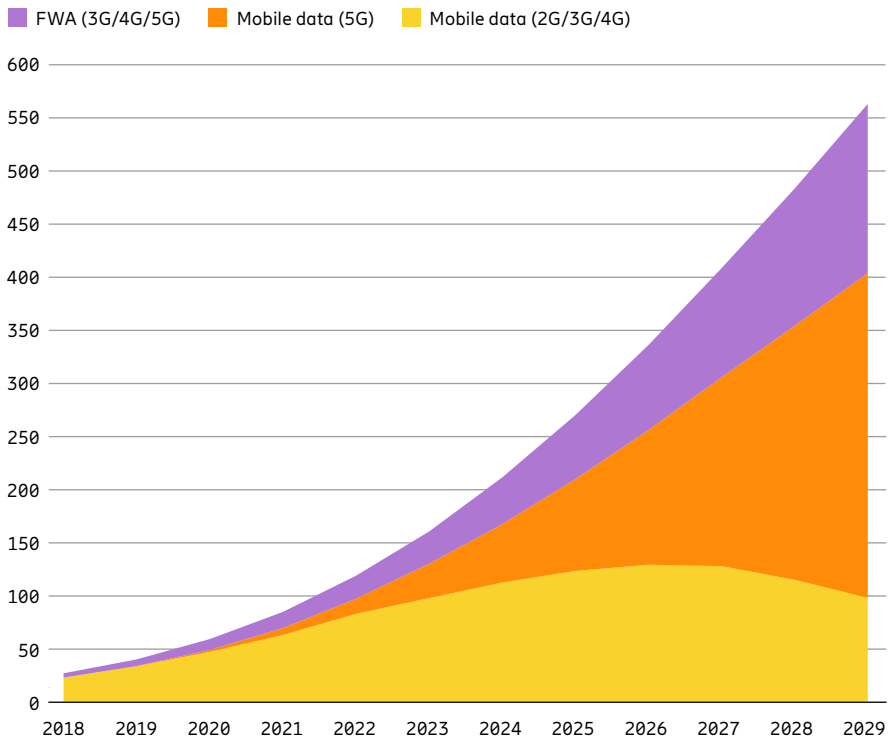
Traffic growth varies across regions

Traffic growth between years can be highly volatile and can vary significantly between countries, depending on local market dynamics. Globally, the growth in mobile data traffic per smartphone can be attributed to three main drivers: improved device capabilities; an increase in data-intensive content; and growth in data consumption, due to continued improvements in the performance of deployed networks.

An example of these differences can be seen in the contrast between the **Sub-Saharan Africa** region, where average monthly mobile data usage per smartphone is expected to be 6.7 GB at the end of 2023, and the **Gulf Cooperation Council (GCC)** countries, where average monthly usage is expected to be 30 GB per smartphone at the end of 2023. The global monthly average usage per smartphone is anticipated to reach 21 GB in 2023 and is forecast to reach 56 GB by the end of 2029.

The average monthly mobile data usage per smartphone in **North America** is expected to reach 66 GB in 2029, as unlimited data plans and improved 5G network coverage and capacity increasingly attract new 5G subscribers. Data traffic will increase significantly in line with the expected uptake of gaming, XR and video-based apps. These experiences require higher video resolutions, increased uplink traffic, and more data from devices off-loaded to cloud computing resources to satisfy users. FWA has started to affect overall traffic patterns, accounting for a large share of total network data traffic.

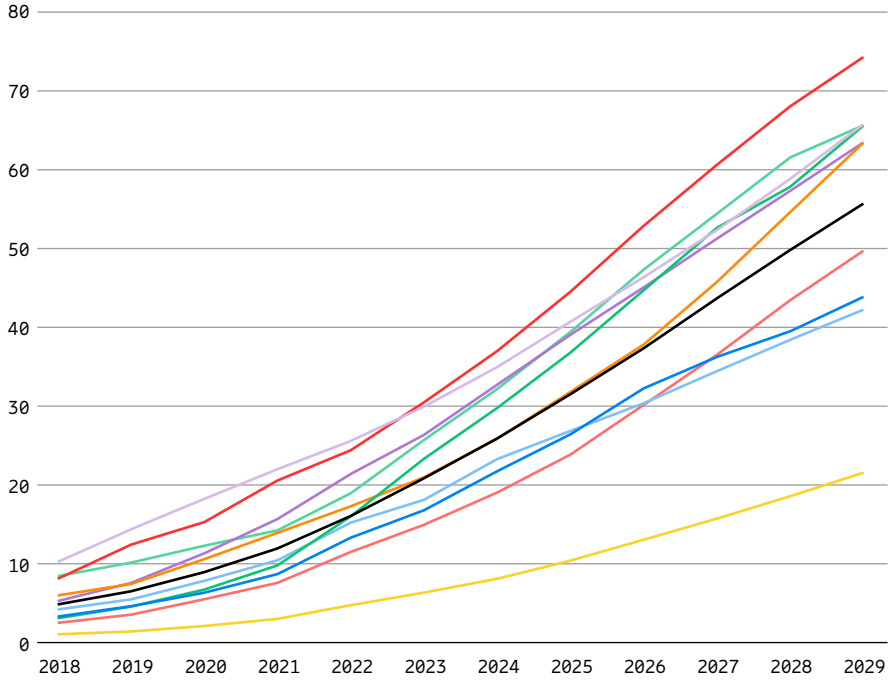
Figure 9: Global mobile network data traffic (EB per month)



Globally, average monthly mobile data usage per smartphone is expected to reach 56 GB, rising from 21 GB at the end of 2023.

56 GB

Figure 10: Mobile data traffic per smartphone (GB per month)



Regions	2023	2029	CAGR 2023–2029
India, Nepal, Bhutan	31	75	16%
GCC	30	66	14%
North America	26	66	17%
South East Asia and Oceania	24	66	19%
Western Europe	27	64	16%
North East Asia	21	64	20%
Global average	21	56	18%
Latin America	15	50	22%
Middle East and North Africa[1]	17	45	17%
Central and Eastern Europe	19	43	15%
Sub-Saharan Africa	6.7	23	22%

In **Western Europe**, service usage and traffic growth are expected to follow similar patterns to those anticipated for North America. In 2029, traffic usage per smartphone is projected to reach 64 GB per month – close to the expected usage in North America at that time.

The **North East Asia** region's share of total global mobile data traffic is expected to be close to 30 percent in 2029. In the region, 5G subscribers currently use, on average, 2–3 times more data than 4G subscribers. As more 4G subscribers migrate to 5G, average mobile data traffic per smartphone will increase and is expected to reach 64 GB per month in 2029. Video is the dominant traffic type. Additional traffic growth is expected with the introduction of new XR-type services.

Sub-Saharan Africa is poised to remain the region with the highest growth in total mobile data traffic, with a CAGR of 33 percent anticipated between 2023 and 2029. This growth will be driven by the expansion of 4G network coverage across the continent and the increasing affordability of data and smartphones. Smartphone traffic is expected to be the primary contributor to total mobile traffic, with average data usage per smartphone reaching 23 GB by 2029.

The **Middle East and North Africa** region is also expected to experience significant mobile data traffic growth, with a CAGR of 23 percent forecast between 2023 and 2029. This growth will be fueled by the transition of more subscribers to 4G, the increasing uptake of 5G, and attractive variable data service offerings. 4G traffic is expected to be the primary driver of growth. Monthly data usage per smartphone is expected to reach 45 GB by 2029, rising 17 percent annually. Mobile data traffic growth in the **GCC** countries is expected to be more modest, with a CAGR of 16 percent forecast between 2023 and 2029. However, data usage per smartphone is still projected to reach 66 GB monthly by 2029, primarily driven by 5G data volumes. Service providers are anticipated to capitalize on diverse industry-specific solutions for 5G, which might lead to an increase in overall data usage in the next few years.

In **India, Nepal and Bhutan**, mobile networks continue to play a pivotal role in driving social and economic inclusion. In India, digital technologies such as e-commerce and e-governance are reshaping the country. 5G is enabling the next phase of growth and transformation in India's digital landscape, thereby supporting the government's vision to transform the country into a digitally empowered society and knowledge-based economy.

Average data traffic per smartphone in the region is the highest globally. It is projected to grow from 31 GB per month in 2023 to around 75 GB per month in 2029 – a CAGR of 16 percent. Total mobile data traffic is estimated to grow from 26 EB per month in 2023 to 73 EB per month in 2029, growing at a CAGR of 19 percent. This is driven by high growth in the number of smartphone users and increased average usage per smartphone. Smartphone subscriptions in India as a percentage of total mobile subscriptions are expected to grow from 82 percent in 2023 to 93 percent in 2029. Smartphone subscriptions in India have grown by 70 million in 2023.

Mobile data traffic per smartphone continues to grow strongly in **South East Asia and Oceania** and is expected to reach around 66 GB per month in 2029 – a CAGR of 19 percent.

In **Latin America**, individual countries have very different growth rates for data traffic per smartphone. Traffic growth is driven by coverage build-out and continuing strong adoption of 4G (and eventually 5G), linked to a rise in smartphone subscriptions and an increase in average data usage per smartphone. The average amount of data traffic per smartphone is expected to reach 50 GB per month in 2029.

In **Central and Eastern Europe**, growth is fueled by the migration of 2G and 3G subscribers to 4G, up to 2024, which is when 5G is expected to overtake previous generations as the technology making the greatest contribution to subscriptions. Over the forecast period, monthly average data traffic per smartphone is expected to increase from 19 GB to around 43 GB per month.

It is important to bear in mind that there are significant variations in monthly data consumption within all regions, with some individual countries and service providers having considerably higher monthly consumption than any regional averages.

[1] All Middle East and North Africa figures include GCC countries.

Uplink traffic dominated by communication and cloud-storage services

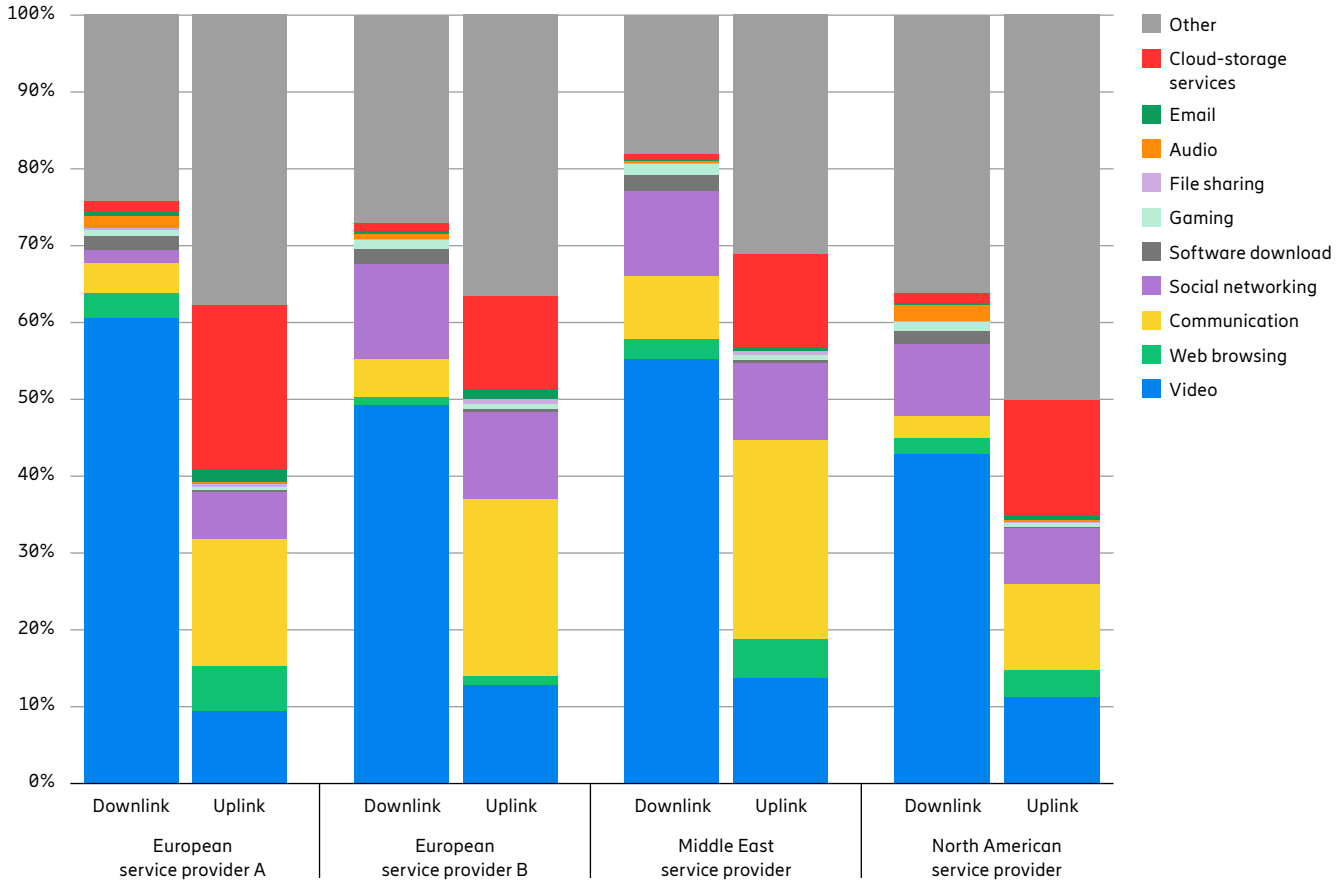
Traffic measurements in a sample of networks show that uplink traffic typically constitutes, on average, around 8 percent of total traffic volume. For cloud-storage services, the traffic split is on average 54 percent in uplink and 46 percent in downlink.

Cloud-storage and communication services have largest uplink share

The uplink share of total traffic over cellular networks can vary by area type, such as dense urban versus rural areas,[1] as well as location. For example, visitors to sports events or concerts frequently share their experiences by uploading video clips and photos, increasing the share of uplink traffic at those locations.

Comparing downlink to uplink traffic shares for different application categories in a few selected mobile networks in Europe, the Middle East and the Americas shows that video traffic has a 97 percent downlink and 3 percent uplink split. As expected, video has the largest share of traffic in downlink across all networks, with social networking typically being the second-largest application category for downlink. The categories with the highest share of uplink traffic in the four sampled networks are cloud-storage services, communication services (including messaging, VoIP and video calls) and video. In two of the networks, cloud-storage services have the highest share of uplink traffic with 15 and 21 percent. In the other two networks, communication services have the highest share of uplink traffic with 23 and 26 percent. In the networks where communication services have the highest share of uplink traffic, video has the second highest share with 13 and 14 percent.

Figure 11: Share of traffic volume in downlink and uplink per application category



[1] Ericsson Mobility Report, "Exploring how traffic patterns drive network evolution" (June 2023).

This correlation indicates user habits and needs that lead to high usage of communication services and sharing of video content in the uplink. For instance, applications like WhatsApp or Viber offer video calling as a popular feature, and sharing of videos in these apps continues to grow each year. The more communication rises, the more video traffic rises (and vice-versa).

Video has highest share of traffic on all device types

The share of traffic volume per application category for three different types of devices – smartphones, tablets and Fixed Wireless Access (FWA) devices – was measured across all the sampled service providers. It shows that video traffic consistently has the highest share of traffic volume, in the range of 30–60 percent, regardless of the device type.

The smartphones category stands out for its significantly higher share of traffic in the social networking and communication categories, compared to traffic on tablet and FWA devices, while web browsing is slightly more common on tablets and FWA devices compared to smartphones. Software downloads and gaming have a relatively higher share of traffic on tablets and FWA devices.

Methodology

The application mix and share of traffic in the sampled networks might not represent the absolute shares of the total traffic, as some traffic could not be classified. For example, the absolute share of video traffic is presumably higher across all networks as part of it is included in the categories "Other" and "Social networking" (for example, Instagram feeds, reels and stories). The analysis is based on one week of data collection.

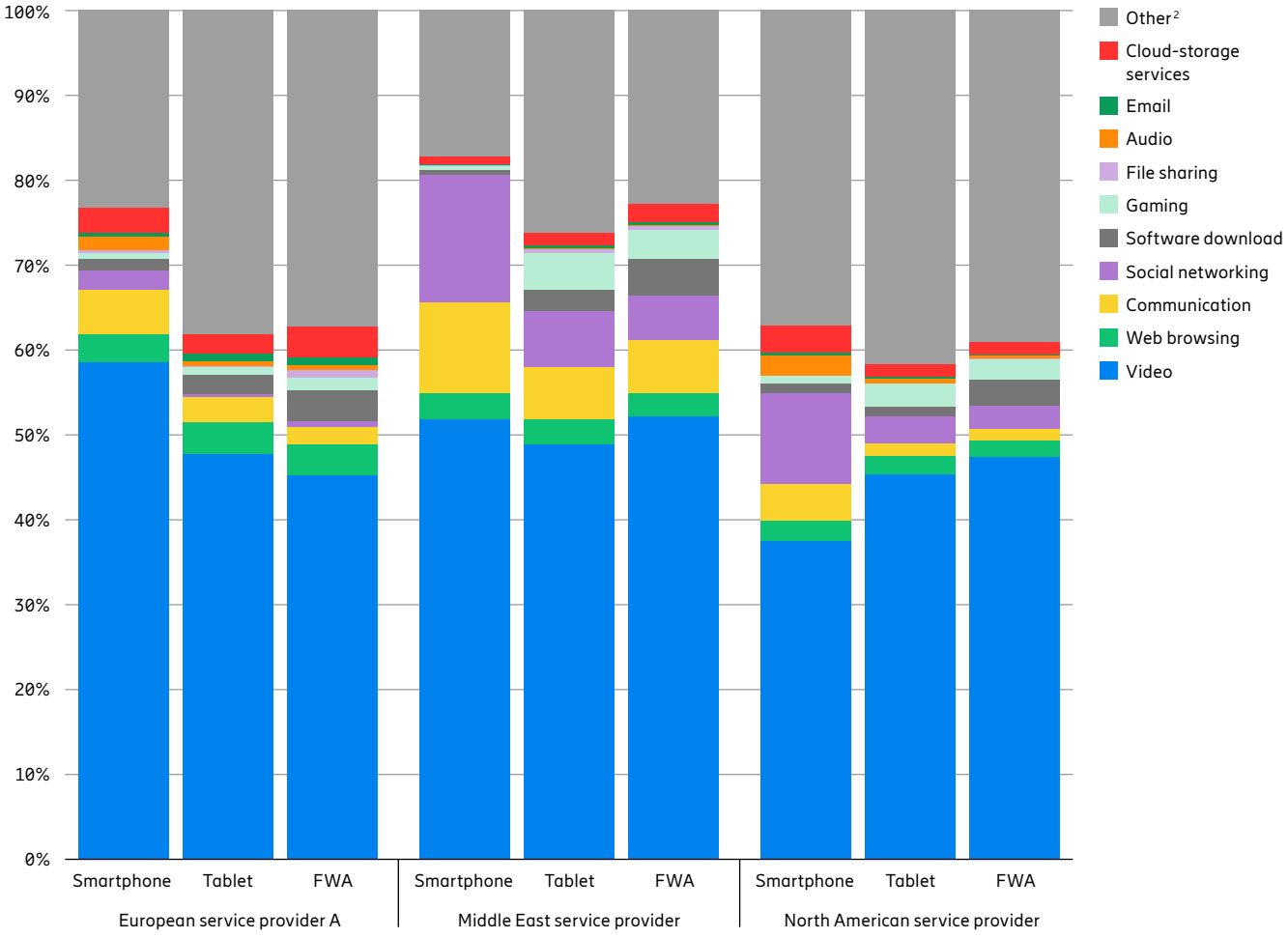
With 97 percent, video traffic has significantly more downlink than uplink traffic.

97%

Uplink share of total traffic was on average around 8 percent in the sampled networks.

8%

Figure 12: Share of traffic volume per application category per device type



[2] "Other" includes uncategorized traffic and traffic from services that have too small a share to be significant compared to the categorized segments in this figure. A large share of "other" is presumably video traffic.

Leveraging 5G capacity in mobile service packages

The capabilities of 5G are allowing service providers to offer new packages that include advanced services such as network slicing, or that boost user experience for specific activities or events.

Key insights

- 5G has matured to become the standard choice offered to users.
- As many as 60 percent of 5G service providers now offer multi-play offerings with media packages, compared to just 30 percent of those still on 4G.
- Packages aimed at live streamers are emerging, using network slicing to guarantee uplink performance when streaming from mobile phones.

An updated Ericsson study[1] of retail packages offered by 308 mobile service providers worldwide shows that as 5G matures, service providers are making it the standard choice for consumers.

The practice of having long-term contracts as the default for SIM-only plans seems to be continuing and expanding among service providers globally, with the majority setting the default option on their websites to 24-month contracts instead of 30 days. In addition, most offer discounts on 24- and 12-month options versus 30-day contract periods.

Some form of data buckets are available from nearly 99 percent of the surveyed service providers, while 45 percent offer at least one unlimited data package to their users. There are significant regional differences, and in Western Europe 89 percent of service providers have unlimited offerings as part of their plan structure. It is also four times as common to have unlimited plans among the service providers who have launched 5G compared to the group that only provide 4G services, 61 percent versus 19 percent.

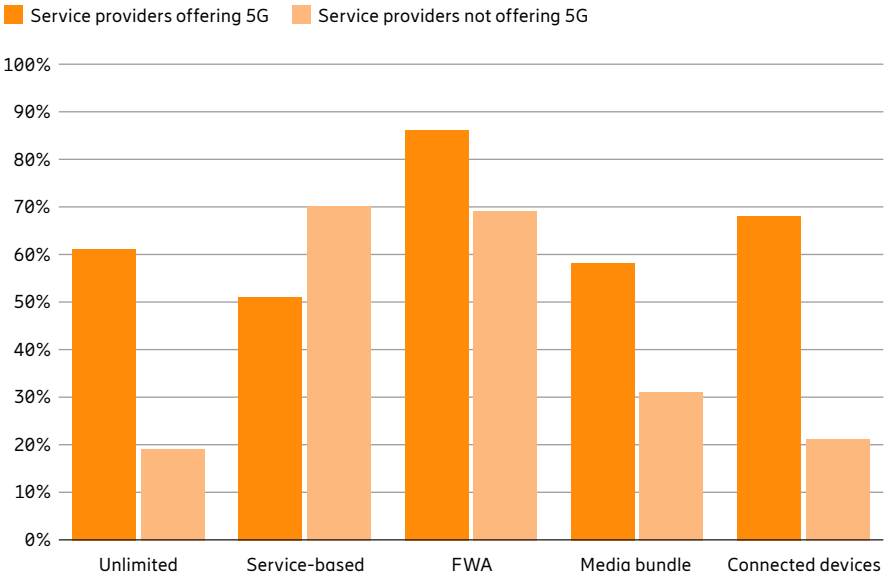
The use of boundary conditions limiting the ability to tether and use cameras or other IoT devices is still quite common within unlimited data plans (16 percent), which speaks toward the high risk associated with unlimited plans. Regular changes in plan structures are common, and a popular trend has been toward minimizing the number of plans available, or changing every plan to include 5G. As in the previous study, a significant percentage of service providers have either removed or introduced unlimited data plans within their offering structure. This makes it the offering type with the highest volatility of all types being surveyed.

The capabilities of 5G drive changes in service provider offerings

This study also examines the specific differences between service providers offering 5G and those who have not yet launched 5G in their markets. Even though unlimited data plans present the risk of subscribers increasing their data usage indefinitely, 5G networks can manage increasing traffic volumes more efficiently. Service providers are likely betting that data consumption from smartphones will grow at a reasonable rate.

Another data plan being offered is service-based connectivity, and there is a correlating higher percentage of this type of data plan among service providers who do not offer 5G yet. Currently, 70 percent of service providers on 4G have these plans available in their structure, compared to 51 percent of 5G service providers. A similar trend can be seen when looking at the off-peak plans, which have previously been commonplace in Africa, parts of Latin America and a few markets in Asia. These plans were introduced with 3G networks and often lived on after the

Figure 13: Percentage of service providers with and without selected 5G offerings



[1] November 2023.

launch of 4G. In later years, and with the introduction of more advanced versions of 4G and/or 5G, these plans are starting to become unavailable. As with many of the other differences being observed, these changes can be tied to the increased network capacity provided by 5G.

Service providers are utilizing 5G's toolbox to create offerings

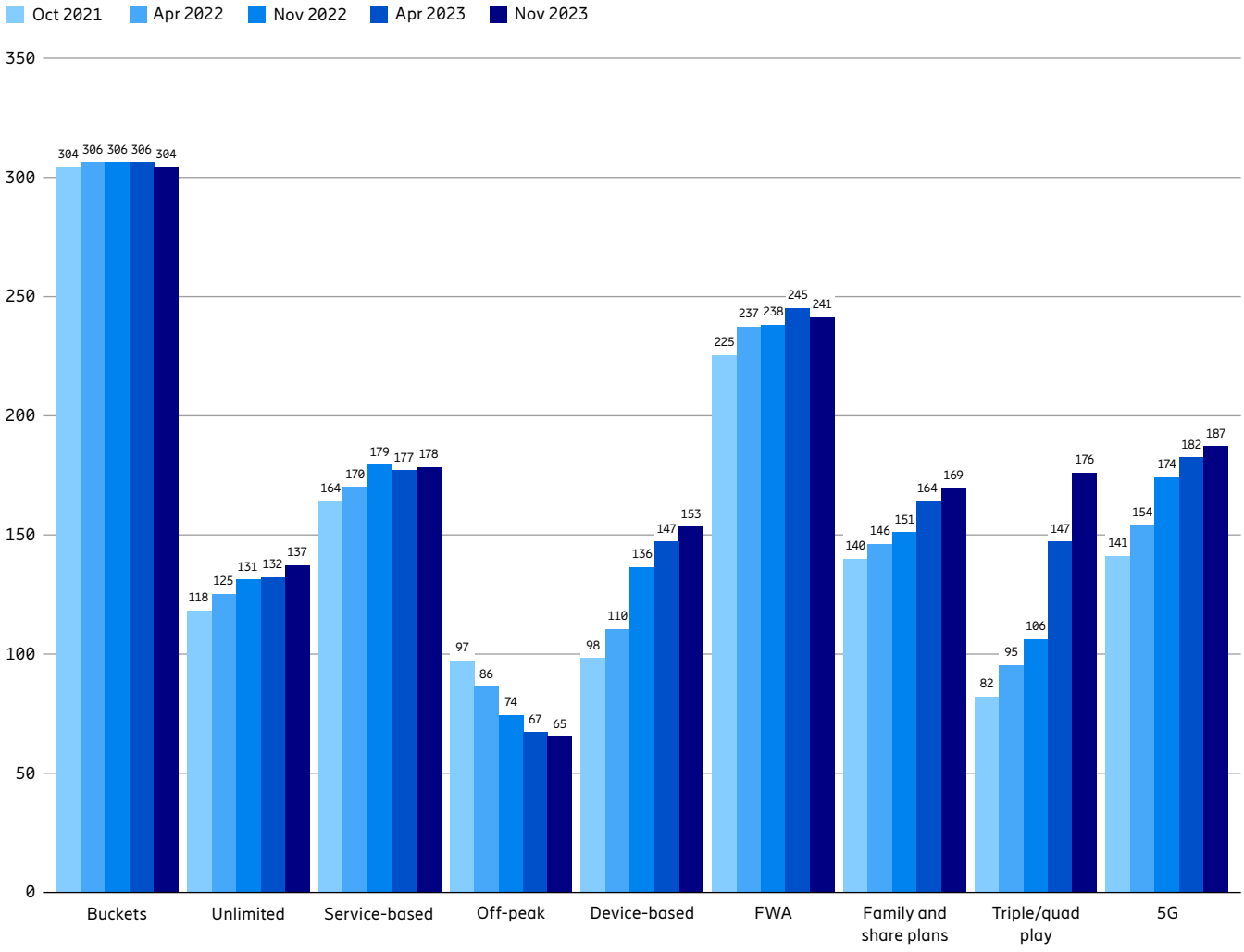
A more profound difference with 5G are the tools becoming available, which allow for greater control of user experience, for example through APIs and network slicing. Here, a new set of offerings with very specific properties are emerging. The basic plan structure remains, with data buckets as the foundation, with or without unlimited plans at the top end. In addition to these, other plans are being made available which target specific use cases and customer segments. This could mean offering certain performance guarantees, such as can be seen in Austria where a service provider is guaranteeing a minimum data speed for their Fixed Wireless Access (FWA) service.

Another example is packages targeting live streamers, for example influencers or anyone wanting to share their favorite moments in real time. These packages are using network priority functions, or network slicing, to guarantee a better uplink performance when live streaming from mobile phones. Other packages are specific to a location or event where many users are gathering, where there is a risk of congestion or other network challenges. It is very common among service providers with 5G to bundle media content with some of their plans. Traditionally, these bundles apply only to the most expensive plans, but it is becoming more common to separate these offerings. While it may still be called a bundle, it is added as an option as decided by the user. Other types of bundle offerings may cover a mobile subscription, home broadband and a home phone. This is commonly known as triple play, and adding a media package into the bundle makes it a quad-play offer. As many as 58 percent of service providers with 5G are now offering multi-play offerings with media packages, versus only 31 percent of those still on 4G. This is another example of the capability of 5G and how it drives changes in service providers' offerings.

For device-based offerings – commonly including smart watches and bag-, dog- and kid-trackers – around 68 percent of service providers with 5G have these types of devices available to consumers, with a data plan attached. Only 21 percent of those not providing 5G offer any such devices with data plans. The reason for this difference is likely not found in the capability of the network, but rather has to do with market segmentation and ARPU levels. Smart watches, especially those with an independent subscription, are still quite expensive and are much more common in high-ARPU regions, which are also the first regions to transition to 5G.

Similarly, family and share plans are quite common in high-ARPU regions where it is being used as an effective churn-reducing tool. Over 64 percent of service providers with 5G are offering these plan structures, whilst that number is around 36 percent among those without 5G service.

Figure 14: Number of service providers per type of offering



Cellular IoT connections expected to reach 3 billion in 2023

Broadband IoT makes up more than 50 percent of all cellular IoT connections.

The Massive IoT technologies NB-IoT and Cat-M – supporting wide-area use cases involving large numbers of low-complexity, low-cost devices with long battery lives and low-to-medium throughput – continue to be rolled out around the world. Globally, 128 service providers have deployed or commercially launched NB-IoT networks and 60 have launched Cat-M, while 45 have deployed both technologies.[1] The total number of cellular IoT connections is forecast to reach around 3 billion at the end of 2023. The growth of Massive IoT technologies is enhanced by added capabilities in the networks, enabling Massive IoT to co-exist with 4G and 5G in frequency division duplex (FDD) bands, via spectrum sharing.

IoT devices connected via 2G and 3G are in slow decline, and are predicted to have a negative annual growth rate of around 20 percent up to 2029, as the rate of switch-off for both generations will continue to increase in the coming years.

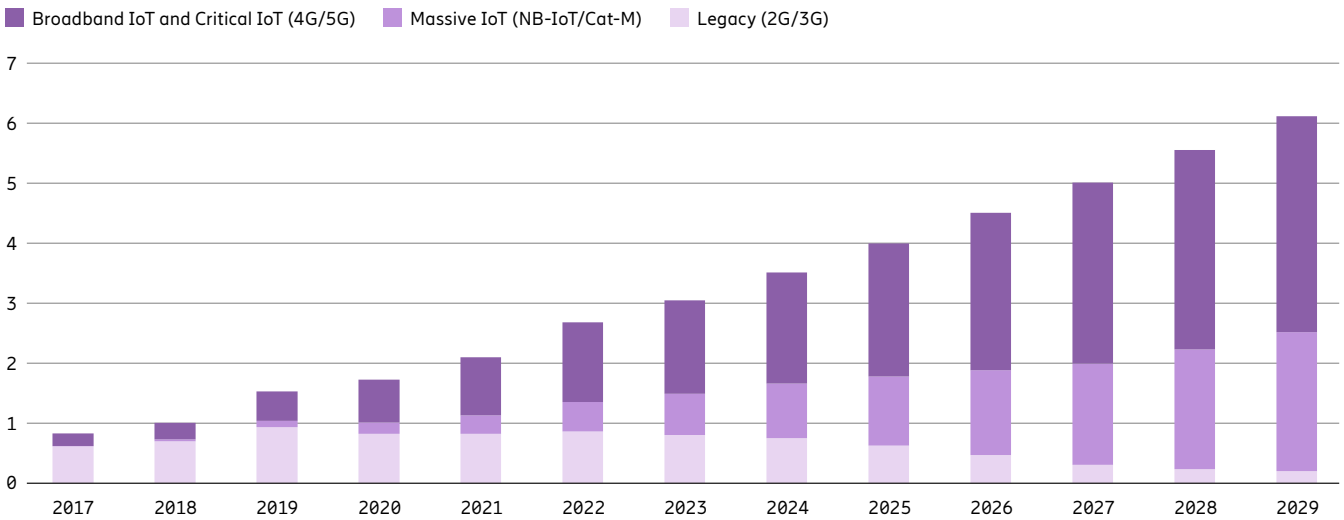
Broadband IoT (4G/5G) is forecast to reach around 1.6 billion connections in 2023, and is the technology that is expected to continue to connect the largest share of cellular IoT devices through 2029. This segment mainly includes wide-area use cases that require higher throughput, lower latency and larger data volumes than can be supported by Massive IoT devices. LTE Cat-1 devices, which support 10 Mbps downlink and 5 Mbps uplink speeds, are increasingly being used for a variety of use cases. Broadband IoT will be further strengthened by the introduction of reduced capability (RedCap) 5G New Radio (NR) devices. By the end of 2029, almost 60 percent of cellular IoT connections are forecast to be broadband IoT, with 4G connecting the majority. As 5G is being introduced in old and new spectrum, throughput data rates will increase substantially for this segment. North East Asia is the leading region in terms of the number of cellular IoT connections, and is expected to pass 2 billion connections in 2023.

Figure 15: IoT connections (billion)

IoT	2023	2029	CAGR
Wide-area IoT	3.3	6.6	12%
Cellular IoT[2]	3.0	6.1	12%
Short-range IoT	12.4	32.3	17%
Total	**15.7**	**38.9**	**16%**

Note: Based on rounded figures.

Figure 16: Cellular IoT connections by segment and technology (billion)



[1] GSA (September 2023).
[2] These figures are also included in the figures for wide-area IoT.

RedCap 5G NR expands Broadband IoT possibilities

Broadband IoT use cases are primarily served by 4G LTE device categories 1 and 4, but the use case possibilities are expanding with the introduction of reduced capability (RedCap) 5G New Radio (NR) devices.

RedCap opens new service opportunities

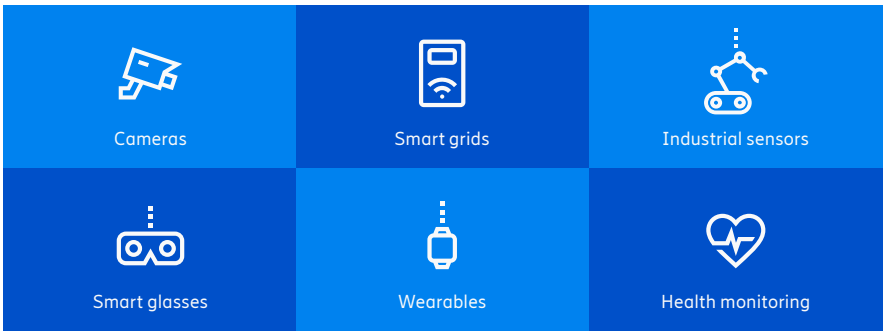
Cellular IoT connections are forecast to have a CAGR of 12 percent through to 2029, with the number of Broadband IoT and Critical IoT (4G/5G) connections expected to double in 3–4 years. However, our current cellular IoT forecast does not yet include RedCap connections, which will enable new service opportunities on 5G networks. Compared to LTE device Cat-4, RedCap offers similar data rates with improved latency, plus device energy and spectrum efficiencies. There is also the potential to support 5G NR features such as enhanced positioning and network slicing.

RedCap software for both time division duplex (TDD) and frequency division duplex (FDD), in low- and mid-frequency bands, is now commercially available as a software addition to 5G standalone (SA) networks. The first pre-commercial RedCap-based modules will soon be available, and commercially available devices are expected during 2024. This device category will expand the ecosystem for new types of devices that can be connected to 5G networks. These have a lower cost and complexity than regular 5G NR devices, as well as a smaller form factor.

Leading service providers in frontrunner markets such as the US, China, Australia and some Asian markets conducted trials with both data and Voice over New Radio (VoNR) sessions over 5G SA networks to test the technology on pre-commercial software during 2023.

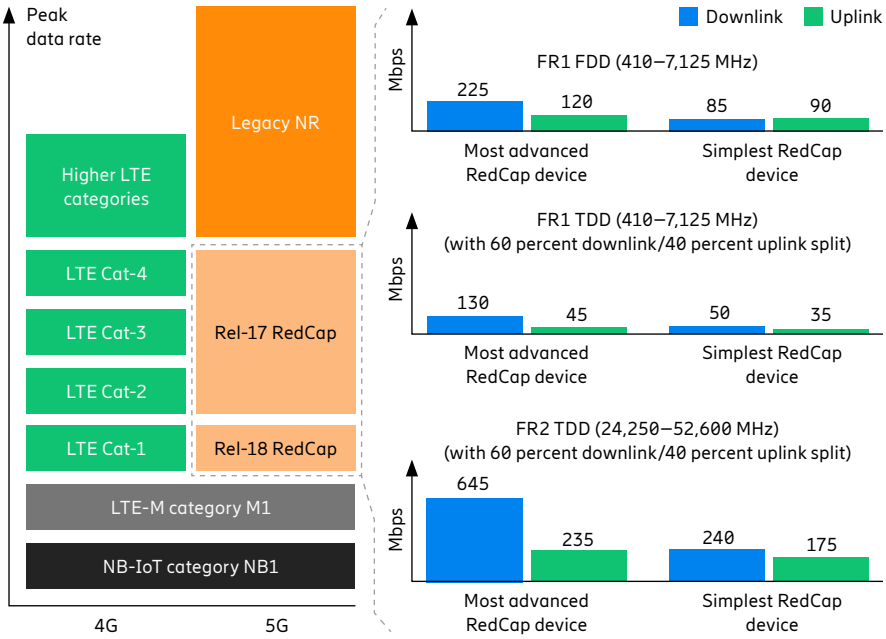
RedCap enables a wide range of cost-effective and power-efficient use cases, such as wearables (for example smartwatches), IoT devices and AR glasses. It is expected to be introduced on low-cost routers, cameras, high-end meters and Fixed Wireless Access (FWA) devices before it advances into the wearable and industrial application segments. New types of service offerings can be created, such as device-based subscriptions or service bundles for different market segments.

Figure 17: Use cases addressed by RedCap devices



Comparing the peak data-rate capabilities of 4G and 5G device types shows that, at the high end of both technologies, there are device types offering high peak rates for demanding use cases. Between the low and high end, there is a range of 4G devices available (Cat-1/2/3/4) and RedCap will provide corresponding 5G device types for this mid-range segment. Achievable downlink and uplink peak data rates for RedCap devices depend on the complexity and frequency band. It ranges from 50/35 Mbps in the downlink/uplink to 240/175 Mbps for the simplest devices, and from 130/45 Mbps to 645/235 Mbps for the most advanced devices.

Figure 18: Peak data rates for RedCap devices



5G FWA service provider adoption reaches 50 percent

The number of service providers offering Fixed Wireless Access (FWA) over 5G is growing in all regions. Over half of the global 5G FWA growth during the last 12 months came from launches in emerging markets.

During the last year, FWA has grown solidly in terms of the:

- number of mobile service providers offering FWA
- proportion of providers offering it over 5G
- share of providers with speed-based tariff plans
- FWA customer premises equipment (CPE) shipment growth, including 5G
- amount of traffic served, both in the number of connections and the traffic volume per connection

Global FWA momentum

An updated Ericsson study[1] of retail packages offered by mobile service providers has shown that around 80 percent have an FWA offering. There are 121 service providers offering FWA services over 5G, representing 50 percent of all FWA service providers.

Shipments of FWA indoor and outdoor CPE are expected to increase by 31 percent during 2023 to reach almost 25 million units. This is driven by strong growth of indoor devices, forecast to reach 21.6 million units, equaling a yearly growth of 34 percent. Shipments of 5G FWA CPE are forecast to increase in 2023 to 13.8 million, rising by 86 percent, and representing more than 40 percent of the total.[2]

Availability of speed-based tariff plans on the rise

Speed-based tariff plans are commonly offered for fixed broadband services, such as those delivered over fiber or cable. This type of plan is well understood by consumers, enabling service providers to monetize FWA as a broadband alternative. About 30 percent of FWA service providers now offer speed-based tariff plans, up from 25 percent a year ago. The remaining 70 percent have volume-based tariff plans (buckets of GB per month).

Figure 19: Global FWA service provider adoption 2020–2023

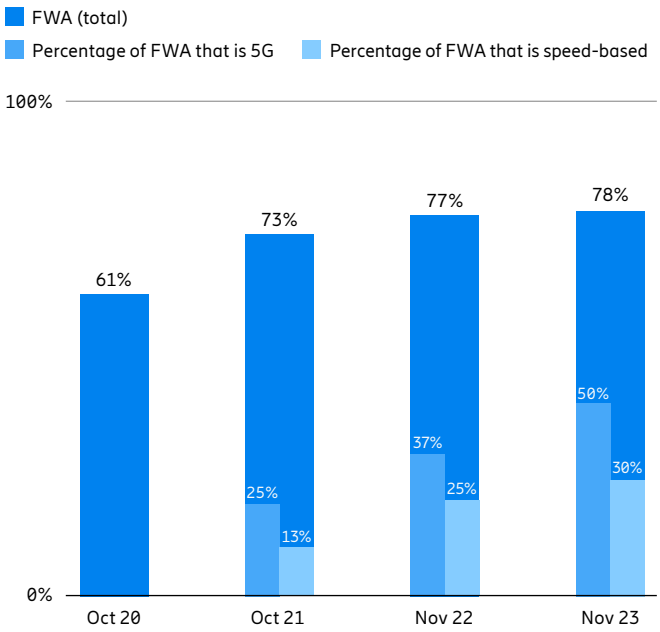
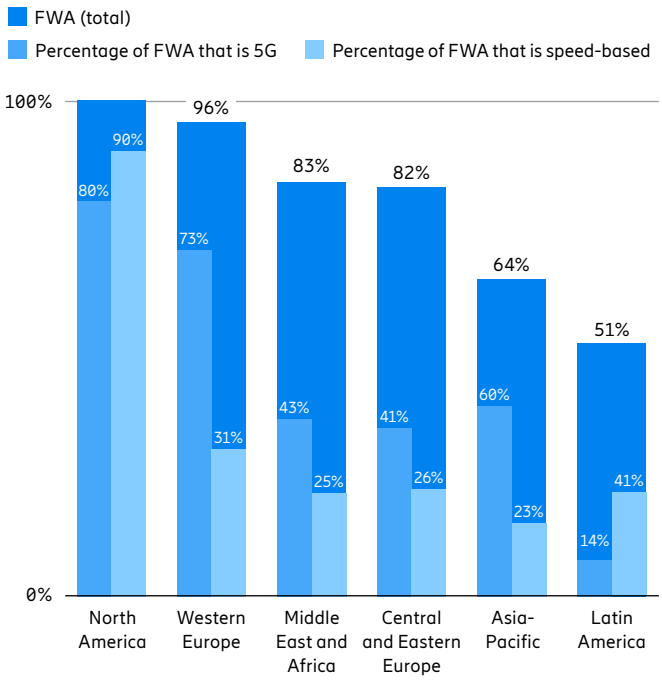
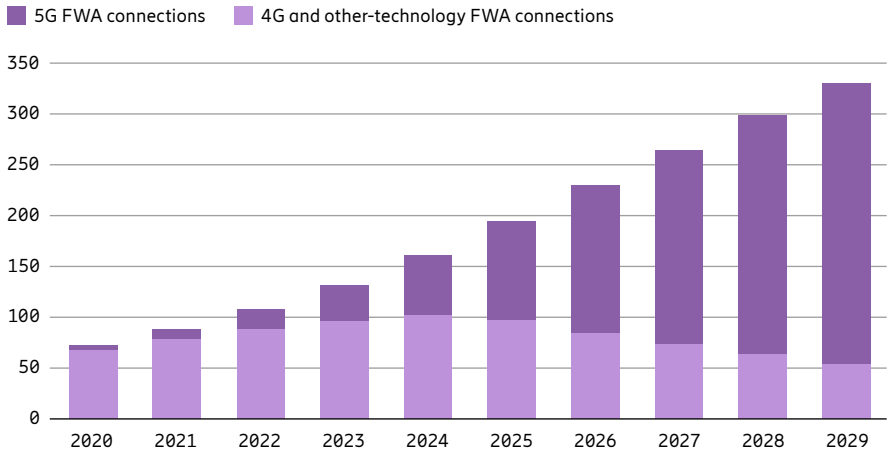


Figure 20: Regional FWA service provider adoption 2023



[1] 310 service providers, representing around 90 percent of global mobile revenues.
[2] Ericsson and GSA, FWA Forum CPE Survey (September 2023).

Figure 21: FWA connections (millions)



Definition of FWA
FWA is a connection that provides primary broadband access through mobile network-enabled CPE. This includes various form factors of CPE, such as indoor (desktop and window) and outdoor (rooftop and wall-mounted). It does not include portable battery-based Wi-Fi routers or dongles.

Regional variations
There are large regional variations in the proportion of service providers adopting FWA:

- In the regions North America, Western Europe, Central and Eastern Europe, Middle East and Africa, over 80 percent of mobile service providers offer FWA.
- Currently, North America stands out as the region with the highest adoption, with 100 percent providing an FWA offering, 80 percent offering services over 5G, and 90 percent having speed-based offerings.
- Latin America has a low percentage of service providers offering FWA, as well as a low percentage offering services over 5G. However, it has the second highest speed-based tariff plan adoption of all regions at more than 40 percent.
- Western Europe has the second-highest adoption, but is average in terms of offering speed-based tier plans.

FWA service provider advancements

- In India, two major service providers have launched 5G FWA services. Between them, they have expressed very high ambitions of serving homes and businesses with 5G FWA services in the coming two to three years.
- During the last year, 18 service providers in emerging markets have launched FWA services over 5G. These launches have been made in highly populated countries such as India, Brazil and Nigeria.
- As of November 2023, 50 out of 121 service providers with 5G FWA offerings are in emerging markets, with 11 of these service providers being in Sub-Saharan Africa.

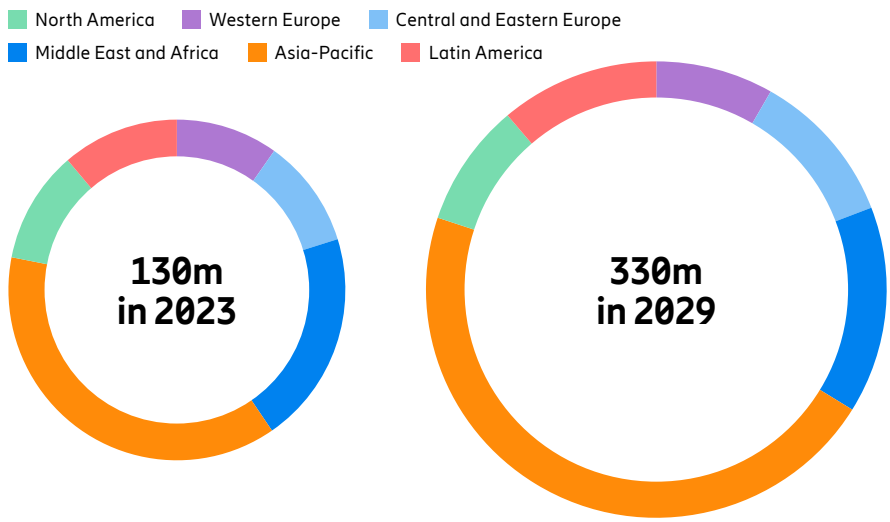
Over 330 million FWA connections by 2029
From 130 million at the end of 2023, FWA connections worldwide are projected to increase to 330 million by the end of 2029. This represents 18 percent of all fixed broadband connections. Of the 330 million projected connections, close to 85 percent are expected to be over 5G.

Over 45 percent of global FWA connections to be in Asia-Pacific by 2029
The forecast has taken the high ambitions of 5G FWA in emerging markets into account, both in terms of increasing the number of connections as well as the share of 5G FWA connections. Higher volumes of 5G FWA in large, high-growth countries, such as India, have the potential to drive economies of scale for the overall 5G FWA ecosystem, resulting in affordable CPE that will have a positive impact across low-income markets.

The number of FWA connections in Asia-Pacific is expected to more than triple, increasing its share of global FWA connections from 38 to 46 percent by 2029.

FWA impact on global mobile data traffic
FWA data traffic is forecast to represent 19 percent of global mobile data traffic at the end of 2023, and is projected to grow by a factor of more than 5 to reach 159 EB in 2029 – close to 30 percent of total mobile network data traffic.

Figure 22: Regional split in FWA connections 2023–2029



Over half of all new 5G FWA launches during the last year came from emerging markets.

55%

5G mid-band population coverage reaches 30 percent at the end of 2023

Mid-band population coverage outside mainland China is expected to reach 30 percent. Further densification is needed for the full 5G experience.

4G population coverage is expected to be around 90 percent globally at the end of 2023 and is projected to reach around 95 percent in 2029. There are currently 822 4G networks deployed worldwide, with 341 upgraded to LTE-Advanced and 68 being Gigabit enabled.[1]

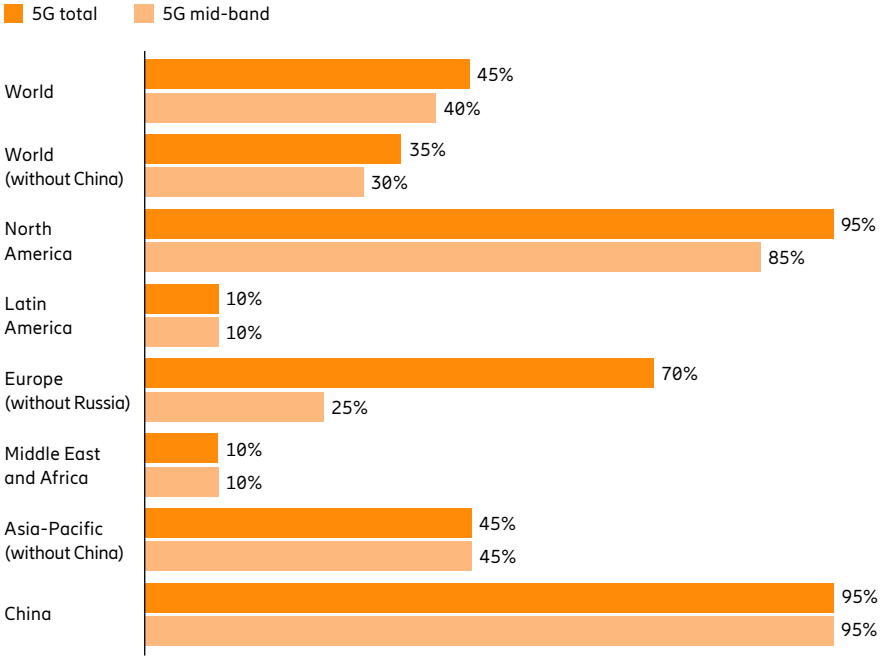
The build-out of 5G continues, with around 280 networks launched worldwide. Global 5G population coverage is forecast to reach 45 percent at the end of 2023 and is projected to increase to around 85 percent in 2029.

5G coverage varies across regions

Mid-band combines high capacity with good coverage and is available in most markets, making it an ideal choice for delivering the full 5G experience. Combined with a low-band frequency division duplex (FDD) 5G carrier, it can provide full coverage and mobility. While 5G mid-band population coverage is anticipated to reach around 40 percent worldwide by the end of 2023, it is now set to reach about 30 percent outside China. The increase outside China is mainly driven by large mid-band deployments in India, but also by several mid-band deployments in Europe during the year.

China has built a 5G population coverage of 95 percent, mainly through mid-band deployments. Meanwhile in Europe, there is a disparity between total 5G population coverage, expected to reach 70 percent, and mid-band coverage, which is expected to reach 25 percent at the end of the year.[2] This is due to the limited availability of mid-band spectrum in some countries, resulting in deployments being mainly low-band. North American service providers have deployed 5G across low-, mid- and high-band frequencies, with low-band now covering around 95 percent. During recent years, mid-band has also been rapidly deployed and is predicted to reach around 85 percent population coverage at the end of 2023.

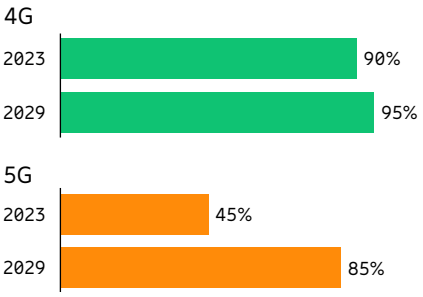
Figure 23: World population and mid-band coverage split by region (end of 2023)



Globally, 5G population coverage is set to reach around 85 percent at the end of 2029.

85%

Figure 24: World population coverage by technology



Note: The figures in these graphs are rounded and refer to coverage of each technology.
The ability to utilize the technology is subject to factors such as access to devices and subscriptions.
[1] Ericsson and GSA (October 2023).
[2] Both of these figures are excluding Russia.

ICT sector's footprint stable despite more subscribers and data usage

The ICT sector consumed about 4 percent of global electricity in the use stage, representing about 1.4 percent of global greenhouse gas (GHG) emissions in 2020. Up to 2030, it is forecast that electricity consumption will grow slightly, while carbon emissions will fall.

The ICT sector's use of electricity is the primary contributor to its GHG emissions. In addition to the use stage, all emissions related to materials, manufacturing and transportation are included within this carbon footprint. Reported data from over 150 companies in the ICT sector value chain was used in the 2020 study.[1,2] The forecast to 2030 is based on observed trends in the entire ICT sector.

ICT sector development 2007–2020

Use-stage electricity consumption in the ICT sector increased from 710 TWh in 2007 to 915 TWh in 2020. In 2020, the carbon footprint of the ICT sector was estimated to be 763 million metric tons (Mt) of carbon dioxide equivalent (CO_2e), compared to 620 Mt of CO_2e in 2007. The increase is mainly related to the use of IoT/machine-to-machine (M2M) technologies, and especially connected surveillance cameras (see lower lines in Figure 25). Many data centers and networks have increased the share of electricity they derive from renewable energy sources, as shown by slower growth of the carbon footprint (see Figure 25).

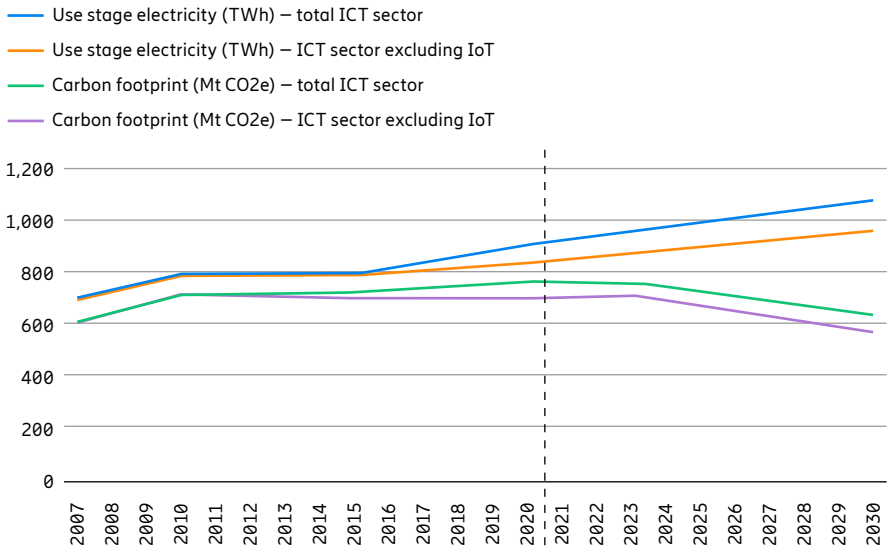
The amount of fixed and mobile data traffic increased about 40 times, while the number of ICT subscriptions (fixed and mobile) has increased 2.75 times since 2007. When considered with the electricity usage detailed above, this shows that electricity usage and carbon footprint has decreased per ICT subscription (not counting IoT subscriptions). Carbon footprint per subscription has decreased from 125 kg to 70 kg CO_2e. For a smartphone user and mobile broadband subscription, the footprint is about 25 kg CO_2e, similar to 2007 when the smartphone was introduced.

Looking forward to 2030

The forecast to 2030 shows an increase in overall ICT electricity usage during use stage, as networks will be built out and subscriptions will rise globally. The ICT sector's carbon footprint is forecast to reduce, as the electricity grid emission factor is forecast to reduce by at least 25 percent, and networks and data centers are expected to further increase the share of renewables. The forecast is based on development from 2007–2020 and subscriptions and sales trends.

The ICT sector could further reduce this forecast by focusing on materials used and energy efficiency, in addition to increased use of renewable energy. Faster sunsetting of older technologies such as 2G and 3G will directly impact use-stage electricity and lower the projected increase. Joint action is necessary to get on par with the 1.5-degree trajectory to 2030, as stated by the International Telecommunication Union (ITU)[3] as well as supporting Net Zero emissions targets.

Figure 25: ICT sector development 2007–2020 and forecast to 2030



ICT sector

The ICT sector is defined here to include data centers, mobile and fixed networks, user devices such as PCs (regardless of purpose), monitors, phones, tablets, customer premises equipment (CPE) such as routers, modems and so on. Payment terminals, surveillance cameras, smart meters, smart home devices and other IoT/M2M communication modules are here referred to as IoT devices. TVs, cable TV and broadcast networks, printers, paper media and other devices are defined as part of the entertainment and media sector and not included in the ICT sector, but are estimated in the cited 2020 study.

[1] "ICT Sector Electricity Consumption and Greenhouse Gas Emissions – 2020 Outcome" SSRN (April 2023).
[2] "Assessing embodied carbon emissions of communication user devices by combining approaches" Renewable and Sustainable Energy Reviews (September 2023).
[3] L.1470: Greenhouse gas emissions trajectories for the information and communication technology sector compatible with the UNFCCC Paris Agreement, International Telecommunications Union (ITU-T) (2020).

Articles

Our articles focus on how service providers and enterprises can prepare and plan 5G coverage. First, with Jio, we discuss large-scale 5G SA deployments to capture nationwide business opportunities. The following two articles explore coverage for specific purposes and places – we look at optimizing user experience in key indoor venues, and finally how enterprises can choose 5G to enhance agility and scale in manufacturing and production settings.

We explore how Jio's large-scale 5G deployment strategy has contributed to considerable 5G SA population coverage in India, and the business and enterprise opportunities that come with such a network.

Page 25

As mobile broadband users, we consume up to 80 percent of our data indoors. This article explores the best deployment scenarios for improving indoor user experiences, especially in congested venues.

Page 29

The automation required to fully optimize and scale floorspaces in gigafactories and green steel plants requires wireless connectivity. Our article explores the features of this growing manufacturing segment and why 5G is an ideal wireless solution.

Page 33

Large-scale 5G SA deployment to drive digital transformation in India

5G is foundational for India's digital transformation. Through ambitious, large-scale deployment of 5G standalone (SA), Jio aims to capture the business opportunity for the consumer and enterprise segments.

Key insights

- Fast and extensive deployment of 5G SA coverage and network slicing enables new business models and innovation for different market segments.
- 5G Fixed Wireless Access (FWA) with network slicing is a key differentiator driving transformation of residential and enterprise connectivity.
- Jio considers that being at the forefront of evolving use cases in network automation, network slicing and XR provides a competitive edge in the market.

Jio entered the mobile broadband market by deploying a greenfield 4G network in 2016. When services were launched in September that year, the network had already reached 80 percent population coverage, sparking intense competition among service providers and causing strong growth in 4G subscription uptake and data usage. Within 5 months of launch in September 2016, Jio's 4G subscriptions passed 100 million. By March 2023, total mobile broadband subscriptions in the country increased to over 830 million, with Jio contributing 53 percent of the base, and skyrocketing average total data usage per subscriber in India from 240 MB to 17.4 GB per month over the same period. Consequently, India's share of global mobile data traffic increased from around 3 percent to 20 percent during this time.

4G made India digital

4G coverage build-out and affordable data plans played a significant role in transforming India's digital landscape. The widespread availability and increased penetration of mobile broadband internet subscriptions fueled consumption of the wide range of new digital services and applications made available by the growing domestic ecosystem. Faster mobile broadband speeds encouraged the adoption of video streaming, social networking, e-commerce, online education and digital payments. The digital transformation brought about by 4G positively impacted the country's economy, creating job opportunities, driving entrepreneurship and launching many start-ups. The government's Digital India program, launched in 2015, also gained momentum, making governance more efficient and accessible to citizens by providing public services digitally.

5G as a foundation for digital transformation

The Indian government's spectrum auction in July 2022 and Jio's acquisition of spectrum across low-band (700 MHz), mid-band (3.5 GHz) and high-band (26 GHz) have enabled rapid 5G expansion.

5G is expected to enable the next phase of growth and transformation in India's digital landscape, supporting the vision to transform the country into a digitally empowered society and knowledge economy.[1]

Indian 5G subscribers are experiencing significantly better mobile network speeds, as 5G SA coverage and capacity continue to be deployed. 5G users in India consistently rate their service providers more positively compared to 4G users, indicating higher customer satisfaction (measured with a Net Promoter Score, or NPS).[2]

Jio has established itself at the forefront of 5G SA deployments in India, with a firm belief that 5G can catalyze economic growth by fostering innovation in various sectors, including manufacturing, healthcare, agriculture, transportation and education.

This article was written in collaboration with Jio, a leading communications and digital services provider deploying 5G everywhere for consumers and enterprises across India.

These innovations can lead to job creation and increased economic productivity, a key goal of India's digital transformation efforts.

5G can also help India meet its ambitious climate commitments and sustainable development goals by improving environmental monitoring and conservation efforts, for example by providing real-time data on climate, pollution and wildlife tracking.

Deploying nationwide 5G SA coverage at scale and speed

Jio has deployed true 5G capabilities by adopting a 5G SA architecture from day one, making it a global pioneer in this regard. Jio pursues a multi-band strategy, with 5G deployments in low-band (700 MHz), mid-band (3.5 GHz) and mmWave (26 GHz). The strategy is to maximize the Massive MIMO coverage on mid-band, by configuring layer management and carrier aggregation features of 5G SA networks. This optimizes mid-band usage over low-band (coverage layer).

Jio's 5G FWA portfolio (AirFiber) of 5G SA and Smart UBR, with its low-latency and high-capacity capabilities, is delivering residential broadband as well as business-connectivity solutions for small, medium and large enterprises.

[1] CSC, Digital India.
[2] Ookla Insights Articles, "India's Remarkable 5G Advancement Elevates it's Global Mobile Ranking" (1 October 2023).

The broader context of India's digital transformation and socio-economic development goals must be considered to understand Jio's decision to choose 5G SA over non-standalone (NSA), despite the relatively nascent state of the 5G SA ecosystem at that time. It is a forward-looking strategy that enables Jio to provide truly differentiated 5G services in a highly competitive market. Jio foresees growing demand for services that utilize the inherent capabilities of 5G SA networks, such as low latency, massive machine-to-machine communication and network slicing. Nationwide 5G SA network deployment has had a significant impact on the 5G SA ecosystem, with a noticeable growth in SA-supported devices. All new 5G devices released in India support SA and more than 90 percent support carrier aggregation and Voice over New Radio (VoNR) out of the box. 5G SA provides greater control over network resources, allowing for more defined service quality and enhanced customization of services compared to NSA architecture.

Jio is set to complete the world's fastest and largest nationwide mid-band 5G rollout outside of China by the end of 2023. In just 12 months after launch in October 2022, it has deployed more than 1 million 5G cells, deploying one 5G cell every 10 seconds at the peak of the rollout. This is stated to account for more than 85 percent of the country's deployed 5G capacity.[3]

The speed of deployment is facilitated by an ahead-of-time infrastructure upgrade, high fiberization and optimal use of E-Band and unlicensed band radio (UBR) for backhaul.

The deployment strategy also encompasses a strong focus on network performance using advanced layer management and optimization with a fully automated self-organizing network (SON). It also encompasses deployment of true 5G services using fully automated service orchestration and management functions.

Subscription and traffic growth follow coverage build-out

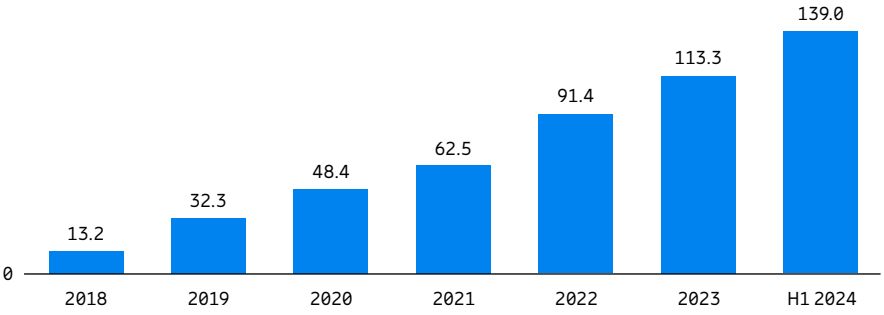
Jio is building 5G coverage and capacity at scale and speed to ensure it can drive new customer acquisition through offering high-quality services, and migrate its 4G customers to 5G at a faster pace. In October 2023, Jio announced that it had reached 70 million 5G customers in less than 11 months from its 5G services launch.

The wide deployment of 5G SA on mid-band spectrum and carrier aggregation has driven substantial growth in data consumption. Jio's monthly total network data traffic has experienced a 29 percent year-over-year growth. Jio's ambition to offer a best-in-class network to their consumers is reflected in the fast 5G SA coverage build-out and mobile broadband speed improvements, as shown in Figures 27 and 28. Third-party Speedtest® measurements on the 5G network have resulted in awards for providing best customer experiences in speed, video and gaming.[4] On a country-wide scale, 5G subscribers are also more satisfied with network performance compared to 4G subscribers. In a recent Ericsson ConsumerLab study comparing consumers' satisfaction with 4G versus 5G network performance – in various aspects such as mobile gaming, video streaming, download speeds and video calling – it was found that 5G consumers in India consistently report significantly higher levels of satisfaction, with a nearly 30 percent increase compared to 4G users.[5] All this is being enabled by ubiquitous 5G coverage, carrier aggregation between mid-band and low-band, and deployment of Massive MIMO radios at each site.

Due to its wide coverage build-out, Jio has also offloaded significant traffic from the 4G to 5G network, improving the experience of its 4G customers. A fast migration of the 4G subscriber base to 5G subscriptions will free up 4G network capacity for new subscribers. India has around 250 million 2G subscribers, which Jio targets for migration to 4G by offering a low-cost 4G phone (USD 12) and an affordable service plan.

Jio considers two factors to be critical for 5G uptake: building ubiquitous 5G coverage, providing high-speed, low-latency connectivity to consumers everywhere; and implementing dynamic network slicing to seamlessly deliver immersive experiences. These two factors will also be key enablers for the introduction of XR services to customers.

Figure 26: Jio's data traffic has grown more than 10 times in the past 6 years (EB)



Note: 2018–2023 are fiscal years. Data traffic for the first half of 2024 is annualized.

Figure 27: 5G test samples. Analysis of Speedtest®, Jio India

Source: Based on analysis by Ericsson of Ookla® Speedtest Intelligence® data, India, Oct 2022, April 2023, Sept 2023.

[3] RIL Q2 2023–2024, Media and Analyst Call Transcript (27 October 2023).
[4] Speedtest awards, India (2023).
[5] Ericsson Consumerlab, 5G value: Turning performance into loyalty (October 2023).

Figure 28: Network performance. Analysis of Speedtest®, Jio India

Note: Jio 4G/5G access. The regions are colored based on median speeds (0–200 Mbps).
Source: Based on analysis by Ericsson of Ookla® Speedtest Intelligence® data, India, Oct 2022, April 2023, Sept 2023.

Challenges with fast 5G deployment in India

When rolling out 5G, the physical sites such as cell towers and related infrastructure must be ready for the new technology. Deployment is highly dependent on automation, but human expertise still plays a significant role. One of the major challenges in 5G network management and troubleshooting is process automation and ensuring that the workforce possesses the required skills and knowledge. Jio tackled this challenge by leveraging AI and proactively automating the complete plan to build processes and provide its workforce with extensive training to bridge any competence gaps.

Consumers have high expectations when it comes to the quality and performance of 5G networks. However, meeting these expectations is a complex challenge that requires optimizing the network, addressing potential issues such as signal interference and latency and ensuring a seamless user experience. Jio conducted thorough testing and network fine-tuning to ensure that its 5G SA network can handle the anticipated loads.

Network slicing opens new opportunities

Jio's approach to network slicing is grounded in its potential and the challenges that need to be overcome. Jio has implemented end-to-end network slicing for its FWA service, providing residential customers with digital entertainment, smart home services and high-speed broadband, without impacting the experience of its mobility customers. Currently, it's employing service- and user-level slicing, while keeping a keen eye on the evolving ecosystem for application-level slicing. As slicing business models are still in their infancy, Jio recognizes that it's crucial to collaborate with industries and enterprises to co-create value propositions concerning slicing solutions.

Jio is actively working with device partners and application providers to build innovative services in various sectors, including healthcare, education, retail, manufacturing and security and surveillance solutions. Jio is also collaborating with enterprise partners to identify areas where slicing benefits can substantially impact their operations. This collaborative approach is helping Jio to develop a robust business case and ensures that deployment plans align with the specific needs of the enterprise.

Jio has deployed a fully automated service management and orchestration function, that enables it to deploy, test and productionize new services using network slicing in a very short time frame.

Network slicing: The go-to-market challenges

One of the primary challenges in bringing slicing-based services to the market is the nascent and rapidly evolving nature of use cases, across both consumer and enterprise domains.

These use cases need to be relevant and impactful for customers, with fast innovation and adaptation necessary to meet the changing demands of the market.

The implementation of slicing solutions necessitates changes in operations support systems (OSS) and business support systems (BSS). These systems need to be agile and flexible to support dynamic slicing. This includes provisioning, monitoring, billing and quality assurance processes that should align with the dynamic nature of slicing services. The ability to efficiently manage and maintain the network slices is crucial for delivering a seamless customer experience.

Solving the go-to-market challenges for slicing services requires a keen focus on staying at the forefront of evolving use cases, ensuring device compatibility and adapting OSS/BSS processes to meet the unique demands of this innovative technology. Successfully addressing these challenges is essential for service providers to bring slicing-based services to market effectively and delivering value to customers.

Differentiating offerings with network slicing

Jio's 5G SA network opens doors to a wide range of new business opportunities, from immediate offerings like gaming and 360-degree live streaming to future XR experiences. While slicing-based B2C services are still evolving, Jio has launched consumer services like cloud gaming, esports and live streaming that will benefit from slicing. With JioGamesCloud and JioGamesESports, Jio aims to expand its foothold in the growing cloud gaming and esports markets. These services can offer engaging and competitive gaming experiences by leveraging the high speeds and low latency of 5G SA.

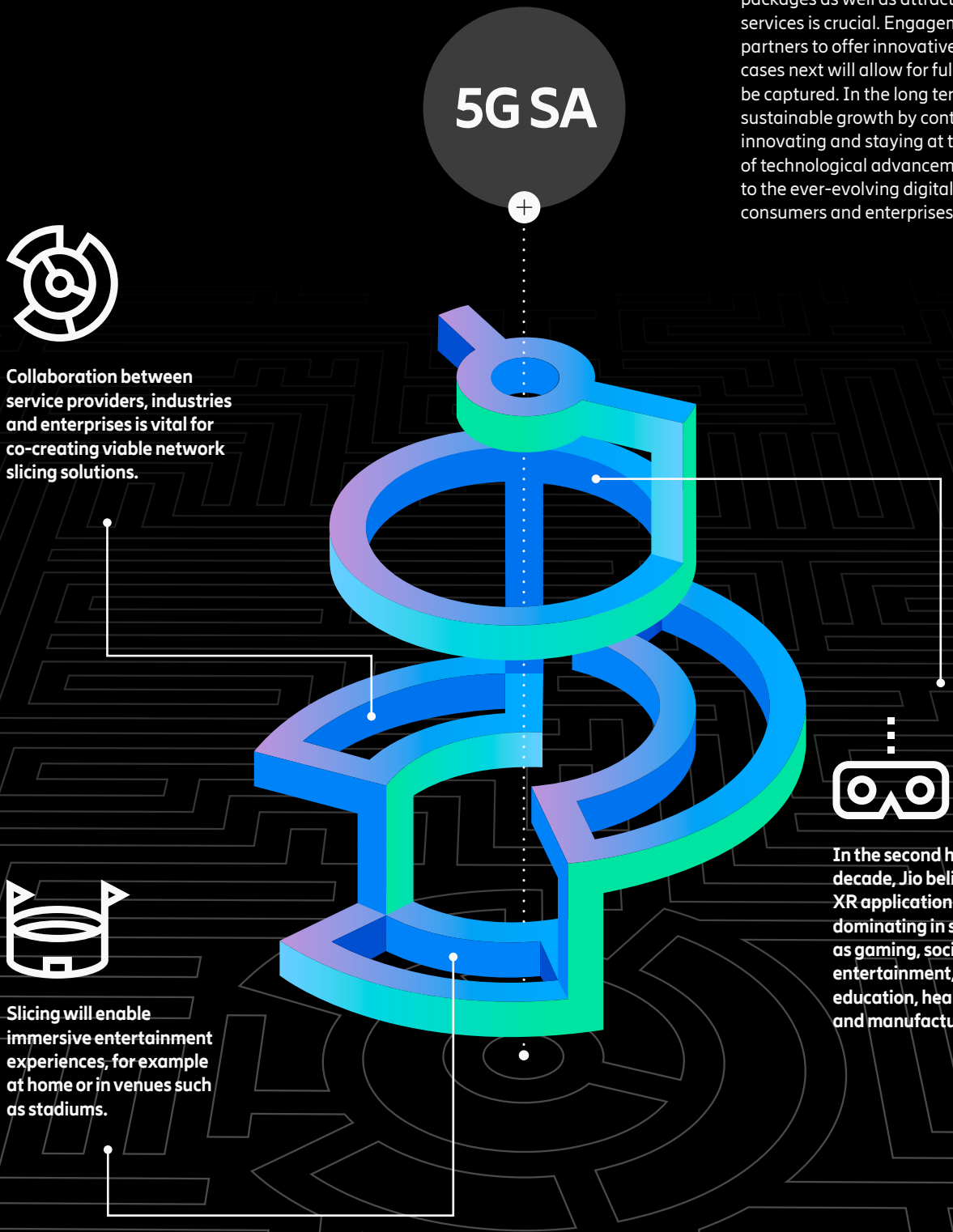
In the mid term, Jio is looking to expand its service offerings based on XR. One example is the launch of the JioDive VR headset and JioImmerse content library, enabling access to a wide range of VR applications and experiences. As an example, with this equipment, matches in a major Indian cricket tournament in 2023 could be watched online on a virtual 100-inch screen with a 360-degree view of the stadium. Jio aims to continue to enrich their content portfolio and provide immersive digital experiences, catering to a diverse user base seeking interactive and virtual experiences.

Jio believes that XR applications will start dominating in the gaming, social media, entertainment, retail, education, healthcare and manufacturing sectors in the second half of this decade. Jio will continue to evolve its 5G network capabilities along with the evolution of XR applications.

There are multiple scenarios that Jio is working on with its partners to extend its reach into the B2B space. These include slicing-based services tailored to various industries, such as dedicated slices for enterprise operations, or for specific events or locations. It's critical to collaboratively define use cases with enterprise partners and ensure both the network and OSS/BSS ecosystem is ready for end-to-end management of multiple slices. Jio has initiated 5G deployments in industries like oil and gas and manufacturing, and is testing solutions in other areas such as: healthcare; public safety and emergency response; secure enterprise applications and services including SD-WAN, supported by SD-WAN, supported by Jio's FWA portfolio (Airfiber) of 5G SA and Smart UBR; remote operations; digital twins; media broadcasting and more. For B2B2C services, Jio considers the ecosystem to still be evolving, calling for extensive collaboration with relevant partners to evolve and refine propositions and establish robust end-to-end management mechanisms.

Continuing to make the most out of 5G

Building out network coverage is an important first step, but as Jio has demonstrated, committing to consumer satisfaction and offering accessible packages as well as attractive additional services is crucial. Engagement with partners to offer innovative business use cases next will allow for full opportunity to be captured. In the long term, Jio envisions sustainable growth by continuously innovating and staying at the forefront of technological advancements, catering to the ever-evolving digital needs of consumers and enterprises.



Demand for indoor connectivity driving the need for enhanced performance

To achieve expected indoor performance, both coverage and capacity must be enhanced in key venues through optimal network deployment scenarios.

Key insights

- Indoor traffic patterns are different compared to outdoor – 1.5–2 times more traffic per user, with large variations across venue types.
- Indoor small cells provide significant throughput improvements over distributed antenna systems (DAS), especially in uplink, paving the way for XR services.
- Current 4G indoor deployments often experience high load and limited user performance. 5G mid-band should be deployed to deliver the full 5G experience.

So far, 5G mid-band time division duplex (TDD) has mostly been deployed at outdoor macro sites to provide coverage and capacity for mobile broadband and Fixed Wireless Access (FWA) services. However, the majority of traffic is generated indoors where people tend to spend most of their time; we spend 90 percent of our time indoors, and up to 80 percent of our data is consumed there.[1]

The importance of indoor performance

With so much of our lives spent inside, it makes sense to focus on providing 5G performance at indoor venues, especially where there are high user concentrations. Indoor environments often have difficult propagation characteristics due to the fabric of buildings containing steel frames and solid walls. Venues typically facing these challenges include train stations, shopping malls, stadiums and airports.

To address these challenges, tailored 5G solutions for indoor deployments are preferred as they can deliver superior user experience.

A recent ConsumerLab study shows the correlation between network performance in key locations and service provider churn. The research found that users who encounter connectivity problems at event venues and airports are three times more likely to churn in the next six months.[2] This highlights the need to invest in improving performance in key locations for today's services to drive up customer satisfaction. It will also be fundamental for new and emerging services such as cloud gaming and XR that have demanding network performance requirements.

Methodology

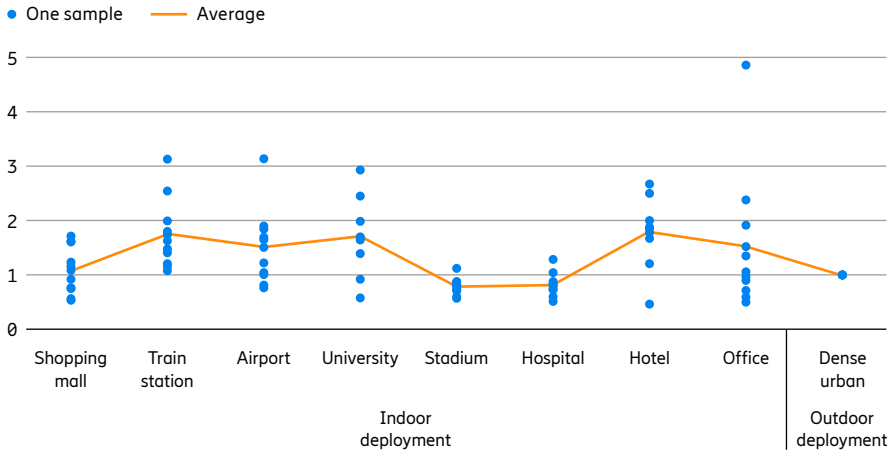
In North America, data was retrieved from nine different venue types, with 30 samples of mobile traffic data taken per venue type, from across three different networks in Q1 2023.

Indoor traffic behavior analysis

Understanding user behavior is important for selecting the best indoor solution to meet user experience and capacity needs. Mobile data usage patterns will be different across venue types depending on the services that users are running on the mobile network. Indoor venues typically have many users concentrated in a limited area, making capacity demands extremely high during peak times.

In many cases, average traffic consumption is also significantly higher in the indoor venues compared to when being served by the outdoor network. Figure 29 shows the relative average traffic per user in indoor venues, normalized with outdoor dense urban traffic. The results show that in busy venues peak traffic per user is 1.5 times higher on average, with one airport in the sample seeing over three times higher traffic. This illustrates that not only is there a difference by venue type but often a large spread within the same venue type.

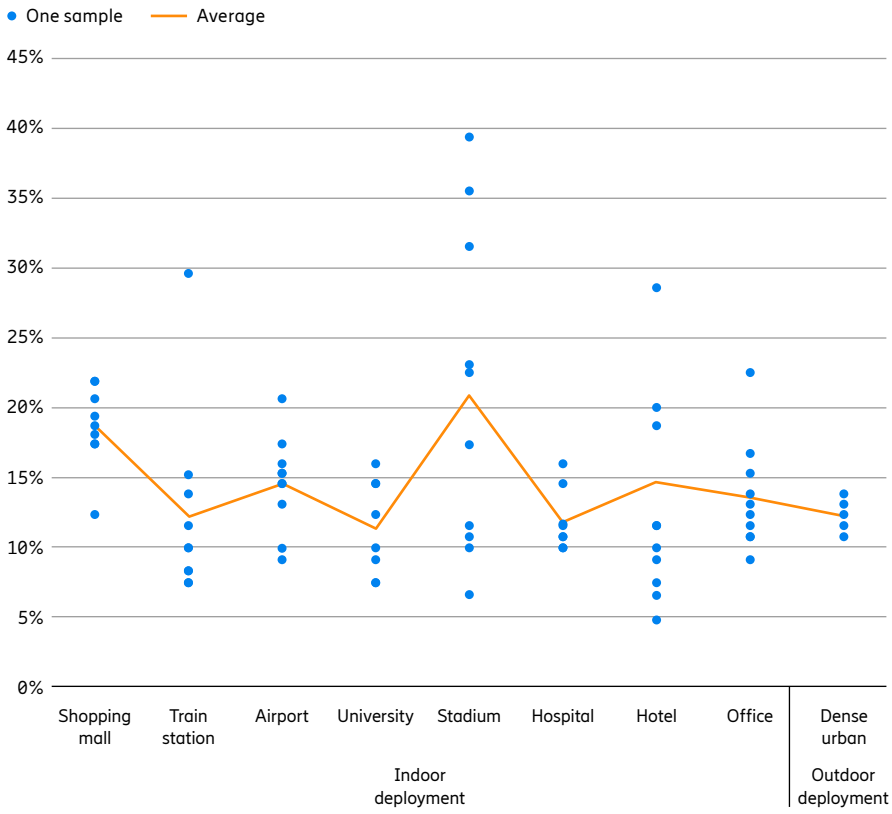
Figure 29: Relative average traffic per user for busy hour



[1] Ericsson Blog, "5 ways indoor 5G will change your life (and mine)" (July 2023).
[2] Ericsson ConsumerLab, 5G value: Turning performance into loyalty (October 2023).

Further analysis of the traffic shows that the share of uplink traffic is significantly higher at many indoor venues, compared to the dense urban benchmark (see Figure 30). There is considerable variation in the share of uplink traffic at stadiums and hotels. Social media sharing from live events could explain the high uplink traffic in stadiums, as highlighted by a major sporting event within a stadium where 35 percent of traffic was uplink. Hotels are likely to have the biggest variation based on their venue, guests, and time of the week. The most-used services here range from uplink services such as uploading of work-related material, video calls and social media, compared to heavy downlink traffic from services like video streaming. Altogether, these results exemplify the need for a good understanding of traffic behavior when planning and deploying an indoor 5G solution.

Figure 30: Share of uplink traffic out of total traffic



Bringing 5G to enhance the fan experience

For the recent major women's football tournament in Australia, Optus upgraded three stadiums, introducing 5G bands (non-standalone and standalone) to enhance the fan experience. The event saw games sell out and stadiums reach full capacity, totaling an excess of 0.75 million live spectators. To analyze the fan experience during the live events, over 1,100 cells were monitored, including within the stadiums, corporate boxes, nearby public transport and the immediate vicinity around the stadiums.

During the event over 29 TB of mobile traffic was generated, of which 37 percent was carried over 5G, with the 5G share peaking at 51 percent.

On average, 40 percent of devices in the stadiums were 5G capable, making it critical to have 5G at such events to meet traffic demands and enhance the fan experience. Of the traffic generated during the tournament, around 25 percent was uplink driven by social and sharing applications, illustrating the importance of considering both uplink and downlink performance when dimensioning deployments in such venues to give fans the complete experience.

When measuring the success of bringing 5G bands to the stadiums for this event, the key performance indicator was reaching greater than 99 percent accessibility. This was achieved across all stadiums for both 4G and 5G.

This success was partly enabled through 7,000 live changes optimizing the cell sites. This resulted in an improvement in uplink throughput that ranged from 5–53 percent compared to matches with similar traffic prior to the improvements made for this tournament.

Optus is working to further enhance two major stadiums with the latest high-capacity design, products, and network performance. One of the key objectives is to monetize the superior network performance through service offerings such as new immersive experiences.

OPTUS

Figure 31: Optus' reported women's football tournament network statistics, 2023

Over 0.75 million live spectators attended the games in total.

>0.75m

Over 29 TB of mobile data traffic was generated, of which 37 percent was over 5G and 25 percent was uplink.

>29 TB

4G and 5G reached over 99 percent accessibility during the tournament.

>99%

Resource utilization is nearing capacity

Deeper analysis of the 4G radio resource utilization in the busy hour has been examined for many venues. When resource utilization is below 50 percent a good user experience can be delivered, with over 95 percent of users experiencing an acceptable time-to-content for web browsing. When utilization reaches a high level, above 50 percent, and a high density of users are requesting services at the same time, this will lead to a degraded user experience. Many users are fighting to share limited resources. Figure 32 shows that resource utilization is very high in many deployments across different venues. Typically, stadiums perform better, having seen more investment in indoor solutions and also being well supported by the macro network.

A key metric for measuring user experience is time-to-content. In a separate Ericsson Smartphone Lab study, results indicated a strong relationship between available downlink throughput and time-to-content.[3] With a time-to-content scale we can derive the throughput that would be required to meet a certain target. This scale grades sites as:

- excellent (<1.5 s)
- good (1.5–2.5 s)
- fair (2.5–4.0 s)
- poor (>4.0 s)

Throughput results are graded as:

- excellent (>20 Mbps)
- good (10–20 Mbps)
- fair (5–10 Mbps)
- poor (<5 Mbps)

When we overlay this onto cell-edge performance across the key venues, shown in Figure 33, we can see that excellent performance is only realized in a small portion of office and stadium deployments, with airports being the worst performing venue type by far.

These high levels of utilization and relatively poor cell-edge performance for time-to-content highlight the need to improve indoor network performance. In a venue with 5G indoor small cells deployed there was double the throughput on average and three times better throughput at the cell edge. Adding 5G mid-band TDD provides a significant improvement in user performance.

Figure 32: Percentage of venues with high radio-resource utilization (above 50 percent)

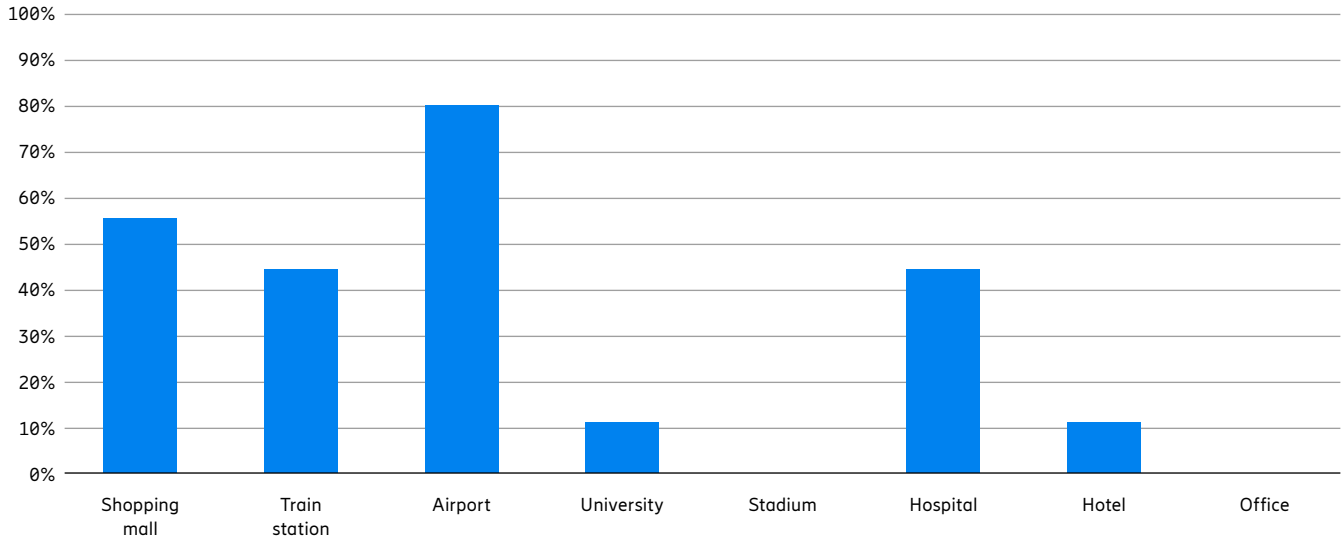
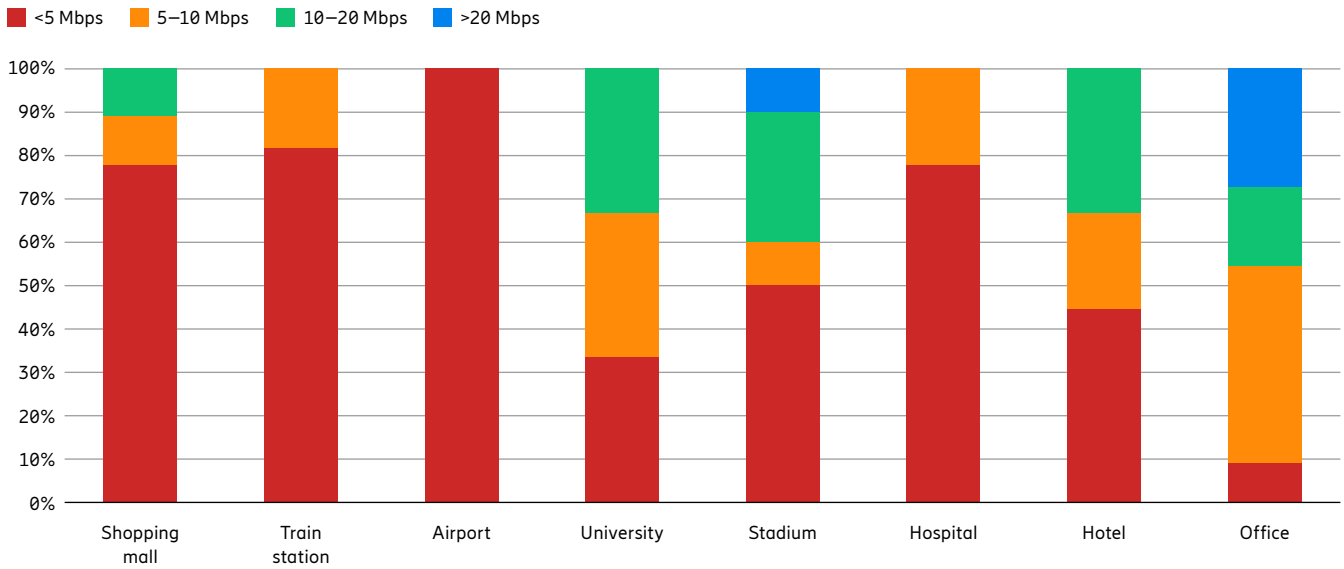


Figure 33: Percentage of different categories of 4G downlink cell-edge throughput



[3] Ericsson Mobility Report, "Time-to-content: benchmarking network performance" (November 2021).

Indoor deployments dominated by 4G DAS in the US

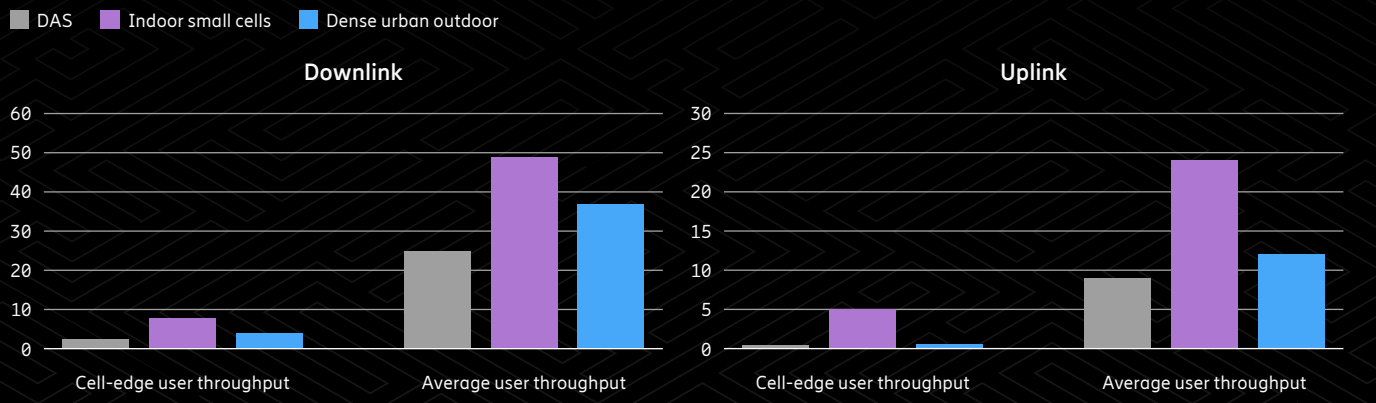
To better understand current indoor network characteristics and the performance of different solutions, a range of deployments from the US across typical indoor sectors has been analyzed. Today, the vast majority of these indoor deployments are still based on 4G solutions, with indoor DAS being the most common, making up over 70 percent. A typical indoor sector is deployed with 20–40 MHz mid-band FDD which is quite limited compared to typical macro 5G mid-band TDD bandwidths.

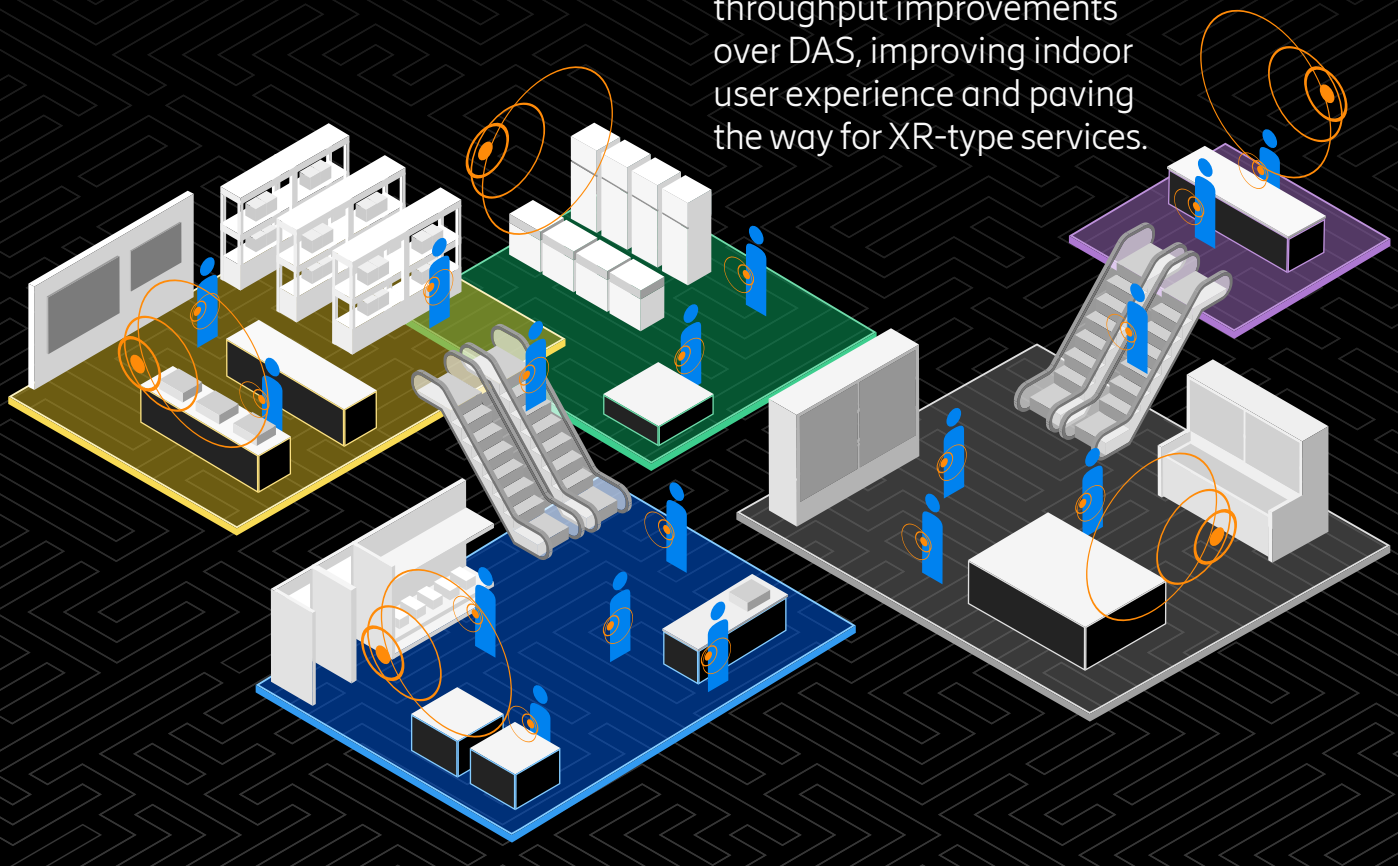
When analyzing the busy hour user experience, Figure 34 shows that an indoor DAS solution falls short compared to outdoor macro deployments for serving these venues, even though DAS has antennas deployed much closer to the users. In comparison, indoor small cells provide a superior user experience in both uplink and downlink, including at the cell edge, which will drive the required improvement in time-to-content. This significant advantage indoor small cells have in the uplink is important for growing uplink traffic, especially in key venues such as airports and stadiums, and will be critical in paving the way for new services like XR.

The time is now to enhance the indoor experience

Upgrading the indoor experience is required today to drive customer satisfaction. The examples discussed here show that user experience is key to driving customer loyalty, and given the time spent indoors, it offers service providers an opportunity to deliver on, or even to exceed, consumer expectations with enhanced experiences. There is a clear need for investment in key locations, especially airports which have some of the worst performance data, alongside being a key location driving churn. 5G mid-band TDD and indoor small cells are the optimal solutions for significantly improving network performance for downlink time-to-content, and even more so for uplink, which will be key to paving the way for new immersive XR services.

Figure 34: 4G user experience shown as downlink and uplink throughput (Mbps per second)





5G-enabled agility in gigafactories and green steel plants

The joint importance of renewable energy and decarbonization have triggered a wave of global investments in sustainable manufacturing.

Key insights

- Agility in manufacturing means wireless connectivity; cables will not suffice.
- Production processes cannot tolerate downtime, intermittent network delays or blind spots in coverage.
- 5G private networks built on mid-band provide the needed coverage, performance, and reliability.

Gigafactories are very large manufacturing sites that were pioneered to rapidly increase the scale of the production of electric vehicles, batteries and clean technologies in order to meet rising demand for these products. "Green steel" plants are preparing to decarbonize the production processes using hydrogen-based reduction. These factories are designed to gain efficiencies by operating at a massive scale with inbuilt agility. To enable this massive scale, 5G private networks are being deployed in green steel plants and gigafactories specializing in auto manufacturing and battery production.

Scale and agility are often competing requirements

Gigafactories require both scale and agility. Scale is often achieved by increasing the levels of automation. Traditionally, this is "hard-wired" automation, which typically limits reconfigurations on the factory floor, for example one factory claims to make around 300 layout changes per year. This could be setting up a new test station to align with production capacity, making improvements to the production line to optimize ergonomics, or changing material placement, having the flexibility to accommodate new product mixes. For gigafactories to achieve optimum efficiencies from their equipment, machinery, tools and workers, agility is needed across the shop floor. To find a solution that retains both dimensions, the manufacturing industry, and especially new gigafactories, have been exploring technology options that support the scale without compromising agility. In connectivity terms, this means a wireless solution is required.

Wireless connectivity is required to provide the agility to support rapid changes and redeployment of factory resources, to be able to begin production even while the site is under construction, to relocate production cells dynamically and to connect workers wherever they are. The production processes cannot tolerate intermittent network delays or coverage blind spots.

These high demands put the wireless network firmly in focus, as a key determinant of production line output. The selected wireless connectivity needs to be able to comfortably handle the sort of high mobility that automated guided vehicles (AGVs) require, such as smooth cell handover. At the same time, it also needs to provide the low latencies demanded by remote-controlled equipment and cycle-based industrial automation protocols, as required by PROFINET.[1]

5G meeting the demands of gigafactories

Factory networks must be capable of much more than serving smartphones. Connectivity for production lines must deliver high performance, with dedicated resources and full redundancy. Across a range of 5G private network deployments, the most commonly observed systems are wireless tablets and tools for workers, remote support on-demand, AGVs and robotic equipment, and sensors and cameras that gather data for AI systems to monitor quality. With this range of use cases in mind, the user may not be a human at all – it could be an autonomous machine or wireless tool, rather than a person with a smartphone.

This creates a different traffic profile, where devices may be latency-sensitive, such as industrial automation equipment or wireless tools, or the throughput may be uplink-intensive, such as HD cameras. Networks need to be designed to fit these traffic parameters. These requirements fit the capabilities of 5G – key factors that make 5G attractive to gigafactories are the coverage capabilities, linked with the reliability to support dedicated connectivity resources and full redundancy.

Typical manufacturing shop floors may reach up to 100,000 sq m, whereas gigafactory floorspaces rise well above these numbers and can be more than 5 times larger. 5G networks are better equipped to cover large areas, with the typical number of Wi-Fi access points required to cover areas this size being much higher than the number of 5G indoor radios. Furthermore, mobility in a 5G network is seamless, whereas in a Wi-Fi network, handover between access points can lead to short traffic interruptions, which are not acceptable for many use cases, for example, AGVs.

The wireless network has become a key determinant of production line output. Production processes cannot tolerate intermittent network delays or coverage blind spots.

[1] PROFINET is an open technical standard for data communication over Industrial Ethernet.

To provide the required reliability, given that the network serves as the heart of the production process, all equipment is duplicated to ensure outages don't lead to downtimes. The indoor coverage can also be extended outdoors to logistics areas and process plants. This broader wide-area coverage means that the connectivity network requires geo-redundancy over distances stretching into the km range. 5G mid-band spectrum, being less sensitive to radio wave reflections, is better suited than Wi-Fi to factory environments where concrete, metal, equipment and inventory present potential signal interruptions. Radio planning must account for the site environment.

Deployment scenarios in gigafactories

Gigafactories are major capital investments that demand early launches to generate returns, so they cannot afford lengthy periods of isolated use-case evaluation. "Single use case" testing is bypassed, while technology needs are determined holistically and applied in parallel from the start. The real value comes when multiple use cases are applied to many stages of the production line.

Auto and battery manufacturers incorporate 5G networks into the design of greenfield factories from the start, so they can utilize both public network coverage for staff and a private network for the production process. The objective is to improve assembly line productivity by providing the right connectivity for critical AGV operations, wireless tools and mobile screens.

Gigafactories have large indoor footprints, and 5G has proven to be more cost-efficient by requiring 8–10 times fewer access points compared to Wi-Fi.

The networks may use up to 100 MHz of mid-band spectrum, with 5G standalone (SA). If 4G is also required due to device availability, then a mixed-mode 5G SA plus 4G could be used. The allocation of spectrum to gigafactories is critical to support the range of use cases with demanding performance characteristics.

Given the significant costs of downtime in such a facility, to minimize interruptions to the production line, full redundancy principles can be applied to all components of the network across power, core, basebands and radio, with each of them duplicated.

The real value of 5G becomes clear when multiple use cases are applied to many stages of the production line.

Case study: Decarbonizing steel

ArcelorMittal France

A global leader in steel and mining, ArcelorMittal is active in programs for the decarbonization of steelmaking. The company targets a 35 percent reduction in its CO2 emissions by 2030 in Europe, and carbon neutrality by 2050.[2]

ArcelorMittal has already introduced 4G and 5G private networks to its plants in France, starting in Dunkerque. ArcelorMittal has announced the operational launch of 5G Steel, the largest 4G/5G network in the industrial environment, with Orange Business Services.

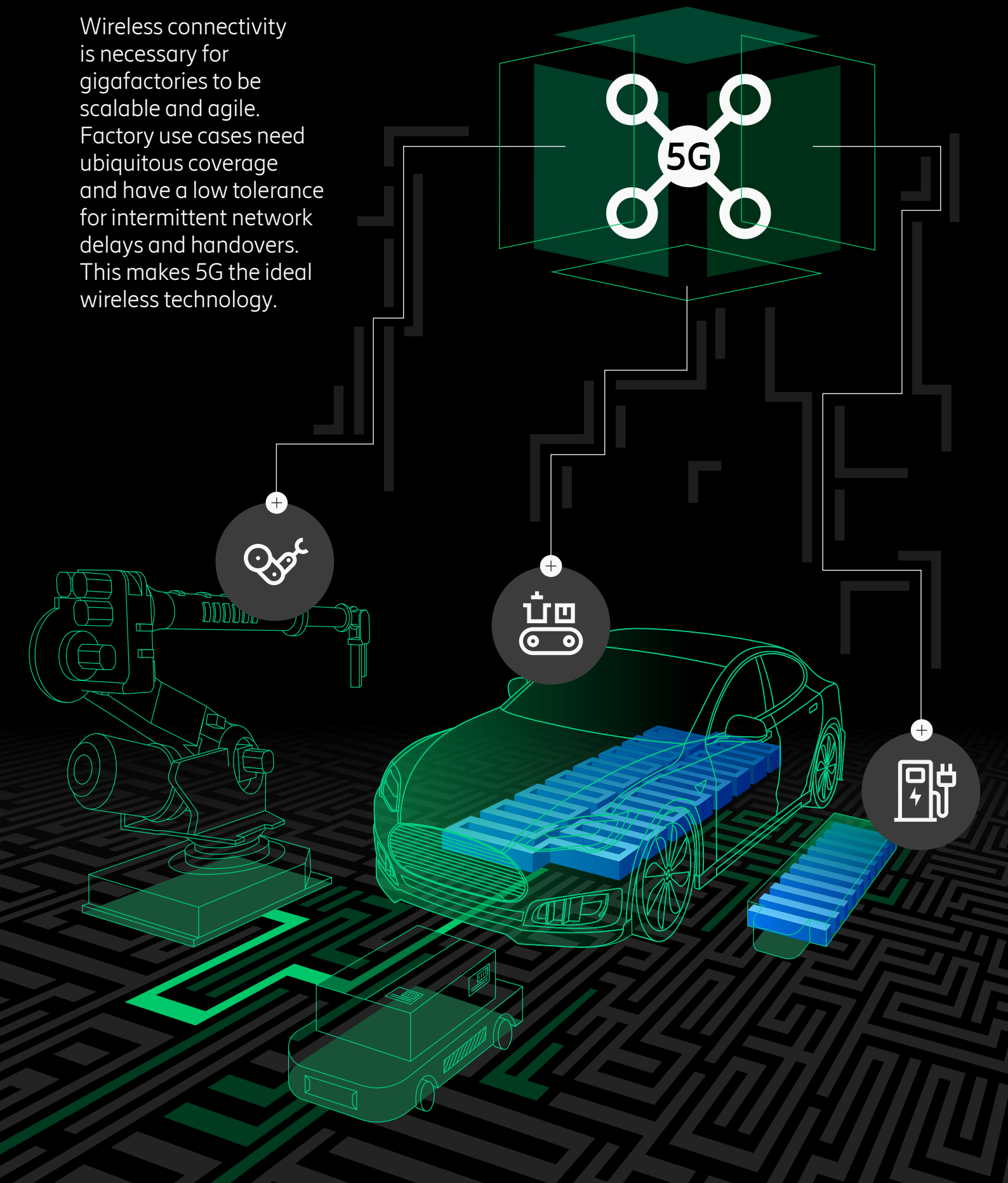
Key considerations in choosing 4G and 5G were:

- Extensive coverage: The mobile network covers all ArcelorMittal's complex industrial sites, outdoors and indoors, including those underneath high-rise metal structures. This coverage provides greater freedom of movement for operators and connectivity across the site.
- Low latency: The reduced latency of 5G supports the deployment of autonomous vehicles and remote-control cockpits as well as security in high-risk areas.
- Data security: The private mobile network protects sensitive industrial data.
- The indoor radio coverage design takes into consideration the site specifics, including large metal and steel areas, and piles of materials which are transitory and move over time.

Photo credit: Jonathan Delahaye/CUD

[2] European Commission, "State aid: Commission approves €850 million French measure to support ArcelorMittal decarbonise its steel production" (July 2023).

Wireless connectivity is necessary for gigafactories to be scalable and agile. Factory use cases need ubiquitous coverage and have a low tolerance for intermittent network delays and handovers. This makes 5G the ideal wireless technology.



Methodology

Forecast methodology
Ericsson makes forecasts on a regular basis to support internal decisions and planning, as well as market communications. The forecast time in the Mobility Report is six years and this moves forward one year in the November report each year. The subscription and traffic forecast baseline is established using historical data from various sources, validated with Ericsson internal data, including measurements in customer networks. Future developments are estimated based on macroeconomic trends, user trends, market maturity and technological advances. Other sources include industry analyst reports, together with internal assumptions and analyses.

Historical data may be revised if the underlying data changes – for example, if service providers report updated subscription figures.

Mobile subscriptions
Mobile subscriptions include all mobile technologies. Subscriptions are defined by the most advanced technology that the mobile phone and network are capable of. Our mobile subscriptions by technology findings divide subscriptions according to the highest-enabled technology they can be used for. LTE (4G) subscriptions, in most cases, also include the possibility for the subscription to access 3G (WCDMA/HSPA) and 2G (GSM or CDMA in some markets) networks. A 5G subscription is counted as such when associated with a device that supports New Radio as specified in 3GPP Release 15, and connected to a 5G-enabled network. Mobile broadband includes radio access technologies HSPA (3G), LTE (4G), 5G, CDMA2000 EV-DO, TD-SCDMA and Mobile WiMAX. WCDMA without HSPA and GPRS/EDGE are not included.
FWA is defined as a connection that provides broadband access through mobile network enabled customer premises equipment (CPE). This includes both indoor (desktop and window-mounted) and outdoor (rooftop and wall-mounted) CPE. It does not include portable battery-based Wi-Fi routers or dongles.

Rounding of figures
As figures are rounded, summing up data may result in slight differences from the actual totals. In tables with key figures, subscriptions have been rounded to the nearest 10th of a million. However, when used in highlights in the articles, subscriptions are usually expressed in full billions or to one decimal place. Compound annual growth rate (CAGR) is calculated on the underlying, unrounded numbers and is then rounded to the nearest full percentage figure. Traffic volumes are expressed to two significant figures.

Subscribers
There is a large difference between the numbers of subscriptions and subscribers. This is because many subscribers have several subscriptions. Reasons for this could include users lowering traffic costs by using optimized subscriptions for different types of calls, maximizing coverage and having different subscriptions for mobile PCs/tablets and mobile phones. In addition, it takes time before inactive subscriptions are removed from service provider databases. Consequently, subscription penetration can be above 100 percent, which is the case in many countries today. However, in some developing regions, it is common for several people to share one subscription, for example via a family- or community-shared phone.

Mobile network traffic
Ericsson regularly performs traffic measurements in over 100 live networks covering all major regions of the world. These measurements form a representative base for calculating worldwide total mobile network traffic. More detailed measurements are made in a select number of commercial networks with the purpose of understanding how mobile data traffic evolves.

No subscriber data is included in these measurements. The Ericsson Mobility Report network data traffic forecast, both global and regional, represents the estimated traffic volume in all networks over the duration of a month. Mobile network data traffic also includes traffic generated by FWA services, but not DVB-H, Wi-Fi or Mobile WiMAX traffic.

Population coverage
Population coverage is estimated using a database of regional population and territory distribution, based on population density. This is then combined with proprietary data on the installed base of radio base stations (RBS), together with estimated coverage per RBS for each of six population density categories (from metro to wilderness). Based on this, the portion of each area that is covered by a certain technology can be estimated, as well as the percentage of the population it represents. By aggregating these areas, world population coverage per technology can be calculated.

Disclaimer
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Ericsson Mobility Visualizer
Explore actual and forecast data from the Mobility Report in our interactive web application. It contains a range of data types, including mobile subscriptions, mobile broadband subscriptions, mobile data traffic, traffic per application type, VoLTE statistics, monthly data usage per device and an IoT connected device forecast. Data can be exported and charts generated for publication subject to the inclusion of an Ericsson source attribution.

Find out more
Scan the QR code, or visit
ericsson.com/mobility-visualizer

Glossary

2CC: Two component carrier

2G: 2nd generation mobile networks (GSM, CDMA 1x)

3CC: Three component carrier

3G: 3rd generation mobile networks (WCDMA/HSPA, TD-SCDMA, CDMA EV-DO, Mobile WiMAX)

3GPP: 3rd Generation Partnership Project

4CC: Four component carrier

4G: 4th generation mobile networks (LTE, LTE-A)

4K: In video, a horizontal display resolution of approximately 4,000 pixels. A resolution of 3840 × 2160 (4K UHD) is used in television and consumer media. In the movie projection industry, 4096 × 2160 (DCI 4K) is dominant

5G: 5th generation mobile networks (IMT-2020)

AI: Artificial intelligence

AR: Augmented reality. An interactive experience of a real-world environment whereby the objects that reside in the real world are "augmented" by computer-generated information

ARPU: Average revenue per user

CAGR: Compound annual growth rate

Cat-M1: A 3GPP standardized low-power wide-area (LPWA) cellular technology for IoT connectivity

CDMA: Code-division multiple access

dB: In radio transmission, a decibel is a logarithmic unit that can be used to sum up total signal gains or losses from a transmitter to a receiver

EB: Exabyte, 10^{18} bytes

EN-DC: EUTRA-NR Dual connectivity

FDD: Frequency division duplex

FWA: Fixed Wireless Access

GB: Gigabyte, 10^{9} bytes

Gbps: Gigabits per second

GHz: Gigahertz, 10^{9} hertz (unit of frequency)

GSA: Global mobile Suppliers Association

GSM: Global System for Mobile Communications

GSMA: GSM Association

HSPA: High speed packet access

IoT: Internet of Things

Kbps: Kilobits per second

LTE: Long-Term Evolution

MB: Megabyte, 10^{6} bytes

Mbps: Megabits per second

MHz: Megahertz, 10^{6} hertz (unit of frequency)

MIMO: Multiple Input Multiple Output is the use of multiple transmitters and receivers (multiple antennas) on wireless devices for improved performance

mmWave: Millimeter waves are radio frequency waves in the extremely high frequency range (30–300GHz) with wavelengths between 10mm and 1mm. In a 5G context, millimeter waves refer to frequencies between 24 and 71GHz (the two frequency ranges 26GHz and 28GHz are included in millimeter range by convention)

Mobile broadband: Mobile data service using radio access technologies including 5G, LTE, HSPA, CDMA2000 EV-DO, Mobile WiMAX and TD-SCDMA

Mobile PC: Defined as laptop or desktop PC devices with built-in cellular modem or external USB dongle

Mobile router: A device with a cellular network connection to the internet and Wi-Fi or Ethernet connection to one or several clients (such as PCs or tablets)

MOCN: Multi-operator core network

MORAN: Multi-operator Radio Access Network

MR: Mixed reality. Immersive technology in which elements from both the real world and a virtual environment are fully interactive with each other

NB-IoT: A 3GPP standardized low-power wide-area (LPWA) cellular technology for IoT connectivity

Net Zero: Defined in ITU standards as a future state where all emissions that can be reduced are reduced, with like-for-like or permanent removals applied by carbon-removal technologies to balance the remaining emissions

NR: New Radio as defined by 3GPP Release 15

NR-DC: NR-NR Dual connectivity

NSA 5G: Non-standalone 5G is a 5G Radio Access Network (RAN) that operates on a legacy 4G/LTE core

PB: Petabyte, 10^{15} bytes

RedCap: Reduced capability

SA: Standalone

Short-range IoT: Segment that largely consists of devices connected by unlicensed radio technologies, with a typical range of up to 100 meters, such as Wi-Fi, Bluetooth and Zigbee

Sunsetting: The process of closing down older mobile technologies

TD-SCDMA: Time division-synchronous code-division multiple access

TDD: Time division duplex

VoIP: Voice over IP (Internet Protocol)

VoLTE: Voice over LTE as defined by GSMA IR.92 specification

VR: Virtual reality

WCDMA: Wideband code-division multiple access

Wide-area IoT: Segment made up of devices using cellular connections or unlicensed low-power technologies like Sigfox and LoRa

XR: Extended reality. An umbrella category for virtual or combined real/virtual environments, which includes AR, VR and MR

Key figures

Global key figures

Mobile subscriptions	2022	2023	Forecast 2029	CAGR* 2023–2029	Unit
Worldwide mobile subscriptions	8,310	8,460	9,210	1%	million
• Smartphone subscriptions	6,620	6,970	8,060	2%	million
• Mobile PC, tablet and mobile router subscriptions	230	260	510	12%	million
• Mobile broadband subscriptions	7,090	7,470	8,740	3%	million
• Mobile subscriptions, GSM/EDGE-only	1,110	890	380	-13%	million
• Mobile subscriptions, WCDMA/HSPA	1,040	850	270	-17%	million
• Mobile subscriptions, LTE	5,180	5,130	3,210	-8%	million
• Mobile subscriptions, 5G	963	1,570	5,330	23%	million
• Fixed wireless access connections	107	132	330	17%	million
Fixed broadband connections	**1,450**	**1,530**	**1,850**	**3%**	**million**
Mobile data traffic					
• Data traffic per smartphone	16	21	56	18%	GB/month
• Data traffic per mobile PC	20	22	34	8%	GB/month
• Data traffic per tablet	12	14	33	16%	GB/month
Total data traffic**					
Mobile data traffic	97	130	403	21%	EB/month
• Smartphones	95	128	398	21%	EB/month
• Mobile PCs and routers	0.8	1	2.4	16%	EB/month
• Tablets	0.7	0.9	2.8	21%	EB/month
Fixed wireless access	22	30	159	32%	EB/month
Total mobile network traffic	119	160	563	23%	EB/month
Total fixed data traffic	270	330	660	12%	EB/month

Regional key figures

Mobile subscriptions	2022	2023	Forecast 2029	CAGR* 2023–2029	Unit
North America	420	430	470	2%	million
Latin America	710	720	790	2%	million
Western Europe	540	550	560	0%	million
Central and Eastern Europe	560	560	560	0%	million
North East Asia	2,160	2,200	2,260	0%	million
China[1]	1,690	1,720	1,760	0%	million
South East Asia and Oceania	1,140	1,160	1,310	2%	million
India, Nepal and Bhutan	1,150	1,160	1,270	1%	million
Middle East and North Africa	730	740	850	2%	million
Gulf Cooperation Council (GCC)[2]	75	76	81	1%	million
Sub-Saharan Africa	900	940	1,130	3%	million

Smartphone subscriptions	2022	2023	Forecast 2029	CAGR* 2023–2029	Unit
North America	360	370	390	1%	million
Latin America	570	600	690	2%	million
Western Europe	440	460	490	1%	million
Central and Eastern Europe	410	410	450	2%	million
North East Asia	2,020	2,060	2,160	1%	million
China[1]	1,600	1,640	1,700	1%	million
South East Asia and Oceania	950	970	1,160	3%	million
India, Nepal and Bhutan	870	950	1,180	4%	million
Middle East and North Africa	560	600	780	5%	million
GCC[2]	63	64	72	2%	million
Sub-Saharan Africa	420	460	760	9%	million

Regional key figures

LTE subscriptions	2022	2023	Forecast 2029	CAGR* 2023–2029	Unit
North America	230	160	40	-21%	million
Latin America	520	540	290	-10%	million
Western Europe	420	380	80	-23%	million
Central and Eastern Europe	420	460	280	-8%	million
North East Asia	1,420	1,230	430	-16%	million
China[1]	1,050	890	260	-19%	million
South East Asia and Oceania	630	720	680	-1%	million
India, Nepal and Bhutan	850	860	390	-12%	million
Middle East and North Africa	420	470	470	0%	million
GCC[2]	55	44	3	-35%	million
Sub-Saharan Africa	265	330	550	9%	million

5G subscriptions	2022	2023	Forecast 2029	CAGR* 2023–2029	Unit
North America	170	260	430	9%	million
Latin America	10	28	400	N/A	million
Western Europe	67	139	480	23%	million
Central and Eastern Europe	5	14	280	N/A	million
North East Asia	646	890	1,800	12%	million
China[1]	569	769	1,480	12%	million
South East Asia and Oceania	33	57	550	N/A	million
India, Nepal and Bhutan	10	130	860	N/A	million
Middle East and North Africa	18	44	350	N/A	million
GCC[2]	13	26	75	19%	million
Sub-Saharan Africa	3	11	180	N/A	million

Data traffic per smartphone	2022	2023	Forecast 2029	CAGR* 2023–2029	Unit
North America	19	26	66	17%	GB/month
Latin America	12	15	50	22%	GB/month
Western Europe	22	27	64	16%	GB/month
Central and Eastern Europe	16	19	43	15%	GB/month
North East Asia	18	21	64	20%	GB/month
China[1]	18	22	66	20%	GB/month
South East Asia and Oceania	16	24	66	19%	GB/month
India, Nepal and Bhutan	25	31	75	16%	GB/month
Middle East and North Africa	14	17	45	17%	GB/month
GCC[2]	26	30	66	14%	GB/month
Sub-Saharan Africa	5	6.7	23	22%	GB/month

Total mobile data traffic	2022	2023	Forecast 2029	CAGR* 2023–2029	Unit
North America	6.8	9.6	27	18%	EB/month
Latin America	5.8	7.8	30	25%	EB/month
Western Europe	8.8	11	28	16%	EB/month
Central and Eastern Europe	4.8	6.3	15	15%	EB/month
North East Asia	30	37	116	21%	EB/month
China[1]	20	26	88	23%	EB/month
South East Asia and Oceania	14	21	69	22%	EB/month
India, Nepal and Bhutan	18	26	73	19%	EB/month
Middle East and North Africa	6.8	9	31	23%	EB/month
GCC[2]	1.3	1.5	3.8	16%	EB/month
Sub-Saharan Africa	1.8	2.7	15	33%	EB/month

[1] These figures are also included in the figures for North East Asia.
[2] These figures are also included in the figures for Middle East and North Africa.

* CAGR is calculated on unrounded figures.
** Figures are rounded (see methodology) and therefore summing up of rounded data may result in slight differences from the actual total.

About Ericsson

Ericsson enables communications service providers and enterprises to capture the full value of connectivity. The company's portfolio spans the following business areas: Networks, Cloud Software and Services, Enterprise Wireless Solutions, Global Communications Platform, and Technologies and New Businesses. It is designed to help our customers go digital, increase efficiency and find new revenue streams. Ericsson's innovation investments have delivered the benefits of mobility and mobile broadband to billions of people globally. Ericsson stock is listed on Nasdaq Stockholm and on Nasdaq New York.

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