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Ericsson Mobility Report

June 2024

Letter from the publisher

5G: Empowering digital transformation through innovation

There is an exciting future ahead of us, as leading communications service providers are now preparing to build high-performing, open and programmable 5G networks. Today, the main connectivity offerings for consumers and enterprises are based on a best-effort performance model. High-performing, open, programmable networks that utilize 5G standalone (SA) architecture provide new opportunities for service innovation and open up possibilities for performance-based business models.

5G is an innovation platform for driving digital transformations of businesses and society. In this edition of the Ericsson Mobility Report, we take a closer look at a leading service provider's journey toward realizing a programmable network, and a new era of performance-based business models built upon differentiated connectivity and an open network infrastructure.

On the forecast side, we have adjusted the mobile network data traffic numbers downward compared to our previous report. This is mainly due to lower numbers being reported by regulators and service providers in populous markets for the second half of 2023. However, the predicted yearly mobile data traffic growth rate between 2023 and 2029 remains similar, although from a lower starting point.

The deployment of 5G is still ongoing, and is far from complete. We continue to see a robust uptake of 5G subscriptions worldwide, anticipating the addition of nearly 600 million new 5G subscriptions in 2024. To fully realize the potential of 5G, there is a need for continued deployments of 5G SA and additional densification of mid-band sites. To date, around 50 service providers have deployed or launched 5G SA in public networks, and the global expansion of 5G mid-band coverage is primarily propelled by extensive deployments in India and North America. However, only around 25 percent of all sites globally, outside of mainland China, have been upgraded to 5G mid-band.

In this edition, we also explore the significance of 5G mid-band for user experience, finding that smartphone users connected to 5G mid-band benefit from faster time-to-content and an overall enhanced user experience when accessing the internet and streaming video content.

This edition also investigates how early access to new 5G network functionalities within the framework of a 5G innovation program is allowing enterprises to develop and test new connectivity solutions through cross-industry collaboration.

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

Fredrik Jejdling
Executive Vice President and
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Forecasts

5G is expected to become the dominant mobile access technology by subscription before the end of the forecast period. Although 5G population coverage is growing, 5G mid-band is only deployed in around 25 percent of all sites globally outside of mainland China. The 5G mid-band spectrum provides a sweet spot between both coverage and capacity, while improving user experience, as shown by measurements from a leading service provider. As 5G matures, the focus for many service providers is expected to shift toward developing differentiated connectivity offerings.

5.6bn

5G mobile subscriptions are set to reach nearly 5.6 billion in 2029.

40%

Speed-based tariffs are now offered by 40 percent of FWA service providers.

97%

Measurements from a leading service provider show that 97 percent of all user activities on 5G mid-band achieved a time-to-content of less than 1.5 seconds.

90%

In North America, 5G is set to make up 90 percent of all mobile subscriptions in 2029.

5G mobile subscriptions to reach close to 5.6 billion in 2029

During the first quarter of 2024, 160 million 5G subscriptions were added to exceed a total of 1.7 billion.

5G is expected to become the dominant mobile access technology by subscription in 2028. Global 5G subscriptions[1] are forecast to reach close to 5.6 billion in 2029, making up 60 percent of all mobile subscriptions at that time. It is projected that North America will still have the highest 5G penetration in 2029 at 90 percent, followed closely by the Gulf Cooperation Council (GCC) at 89 percent and Western Europe at 86 percent.

Stronger outlook in Sub-Saharan Africa than expected

5G subscriptions in Sub-Saharan Africa in 2029 are anticipated to exceed 320 million, accounting for 28 percent of all mobile subscriptions at that time. This has been adjusted upward compared to our previous report, in line with a more positive outlook for the region, supported by spectrum releases in low- and mid-bands and more affordable devices.

At the end of 2023, North America had the highest 5G subscription penetration globally at 59 percent. In North East Asia, penetration reached 41 percent, followed by the GCC countries at 34 percent and Western Europe at 26 percent. 5G subscriptions increased by 160 million during the first quarter of 2024, to total 1.7 billion.

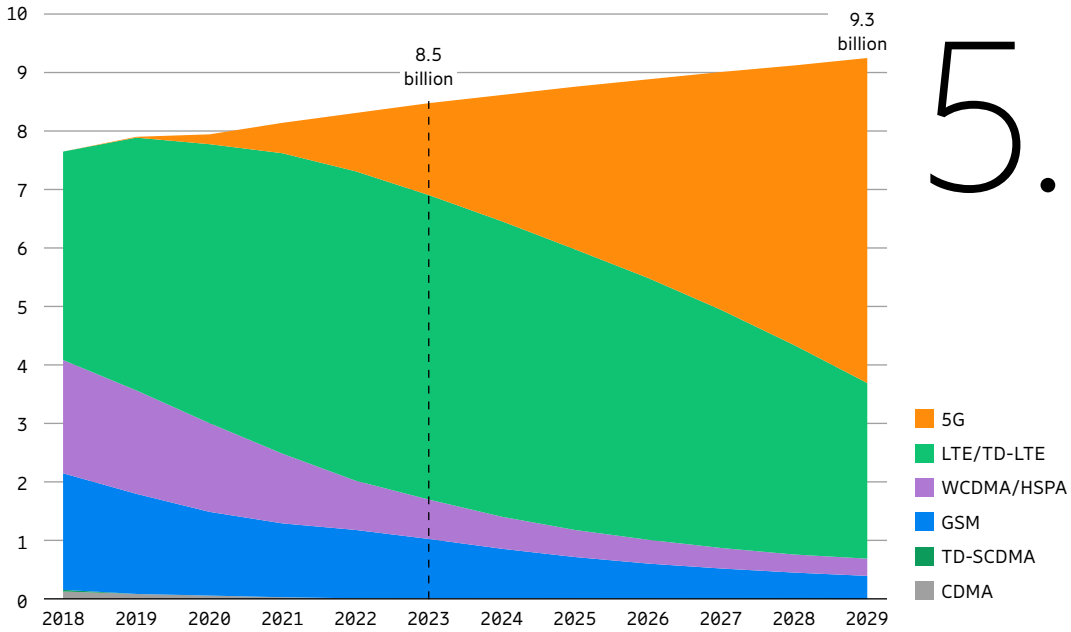
Subscriptions for 4G now total 5.2 billion, falling by 26 million during Q1 2024. 4G subscriptions are projected to continue declining to around 3 billion by the end of 2029, as subscribers continue to migrate to 5G.

During the first quarter, 3G subscriptions declined by 37 million, while 2G subscriptions dropped by 41 million.

2G and 3G network sunsetting continues around the world. The timeline for this transition varies based on the country and service provider, but the phase-out of 3G networks is anticipated to happen more quickly than for 2G in the coming years. For example, an overwhelming majority of service providers in Europe are currently shutting down 3G networks to refarm spectrum for use with 4G and 5G, while maintaining 2G for legacy IoT services.

Around 300 service providers have now launched commercial 5G services, and around 50 have deployed or launched 5G standalone (SA).[2]

Figure 1: Mobile subscriptions by technology (billion)



5G subscriptions are forecast to reach 5.6 billion by the end of 2029.

5.6bn

[1] 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.
[2] GSA and Ericsson (May 2024).

Smartphone market recovering in 2024

Chipsets with generative AI (GenAI) capabilities, as well as phones that can process AI without connecting to a server (on-device AI) have entered the market. These devices could shape new user behavior and change how apps and services are consumed in the future.

Smartphone shipment growth is back after nearly a three-year decline, with a year-on-year increase of 6 percent in the first quarter of 2024.[1] In the high-end device segment, AI-powered smartphones are becoming increasingly available, while the mid- and lower-tier segments are refreshing their offerings and experiencing double-digit growth. Meanwhile, the replacement cycle of smartphones has been prolonged in recent quarters, as consumers hold on to their devices for longer due to growing financial and environmental concerns. However, AI and new chips for on-device AI might move more users to upgrade their devices.

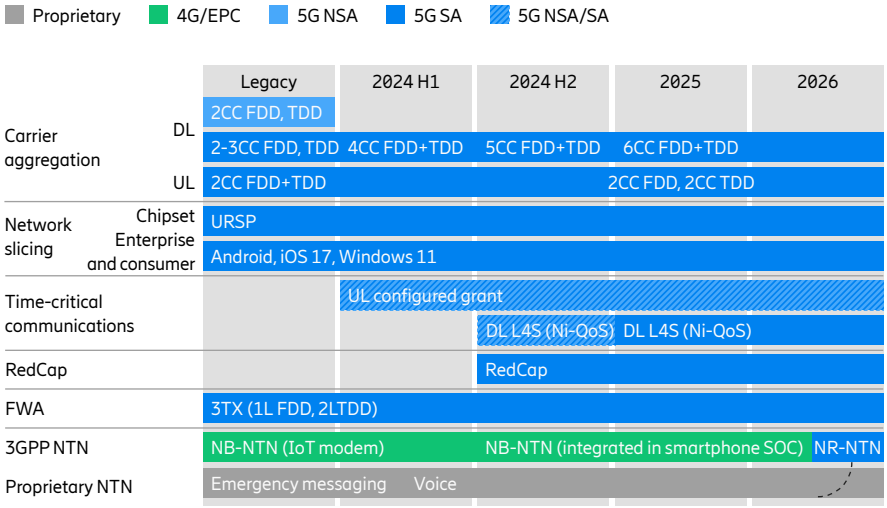
Multiple new XR-device models are expected to come to market during 2024, but mass-market uptake is still limited.

Devices are prepared for standalone

5G non-standalone (NSA) networks are dominating the market, but there are compelling reasons to move to a 5G standalone (SA) architecture. It offers greater flexibility, scalability and support for new services and applications, enabling service providers to dedicate specific network slices for different use cases, as well as offering premium support for time-critical communications. The device domain supports the NSA to SA transition:

- Many devices already provide support for 5G network slicing and, starting from Android 13 and iOS 17, developers can include functions and capabilities in their apps to align with certain network characteristics (such as lower latency or higher bandwidth) offered by service provider-provisioned network slices.
- Reduced capability (RedCap) is gaining momentum, and there are now more than five modem vendors with support for this. Module support is seen from multiple players and device offerings are emerging. During 2024, the RedCap market is expected to include routers, cameras and even connected laptops, while RedCap-based wristband wearables and the first industrial devices are expected to come to market from 2025.
- Low-cost devices will play a big role in the continued 5G smartphone market uptake, as the low price point will facilitate 4G device replacement in price-sensitive market segments. There are industry initiatives to provide SA-only devices, with LTE fallback but no NSA support, addressing the sub-100 USD smartphone market segment.

Figure 2: 5G technology area readiness on device



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

Uplink is in focus

In the downlink, the premium devices will support 6 carrier aggregation in low- and mid-bands in the coming one to two years, exceeding 3.5 Gbps speeds.

Uplink performance has not evolved as much as downlink in 5G. In 2024, FDD and TDD carrier aggregation in the uplink on premium devices is emerging. In the future, FDD-FDD and TDD-TDD spectrum will also be aggregated in the uplink. For the FWA domain, using more than two uplink antennas is also a way to address a better uplink performance, and there is market interest in the premium FWA segment for this solution.

NB-NTN on smartphones

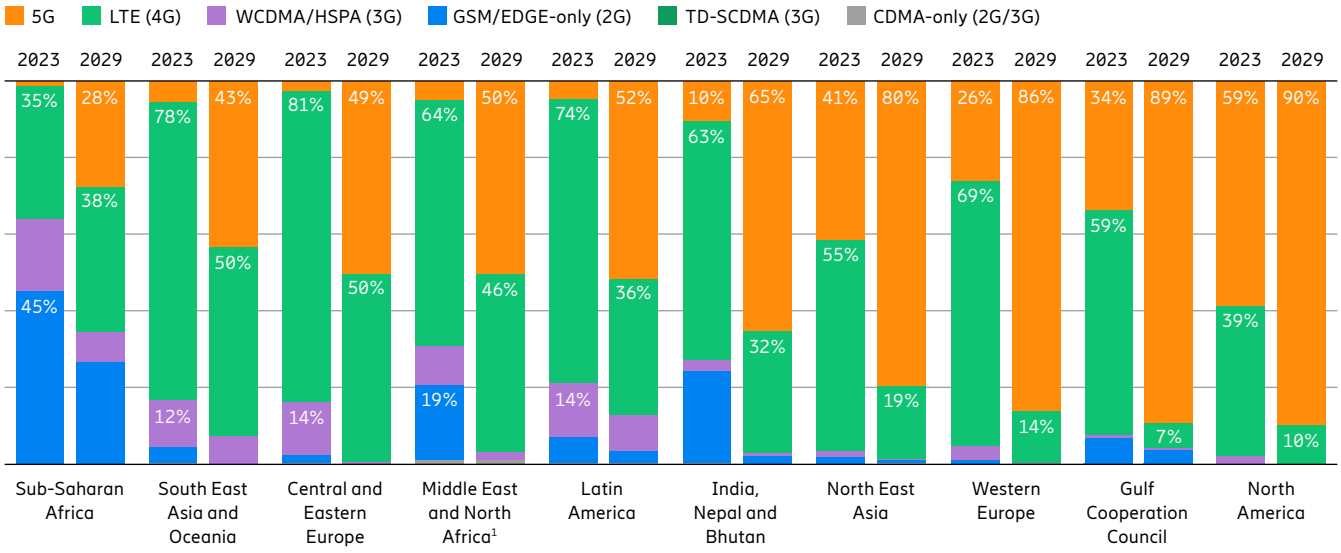
Narrowband non-terrestrial networks (NB-NTN) enable many new use cases, including asset tracking, remote monitoring and emergency services. Introduced in the first devices in 2023, the device ecosystem is striving toward integrating NB-NTN into systems-on-a-chip (SOCs), with the first chipsets in 2024, and will initially support text messaging and low-data-rate services. 5G NR-NTN in devices is expected to be supported from 2025. Using the 3GPP version of satellite calling can unite the industry, focusing development to a single standard that benefits all smartphone users needing to communicate in areas without cellular coverage.

[1] Counterpoint (May 2024).

5G subscription uptake rising in every region

Uptake is strong in North America, with the region reaching a 5G subscription penetration of 59 percent by the end of 2023. At the same time, 5G penetration in India reached 10 percent.

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



Sub-Saharan Africa

Sub-Saharan Africa's economic outlook remains positive, with growth between 3 and 5 percent over the next 5 years.[2] The telecommunications sector maintains an upward trajectory, driven by a young population and rising demand for mobile data and advanced services.

Mobile subscription growth is forecast at 4 percent annually between 2023 and 2029. Key drivers include the younger demographic entering the workforce, alongside increasing smartphone affordability. Government initiatives promoting internet access will further fuel this growth.

Driven by more available spectrum and affordable 5G devices, 5G subscriptions are forecast to have strong growth, reaching 320 million by 2029. A key driver will be service providers rolling out networks in urban areas, targeting higher-spending consumers.

By 2029, 5G is expected to hold the second-largest share of subscriptions at 28 percent. 4G is expected to grow steadily at 5 percent annually, adding the largest number of subscriptions and holding the largest subscription share at 38 percent in 2029.

3G subscriptions are declining as 4G becomes more available and is expected to make up 8 percent of all mobile subscriptions in 2029. 2G subscriptions are also expected to decline but will maintain a significant share of 27 percent.

Beyond subscriptions, service providers are expanding offerings to include fintech services such as mobile money transactions, including banking which caters to the high mobile penetration and unbanked population. Smartphones will rise from 460 million in 2023 to 790 million in 2029, driving more data usage.

Middle East and North Africa

The region's telecom industry continues to demonstrate stability and growth despite economic challenges in several countries. Overall subscriptions are projected to rise 2 percent annually between 2023 and 2029. Smartphone subscriptions are forecast to have a similar growth, reaching 750 million in 2029.

5G will experience the highest subscription growth – rising at 51 percent annually in the period with increasing network coverage and availability of affordable 5G-capable smartphones. In 2029, 5G is expected to account for the largest share of total subscriptions at 50 percent, while 4G declines to make up 46 percent. Service providers continue to diversify their offerings, owing to the high mobile penetration, with services such as e-health and mobile financial services. 3G subscriptions are projected to decline to 2 percent in 2029, while 2G will decline to near zero.

[1] All Middle East and North Africa figures include GCC countries.
[2] IMF, "Regional Economic Outlook: Sub-Saharan Africa" (April 2024).

Gulf Cooperation Council (GCC)
As a region with high mobile penetration and urbanization as well as strong consumer purchasing power, the GCC is a highly developed market.

A major trend emerging in the region is the transformation of service providers from "telcos" to "tech-cos" focusing on de-layering network elements and offering digital services. Examples include factory network automation, AI, IoT and content services.

By 2029, 5G will be the dominant technology, carrying close to 90 percent of the total mobile subscription base with more than 80 million subscriptions. 4G subscriptions will decline substantially during the period to account for 7 percent of the total subscriptions in 2029.

For the combined Middle East and Africa region, Fixed Wireless Access (FWA) connections are forecast to exhibit strong growth, as service providers seek to monetize their 5G networks and connect areas with limited fiber access.

South East Asia and Oceania
5G subscriptions are predicted to reach around 560 million in the region by the end of the forecast period. The 5G subscriber base continues to grow in Australia, Malaysia, Singapore and Thailand as subscribers migrate to 5G, driven by more affordable 5G devices, promotional plans, discounts and large data bundles from service providers. 5G subscriber base as a percentage of the total subscriber base has reached over 20 percent in these markets.[3]

Service providers in the advanced 5G markets of Australia and Singapore continue to focus on innovations in speed, coverage and differentiated services. In the Philippines, while 5G network coverage has increased over the past year, 5G penetration and data consumption remain low. In Indonesia, 5G subscriber uptake has been limited, as service providers are waiting to be awarded mid-band spectrum for expanding their 5G coverage. Indonesian service providers launched 5G in 2021 with the 2.3 GHz, 2,100 MHz and 1,800 MHz bands. Among other countries, Vietnam recently auctioned 5G mid-band spectrum, and the launch of commercial 5G is expected in the next 6–12 months.

Central and Eastern Europe
Technology adoption and subscription uptake have historically been slower than in Western Europe. 5G deployment varies by country, partly due to slower spectrum allocation processes – for example, 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. Poland is anticipated to follow, given its large manufacturing base and 5G-for-industry spectrum availability.

4G is currently the dominant technology, accounting 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, 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.

Latin America
4G is still growing and is currently the dominant technology in the region. It accounted for 74 percent of all subscriptions at the end of 2023, with around 13 million subscriptions added during the year. 3G subscriptions are declining as users migrate to 4G and 5G.

Several countries are currently auctioning 5G spectrum. In 2023, Colombia, Uruguay and Argentina successfully concluded their auctions, while Mexico, Paraguay, El Salvador and Costa Rica are expected to hold 5G auctions in 2024. The Dominican Republic has scheduled a tender for spectral resources for 2024, aiming to enhance coverage across its territory and reallocate unused resources. The spectrum bands to be tendered include the 700 MHz, 2,300 MHz and 3,600 MHz bands. Peru's auction is anticipated to occur around 2025.

5G subscription uptake has been slow due to macroeconomic difficulties in the region, with the number of subscriptions reaching around 33 million at the end of 2023. More substantial uptake is anticipated from 2024 onwards, with 5G expected to account for 52 percent of all mobile subscriptions by the end of 2029.

India, Nepal and Bhutan
Due to intensive 5G network deployments, widespread coverage and availability of affordable 5G services in the country, 5G subscriptions in India reached around 119 million by the end of 2023. 5G subscriptions are expected to reach around 840 million by the end of 2029, accounting for 65 percent of mobile subscriptions in the region. Enhanced mobile broadband and FWA are emerging as initial 5G use cases. Total mobile subscriptions in the region are estimated to grow from 1.2 billion in 2023 to 1.3 billion in 2029. 4G continues to be the dominant subscription type driving connectivity and fueling data growth. However, based on strong 5G uptake, 4G subscriptions are forecast to decline from 740 million in 2023 to 410 million by 2029.

North East Asia
Service providers in the region have invested in 5G to improve coverage and capacity, focusing on indoor coverage. Strong 5G subscription growth continued in 2023, rising by 234 million to total 908 million subscriptions. 5G is the only growing subscription type and is expected to reach 1.8 billion in 2029. 5G subscription uptake, 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 that 5G subscribers have had a positive impact on service revenues and ARPU. There is strong regional interest in new 5G IoT solutions based on reduced capability (RedCap). For example, in mainland China, the regulator is encouraging faster ecosystem readiness, and urban area coverage is planned by 2024 in all major cities. Availability of commercial RedCap services has been claimed by three service providers in early 2024.

Western Europe
Although penetration is behind other developed markets, 5G subscription growth was strong during 2023, rising from 72 million in 2022 to 143 million by the end of 2023. This equals a penetration of 26 percent for the region, however, it varies between countries. Markets such as the UK and Finland, which launched 5G early, have already achieved high penetration relative to other markets. 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 86 percent penetration at that time.

North America
The addition of mid-band spectrum enables superior multi-band 5G experiences for many users. In 2023, 5G adoption continued to grow strongly, with close to 260 million subscriptions at the year's end. By 2029, around 430 million 5G subscriptions are expected, accounting for 90 percent of mobile subscriptions. 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.

[3] Based on data from service providers (Thailand, Australia), regulator (Singapore) and government statements (Malaysia).

North America: A closer look

Both the US and Canada have made impressive progress in deploying 5G nationwide, despite differences in which spectrum bands they have used.

In each edition of the Ericsson Mobility Report, we take a closer look at the trends in one specific region. This time we are exploring the US and Canada in the North America region.

In the US, over 300 million people (90 percent) live in areas served by 5G low-band from all three tier-1 service providers, while 210–300 million are covered by 5G mid-band.[1] Furthermore, 5G mmWave is deployed in major metropolitan areas. These significant deployments reflect commitment to technological advancements and innovation five years into the 5G deployment cycle.

Mobile broadband to smartphones

The rapid network build-out has enabled 5G smartphone subscriptions to grow faster than any previous generation. Today, 59 percent of North American smartphone subscriptions are 5G, with 53 percent of US subscribers and 37 percent of Canadian subscribers satisfied with their 5G services.[2]

With the introduction of 5G, there are now various data plans beyond fast and reliable connectivity services. Four 5G data plan building blocks stand out: micro-segmentation of the market, differentiated connectivity, service bundling and commercial bundling. These building blocks are the basis for between two and four data plans per target segment.

The combination of powerful networks that satisfy customers' growing data traffic needs and attractive plans has led to monthly post-paid churn rates of below 1 percent.[3] With 5G, service providers have been able to turn the declining revenues per subscriber that characterized 4G into growth. Revenue growth is still below inflation and will depend on connectivity, device and application innovations to deliver on the full 5G potential.

FWA matches fiber and beats cable

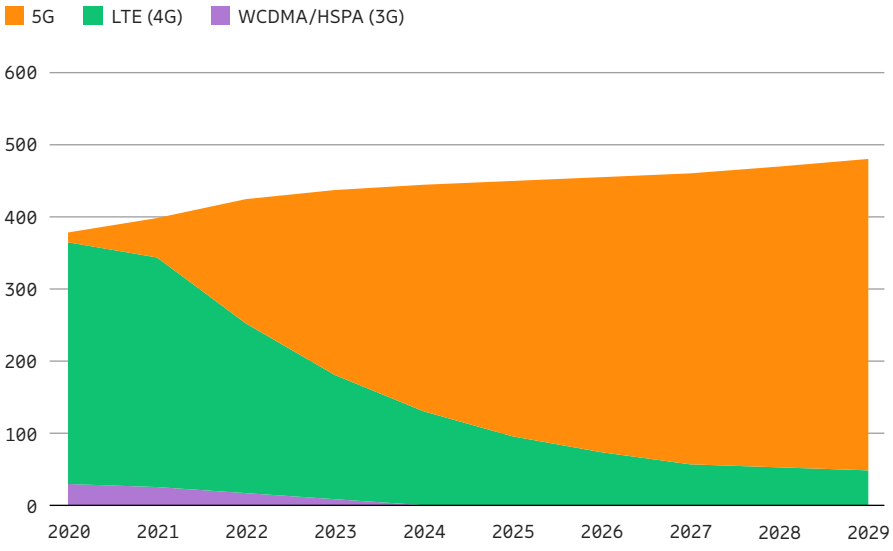
Fixed Wireless Access (FWA), which quickly became the second-largest 5G use case, reached around 9 million connected business and residential locations across the US in Q1 2024.[4] This expansion was possible through innovative solutions that address the complete value proposition for FWA, offering reliable and high-speed connectivity to a wide range of users.

5G in the mid-band spectrum has closed the performance gap compared to wired infrastructure. The Federal Communications Commission (FCC) recently increased the US benchmark for what is considered fixed broadband to 100/20 Mbps, a target FWA can meet with 5G in mid- and high-band spectrum.

Initial launches of 5G FWA were focused on simplicity, self-install indoor equipment and discounted price plans with promotions. Over the past year, service providers started to become more selective about pricing, reducing promotions and even increasing prices. In addition, new FWA offerings were launched, including offerings focused on home experience, nomadic FWA, and new self-install outdoor receivers.

Three years into the ramp-up, FWA captures all fixed broadband net adds with a Net Promoter Score that matches fiber and outperforms cable.

Figure 4: North America region mobile subscriptions by technology (million)



[1] Quarterly reports: AT&T, Verizon and T-Mobile.
[2] Ericsson Consumerlab, 5G value: Turning performance into loyalty (October 2023).
[3] Quarterly reports: AT&T, Verizon and T-Mobile.
[4] Quarterly reports: AT&T, T-Mobile, USCC and Verizon.

5G networks at prominent use places

From the start, the US market adopted mmWave at use places with a high concentration of people or with unserved business needs. Two types of deployments have dominated: private 5G networks deployed to support a business, or hybrid public/private networks in locations serving both consumers and companies in one location.

The lessons from the build-out of 5G in arenas and large venues, today serving more than 100 locations for sports and concerts, provide a good recipe for how to scale down from a few prominent use places to many smaller key venues.

The first 5G deployments were at the venues selected for the annual American football final in 2020, starting with public 5G for all fans. Phase two was scaling this offering to all venues hosting professional football games and then other professional sports. Once this market was saturated, expansion continued to college sports. In the US alone, there are 243 sports venues with more than 20,000 seats each, representing an excellent market opportunity.

After the initial build-out of public 5G networks, the sports venue has entered a second innovation phase focused on supporting all businesses operating at these locations. 5G supports ticket and security screening at the entrances, connects concession stands for food and merchandise and makes life easier for professional photographers and TV crews to connect their cameras.

This approach can serve as a model when scaling to other types of use place categories serving visitors and businesses, such as:

- airports (64 airports carry over 0.5 percent of all US passenger traffic each)
- hotels (there are 70 hotels with more than 1,000 rooms in the US)
- universities (there are 279 research universities based in the US)

Starting big and then scaling down in steps is also the recipe for pure private networks in factories, ports, warehouses, military bases and mines. Previous generations of cellular networks were defined to support large public networks. The scaling challenge for private networks is therefore to scale down from the largest use place in a category and reach smaller locations to maximize market reach.

Major differences between the US and Canada

5G deployments in the US and Canada differ on a few points. US service providers have deployed 5G in low-, mid- and high-band spectrum, whereas Canadian deployments are in low- and mid-band spectrum. The US has allocated 150 MHz of unlicensed/shared CBRS spectrum (3.55–3.70 GHz) and Canada 80 MHz (3.90–3.98 GHz). The US leads in the adoption of FWA, and fiber's share of total broadband connections is higher in Canada (30 percent) versus the US (22.6 percent).[5]

The US technology ecosystem

The technology ecosystem in the US enjoys having a powerful 5G infrastructure in their home market as a foundation for creating the next generation of innovations; in the same way, the early build-out of 4G infrastructure in the US paved the way for the US-led digital economy.

Mobile operating systems and smartphones have been central to the mobile broadband ecosystem momentum. System-on-a-chip, server hardware, cloud execution environments, hyperscale cloud infrastructure, mobile operating systems and devices are all categories where two or more US companies define the global market. The transition to cloud-native Core and RAN is enabled by US silicon, server and cloud providers. 5G is growing in importance for hybrid workers wanting secure connectivity beyond homes and offices for their personal productivity devices. In the second half of the deployment cycle, we expect further ecosystem expansion where US system integrators with solid vertical competence, application developers and Fortune 500 companies can vet solutions at home before scaling globally, especially when enabling innovations combining 5G, AI and cloud.

[5] OECD broadband report (March 2024).

Mobile network data traffic

Mobile network data traffic grew 25 percent between Q1 2023 and Q1 2024.

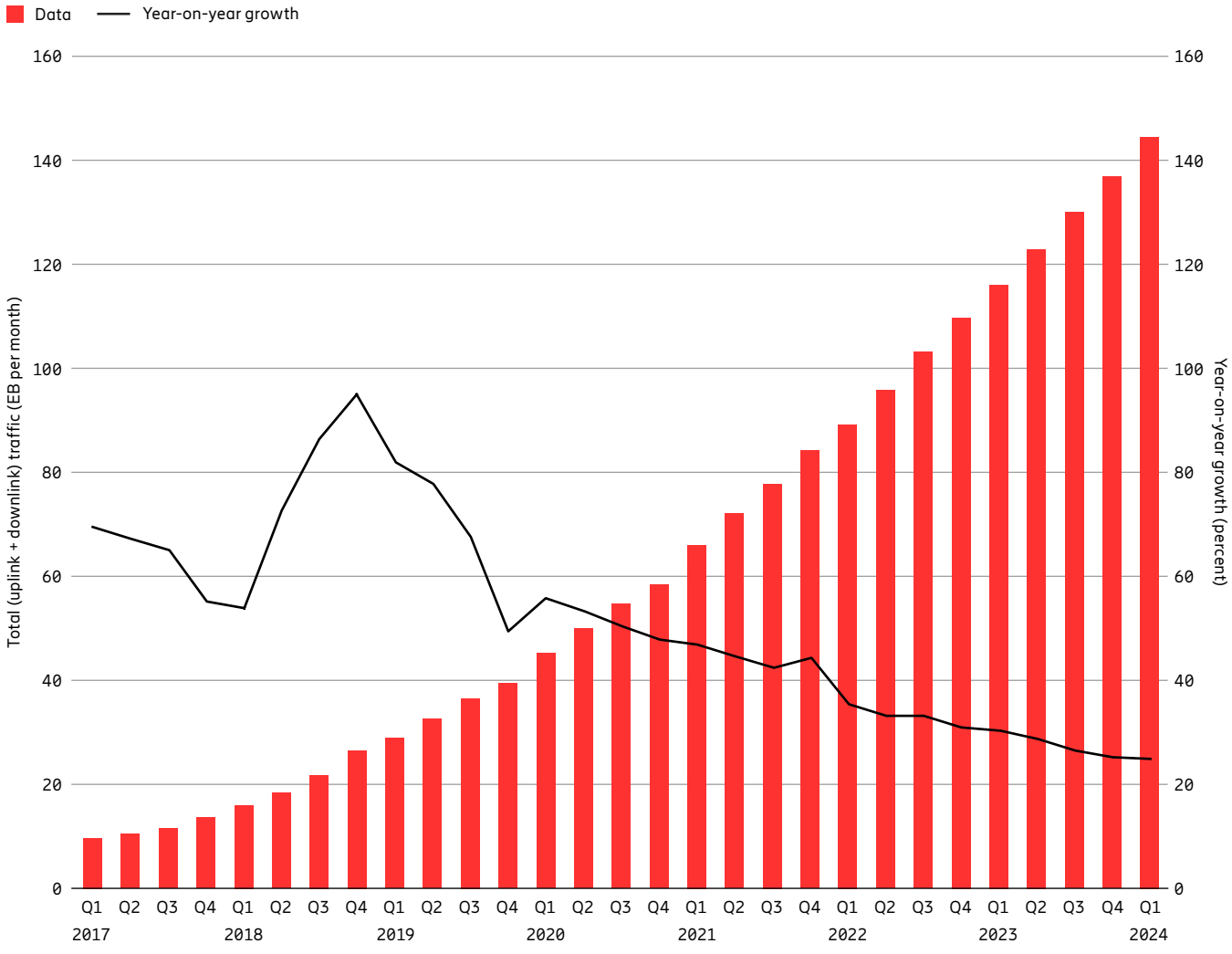
The year-on-year mobile network data traffic – depicted in the graph below – has been adjusted downwards from Q1 2022, compared to the previous report. This is due to changes in the underlying data, such as lower numbers reported by regulators and service providers in populous markets for the second half of 2023.

The quarter-on-quarter mobile network data traffic growth between Q4 2023 and Q1 2024 was around 6 percent. Total monthly global mobile network data traffic reached 145 EB.

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. At the end of 2023, video traffic accounted for 73 percent of all mobile data traffic.

Figure 5 shows the total global monthly network data traffic from Q1 2017 to Q1 2024, along with year-on-year percentage growth for mobile network data traffic.

Figure 5: Global mobile network data traffic and year-on-year growth (EB per month)



Note: Mobile network data traffic also includes traffic generated by Fixed Wireless Access services.

5G set to account for around 75 percent of mobile data traffic in 2029

Subscriber migration to later generations of mobile technologies is one of the factors fueling traffic growth.

As described on page 10, the figures for mobile network data traffic have been adjusted down compared to the previous report, mainly due to lower numbers reported by regulators and service providers in populous markets for the second half of 2023.

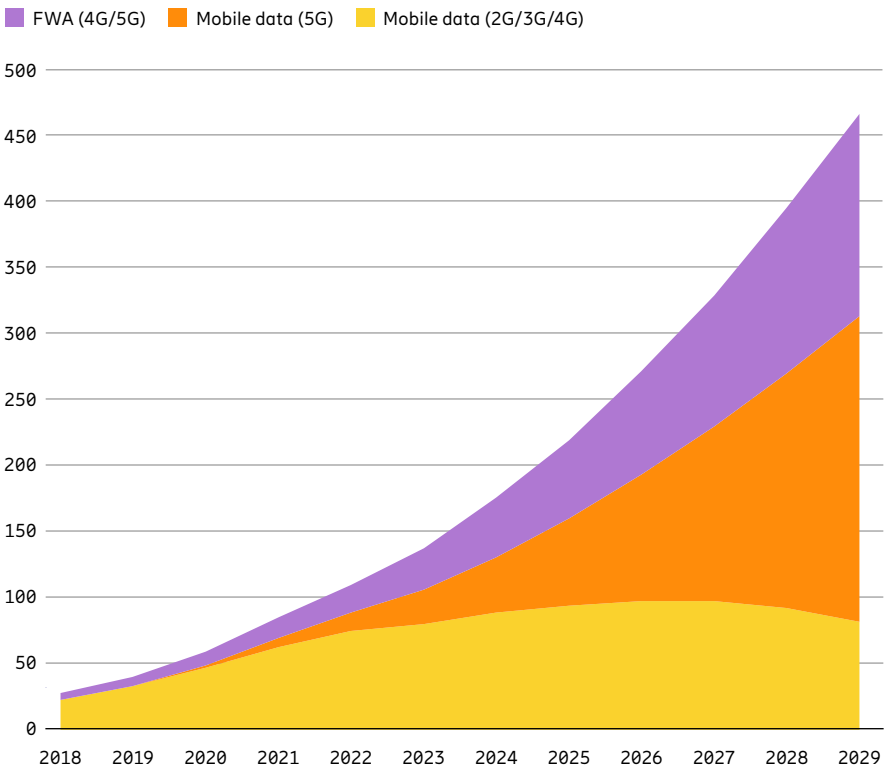
However, the predicted mobile data traffic yearly growth rate between 2023 and 2029 remains similar, although from a lower starting point. Total global mobile data traffic – excluding traffic generated by Fixed Wireless Access (FWA) – is expected to grow by a factor of around 3 and reach 313 EB per month in 2029. When FWA is included, total mobile network traffic is anticipated to grow by a factor of around 3.5, rising to 466 EB per month by the end of the forecast period.

5G's share of mobile data traffic was 25 percent at the end of 2023, an increase from 17 percent at the end of 2022. This share is forecast to grow to around 75 percent in 2029.

Challenges in the forecast

Mobile data traffic is forecast to grow with a CAGR of around 20 percent through 2029. Yearly mobile data traffic growth rates are expected to slow at different paces in different regions up to 2029. The yearly net added data traffic volume is expected to increase up to 2027, whereafter it will be somewhat stable. With similar mobile data traffic growth rates but from a lower staring point, the predicted absolute numbers for 2029 are lower than previously reported.

Figure 6: Global mobile network data traffic (EB per month)



There are several factors impacting the forecast numbers. To highlight the challenges, Figures 8 and 9 additionally depict high- and low-growth scenarios for the total mobile data traffic (EB per month) and the mobile data traffic per active smartphone (GB per month).

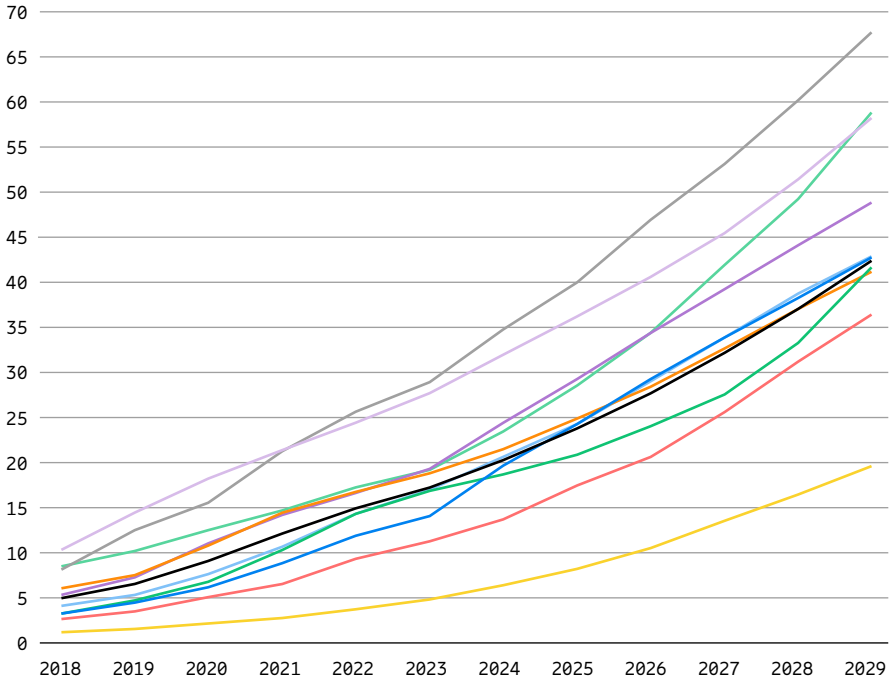
Mobile data traffic growth between years can be highly volatile and vary significantly between regions, markets and service providers, depending on local market dynamics. Some factors that could impact whether the forecast for 2029 follows the higher or lower scenario for mobile data traffic could include:

- global macroeconomic changes (inflation and interest rates)
- subscriber migration to later generations in India, Latin America, South East Asia and Africa
- smartphone shipment development
- uptake of new consumer applications (such as XR), new advanced devices and AI-enabled tools
- split between FWA and mobile data traffic changes as FWA connections grow
- continued improvements in the performance of deployed networks

As seen in the last couple of years, the macroeconomic situation can change significantly with global inflation, interest rates and other factors. This can have a big impact on consumer willingness to pay for mobile services, thereby affecting mobile data usage.

Several large regions such as India, Latin America, South East Asia and Africa are expected to significantly migrate the subscriber base to later generations of mobile technologies in the coming years. The future traffic patterns of these users will depend on network capabilities, tariff plans and available services.

Figure 7: Mobile data traffic per active smartphone (GB per month)



Regions	2023	2029	CAGR 2023–2029
India, Nepal, Bhutan	29	68	15%
North America	19	59	21%
GCC	28	58	13%
Western Europe	19	49	17%
Middle East and North Africa[1]	14	43	20%
Central and Eastern Europe	17	43	17%
South East Asia and Oceania	17	42	16%
Global average	17	42	16%
North East Asia	19	41	14%
Latin America	11	36	22%
Sub-Saharan Africa	5	20	26%

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 accelerated, data traffic could significantly surpass our current traffic outlook at the end of the forecast period.

With continued strong FWA uptake in parts of the world where fixed broadband connections have been limited, it is likely that household-based traffic will move from smartphones to FWA – especially for streaming services. This could then impact the GB per smartphone numbers in those regions.

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.

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

Figure 8: Global mobile data traffic (EB per month) scenarios

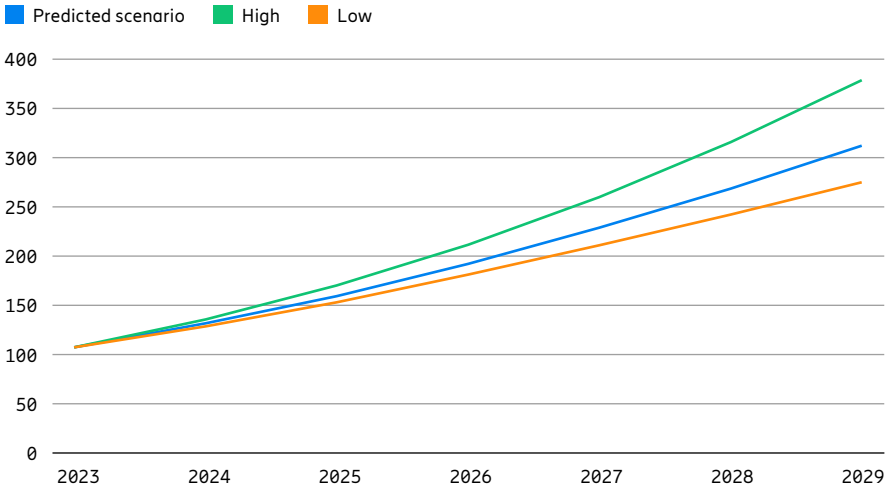
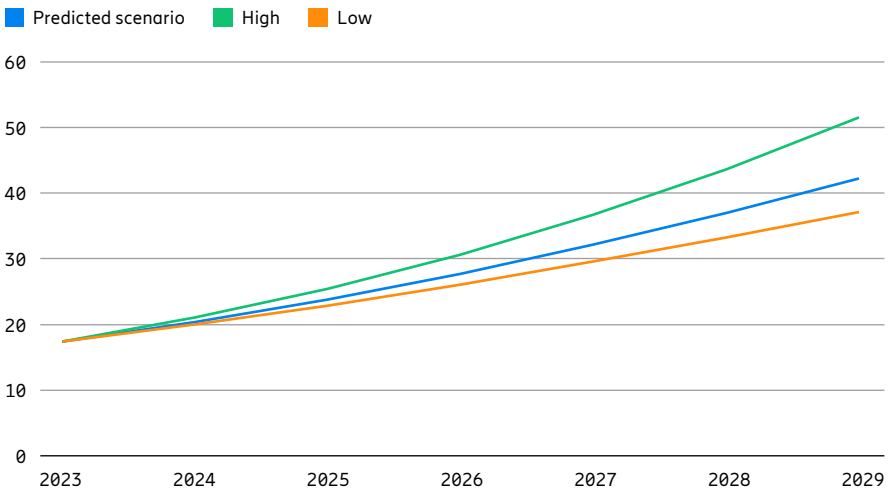


Figure 9: Global mobile data traffic per active smartphone (GB per month) scenarios



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

Differentiated connectivity to drive growth and service innovation

Service providers' main connectivity offerings for consumers and enterprises are based on a best-effort performance model. High-performing programmable networks, utilizing 5G standalone (SA) architecture, provide new opportunities for service innovation and performance-based business models.

Digitalization, automation and electrification are transforming the societal and business landscapes. The underlying enabling technologies driving change are cloud computing, artificial intelligence (AI) and mobile connectivity. AI technologies are increasingly used to create smart solutions across various sectors, such as transportation, energy, education and everyday life. There is also significant momentum in enhancing mobile connectivity to supplement today's best-effort[1] mobile broadband to ensure predictable performance levels for specific traffic flows and applications. This is expected to bring economic benefits to business and societies and support governments in their sustainability agendas.

Enabling new services

Differentiated connectivity with predictable performance is made possible by 5G SA network capabilities such as network slicing, radio resource partitioning and enhanced traffic scheduling. The ability to program these capabilities end-to-end, meeting different performance-level needs from consumer and enterprise applications, lays the foundation for a 5G innovation platform that is user oriented for application service providers (ASPs) to comprehend, utilize and pay for when implementing access to specific mobile network requirements. These performance levels could be offered as subscription services or accessed through an API, enabling new business models.

The 5G innovation platform, combining predictable performance with network APIs, will empower ASPs to create enhanced applications that will accelerate the digitalization of business and society.

Directing the flow of traffic

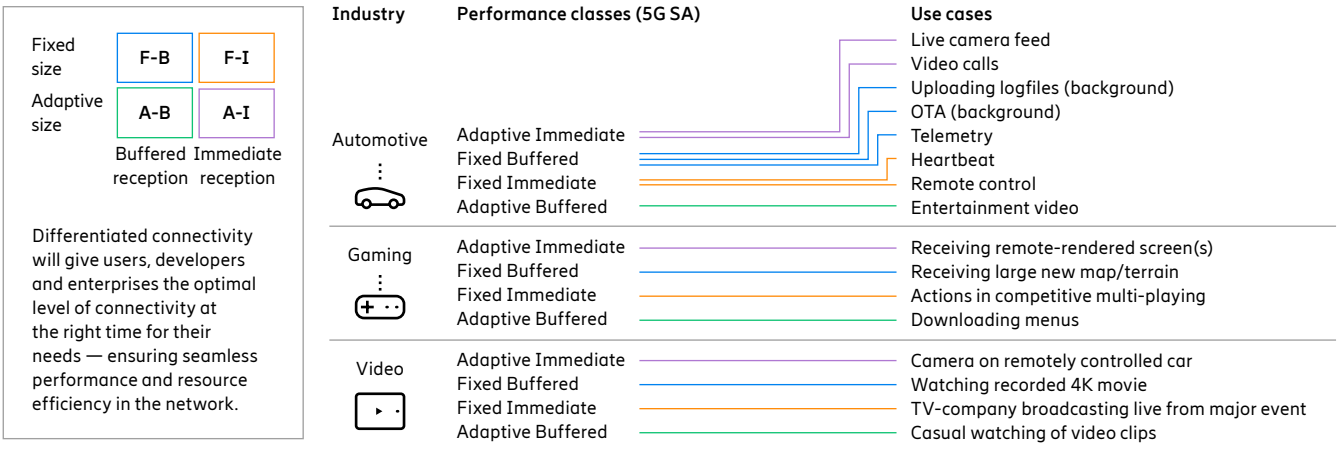
In order to streamline the utilization of the 5G innovation platform by ASPs and foster the development of new innovative services, wireless data transmission performance classes are categorized into four distinct types. Based on this, ASPs can readily allocate traffic flows to the appropriate performance class by answering two simple questions: First, does the application require the transmission of a fixed amount of data, or can it be adapted to the available throughput? Second, is immediate reception of the traffic essential, or can it be buffered? The answers determine the allocation of traffic flow to the respective performance classes.

Offering services that meet the needs of different customer segments, by delivering the right levels of network performance at a premium, provides new revenue opportunities for service providers. This can foster profitable growth through the provisioning of services with different performance levels.

Performance classes are categorized into four types based on how data is sent (fixed or adaptive) and consumed (immediately processed or buffered before use).

Performance levels provide a framework to differentiate capabilities and characteristics within classes. For example, "Adaptive Buffered" requires >2 Mbps 98 percent of the time, while "Fixed Immediate" needs <90 ms 95 percent of the time.

Figure 10: Automotive, gaming and video use cases mapped into four performance classes



[1] "Best-effort" mobile broadband refers to a service where the provider does not guarantee specific levels of performance.

Time-to-content: Great user experience on 5G mid-band

Smartphone users who are connected to 5G mid-band enjoy faster content load times and an overall better user experience.

Key insights

- Measurements from a leading service provider show that 97 percent of all user activities on 5G mid-band achieved a time-to-content of less than 1.5 s, compared to 67 percent on 5G low-band and 38 percent on 4G (all bands).
- Great smartphone user experience requires a consistent throughput "at click" of at least 20 Mbps in the downlink, anywhere and anytime.
- Leading service providers are deploying 5G mid-band to offer great smartphone user experiences while offloading their often-congested lower bands.

Time-to-content is the time between a user's "click" and the point at which a video starts playing or the web page is perceived to have loaded. Consumer research shows that time-to-content heavily influences user experience on mobile broadband; consumers expect instant access to content at any time and location, particularly when the 5G icon is shown on their smartphone. Great user experiences are crucial for minimizing churn and maintaining customer satisfaction and loyalty.

An Ericsson SmartphoneLab study showed that a downlink throughput at click of 20 Mbps and an uplink throughput at click of 1 Mbps is required for a great smartphone user experience, given today's most popular web and streaming video content.[1] Beyond these speeds, user experience only improves marginally.

Why content providers care about time-to-content

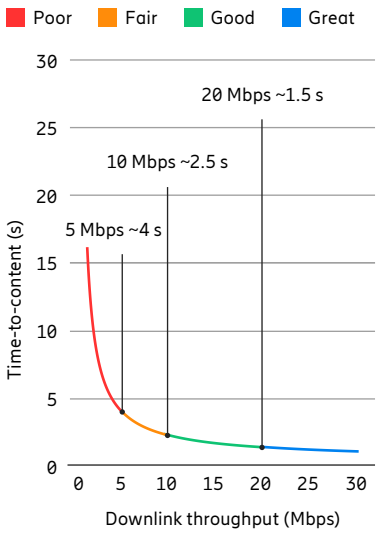
Time-to-content is a key metric that the content provider industry has long relied on to evaluate user experience. Entire industry branches, such as content distribution networks, have emerged to minimize time-to-content and enhance user experience. Today, nearly every online company that prioritizes user experience has integrated content distribution networks into its operations. The rationale includes protecting brand perception, retaining customers and increasing conversion rates. Maintaining consistently low time-to-content is vital for any online business. On 5G and 4G networks, time-to-content is mainly determined by the upload and download speeds available to the device when a user "clicks."[2]

5G mid-band improves user experience

The time-to-content model in Figure 11 rates user experience based on a scale introduced by Google[3] with an additional level of user experience, "great," added to form a scale ranging from "great" (<1.5 s) to "poor" (>4.0 s). According to the model, achieving a "great" time-to-content requires a downlink throughput of at least 20 Mbps.

Based on measurements in a commercial mobile broadband network in North America, an analysis was conducted to compare time-to-content for users that connect to the network via 5G mid-band versus 5G low-band versus 4G (all bands). Every experience for all users connected to the network was measured for 24 hours a day over the course of one week. The analysis is based on several billion data samples collected in the Radio Access Network.

Figure 11: Time-to-content model for user experience

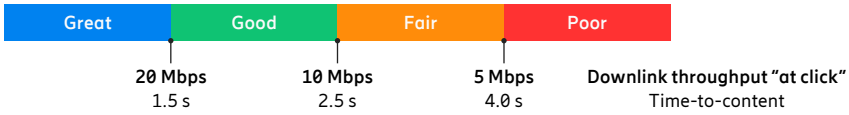


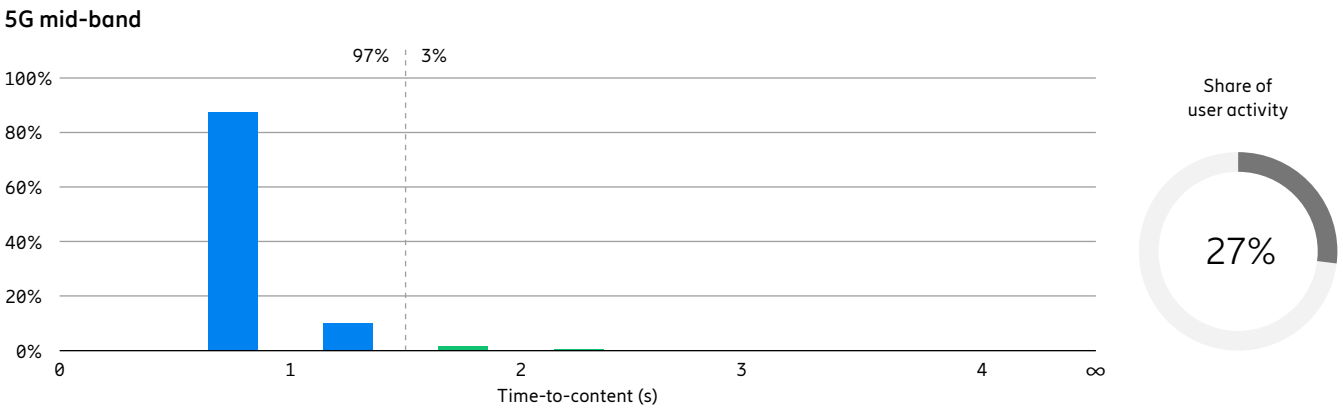
Methodology

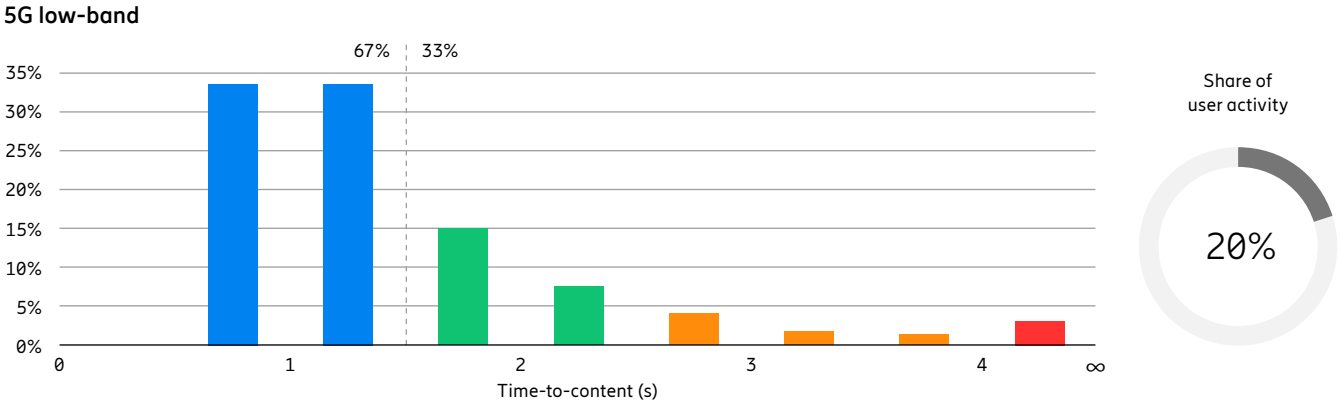
Ericsson's SmartphoneLab conducted a study[4] into the relationship between time-to-content and downlink throughput at click, meaning the throughput available to the device during the time-to-content phase. A wide range of different content types, such as video streaming, social media, e-commerce, media news and company pages, was used to determine the relationship. The result is shown in Figure 11. The analysis includes factors such as the expected increase in size (in MB) of popular content and advancements in device processing power.

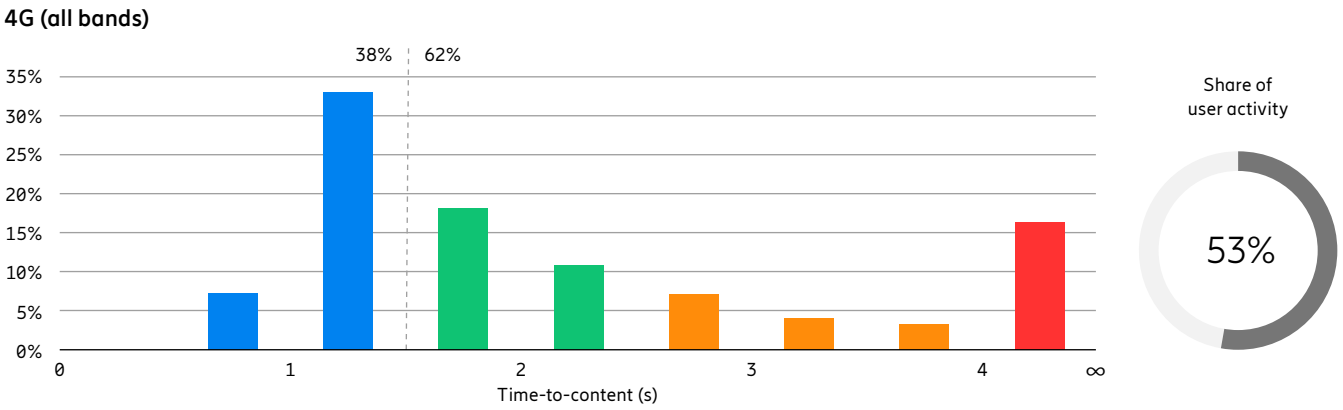
[1] Note: For video conferencing, an uplink throughput of 4 Mbps is recommended for best performance. See learn.microsoft.com/en-us/microsoftteams/prepare-network.
[2] Ericsson, "Who cares about peak download speeds in 5G?" (January 18, 2022).
[3] web.dev, Optimize Largest Contentful Paint.
[4] Ericsson Mobility Report, "Time-to-content: Benchmarking network performance" (November 2021).

Figure 12: User experience in a North American network









Each throughput at click sample was mapped to a time-to-content sample based on the relationship shown in Figure 11. The results are shown in Figure 12. The analysis reveals that on 5G mid-band, 97 percent of user activities achieved a time-to-content of less than 1.5 s, whereas on 5G low-band, 67 percent achieved the same, and on 4G (all bands), the result was 38 percent.

This analysis demonstrates a significant user experience boost with 5G compared to 4G. The mid-band spectrum provides the sweet spot between both coverage and capacity, effectively bridging the speed, capacity, coverage and penetration gaps between the low-band and high-band frequencies. Aggregating mid-band carriers with existing low-band carriers extends the mid-band coverage, while also offloading the often-congested low-band. This improves the user experience on both spectrum bands. Leading service providers are deploying 5G mid-band nationwide to ensure consistently great user experiences.

Boosting capacity across the network ensures a great user experience

Slow download speeds often occur due to congestion on the radio interface when numerous devices are active simultaneously in the same place. Different areas of a network are exposed to high traffic load at different times during a day as population density changes. For example, density is typically high in the morning near bus and train stations, while it is not as high, yet, in the city's business district. To ensure a great smartphone user experience, a throughput of 20 Mbps downlink should be consistently available to a user's smartphone at every "click", even in busy areas and during peak times.

Leveraging 5G capabilities for innovative mobile service packages

An updated Ericsson study[1] of retail packages offered by 308 mobile service providers worldwide shows a continuing shift toward 5G being the standard choice for consumers, especially in high-ARPU markets.

Key insights

- In a few markets, service providers are starting to make use of the capabilities that 5G standalone (SA) brings, by offering differentiated connectivity services.
- No clear correlation can be seen between the introduction of unlimited data plans and market share development.
- Competition mitigates basic changes to offerings and eliminates the effect they may have over time.

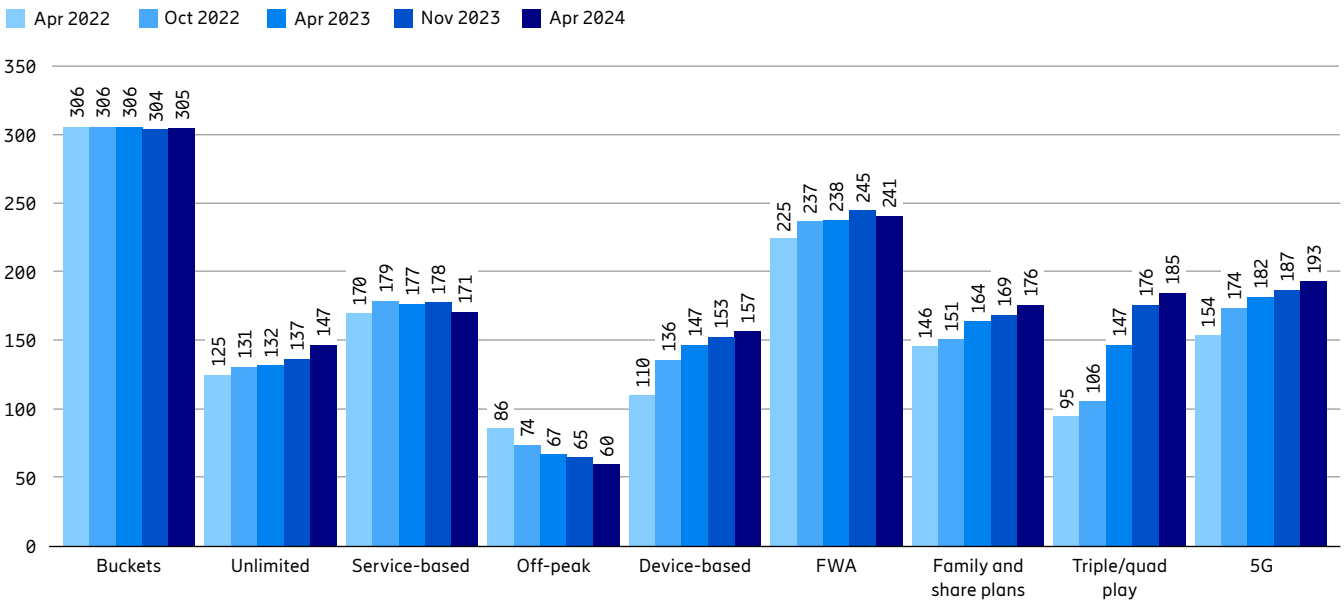
5G SA has been implemented in around 50 networks worldwide. Service providers are promoting it in markets where it is being rolled out, calling it 5G+ in their data plans. In some markets, service providers are starting to make use of the capabilities that 5G SA enables by offering differentiated connectivity services. Some of these services are offered on Fixed Wireless Access (FWA), where minimum speeds or broadband connectivity quality on par with fixed broadband are being guaranteed.

Another area targeted with differentiated offerings is uplink-related connectivity, for example, services used for live broadcasting or streaming. Such services are aimed at professional and national broadcasters, or influencers in need of a more stable uplink for sharing their content on social media platforms.

Some form of data buckets are available from around 99 percent of the surveyed service providers, while around 48 percent offer one or more unlimited data plans to their users. The regional differences are significant and Western Europe has the most, with 89 percent of service providers having unlimited offerings as part of their plan structure. It is also around three times as common to have unlimited plans among the service providers who have launched 5G compared to those that still only provide a 4G service, 64 percent versus 22 percent.

Regular changes to plans are common and can sometimes involve major restructuring. Our research shows that one popular trend is minimizing the number of available plans, or changing every plan to include 5G. A reason for these changes may be to simplify the structure and minimize costs associated with overly complex plan catalogs. Another reason can be attempts to gain market share or increase ARPU; with fierce competition in most markets, service providers are closely watching each other, and often copy each other or find other ways to try to mitigate any major effects on market share or revenue.

Figure 13: Number of service providers per type of offering



[1] April 2024.

Unlimited data plans do not drive market share

One of the more significant changes a service provider can make to their offering structure is the introduction of unlimited data plans. Once that step has been taken there is no higher tier, based on data buckets, that can be offered. Data traffic can grow indefinitely without adding to revenue, and segmentation must be made using additional parameters and criteria. These could include using speed as a differentiator or offering additional content or value adds. The motivation for introducing such plans has often been to drive up user growth and data usage.

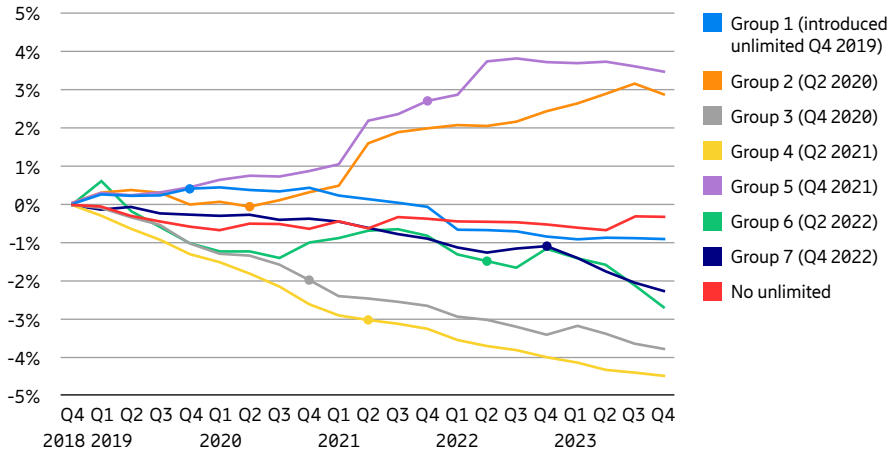
One interesting question is if the introduction of unlimited plans, by one or a few service providers, will have a noticeable effect on their subscriber market share. By correlating service packaging data collected twice per year since the beginning of 2019 with reported financial data from the same time up to Q4 2023, it is possible to see some trends.

Western Europe (17 larger markets) is the region with the highest use of unlimited data plans. A total of 41 service providers in 12 markets have been grouped and named based on when (in which quarter) unlimited plans were introduced, and each groups' combined market share development has been plotted from 2018. Five markets were excluded from the analysis, since either no relevant changes happened during the period or all service providers launched unlimited plans within the same half-year period. However, this analysis does not reveal any clear pattern, as shown in Figure 14.

The dots mark the quarter in which unlimited data was introduced, and only four service providers – Group 2 (Q2 2020) – showed any sustained growth after they launched unlimited plans. The three service providers making up Group 5 (Q4 2021) saw market share growth long before they introduced unlimited. All other service providers are showing flat or declining market share numbers, both before and after the introduction of unlimited. Looking at the numbers at this aggregated level, service providers who never introduced unlimited plans seem largely unaffected by what the others are doing. Their market share development is similar to the group which were first to introduce unlimited plans.

In addition, when studying revenue growth for these groups, the ones that have not introduced unlimited offerings are showing the strongest revenue growth, together with one incumbent service provider that launched as late as Q4 2021.

Figure 14: Market share over time in relation to introduction of unlimited service offerings, Western Europe



A closer look at the market

In most markets in Western Europe, as is often the case in other regions, it takes less than one to one-and-a-half years after the first offering was introduced for competitors to follow with similar offers. Effectively, this means that unlimited offerings are no longer a differentiator, meaning other factors are taking over as the main contribution to market share.

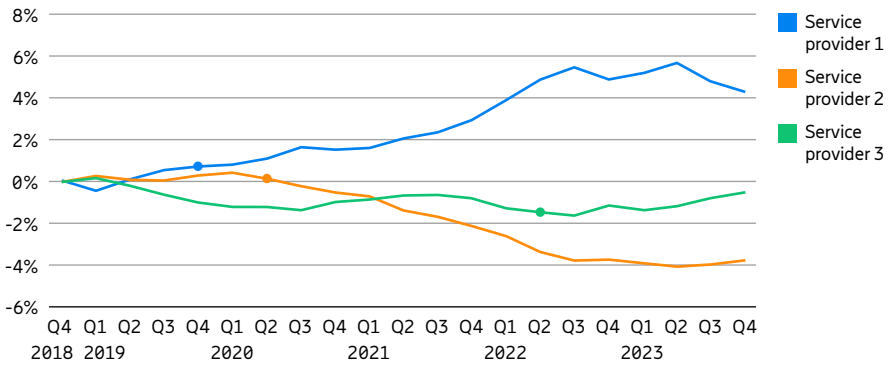
There are, however, six markets where one or more service providers introduced unlimited plans either more than eight quarters after the first, or not at all. Looking at these markets individually, we see almost the same pattern as before. Only in one market does the first service provider to introduce unlimited show any sustained growth starting shortly after they launched it (see Figure 15). In four of the markets, the results are reversed, and the first to introduce unlimited is losing market share. In one market, the increase in market share started 2 years after the introduction and therefore can't be attributed to the change in offering.

In conclusion, market share is the result of a number of variables, and it is likely that several other factors have a more significant impact on market share numbers; constant changes are being made to price levels and marketing messages, as well as to service packaging, and many or most changes are being challenged and countered by the competition.

More differentiation to increase revenues

In the previous report, it was found that there is little to no differentiation between offerings available to consumers when looking at each individual market.[2] Any changes in market share for an individual service provider in mature regions like Western Europe simply mean that subscribers are moving between the providers. The total market size is not changing, and when competition tries to mitigate these changes, the end result can in reality mean that the combined revenue is decreasing and the market is shrinking. Given the results shown here, there may be merit in exploring new ways to address the needs of the users that can provide a sustainable result, especially in terms of increased revenue, most likely by providing far more differentiation than the studies show is currently being offered.

Figure 15: One market, showing increased market share for one service provider after launching unlimited first



[2] Ericsson Mobility Report, "Leveraging 5G capacity in mobile service packages" (November 2023).

Speed-based FWA now offered by 40 percent of FWA service providers

The number of Fixed Wireless Access (FWA) service providers offering speed-based tariff plans has risen to 40 percent compared to 27 percent a year ago, highlighting the momentum in the market.

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

- proportion of service providers offering it over 5G
- share of service providers with speed-based tariff plans
- amount of traffic served, both in the number of connections and the traffic volume per connection

Continued 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 128 service providers offering FWA services over 5G, representing 53 percent of all FWA service providers.

Figure 16: Global FWA service provider adoption 2021–2024

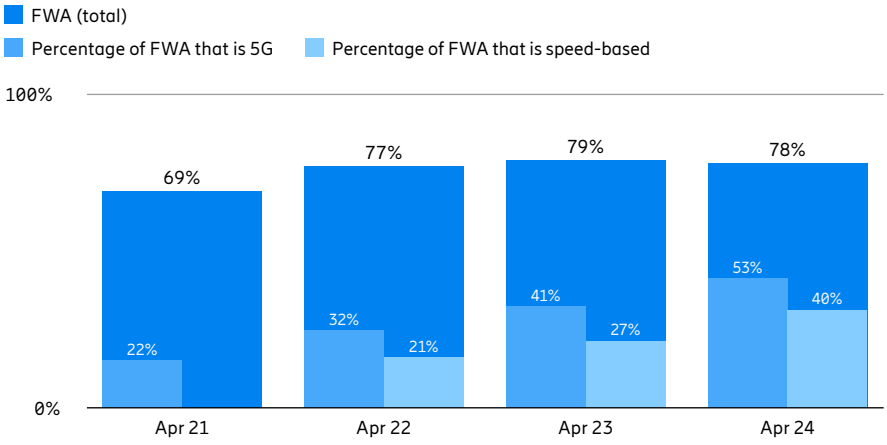
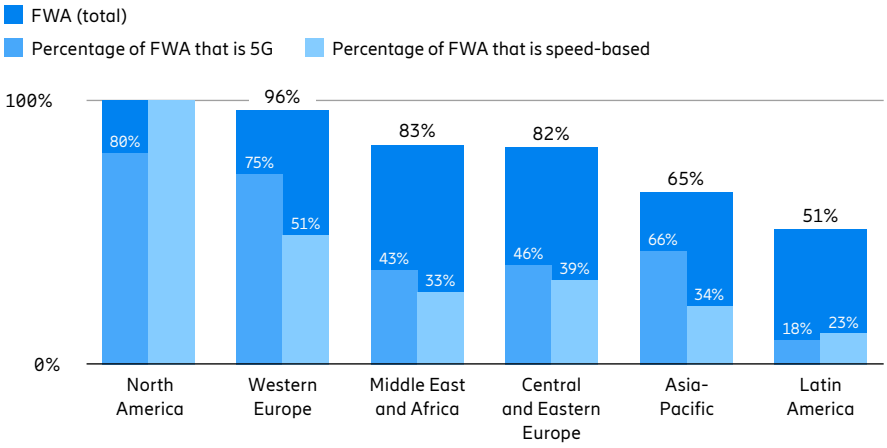


Figure 17: Regional FWA service provider adoption 2024



Speed-based tariff plans are becoming increasingly available

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. Speed-based tariff plans are now offered by 40 percent of FWA service providers, up from 27 percent a year ago. The remaining 60 percent have volume-based tariff plans (buckets of GB per month).

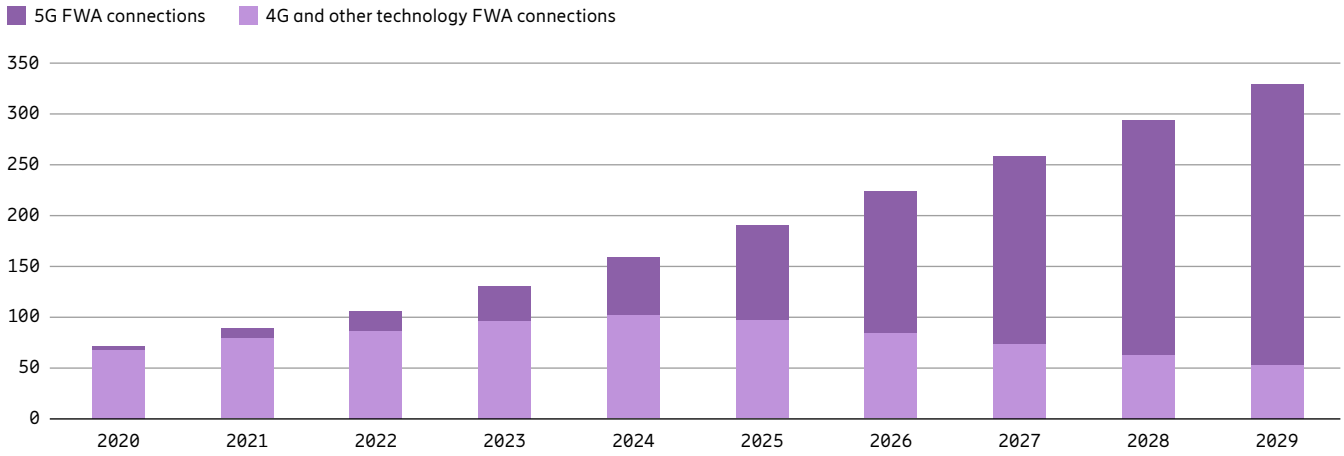
Regional variations

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

- FWA adoption is widespread worldwide, with more than 80 percent of service providers offering FWA in four out of six regions.
- North America stands out as the region with the highest adoption, with 100 percent providing FWA services with speed-based offerings, while 80 percent offer services over 5G.
- In the past year, Western Europe experienced the strongest growth in speed-based offerings, and has the second-highest service provider FWA adoption globally, rising from 30 to 50 percent.
- The Middle East and Africa region has seen solid growth in the proportion of mobile service providers offering FWA over 5G, growing from 30 to 43 percent, as well as the percentage of mobile service providers offering speed-based plans, growing from 14 to 33 percent.

[1] 310 service providers, representing around 90 percent of global mobile revenues.

Figure 18: FWA connections (millions)



FWA service provider advancements

- During the last year, 18 service providers in emerging markets have launched FWA services over 5G, representing around 65 percent of global launches. These launches have taken place in highly populated countries such as India, Brazil and Nigeria.
- As of April 2024, 54 out of 128 service providers with 5G FWA offerings are in emerging markets, representing 42 percent of all global 5G FWA service providers.
- Two service providers, one in Finland and the other in India, have introduced premium 5G FWA connectivity services enabled by 5G standalone (SA). These FWA services utilize network slicing to deliver reliable, assured services, for example, a high-performance experience such as 8K video.
- In the US, four major service providers have seen solid FWA connection growth, going from 5 million connections in the first quarter of 2023 to almost 9 million connections a year later.
- The financial impact of FWA is becoming evident in recent results. A service provider in the US recorded quarterly FWA revenues of USD 452 million, marking a 76 percent year-over-year growth. Similarly, a leading service provider in North East Asia reported a 40 percent increase in FWA revenues along with an 80 percent EBITDA margin.

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.

Almost half of global FWA connections to be in Asia-Pacific by 2029

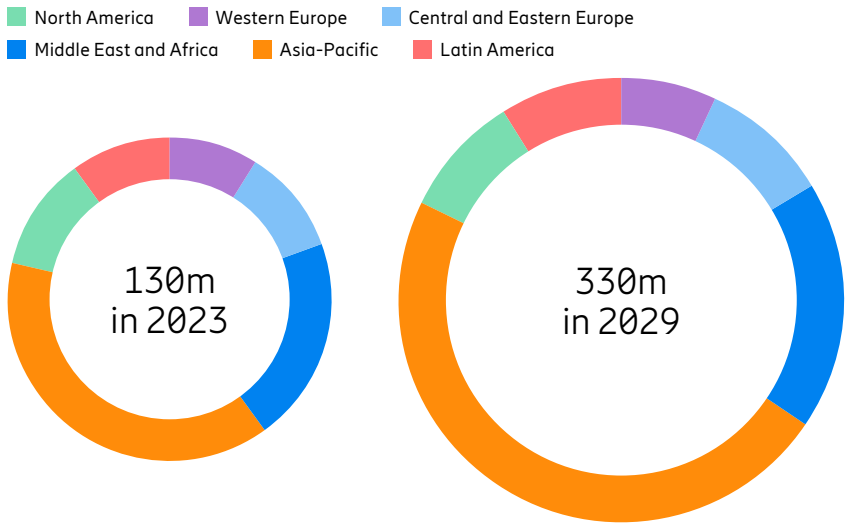
The forecast has taken the high ambitions of 5G FWA in emerging markets into account, both in terms of increasing the number of connections and the share of 5G FWA connections. Higher volumes of 5G FWA in large, high-growth countries, such as India, have the potential to drive economies of scale for the overall 5G FWA ecosystem, resulting in affordable customer premises equipment (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 39 to 48 percent by 2029.

FWA impact on global mobile data traffic

FWA data traffic represented 22 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 154 EB in 2029 – representing over 30 percent of total mobile network data traffic.

Figure 19: Regional split in FWA connections 2023–2029



During the last year, 65 percent of all new 5G FWA launches came from emerging markets.

65%

5G mid-band population coverage reaches 35 percent

Mid-band population coverage outside of mainland China has reached 35 percent. The North America and India regions have made rapid deployments, reaching 85 and 90 percent mid-band coverage respectively.

The build-out of 5G continues, with around 300 networks launched worldwide. Global 5G population coverage, outside of mainland China, reached around 40 percent at the end of 2023 and is projected to increase to about 80 percent in 2029. There are currently 830 4G networks deployed worldwide, with 346 upgraded to LTE-Advanced and 161 Gigabit enabled.[1] 4G population coverage, outside of mainland China, surpassed 85 percent globally at the end of 2023 and is projected to reach over 95 percent in 2029.

Large regional variations in 5G coverage

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.

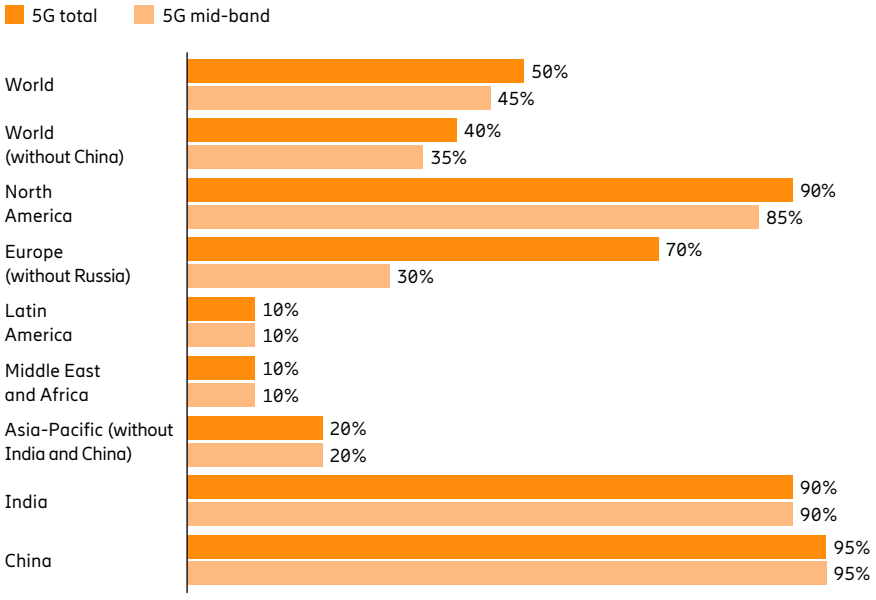
By the end of 2023, 5G mid-band population coverage outside of mainland China reached 35 percent, but coverage varies between regions. Latin America as well as the Middle East and Africa have less than 10 percent total and mid-band coverage. The Asia-Pacific region outside China and India has reached 20 percent total and mid-band coverage. Meanwhile, in Europe there is a disparity between total 5G population coverage, which has reached 70 percent, and mid-band coverage, which reached 30 percent at the end of 2023.[2] This is due to the limited availability of mid-band spectrum in some countries, resulting in mainly low-band deployments.

In these regions, further densification is needed for the full 5G experience. The increase in mid-band population coverage outside of mainland China is mainly driven by large mid-band deployments in India and North America.

India has made large-scale mid-band deployments, reaching over 90 percent population coverage by the end of 2023. North American service providers have deployed 5G across low-, mid- and high-band frequencies, with low-band now covering around 90 percent. Mid-band has also been substantially deployed and reached around 85 percent population coverage at the end of 2023.

Despite these coverage advancements, only around 25 percent of all sites globally outside of mainland China have been upgraded to mid-band 5G.

Figure 20: World population and mid-band coverage split by region (end of 2023)



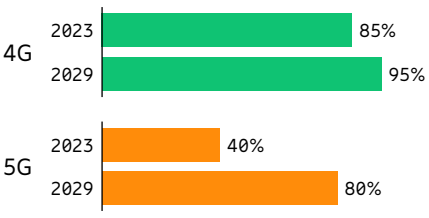
Note: The figures in these graphs are rounded and refer to coverage of each technology. The ability to utilize the technology is subject to factors such as access to devices and subscriptions.

[1] Ericsson and GSA (May 2024).

[2] Both of these figures are excluding Russia.

Globally, 5G population coverage outside of mainland China is set to reach around 80 percent at the end of 2029.

Figure 21: World population coverage outside mainland China, by technology

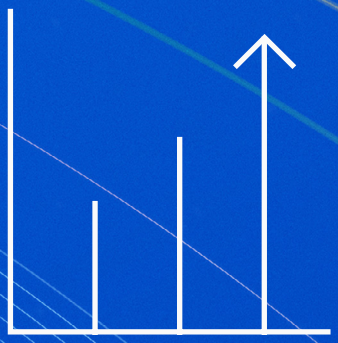


Note: The equivalent graph in previous editions of the Ericsson Mobility Report included figures for mainland China.

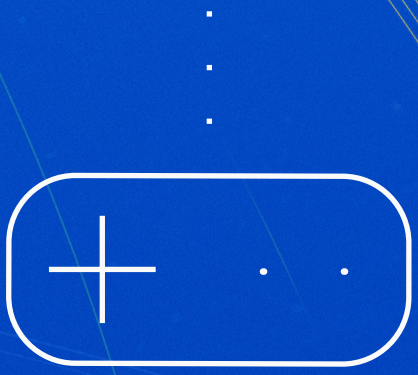
Articles

5G is a springboard for innovation, and service providers are now looking forward to using it to drive change. In our articles, we explore the future of intelligent transport systems with Telia and AstaZero, the transformational opportunities that Airtel's 5G network is offering businesses in India, the possibilities of programmable networks with AT&T, and how 5G was deployed underground with Rogers.

At the AstaZero proving ground, 5G standalone (SA) connectivity via the NorthStar network provides the means to advance the development of intelligent transport systems.



Airtel's extensive 5G deployment in India offers transformational opportunities for businesses, as well as enhancing consumer experiences through wider 5G availability with higher speeds.



Network programmability is providing AT&T with the agility and reliability necessary to meet the increasing demand for differentiated services.

Over 300 million passengers ride the Toronto subway every year. Here's how Rogers deployed underground 5G to connect them all on their commutes.

How the NorthStar 5G network inspires innovation

Early access to new 5G network functionality with NorthStar is allowing leading enterprises in Sweden to develop and test new differentiated connectivity solutions. AstaZero is seizing this opportunity to pioneer autonomous vehicle solutions and active safety systems.

Key insights

- 5G technology, especially network slicing, has great potential for establishing new standards for how vehicles communicate via differentiated levels of connectivity.
- Access to 5G technologies in a safe environment will speed up the development of new offerings for safer and more sustainable transport solutions.
- AstaZero explores automotive use cases, but the model of providing network performance levels based on connectivity characteristics resonates across all industries.

Telia

Telia is a market-leading service provider in Sweden, delivering innovative services for more digitalized and sustainable societies across the Nordics and the Baltics.

AstaZero

AstaZero is the world's first full-scale proving ground, specially designed to support the development of advanced automotive technology and active safety systems. AstaZero is owned by RISE Research Institutes of Sweden, with industrial partners including Volvo Group, Volvo Cars, Scania, Qualcomm and APTIV.

The proving ground

AstaZero's proving ground, located outside Gothenburg in Sweden, offers a controlled environment for testing active safety systems, autonomous driving and vehicle-to-vehicle communication. Access to cutting-edge 5G technologies is provided through the NorthStar innovation program's 5G network.[1] This access enables thorough testing of performance and safety in use case scenarios related to autonomous driving and active safety systems, in realistic traffic environments such as highways, cityscapes and rural areas. These research efforts will make a significant contribution to advancing the development of next-generation vehicle safety and automation.

5G network slicing for automotive applications

Automated vehicles operate within systems that are far more complex than traditional transport infrastructure. Advancing automated transport technologies will require ongoing research and development of system integration, cyber security, edge computing and connectivity solutions. By establishing a collaborative forum for sharing and testing new ideas, AstaZero aims to expedite the global transition toward safe and sustainable automated transportation.

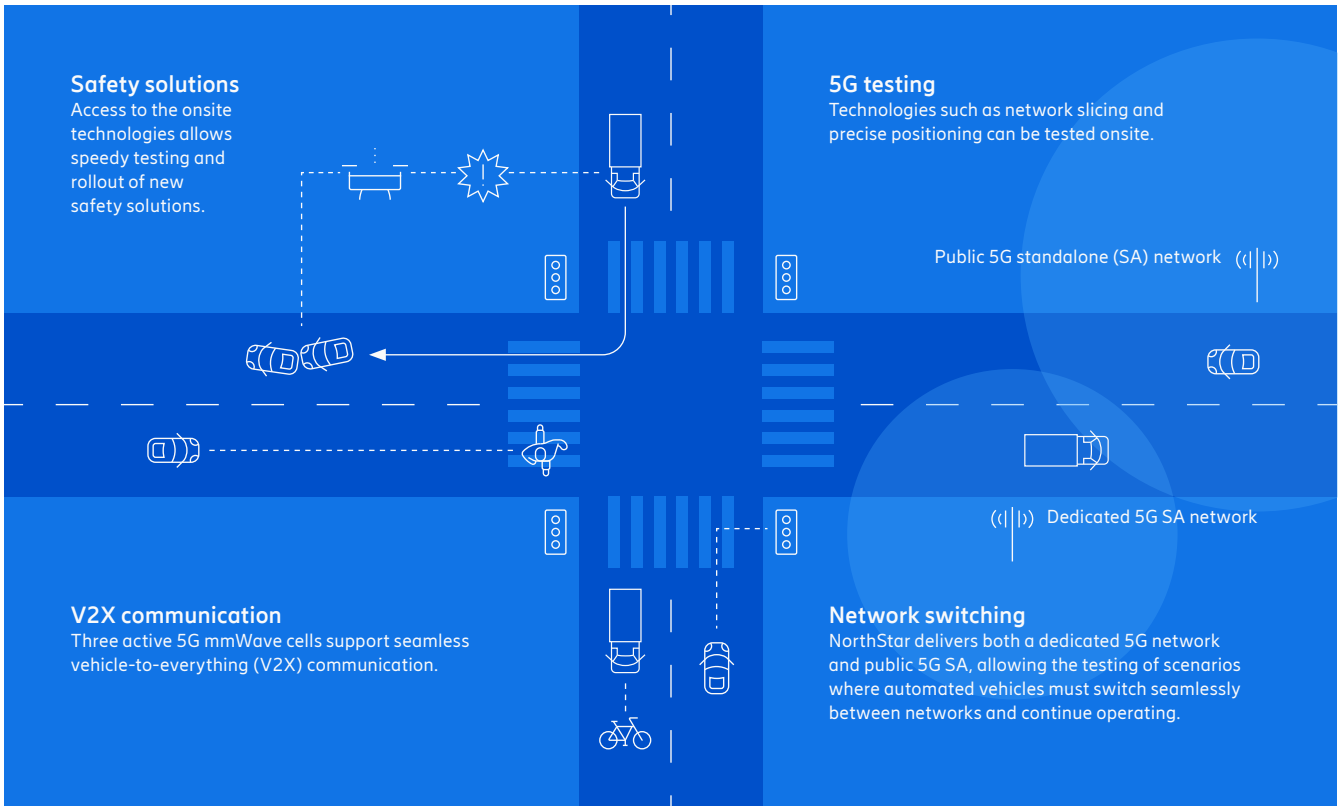
Leveraging 5G network slicing, AstaZero can create customized connectivity for specific applications and customer requirements. Each network slice functions as an independent entity with its own distinct set of resources, characteristics and performance parameters, including bandwidth, latency and reliability. For an automated vehicle, it is essential for the remote operator to have a real-time view of the vehicle's surroundings in order to respond promptly to unexpected obstacles. This necessitates a network connection with low latency. Likewise, a video feed requires sufficient bandwidth to maintain a certain quality of video resolution, enabling a remote operator to accurately detect and identify distant objects, such as vehicles or animals, and take necessary actions. A critical aspect of the research at AstaZero is facilitating cooperation and dialogue between service providers and original equipment manufacturers (OEMs), to establish a mutual understanding of the end-to-end requirements and network capabilities essential for each specific test. This is crucial for correctly configuring the network slices for each use case. AstaZero demonstrates the practical application of 5G network slicing and quality of service (QoS) functions in various test cases, positioning itself as a pioneer in implementing this functionality at an automotive proving ground. One particular setup currently being tested and demonstrated, in both research and customer projects, is remote vehicle operation where latency requirements and reliability of data flows for control signaling are at the core of the operations.

Remote control, no reconfiguration

A distinctive aspect of NorthStar's 5G innovation network is its capability to share setups across various locations and enable connections from one place to another. This means scenarios with the same configuration can be established in different locations. For example, this capability allows AstaZero to transfer the control center for a remotely operated vehicle to Telia Sweden's main offices in Stockholm, as well as at any test customers' premises. Leveraging NorthStar network instances, AstaZero can replicate the setup used at the test track. Consequently, the research vehicle at the AstaZero test track can be remotely operated from entirely new locations without requiring additional configuration.

[1] Telia's purpose-built mobile network, run alongside its public 5G network.

Figure 22: Capabilities at the AstaZero proving ground, Gothenburg



Remote operations test setup

During remote operation tests, a control tower is established at a distant geolocation, while the remotely operated vehicle remains at the AstaZero proving ground. The test vehicle is equipped with cameras that stream a video feed from the perspective of the driver's seat. Remote control centers can be established at the offices of commercial partners, enabling the vehicle at the test track to be operated without personnel needing to be physically present.

A geofence solution ensures that the vehicle never leaves the designated safe driving area, with video feeds tracking the vehicle's position. This information is streamed to the control center along with other critical data points, such as velocity and course.

The various video feeds are organized using video streaming software to ensure the remote operator receives all the necessary information to conduct the test. This setup requires high-performance network connectivity, adapted to specific workloads of high throughput and constant latency. Throughout testing, all critical infrastructure is connected to slices with higher priorities ensuring vital signals always maintain a high priority.

Utilizing multiple slices

At the AstaZero proving ground, the network was configured for a test scenario that enabled the remote operation of a vehicle over 5G, while simultaneously utilizing multiple automotive applications on different network slices. This involved managing three 4K video streams from the research vehicle and one from the stationary vehicle, geofencing data, positioning data for supervising the actual test, and uploading a substantial amount of test data from the vehicles. The video stream quality on the "best-effort" slice noticeably degraded during times of network congestion, a problem not experienced by the research vehicle on the "premium" slice. Likewise, vehicle control for the remotely operated car remained unaffected. By assigning critical data to dedicated network slices, consistent transmission of this data can be ensured at a defined performance level, in contrast to non-critical data transmitted over a best-effort slice, which may be affected by congestion or may not meet specific bandwidth or QoS requirements.

5G network slicing for remote-controlled vehicles

Two vehicles were present at the test track, including the AstaZero research vehicle. It was equipped with a drive-by-wire kit, a comprehensive hardware kit, and software system enabling electronic control of the car's brake, throttle and steering. This setup allowed for fully automated driving of the vehicle. An additional software layer was integrated into the system, enabling it to interface with both a test orchestrating platform[2] and the geofencing solution at the proving ground. This configuration also facilitated the direct transmission of control signals to the vehicle from a steering wheel and pedals located at any given geolocation, enabling remote operators to control the vehicle from a distance. Additionally, a navigational system for precise positioning was installed in the car. This enabled test engineers to refine the vehicle's positioning data and extract time-synchronized logs detailing various aspects of the vehicle's behavior.

To maintain a stable connection to the 5G networks and facilitate the execution of specific test cases, the research vehicle was equipped with an automotive antenna,[3] Wi-Fi router[4] and a Global Navigation Satellite System (GNSS) antenna[5] connected to an industrial 5G router.

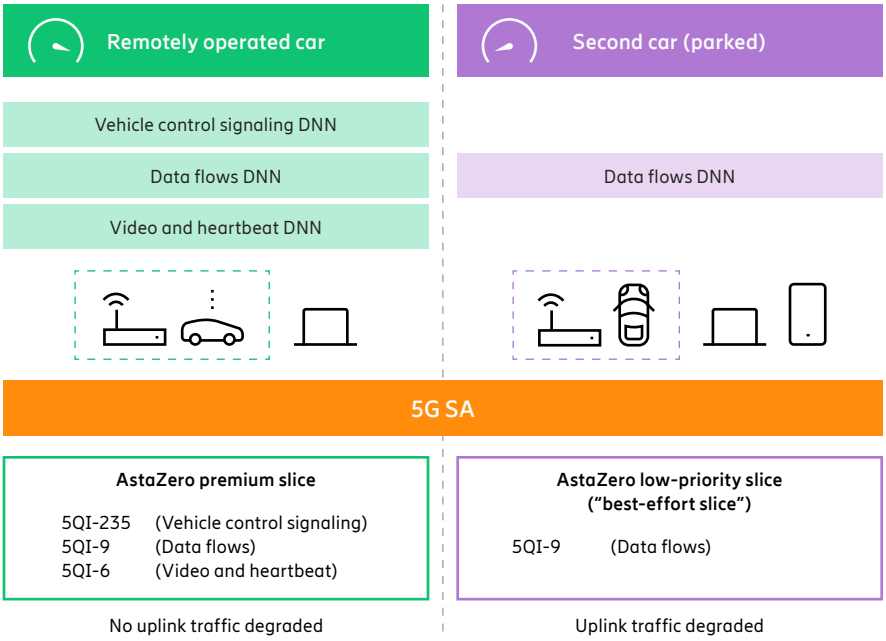
[2] Using the iso22133 standard for test infrastructure.
[3] 410–3,800 MHz; 4X4 LTE (MIMO), 6.2dBi.
[4] 2X2 Wi-Fi (MIMO), 7 dBi.
[5] 21 dBi.

This setup enabled the research vehicle to receive satellite-based positioning and connect to the 4G/5G networks at the test track. This capability made it possible to run various applications directly in the vehicle and send relevant data to central monitoring systems, such as the test orchestration software or the geofencing solution. Importantly, the ability to transfer location data and other information from objects on the track is not limited to vehicles. For instance, a connected vest has been used in demonstrations to illustrate how vulnerable road users at the test track can be safeguarded. By connecting the high-visibility vests worn by personnel at the test track to the geofencing solution, emergency stop functionality can be enabled when someone enters a restricted area during an active test.

The AstaZero research vehicle was connected to the high-priority slice with the data flows below, defined by individual 5G QoS identifier (5QI) values for different QoS levels within the slice. 5QI is a unique identifier, as defined by 3GPP, that is used to manage and prioritize different types of network traffic based on their specific QoS requirements. It is used to ensure that each traffic type receives the appropriate level of service quality, such as low latency, high throughput or reliability. A higher 5QI level can broadly be considered to indicate a better quality of service in the network:

- High priority vehicle control signaling (5QI-235).[6] In this demo case, the setup involved USB over IP signaling from a hand controller, but the configuration is designed to be versatile, enabling future demonstrations to utilize the same software with a steering wheel and pedals. These signals interface with a software layer integrated into the drive-by-wire system of the research vehicle, enabling comprehensive control of the vehicle.

Figure 23: High-level setup of demo and the 5G network slicing

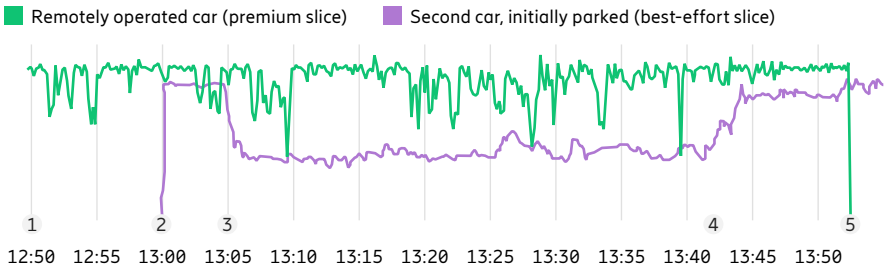


- Actual positioning data and simulated data flows in the form of large binary files (5QI-9).
- Video and heartbeat stream (5QI-6). This stream enables the remote operator to see the same view from the control center that they would if located inside the car. The heartbeat functionality ensures that this feed is always kept on.

In addition, a low-priority network slice ("best-effort" slice) was set up for one of the vehicles which consisted of data flows (5QI-9).

The Data Network Name (DNN) is used to identify and route traffic to a specific network slice. As can be seen in this demo setup, the division of which data will be transmitted using a particular slice is of paramount importance when creating a certain setup to ensure that critical data, in this case the control signaling and video for the remotely operated vehicle, can be continuously transmitted. As the network becomes congested, the video feed from the stationary (parked) car on the best-effort slice starts to degrade, while the operation of the remotely driven research vehicle continues unaffected. When the stationary car moves to a different cell without congestion the quality of its video feed is restored.

Figure 24: Load test of network slices



1. Video stream from remote operated car started
2. Video stream from parked car
3. Data load from additional load clients started: Quality of video stream degrades
4. Parked car starts moving and connects to another network cell: Quality of video stream restored
5. End of test

Secure, reliable connectivity

One of the key research objectives is to investigate how autonomous vehicles can maintain secure and reliable connectivity and determine the appropriate slices and QoS levels. Together, this ensures the seamless flow of critical data when transferring testing of autonomous driving vehicles from the confined area of AstaZero to public roads. With the implementation of 5G-enabled corridors on public roads using NorthStar,[7] a configuration that has demonstrated success within the confines of the test track can be safely and seamlessly transferred to these corridors without the need for additional network configuration.

For example, self-driving trucks can be operated via AstaZero's dedicated network, replicating a port or logistics center scenario, and seamlessly transition to the public network, mirroring real-world scenarios such as a vehicle departing from a port or logistics center. A control center similar to the one at the AstaZero test track for this demonstration can then be deployed at any other NorthStar-enabled site to allow remote operation or visualization of the vehicle performance.

[6] 5QI-235 in this use case is not defined by 3GPP.

[7] A development co-financed by the European Union under their Connected Europe Facility 2 Digital program.

Creating value with differentiated connectivity

The AstaZero proving ground case demonstrates the capabilities of 5G SA. It highlights the previously unavailable value of new connectivity technologies. For the automotive industry, it illustrates basic aspects such as how network changes, outages, congestion or other parameters affect system components and their associated data streams. This leads to better understanding of how to ensure that, for example, safety systems in vehicles are guaranteed to immediately, securely and reliably receive information. This results in a deeper understanding of the design requirements for applications and features, as well as the necessary network performance requirements to support their functionality.

Different connection characteristics have an impact on the required network performance level for an application to function effectively. Examining these gives an opportunity to understand what type of connection is right for specific tasks. For example, a slice with ultra-low latency is essential for controlling the movement of a remotely operated vehicle, while a best-effort slice may be sufficient to handle background vehicle status data, for example fuel levels. With this understanding, application and service designers can build new features, or significantly improve existing ones – relying on fit-for-purpose, performance-based connectivity instead of relying on best-effort.

To advance intelligent transportation systems, 5G SA networks must support diverse use cases, enabling the development of compelling service propositions with assured service levels. In addition, a broader ecosystem of automotive industry players and partners must come together to evolve the capabilities that allow vehicles to communicate with other vehicles (V2V), infrastructure (V2I), pedestrians (V2P) and networks (V2N).

While the AstaZero project explores automotive use cases, the model of providing network performance levels based on connectivity characteristics is one that resonates across all industries.

NorthStar program

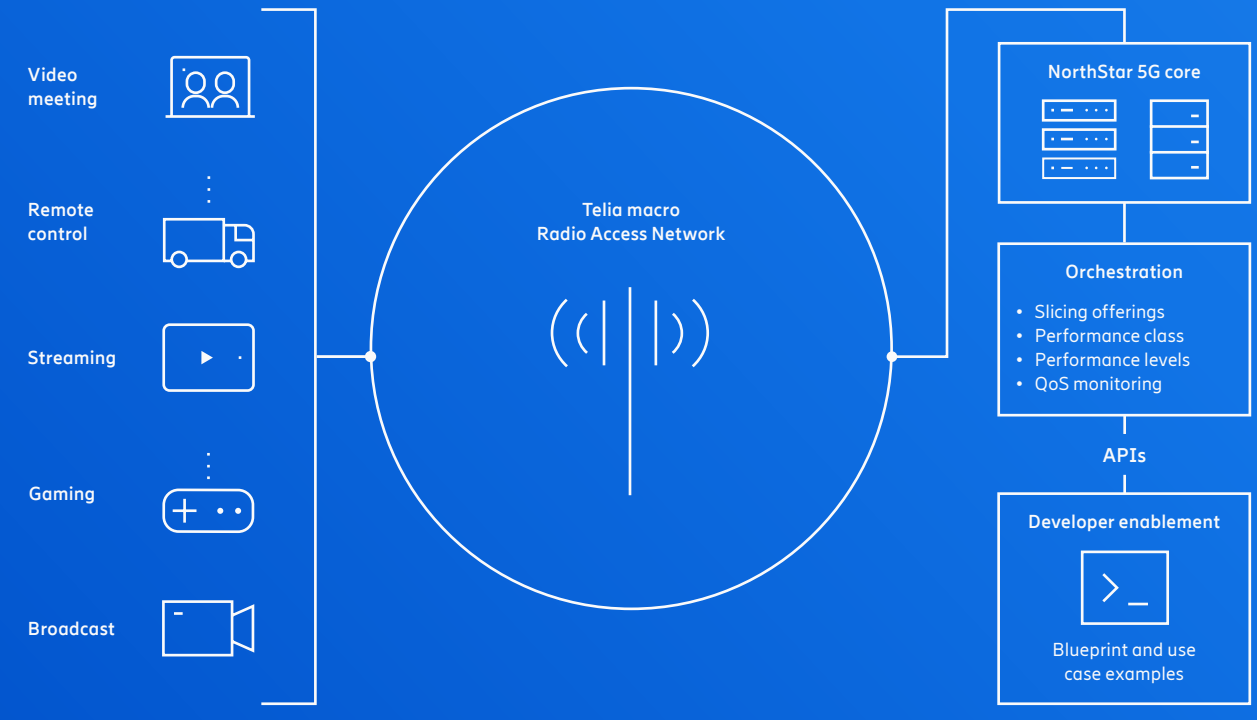
The NorthStar 5G network

NorthStar is a 5G innovation program for industrial enterprises, for the development and implementation of digital solutions driving efficiency, safety and sustainability. It has a dedicated, purpose-built mobile network, which is run by Telia alongside its public 5G network.

As NorthStar deploys the latest 5G enablers immediately, making them available exclusively to its customers and partners at any location, it gives them a head start in developing, testing and monetizing new, advanced solutions.

Aside from the 5G technology aspect, the program seeks to foster new models of collaboration between enterprises, start-ups, academia and the public sector with the aim of creating more sustainable and resilient communities. It brings together experts and specialists from Telia and its customers and partners from various industry fields. NorthStar's customers can also build dedicated network infrastructure – for example at test sites and R&D facilities – and connect it to the innovation network. The ability to leverage both public and dedicated networks will allow customers to access the innovation hub regardless of where they are located. Examples of technologies customers can explore include network slicing, positioning for high accuracy, high availability and low latency. The ability to provide this advanced level of service is in part due to Telia's drive to evolve IT support systems to align with industry and customer demands. This transformation journey is a key enabler for its ambition to monetize, operate and scale services based on differentiated connectivity.

Figure 25: NorthStar 5G innovation network enables a multitude of use case scenarios



Enhancing customer experiences with 5G

Leveraging its extensive deployment of high-performance 5G networks, Bharti Airtel aims to deliver a superior user experience while seizing emerging business opportunities.

Key insights

- Airtel has invested significantly in its 4G and 5G networks as well as its digital platforms, elevating customer experience and delivering strong operating performance.
- 5G is expected to be key for Airtel to fulfill its strategic priorities, including acquiring and retaining high-value customers and scaling up digital solutions.
- Airtel collaborates with enterprises in sectors such as manufacturing, mobility, healthcare, ports, mining, logistics and advanced robotics, where 5G technology can help transform their businesses.

India has embraced 5G

India's digital transformation vision aims to leverage technology to drive economic growth, improve governance and enhance citizens' quality of life. This vision encompasses initiatives to expand digital access and services to various segments of society, promote innovation and bridge the digital divide. Within this vision, 5G is expected to bring about transformative changes by providing faster, differentiated and more reliable connectivity. This will enable the widespread adoption of emerging technologies, support the development of smart cities and IoT ecosystems and facilitate the seamless integration of various digital services and applications.

India saw one of the world's fastest large-scale 5G network deployments following its launch in 2022. This elevated India's median mobile download speed by 259 percent between September 2022 and August 2023, resulting in its ranking rising from 119th to 47th position on the Speedtest Global Index™.[1] By April 2024, India's ranking had further climbed to 15th position. The introduction of more affordable 5G-capable devices in the market has helped boost 5G adoption in the country. India's 5G smartphone shipment share crossed 52 percent in 2023,[2] with strong growth in the USD 100–199 price range.

Amid the rapidly growing demand for mobile services and the ongoing digital transformation, Indian service providers are implementing diverse strategies to expand digital access and provide services to a wide range of societal market segments.

Strategic priorities

Airtel has made significant investments toward building its nationwide digital infrastructure, including a 5G network to support India's digital transformation goals. A range of connectivity and digital services are offered through its four primary business segments – mobile broadband, fixed broadband, digital TV (direct-to-home (DTH), satellite TV) and Airtel Business (enterprise services). Its consumer services portfolio includes digital banking, mobile payments and music streaming, while its enterprise offerings include IoT network-as-a-service (NaaS), communications-platform-as-a-service (CPaaS) and advertising solutions.

Over the past two years, Airtel has executed a strategy of winning high-value customers, premiumizing its portfolio with bundled offerings, enhancing customer experience through extensive use of digital tools and building a future-ready digital network. Alongside 5G, the 4G network is also being optimized to enhance customer experience. Leveraging the power of data, Airtel is unifying customer insights and channel strategies to effectively target and engage customers, maximizing the impact of its marketing efforts.

This article was written in collaboration with Airtel, a global communications solutions provider with over 500 million customers in 17 countries across South Asia and Africa. The company ranks among the top three mobile operators globally, and its networks cover over 2 billion people.

Targeting high-value customer segments

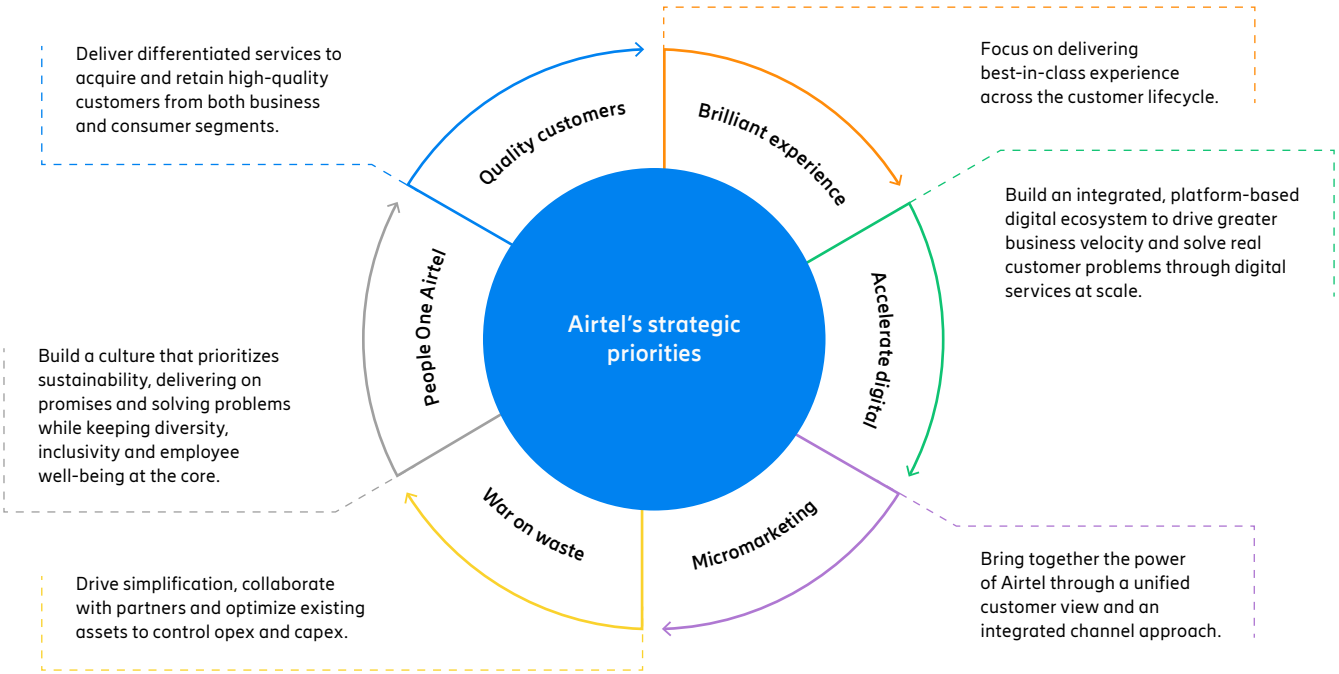
A cornerstone of Airtel's consumer business strategy for increasing ARPU involves the premiumization of its customer base, achieved by tailoring value propositions to various market segments. This strategy aims to attract various segments of the customer base to:

- upgrade from feature phones to smartphones
- upgrade from pre-paid to post-paid service plans
- upgrade to converged services, allowing subscribers to combine any two or more services (mobile, fiber, satellite TV) in one service plan under a single bill
- foster customer loyalty by providing tailored digital-service offerings for diverse customer segments, engaging in real-time marketing and facilitating convenient online upgrades for data plans and content bundles

High-value customers are a key target, in both consumer and enterprise segments, with emphasis on the top 150 cities. Offering upgrades to converged services, Airtel has launched an all-in-one solution for homes.

[1] speedtest.net/global-index.
[2] Counterpoint, "India Smartphone Market Remains Flat in 2023; Apple Shipments Cross 10 Million for First Time" (31 January 2024).

Figure 26: Airtel's strategic priorities



A customer can bundle two or more services (such as fiber, DTH or mobile) into one single bill, with one customer care number and a dedicated team of relationship managers, with priority resolution of faults and issues.

Excel in delivering a superior customer experience

By focusing on customer satisfaction and loyalty – with, for example, responsive customer service, user-friendly digital interfaces and personalized offerings – Airtel aims to retain its existing customer base and attract new subscribers.

The network has been continuously optimized to ensure high performance. Curated circle-wide programs across India, aimed at optimizing the network, have reduced the customer churn rate. A high-value customer experience program was initiated to proactively identify poorly performing parts of the network, using a digital module to identify such locations based on user experience KPIs. The identified regions were prioritized for optimization and capacity augmentation, leading to a substantial reduction in customer-reported errors.

Airtel has invested in digitizing its operations using automation and artificial intelligence/machine learning (AI/ML) practices. This has helped improve customer experience through faster resolution of customer complaints and queries and has brought efficiencies to the network. An in-house tool has also been developed, Airtel Self Optimization Network (A-SON) to predict degradation and proactively make changes in the network to enhance customer experience. Advanced AI/ML use cases were introduced for intelligent network troubleshooting, including auto-correction of cell-neighbor relations, ducting mitigation (4G), load balancing and sleeping-cell detection and correction.

Approach to 5G deployment

In October 2022, Airtel launched 5G in India and rapidly expanded coverage to more than 3,500 cities/towns and about 20,000 villages within a year. The approach to 5G coverage expansion mirrors the strategy for 4G, namely prioritizing areas with significant 5G device penetration. As of March 2024, Airtel had attained 5G coverage across most of the nation's urban centers and garnered a 5G subscriber base of roughly 72 million, representing approximately a 20 percent share of its customer base.

Airtel's strategic selection of technologies was instrumental in the swift rollout of 5G. Choosing globally adopted and mature 5G non-standalone (NSA) architecture enabled a faster time to market and enhanced capex efficiency. 5G NSA uses the existing 4G layer as an anchor and capitalizes on the existing evolved packet core (EPC) to expand 5G coverage in the specified service region, resulting in reduced capital investment. In addition, the company made the strategic decision to exclusively implement Massive Multiple Input, Multiple Output (MIMO) radios for its 5G network. The capabilities of Massive MIMO – including beamforming, spatial multiplexing and spatial diversity – were leveraged to bolster network capacity, extend coverage and enhance the overall user experience.

Carrier aggregation in the 4G network further supplemented the New Radio (NR) carrier. The network parameters were optimized to accommodate cell edge users, along with dedicated measures to reduce uplink interference.

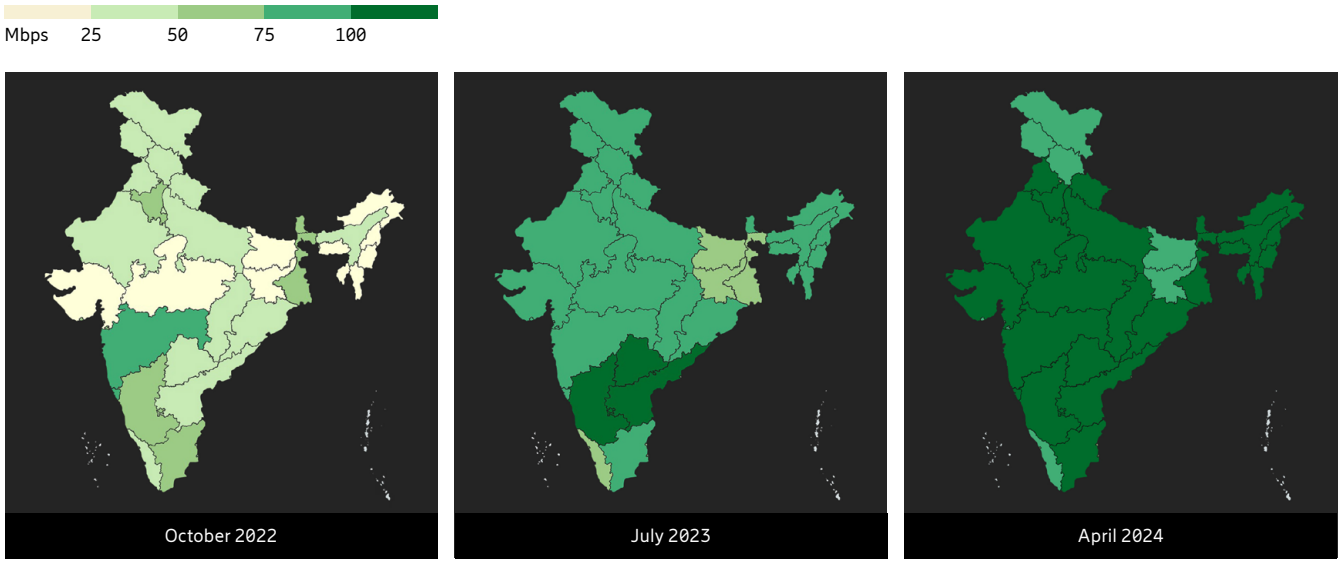
By coupling the technological advantages of Massive MIMO radios with the ease of deployment, a high-performing 5G network has led to improved user experience and higher customer satisfaction. 5G customers in Airtel's network are experiencing 20–30 times higher speeds and a significantly improved user experience compared to the legacy network.

Airtel is currently conducting trials for running 5G standalone (SA) in addition to 5G NSA technology. The aim is to implement dual-mode 5G SA and NSA, harnessing the capabilities of both architectures to enhance its service portfolio. Airtel is collaborating with device manufacturers to enable NSA and SA combined and carrier aggregation functionality in smartphones. As traffic increasingly transitions from 4G to 5G networks, mid-band spectrum is being refarmed from 4G to 5G, which contributes to enhanced 5G indoor coverage as a result. The company holds spectrum in the 850/900 MHz, 1.8 GHz, 2.1 GHz, 2.3 GHz, 3.3 GHz and 26 GHz bands.

Digital tools for fast 5G deployment

Airtel has harnessed a range of digital tools and data-science methodologies for 5G deployment in India. During the planning phase, it employed a comprehensive multi-technology radio planning and optimization solution to design an appropriate site solution for potential markets.

Figure 27: Network performance, Airtel India



Note: Airtel 4G/5G access. The regions are colored based on downlink throughput (0–>100 Mbps).
Source: Based on Airtel's analysis of crowdsourced data. India: Oct 2022, July 2023 and April 2024.

By iterating various implementation scenarios and simulating projected coverage areas and traffic patterns, this solution empowered Airtel to swiftly craft an optimal network plan, expediting the deployment process.

Additionally, during the deployment phase, an in-house tool was developed and extensively used to streamline the entire process. Tracking the site integration process from the initial stages of raising a service request, to infrastructure readiness and finally to site installation, the tool seamlessly provides an easy-to-use management platform for each stakeholder to oversee the process. Further, the site acceptance process was also streamlined through digital transformation.

A customized, self-designed, advanced network test solution was deployed for this. The solution automated single-cell functionality testing (SCFT), cluster drive log processing and report generation, facilitating auto-acceptance and significantly enhancing the efficiency of the deployment and site integration processes. Additionally, it also automated drive route generation based on the predicted coverage of the newly integrated sites and provided real-time monitoring of the on-ground drive test teams.

Seizing the 5G FWA opportunity

The demand for home internet has surged in India, driven by the changes brought by the COVID-19 pandemic, such as remote work, higher data consumption and more available devices. With fiber-to-the-home connecting only 34 million residential homes, there is an opportunity to bridge the digital divide with 5G FWA services. Airtel aims to tackle the last-mile connectivity challenge in both rural and urban India where fiber infrastructure is lacking. 5G FWA is regarded as an important use case with significant potential for monetization. Once SA is implemented in the network, this will also be among the first use cases to use the newly evolved architecture. Currently FWA has been implemented using outdoor customer premises equipment (CPE) in 25 cities across India. Airtel is preparing to expand and accelerate the FWA deployment pace in Q2 2024.

5G services are delivered to consumer homes and business premises through CPE, providing consistent network availability and high throughput capacity. Airtel offers affordable plans with speeds of up to 100 Mbps.

Solutions for multi-dwelling units are also being explored, allowing multiple customers to connect through a single CPE device. Ongoing innovations include testing in the mmWave spectrum. Airtel has successfully demonstrated mmWave 5G functionality for FWA on its network, achieving peak speeds of 4.7 Gbps during testing, showcasing that it is future proof and can meet high-capacity network requirements.

Capturing the enterprise opportunity

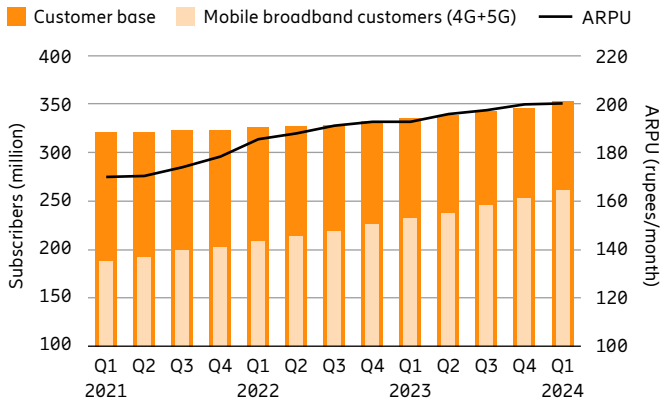
Airtel deployed India's first 5G private network at a manufacturing facility in Bangalore, implementing two industrial-grade use cases for quality improvement and operational efficiency. Airtel is collaborating with enterprises engaged in sectors such as manufacturing, mobility, healthcare, ports, mining, logistics and advanced robotics, where 5G technology can help transform their businesses and generate new revenue streams. Trials have taken place for use cases such as smart inventory and anomaly detection in warehouses and also for manufacturing sites, connected factories, connected frontline workers and connected ambulances, all of which stand to benefit from the advancement of 5G technologies. Airtel has chosen to primarily deploy SA in private 5G networks for enterprises which offers businesses the opportunity to enhance their on-site operations with reliable, secure and agile connectivity.

Currently, Airtel has multiple projects in different stages for both proofs-of-concept as well as commercial deployment across India – steel manufacturing plants in the north, automobile manufacturing plants and warehouses in the south and the mining industry in the west – channeling the unique advantages of 5G in its solutions for enterprises.

In addition, Airtel aims to provide an extensive array of value-added enterprise solutions, utilizing its portfolio of CPaaS, NaaS, IoT, cloud and security solutions offerings. It is also leveraging macro 5G networks to provide a high-speed wireless connectivity option for enterprises across diverse locations in India, along with its multiprotocol label switching (MPLS) and SD-WAN offering.

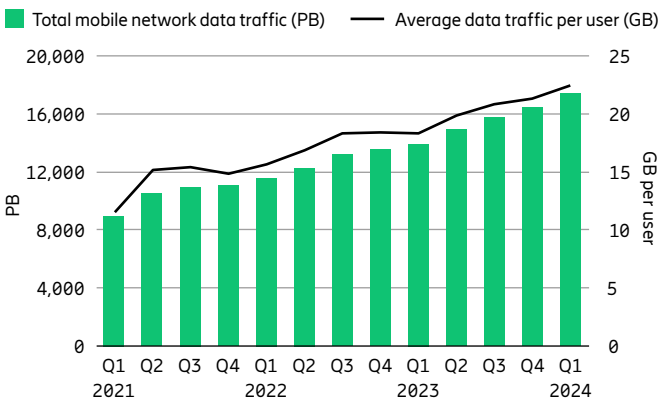
Numerous initiatives are in progress to establish a more extensive ecosystem for the development of 5G use cases and applications catering to both consumers and enterprises. This includes collaborating with various academic institutions to co-create 5G solutions and use cases as part of the Government of India's initiative to establish 100 5G labs in academic institutions.

Figure 28: Airtel's subscriber and ARPU growth 2021–2024



Note: Mobile subscriber numbers, blended ARPU and traffic metrics are as reported by the company in financial reports.

Figure 29: Airtel's mobile network data traffic growth 2021–2024



These labs aim to foster the development of applications utilizing 5G services in smart classrooms, precision farming, intelligent transport systems and healthcare.

Business growth momentum

Airtel's business performance has improved over the last three financial years, with a CAGR of 12 percent for its wireless service revenues between 2021 and 2024. The improvement in ARPU is mainly driven by three factors: feature phone to smartphone upgrades, prepaid to postpaid upgrades and wallet share increases through a combination of data monetization and international roaming. The strategy is to acquire higher-value post-paid subscribers, as well as upgrade existing customers to higher value plans. In the last two quarters, 44 percent of incremental ARPU growth came from customers converting from prepaid to postpaid, 2G to 4G transition and increased data usage.

Currently, 5G connectivity is offered within 4G data plans at no additional cost. The initial 5G deployments, resulting in enhanced customer network experience, are a lever to retain the existing customer base, attract new subscribers and monetize increased data usage. Airtel believes that 5G FWA services and 5G private networks for enterprises will contribute to revenue growth in the future.

Enhancing user experience is a pillar in Airtel's strategy to acquire high-value subscribers, contributing to an increase in its mobile broadband customer base of 12 percent and an ARPU growth of 8 percent in financial year 2024. Total mobile network data traffic has grown by 93 percent in the last 3 years with consumption per subscriber jumping from 16.4 GB per month in March 2021 to 22.6 GB per month in March 2024.[3]

New opportunities with slicing and RedCap

In India, various industries such as manufacturing, healthcare, agriculture and smart cities are increasingly deploying IoT solutions to improve efficiency, productivity and customer experience. Government initiatives and investments in smart cities and digital infrastructure are further driving the growth of the IoT market.

IoT is one of the fastest-growing business segments for Airtel. Deployment of smart meters to 20 million homes has already been initiated in cooperation with a power transmission company.

At present, IoT applications mainly rely on NB-IoT as well as 4G LTE devices. However, the scope of potential use cases is broadening with the evolution of 5G SA network architecture and the emergence of reduced capability (RedCap) 5G NR devices. RedCap offers improved latency and lower energy consumption, while enabling a wide range of use cases for consumers and enterprises. Airtel is also testing end-to-end network slicing that enables new business model innovation and use cases across verticals, creating new revenue opportunities. 5G network slicing allows the creation of multiple virtual networks within a physical 5G network infrastructure, each tailored to specific use cases and requirements of different industries like healthcare, transportation and manufacturing. It provides service flexibility and the ability to deliver services faster with high security, isolation and the applicable characteristics to meet the contracted service level agreement (SLA). These technology advancements are important building blocks for future communications networks and will play a crucial role in the Industry 4.0 transformation. Airtel continues to explore new avenues to enhance network performance, drive digital inclusion, enable enterprises to digitalize their operations and build a strong 5G ecosystem in the country.

Case study: Private 5G network deployment in a manufacturing unit

A leading group in India's engineering sector – known for pioneering technology adoption, including SAP implementation and digital factory projects – faced multiple challenges deploying industrial automation and digitization use cases within their plant due to coverage and latency issues with their existing Wi-Fi network. Adding to the challenges were the poor control and visibility of the network, which made the overall productivity sub-optimal.

In essence, network infrastructure became a bottleneck, throttling their day-to-day manufacturing operations. A private 5G network was therefore deployed to enhance their operations, with a plan to deploy the solution across their 165-acre manufacturing plant to alleviate the challenges.

The implementation has delivered significant benefits to the organization. With a remarkable 99.9 percent uptime guarantee and redundant coverage, the company now enjoys uninterrupted connectivity. Additionally, the reduction in latency to 20–25 ms has improved network responsiveness, facilitating real-time communication. Moreover, the advanced connectivity of the 5G network ensures reliable, long-lasting connectivity for a wide variety of devices, setting a solid foundation for future growth and innovation.

[3] Airtel reports GB per month per user figures, while the average monthly data consumption for the India region on page 39 is GB per active smartphone.

Building a high-performing programmable network

AT&T has embarked on the journey toward realizing an open, programmable network. This transformation marks a pivot from one-size-fits-all, best-effort mobile broadband, to a new era of performance-based business models built upon differentiated connectivity and open network infrastructure.

Key insights

- High-performing programmable mobile networks exhibit:
  - Openness: Open ecosystem, development tools, interfaces and technology.
  - Agility: Incorporating new and innovative technologies and features rapidly.
  - Optimization: Continuous use of predictive AI/ML-based analytics, improving maintenance, performance and user experience.
  - Reliability: Proactive resolution of network issues before they occur, to provide low latency and a highly reliable service for critical applications.
  - Quality: Consistent user experiences while ensuring security and privacy.
- AT&T is improving its network to meet the growing demands of users, manage increasing complexity without compromising total cost of ownership, and provide a competitive edge in the market.

AT&T

This article was written in cooperation with multinational telecommunications service provider AT&T, which has the largest network in North America.[1]

Today, the AT&T nationwide 5G network covers more than 300 million people in nearly 24,900 cities and towns across the US. AT&T 5G is driving the next wave of innovation for consumers, businesses, first responders and government agencies with fast, reliable and secure connectivity.

The transformation to an open, programmable network is driven by the increasing demand for tailored network services that can meet the diverse and dynamic needs of users, applications, devices and enterprises. Examples include: high upload speeds at major events for video streamers, low latency for cloud gaming and guaranteed characteristics for business-critical processes. As part of the network evolution, AT&T will utilize intelligent automation to enable its network to be more flexible, efficient and responsive.

Enabling differentiated connectivity through programmable networks

Programmability in radio access networks (RAN) is a pivotal technology advancement, driving the shift toward more adaptive, efficient and differentiated networks. By integrating intelligent, programmable capabilities directly within the RAN layer through smart applications (rApps) and a service management and orchestration (SMO) framework, the delivery of optimized network performance and differentiated connectivity is made possible. Differentiated connectivity is the ability to offer a tailored set of performance characteristics like throughput, latency and jitter on both downlink and uplink through network slices. The characteristics are matched to an application's requirement in a given service area to provide a predictable experience. Monitoring via observability capabilities is required to ensure those characteristics are delivered.

For example, not all types of video traffic have the same requirements:

- "best-effort" is good enough for casual viewing
- for 4K video viewing, a volume-centric offering that can support large amounts of data would be more appropriate
- live camera feeds require latency-centric offerings
- for live broadcasting, a fully dedicated service would be required, supporting both high data volumes and low latency in the uplink

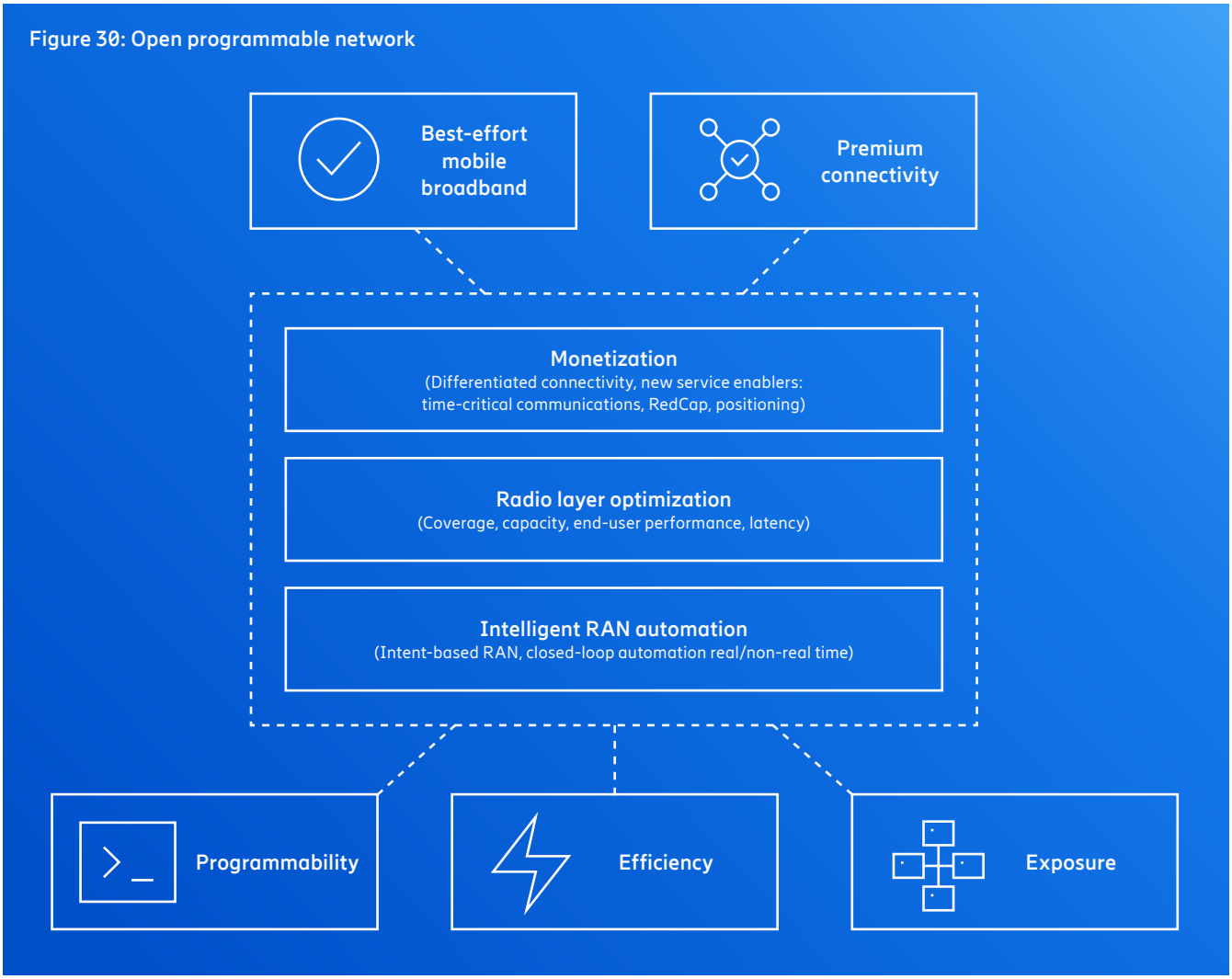
The flexibility within the network to meet distinct requirements will spur new innovations and meet the various dynamic needs of consumers and enterprises. Different types of connectivity characteristics could be requested via a quality on demand (QoD) API or via user equipment route selection policy (URSP) from the device.

RAN data enrichment for network optimization

The evolution of 5G has brought diverse use cases with varied performance demands. Programmability facilitates the management of such complex networks by enabling the tuning of the RAN behavior through standard interfaces defined in the O-RAN Alliance. These interfaces help developers to build portable applications (rApps using the R1 interface), manage behavior in the RAN elements (using the A1 policy interface), as well as perform operations, administration and maintenance (OAM) functionality on RAN elements (via the O1 interface). These open interfaces, supported by standardized software development kits (SDK), facilitate an ecosystem of rApp innovation.

[1] Based on comparison of carrier owned and operated networks. No AT&T on-net coverage in select countries, including Canada.

Figure 30: Open programmable network



Data enrichment plays a crucial role in delivering RAN optimization capabilities. True programmability is realized by enhancing decision-making with comprehensive insights based on network data, enabling more precise network management and dynamic performance adjustments. Advanced data management provided by the SMO enables more ubiquitous and low-latent access to dynamically move and control the network data required to realize this programmability.

Driven by efficient data management controls and movement within the network, timely and accurate distribution of diverse data sources will significantly enhance optimization logic and render improved RAN performance. The data can originate within RAN, such as from cell traffic and usage patterns, or from external sources like weather forecasts and IoT device interactions, providing a holistic view for enhanced network optimization. An inclement weather forecast, for example, can trigger allocation of the additional network resources necessary to address the potential higher usage during the forecast window. As a reference, the typical latency for RAN-generated data to reach a self-optimizing network (SON) platform in today's network is 25–40 minutes. As a result of efficient data management controls and movement, the same data has been made available to an rApp in a few minutes in an AT&T trial of SMO. A key contributor to this efficiency is moving from an aggregated event stream to an event-based data collection and reporting model for RAN telemetry, which took only seconds to reach the SMO's data collector.

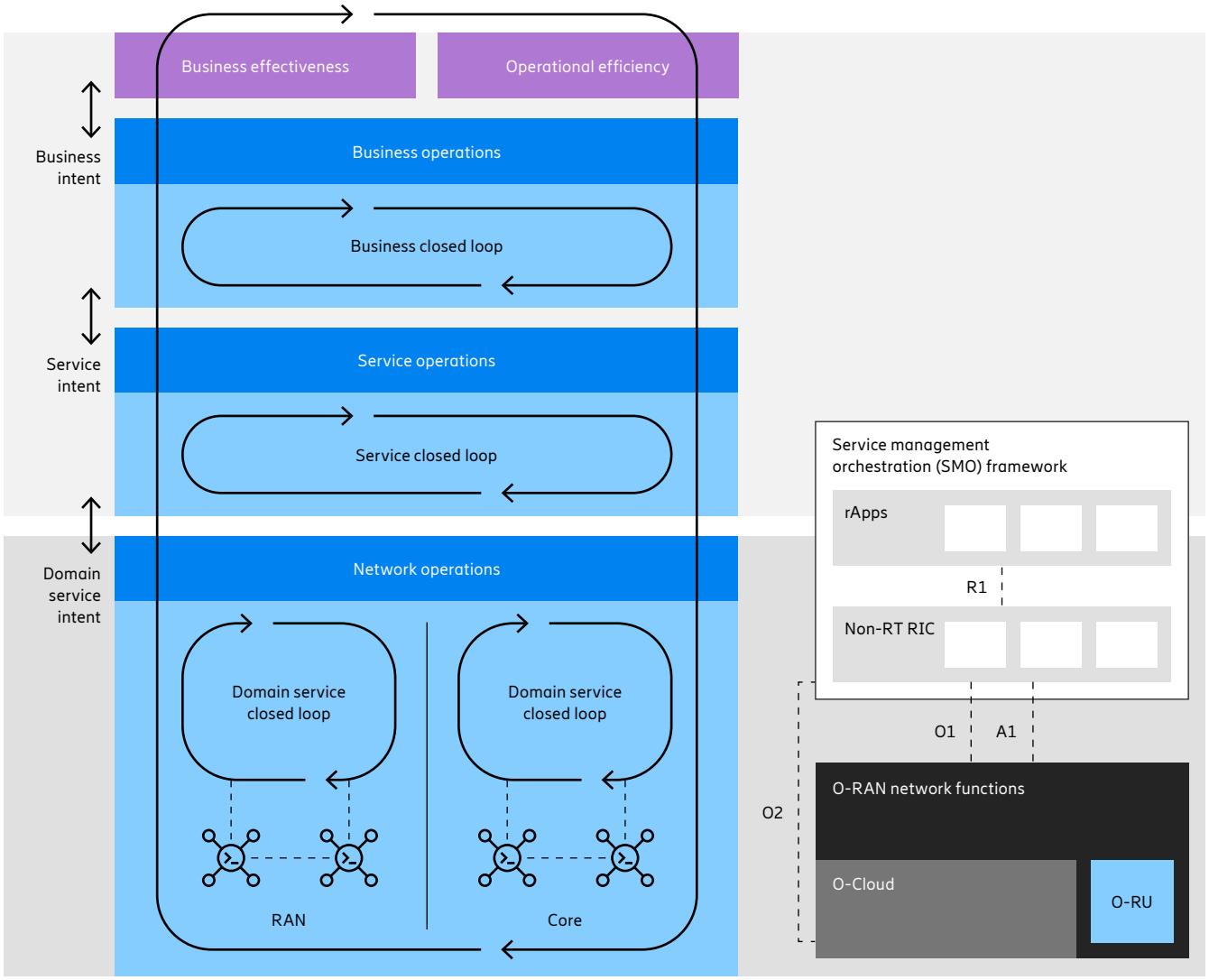
Scope of SMO and programmability via rApps

Programmability introduces a new paradigm in network management through rApps that utilize real-time data for network optimization, network healing, network deployment and network evolution. The capacity of SMO to oversee a larger geographical area than a single NodeB enables consistent and comprehensive network optimizations across broader network zones, enhancing overall service delivery and service level agreement (SLA) management. Creating a "single pane of glass" across SMO instances creates extremely proficient management across the network. All these advancements will enable networks to evolve incrementally rather than via huge network-generation growth spurts. This will also enable service providers to embrace more consistent investment paces for new technology in these areas.

Differentiated connectivity via intent-driven networking

An essential part of network programmability is intent-driven operations which add an abstraction layer above the traditional RAN configuration approach. This allows service providers to specify desired outcomes, or "intents," which are then autonomously implemented by the network through sophisticated algorithms embedded in the SMO, rApps, RAN and other service and network assurance functions. By aligning network operations with business objectives, network programmability facilitates the creation of differentiated connectivity options that can cater to diverse customer needs, thereby enabling service differentiation at an unprecedented scale that challenges traditional operational models.

Figure 31: Intent-driven networking



In a recent proof-of-concept for intent-based automation, it was demonstrated that an automated solution can meet user requirements for defined minimum or bounded data rates with bounded latency (for example a certain performance level: 1 Mbps throughput with 50 ms latency) for new applications and services for content consumption, generation, or business processes. In this proof-of-concept, Fixed Wireless Access user experience was enhanced and kept within the bounded throughput and latency requirements, even in congested scenarios.

Implementation in AT&T's network

AT&T is at the forefront of leveraging network programmability to enhance service differentiation, identifying new operating models and rapidly delivering new product opportunities. Through initial proofs-of-concept and trials of intent-driven networks, AT&T is exploring the potential of this technology to provide tangible benefits such as enhanced network flexibility and superior service quality.

Furthermore, the deployment of an intelligent automation platform as the foundational architecture underscores AT&T's commitment to this advanced network paradigm. This intelligent automation platform supports the effective implementation of programmability within the RAN, ensuring that in the near future the network can support differentiated connectivity at scale that is tailored to meet specific customer requirements and evolving market demands.

The journey ahead

AT&T is in the early stages of realizing its programmable network, marking the transformation from the traditional one-size-fits-all, best-effort mobile broadband, toward a new era of performance-based business models built upon differentiated connectivity. A key step being explored is a converged SMO for both core and RAN networks to deliver a unified wireless network management and automation solution, efficiently providing end-to-end visibility across the mobile network.

On the business side, they continue to push the boundaries and explore differentiated connectivity across the ecosystem, with proofs-of-concept and live commercial offerings including AT&T Turbo, a premium connectivity offering for consumers to upgrade their experiences.

Taking 5G connectivity underground

In a milestone investment, Rogers has activated 5G services across the Toronto subway through a neutral host solution, providing connectivity for all users regardless of their service provider.

Key insights

- The solution fulfills consumer demands for limitless and reliable connectivity, with 16 TB of data consumed daily on average since deployment.
- The neutral host solution was deployed in just three weeks, bringing 5G connectivity to all commuters.
- New 5G capabilities will enable new services for both consumer applications and public safety use cases.

ROGERS

Rogers Communications Inc. is a Canadian communications and media company that offers wireless, cable, media, TV, internet and telephony products to households and businesses across Canada.

Rogers offers 5G wireless coverage to over 31 million Canadians and is committed to delivering fast and reliable networks in more places. This is reflected in the Rogers acquisition of BAI Canada along with its legacy Toronto subway cellular infrastructure, and the rights for future network builds in the Toronto Transit Company (TTC) system.

Deploying 5G underground

The Toronto subway is the fourth busiest public transit system in North America, serving over 300 million passengers a year, with a total of 75 stations and 80 km of tunnels. However, while 5G coverage is significant in Canada's most populous city, once users went underground, they could no longer benefit from reliable connectivity. No matter which provider they used, subway passengers could only call 911 where the cellular network existed – on station platforms, concourses and in around 25 percent of the tunnels.

In September 2023, Rogers committed to provide an operational neutral host environment, within an accelerated timeline. This would enable every wireless user in Canada to use their devices in the Toronto subway, regardless of their service provider. This was to be delivered over a legacy distributed antenna system (DAS), initially capable of supporting only one band. The positive safety impact of passengers being able to reliably contact 911 in an emergency has been a key driver.

A challenging deployment

Alongside planning for the long-term modernization of the existing DAS system, there was a regulatory requirement for Rogers to provide an interim solution to host all the service providers in the area within a required time of three weeks. In addition, all upgrade work at any station or tunnel, including Enhanced 911 (E911) testing,[1] had to be performed during a maintenance window of just four hours between 2:00 and 6:00 AM. Rogers had to act quickly to address gaps in the busiest and most critical sections of the subway system to enable the requested connectivity capabilities within the tight three-week timescale.

Rogers chose to execute a full deployment plan that included network design and rollout logistics for both network improvements and expansion in the targeted stations, concourses and some of the subway tunnels. This demonstrated their willingness to take on a challenge with an innovative approach.

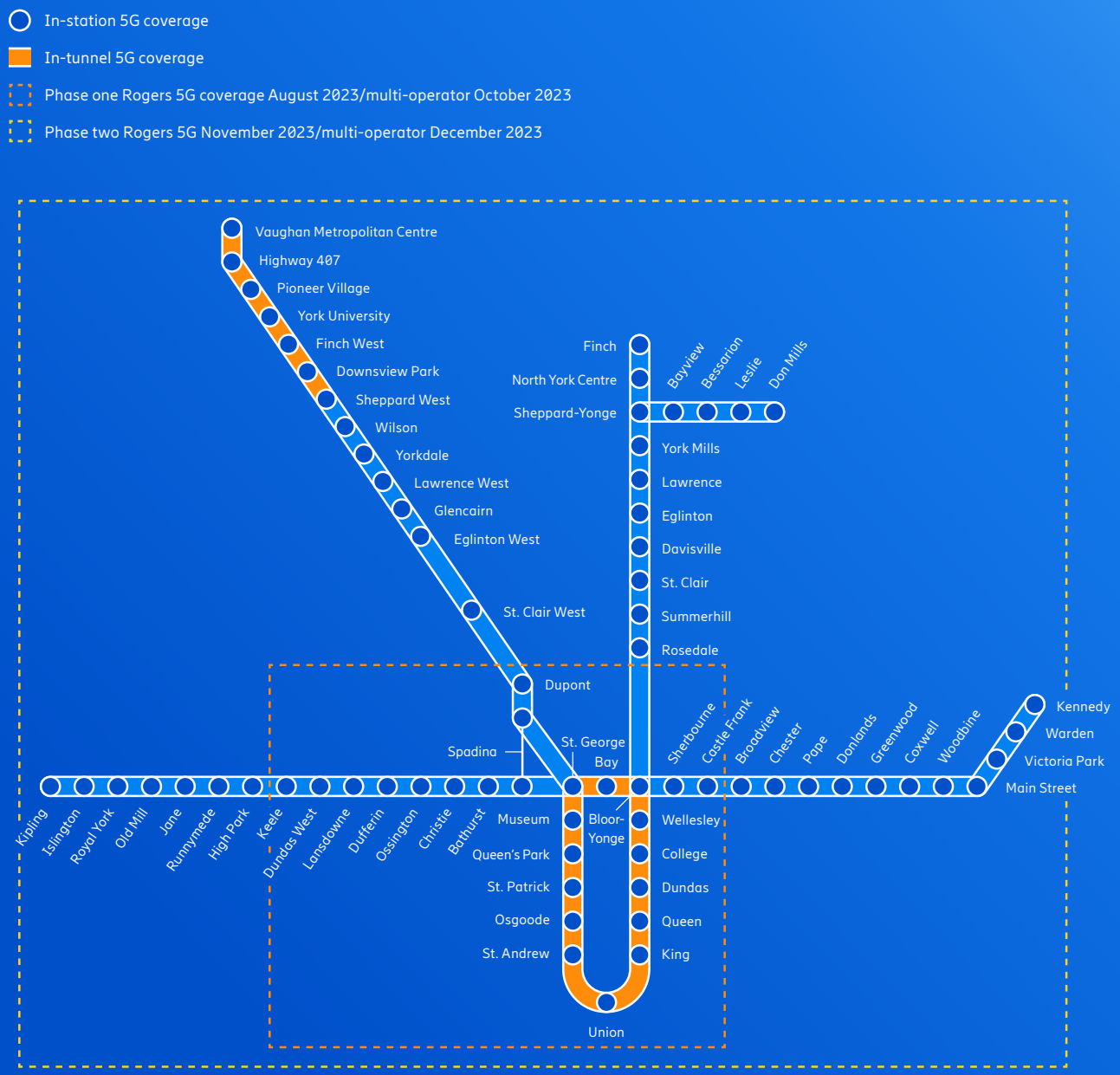
Figure 32 shows the Toronto subway map, highlighting the cellular service. The legacy system that provided just 3G and 4G services was upgraded in August 2023 in the initial phase with 5G coverage for mainly Rogers customers. The area in the yellow box shows where 3G, 4G and 5G are now available, mainly for Rogers customers, following the second phase in November 2023. The initial phase became multi-operator in October 2023, and phase two in December 2023.

Fulfilling unmet consumer demands

A 2023 ConsumerLab study on what Canadians think of 5G showed a correlation between network performance in key locations such as subways and airports and consumers' willingness to recommend, called the Net Promoter Score (NPS).[2] Prior to this deployment, the study found that around 30 percent of Canadian 5G users surveyed used the subway weekly, and one-third identified their subway commute as an area where connectivity was an issue. The NPS dropped by 11 points for those encountering connectivity problems while using the subway. These findings highlight the need to invest in improving performance in the subway system to drive up consumer satisfaction and experience. Once Rogers acquired and then executed the upgrades and expansion to the subway network, commuters consumed an average of 16 TB per day in January 2024, showing how much demand there was for an upgraded customer experience.

[1] E911 automatically provides a caller's location to emergency services in North America.
[2] Ericsson ConsumerLab, 5G value: Turning performance into loyalty (October 2023).

Figure 32: Cellular service subway map



The 5G coverage in the subway tunnels gives passengers more reliable access to 911 services, but also satisfies consumer appetite for connectivity while commuting. On average, 16 TB of data has been consumed daily by passengers since deployment.

Source: Rogers website, February 2024.

Building a solution that works for everyone

One of the biggest challenges was to urgently provide connectivity for subscribers of two other major service providers. Rogers had to upgrade the entire system with more bands to ensure it was multi-operator compatible. As such, Rogers designed a three-way multi-operator core network (MOCN) to provide like-for-like 3G, 4G and 5G coverage for other service providers. There were key challenges to address in both the mobile core and IP transport layers.

As with any MOCN setup, connectivity between each of the service providers' networks requires IP transport between networks to carry traffic from shared RAN (3G, 4G and 5G) to the respective cores. With the compressed timeline, setting up new links was not possible. Rogers took an unprecedented approach, where design leads leveraged existing links between Rogers and a partner (service provider 1), and, as illustrated in Figure 33, used service provider 1 as a transit IP network to server connectivity for a second partner (service provider 2). Leveraging links originally designed for other purposes presented routing challenges in terms of latency. To mitigate the impacts, the design leads creatively made use of asymmetrical routing to reduce latency in the predominantly used downlink. The latter was key to securing superior end-user experience.

Delivering an optimized service

Rogers transmitted two sector channels from one radio using a power split. This reduced the radio unit footprint by using one radio instead of two. However, the introduction of more bands from different service providers into the legacy DAS, mixing different channels and technology, generated noise issues in the DAS system. To deliver a good user experience for commuters, each segment needed troubleshooting and optimization. To enhance radio frequency performance, Rogers optimized the DAS with noise mitigation through active DAS hardware and the network management user interface. Additionally, some of the key parameters optimized were:

- extended cell range for base station hotel-type active DAS deployments
- traffic delays for longer fiber ranges
- all mobility parameters for smooth handoff between tunnel-tunnel and tunnel-station sectors
- AI-powered downlink adaptation and data-aware uplink scheduling

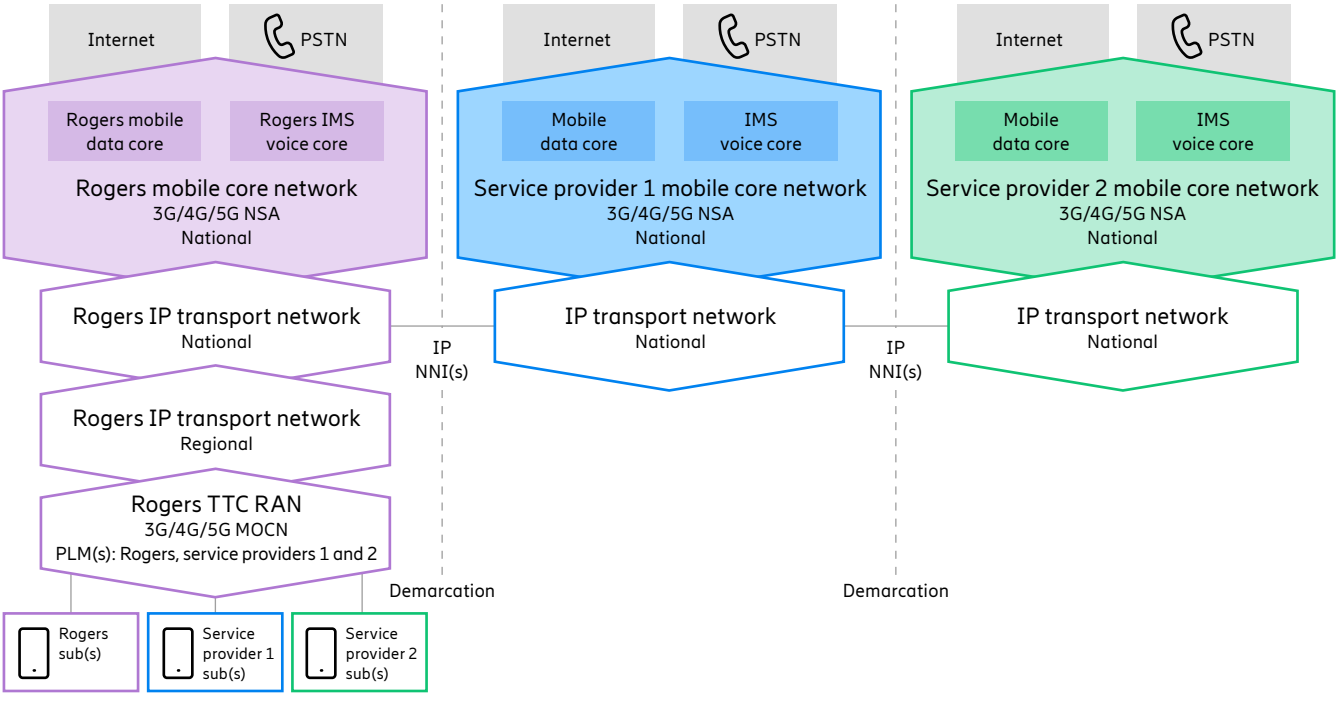
A network strategy for the future

In the first three weeks, service was delivered by Rogers to all passengers, enabling them to connect to 5G and reliably access 911 across the subway system. The 5G network buildout is expected to take approximately two years to finalize, because of the limited overnight construction windows available to ensure the subway remains operational for passengers. Extensive fiber network and radio equipment upgrades are needed to modernize the network and increase cellular capacity of the current 3G and 4G network, adding 5G mobile services for millions of users.

Commitment to improving energy efficiency is key in any network modernization strategy. Accordingly, this was considered in the network design, for example, power splitting the 1,900 MHz frequency range radios to serve both 3G and 4G and multiplexing other service providers into the system instead of deploying additional radios. Additionally, a range of software features, such as transmitter micro sleep (switching off radio transmitters when no transmission is required) and deep sleep (hibernating radios during low-traffic hours), can enable huge energy savings without degrading network performance. These energy-reducing software solutions make use of load variations and allow the power consumption of modern radio equipment to vary up to 97 percent between full-traffic and no-traffic hours, a pattern that will be seen during both peak and off-peak times, as well as during downtime when the subway is closed.

New 5G standalone (SA) capabilities realized in the next waves of deployment will enable new services for both consumer applications and public safety use cases. This could range from utilizing reduced capability (RedCap) technology for surveillance cameras, network slices for emergency services, or enhanced video streaming for consumers. In order to realize this evolution of capabilities and future services, indoor small cells will form part of the future network strategy, given that they offer throughput improvements over DAS, especially in uplink, paving the way for new uplink-heavy services.

Figure 33: Deployment of the MOCN



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 Ericsson 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 around 100 live networks covering all major regions of the world. These measurements form a representative base for calculating worldwide total mobile network traffic. Mobile network data traffic also includes traffic generated by FWA services. 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. Please note that the Ericsson Mobility Report data traffic forecast, both global and regional, represents the estimated traffic volume in all networks over the duration of a month. Traffic (in terms of throughput) in high-traffic areas will be much higher than the average 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.

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Ericsson Mobility Visualizer
Explore actual and forecast data from the Ericsson 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	8,320	8,500	9,260	1%	million
• Smartphone subscriptions	6,570	6,930	8,100	3%	million
• Mobile PC, tablet and mobile router subscriptions	230	260	490	12%	million
• Mobile broadband subscriptions	7,050	7,390	8,820	3%	million
• Mobile subscriptions, GSM/EDGE-only	1,160	1,010	380	-15%	million
• Mobile subscriptions, WCDMA/HSPA	850	670	290	-13%	million
• Mobile subscriptions, LTE	5,290	5,210	3,010	-9%	million
• Mobile subscriptions, 5G	1,000	1,580	5,560	23%	million
• Fixed wireless access connections	107	131	330	17%	million
Fixed broadband connections	**1,450**	**1,530**	**1,850**	**3%**	**million**
Mobile data traffic					
• Data traffic per smartphone	15	17	42	16%	GB/month
• Data traffic per mobile PC	19	22	34	8%	GB/month
• Data traffic per tablet	11	14	32	16%	GB/month
Total data traffic**					
Mobile data traffic	88	106	313	20%	EB/month
• Smartphones	87	104	307	20%	EB/month
• Mobile PCs and routers	0.8	1	2.4	17%	EB/month
• Tablets	0.7	0.9	2.7	21%	EB/month
Fixed wireless access	22	30	154	31%	EB/month
Total mobile network traffic	110	137	466	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	430	440	480	2%	million
Latin America	710	720	780	1%	million
Western Europe	540	550	560	0%	million
Central and Eastern Europe	560	560	560	0%	million
North East Asia	2,160	2,200	2,290	1%	million
China[1]	1,690	1,730	1,790	1%	million
South East Asia and Oceania	1,140	1,160	1,300	2%	million
India, Nepal and Bhutan	1,150	1,180	1,290	1%	million
Middle East and North Africa	730	730	830	2%	million
Gulf Cooperation Council (GCC)[2]	75	77	91	3%	million
Sub-Saharan Africa	900	950	1,170	4%	million

Smartphone subscriptions	2022	2023	Forecast 2029	CAGR* 2023–2029	Unit
North America	360	380	400	1%	million
Latin America	570	600	690	3%	million
Western Europe	470	480	490	0%	million
Central and Eastern Europe	410	450	450	0%	million
North East Asia	2,020	2,070	2,180	1%	million
China[1]	1,600	1,640	1,720	1%	million
South East Asia and Oceania	950	970	1,150	3%	million
India, Nepal and Bhutan	810	880	1,200	5%	million
Middle East and North Africa	560	640	750	2%	million
GCC[2]	63	66	80	3%	million
Sub-Saharan Africa	420	460	790	9%	million

Regional key figures

LTE subscriptions	2022	2023	Forecast 2029	CAGR* 2023–2029	Unit
North America	240	170	50	-19%	million
Latin America	520	530	280	-10%	million
Western Europe	430	380	80	-23%	million
Central and Eastern Europe	410	460	280	-8%	million
North East Asia	1,400	1,220	440	-16%	million
China[1]	1,050	890	260	-18%	million
South East Asia and Oceania	840	910	640	-6%	million
India, Nepal and Bhutan	780	740	410	-9%	million
Middle East and North Africa	420	470	380	-3%	million
GCC[2]	55	46	6	-29%	million
Sub-Saharan Africa	267	330	440	5%	million

5G subscriptions	2022	2023	Forecast 2029	CAGR* 2023–2029	Unit
North America	173	257	430	9%	million
Latin America	10	33	400	N/A	million
Western Europe	72	143	480	22%	million
Central and Eastern Europe	6	14	280	N/A	million
North East Asia	674	908	1,820	12%	million
China[1]	569	771	1,500	12%	million
South East Asia and Oceania	33	61	560	N/A	million
India, Nepal and Bhutan	10	119	840	N/A	million
Middle East and North Africa	18	36	420	N/A	million
GCC[2]	13	26	81	21%	million
Sub-Saharan Africa	3	11	320	N/A	million

Data traffic per smartphone	2022	2023	Forecast 2029	CAGR* 2023–2029	Unit
North America	17	19	59	21%	GB/month
Latin America	9.3	11	36	22%	GB/month
Western Europe	17	19	49	17%	GB/month
Central and Eastern Europe	14	17	43	17%	GB/month
North East Asia	17	19	41	14%	GB/month
China[1]	17	19	41	13%	GB/month
South East Asia and Oceania	14	17	42	16%	GB/month
India, Nepal and Bhutan	26	29	68	15%	GB/month
Middle East and North Africa	12	14	43	20%	GB/month
GCC[2]	24	28	58	13%	GB/month
Sub-Saharan Africa	3.7	5	20	26%	GB/month

Total mobile data traffic	2022	2023	Forecast 2029	CAGR* 2023–2029	Unit
North America	6.3	7.4	24	22%	EB/month
Latin America	4.6	5.8	22	25%	EB/month
Western Europe	7	8.3	22	17%	EB/month
Central and Eastern Europe	4.5	5.8	15	17%	EB/month
North East Asia	29	33	78	15%	EB/month
China[1]	25	29	65	15%	EB/month
South East Asia and Oceania	12	15	44	20%	EB/month
India, Nepal and Bhutan	17	21	67	21%	EB/month
Middle East and North Africa	5.9	7.9	28	24%	EB/month
GCC[2]	1.2	1.5	3.7	17%	EB/month
Sub-Saharan Africa	1.4	2	13	38%	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's high-performing, programmable networks provide connectivity for billions of people every day. For nearly 150 years, we've been pioneers in creating technology for communication. We offer mobile communication and connectivity solutions for service providers and enterprises. Together with our customers and partners, we make the digital world of tomorrow a reality.

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