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Ericsson Mobility Report

November 2021

Letter from the publisher

Exciting times

Over the last 10 years, mobile technology has had an incredible impact on society and business, above and beyond what anyone could have imagined. With this edition of the Ericsson Mobility Report, we take a look back at some of the key trends and events that have shaped the last decade as we celebrate the 10-year anniversary of this report.

Rather than only looking back, it is more interesting to reflect on the learnings of the past 10 years and apply them to the future. If the last decade saw a lot of change, it's probably nothing compared to what we expect to happen in the next. When we lift our gaze to 2027 and consider the 5G subscription forecast, which estimates that around half of all mobile subscriptions will be for 5G at that time, it is clear that underneath the numbers lies a continuous change in how we act, live and work.

The pandemic has shown us how fast things can change, and how critical a digital infrastructure is to society. 5G is entering a new phase, where not only will consumers benefit from new applications, but also businesses and industries will take advantage of new capabilities. No doubt, the pace of change will continue to be high, and 5G will play a key role in our lives.

The Ericsson Mobility Report aims to continue its mission to be a beacon for the mobile industry, shining at least some light onto what that future might look like.

We hope you find the report engaging and useful!

Fredrik Jejdling
Executive Vice President and
Head of Business Area Networks

5G will account for nearly half of all mobile subscriptions by 2027.

49%

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Ten years of change

4.7bn

4G has rocketed from 9 million to a projected 4.7 billion subscriptions by the end of 2021.

5.5bn

There are more than 5.5 billion new smartphone subscriptions.

300

Mobile networks carry almost 300 times more mobile data traffic than in 2011.

Ten years of the Ericsson Mobility Report

In November 2011, Ericsson published the first edition of the “Traffic and Market Data Report”. One year later, the report was renamed “Ericsson Mobility Report”, and the rest, as they say, is history...

The foreword of the first report began with the following:

“Total smartphone traffic will triple in 2011. By 2016, users living on less than 1 percent of the Earth’s total land area are set to generate around 60 percent of mobile traffic. We are living in exciting times.”

This paragraph captured, more than we realized when we wrote it, some of the fundamental events that shaped the last decade; mobile technology evolved and proliferated rapidly as smartphones became everyone’s go-to-device, its usage impacting our daily lives and changing behaviors across the world. It’s been a privilege to follow this exciting industry so closely over the years through the lens of this report.

The history of the Ericsson Mobility Report (or EMR, as we usually refer to it) tells us a lot about the mobile industry – not only why things happened (or didn’t) but also about big trends and disruptive events that impacted the industry. We have written over 90 articles that – sometimes even better than the forecast data – described the big trends, discussing everything from video streaming and mobile tethering driving usage, to the value created by AI and private networks.

The early years of 4G – getting the drivers right

In November 2011, the majority of data traffic across most mobile networks was generated by laptops with cellular connections, with a small number of users generating a large proportion of the data traffic. Smartphones were growing in popularity and there were around 720 million smartphone subscriptions globally. The end of 2009, only two years earlier, was the first time the volume of monthly data traffic exceeded voice traffic, and also the year 4G was launched.

The visible market drivers at the time led us to underestimate the pace of smartphone and 4G subscription growth – and thereby also traffic growth on handheld devices – while overestimating the potential growth of 4G-connected laptops and tablets, as the smartphone became the device of choice for connecting other devices over Wi-Fi to the mobile network.

One key lesson from the early reports is that once a mobile standard becomes global and reaches significant population coverage, and the ecosystem around it is established, the uptake towards mass market can be faster than even the most optimistic hockey-stick forecasts indicate. For 4G, this mass-market growth happened around 2014–2015 when the global population coverage had reached around 40 percent.

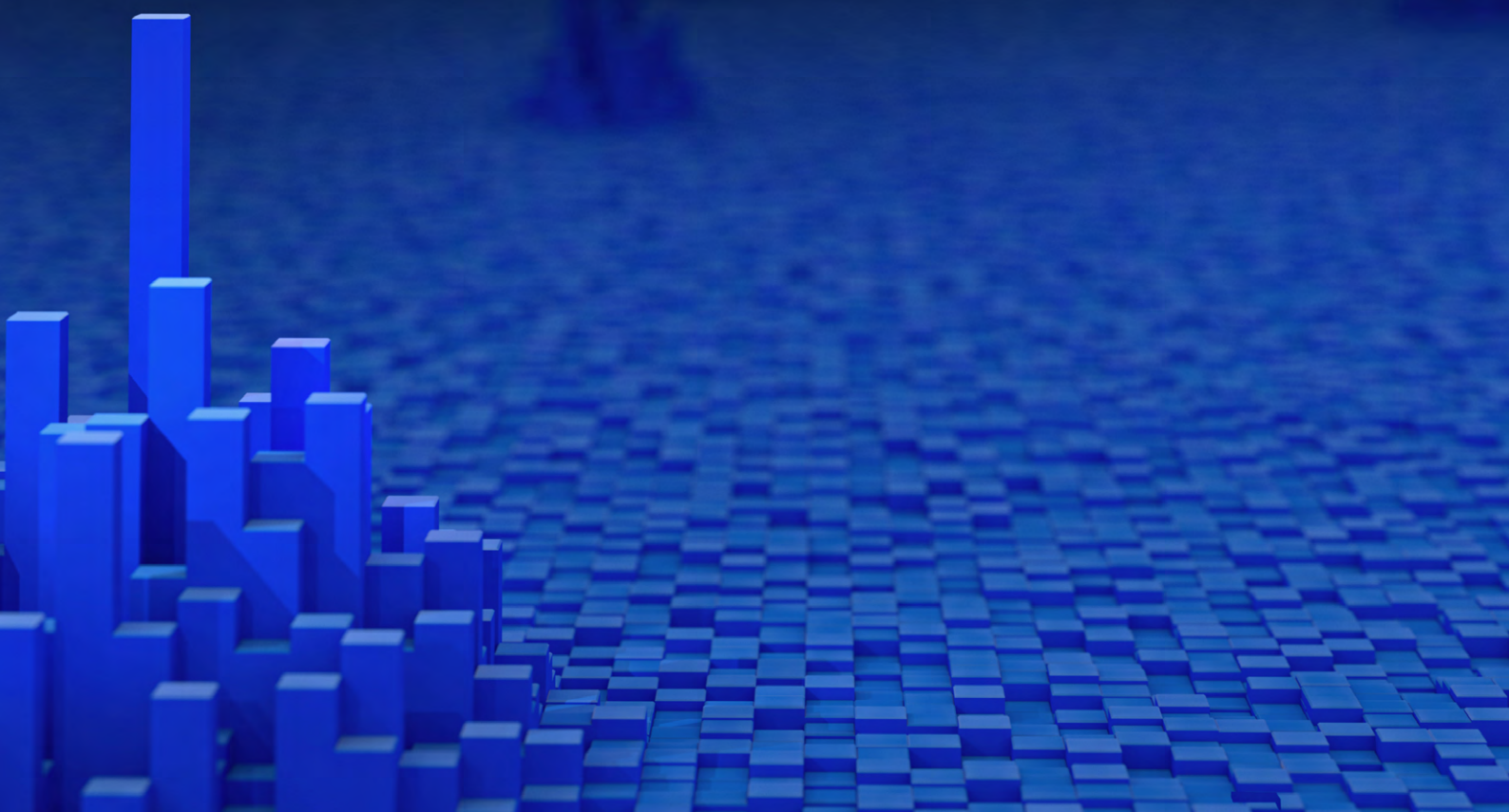
An established ecosystem means new opportunities

If EMR’s early years marked a phase when 4G networks, smartphones and the app ecosystem became mass-market, the later years can be described as a phase when the established ecosystem led to a string of disruptive events as new business models, new entrants in the market and increased competition took center stage. The performance of networks during this time continuously improved, driven by new technology that, together with increased video content, further fueled mobile data traffic consumption and subscriber migration from 3G. This eventually led to the industry gaining the ability to address new market segments with high-speed internet access using 4G.

Comparing our November 2015 forecast to the up-to-date estimated figures for 2021, it is clear we correctly predicted the single most important parameter for this industry’s growth – smartphone subscription outlook. However, as 4G rollout was faster than anticipated, traffic growth was also steeper. The acceleration of the 5G standardization timeline agreed during 2017 naturally resulted in a faster uptake of 5G than could possibly have been predicted in 2015. The overestimation of mobile subscriptions comes down to the uncertainty around the number of passive subscriptions and the interest in dual-SIMs, but that had less impact on actual users or traffic in the networks.

Figure 1: Comparison of forecasts vs. up-to-date data

		Forecasted for 2016 (Predictions made in November 2011)	Actual 2016	Forecasted for 2021 (Predictions made in November 2015)	Estimates for 2021 (End of year figures)
	Mobile subscriptions	8.4 _{bn}	7.4 _{bn}	9.1 _{bn}	8.1 _{bn}
	Mobile PC/tablet subscriptions	550 _m	180 _m	350 _m	300 _m
	Smartphone subscriptions	2.6 _{bn}	3.7 _{bn}	6.4 _{bn}	6.3 _{bn}
	4G subscriptions	510 _m	2.0 _{bn}	4.1 _{bn}	4.7 _{bn}
	5G subscriptions	–	–	150 _m	660 _m
	Average traffic per smartphone	800 _{MB/m}	1.9 _{GB/m}	8.5 _{GB/m}	11.4 _{GB/m}
	Total mobile traffic	4.6 _{EB/m}	6.7 _{EB/m}	51 _{EB/m}	65 _{EB/m}



Disruptive events shaping the growth

Year-over-year (YoY) global mobile traffic growth reveals a few disruptive events in some big markets that impacted the overall traffic on a global scale. Figure 2 shows a few bumps in the YoY traffic curve, highlighting that mobile traffic growth is not just demand-driven, but also sensitive to network capabilities, operator tariffs, traffic shaping and market legislation.

In 2015, a US Tier 1 service provider started offering data bundles with a zero-rated unlimited offering for a few of the most attractive video services on the market. Similar offerings were soon launched by competitors, leading to a steep increase in traffic volumes over mobile networks that could be seen on a global scale.

In 2017, the next unexpected traffic growth event occurred as a result of a new entrant to the Indian market that offered very competitive 4G prices, attracting a huge amount of new smartphone users with very high traffic usage per smartphone. Today, the Indian subcontinent is one of the regions with the highest GB usage per smartphone.

4G arrived in China later than in many other markets. In 2018, the Chinese market showed incredible traffic growth as a result of attractive new offerings and fierce competition, which had a huge impact on the global numbers. Remember, in 2018, global traffic was already 3–4 times higher than it had been just 3 years earlier, and still led to YoY growth figures in the 90 percent range.

Looking ahead – future demand is built today

Today, mobile networks carry almost 300 times more traffic than in 2011, excluding fixed wireless access (FWA), network speeds have increased hundreds of times and there are now almost 20,000 different 4G device models on the market.¹ This would not have been possible without the industry's ability to scale and the never-ending improvements to network efficiency.

The big question is how past learnings can be applied to the future. Forecasting will continue to be difficult. On the surface, it seems quite straightforward to expect continued growth of 5G subscriptions, and thereby traffic-per-device growth. However, as 5G population coverage increases, we could expect some new disruptive events, maybe in the mid-2020s, that take advantage of 5G capabilities in totally new ways, be it with new devices, business models or applications. With the emergence of mirror worlds, hyperconnectivity and AI, it is also possible that the digitalization of industries and businesses will accelerate more than we can imagine today.

On top of this, there are a number of global societal and geopolitical forces that will inevitably shape the future. The climate crisis and global fragmentation, together with a post-pandemic society with increased virtual connections, will also change the way we act, live and work.

But regardless of how these possible forces of change will impact the mobile industry, it is clear that we are still living in exciting times!

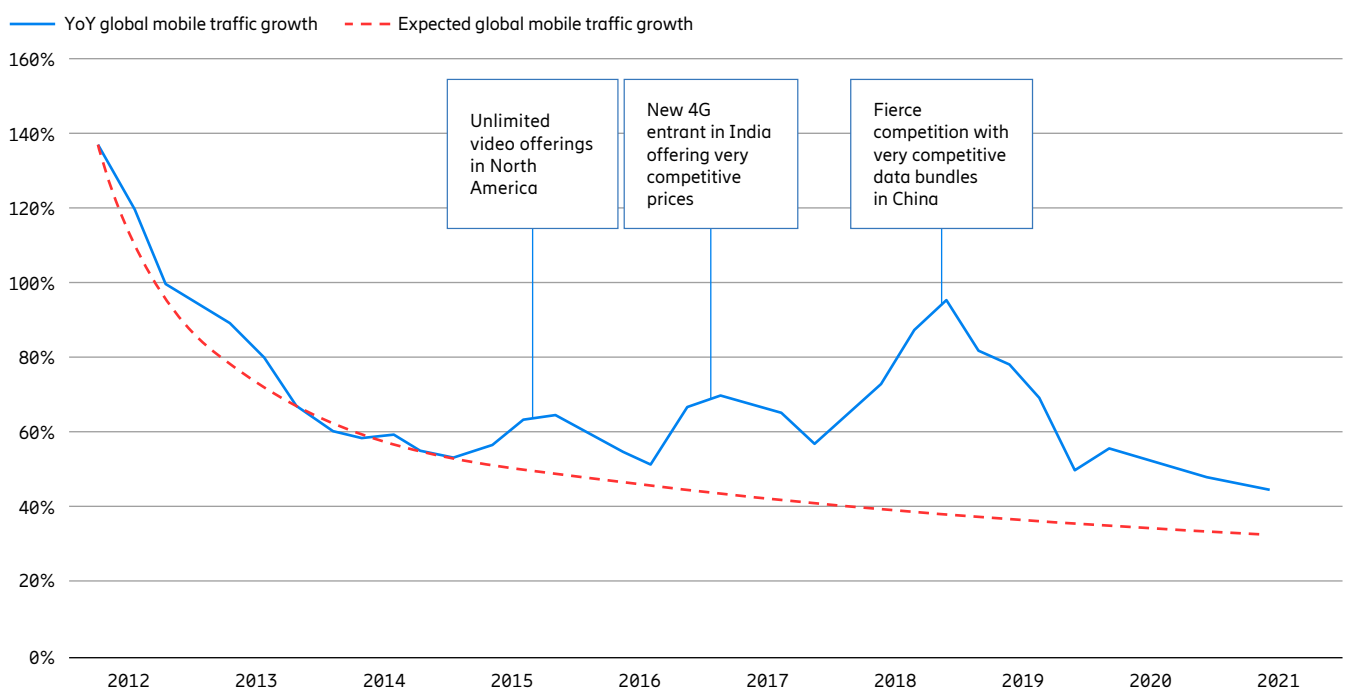
Mobile networks carry almost 300 times more mobile data traffic than in 2011.

300

Around 2 billion more people now have a mobile phone.

2.0_{bn}

Figure 2: YoY global mobile traffic growth



¹ GSA (October 2021).

Forecasts

The numbers are in – 5G is well and truly here. Uptake is expected to be faster than for any previous generation of mobile technology.

660_m

By the end of this year, we estimate there will be more than 660 million 5G subscriptions.

23%

5G handsets account for 23 percent of global volumes.

800_m

FWA will offer broadband to over 800 million people by 2027, through around 230 million connections.

51%

Massive IoT will make up 51 percent of cellular IoT connections by 2027.

5G mobile subscriptions forecast to overtake 4G

By the end of 2027, 5G subscriptions are expected to reach 4.4 billion.

Service providers continue to switch on 5G and more than 180 have launched commercial 5G services globally.¹

5G subscriptions² grew by 98 million during the third quarter, to around 570 million. By the end of the year we estimate more than 660 million 5G subscriptions. This is an increase from our previous estimate and is mainly due to stronger than expected demand in China and North America, impacted partly by decreasing prices of 5G devices. Currently, North East Asia has the highest 5G subscription penetration, followed by North America, the Gulf Cooperation Council countries and Western Europe. In 2027, it is projected that North America will have the highest 5G penetration at 90 percent.

5G subscription uptake is expected to be faster than that of 4G following its launch in 2009, reaching 1 billion subscriptions over 2 years sooner than 4G did. Key factors include the timely availability of devices from several vendors, with prices falling faster than for 4G, as well as China's early engagement. By the end of 2027, we forecast 4.4 billion 5G subscriptions globally, accounting for 49 percent of all mobile subscriptions. 5G will become the dominant mobile access technology by subscriptions in 2027.

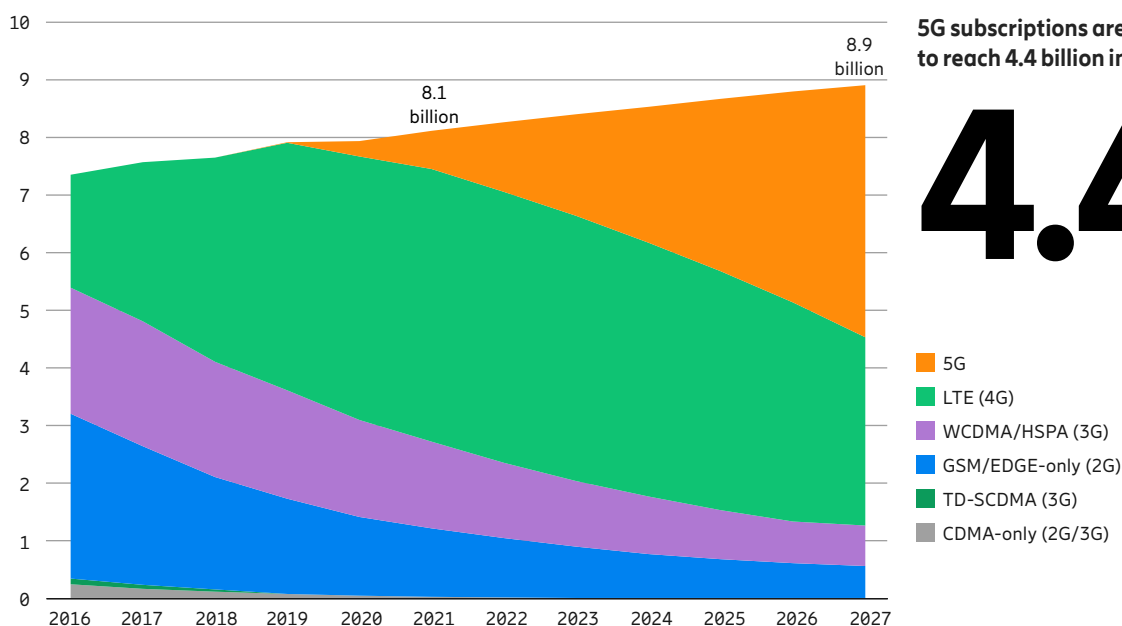
4G subscriptions increased by approximately 48 million during the quarter and now total more than 4.6 billion in Q3. 4G subscriptions are projected to peak at 4.7 billion in Q4 2021,

then decline to around 3.3 billion by the end of 2027 as subscribers migrate to 5G.

3G subscriptions declined by 45 million, while GSM/EDGE-only subscriptions dropped by 43 million during the quarter and other technologies³ decreased by about 5 million.

During the quarter, China had the most net additions (+23 million), followed by Indonesia (+7 million) and Ghana (+5 million).

Figure 3: Mobile subscriptions by technology (billion)



5G subscriptions are forecast to reach 4.4 billion in 2027.

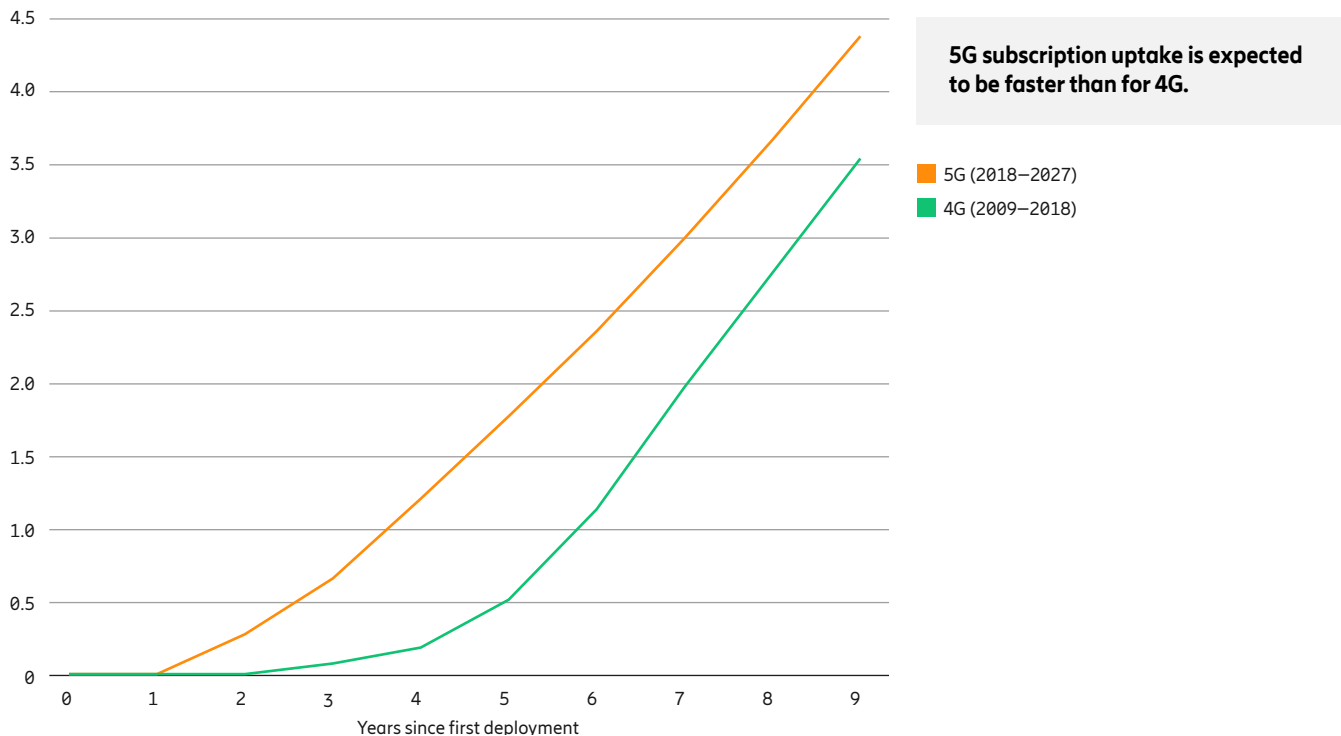
4.4bn

¹ GSA (October 2021).

² A 5G subscription is counted as such when associated with a device that supports New Radio (NR), as specified in 3GPP Release 15, and is connected to a 5G-enabled network.

³ Mainly CDMA2000 EVDO, TD-SCDMA and Mobile WiMAX.

Figure 4: Comparison of 5G and 4G subscriptions uptake in the first years of deployment (billion)



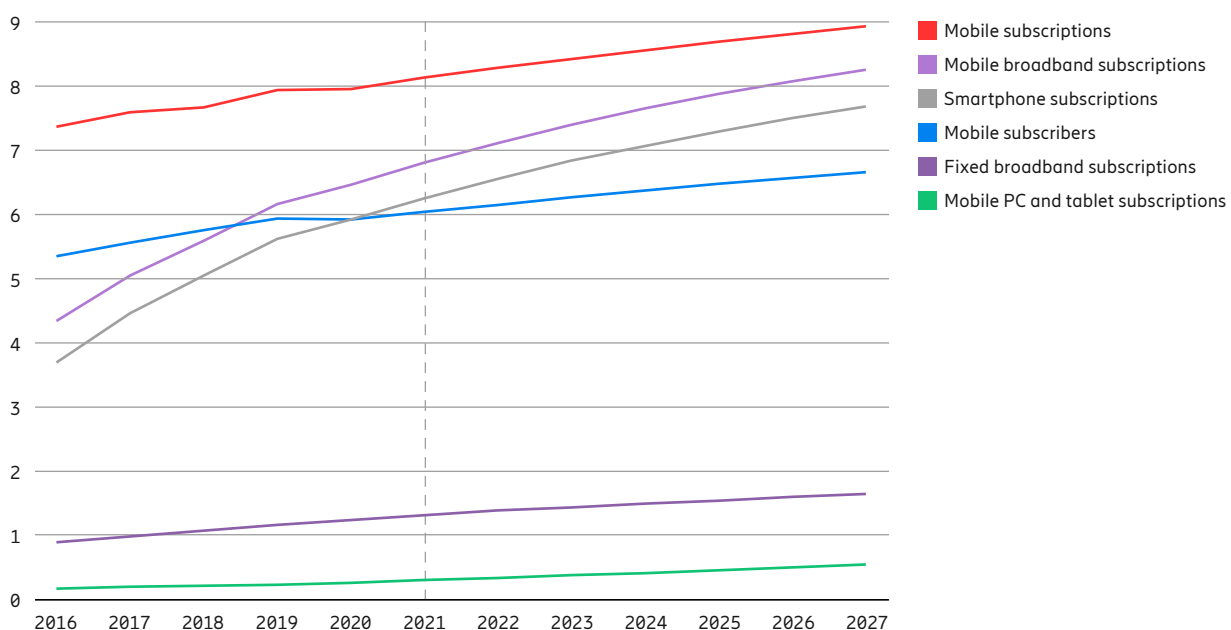
Mobile broadband dominates mobile subscriptions

Today, there are around 8.1 billion mobile subscriptions. We project this figure will increase to around 8.9 billion by the end of 2027, of which 92 percent will be for mobile broadband. The number of unique mobile subscribers is projected to grow from 6 billion in Q3 2021 to 6.7 billion by the end of the forecast period.

Subscriptions associated with smartphones continue to rise. At the end of 2021 we estimate that there will be 6.3 billion, accounting for about 77 percent of all mobile phone subscriptions. This is forecast to reach 7.7 billion in 2027, accounting for around 86 percent of all mobile subscriptions at that time.

Subscriptions for fixed broadband are expected to grow around 4 percent annually through 2027.⁴ FWA connections are anticipated to show strong growth of 17 percent annually through 2027. Subscriptions for mobile PCs and tablets are expected to show moderate growth, reaching around 540 million in 2027.

Figure 5: Subscriptions and subscribers (billion)

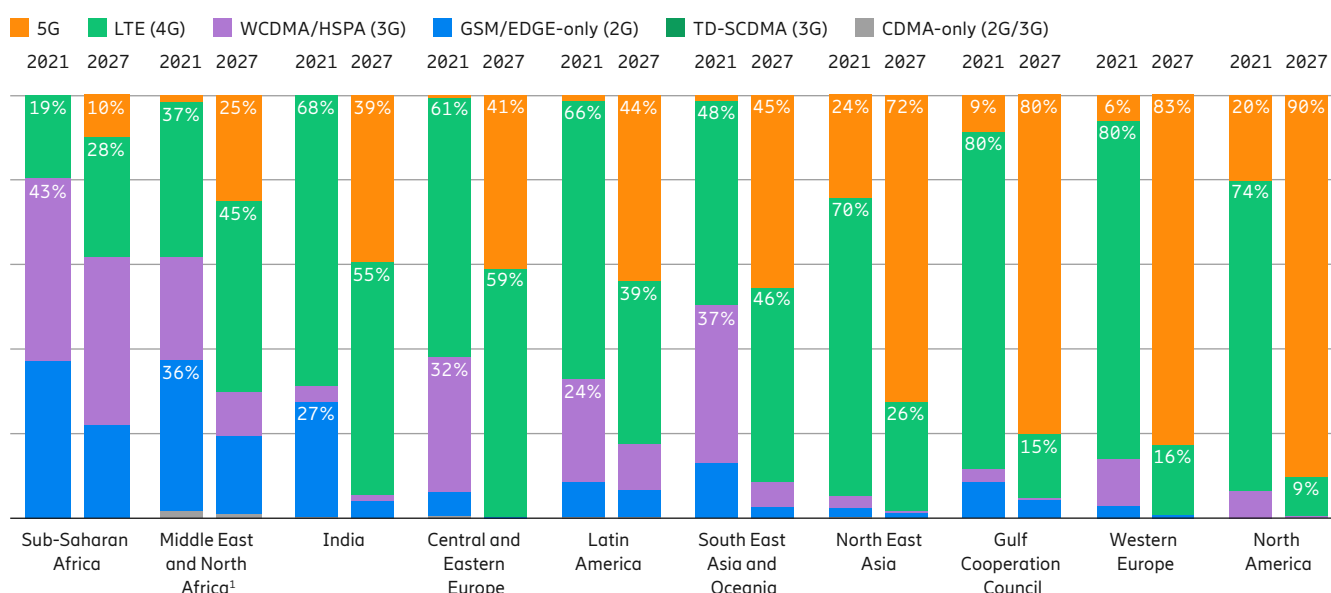


⁴ The number of fixed broadband users is at least three times the number of fixed broadband connections due to shared subscriptions in households, enterprises and public access spots. It is the opposite for mobile phones, where subscription numbers exceed user numbers.

5G subscriptions to be mainstream in every region

Mobile broadband subscriptions currently make up 84 percent of all mobile subscriptions.

Figure 6: Mobile subscriptions by region and technology (percent)



Sub-Saharan Africa

In Sub-Saharan Africa, mobile penetration is less than the global average and mobile subscriptions will continue to grow by an additional 25 percent over the forecast period. 4G is estimated to account for close to 20 percent of subscriptions at the end of 2021. Over the forecast period, the total number of mobile broadband² subscriptions is predicted to increase, reaching 78 percent of mobile subscriptions. While 5G and 4G subscriptions will continue to grow over the next 6 years, HSPA will remain the dominant technology with a share of 40 percent in 2027. Driving factors behind the growth of mobile broadband subscriptions include a young, growing population with increasing digital skills and more affordable smartphones. Over the forecast period, discernible volumes of 5G subscriptions are expected from 2022, reaching 10 percent in 2027.

Middle East and North Africa

In the Middle East and North Africa region, around 37 percent of mobile subscriptions are estimated to be for 4G at the end of 2021. The region is anticipated to evolve over the forecast period. By 2027, 81 percent of subscriptions are expected to be for mobile broadband with 4G being the dominant technology, accounting for 45 percent of subscriptions at that time. This will be a decline from a peak of 50 percent in 2026, as subscribers migrate to 5G. The region is likely to reach close to 210 million 5G subscriptions in 2027, representing 25 percent of total mobile subscriptions.

Gulf Cooperation Council (GCC)

The GCC countries, part of the Middle East and North Africa region, are among the most advanced ICT markets in the world – 91 percent of mobile subscriptions are

estimated to be for mobile broadband at the end of 2021, and this is projected to reach 96 percent in 2027. 4G is the dominant technology, accounting for about 80 percent of the subscriptions at the end of 2021. However, with 5G adoption accelerating in the forecast period, the majority of mobile subscriptions are anticipated to be for 5G at over 65 million in 2027, representing 80 percent of total mobile subscriptions.

India

In the India region, 4G is expected to remain the dominant technology in 2027, however the 4G subscriptions are forecast to drop from 790 million in 2021 to 710 million in 2027, showing an annual average decline of 2 percent. Thus, 4G subscriptions are expected to reduce from 68 percent of mobile subscriptions in 2021 to 55 percent in 2027 as subscribers migrate to 5G.

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

² Mobile broadband includes radio access technologies HSPA (3G), LTE (4G), 5G, CDMA2000 EV-DO, TD-SCDMA and Mobile WiMAX.

5G will represent around 39 percent of mobile subscriptions in India at the end of 2027, estimated at about 500 million subscriptions. The number of smartphone subscriptions is expected to be 810 million at the end of 2021 and is projected to grow at a CAGR of 7 percent, reaching over 1.2 billion by 2027. Smartphone subscriptions accounted for 70 percent of total mobile subscriptions in 2021 and are projected to constitute around 94 percent in 2027, driven by rapid smartphone adoption in the country.

Central and Eastern Europe

In Central and Eastern Europe, 4G is the dominant technology, accounting for 61 percent of all subscriptions at the end of 2021. In 2027, 4G will remain the dominant technology and is expected to account for 59 percent of mobile subscriptions, while 5G subscriptions are forecast to make up 41 percent. During the forecast period, there will continue to be a significant decline in WCDMA/HSPA, from 32 percent to virtually zero, as users migrate to 4G and 5G.

To date, around 25 5G networks have been commercially launched across the region.

Latin America

In Latin America, 4G is currently the dominant radio access technology, accounting for 66 percent of subscriptions at the end of 2021 and a predicted 39 percent in 2027. A steady decline in WCDMA/HSPA is forecast as users migrate to 4G and 5G, falling from 24 to 11 percent. The region is already advancing towards 5G with commercial launches in the initial stages in 10 countries, including Colombia, Brazil, Peru and Puerto Rico. By the end of 2027, 5G is set to account for 44 percent of mobile subscriptions, making it the dominant radio access technology at that time.

South East Asia and Oceania

Mobile subscriptions in the region have exceeded 1.1 billion, with Indonesia being second globally when it comes to net additions during Q3 2021. 5G subscriptions are expected to reach close to 15 million at the end of 2021 and grow strongly over the next few years, with a forecast total of about 560 million in 2027.

Important technology milestones continue to be achieved in the region. In Australia, operators testing with millimeter-wave (mmWave) frequencies have achieved 5G broadband speeds beyond 5Gbps. Commercially, mmWave 5G has started to be rolled out in certain areas around Australia in different frequency bands. In Singapore, one of the first 5G standalone (SA) networks in the world has been launched, opening up possibilities for the development of new 5G use cases.

In Malaysia, a rather different approach to 5G deployment is being pursued. Unlike existing 4G networks, Malaysia is assigning the 5G spectrum to a single government-owned special purpose vehicle to build and manage a national 5G network. Service providers will then be able to tap into the network via wholesale agreements to offer 5G services. It is expected that commercial 5G services will arrive by the end of 2021 in several cities.

North East Asia

In North East Asia, service providers continue to invest in 5G deployments to further fuel 5G subscription growth. A current focus area for service providers is to improve nationwide coverage. Meanwhile, the rapid growth of 5G subscriptions, supported by an increased number of available 5G-device models, has had a positive impact on service providers' financial performance. Major service providers in leading 5G markets, such as China and South Korea, have reported a positive impact of 5G subscribers on mobile service revenues and ARPU in 2021.

At the close of the forecast period, the region is anticipated to have more than 1.6 billion 5G subscriptions, equaling a 5G subscription penetration of 72 percent.

Western Europe

In Western Europe, 4G is the dominant access technology, accounting for 80 percent of all subscriptions at the end of 2021. 4G is predicted to decline to 16 percent and WCDMA/HSPA to virtually zero percent of subscriptions in 2027 as subscribers migrate to 5G. Around 60 service providers have launched 5G services across the region. 5G subscription penetration is projected to reach 83 percent by the end of 2027.

North America

In North America, 5G commercialization is moving at a rapid pace. Service providers have launched commercial 5G services, focusing on mobile broadband and fixed wireless access (FWA). The addition of C-band spectrum will secure consistent 5G user experiences. FWA will play a key role in closing the digital divide where the pandemic has exposed large gaps for education, remote working and small businesses. By 2027, more than 410 million 5G subscriptions are anticipated in the region, accounting for 90 percent of mobile subscriptions.

5G will account for 90 percent of North American mobile subscriptions in 2027.

90%

The state of 5G in Latin America: A closer look

Interest in 5G is growing in Latin America, and its deployment and adoption presents a real opportunity to promote economic recovery and social inclusion throughout the region.

During the COVID-19 pandemic, mobile broadband played a critical role in connectivity, often as an alternative to the limited availability of fixed broadband. There is a general interest in the adoption of 5G technology due to its relevance in promoting innovation, competitiveness and productivity in a digital transformation scenario.

A stable, ultra-fast and affordable mobile broadband service should be an overall priority in the region to help close the digital divide. Fixed wireless access (FWA), as a use case, can also be better leveraged for both business and social purposes.

Economics: 5G helping to kickstart recovery

Latin America is expected to achieve GDP growth of 5.2 percent in 2021, showing a partial recovery from the contraction of 6.8 percent in 2020 that was largely due to the COVID-19 pandemic. However, challenges to a full recovery remain, with persistent and widespread social and economic problems across the region. By 2022, the Economic Commission for Latin America and the Caribbean (ECLAC) projects that countries in the region will grow by an average of 2.9 percent, which implies a slowdown compared to the 2021 rebound.¹

Spectrum

Latin American countries have scheduled several spectrum allocation processes for the end of 2021 and the first half of 2022. There is still an opportunity for spectrum harmonization on the mid-bands (3.3–3.7GHz) across Latin America, as well as opportunities for sharing low-band spectrum with previous technologies.

Rolling out 5G

There have been commercial 5G launches in countries such as Colombia, Brazil, Peru and Puerto Rico. New 5G roll-outs are expected in 2022 after the success of recent auctions in Brazil, Chile and the Dominican Republic. Many service providers – in at least 15 countries – continue to test 5G technology in preparation for upcoming auctions.

Outlook

By the end of 2027, 5G is expected to represent 44 percent of mobile subscriptions in Latin America and the average traffic per smartphone is forecast to be approximately 35GB per month.

The deployment of 5G networks represents a significant opportunity for development in the region. Last year, it was projected that the digitalization of industries in Latin America could develop into a market worth more than USD 21 billion annually, and in the long term this critical infrastructure could increase regional competitiveness and translate into a GDP increase of more than 5 percent.

Bridging the digital divide in Latin America

FWA has been identified as a potential solution to help connect the unconnected. Many countries in the region have been testing technology and formulating plans, and now the roll-out is underway. FWA is ideal for places that are difficult to access with traditional fixed broadband. An estimated 244 million people in Latin America – one-third of the population – do not have access to the internet.² The pandemic has had a huge impact on efforts to digitalize the region.

Countries such as Chile, Colombia and Mexico had a boost in the digitalization of companies and their employees, but there is still a wide gap between rural and urban areas in most of the countries that make up the region.

A study published by the Inter-American Development Bank (IDB) describes how Latin America and the Caribbean could dramatically increase employment while boosting sustainable economic growth if they succeed in promoting digital connectivity.³ According to the study, closing the gap with Organization for Economic Co-operation and Development (OECD) countries could generate more than 15 million jobs, boost regional GDP by 7.7 percent and increase productivity by 6.3 percent.

Despite multiple efforts to connect the region, there is still a lag that must be addressed. It is essential for governments, organizations and companies to collaborate to achieve the objectives of economic growth with social inclusion.

5G and private networks to enable Industry 4.0

The characteristics of 5G are ideal for new use cases in business and industry. Its deployment becomes a catalyst for digital transformation and Industry 4.0. Latin America is an industrial hub of global relevance. Mining, manufacturing, seaports, airports, warehouses and energy plants are examples of sectors developing innovative solutions to take advantage of the emerging opportunities for private networks.

A mining company in Mexico will deploy a private network covering 3 underground copper mines with operations down to a depth of nearly 1km.

¹ Economic Commission for Latin America and the Caribbean, www.cepal.org/es.

² Ibid.

³ IDB: Banco Interamericano de Desarrollo, Informe anual del Índice de Desarrollo de la Banda Ancha (2020).

By the end of 2027, 5G is expected to represent 44 percent of mobile subscriptions in Latin America.

44%

It will be the first 5G-ready cellular network deployed in an underground mining production environment in Latin America and emphasizes the possibilities for private networks in the industry and the region. The mines will use the private network with 20MHz bandwidth in the 700MHz band to monitor in real-time the mining machines, sensors and energy system in 10s of kms of mining tunnels. The private network will also allow the mines to remotely control ventilation and locate workers in real-time through smart helmets, including sending emergency messages or mission-critical push-to-talk and push-to-video communications. All these use cases translate into significant improvements to employee safety, an increase in productivity and the reduction of operational expenses.

5G consumer potential

The Latin American 5G market is projected to generate over USD 28.4 billion annually by 2030 in enhanced mobile broadband revenues. In addition, the 5G FWA market has the potential to connect rural areas and expand broadband coverage. It is expected to be worth nearly USD 4 billion in 2030, with 21 million subscriptions. Maintaining this momentum and accelerating commercial deployments and adoption can help drive the region's recovery from COVID-19.⁴

Figure 7: Latin America mobile subscriptions by technology (million)

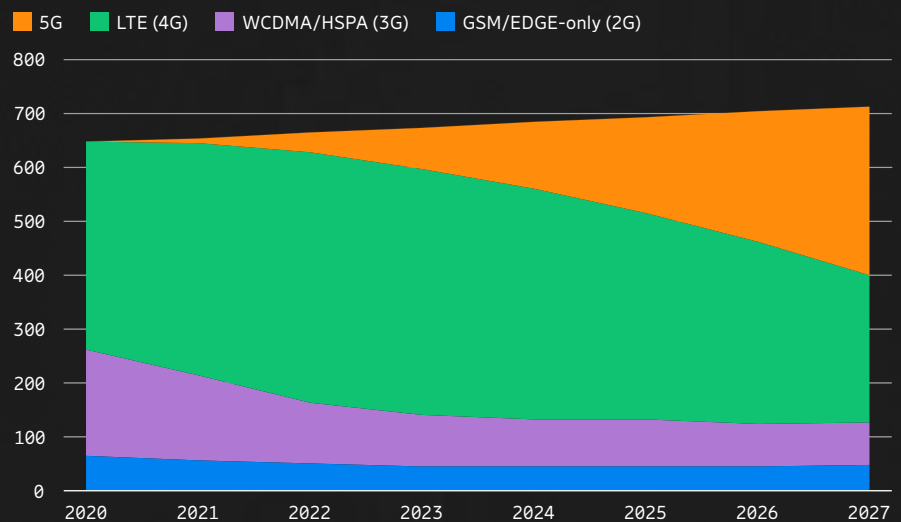
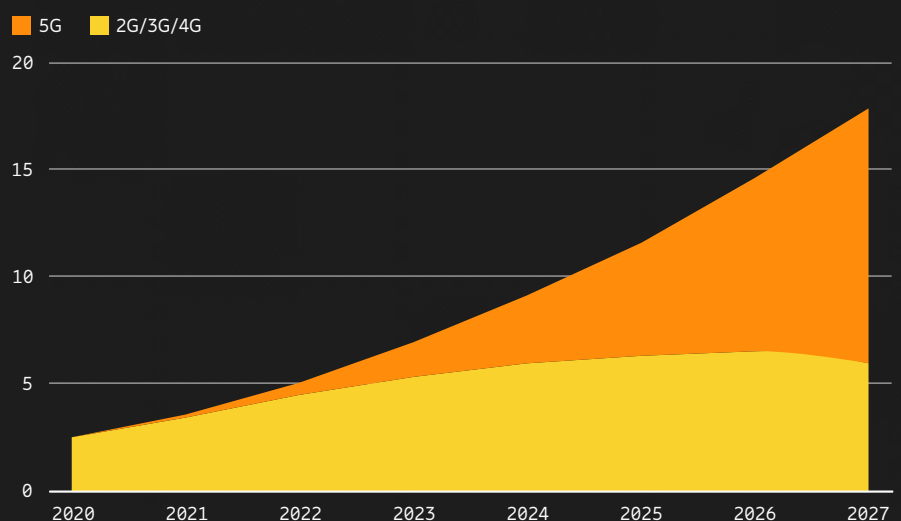


Figure 8: Latin America mobile data traffic (EB per month)



⁴ Ericsson Consumer and IndustryLab analysis, Harnessing the 5G consumer potential study, Latin America (November 2020).

5G FWA speed-tier offerings are emerging

Over 75 percent of service providers are now offering fixed wireless access (FWA) services. The majority are best effort, but monetization with speed-based offerings are picking up.

Over 75 percent of service providers now offer FWA

In October 2021, Ericsson, for the sixth time, updated its study of retail packages offered by service providers worldwide. Out of 312 service providers studied, 239 had an FWA offering, representing an average of 77 percent globally. Service providers' adoption of FWA offerings has more than doubled in the last three years.

High growth of service providers offering 5G FWA services

During the last 6 months, the number of service providers offering 5G FWA services has increased from 46 to 57, representing a growth of almost 25 percent. There is strong 5G FWA momentum in the Middle East and Africa, which accounts for 60 percent of 5G FWA launches in the last 6 months.

During the last 6 months, the number of service providers offering 5G FWA services has grown by almost 25 percent.

~25%

Figure 9: Global number of service providers offering FWA

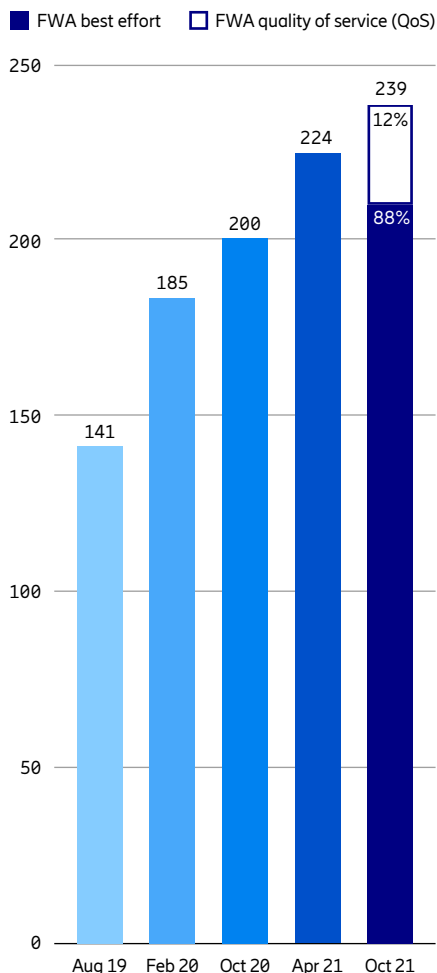


Figure 10: Regional percentage of service providers offering FWA

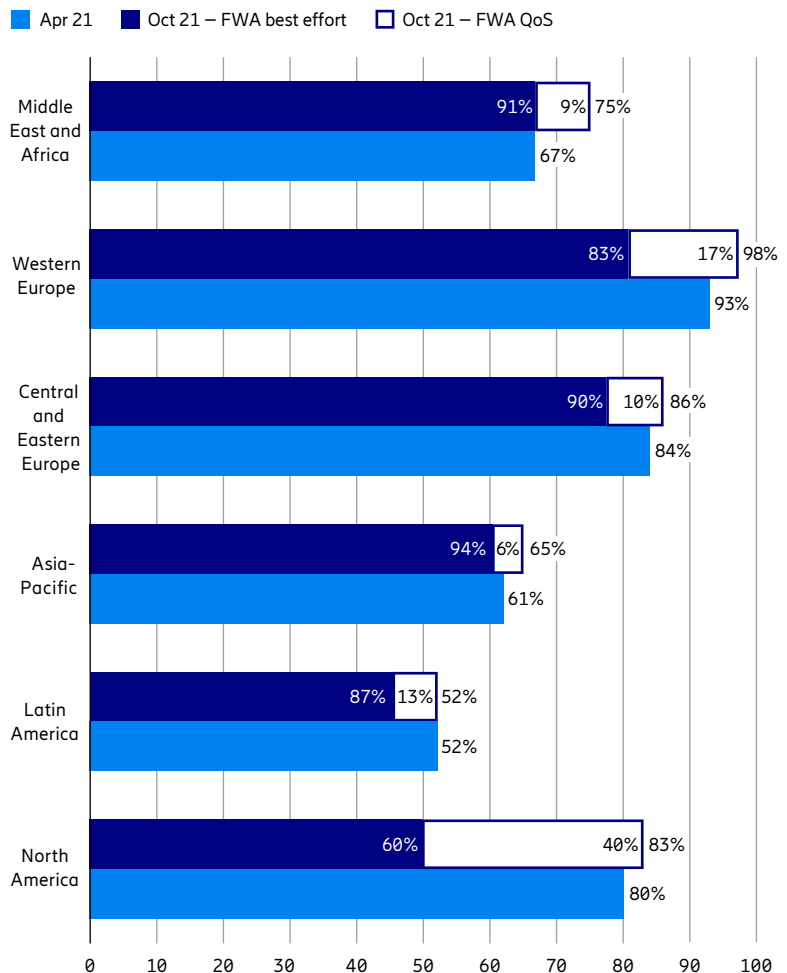
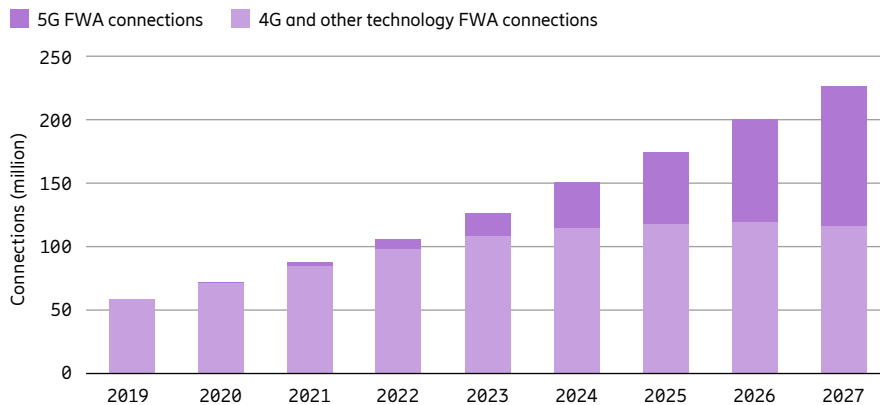
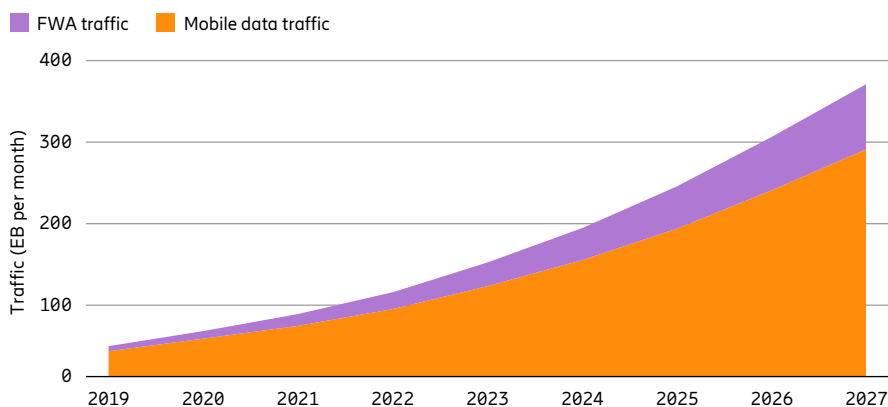


Figure 11: FWA connections

**Definition of FWA**

A connection that provides primary broadband access through wireless wide-area mobile-network-enabled customer premises equipment (CPE). This includes various form factors of CPEs, such as indoor (desktop and window) and outdoor (rooftop and wall-mounted). It does not include portable battery-based Wi-Fi routers or dongles.

Figure 12: Mobile data and FWA traffic

**QoS with speed offerings are picking up**

The majority (88 percent) of FWA offerings are best effort with a monthly volume tariff plan based on usage (GB/month). About 12 percent of service providers offer a QoS. This is defined as selling FWA services with "speed tiers" enabling higher monetization, like fiber-based broadband services. About 40 percent of these QoS offerings are "basic", with average/typical speeds being advertised. Some 60 percent are more advanced QoS offerings, involving "speed tiers", such as 100Mbps, 300Mbps and 500Mbps. Service providers with 5G FWA are more likely to have a QoS offering, with 17 out of 56 utilizing this approach (30 percent). North America is the region with the highest adoption, with 40 percent of all offerings based on QoS.

Half of all service providers in every region now offer FWA

According to the regional breakdowns, more than 50 percent of service providers in every region offer FWA. In Western Europe, almost all service providers have an FWA offering (98 percent). This is also the region with the highest percentage of 5G FWA offerings, representing almost 40 percent of global offerings. The highest

growth during the last 6 months was in the Middle East and Africa, with the number of service providers with an FWA offering increasing from 67 percent to 75 percent.

FWA connection set to rise almost threefold until 2027

Some service providers are starting to report FWA connections, but globally there is still limited reporting. Based on a recent FWA CPE shipment survey,¹ and Ericsson's own research, we estimate that there will be close to 90 million FWA connections by the end of 2021. This number is forecast to grow almost threefold through to 2027, reaching almost 230 million. Out of these, 5G FWA connections are expected to grow to around 110 million by 2027, representing almost half of total FWA connections.

FWA data traffic projected to grow almost six times

FWA data traffic represented over 15 percent of global mobile network data traffic by the end of 2021, and is projected to grow almost 6 times to reach 82EB in 2027. This accounts for more than 20 percent of total mobile network data traffic globally.

FWA to offer broadband to over 800 million by 2027

FWA's societal impact is larger than the number of FWA connections, as it brings connectivity to three to five people in a household, depending on regional demographics. The forecast of almost 230 million FWA connections by the end of 2027 represents over 800 million individuals having access to a wireless broadband connection.

By 2027, FWA will offer broadband to over 800 million people.

800m

¹ GSA (Sept 2021).

5G drives innovation in service packaging

More than 50 percent of service providers now offer some form of service-based connectivity.

The amount of data included in packages continues to rise, but service providers are also adding to both the variety and options available to consumers. Notably, there is an increase in the use of what is known as service-based connectivity, which has emerged as an alternative to unlimited packages. They can best be described as add-on packages that wrap around a specific service type, or even a selection of varying services. Previously, the main services targeted by these connectivity packs have been social media, music and video streaming. Around 52 percent of service providers offer these types of packages.

The pandemic seems to have triggered providers to offer these connectivity packs, especially for video conferencing services.

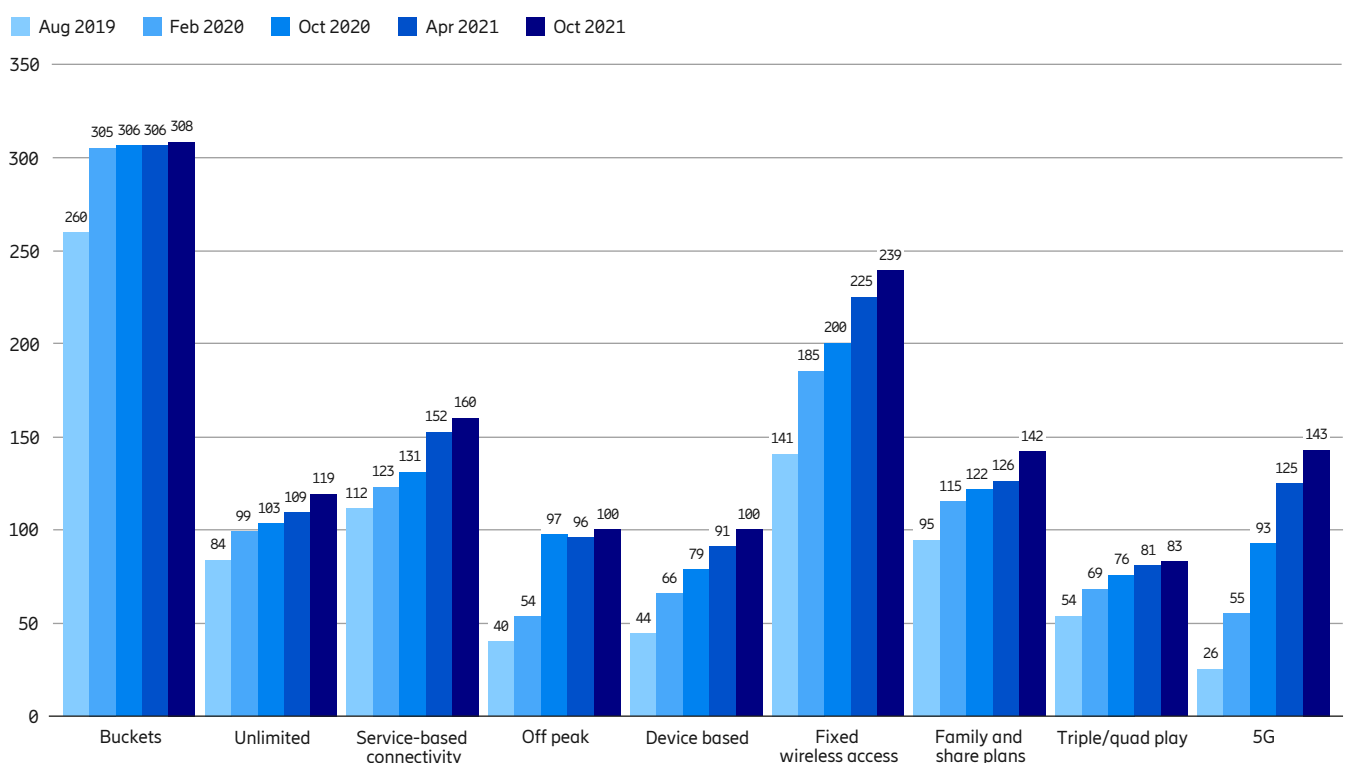
Today, even more advanced versions can also be found. For example, the aptly named “work and education packs” have appeared with discounted packs of gigabytes for the combined use of video conferencing, web browsing, video streaming and office software suites. In 2021 we have observed an increasing number of this type of package targeting cloud gaming.

The number of service providers who offer unlimited data as premium packages continues to increase, standing at around 37 percent – up from 35 percent 6 months ago. A recent trend among these is the introduction of boundary conditions, which include limits when tethering or using IoT devices, as well as restrictions

on the amount of data that can be shared within family or device plans. More than 80 percent of service providers with these limitations have already made 5G commercially available.

Nearly 46 percent of the service providers surveyed have now launched 5G for smartphones and, of these, about 36 percent are charging a premium for 5G over the nearest comparable 4G offering. A little over one-third of the 5G service providers are bundling media content with their subscriptions. Speed tiering is also being used as an effective means to incentivize consumers to move up the price tiers in conjunction with both unlimited and bucket plans.

Figure 13: Number of service providers per type of offering



Fast, foldable and everywhere: 5G devices today

5G handset sales have taken off, outpacing the 4G handset market share 10 quarters into the technology cycle.

5G adoption is accelerating for both networks and devices:

- Over 400 5G smartphone models have been launched.
- Global smartphone shipments were up by 19 percent in the first half of 2021 compared with the first half of 2020.¹ There is a risk that supply challenges will have a negative impact on shipments in the second half of 2021.
- 5G device shipments are on par with, or exceeding, predictions at the beginning of 2021.
- At the tenth quarter of the cycle, 5G handsets account for 23 percent of global volumes, compared to 8.7 percent for 4G at the corresponding time in its cycle.
- Devices with New Radio (NR) carrier aggregation capability are becoming mainstream.
- Significant investment in extended reality (XR) use cases is expected to drive the need for time-critical communication services, including network slicing.

Standalone taking new steps

5G standalone (SA) has taken off slower than initially anticipated, despite proven device readiness in markets that have already deployed it. Mid-band spectrum availability remains a key factor for market traction.

China and North America were the first markets in which 5G SA was launched. Now, service providers have launched commercial SA services in markets including Korea, Singapore and Thailand, as well as a few markets in Europe.

We continue to anticipate the first introduction of commercial 5G-native voice (VoNR) services towards the end of 2021 or beginning of 2022.

5G SA services have been offered using frequency bands below 6GHz. To maximize the user experience, mmWave bands can be combined with sub-6 bands using

NR-NR dual connectivity (NR-DC). NR-DC will be widely supported at the chipset level by the end of the year and is expected to become commercially available in devices during 2022.

mmWave becomes affordable

The price of mmWave-capable devices has continued to decline as competition in that space increases. Recently, new mmWave-capable devices priced at around USD 300 have emerged. The chipset domain continues to expand, and we expect to see increased competition in this price range.

Foldable devices here to stay

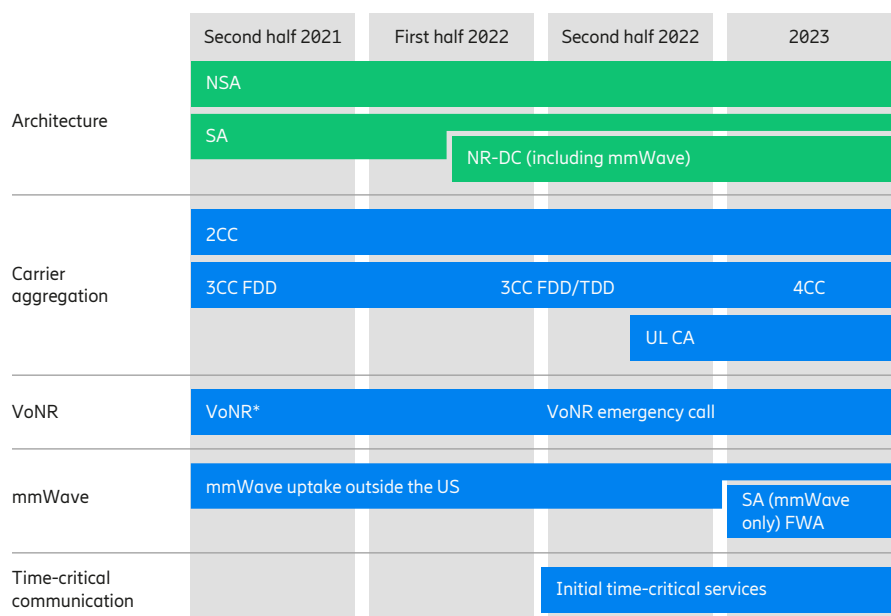
Initially, folding screens were exclusive to high-end devices and significantly more expensive than regular flagship smartphones. However, increasingly innovative concept designs have since

been showcased and the price of foldable phones has dropped significantly. Device manufacturers are investing in this technology and the current outlook is that foldable smartphones are here to stay.

Time-critical communications

Another service category currently inspiring minds in both the device and network communities is time-critical services, combined with new form factors like VR, XR and AR glasses. Large tech companies are investing significant resources, and it is seen as the next frontier for 5G. It will put new requirements on chipsets, devices and networks to provide bounded latency in order to enhance the user experience. The first steps in this direction are about to be taken, and with more 5G traffic in the networks, more refined functionality will be needed.

Figure 14: 5G technology market readiness



*Commercial service activation also depends on 5G coverage.

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

¹ IDC Worldwide Quarterly Mobile Phone Tracker.

Broadband IoT still rising as 2G and 3G continue to decline

During 2021, broadband IoT (4G/5G) will overtake 2G and 3G as the segment that enables the largest share of IoT applications globally.

Broadband IoT mainly includes wide-area use cases that require high throughput, low latency and large data volumes. By the end of 2027, 40 percent of cellular IoT connections will be broadband IoT, with 4G connecting the majority. As 5G New Radio (NR) is being introduced in old and new spectrum, throughput data rates

will increase substantially for this segment.

Meanwhile, the Massive IoT technologies NB-IoT and Cat-M¹ – primarily consisting of wide-area use cases involving large numbers of low-complexity, low-cost devices with long battery life and relatively low throughput – continue to be rolled out around the world. Although emerging from

a relatively small base now, these Massive IoT technologies are expected to overtake broadband IoT during the forecast period. In 2027, these technologies are forecast to make up 51 percent of all cellular IoT connections.

IoT devices connected via 2G and 3G have been in slow decline since 2019.

Telia's reflections

Telia Company has seen a 30 percent² year-on-year increase in IoT devices on its networks across the Nordics and Baltics during 2021. This is more than double the growth compared to 2020, with percentages in the low- to mid-teens.

Large-scale smart meter deployments using low-power wide-area (LPWA) networks and the adoption of embedded universal integrated circuit cards (eUICC) have contributed to much of that growth.³ Thanks to the availability of both NB-IoT and Cat-M on Telia's networks, as well as customers' greater understanding of LPWA's capabilities and value, Telia has seen interest in these technologies rise significantly. Growth is further fueled by an expanding ecosystem of LPWA devices and applications, lowering deployment costs while readily

available device modules and increased battery life continue to facilitate rapid adoption.

Besides smart meters, Telia sees growth within the smart buildings, transportation and logistics, security and surveillance applications, and automotive sectors. Automotive use cases are more likely to leverage 4G/5G network capabilities. The average monthly data consumption within this industry is 1GB for a 4G device, compared to 10MB for a 2G/3G smart meter. As the market shifts from legacy IoT to broadband IoT, Telia's 2G and 3G networks in the Nordics and Baltics are being retired, while 5G networks are rolled out to complement and strengthen the 4G networks with new capabilities. NB-IoT and Cat-M technologies, both forming part of the 5G standard, are very well suited to massive IoT applications in

the 5G era and are natural successors to 2G/3G-based use cases. Telia expects to see continued growth in both LPWA and broadband IoT as ecosystems around these technologies evolve to support the growing need for diverse IoT use cases.



"Telia's reflections" was written in cooperation with Telia Company's global IoT unit, which offers IoT solutions for a broad range of companies and industries. Telia's services help millions of people to be connected, communicate, do business and be entertained.

Figure 15: IoT connections (billion)

IoT	2021	2027	CAGR
Wide-area IoT	2.1	5.9	19%
Cellular IoT ⁴	1.9	5.5	19%
Short-range IoT	12.5	24.3	12%
Total	14.6	30.2	13%

¹ Cat-M includes both Cat-M1 and Cat-M2.

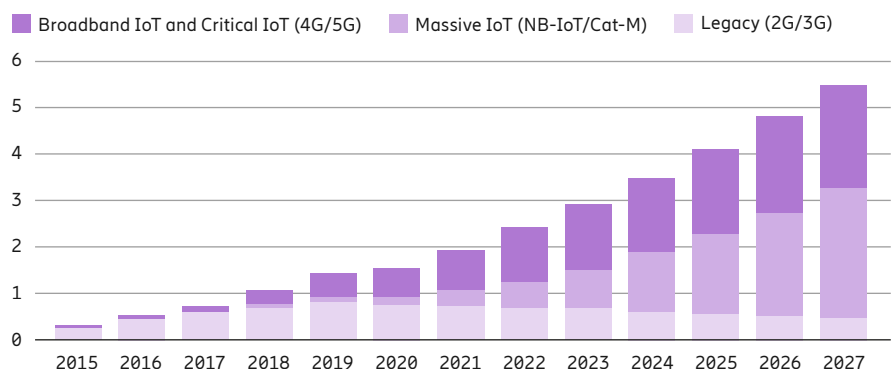
However, only Cat-M1 is being supported today.

² For the 12 months to August 2021.

³ eUICC offers flexibility as it makes over-the-air provisioning possible.

⁴ These figures are also included in the figures for wide-area IoT.

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



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

Mobile network traffic still climbing steadily

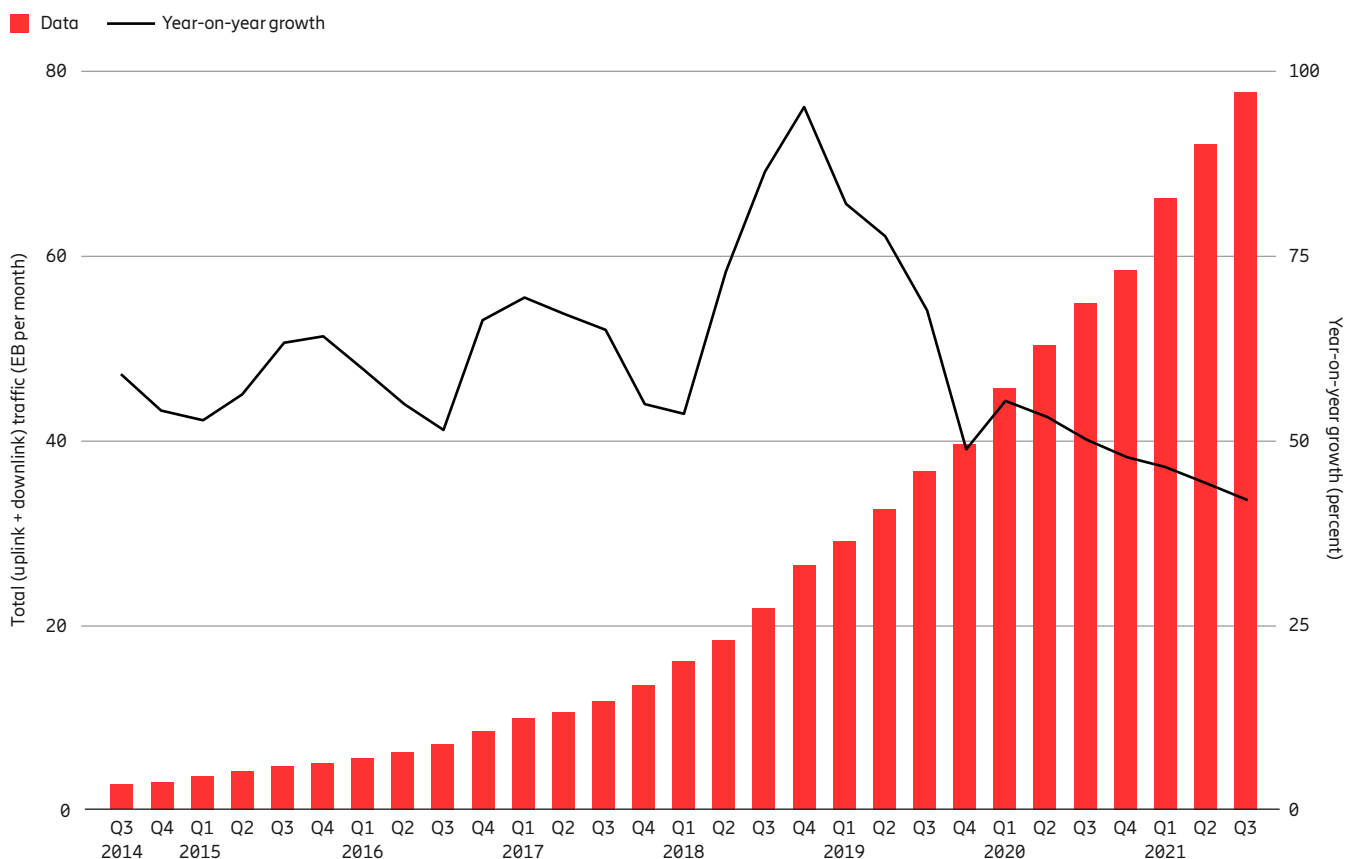
Mobile network data traffic grew 42 percent between Q3 2020 and Q3 2021.

As in the previous quarters during 2021, the year-on-year traffic growth rate remained at the expected level – 42 percent – compared to the extraordinary peak in 2018 and the first part of 2019.

The quarter-on-quarter growth was around 8 percent. In absolute numbers this equals an addition of 5.6EB per month in just one quarter, which is the same as the total was in Q1 2016. Total monthly mobile network data traffic in Q3 2021 reached around 78EB.

Over the long term, traffic¹ growth is driven by both the rising number of smartphone subscriptions and an increasing average data volume per subscription, fueled primarily by more viewing of video content. Figure 17 shows the net addition and total global monthly network data traffic from Q3 2014 to Q3 2021, along with the year-on-year percentage change for mobile network data traffic.

Figure 17: 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 (FWA) services.

¹ Traffic does not include DVB-H, Wi-Fi or Mobile WiMAX. VoIP is included.

Smartphones and video drive up mobile data traffic

In 2027, 5G networks will carry 62 percent of the world's smartphone traffic.

Total global mobile data traffic – excluding traffic generated by fixed wireless access (FWA) – is estimated to reach around 65EB per month by the end of 2021, and is projected to grow by a factor of around 4.4 to reach 288EB per month in 2027. Including FWA traffic, this takes the total mobile network traffic to around 80EB per month by the end of 2021, and 370EB per month by the end of 2027.

The monthly global average usage per smartphone will reach 11.4GB by the end of 2021 and is forecast to reach 41GB by the end of 2027.

Smartphones continue to be at the epicenter of this development as they generate most of the mobile data traffic today – about 97 percent – a share that is projected to increase throughout the forecast period.

Currently, video traffic is estimated to account for 69 percent of all mobile data traffic, a share that is forecast to increase to 79 percent in 2027.

Populous markets that launch 5G early are likely to lead traffic growth over the

forecast period. By 2027, we expect 5G networks to carry 62 percent of total mobile data traffic.

Large variations in traffic growth across regions

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

Over 1.2 billion smartphone subscriptions in the India region in 2027

In India, COVID-19 increased reliance on telecom networks to fulfill personal and business needs – be it remote health consultations, online ordering, online education, content consumption or video conferencing, amongst others.

Globally, the average usage per smartphone has reached 11.4GB.

11.4

The reliance on mobile networks to stay connected and work from home has contributed to the average traffic per smartphone increasing to 18.4GB per month in 2021, up from 16.1GB per month in 2020. The average traffic per smartphone in the India region is the second-highest globally and is projected to grow to around 50GB per month in 2027. Competitive pricing by service providers for subscription packages, affordable smartphones and increased time spent online all contribute to monthly usage growth in the region.

Total mobile data traffic in India has grown from 9.4EB per month in 2020 to 12EB per month in 2021 and is projected to increase by more than 4 times to reach 49EB per month in 2027. This is driven by two factors: high growth in the number of smartphone users, including growth in rural areas, and an increase in average usage per smartphone.

Figure 18: Global mobile network data traffic (EB per month)

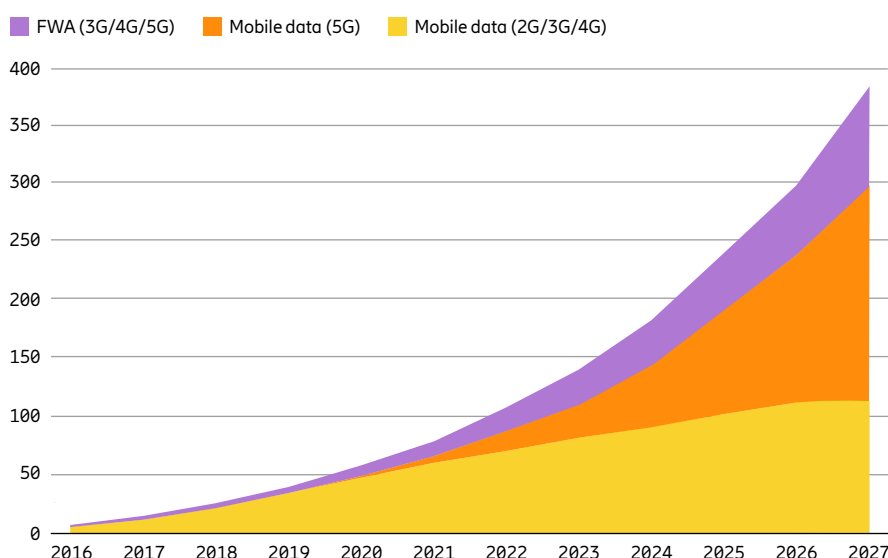
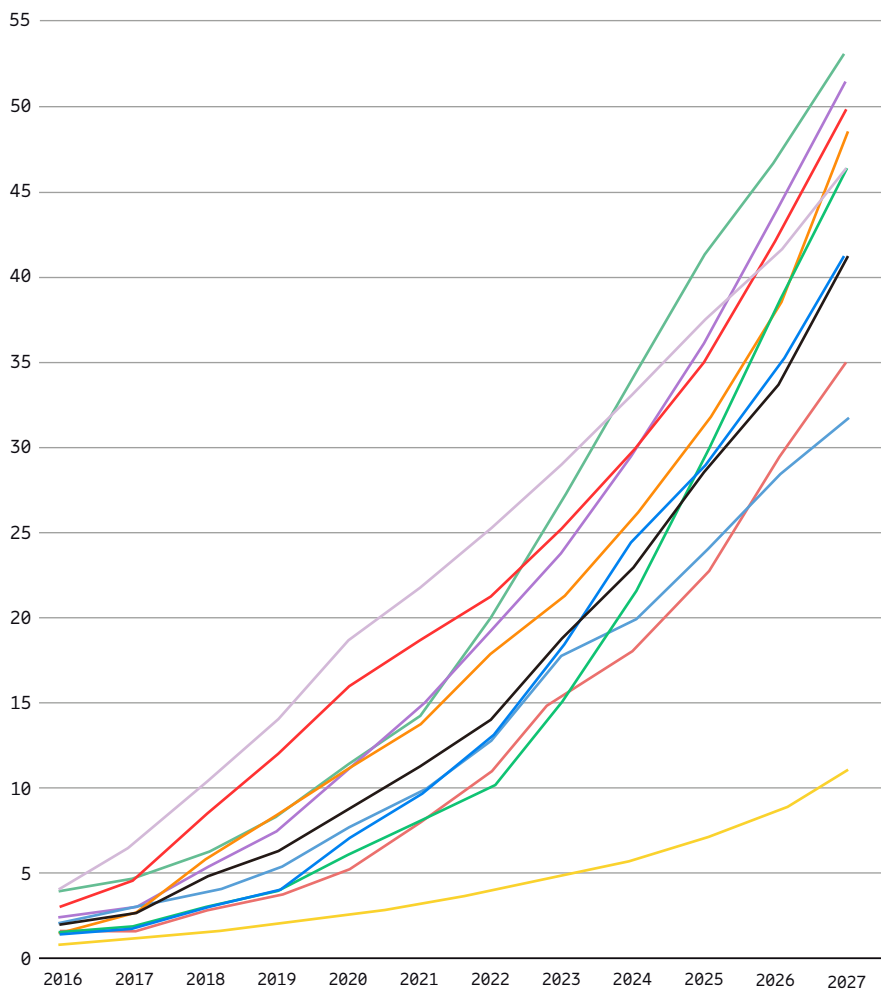


Figure 19: Mobile data traffic per smartphone (GB per month)



Data growth in North America depends on 5G service uptake

The average monthly mobile data usage in North America is expected to reach 52GB per smartphone in 2027. A smartphone-savvy consumer base and video-rich applications, in combination with large data plans, will drive traffic growth. While there may be strong growth in traffic per smartphone in the near term, the adoption of immersive consumer services using AR/VR is expected to lead to even higher growth in the long term. In 2027, 5G subscription penetration in North America is set to be the highest of all regions at 90 percent.

Traffic growth in **Western Europe** follows a similar pattern to that expected in North America. The more fragmented market situation is anticipated to lead to later mass-market adoption of 5G, but in 2027, traffic usage per smartphone is expected to reach 51GB per month – close to the usage in North America at that time.

5G growth in monthly mobile data usage continues in North East Asia

Video consumption, remote working, mobile gaming and new types of streaming such as AR/VR are driving up mobile data usage in the region. Monthly usage per smartphone is estimated to reach 13.9GB by the end of

2021, increasing from 11GB at the end of 2020. As a leading 5G market, the region is expected to continue its high growth and the data traffic per smartphone is forecast to reach 48GB per month in 2027.

The **Middle East and North Africa** region is expected to have the third-highest growth rate during the forecast period, increasing total mobile data traffic by a factor of almost 6 between 2021 and 2027. The average data per smartphone is expected to reach 41GB per month in 2027. Looking more closely at the **Gulf Cooperation Council (GCC)** countries, data traffic per smartphone is expected to be the highest globally at the end of 2021 at 22GB per month. By the end of the forecast period, it is expected to reach an average of 46GB per month.

Sub-Saharan Africa is expected to have the second-highest growth rate in total mobile data traffic during the forecast period, but from a relatively small base, with total mobile data traffic increasing from 1.3EB per month in 2021 to 7.6EB in 2027. Average traffic per smartphone is expected to reach 11GB per month over the forecast period.

South East Asia and Oceania will see data traffic per smartphone increasing at the fastest rate globally over the forecast

period, reaching 46GB per month in 2027 – a CAGR of 34 percent. Total mobile data traffic will grow accordingly, with a CAGR of 39 percent, reaching 46EB per month, driven by continued growth in 4G subscriptions and 5G uptake in markets where 5G has been launched.

Latin America is expected to follow a similar trend as South East Asia and Oceania over the forecast period on a regional level, while individual countries show very different growth rates for traffic per smartphone. Traffic growth is driven by coverage build-out and continued adoption of 4G (and eventually 5G), linked to a rise in smartphone subscriptions and an increase in average data usage per smartphone. The data traffic per smartphone on a regional level is expected to reach 35GB per month in 2027.

In Central and Eastern Europe, growth is fueled by 4G and 5G adoption. Over the forecast period, the monthly traffic per smartphone is expected to increase from 9.9GB to 32GB per month.

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

5G network coverage momentum continues

5G is expected to be the fastest-deployed mobile communication technology in history and is forecast to cover about 75 percent of the world's population in 2027.

Global 4G population coverage was over 80 percent at the end of 2020 and is forecast to reach around 95 percent in 2027. 4G networks are evolving to deliver increased network capacity and faster data speeds. There are currently 796 commercial 4G networks deployed across the world. Of these, 336 have been upgraded to LTE-Advanced, and 47 Gigabit LTE networks have been commercially launched.

5G is estimated to cover over 2 billion people in 2021

The build-out of 5G networks is continuing to accelerate and, to date, there have been more than 180 commercial launches across the world. It is estimated that 5G networks will cover over 2 billion people at the end of 2021.

By end of 2027, we estimate that 5G population coverage will have reached around 75 percent. This higher uptake is driven by several factors, one of them being that population-rich countries, such as India, will have achieved a high

population coverage. 5G is still expected to be the fastest-deployed mobile technology in history.

Network sunsets becoming a reality

The continuous global built-out of 4G and 5G networks, and the corresponding increase in capabilities, have become an enabler for "sunsetting" or shutting down legacy technologies – that is, 2G/3G. This enables further enhancements of the networks by releasing more, important parts of the spectrum for 4G and 5G.

Globally, this can be recognized in three different "waves":

- First wave: Mainly parts of North America, North East Asia, Australia and New Zealand are closing down 2G. This has, to a large extent, already taken place. The next step in these areas is the sunset of 3G, which is expected before the mid-2020s.
- Second wave: In Western Europe there is a larger dependency on 2G, so the second wave has started with the

sunsetting of 3G. This is expected to stretch until the mid-2020s, in parallel with the 3G sunset in the first wave. The second step is the sunset of 2G, which is not expected until closer to 2030. For this step, technologies like spectrum sharing are important enablers to keeping a thin layer of 2G. This wave also includes parts of South East Asia and the remaining parts of North America.

- Third wave: This includes parts of the world with lower penetration of 4G and 5G technologies, mainly in Eastern Europe, Africa, the Middle East and the remaining parts of South East Asia. Here, 3G will still be important to provide mobile broadband for some years to come. Both 2G and 3G are then expected to reach sunset closer to 2030. The Gulf Cooperation Council countries are an exception, where the plans are somewhere between the first and second waves.

Figure 20: World population coverage by technology¹

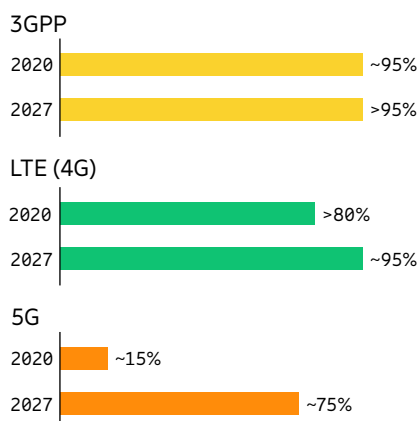
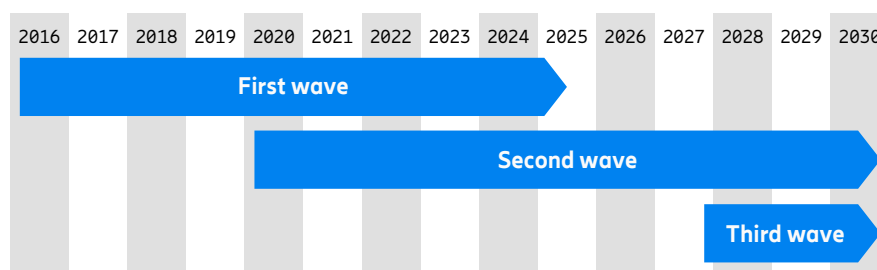


Figure 21: Legacy technology sunsetting timeline



Note: This is a generic description of what could happen based on current data. There are of course countries and service providers that do not follow these three mainstream waves.

¹ The figures refer to coverage of each technology. The ability to utilize the technology is subject to factors such as access to devices and subscriptions.

Articles

This is a time of incredible innovation within mobile networks. These articles explore how networks can be made faster, more sustainable and even contribute to economic recovery.



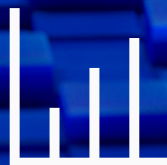
With FET, we explore how a strong 5G infrastructure is the foundation for the digital future.



The Kingdom of Saudi Arabia has a bright vision for a digital future; here's how stc's 5G deployment is contributing to the vision.



A Smartphone Lab study showed that web browsing is more demanding on downlink throughput than video – what does this mean for service providers?



Mobile data traffic grew by a factor of 287 over 10 years – how can service providers keep their networks sustainable, while growth is so high?

Building 5G infrastructure for the digital future

High-performance networks as the foundation for digital transformation.

Far EasTone (FET), Taiwan, is building a 5G network targeting premium performance and coverage to maximize customer experience. A network infrastructure that is the foundation to fulfill the increasing customer demand for daily and instantaneous digital access to healthcare, entertainment, education, e-commerce and information. An easy-to-access, and secure digital environment for consumers, enterprises, and society.

Strong demand fueling data traffic growth

Taiwan is a highly competitive market, with 5 service providers serving a combined total of 29.5 million mobile subscriptions. Mobile data consumption per subscriber is among the highest in the world, yet despite this high consumption, service providers in Taiwan are top ranked in global mobile network experience benchmarks measured by external parties. The first 5G networks in Taiwan were commercially launched in mid-2020, as a measure to meet the increasing demand for mobile data with cost-efficient capacity enhancements and to enable new digital services that require more network bandwidth and lower latencies for a satisfactory service experience.

In 2017, the average mobile data traffic per subscriber in Taiwan was over 5 times higher than the average in North East Asia – 13.7GB compared to 2.6GB per month. When all service providers introduced unlimited data plans at a comparably low price (USD 15 per month) in 2018, the average data consumption increased and reached 18GB per month in 2019. This has increased further over the last 2 years to around 26GB per month in 2021. Currently, the majority of mobile subscribers in Taiwan have an unlimited data plan which, together with a strong demand for mobile services, drives the high data consumption.

AI enables a cost–performance optimized network deployment

FET is one of the top 3 service providers in Taiwan, with around 7 million mobile subscriptions. At about USD 20, they have the highest average revenue per user (ARPU)¹ of all service providers in Taiwan. ARPU was in decline prior to the launch of 5G services, but is now growing due to 5G subscribers' higher contribution. FET launched its 5G commercial services in July 2020, achieving a 14 percent 5G penetration (1 million subscriptions) by August 2021, with a target of 20 percent by the end of 2021.

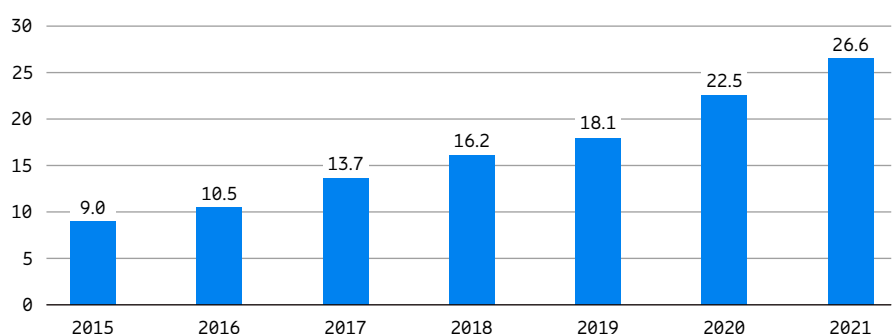
FET's initial 5G network deployment strategy is based on a large-scale, fast-paced, wide-coverage deployment of high-quality 5G New Radio (NR) equipment on the mid-band 3.5GHz frequency (80MHz bandwidth). This provides a significant increase in network speeds. It will be followed by deploying 5G NR on low-band frequencies and enabling 5G NR carrier aggregation to improve both throughput and mid-band coverage. Continuous field testing provides valuable insights for planning, designing, tuning and optimizing the network performance. When the 4G network was deployed, the geographical site selection was based solely on technical considerations.



This article was written in cooperation with Far EasTone, a market-leading service provider in Taiwan, which provides telecommunications and digital application services to help people stay connected and be the best partner in everyone's digital life.

For 5G network deployment, site selection is based on AI analytics of real traffic usage and user behavior. This enables a more precise cost–performance analysis to prioritize the sites that most urgently need capacity enhancements. However, for optimized network deployment it is not only site-level decisions that are considered, but also how to deploy 5G in clusters to achieve better network optimization and tuning across the whole network. FET's mid-band deployment has resulted in 5G population coverage of 75 percent in the first 12 months, with a target of 90 percent by the end of 2021.

Figure 22: Taiwan's mobile data traffic per subscriber (GB per month)



¹ Blended ARPU, Q2 2021.

Note: All service providers' subscribers included. 2021 data as of September.

COVID-19's impact on data consumption

On May 19, 2021, authorities raised the COVID-19 warning to level 3 throughout Taiwan, meaning the virus was in general circulation. Consequently, travel and meeting restrictions were imposed across Taiwan. The pandemic brought significant changes in mobile data consumption patterns, with traffic redistribution from densely urban areas to residential areas. People's mobility behavior changed and about 10 percent of FET's subscriber base stayed in their residential areas permanently, resulting in a high load on parts of the 4G network.

Before the pandemic, mobile traffic peak hours were usually 7:00 PM to 11:00 PM, but once restrictions were put in place high usage levels began at 7:00 AM as home working and remote study classes started, with longer busy hours throughout the day. The services that grew most during the level 3 restriction period (May–July) were primarily business communications services, video conferencing and streamed audio/video content. The 19 percent traffic growth during the 3-month restriction period became difficult to manage, as network engineers were restricted from going out to sites and installing additional network capacity.

Improving network performance during COVID-19 restrictions

FET adjusted its network deployment strategy to meet customer behavior changes and further enhance network performance to meet the increased traffic demand. In-person site visits to add additional spectrum resources and hardware were not an option. Instead, the priority was on tuning and activating software features. The importance of increased flexibility for assigning resources more dynamically to high-loaded network areas became apparent. This was achieved by using different techniques:

- a new customer relationship management (CRM) system supporting identification of areas with the most customer complaints
- leveraging traffic detection function (TDF) to accurately identify which areas displayed traffic pattern changes
- using TDF in the core network to impose the correct fair usage policies
- identifying the most congested areas and optimal use of the number of carriers for subscribers, for example, instead of having 3CC² carrier aggregation per subscriber, it was reduced to 1CC – giving less peak throughput per subscriber, and allowing more users to share the spectrum resources to secure user experience

These techniques resulted in an 80 percent drop in customer complaints in 90 percent of the network's most congested areas.

The change in customer behavior and the increased data consumption during the COVID-19 restrictions highlighted the need for fast and reliable broadband connectivity. It soon became clear that an agile response to free up network resources to meet the increased traffic demand was needed, with a priority to maintain high customer satisfaction.

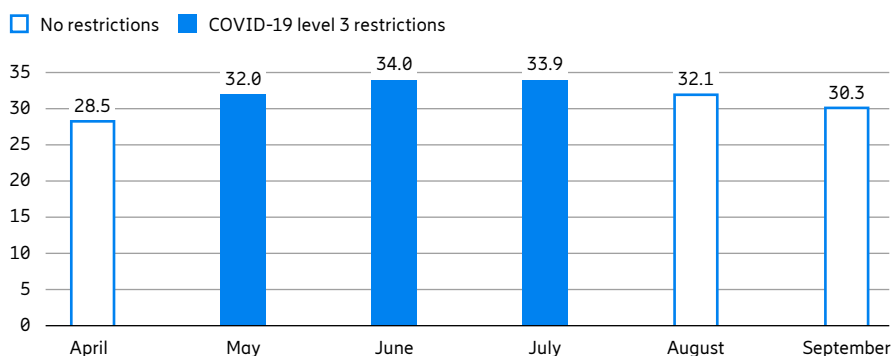
5G subscribers consume more data than 4G subscribers

The 4G network is highly loaded, so subscribers are migrating to 5G to experience even better network performance. In September 2021, 39 percent of 5G subscriber-generated traffic was carried by the 5G network and they were attached to the 5G network 25 percent of the time. The average data usage of FET's subscribers with unlimited 5G plans is 60GB per month compared to 51GB for 4G subscribers on similar plans, which is about a 20 percent difference. Compared to another leading 5G market with high average monthly data consumption, the consumption difference between subscribers on unlimited data plans in South Korea is around 35 percent (39.1GB compared with 28.8GB, September 2021). In both markets, early adopters migrating from 4G to 5G spend more time on consuming data and services in higher resolution or VR/AR formats, which contributes to the difference in data consumption between 4G and 5G subscribers.

The main contributing factors to FET subscribers' current high average monthly data consumption are:

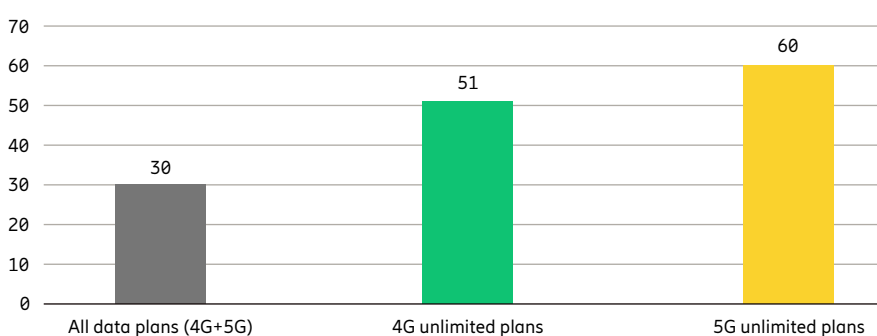
- high usage of video streaming services
- a large proportion of the subscriber base on unlimited 4G and 5G data plans
- with unlimited data plans, consumers continuously use their mobile phones over mobile networks instead of occasionally switching to Wi-Fi, which was especially apparent during the pandemic
- the continuing evolution of new device capabilities and improved network performance with 5G stimulates data consumption, that is, device-driven organic traffic growth
- fast 5G population coverage build-out, with 75 percent build-out during the first 12 months of deployment

Figure 23: FET mobile data traffic per subscriber (GB per month)



Source: National Communication Committee (NCC), Taiwan.

Figure 24: FET mobile data traffic per subscriber (GB per month), September 2021



Source: FET.

² Each aggregated carrier is referred to as a component carrier, CC. The CC can have a bandwidth of 1.4, 3, 5, 10, 15 or 20MHz and a maximum of 5 CCs can be aggregated, hence the maximum aggregated bandwidth is 100MHz. (www.3gpp.org).

Figure 25: Taiwan regions

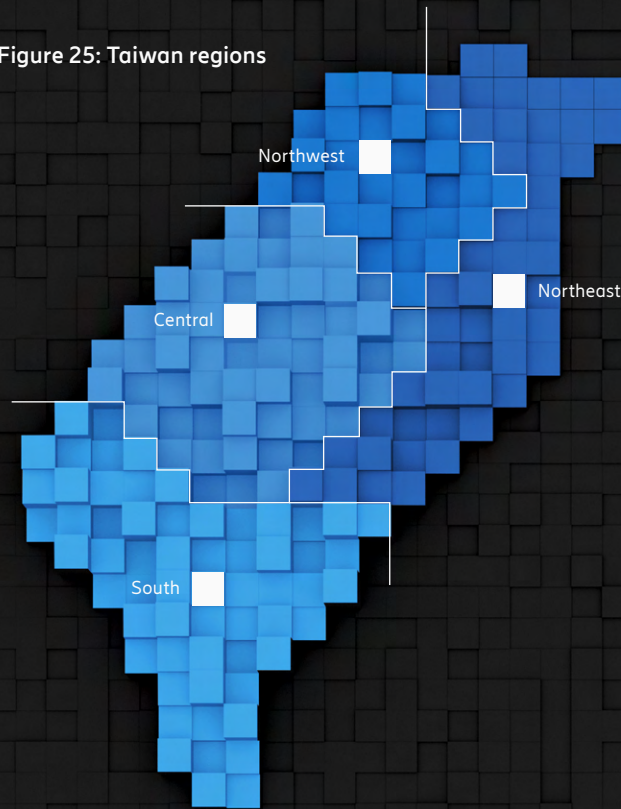
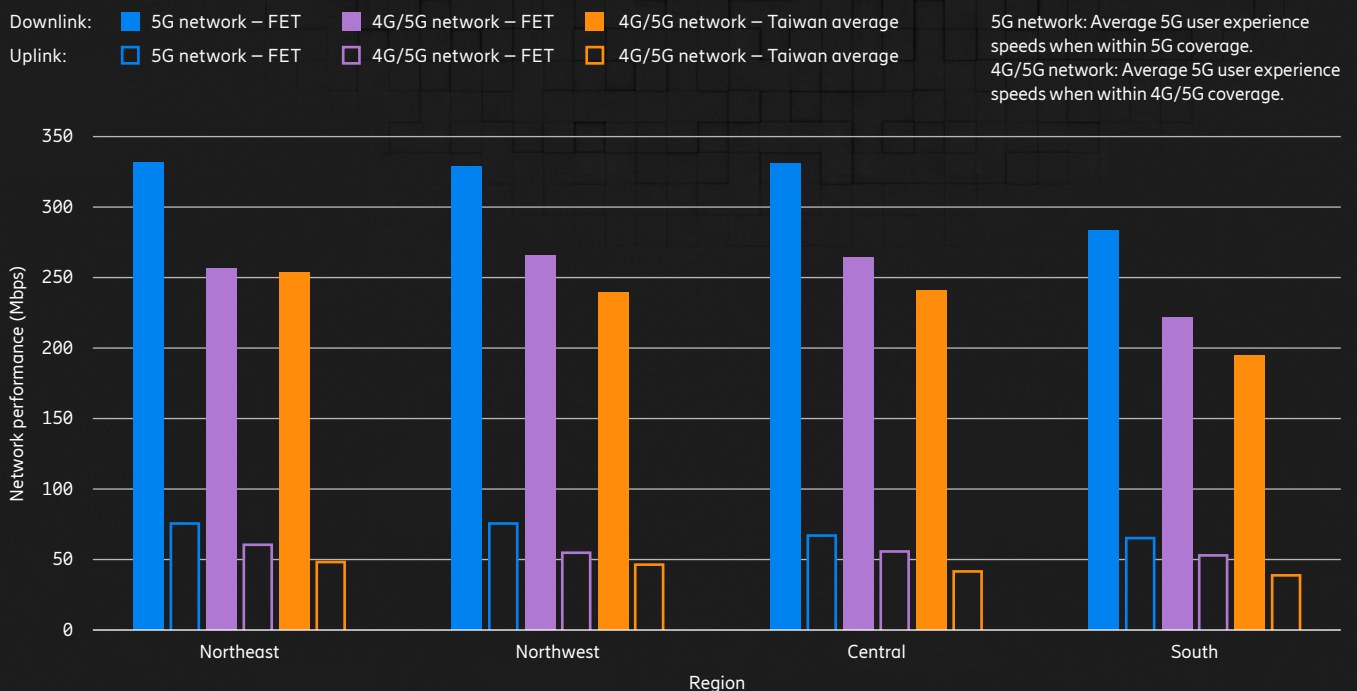


Figure 26: User average experienced speeds



Source: Ericsson field tests, Q3 2021.

Note: The field test results are somewhat lower compared to third-party published network performance data. The difference mainly relates to methodology, where field tests are using full-buffer downloads. Hence, data transmission is included on top of the original network load. 5G speed samples are on 3.5GHz.

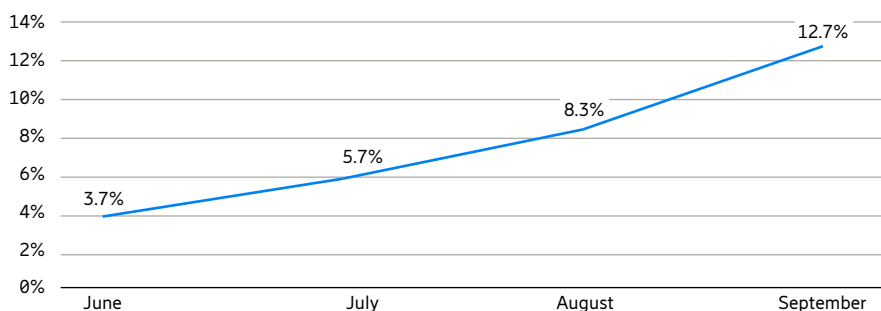
Improved network performance drives higher satisfaction

Service providers in Taiwan use 5G network performance as a key to differentiation in the highly competitive market. FET's strategy of a fast-paced build-out and a continuously optimized 5G network has resulted in a high-performing network with

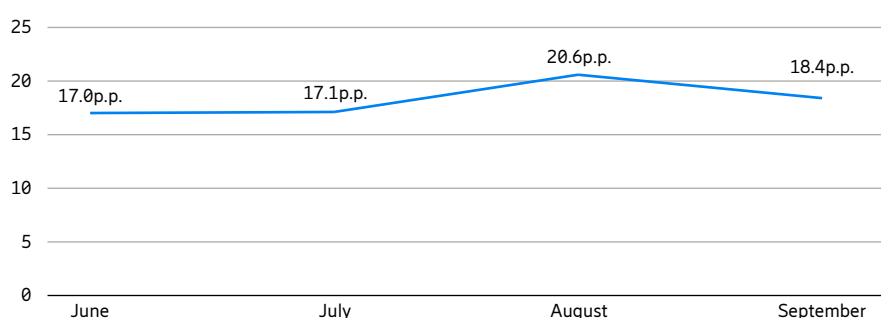
uplink and downlink speeds better than the average speeds for the three largest operators throughout Taiwan.

This strong focus on network performance has paid off. FET consumer research shows that the Net Promoter Score (NPS) of 5G subscribers is higher than the NPS of 4G subscribers.

This difference is driven by better 5G network performance. FET adopted a targeted approach to achieve this, focusing on deploying capacity enhancements in 7,000 specifically identified village areas to improve smartphone experience for increased customer satisfaction.

Figure 27: FET's NPS (4G+5G users)

Note: Based on FET's regular monthly survey of existing customers.

Figure 28: Difference between FET's 5G and 4G users NPS (percentage points – p.p.)

Source: FET (Taiwan).

Note: Based on FET's regular monthly survey of existing customers.

FET's 5G subscriber NPS was about 18 p.p higher than for its 4G subscribers in September 2021.

18

Video streaming services popular among 5G subscribers

FET pursues a long-term, focused consumer service strategy with a prime objective of providing a high-quality 5G network performance. The current main driver for consumers to upgrade from 4G to 5G is the elevated mobile internet user experience for streaming services made possible by 5G's improved network performance. Consumers who have migrated from 4G to 5G display similar usage behaviors as before, mainly using over-the-top (OTT), but streaming more video in higher resolutions. The most used services by 5G subscribers are video streaming and cloud gaming. However, 5G service usage is not yet driving significant traffic volumes.

FET's 5G digital entertainment services include 4K video streaming, VR and multi-view content, lossless sound quality music streaming and cloud gaming. These services provide new user experiences and differentiate 5G from 4G. The multi-view streaming video service is included on all 5G plans, while VR is only included on top of the four premium plans.

More 5G choice drives higher ARPU

FET offers a range of 5G data plans differentiated by price, data allowance, maximum speed and value-added services. An important strategy going forward is to add new content and devices while updating existing content and benefits on the different 5G service plans. This will help drive subscriber uptake further, motivate the price premium and differentiate from the 4G service plans. Offering a wider choice of data plan options and enticing customers to subscribe to premium 5G plans has resulted in higher ARPU. More than 85 percent of FET's 5G subscribers are on data plans priced USD 36 or higher, as of Q2 2021.

Emerging 5G enterprise opportunities

FET has initially focused on a fast deployment of a high-quality, wide-area 5G network to address the consumer business opportunity. FET is committed to developing new innovative 5G services through partnerships and collaborations, along with a continued strong focus on providing high network quality. New network capabilities will be implemented to enable a wide variety of services with enhanced network flexibility and faster time-to-market.

More than 85 percent of FET's 5G subscribers are on data plans priced USD 36 or higher.

85%

At the same time, several initiatives have been launched with enterprises and the public sector to improve their services and efficiency with 5G applications in segments like smart manufacturing, smart cities, automotive intelligent transport systems, ports, mining, and healthcare (such as telemedicine). These represent some of the emerging business areas that will benefit from the reliability, security, high data rates and low deterministic latency that come with a 5G network.

It's possible to envision the 5G network infrastructure as the foundation for supporting all aspects of the customer's daily life. More applications and services will be developed to help meet consumer demand for a worry-free life as the digital future becomes the digital today.

Network build-out to boost digitalization

The Kingdom of Saudi Arabia (KSA) is undergoing a radical, nationwide digital transformation. 5G investment and the creation of a solid infrastructure to boost coverage are key to realizing the vision of the future.

The KSA ranked second globally among the G20 countries in the Digital Riser report 2021,¹ recently issued by the European Center for Digital Competitiveness, advancing 20 ranks in the general index compared to the previous year. The report analyzed and ranked 140 countries by their digital competitiveness over the last 3 years. Based on the evaluation criteria, countries implementing public-private partnerships to foster innovation and entrepreneurship come out on top of the list. The leap in ranking reflects the ambition and progress of the KSA's strategy in developing the country's telecommunications infrastructure's digital capabilities as part of the Saudi Vision 2030 initiative.

When the Saudi Vision 2030 initiative was introduced in 2016, there was an increased governmental focus on reducing dependency on oil by diversifying the economy and developing public service sectors such as health, education, infrastructure, recreation and tourism. Several digital programs were administrated under this initiative. Among these are collaborations between service providers and the government to build solid telecommunications infrastructure as part of the National Transformation Program, one of the Saudi Vision 2030's realization programs, enhancing both the fixed and mobile network infrastructure.

The KSA is in a transitional phase where digitalization, supported by a solid network infrastructure build-out, is a national priority for the coming years. As part of this program, during 2018–2020, the digital enabler Saudi Telecom Company (stc) achieved the roll-out of high-speed fixed

broadband connections (fiber) to more than 1 million households and provided fixed wireless broadband connectivity to around 500,000 households, connecting more than 2.6 million people in 3,000 remote localities. In addition, the 4G mobile network has undergone extensive modernization and expansion to improve network performance. stc contributed to the deployment of 60,000 Wi-Fi hotspots through its collaboration with the Communications and Information Technology Commission (CITC) to serve public locations, for example, in hospitals, shopping malls and city parks, allowing users 2 hours of free access every day, to further boost digitalization in the KSA.

stc was among the first service providers in the world to launch 5G, with commercial services available since June 2019. It has deployed about 6,200 sites with 5G in 75 cities, in 56 out of 136 governorates. The deployment of 5G networks is a cornerstone of stc's strategy to improve network performance. However, when the COVID-19 pandemic hit in 2020, there was a strong increase in demand for mobile data which quickly surpassed the forecasted data traffic growth. In response, stc accelerated its 5G roll-out pace to raise network capacity and ensure continuity of services and network performance for its customers. In addition, several digital initiatives related to the health care sector – for example facilitating connections between patients and doctors, as well as managing, storing and displaying medical images remotely – were launched to support in curbing the spread of the disease.



This article was written in cooperation with stc, a market-leading digital enabler in Saudi Arabia, providing innovative digital services and platforms to customers in the MENA region.

5G network deployment strategy

stc is the largest digital enabler in the KSA, with around 20 million mobile subscriptions, earning them a market share of 40 percent. stc launched its 5G commercial services in June 2019 and currently has more than 1.5 million 5G subscribers. The network deployment has resulted in a 5G population coverage of 32 percent since the launch of commercial services, with a target of 42 percent by the end of 2022.

¹ The European Center for Digital Competitiveness, "Digital Riser report 2021", (September 2021), digital-competitiveness.eu/digitalriser.

stc's 4G subscribers have an average monthly data consumption, including all types of terminals, of 43GB, while the same for stc's 5G subscribers is 101GB. This difference is mainly due to the 5G fixed wireless access (FWA) subscribers' higher data consumption and more customers on unlimited 5G plans. Since December 2020, the number of active 5G users has grown by 12 percent monthly, and is expected to grow even faster as device vendors are increasingly promoting 5G models over the 4G ones in their portfolios.

stc's initial network deployment strategy is to extend 5G coverage throughout the KSA to:

- accelerate 5G adoption for enhanced customer experience
- address the business data usage demand while maintaining top ranking in network downlink speed performance
- enable new services and products using advanced 5G use cases and capabilities
- accelerate network innovation
- accelerate digital transformation through the build-out of a solid network infrastructure

One of the driving forces behind the 5G coverage build-out is the demand rate of mobile subscribers in the KSA to this new technology generation, which is much faster than the industry average. A precision-based 5G deployment strategy has also resulted in improved network downlink and uplink speeds. stc uses advanced analytics to identify and prioritize its 5G investment to yield maximum value and return on investment.

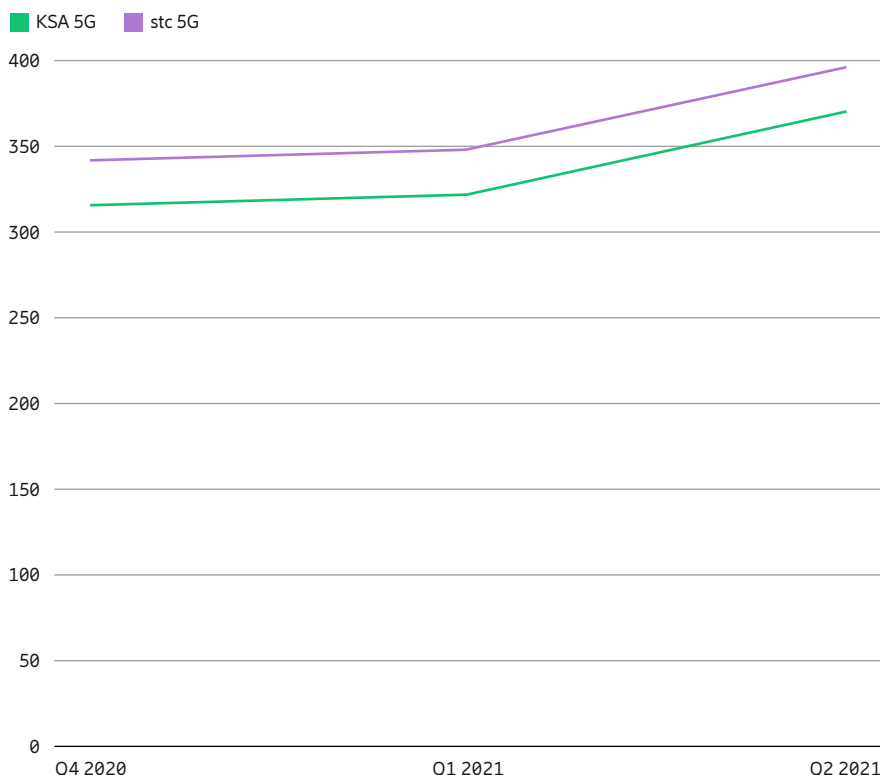
Investing in network performance

The strong focus on investing in mobile network performance has put the KSA among the top-ranked countries in mobile network speed benchmarking by external parties.² Since Q1 2020, the average mobile network downlink speed has increased by a factor of 3, rising from 56 to 147Mbps.³ In stc's mobile network, the average downlink and uplink performance is about 10 percent better than the KSA average. The average download speed using 5G throughout stc's network was 398Mbps in Q2 2021, a 14 percent increase compared to the average of 348Mbps in Q1. In the KSA, the average 5G download speed was 370Mbps in Q2 2021.⁴ The improved performance for stc is due to continuous ongoing projects for expanding, modernizing and upgrading the network with the latest technologies.

5G consumer offerings

stc currently offers a range of pre- and postpaid 5G mobile data packages, 5G FWA and 5G MiFi-packages. The 6 available postpaid 5G mobile data packages range from USD 21 for 6GB (+6GB social media) up to USD 138 for the cheapest of the 2 unlimited data packages. As a value-added service, the two unlimited packages include a subscription to a video streaming service. Additional services, such as subscriptions to app store galleries, gaming, video and audio streaming services provided by stc partners, can be directly billed on the postpaid monthly bill or prepaid credit balance. There is no price premium charged for 5G on the mobile data plans. All subscribers with a 5G-enabled device and a subscription can access the 5G network.

Figure 29: 5G network performance, average downlink speed comparison (Mbps)



The average 5G download speed in the KSA was 370Mbps in Q2 2021.

370

² See for example: opensignal.com/2021/04/15/benchmarking-the-global-5g-experience-april-2021.

³ Communications and Information Technology Commission, citc.gov.sa.

⁴ Average download speed including all service providers' data.

Closing the digital divide

An important objective with extending coverage, modernizing and optimizing stc's fixed and mobile broadband network performance is to further close the digital divide between densely populated and remote areas. The infrastructure should support flawless delivery of online services like e-education, e-government and e-commerce to consumers, enterprises and society. This is all part of stc's contribution strategy to the Saudi Vision 2030 strategic framework.

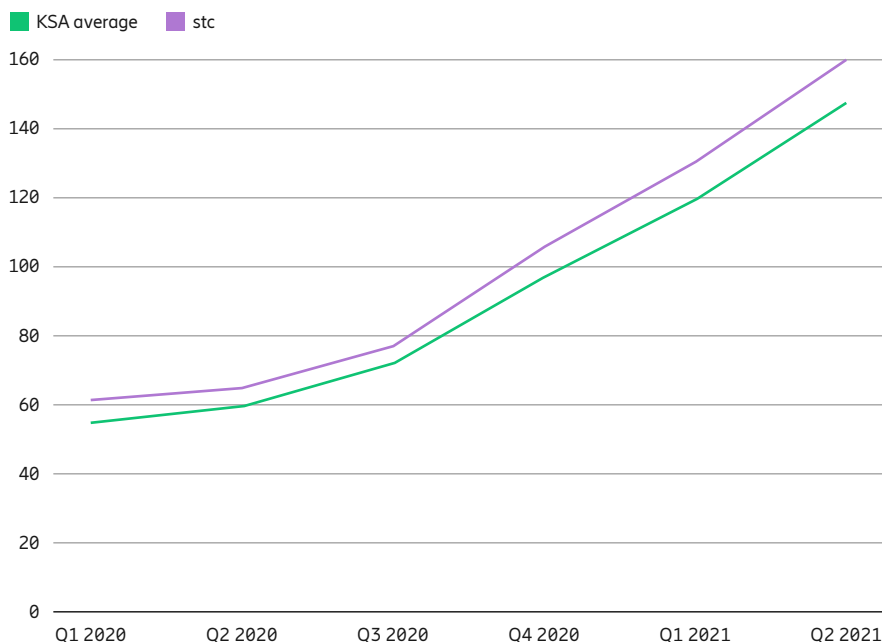
One key principle of the Saudi Vision 2030 is that access to the internet should be a basic right for all people in the KSA, regardless of personal economic conditions.

stc is working on reducing the digital divide by developing the ICT infrastructure needed to fulfill that vision. Facilitating and developing high-quality, reliable, sustainable and resilient telecommunications network infrastructure is considered essential for supporting the economic development of the society and increasing digital literacy and skills. 5G is one of the most important pillars to providing the required connectivity infrastructure for both consumers and enterprises to accelerate their digital transformation.

5G use case areas in focus

The growth of 5G mobile services plays a crucial part in the KSA's overall plan to modernize and digitize its economy. stc are currently exploring new innovative solutions and services that will make full use of the 5G network capabilities. Part of this work is about identifying new business models for entrepreneurs and enterprises that enable them to transform their business with the support of the latest network technologies and services. An innovation hub has been established in partnership with international companies to work with enterprises to co-develop solutions to accelerate innovation and digitization.

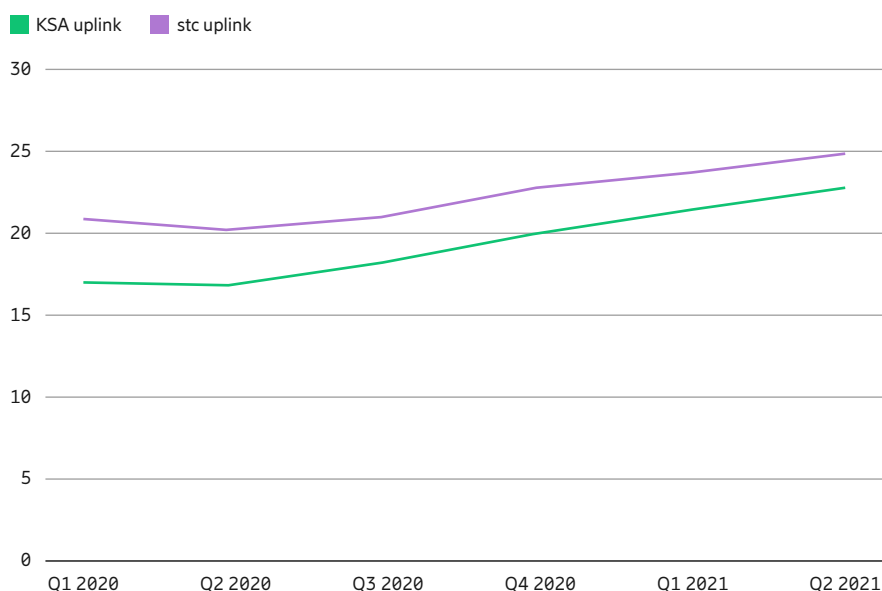
Figure 30: Mobile network performance (all technologies), average downlink speed comparison (Mbps)



Since Q1 2020, the average downlink speed in the KSA has increased by a factor of 3, rising to 147Mbps.

147

Figure 31: Mobile network performance (all technologies), average uplink speed comparison (Mbps)



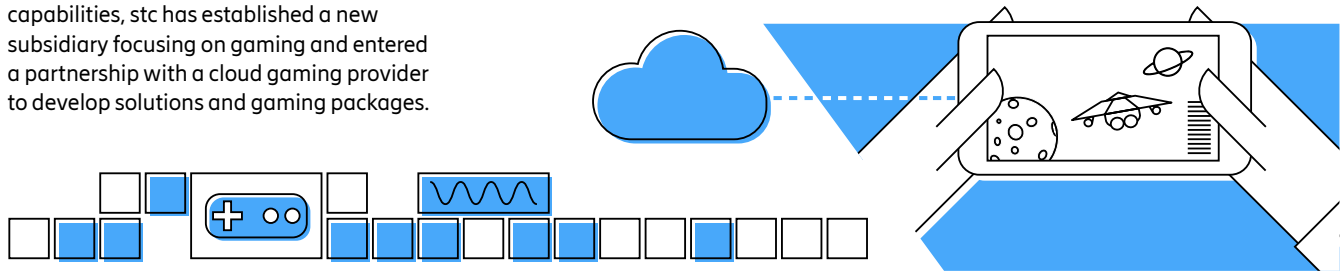
The average downlink and uplink performance in stc's mobile network is around 10 percent better than the KSA average.

10%

Use case areas in particular focus are:

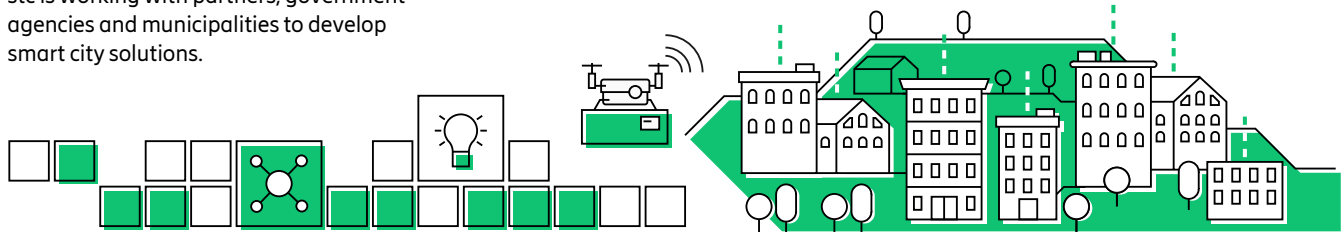
Gaming

Leveraging 5G networks' ultra-low latency capabilities, stc has established a new subsidiary focusing on gaming and entered a partnership with a cloud gaming provider to develop solutions and gaming packages.



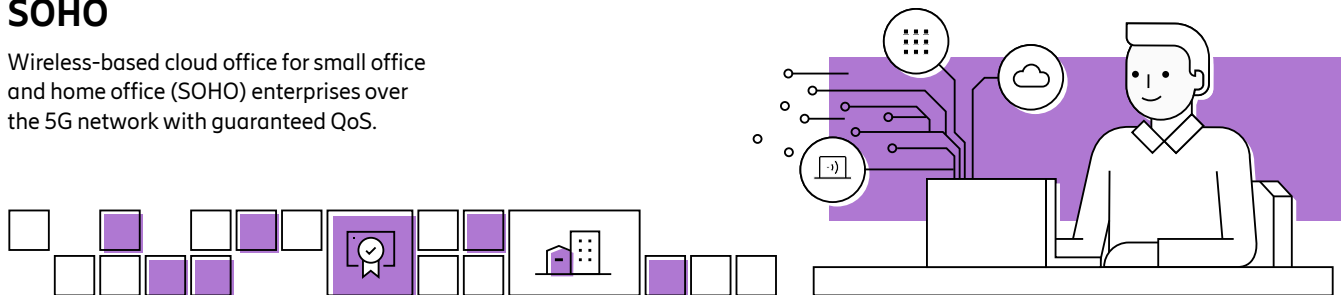
Smart cities

stc is working with partners, government agencies and municipalities to develop smart city solutions.



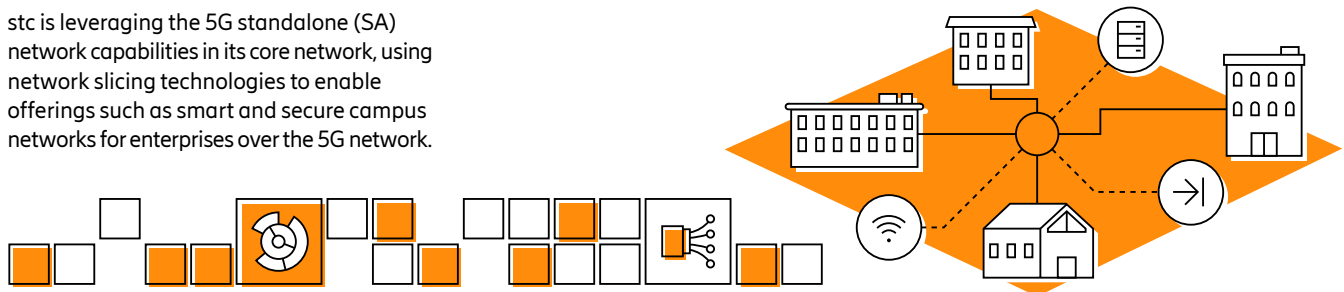
SOHO

Wireless-based cloud office for small office and home office (SOHO) enterprises over the 5G network with guaranteed QoS.



Secure campus network over 5G

stc is leveraging the 5G standalone (SA) network capabilities in its core network, using network slicing technologies to enable offerings such as smart and secure campus networks for enterprises over the 5G network.



Use case exploration will rely on the availability of high-performance networks that can immediately show value in limited proof-of-concept trials, while being ready to support upscaling to larger swathes of industries.

stc will also deploy 5G and IoT networks to support the development of NEOM, a planned cross-border city in the north-western KSA that is intended to become a model for

future sustainable cities, integrating "smart city" technologies to benefit both residents' and enterprises' daily business. The city will also host an innovation center for applications in VR, AR, smart home development, autonomous vehicles and the interaction between residents and digital infrastructure.

Time-to-content: Benchmarking network performance

Service providers are aware that a good user experience is key for driving customer satisfaction, thereby reducing churn and improving financial return. Here, we outline an objective method to measure and benchmark the network performance required for a positive user experience.

Video streaming accounts for the majority of mobile network traffic, and has naturally been a focus area for improvement. Compression techniques and adaptive mechanisms have been very effective at lowering the time-to-play and adapting to changing network conditions. But while streaming is buffered, web services place higher demands on network performance as they require instant speed. Therefore, meeting the requirements for web browsing will also satisfy the demands of many other use cases, including HD video streaming and social media.

Web services are interactive, which means that every time a user makes a choice or sends a request by clicking on a link or filling in a form it sets up a delay that directly contributes to user experience. This is different to services like video, where users tend to stay with the content for a longer period. The responsiveness of the service is measured in seconds, and while a good time-to-content (TTC) is very much subject to context and user expectations, there are scales that can be applied, such as the one defined by Google in their Core Web Vitals developer framework.¹

Web browsing versus video streaming

Webpages consist of many objects that are fetched to form a complete page. The design and type of webpages can have a substantial impact on TTC as shown in Figure 32. Moreover, web services are usually interactive with content leading to more user requests – each with its own TTC delay. This is unlike video streaming behavior, which is characterized by a request followed by a length of video played out. The interactivity and TTC for web services are what demand instant speed.

Ericsson Smartphone Lab tested webpage downloads using the Google Chrome web browser on a recently launched flagship mobile device. Google's "Largest Contentful Paint" (LCP) metric was used to determine how fast the main content of a page was rendered on the device display.

For video, the user experience is affected by both the time-to-play and avoiding stalls during play-out. Video streaming uses buffering to smooth out throughput variability.

Video is also a key element in a growing set of media that includes VR, AR and gaming. These are real-time services that generally cannot be buffered, as with most current streaming video services, so will increasingly put demands on network performance over time beyond those for web-browsing and related services. Current consensus is that these real-time applications will not be a material portion of mobile traffic before 2025.

Ericsson's Smartphone Lab study

A selection of 50 popular websites were tested using an automated lab environment. Figure 32 represents the TTC measurement for the webpages at different downlink throughput rates. The results were calculated for each throughput in a range from 1–30Mbps. The results indicated a strong relationship between available downlink throughput and the TTC.

The results indicated a decreasing TTC (y-axis) as the downlink throughput (x-axis) increased. A regression model of the downlink throughput was chosen to fit a curve that would be representative of the results. Factors used in the regression analysis, including device performance, network latency and web content size, were then projected in a model for 2025 (Figure 33).

Some sites keep their webpage content intentionally low in order to be fast-loading with a reduced dependency on factors such as throughput. However, the majority have richer content with a high dependency. By taking the 75th percentile instead of the median, throughput requirements can be determined that are representative of a large number of websites.

With a TTC scale, which grades sites on a scale of excellent (<1.5s), good (1.5–2.5s), fair (2.5–4.0s) or poor (>4.0s), we can derive the throughput that would be required to meet a certain TTC target. For example, based on the results of the 2025 model, a TTC target of below 1.5s would require a throughput of at least 20Mbps (Figure 33).

What does this mean for service providers?

Service providers can adopt this approach while optimizing their networks. Throughput measurements taken on live network data sessions, and logged on performance counters in network nodes, can be benchmarked and plotted on a scale. This will help to identify and prioritize network improvements on the cell level in order to make the biggest impact on user experience possible for any given level of network investment.

¹ Web Vitals, Essential metrics for a healthy site, web.dev/vitals.

A snapshot of the results from the Ericsson Smartphone Lab study

Figure 32: Automated lab environment website test results

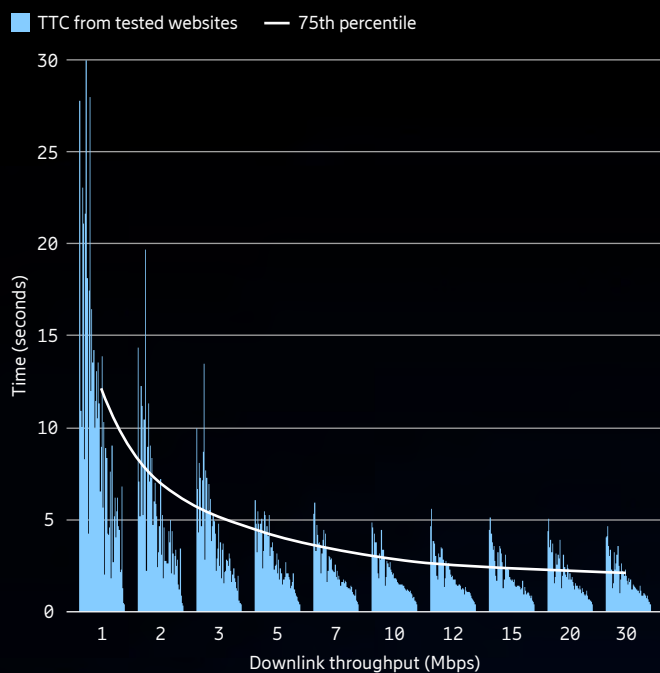
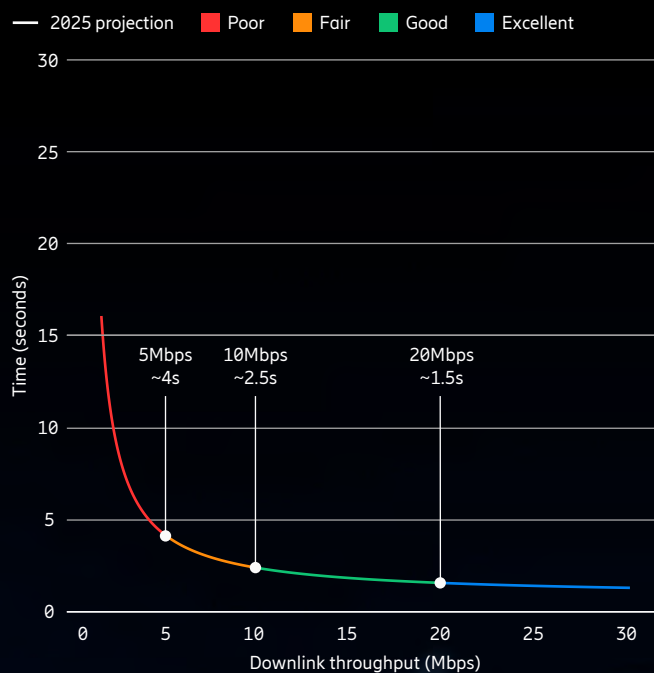


Figure 33: TTC targets for 2025 model



Building sustainable networks

287x
Mobile data traffic

Mobile data traffic is projected to grow by over 4 times to reach 288EB per month in 2027. Service providers must simultaneously reduce energy consumption to contribute towards reducing carbon emissions.

Mobile subscriptions have grown from 6 billion in 2011 to 8.1 billion in 2021, with smartphone subscriptions growing from 0.7 billion to 6.3 billion over the same period, driving traffic from just below 0.25EB per month to 65EB per month – a factor of almost 300 times. This traffic growth has been supported by an increased population coverage and multiple mobile generations running in parallel, adding the required traffic capacity.

Whilst traffic has grown exponentially over the last 10 years, service providers' global network energy consumption has risen by just 64 percent, from 91TWh to an estimated 150TWh. This illustrates that there is only a weak correlation between traffic growth and increased energy consumption. There is a stronger linkage to the deployment of new bands and equipment, reflected in increasing population coverage with multiple mobile generations.

Technological innovation rising to the challenge

Major technological innovations have enabled mobile networks to support significantly more traffic while consuming only marginally more energy. Through 5G standards and specification, new innovations are being deployed to not only continue supporting growing data demands, but to help drive down energy consumption.

The Radio Access Network (RAN) is a key focus area, as it accounts for the vast majority of the total energy consumption in mobile networks.

One innovation area supporting traffic growth is the evolution of spectrum efficiency.¹ This has significantly increased with every generation of mobile technology, including rising by 200 percent for 5G compared to 4G. This stems from modulation improvements and scale effects as bandwidths increase and are major contributors to preventing energy consumption from growing at the same rate as traffic.

When examining typical network traffic patterns, several short gaps in data transmissions can be observed, even during highly loaded times. During these gaps, power consumption is reduced by quickly putting components into sleep mode, and only activating them again before the next transmission. Longer gaps mean more components can be put to sleep, further lowering energy consumption.

In the 4G standard, the gaps where Micro Sleep and other energy-saving features can operate are very short – 0.2ms at the most. The 5G New Radio (NR) standard has been designed based on knowledge of typical traffic activity in radio networks and the need to support sleep states in radio-network equipment. This allows 5G NR to provide much better support for implementing energy-saving features.

Figure 34: 10-year growth factors

1.1x

Total ICT energy consumption (TWh)

1.6x

Mobile network energy consumption (TWh)

1.1x

3GPP population coverage (%)

1.4x

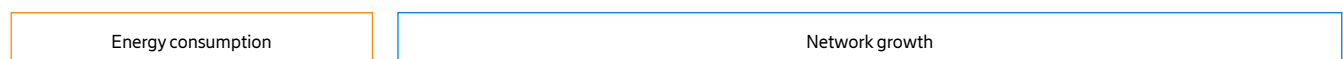
Mobile subscriptions

8.7x

Smartphone subscriptions

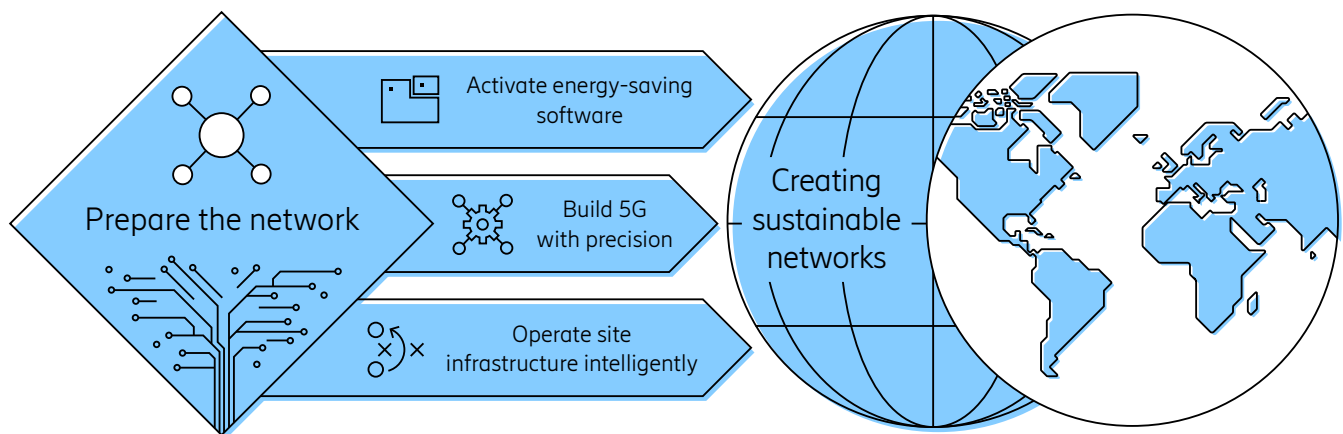
17.2x

4G population coverage



¹ "Spectrum efficiency" here refers to bits per second, per hertz, per cell (essentially, the information rate per cell over a given bandwidth).

Figure 35: A holistic approach to energy efficiency in mobile networks



The time between mandatory transmissions can be as long as 20ms in standalone mode and 160ms in non-standalone mode – 100 to 800 times longer than 4G. In addition, 5G NR requires far fewer always-on signaling transmissions in the frequency domain.

Superior radio network energy performance was an important consideration when the 5G NR standard was agreed upon. Its ultra-lean design creates new possibilities for drastically decreasing network energy consumption compared to previous generations. It also has a much higher capacity and is able to produce lower loads as a percentage of the total capacity a certain traffic volume utilizes. This, coupled with the ability for deeper and longer periods of sleep, results in the potential to significantly reduce the energy consumption of 5G NR products – eventually lowering overall network energy consumption.

A holistic approach for service providers

The deployment of every new mobile generation since 3G has led to concerns about increasing mobile network energy consumption, and 5G is no exception. There are fears that if 5G is deployed in the same way as previous generations to meet rising traffic demands, the energy consumption of mobile networks will increase dramatically. However, while historic figures show a rise in global energy consumption over time, it is not as significant as some early expectations. Utilizing efficiency gains from new mobile generations, combined with new innovative operational approaches, has been critical for keeping network energy consumption at a manageable level.

To meet the industry aspiration for net-zero carbon emissions, an approach that breaks the upward trajectory of global network energy consumption is required. Leading service providers are addressing

this challenge by applying a holistic network approach that will gradually reduce energy consumption. This is achieved by combining network modernization with new features and capabilities that can be applied in network design, build and energy-smart operations, as exemplified in Figure 35. In addition to this holistic approach, the switch to renewable energy sources is critical for achieving the overall reduction in carbon emissions.

Building 5G with precision

Having a wide range of equipment to cover different deployment scenarios enables networks to be built with precision. In order to fit in more locations, an ultra-lightweight design is used in the latest Massive MIMO radios making them smaller and more energy efficient. This was illustrated at the site level by Vodafone UK, which placed an antenna on the roof of the Speechmark – Vodafone UK's London office. The deployment of the latest antenna-integrated radio solution saw equipment's daily energy consumption drop by an average of 43 percent compared to previous generations, and by as much as 55 percent at off-peak times – all while still meeting the site's traffic demands.

A 360-degree view of an energy-efficient mobile service

A challenge for Indosat Ooredoo in Indonesia was to reduce power consumption without degrading KPIs in a highly loaded 4G residential cluster of 68 macro sites. To achieve this, they took a holistic approach, activating energy-saving software and operating the site infrastructure intelligently. The 4G energy-saving features focused on sleep modes, additionally embracing AI and data analytics for intelligent management of infrastructure across 3,000 sites. Indosat Ooredoo realized improved

operational efficiencies and achieved significant power savings whilst maintaining network KPIs.

Introducing renewable energy to mobile network sites

The switch to renewables goes beyond purchasing sustainable energy. In a decisive step towards net-zero emissions, Deutsche Telekom has brought solar power to commercial mobile broadband sites for the first time.

The 12sq m solar panels were installed at Deutsche Telekom's mobile site in Dittenheim, Germany during the second half of 2020. Throughout July 2021, they contributed an average of 14 percent to the site's overall power supply, increasing to about 83 percent between 12:00 PM and 2:00 PM. This enabled average solar energy harvesting of 11.5kWh per day in June, increasing to 15.1kWh on sunny days. Across the year, including winter, solar is forecast to contribute to about 11 percent of total RAN site energy.

Mobile networks are only part of the story

A combination of switching to renewables, modernizing equipment and fully utilizing the energy-saving capabilities of today's mobile networks can immediately make a positive difference, contributing significantly towards service providers' net-zero emissions targets.

However, the societal impact is much greater. Connectivity is an enabling technology, representing a fast, scalable tool to help address climate change. Indeed, digital technology may be the most powerful, scalable tool the world has to tackle the climate crisis. As an accelerator, it could reduce global emissions by up to 15 percent by 2030,² and indirectly support a further reduction of 35 percent through influencing consumer and business decisions and systems transformation.

² Exponential Roadmap (January 2020), exponentialroadmap.org.

Methodology

Forecast methodology

Mobile subscriptions

Rounding of figures

Subscribers

Mobile data traffic

Population coverage

Forecast methodology

Ericsson makes forecasts on a regular basis to support internal decisions and planning, as well as market communications. The forecast time horizon in the Mobility Report is six years and is moved forward one year in the November report each year. The subscription and traffic forecast baseline in this report 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 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 in two or three significant figures.

Subscribers

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

Mobile network traffic

Ericsson regularly performs traffic measurements in over 100 live networks covering all major regions of the world. These measurements form a representative base for calculating worldwide total mobile network traffic. Mobile network data traffic also includes traffic generated by FWA services. More detailed measurements are made in a selected 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.

Disclaimer

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Ericsson Mobility Visualizer

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

Find out more

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



Glossary

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

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)

5G TF: A pre-3GPP NR technical forum open specification

AI: Artificial intelligence

App: A software application that can be downloaded and run on a smartphone or tablet

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, 10¹⁸ bytes

EDGE: Enhanced Data Rates for Global Evolution

EN-DC: EUTRA-NR Dual connectivity

FDD: Frequency division duplex

GB: Gigabyte, 10⁹ bytes

Gbps: Gigabits per second

GHz: Gigahertz, 10⁹ hertz (unit of frequency)

GSA: Global mobile Suppliers Association

GSM: Global System for Mobile Communications

GSMA: GSM Association

HSPA: High speed packet access

Kbps: Kilobits per second

LTE: Long-Term Evolution

MB: Megabyte, 10⁶ bytes

Mbps: Megabits per second

MHz: Megahertz, 10⁶ 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)

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

NR: New Radio as defined by 3GPP Release 15

NR-DC: NR-NR Dual connectivity

PB: Petabyte, 10¹⁵ bytes

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

Smartphone: Mobile phone with OS capable of downloading and running “apps”, e.g. iPhones, Android OS phones, Windows phones and also Symbian and BlackBerry OS

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

Global and regional key figures

Global key figures

	2020	2021	Forecast 2027	CAGR* 2021–2027	Unit
Mobile subscriptions					
Worldwide mobile subscriptions	7,970	8,140	8,940	2%	million
• Smartphone subscriptions	5,910	6,260	7,700	3%	million
• Mobile PC, tablet and mobile router subscriptions	270	300	540	10%	million
• Mobile broadband subscriptions	6,470	6,820	8,260	3%	million
• Mobile subscriptions, GSM/EDGE-only	1,370	1,200	560	-12%	million
• Mobile subscriptions, WCDMA/HSPA	1,690	1,510	700	-12%	million
• Mobile subscriptions, LTE	4,590	4,740	3,280	-6%	million
• Mobile subscriptions, 5G	274	660	4,390	37%	million
• FWA connections	72	88	230	17%	million
Fixed broadband connections	1,250	1,320	1,650	4%	million
Mobile data traffic					
• Data traffic per smartphone	9.1	11.4	41	24%	GB/month
• Data traffic per mobile PC	16	17	26	7%	GB/month
• Data traffic per tablet	8.1	9.3	22	15%	GB/month
Total data traffic**					
Mobile data traffic	49	65	288	28%	EB/month
• Smartphones	47	63	281	28%	EB/month
• Mobile PCs and routers	0.5	0.6	2.4	24%	EB/month
• Tablets	1.1	1.3	4.1	21%	EB/month
Fixed wireless access	9.5	14.5	82	34%	EB/month
Total mobile network traffic	59	80	370	29%	EB/month
Total fixed data traffic	170	220	550	17%	EB/month

Regional key figures

	2020	2021	Forecast 2027	CAGR* 2021–2027	Unit
Mobile subscriptions					
North America	390	400	460	2%	million
Latin America	650	660	720	1%	million
Western Europe	510	510	520	0%	million
Central and Eastern Europe	560	560	560	0%	million
North East Asia	2,070	2,130	2,260	1%	million
China ¹	1,600	1,630	1,690	1%	million
South East Asia and Oceania	1,130	1,150	1,230	1%	million
India, Nepal and Bhutan	1,130	1,150	1,280	2%	million
Middle East and North Africa	710	720	830	2%	million
Gulf Cooperation Council (GCC) ²	75	76	82	1%	million
Sub-Saharan Africa	820	860	1,080	4%	million
Smartphone subscriptions					
North America	320	330	360	1%	million
Latin America	500	520	590	2%	million
Western Europe	410	400	440	1%	million
Central and Eastern Europe	390	390	430	1%	million
North East Asia	1,860	1,950	2,140	2%	million
China ¹	1,460	1,510	1,610	1%	million
South East Asia and Oceania	840	910	1,120	3%	million
India, Nepal and Bhutan	730	810	1,200	7%	million
Middle East and North Africa	420	450	620	6%	million
GCC ²	61	63	72	2%	million
Sub-Saharan Africa	440	500	800	8%	million

Regional key figures

LTE subscriptions	2020	2021	Forecast 2027	CAGR* 2021–2027	Unit
North America	340	290	40	-28%	million
Latin America	390	430	280	-7%	million
Western Europe	390	410	80	-23%	million
Central and Eastern Europe	300	340	330	-1%	million
North East Asia	1,670	1,490	590	-14%	million
China ¹	1,260	1,080	350	-17%	million
South East Asia and Oceania	470	560	560	0%	million
India, Nepal and Bhutan	680	790	710	-2%	million
Middle East and North Africa	220	260	380	6%	million
GCC ²	60	61	12	-23%	million
Sub-Saharan Africa	127	170	300	11%	million

5G subscriptions	2020	2021	Forecast 2027	CAGR* 2021–2027	Unit
North America	14	80	410	31%	million
Latin America	1	8	310	N/A	million
Western Europe	7	31	430	56%	million
Central and Eastern Europe	0	2	230	N/A	million
North East Asia	247	517	1,630	21%	million
China ¹	228	460	1,310	19%	million
South East Asia and Oceania	3	15	560	N/A	million
India, Nepal and Bhutan	0	0	500	N/A	million
Middle East and North Africa	1	10	210	N/A	million
GCC ²	1	6	65	47%	million
Sub-Saharan Africa	0	3	100	N/A	million

Data traffic per smartphone	2020	2021	Forecast 2027	CAGR* 2021–2027	Unit
North America	11.1	14.6	52	24%	GB/month
Latin America	5.9	7.9	35	28%	GB/month
Western Europe	11.2	15.2	51	23%	GB/month
Central and Eastern Europe	7.6	9.9	32	22%	GB/month
North East Asia	11.0	13.9	48	23%	GB/month
China ¹	11.4	14.5	50	23%	GB/month
South East Asia and Oceania	6.1	8.0	46	34%	GB/month
India, Nepal and Bhutan	16.1	18.4	50	18%	GB/month
Middle East and North Africa	7.0	9.6	41	27%	GB/month
GCC ²	18	22	46	13%	GB/month
Sub-Saharan Africa	2.2	2.9	11.0	25%	GB/month

Mobile data traffic	2020	2021	Forecast 2027	CAGR* 2021–2027	Unit
North America	3.7	4.9	20	26%	EB/month
Latin America	2.5	3.5	18	31%	EB/month
Western Europe	4.3	5.7	21	24%	EB/month
Central and Eastern Europe	2.4	3.1	11	24%	EB/month
North East Asia	18.3	24	93	25%	EB/month
China ¹	15.0	20	74	25%	EB/month
South East Asia and Oceania	4.7	6.5	46	39%	EB/month
India, Nepal and Bhutan	9.4	12	49	27%	EB/month
Middle East and North Africa	2.6	3.8	23	34%	EB/month
GCC ²	0.9	1.1	2.6	16%	EB/month
Sub-Saharan Africa	0.86	1.3	7.6	35%	EB/month

¹ These figures are also included in the figures for North East Asia.

² These figures are also included in the figures for Middle East and North Africa.

* CAGR is calculated on unrounded figures.

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

About Ericsson

Ericsson enables communications service providers to capture the full value of connectivity. The company's portfolio spans Networks, Digital Services, Managed Services, and Emerging Business and is designed to help our customers go digital, increase efficiency and find new revenue streams. Ericsson's investments in innovation have delivered the benefits of telephony and mobile broadband to billions of people around the world. The Ericsson stock is listed on Nasdaq Stockholm and on Nasdaq New York.

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