GSMA

The Mobile Economy North America 2024

GSMA

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Our team of analysts and experts produce regular thought-leading research reports across a range of industry topics.

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Executive summary

Driving growth and innovation

The US and Canada continue to be among the global frontrunners in 5G adoption, a testament to the significant investments by operators and the strong demand from customers for enhanced connectivity. The rollout of 5G across North America is occurring alongside a wave of mobile network innovations and technological advancements, including the rise of generative AI (genAI), the expansion of satellite capabilities and increased network API exposure. Operators and the wider mobile ecosystem see these trends as critical to unlocking innovation and generating new revenue opportunities.

5G connectivity is already emerging as a powerful driver of GDP growth, with its contribution to GDP in North America projected to exceed $210 billion by 2030, accounting for more than 15% of the region's overall mobile economic impact. Beyond GDP, the mobile ecosystem supports 2.7 million jobs (directly and indirectly) and makes a significant contribution to public-sector funding, with $130 billion raised through taxation in 2023.

Key trends shaping the mobile ecosystem

5G enters its next phase

North America continues to be a global leader in 5G. By the middle of 2024, 5G accounted for over 55% of connections in the region. 5G fixed wireless access (FWA) services have also gained significant traction, with the US reaching nearly 10 million FWA subscribers at the end of Q2 2024. With initial 5G rollouts complete, operators in the region are increasingly shifting their focus to more advanced forms of 5G to unlock new use cases and monetisation opportunities. In particular, operators have begun deploying 5G networks based on the standalone (SA) architecture and leveraging 5G-Advanced. There is also growing interest in 5G RedCap, which serves as an important enabler for mid-tier cellular IoT applications.

A new chapter begins for private wireless networks

Private wireless networks have existed for some time, but adoption had been relatively low. Thanks to evolving 4G and 5G networks, however, mobile technologies and networks can now more tightly link with enterprise needs. An improved ability to customise networks for specific enterprise use cases, facilitate greater security and enable connected machines and processes are among the many operational benefits conferred by private wireless networks. These opportunities are being explored in a range of enterprise sectors.

Momentum builds behind aerial connectivity

Telecoms networks remain the primary form of connectivity, supported by the wide area coverage of wireless networks and the mass production and adoption of mobile devices. In recent years, however, technological advances in various satellite and other non-terrestrial networks (NTNs) have helped to overcome several limitations associated with aerial connectivity. This has resulted in significant performance improvements, lower deployment costs and more commercially viable business models for satellite and NTN-based connectivity solutions.

Operators take steps to fulfil generative AI's potential

Operators in North America are adopting genAI across various domains, supporting both internal transformation and new business opportunities. Much of the focus is on deploying genAI in customer service departments to enhance employee productivity and deliver more personalised customer offers. GenAI is also being used in network management, aligning with operators' focus on improving user experience and network security. Many strategic collaborations are underway to help operators maximise the value of this new technology. However, challenges such as data privacy concerns and the shortage of skilled AI professionals remain key barriers to AI adoption.

GSMA Open Gateway gains traction

By June 2024, 53 operator groups had signed up to the GSMA Open Gateway, representing 240 mobile networks and accounting for 67% of mobile connections globally. Between the participating operators, all regions are covered; AT&T, Dish, Rogers, T-Mobile US and Verizon are among the operators in North America that have signed up to the initiative. Many of the early API launches around the world have focused on fraud prevention and security, using SIM Swap and Number Verification. These represent easy wins, given the ever-present risks from fraudsters and breaches for operators and their customers. Other parts of the API library are also being deployed, as evidenced by the work done by US operators and drone manufacturers to test the Device Status API.

Operators in North America are adopting genAI across various domains, supporting both internal transformation and new business opportunities

Policies for success

Continued mobile evolution depends on the expansion of operators' mobile spectrum holdings across low, mid- and high bands to deliver speed, capacity and geographical coverage. Additional spectrum can boost the provision of cost-efficient investment and enhance network quality in North America, which can support mobile to grow its role in regional economic development strategies.

For example, mobile networks will need on average 2 GHz of mid-band spectrum per country by 2030. In North America, that goal leaves a shortfall of almost 1 GHz beyond today's assignments, so maximising existing harmonised bands is crucial.

Meeting mid-band capacity needs is a challenge because of the sharing limitations in parts of the 3.5 GHz range and the lack of availability of the 6 GHz band for licensed mobile in the US and Canada. The launch of the US National Spectrum Strategy in November 2023, which includes the lower part of the 3.5 GHz range (3.1–3.45 GHz), was an important step as the US works to address this challenge and increase the amount of mid-band spectrum available for mobile services. This will be crucial to delivering sustainable social and industrial development.

The Mobile Economy North America

Unique mobile subscribers

2023 **332m**
82% penetration rate*

2030 **364m**
87% penetration rate*

CAGR 2023-2030 **1.4%**

*Percentage of population

Mobile internet users

2023 **313m**
78% penetration rate*

2030 **351m**
84% penetration rate*

CAGR 2023-2030 **1.6%**

*Percentage of population

SIM connections

(excluding licensed cellular IoT)

2023 **459m**
114% penetration rate*

2030 **510m**
122% penetration rate*

CAGR 2023-2030 **1.5%**

*Percentage of population

4G

Percentage of connections (excluding licensed cellular IoT)

2023 **41%**

2030 **7%**

5G

Percentage of connections (excluding licensed cellular IoT)

2023 **55%**

2030 **90%**

Smartphones

Percentage of connections

2023 **85%**

2030 **89%**

Licensed cellular IoT connections

2023 **250m**

2030 **542m**

Operator revenues and investment

2023 **$311bn**

Total revenues

2030 **$395bn**

Total revenues

Operator capex for the period 2023–2030: **$403bn**

Mobile's contribution to GDP

2023 **$1.3tn**

4.5% of GDP

2030 **$1.4tn**

Public funding

2023

$130bn

Mobile ecosystem contribution to public funding (before regulatory and spectrum fees)

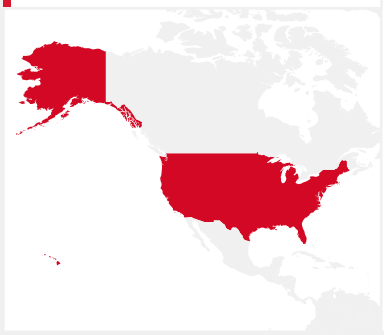
Employment

2023 **1.3m jobs**

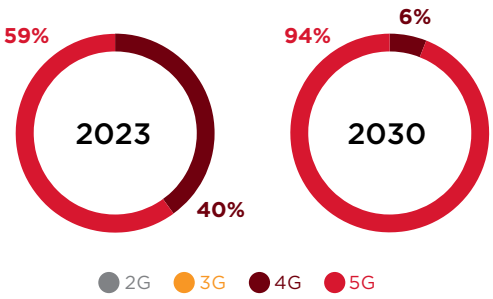
Directly supported by the mobile ecosystem

Plus 1.3m indirect jobs

US



Technology mix*



Subscriber penetration

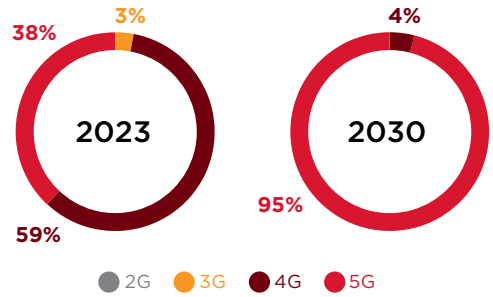
2023	85%
2030	89%

Smartphone adoption

2023	85%
2030	89%

Canada

Technology mix*



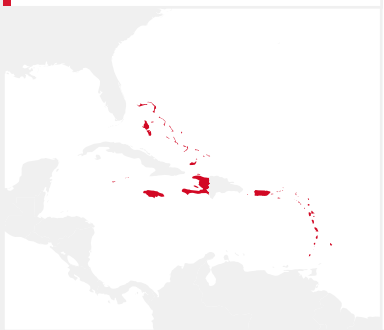
Subscriber penetration

2023	75%
2030	85%

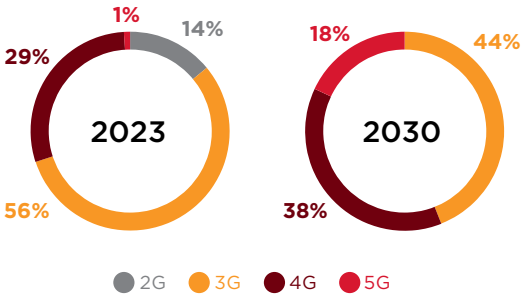
Smartphone adoption

2023	91%
2030	96%

The Caribbean



Technology mix*



Subscriber penetration

2023	61%
2030	74%

Smartphone adoption

2023	68%
2030	88%

* Percentage of total connections (excluding licensed cellular IoT)
Note: Totals may not add up due to rounding.

Defining North America

We define North America in this report as the US, Canada and the Caribbean (for Mexico, please see The Mobile Economy Latin America).

The Caribbean includes the following countries or territories: Anguilla; Antigua and Barbuda; Aruba; Bahamas; Barbados; Bermuda; Cayman Islands; Curacao; Dominica; Grenada; Guadeloupe; Haiti; Jamaica; Martinique; Montserrat; Puerto Rico; Saint Kitts and Nevis; Saint Lucia; Saint Pierre and Miquelon; Saint Vincent and the Grenadines; Trinidad and Tobago; Turks and Caicos Islands; British Virgin Islands; and the US Virgin Islands.

01

The mobile industry in numbers

The mobile internet usage gap continues to narrow

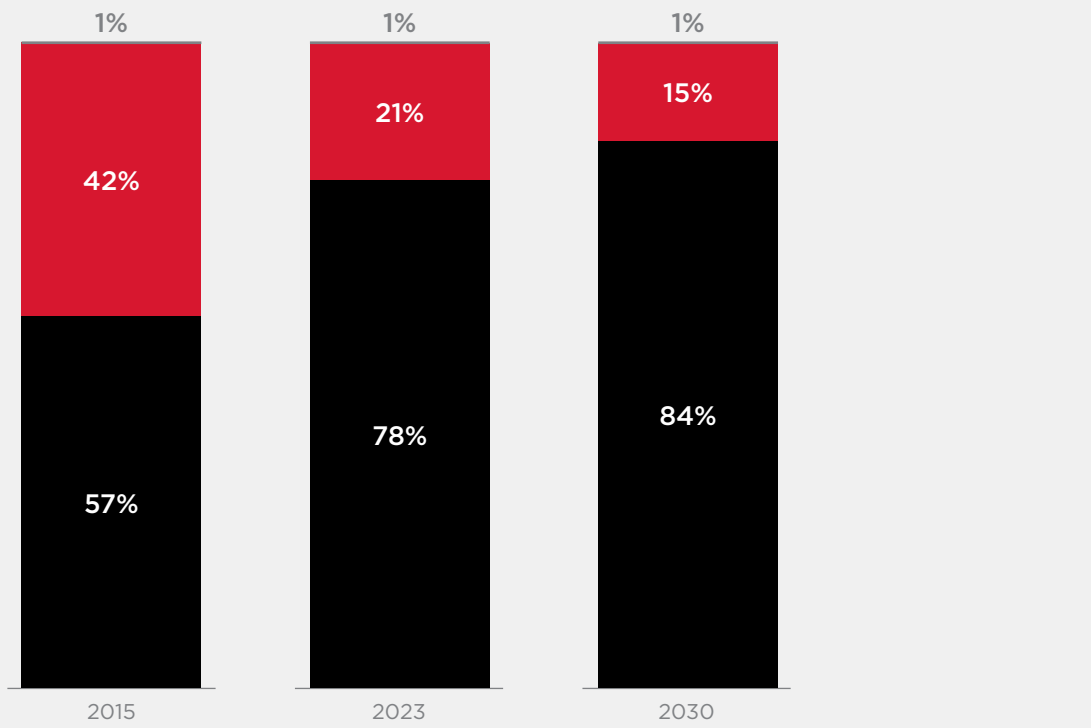
By the end of 2023, 332 million people in North America (82% of the population) subscribed to a mobile service – an increase of 70 million people since 2015. Mobile adoption will reach 87% by 2030, with 364 million people subscribing to mobile services.

Slightly more pronounced changes can be expected in mobile internet adoption. At the end of 2023, 78% of the population used mobile internet, equating to 313 million users. This figure will rise to 84%, or 351 million people, by 2030. The remaining 66 million people who do not use mobile internet will mostly be either children or older people.

Figure 1

North America: mobile internet connectivity

Percentage of population



Note: Totals may not add up due to rounding.
Source: GSMA Intelligence

5G adoption in North America will reach 60% by the end of 2024

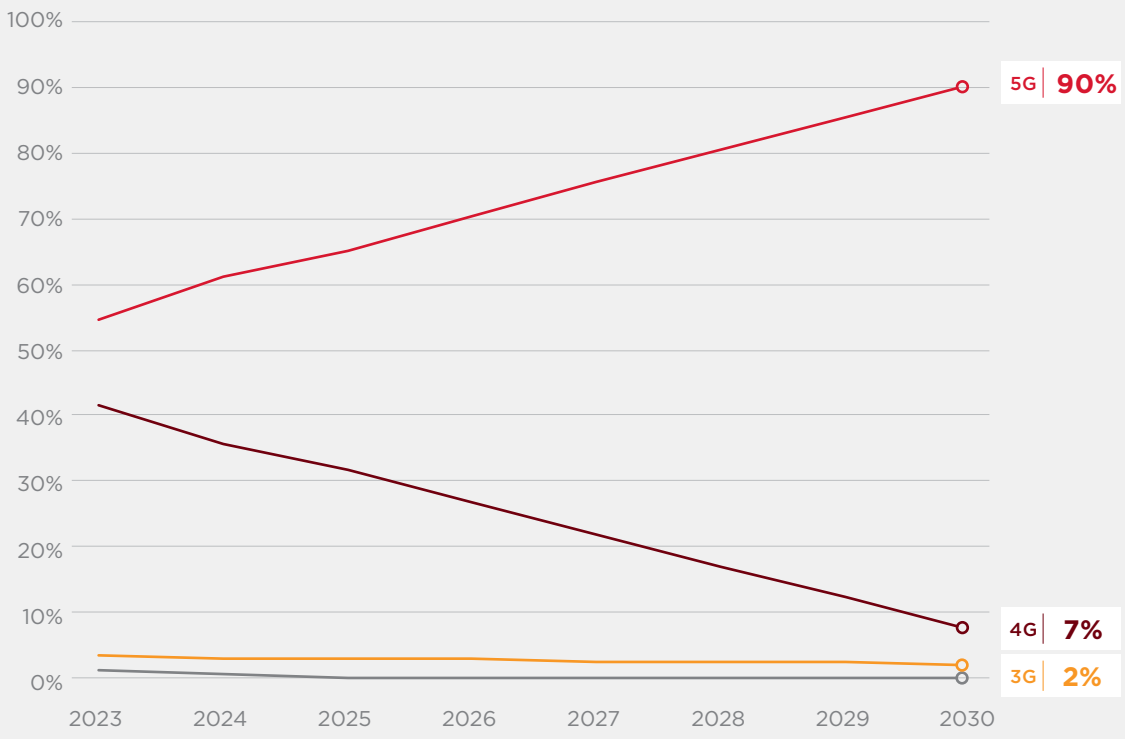
5G adoption in North America will hit 60% by the end of 2024, rising to 90% by the end of the decade. By 2030, 4G's share of total connections as a percentage will be in the single digits, while 3G adoption will hover at 2% due to the maintenance of legacy networks in the Caribbean islands.

The US is one of a small number of countries globally where both 2G and 3G sunsets have already taken place. In Canada, operators have shut down 2G networks, with 3G sunsets due to commence in 2025. These shutdowns give operators the opportunity to repurpose spectrum assets for more spectrally efficient 4G and 5G networks while also improving energy efficiency in the network (as legacy networks are less energy efficient).

Figure 2

North America: mobile adoption by technology

Percentage of total connections



Source: GSMA Intelligence

By 2030, there will be over 460 million 5G connections in North America

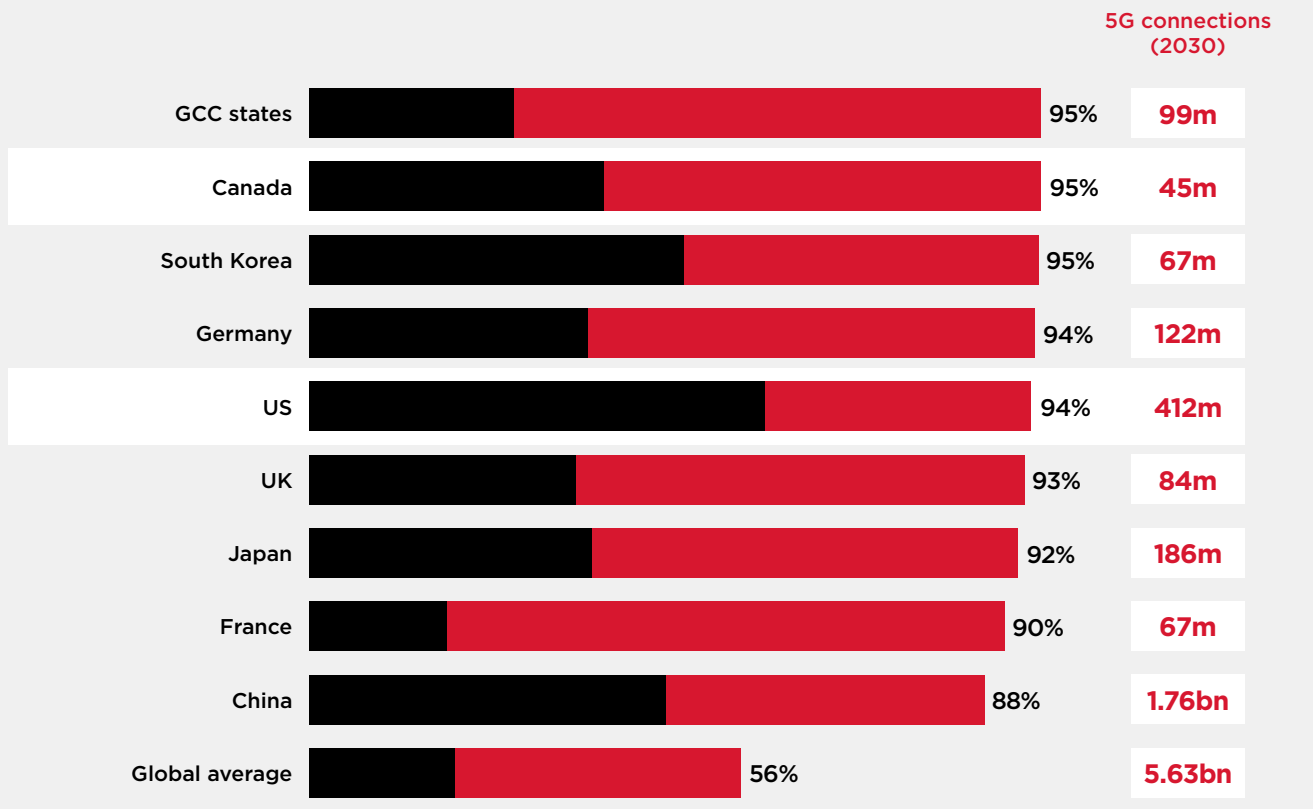
Canada and the US continue to be among the global leaders in 5G adoption, driven by the expansion of 5G coverage, intensified 5G marketing efforts and the increasing prevalence of 5G devices. To support 5G monetisation efforts, leading operators are increasing their focus on 5G SA deployment while also making plans for 5G-Advanced.

In the Caribbean, 5G will follow a slower trajectory given the prevalence of 3G services, which still account for almost 60% of mobile connections. To date, operators in Bermuda, the Cayman Islands, Martinique, Puerto Rico and the US Virgin Islands have launched commercial 5G services. With further 5G launches planned over the next few years, 5G adoption in the Caribbean will gather pace, reaching 18% (4.3 million connections) by 2030.

Figure 3

5G adoption in 2030

Percentage of total connections



Source: GSMA Intelligence

Mobile data traffic in North America will triple between 2023 and 2030

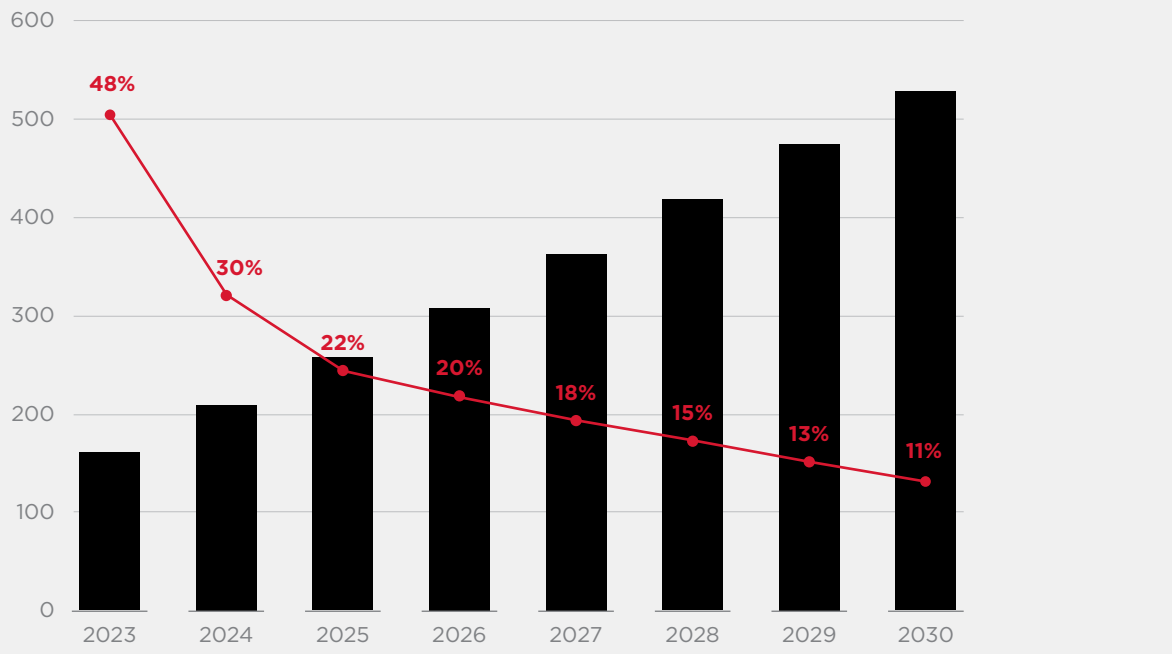
In 2023, the average monthly mobile data usage per connection in North America reached 29 GB, up from 6 GB in 2018. This has been primarily driven by the rising consumption of short-form videos on social media applications.

The rate of mobile data traffic growth is expected to moderate over the next few years, with new applications such as AR/VR and the metaverse yet to reach the mainstream. However, mobile data traffic in North America is still projected to increase threefold between the end of 2023 and 2030.

Figure 4

Mobile data traffic per connection

Exabytes (EB)



Source: GSMA Intelligence

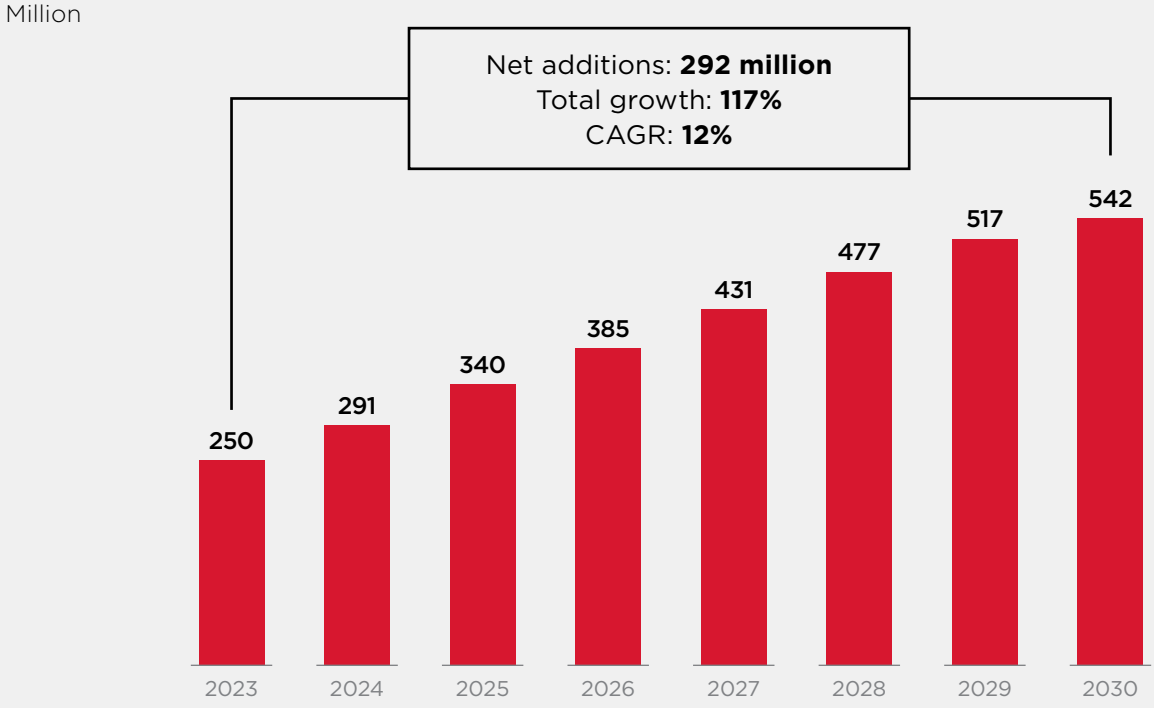
Licensed cellular IoT connections in North America will more than double between 2023 and 2030

By 2030, there will be more than 540 million licensed cellular IoT connections in North America, with the US accounting for more than 90% of these. To address the diverse needs of IoT use cases, operators will leverage a combination of connectivity options. This will help ensure optimised performance across different applications.

For example, there is growing interest among operators in 5G RedCap technology, which can serve as an important enabler for mid-tier cellular IoT applications. In June 2024, AT&T announced that it was the first US mobile operator to introduce 5G RedCap, with commercial services now available in select areas of the Dallas metro area. Other operators are likely to follow suit, with multiple 5G RedCap trials having taken place over the last 12 months.

Figure 5

North America: number of licensed cellular IoT connections



Source: GSMA Intelligence

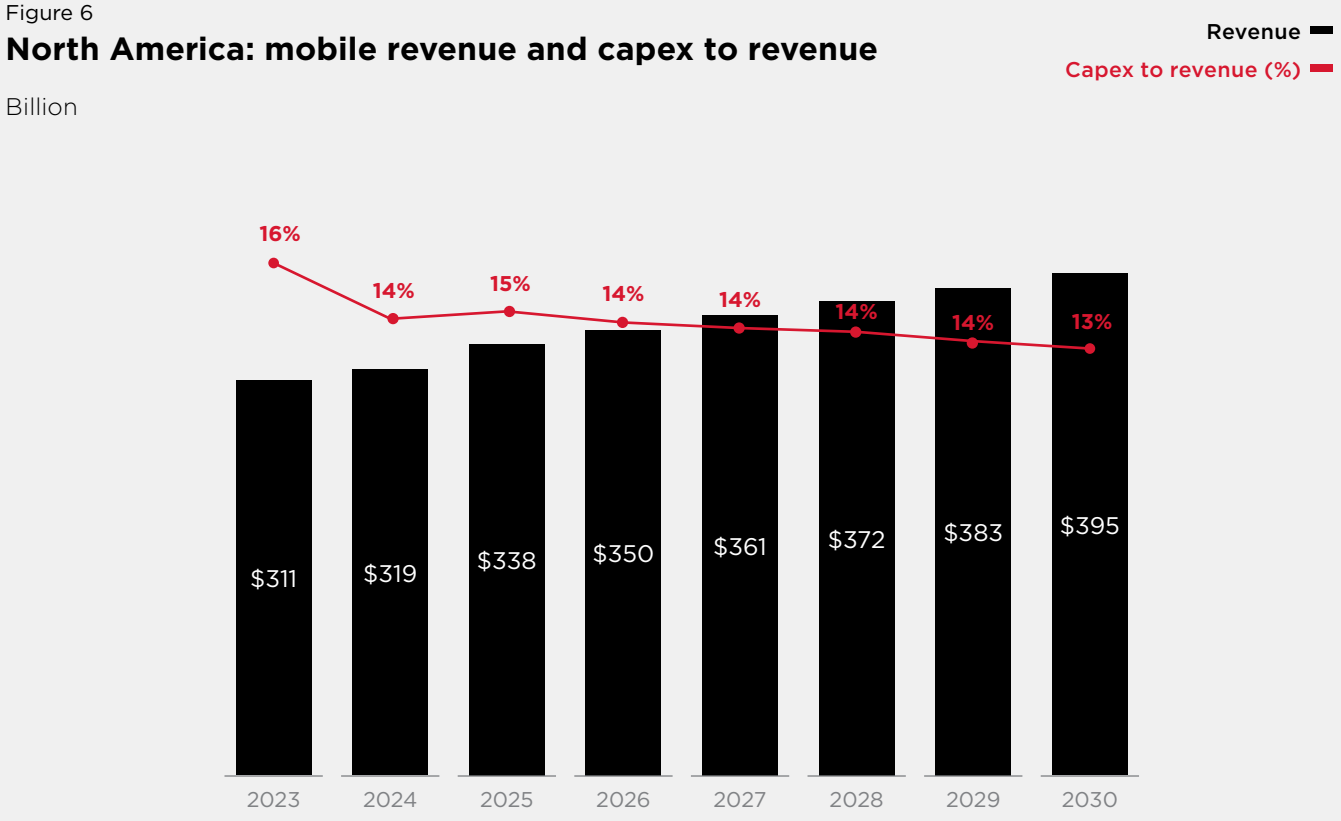
By 2030, mobile revenues will reach $395 billion in North America

For much of the past decade, mobile revenue growth has been in the low single digits in percentage terms. The introduction of 5G services has driven incremental revenues in areas such as 5G FWA and private 5G, but there is still work to be done on 5G monetisation. There will therefore be increased attention on other prospective future drivers, including genAI and network API exposure.

On the cost side, North American mobile operators have invested over $270 billion in mobile capex over the past five years, much of which has been spent on 5G networks. Mobile capex/revenue in the region was 20% at the end of 2022, likely marking the peak of the 5G investment cycle. However, mobile operator capex is still projected to surpass $45 billion in each year to 2030.

Figure 6

North America: mobile revenue and capex to revenue



Source: GSMA Intelligence

The mobile sector added $1.3 trillion of economic value to the North American economy in 2023

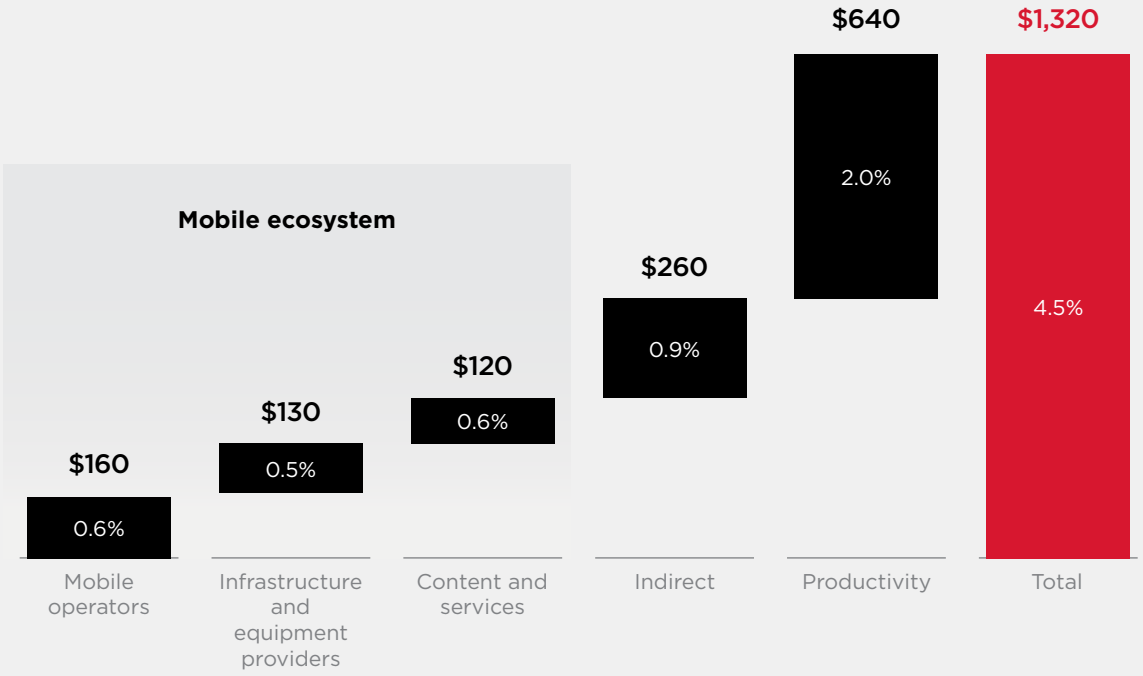
In 2023, mobile technologies and services generated 4.5% of GDP across North America, a contribution that amounted to $1.3 trillion of economic value added. The greatest benefits came from the productivity effects generated by the use of mobile services across the economy, which reached $640 billion. The direct contribution by the mobile industry ecosystem was also significant at $420 billion.

The mobile ecosystem comprises three categories: mobile operators; infrastructure and equipment providers; and content and services. The infrastructure and equipment category includes network equipment providers, device manufacturers and IoT companies. Meanwhile, the content and services category encompasses content, mobile application and service providers, distributors and retailers, and mobile cloud services.

Figure 7

North America: total economic contribution of mobile, 2023

Billion, percentage of GDP



Note: Totals may not add up due to rounding.
Source: GSMA Intelligence

At the end of the decade, mobile's economic contribution will reach $1.4 trillion

By 2030, mobile's contribution will reach $1.4 trillion in North America, driven mostly by the continued expansion of the mobile ecosystem and from verticals increasingly benefiting from the improvements in productivity and efficiency brought about by the take-up of mobile services.

Figure 8

North America: economic impact of mobile

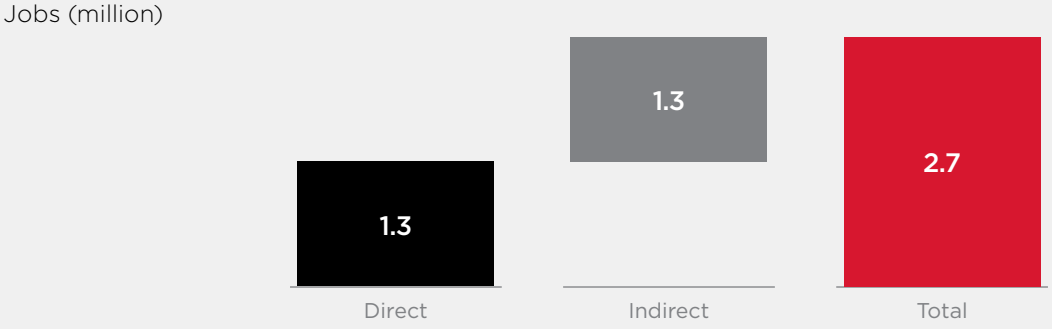
Source: GSMA Intelligence

The mobile ecosystem in North America supported 2.7 million jobs in 2023

Mobile operators and the wider mobile ecosystem provided direct employment to around 1.3 million people in North America in 2023. In addition, economic activity in the ecosystem generated more than 1.3 million jobs in other sectors, meaning roughly 2.7 million jobs were directly or indirectly supported.

Figure 9

North America: employment impact of the mobile industry, 2023



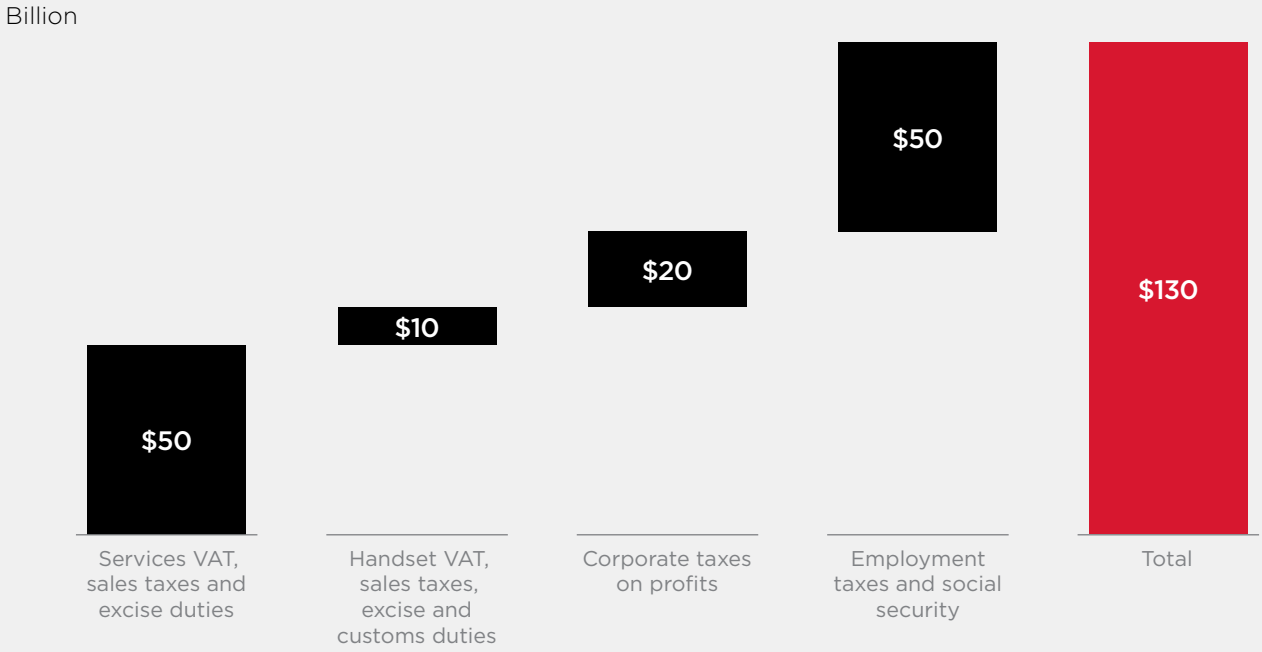
Note: Totals may not add up due to rounding.
Source: GSMA Intelligence

The fiscal contribution of the mobile ecosystem reached $130 billion in 2023

In 2023, the mobile sector in North America made a substantial contribution to the funding of the public sector, with more than $130 billion raised through taxes. The largest contribution came from services VAT, sales taxes and excise duties, which generated over $50 billion, followed by employment, taxes and social security at $50 billion.

Figure 10

North America: Fiscal contribution of the mobile industry, 2023



Source: GSMA Intelligence

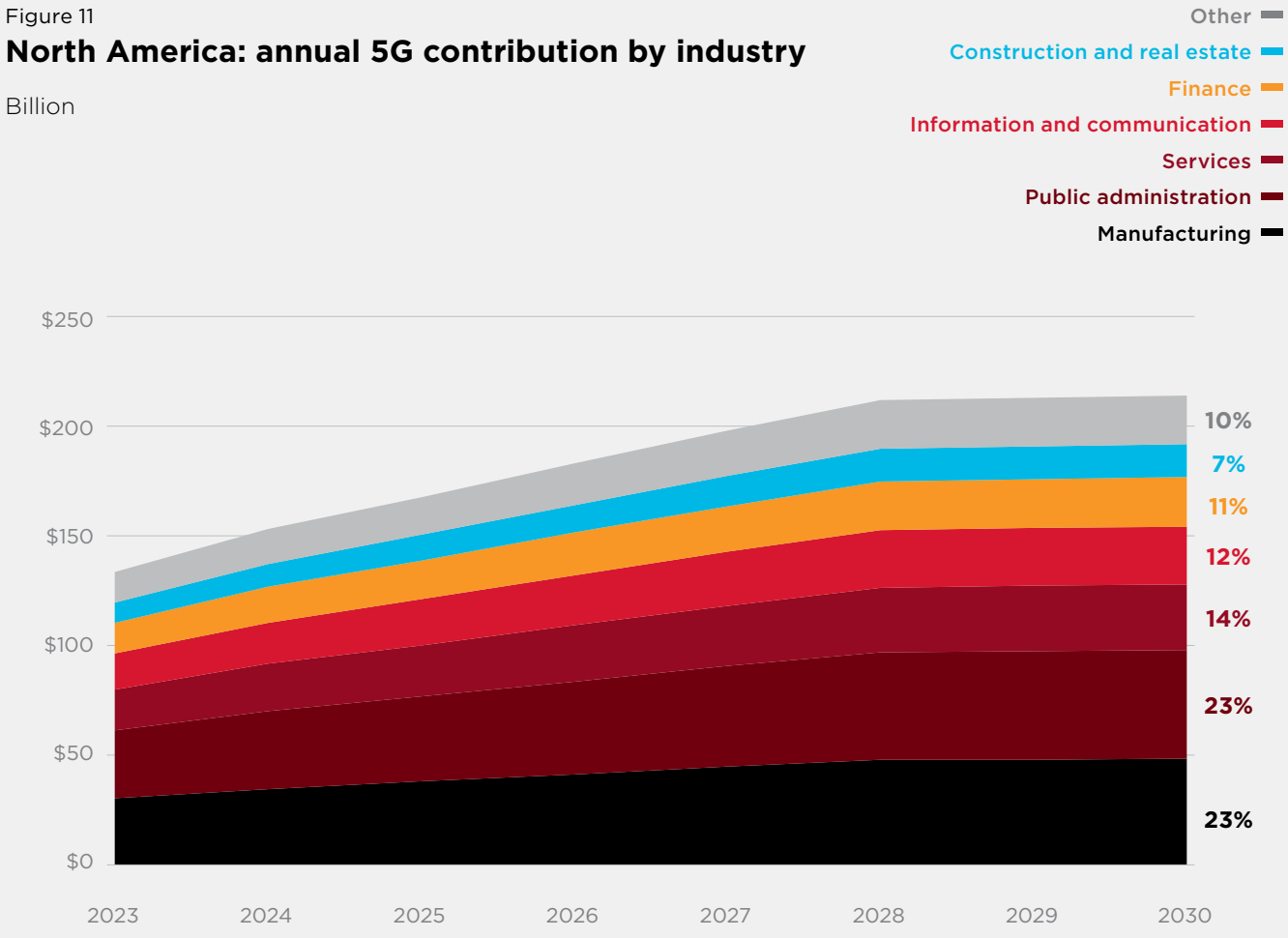
5G will add more than $210 billion to the North American economy in 2030

5G's contribution to the North American economy is expected to exceed $210 billion in 2030, accounting for more than 15% of the overall economic impact of mobile. Much of this will materialise over the next five years. Towards the end of the decade, 5G's economic benefits will level off as the technology achieves scale and adoption begins to plateau.

While 5G is expected to benefit most sectors of the North American economy, some industries will benefit more than others due to their ability to incorporate 5G use cases in their business. Between 2023 and 2030, 23% of benefits are expected to originate from the manufacturing sector, driven by applications such as smart factories, smart grids and IoT-enabled products. Other sectors that will experience significant benefits are the public administration and services sectors at 23% and 14%, respectively.

Figure 11

North America: annual 5G contribution by industry



Source: GSMA Intelligence

02

Mobile industry trends

2.1
5G's next wave: 5G standalone and 5G-Advanced come into focus

5G technology is now available in more than 100 countries around the world. As of June 2024, 295 operators in 114 countries had launched commercial 5G services. GSMA Intelligence data shows that the number of 5G connections will reach 2 billion globally by the end of 2024, accounting for nearly a quarter of total mobile connections. In several pioneer countries, notably China, South Korea and the US, 5G adoption has reached mass-market levels. In the US, for example, 5G is expected to account for nearly two thirds of total connections by the end of this year.

The US is also a global leader in the adoption of 5G FWA services. In the second quarter of 2024, the four major operators (AT&T, T-Mobile US, US Cellular and Verizon) registered over 930,000 new FWA subscriptions in total, taking the number of FWA subscriptions in the country to nearly 10 million.

Alongside the consumer market, the enterprise segment has emerged as a key growth driver. Targeted use cases of 5G FWA services to enterprises include providing point of primary connectivity for selected applications (e.g. mobile payments), connectivity for temporary sites (e.g. pop-up stores or construction zones) and back-up connectivity in case of failure of the primary fixed broadband connection. 5G FWA is particularly needed in areas where businesses have little choice of providers or where fibre connections may not be cost effective. In March 2024, for example, AT&T introduced a new 5G FWA service (Internet Air for Business) for small and medium-sized enterprises (SMEs) and large businesses.

5G SA and 5G-Advanced gain traction

Operators in the US and Canada are increasingly shifting their focus to more advanced forms of 5G to unlock new use cases and monetisation opportunities. In particular, operators have begun deploying 5G networks based on the SA architecture, which offers several capabilities, including network slicing – the flexibility of allocating network resources dynamically to specific service-level agreements.

T-Mobile US first announced the rollout of its 5G SA network in 2020, and in December 2023 it claimed it had achieved download speeds of 4.3 Gbps on a 5G SA network based on mmWave spectrum, in collaboration with Ericsson and Qualcomm. Verizon and AT&T have also stepped up efforts to deploy 5G SA networks. In January 2024, Verizon disclosed that it had begun moving commercial traffic onto its converged 5G core, which it expects to open up opportunities around network slicing and enable network efficiencies and performance improvements.

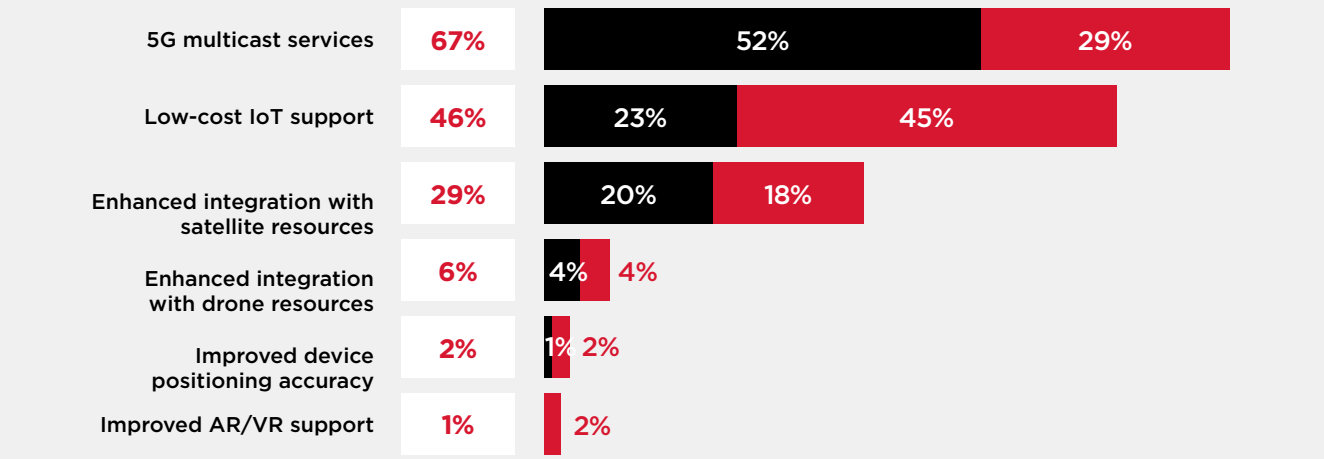
In Canada, Telus, which began its 5G SA deployment in 2020, has partnered with Ericsson to launch and optimise its 5G SA network from coast to coast. Until recently, Telus delivered 5G SA only in select locations. In February 2024, Rogers successfully conducted a nationwide live test of 5G network slicing in major Canadian cities, including Toronto, Montreal and Vancouver, on its 5G SA core network. The operator plans to utilise network slicing to create a dedicated lane for first responders and to separate fixed and mobile traffic on its national 5G network.

Beyond the deployment of 5G SA networks, operators in the US and Canada are looking to leverage 5G-Advanced technologies to deliver new solutions for consumers and enterprises. 5G-Advanced, as part of 3GPP Release 18 in 2024, is the next milestone in the 5G era and is set to enhance mobility by enabling uplink and multicast at better latency, increasing accuracy for extended reality (XR) applications and improving the reliability of AI/machine-learning data-driven designs. Insights from the GSMA Intelligence Network Transformation Survey 2023 show that 5G multicast and low-cost IoT top the list of 5G-Advanced use cases for operators.

Figure 12

5G-Advanced: priority use cases

Which 5G-Advanced use cases and applications are most important to your network transformation priorities? (Top two choices – ranked)



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

Low-cost IoT support will be a key requirement of 5G-Advanced networks

3GPP Release 17 introduced the RedCap user equipment category for energy- and cost-efficient 5G IoT connectivity (also known as 5G NR-Light). In comparison to 5G enhanced mobile broadband (eMBB) devices that can deliver gigabits per second throughput in both the downlink and uplink, RedCap devices efficiently support 150 Mbps and 50 Mbps in the downlink and uplink, respectively. The reduced complexity of RedCap devices contributes to cost efficiency, a smaller device footprint and longer battery life due to lower power consumption.

5G RedCap is therefore an important enabler for mid-tier cellular IoT applications; it serves as a platform for the successful migration of IoT applications to 5G networks in order to take advantage of the benefits of 5G beyond just speed. A range of use cases will benefit from RedCap, notably wearables, video monitoring and telematics. For example, most wearables support medium data rates in small form factors with relatively low power consumption, which is not achievable with eMBB or massive machine-type communications (mMTC). Also, many video applications for surveillance don't require eMBB's high data rates and so can benefit from the lower power consumption achievable with 5G RedCap.

In June 2024, AT&T formally launched 5G RedCap technology for IoT services, following successful trials a year earlier, with commercial services initially available in select areas of Dallas. The operator has over 120 million IoT connections and expects 5G RedCap to support use cases around smart security cameras and alarms, voice-activated sound systems, parking lot sensors, smart ambulances and remote patient care, and connected home appliances. Meanwhile, Verizon has trialled data and voice sessions over its 5G network using Ericsson's RedCap-compatible software and MediaTek's RedCap testing platform. The 5G RedCap technology will enable lower-complexity and lower-cost 5G devices, including fitness trackers, mobile medical devices and various enterprise IoT solutions.

The growing focus on 5G-Advanced and 5G RedCap will kick-start a new round of 5G investments in 2024 and beyond, and lay the foundation for the next wave of 5G use cases that could unlock new revenue streams for operators and the wider ecosystem in both the consumer and enterprise segments. More than half of respondents in the GSMA Intelligence Network Transformation Survey 2023 indicated that they plan to deploy commercial 5G-Advanced solutions and services within one year of the release of the 5G-Advanced standards.

5G development is still nascent in the Caribbean

5G is in its early stages of deployment in the Caribbean, constituting only 1% of all mobile connections at the end of 2023. The transition to 5G represents a significant opportunity for the region, considering the large socioeconomic benefits the technology can bring. However, 5G requires a significant financial outlay by operators, which is harder to justify in regions with lower mobile ARPU levels (such as the Caribbean).

Positive developments are nonetheless underway, with some countries and territories having successfully launched 5G networks. For example, 5G coverage reached 94% of the population in Puerto Rico at the end of 2023, which is comparable to coverage levels in leading countries. However, the rollout of 5G networks is limited for now to a select few islands in the region. GSMA Intelligence forecasts show that apart from Puerto Rico and the Dominican Republic, only the Bahamas, US Virgin Islands, Saint Barthélemy and Saint Martin are projected to achieve a 5G network population coverage of 50% or higher by the end of 2027.

2.2
Private wireless networks: poised for a new era

Private wireless networks have existed for some time, but adoption had been relatively low. Thanks to evolving LTE and 5G networks, however, mobile technologies and networks can now more tightly link with enterprise needs. An improved ability to customise networks for specific enterprise use cases, facilitate greater security and enable connected machines and processes are among the many operational benefits conferred by private wireless networks.[1] These opportunities are being explored in a range of enterprise sectors (see Figure 13).

Figure 13
Selected examples of private 5G deployments in the US

Sector	Location	Customer	Companies involved	Primary use case(s)
Airports	Dallas Fort Worth International Airport	Dallas Fort Worth International Airport	AT&T, Nokia, Cisco	Autonomous shuttles in parking facilities, video surveillance, asset monitoring
Defence	Joint Base Pearl Harbor-Hickam in Hawaii; Naval Air Station Whidbey Island in Washington	US Department of Defense	EchoStar, Cisco, Dell, JMA Wireless, Intel, Boingo Wireless	Autonomous vehicles, developing immersive and virtual training environments
Ports	Port of Virginia	Norfolk International Terminal	Verizon, Ericsson	Autonomous cranes and trucks, drones for safety and surveillance, push-to-talk communications
Sports	Valhalla Golf Club	PGA of America	T-Mobile US, Sony	Live video broadcast, event ticketing, video surveillance

Source: GSMA Intelligence

1. Private wireless networks: changing ecosystem dynamics and the way forward for operators, GSMA Intelligence, September 2023

Assessing the private 5G revenue opportunity for operators

Around two thirds of operators expect private wireless networks to account for 6–20% of their total enterprise revenues by 2025 (see Figure 14), reflecting optimism about the potential of private wireless networks. To meet these targets, most operators will need significant growth in their private wireless divisions, indicating a somewhat aspirational outlook. Nevertheless, the contribution of private wireless to operator enterprise revenues is expected to increase throughout the decade as awareness of private 5G and its benefits grows among enterprises.

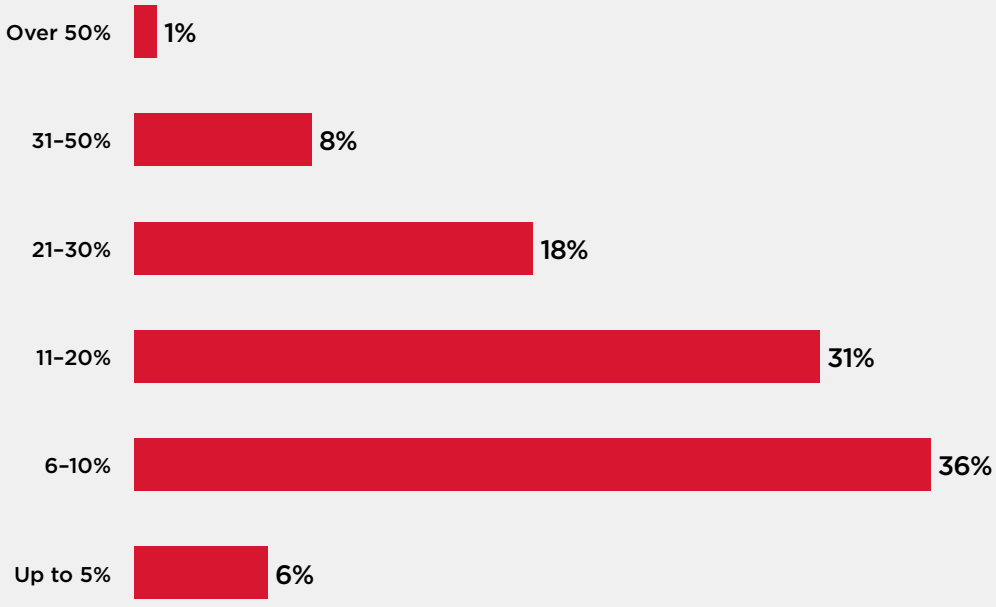
Operators expect connectivity to be the largest individual source of revenue associated with private wireless networks, accounting for around a third of private wireless revenues.[2] The focus on connectivity is not surprising since this is the core business of operators. It will also be important for operators to grow their expertise in other areas (such as initial consulting and solution design, network design and system integration) to maximise revenue from private wireless deployments.

In some cases, it will make sense for operators to form new partnerships in the private 5G space to offer a wider range of capabilities. For example, KPMG is supporting Verizon's growth in the healthcare sector by offering business and technology consulting capabilities to the end customer. Meanwhile, Bell Canada is working with IT company Meglab to target private 5G opportunities in the mining sector, leveraging Meglab's mining expertise and specialised workforce in the sector.

Figure 14

Private wireless network contribution to total enterprise revenues by 2025

Thinking about revenues for your company generated by private wireless networks, how do you expect such revenues to contribute to total enterprise revenues by 2025? (Percentage of respondents)



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

2. GSMA Intelligence Operators in Focus: Enterprise Opportunity Survey 2023

Positioning operators for sustained success in private wireless

For operators, making private networks a successful line of business and a core component of their enterprise services portfolios requires customer wins and positive customer feedback – both of which operators are already reporting. However, it also requires operators to penetrate further into the long tail of SMEs. The cost and technical understanding required to deploy and manage private wireless networks mean that uptake is still concentrated among large enterprises.

Operators should therefore develop solutions that can be more easily adopted by SMEs and offer cost efficiencies, such as relieving customers of significant upfront investments and simplifying billing relationships. Pricing can be based on size, capacity requirements and, more generally, on the consumption of network services in a way that allows customers to pick and choose features and expand at will.[3]

3. Resolving the private networks monetisation, GSMA Intelligence, August 2024

2.3
Satellite: momentum builds behind aerial connectivity

Telecoms networks remain the primary form of connectivity, supported by the wide area coverage of wireless networks and the mass production and adoption of mobile devices. In recent years, however, technological advances in various satellite and other NTNs, such as unmanned aerial vehicles (UAVs), have helped to overcome several limitations associated with aerial connectivity. This has resulted in significant performance improvements, lower deployment costs and more commercially viable business models for satellite and NTN-based connectivity solutions.

Low Earth orbit (LEO) satellite and high-altitude platform station (HAPS) providers have attracted much attention on the back of significant investments and technical breakthroughs that have improved the business case for delivering connectivity at scale. A key selling point for aerial connectivity solutions is the potential to provide ubiquitous coverage all over the globe. Telecoms networks now cover more than 95% of the world's population but less than 45% of the world's landmass. Satellites and NTNs are well suited to deliver connectivity in maritime, remote and polar areas, where deploying conventional terrestrial networks could be costly and challenging.

The 3GPP has laid the foundation for satellite-based connectivity through standardisation to extend the reach of 5G to regions lacking terrestrial infrastructure. Four broad use cases have been identified:

- **Service continuity:** For coverage where it is not feasible with terrestrial networks such as maritime or remote areas.
- **Service ubiquity:** For mission-critical communications, such as for disaster relief during outage of terrestrial networks.
- **Service scalability:** For offloading traffic from terrestrial networks to NTNs for better system efficiency.
- **Backhaul services:** For transport for sites with weak or no backhaul capacity.

Broad stakeholder interest in satellite connectivity across North America

North America is home to some of the world's leading LEO satellite providers, notably AST SpaceMobile, Lynk Global, Starlink, Telesat and Amazon's Project Kuiper. As of September 2024, SpaceX had launched over 7,000 Starlink satellites into orbit, with plans to expand this number to 12,000, and possibly as many as 42,000 in the future. While the other providers have fewer operational satellites today, some of them have announced ambitious plans to launch and operate hundreds to thousands of satellites in the future. For example, AST SpaceMobile plans to operate a constellation of 243 satellites in 16 orbital planes, while Amazon's Project Kuiper plans to launch 3,232 satellites in 98 orbital planes.

The US Federal Communications Commission (FCC) has been at the forefront of satellite and NTN regulations globally. In March 2024, the FCC adopted a licensing framework for supplemental coverage from space (SCS), which enables satellite operators to provide satellite-to-smartphone coverage to expand the reach of communications services, especially emergency services, in rural areas. The framework, which took effect on May 30 2024, allows SCS deployments in a limited number of spectrum bands, including 600, 700 and 800 MHz, and specifies rules around service quality, spectrum usage rights and harmful interference.

Other ecosystem players, notably device OEMs, have innovated on and increased investments in solutions to enable NTN-based connectivity. For example, in June 2024, Apple disclosed that it was expanding the capabilities of satellite messaging on the iPhone 14 and subsequent models by broadening the availability of the service beyond emergency messaging and making messages via satellite an option when cellular and Wi-Fi connections are not available. In February 2024, Qualcomm announced the introduction of the Snapdragon X80 5G modem, which would enhance the connectivity of smartphones and other devices to 5G and satellite networks.

A new era of telco-satellite partnerships

The emergence of LEO and HAPS solutions has ushered in a new era of collaboration between telecoms and satellite operators for solutions spanning several use cases, including remote area connectivity, disaster response and maritime services. Some examples of partnerships and other recent activities are highlighted below:

- In August 2024, **Verizon** teamed up with **Skylo** to launch a commercial direct-to-device messaging service for customers on compliant smartphones, giving them access to emergency messaging and location sharing even when a terrestrial cellular network is not available. Skylo utilises dedicated, licensed mobile satellite spectrum for connectivity that avoids network interference with terrestrial signals and ensures ubiquitous coverage in rural areas.
- SpaceX's **Starlink** and **T-Mobile** intend to launch commercial services on their satellite-to-phone offering during 2024, following an agreement announced in 2022. The service promises to connect all of T-Mobile's customers to Starlink satellites in areas where the operator does not offer terrestrial coverage, regardless of the users' phones.
- In May 2024, **AT&T** and **AST SpaceMobile** entered a definitive commercial agreement to provide a satellite-based broadband network direct to everyday mobile phones. The agreement, which builds on a previous memorandum of understanding, extends to 2030.
- In May 2024, **Verizon** announced a strategic partnership with **AST SpaceMobile** that will enable it to reach 100% coverage of the US on 850 MHz spectrum. The operator aims to eliminate dead zones and empower remote areas with satellite-based connectivity.
- In December 2023, **Rogers** and **Lynk Global** completed a satellite-to-cell call using Samsung S22 smartphones. The two companies also tested SMS, data and emergency alerting services. Rogers is also working with Starlink for a satellite-to-phone service in Canada.
- In November 2023, **Telus** announced that, in collaboration with **TerreStar** and **Skylo**, it had used satellite connectivity to conduct voice calls, send text messages between smartphones and connect to IoT devices.

For telecoms operators, satellite and NTN connectivity offers access to new customers in underserved areas and the capability to provide connectivity in remote areas. For satellite providers, operators' existing relationships with end users and, where relevant, existing spectrum holdings is crucial for satellite solutions to scale up. It is worth noting that the availability of compatible devices will contribute to the uptake of end-user satellite-enabled services, for example messaging and voice calling in emergency situations or areas without access to terrestrial networks. GSMA Intelligence estimates a total incremental revenue opportunity from satellite-to-phone services of over $30 billion for telecoms operators by 2035.

2.4
Generative AI: exploring new use cases and collaborations

Operators are increasingly adopting genAI across various areas, supporting both internal transformation and new business opportunities. Much of the early work on genAI in the mobile industry has focused on using the technology to improve customer services, such as by developing more intelligent chatbots and crafting sales scripts for call centre agents. Networks are also a key focus area, with operators evaluating the use of genAI for network coding support as well as network optimisation and predictive maintenance tools.

Driving customer engagement and network optimisation

According to a GSMA Intelligence survey, operators were testing genAI more than any other technology at the end of 2023, pointing to an intense interest in genAI and signalling that 2024 is a pivotal year for proving its value.[4] Operators in North America are increasingly leveraging genAI to automate customer services and create new revenue streams. For instance, AT&T and Verizon have started deploying advanced AI chatbots and virtual assistants powered by genAI to handle customer inquiries, troubleshoot issues and upsell services. These AI systems have the potential to improve customer satisfaction by providing instant and accurate responses while freeing up customer service employees to work on higher-value tasks.

GenAI is also helping operators to deliver more tailored customer experiences. Operators are beginning to use AI to analyse vast amounts of customer data, enabling them to offer personalised services and content recommendations. T-Mobile, for instance, is working on AI-driven platforms that can suggest customised data plans or entertainment packages based on individual user behaviour, enhancing customer engagement and loyalty.[5]

In addition to customer-facing applications, networks remain a primary genAI focus area for operators. According to the GSMA Intelligence Network Transformation Survey 2023, network troubleshooting, maintenance and threat detection are the top expected benefits from genAI, aligning with operators' strategic focus on user experience and security. For example, Verizon is exploring the use of genAI to analyse network traffic patterns in real time, allowing operators to address potential bottlenecks and improve overall service quality.

Beyond network deployment and operations, there is recognition that fully exploiting AI will require new network capabilities. The use of edge networking for AI inferencing, for example, has been suggested as a 5G monetisation opportunity for operators but one that would require new edge computing assets and management capabilities. Similarly, the launch of the AI-RAN Alliance has spurred discussion of the potential for AI to improve RAN performance as well as the use of RAN compute assets to support new AI workloads.[6]

4. Network Transformation 2023, GSMA Intelligence, November 2023
5. "T-Mobile drives AI adoption for more relevant customer interactions", Pega,
6. Launched at MWC 2024, the AI-RAN Alliance includes AWS, Arm, DeepSig, Ericsson, Microsoft, Nokia, Northeastern University, NVIDIA, Samsung, SoftBank and T-Mobile US.

Partnerships steering AI innovation

The growing use of genAI in North America is underpinned by new partnerships aimed at developing varied use cases. For example, AT&T has partnered with IBM to develop AI models that can enhance network security, improve operational efficiency and enable more sophisticated customer interactions. The collaboration will also explore how to better manage data from connected devices, particularly in the automotive sector, underscoring the potential of AI to transform mobility and telecommunications.

Similar partnerships have emerged in Canada, where Bell has been working with Microsoft Azure to explore the potential of genAI in enhancing customer service and network management. This partnership has led to the deployment of AI-powered virtual agents capable of handling complex customer queries and improving the efficiency of Bell's customer support teams. Additionally, Bell is utilising Microsoft's AI technology to analyse network data and predict equipment failures before they occur, ensuring a more reliable service for its customers.

Such partnerships are key to enhancing operators' AI capabilities and paving the way for new business models and revenue streams. But challenges remain, such as the shortage of skilled AI professionals. To support AI adoption and skills for the telecoms sector, the GSMA and IBM have jointly launched the GSMA Advance AI Training programme and the GSMA Foundry Generative AI challenge and programme, furthering genAI progress across the telecoms industry.

Ethical concerns around AI also need to be addressed. The mobile industry is committed to the ethical use of AI in its operations and customer interactions to protect customers and employees, remove any entrenched inequality and ensure that AI operates reliably and fairly for all stakeholders. The GSMA's AI Ethics Playbook[7] serves as a practical tool to help organisations consider how to ethically design, develop and deploy AI systems. Increased collaboration between policymakers can also help private-sector organisations establish appropriate AI guidelines. To support this outcome, the EU AI Office and the US AI Safety Institute recently announced they will work together on tools to evaluate AI models.

7. The AI Ethics Playbook, GSMA, 2022

2.5
Open Gateway: capturing the opportunities ahead

While it has long been possible to expose network APIs, operators have struggled to adopt a standardised approach that unlocks innovation at a global scale. This is the driving force behind the GSMA Open Gateway, which helps developers and cloud providers enhance and deploy services more quickly via single points of access to operator networks.

The GSMA Open Gateway is achieved via common, northbound service APIs that expose mobile operators' network capabilities within a consistent, interoperable and federated framework. The APIs are defined, developed and published in CAMARA, the open-source project for developers to access enhanced network capabilities, driven by the Linux Foundation in collaboration with the GSMA.

The GSMA Open Gateway comprises a library of 17 APIs. These are split into different families based on the use case being addressed. The APIs have the potential to facilitate numerous use cases, including tackling digital fraud, simplifying user authentication and addressing quality-of-service issues.

GSMA Open Gateway gains traction

By the end of June 2024, 53 operator groups had signed up to the GSMA Open Gateway, representing 245 mobile networks and accounting for 67% of mobile connections globally. Between the participating operators, all regions are covered; AT&T, Dish, Rogers, T-Mobile US and Verizon are among the operators in North America to have signed up to the initiative. This shows clear intent to establish the supply side of the API equation.

Many of the early API launches around the world have focused on fraud prevention and security, using SIM Swap and Number Verification. These represent easy wins, given the ever-present risks from fraudsters and breaches for operators and their customers. Other parts of the API library are also being deployed, as evidenced by the work done by US operators and drone manufacturers to test the Device Status API.

GSMA Open Gateway in action: operators use APIs to support drone management

The Device Status API checks the connectivity status of user equipment. The API can be used to confirm whether a device is roaming and the country it is in. It can also provide information on the connection status of a device, confirming whether it is reachable by data or SMS. The ability to access this type of information is valuable in several scenarios, ranging from supporting drone flights to identifying potentially fraudulent SIM card locations.

AT&T, T-Mobile and Verizon have each carried out tests of the Device Status API in collaboration with developers at US drone manufacturer Inspired Flight Technologies (IFT).[8] The Device Status API allows drone companies such as IFT to improve flight support and management, pinpointing where to send flyover communications and relief immediately after unexpected weather events to expedite recovery efforts. It can also help drones maintain connectivity mid-flight and allow them to be re-contacted if any technical issues are encountered.

The testing of GSMA Open Gateway APIs for drone application is likely a sign of things to come with the growing use of NTN vehicles in hard-to-reach areas and for emergency response. For operators, leveraging GSMA Open Gateway APIs can develop value-added services for drone companies, driving new revenues beyond traditional connectivity.

8. "US giants complete drone safety API trials", Mobile World Live, February 2024

North American companies are key channel partners for operator APIs

Partnerships between operators and channel partners (companies that connect multiple operators to multiple developers) will be important for operators if they are to monetise their networks at scale. North American operators are pursuing several routes to market, collaborating with hyperscalers, communications platform-as-a-service (CPaaS) suppliers and network infrastructure vendors to get their APIs in the hands of developers. Examples of channel partners are listed below:

- **AWS:** AWS has been an active GSMA Open Gateway supporter since the inception of the initiative. In a blog from early 2024, AWS noted support for the GSMA Open Gateway Device Status, Quality on Demand and Edge Discovery APIs. AWS's messaging on network APIs includes details of collaborations with T-Mobile US and Verizon.
- **Ericsson:** Eight communication APIs (aggregated) are supported through Ericsson's Vonage Global Network Platform, covering more than 28 communication channels and methods.[9] Ericsson claims nine operators are using its network APIs.[10] Notable examples include AT&T, Deutsche Telekom and Verizon.
- **Glide:** Glide announced the release of its GSMA Open Gateway API beta on Google Cloud in June 2024. This beta version exposes APIs provided by partners, including EnStream (a joint venture of Canadian operators Bell, Rogers, and Telus), integrating their network capabilities into the Glide platform on Google Cloud.
- **Microsoft:** Microsoft's Azure Programmable Connectivity (APC) currently supports the GSMA Open Gateway SIM Swap, Number Verification and Device Location APIs. Meanwhile, AT&T, Rogers and Verizon are listed among the APC partners.
- **Nokia:** Nokia's Network as Code solution supports several GSMA Open Gateway APIs, including Device Status, Number Verification, SIM Swap, Device Location Verification, Location Retrieval, Connectivity Insights and Quality on Demand. Nokia lists Dish Network among the operator customers for Network as Code.

Collaboration is key to the success of the GSMA Open Gateway. Over time, there needs to be a deeper set of engagements between operators, channel partners and developers to bring new solutions to market. It will also be important to see visible markers of progress, such as API usage and the extent to which usage is monetised.

9. GSMA Open Gateway: State of the Market, H1 2024, GSMA Intelligence, June 2024
10. Ibid.

03

Mobile industry impact

3.1
Action on climate change

North American operators are playing a leading role on climate action. Nearly all North American operators disclose their carbon impact to the CDP and have committed to climate targets. These strong ambitions are matched by action, with operational emissions per connection falling by more than 35% between 2019 and 2022, thanks in part to progress on energy efficiency and renewable energy. Moreover, mobile operators in the region collectively purchased nearly 15 TWh of renewable electricity in 2022, or around 40% of their total electricity use.[11]

One area for further progress is fleet electrification. Vehicle fleets account for a relatively high share of operational emissions in North America compared with other regions, highlighting the significant potential for emission and fuel savings from switching to electric vehicles. Government policies and incentives for fleet electrification can help operators accelerate this transition.

Enabling emission reductions

Digital technologies, including mobile connectivity, are key enablers of climate action. Several reports, including the GSMA's Enablement Effect 2019 and 2021,[12] have shown how smart and connected technologies can help reduce emissions across the economy, including in services, transportation, manufacturing and energy. North American operators continue to support digital transformation in these industries, underpinned by recent enterprise contract successes and new cross-sector collaborations, such as the following:

- **AT&T builds new solutions to tackle climate change:** AT&T and L&T Technology Services announced a strategic alliance at curbing global emissions. The collaboration aims to combine AT&T's telecoms infrastructure and L&T's engineering expertise to develop new solutions geared towards driving digital transformation for a greener future across various industries. The agreement builds on AT&T's existing collaborations focused on addressing climate change. For example, the operator works with Geotab (a fleet tracking and telematics solution provider) to develop new solutions aimed at reducing emissions in the transportation sector.
- **Verizon secures contract to modernise National Weather Service infrastructure:** Verizon has won a $78 million contract to help the National Weather Service (NWS) modernise its voice and data network. This will help support the NWS's mission-critical work by providing weather, water and climate data, forecasts, warnings and impact-based decision support services.

11. Mobile Net Zero 2024, GSMA, 2024
12. See The Enablement Effect, GSMA

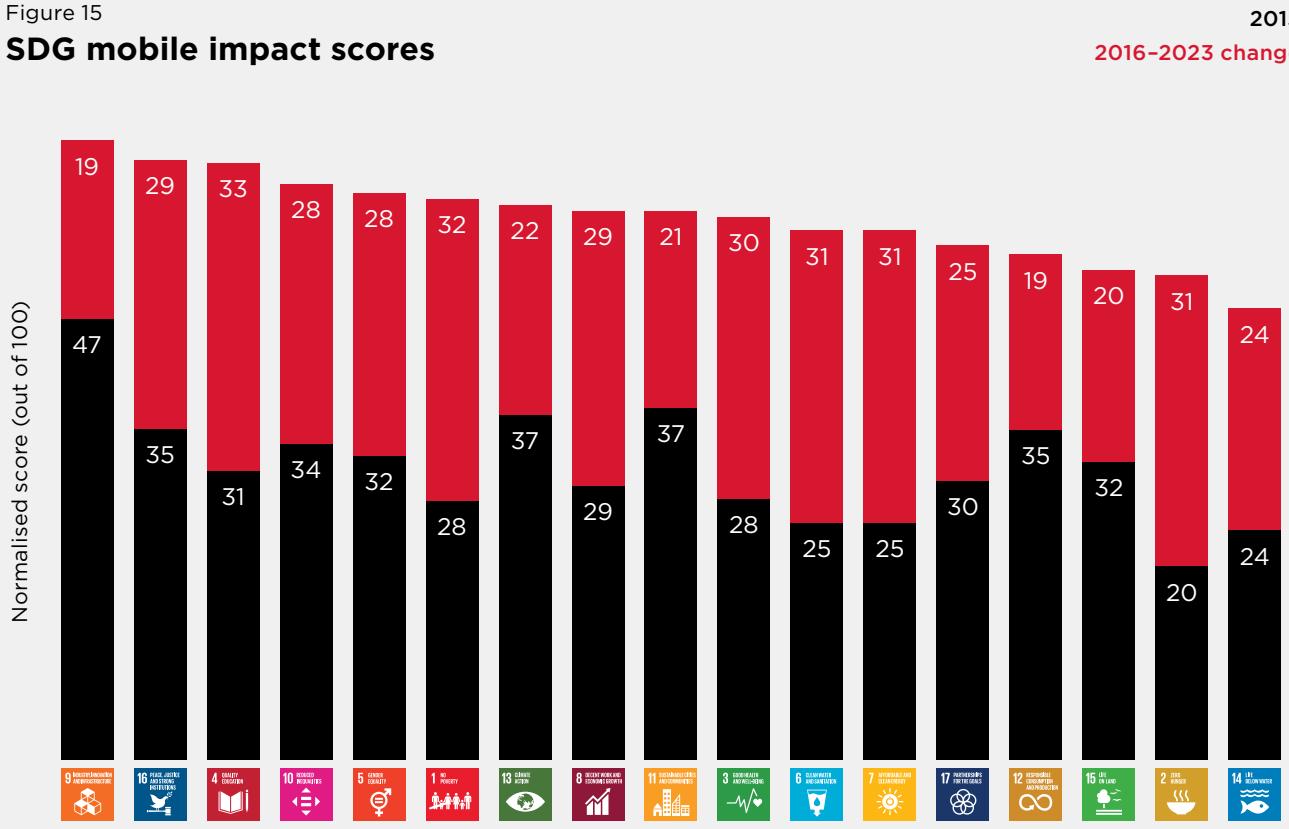
3.2
The mobile industry's impact on the SDGs

In 2016, the mobile industry became the first sector to commit to the 17 UN Sustainable Development Goals (SDGs). Each year since then, the GSMA has measured the impact of the mobile industry across all SDGs. In 2023, the average SDG impact score across the 17 goals was 58. This means the industry achieved 58% of its potential contribution to the SDGs – up from 31% in 2015.

The most recent analysis shows that the mobile industry continues to achieve its highest impact on SDG 9: Industry, Innovation and Infrastructure, driven by the increased reach of mobile networks and growing take-up of mobile internet services. Progress has also been made in reducing disparities in mobile internet adoption between different user segments, supporting the industry's contribution to SDG 5: Gender Equality and SDG 10: Reduced Inequalities.

Figure 15

SDG mobile impact scores



Source: GSMA Intelligence

Figure 16

Examples of mobile's impact on the SDGs in North America

Mobile technology contributes to SDG 2 through improvements to agricultural practices, nutritional knowledge and household food security. In North America, there is growing interest in the use of autonomous tractors, which are seen as a way to increase global food production in the face of labour shortages. Such solutions would allow farm workers to increase productivity by focusing on other tasks while the tractor readies the soil for planting.

Example: Verizon Business teamed up with Monarch Tractor, a US-based electric vehicle tractor company, to support sustainable farming practices through the use of Verizon's wireless network to enable autonomous operations for farmers. Monarch Tractor claims its driver-optional MK-V is the world's first fully electric and autonomous tractor. It uses machine learning and data analysis to improve agricultural operations by increasing labour productivity and safety measures in fields.

Mobile health solutions are playing a growing role in achieving SDG 3: Good Health and Well-being, primarily through the use of mobile technologies to provide access to health programmes and qualified practitioners. Mobile technology can also play a crucial role in specific areas such as road safety. For example, mobile operators and their partners establish the technical architecture through which data acquired by smart vehicles and related IoT traffic sensors is shared harmoniously with applications that can enhance road safety.

Example: Telus and Cisco are launching new 5G capabilities in North America to serve IoT use cases across industry verticals, with a focus on connected cars. The network will serve as a foundation to support drive testing by a major North American automotive manufacturer's 5G Connected Car while setting the stage for enhanced experiences for customers and revenue opportunities for carmakers. Telus expects to onboard more than 1.5 million 5G SA connected cars onto the Cisco IoT Control Center over the next several years, starting from 2024.

Mobile technology contributes to SDG 4: Quality Education, which seeks to ensure inclusive and equitable quality education and to promote lifelong learning opportunities for all. The increasing adoption of digital technologies can drive improvements in the quality and accessibility of education. One such example is the rollout of new interactive technologies that have the potential to boost student engagement with learning materials.

Example: T-Mobile is working with Prisms VR, a learning platform pioneering a new paradigm for maths education, and Lenawee Intermediary School District. The organisations have deployed Prisms VR's learning programmes on Meta Quest 2 VR headsets connected to T-Mobile's 5G network across 11 school districts in rural Michigan.

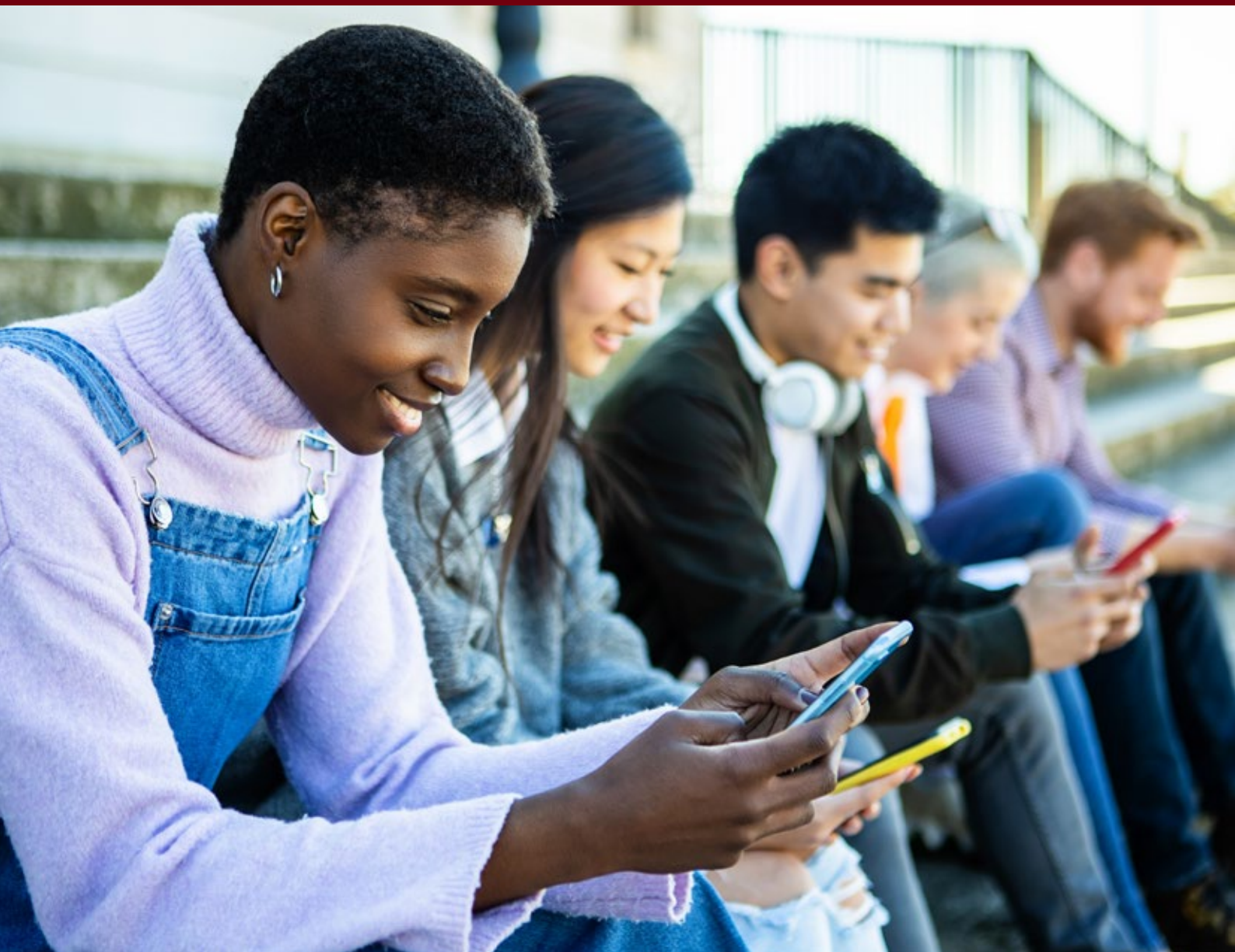
SDG 6: Clean Water and Sanitation aims to ensure the availability and sustainable management of water and sanitation for all. One of the key challenges faced by the utility industry is effective water management and minimising wastage due to leakages. Connectivity leveraged by AI and IoT solutions are instrumental in addressing these challenges by enabling the automatic detection and analysis of water quality and quantity. These technologies facilitate real-time monitoring and data-driven decision-making, helping the industry achieve more efficient and sustainable water management practices.

Example: T-Mobile is working with Bradley University to deploy a 5G network to deliver innovative learning experiences for students while also exploring how 5G connectivity can be used to increase operational efficiencies on its campus. For example, Bradley plans to use sensor-based data analysis to get automatic updates on information such as water quality, leak detection or refrigeration issues and use that data to automatically address any malfunctions.

Source: GSMA Intelligence

04

Mobile industry enablers



4.1
Spectrum availability as a driver of connectivity

North America continues to be a leader in 5G development. Strengthened by the use of the 3.5 GHz band and bolstered by further spectrum assignments, 5G connectivity is already proving to be a powerful driver of innovation and GDP growth. In 2030, 5G's contribution to GDP is expected to surpass $210 billion in the region.

Continued mobile evolution depends on the expansion of operators' mobile spectrum holdings across low, mid- and high bands to deliver speed, capacity and geographical coverage. Additional spectrum can boost the provision of cost-efficient investment and enhance network quality in North America, which can support mobile to grow its role in regional economic development strategies.

Low-band spectrum

Low-band spectrum helps deliver widespread and affordable connectivity and is therefore an important building block for digital equality. Increased sub-1 GHz spectrum is essential to building coverage in thinly populated areas and supporting indoor coverage in built-up and hard-to-reach urban areas.

Rural connectivity challenges in North America continue to be met with the appropriate low-band spectrum. In the US and Canada, the 600 MHz band is already used for mobile (band n71) with 2x35 MHz and this spectrum is being used to enhance rural broadband. Adding 600 MHz to existing low bands is shown to raise download speeds by 30–50% in rural areas.

Mid-band spectrum

Mid-band spectrum can play a central role in sustainable social and industrial development, but ensuring sufficient spectrum is available is important – mobile networks will need on average 2 GHz of mid-band spectrum per country by 2030.

In North America, that goal leaves a shortfall of almost 1 GHz beyond today's assignments, so maximising existing harmonised bands is crucial. Meeting mid-band capacity needs is a challenge due to the sharing limitations in parts of the 3.5 GHz range and the lack of availability of the 6 GHz band for licensed mobile in the US and Canada. The launch of the US National Spectrum Strategy in November 2023, which includes the lower part of the 3.5 GHz range (3.1–3.45 GHz), was an important step as the US works to address this challenge and increase the amount of mid-band spectrum available for mobile services.

Access to more exclusively licensed spectrum, operating at harmonised, full-power limits, is crucial in the region. Licensed spectrum provides certainty, incentivises investment and gives the predictability needed for US mobile operators to continue being leaders in 5G development.

High-band spectrum

mmWave frequencies help realise the full potential of 5G by enabling very fast download speeds, huge capacity and the lowest latencies. North America has been a pioneer on mmWave spectrum assignments, and this leadership has paid off, expanding to other bands and unlocking additional possibilities. mmWave spectrum is essential for peak performance.

According to a report by the GSMA, 5 GHz of mmWave spectrum is required per mature market for enhanced mobile broadband, FWA and enterprise applications. Successful and effective mmWave spectrum assignments are therefore important to ensure 5G achieves its true potential in terms of performance and socioeconomic impact.

4.2
WRC offers a pathway to the future of connectivity

The ITU's World Radiocommunication Conference 2023 (WRC-23) opened the doors to a new era of connectivity and laid the spectrum foundations for mobile to progress into 5G-Advanced and 6G.

In mid-bands, WRC-23 took action to meet mobile data growth by identifying additional spectrum for mobile. Final harmonisation of the 3.5 GHz band (3.3–3.8 GHz) – the pioneer 5G band – was achieved across Europe, the Middle East and Africa (EMEA) and throughout the Americas.

WRC-23 also identified 6 GHz (6.425–7.125 GHz) for mobile use by countries in every ITU Region – EMEA, CIS, the Americas and Asia Pacific – and global, harmonised conditions for its use have been agreed in the ITU's Radio Regulations. This brings together billions of people into a harmonised 6 GHz mobile footprint. It also serves as a critical developmental trigger for manufacturers of the 6 GHz equipment ecosystem.

However, the full 6 GHz band is unlicensed in the US and Canada. Its identification elsewhere gives countries that plan to use macro-cell licensed 6 GHz a more robust spectrum roadmap than those in the North America region.

Looking ahead to WRC-27

The next WRC, to be held in 2027, will be a critical event for North America due to the lack of 6 GHz spectrum assigned to licensed mobile services in the region. WRC-27 will discuss further spectrum bands, including 4.4–4.8 GHz, 7.125–8.4 GHz and 14.8–15.35 GHz.

The inclusion of the 7–8 GHz band in the National Spectrum Strategy is an opportunity for the US to take the lead on its development and drive harmonisation ahead of WRC-27. To succeed, stakeholders must work collaboratively to investigate all options.

Mobile evolution in the 2030s promises an era of meaningful universal connectivity – ensuring everyone is connected everywhere. One element of this is ensuring affordability is maximised with the right capacity placed in long-term spectrum roadmaps, in harmonised bands secured at WRCs. WRC-27 will also seek to further integrate terrestrial mobile with NTNs, an element that has been worked on in the last two WRC cycles with the harmonised integration of high-altitude platforms into mobile. WRC-27 will consider network elements still further from Earth with the possible development of satellite integration into mobile networks that will support wider coverage in unconnected areas, such as uninhabited zones.

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