Realising 5G's full potential: Setting policies for success

March 2020

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Executive Summary

The transition to 5G mobile technology is here. Telecom operators around the world are rolling out networks. But while early indications show lots of momentum, further investments in network capabilities are required to establish the ubiquity, reliability, throughput, and latency that will unlock the full value of 5G. As things stand today, these investments will likely be deferred until there are tangible signs that the revenue growth required to sustain necessary capex levels can be achieved. The industry, its customers, and society could miss out on substantial economic and social value.

There has been a lot of progress, but it is uneven. Auctions for 5G spectrum are well underway globally. But operators have focused their available capital on investments that promise the largest and quickest returns and that protect and strengthen their core businesses, typically pursuing deployments in the 3 GHz spectrum band in cities combined with coverage deployments in lower spectrum bands.

Consumers so far are receptive. The frontrunner in global 5G deployment, South Korea, is on track to reach 12 million 5G subscribers in 2020 and 36 million—or 90% penetration—by 2026. All three major South Korean operators also have reversed declining average-revenue-per-user trends.

But, just about everywhere, the business case contains multiple challenges. The major hurdles are the monetisation of 5G investments for operators and ensuring sufficient infrastructure investment and deployment to meet the full 5G vision for both B2B and B2C uses. At the moment, the lack of clear ROI for operators hinders the case for the infrastructure investment necessary to accelerate full 5G deployment.

To quantify the amount of additional 5G investments a typical operator needs to make, BCG ran simulations using its proprietary geo-based simulation software and representative network operator data. The 5G base case assumes capital expenditures are primarily driven by the need for capacity extension from increasing traffic. In subsequent scenarios, we factor in the addition of key infrastructure components required to further boost capacity, extend 5G coverage, reduce latency, and increase reliability to full 5G levels. For the base case, our simulations show that capex can be kept roughly at pre-5G levels, requiring only about a 10% increase between now and 2027. When we add the requirements of the incremental scenarios, however, we found that enabling the full 5G vision will require approximately 2.4 times the capital expenditures of the base case over the course of the simulation period.

Mobile network operators need to both tap new sources of revenue growth and optimise their cost structure to meet the substantial increase in investment required to bring the full socio-economic vision for 5G to life. Operators need to think more innovatively about how they build a B2C case for their 5G offerings. They also have multiple opportunities to identify promising B2B verticals and find partners that can help deliver high-value, data-centric products or services to be distributed over the 5G network

As the industry explores opportunities for creating new revenue streams and optimising infrastructure, policy makers and regulators must also play a critical role in unlocking the potential of 5G. Striking a balance between incentivising competition with keeping prices low for consumers and supporting industry investment in next generation infrastructure is critical. In many markets, current policy and regulations still inhibit investment in advanced mobile infrastructure. While we have seen material progress in many areas in the last few years, a continuation of the current pace of regulatory change will not enable the industry to realise the 5G vision.

In the past, we have identified six regulatory levers that can foster infrastructure investment: making additional affordable spectrum available, facilitating access to site locations, enabling small cell deployment, facilitating deployment of backhaul, permitting the freedom to establish network sharing agreements, and harmonizing power density limits. Governments around the world have taken concerted steps in most of these. But they will need to do more to stimulate full 5G deployment. There are also two additional areas in which action by policy makers and regulators can spur the rollout of 5G: providing adequate subsidies for deployments, and providing regulatory flexibility for vertical partnerships. Seizing the full macroeconomic opportunity of 5G requires concerted commitments from policy makers and the industry in all of these areas.

Introduction

Network operators around the world are rolling out 5G networks. A new era of high data rates, massive connectivity and ultra-low latency, enabling everything from remote health care to autonomous driving to the Internet of Things (IoT), is here.

That's the promise. The facts point to a more uncertain future. While early indications show lots of momentum, further investments in network capabilities are required to meet the needs of ubiquity, reliability, throughput, and latency required to unlock the full value of 5G. New network infrastructure can so far be found mainly in major cities. Few B2C or B2B uses have gained significant traction. Despite continuing progress, further actions are required to accelerate 5G deployments.

5G technology promises vast socio-economic benefits. Leaders from all parts of the digital ecosystem—network operators and vendors, technology firms, and policy makers—have long heralded the potential. Ultra-low latency and high reliability will provide dramatic improvement in user experience for consumers, entirely new businesses built on IoT, and new life-saving capabilities—even remote robotic surgery. It is likely that 5G will lead to entirely new uses that we cannot envision today. A recent report by the GSMA and TMG estimates the total economic impact of 5G on global GDP could reach $2.2 trillion by 2034.[1]

Against this backdrop, BCG has undertaken an analysis for the GSMA, including the current state of 5G deployment and the path for the future. The clear conclusion: while progress to date is encouraging and offers several lessons, further incentives and actions are required to accelerate mobile industry investments in 5G infrastructure. Current indications are that network operators will hold to their current capital expenditure trajectories, which support continued traffic growth at the same revenue levels. Investments to deliver the full 5G vision will likely be deferred until there are tangible signs that the revenue growth required to sustain such capex levels can be achieved. The industry, its customers, and society could miss out on substantial economic and social value. This risk can either be increased or mitigated with specific policy and regulatory moves.

In this report, we examine the requirements to capture the full value of high-quality mobile connectivity promised by 5G and how to accelerate network investments within appropriately adjusted regulatory frameworks and policies. We hope this will help industry leaders and policy makers to surmount the hurdles and accelerate the rollout of 5G for the benefit of consumers, businesses, and countries worldwide.

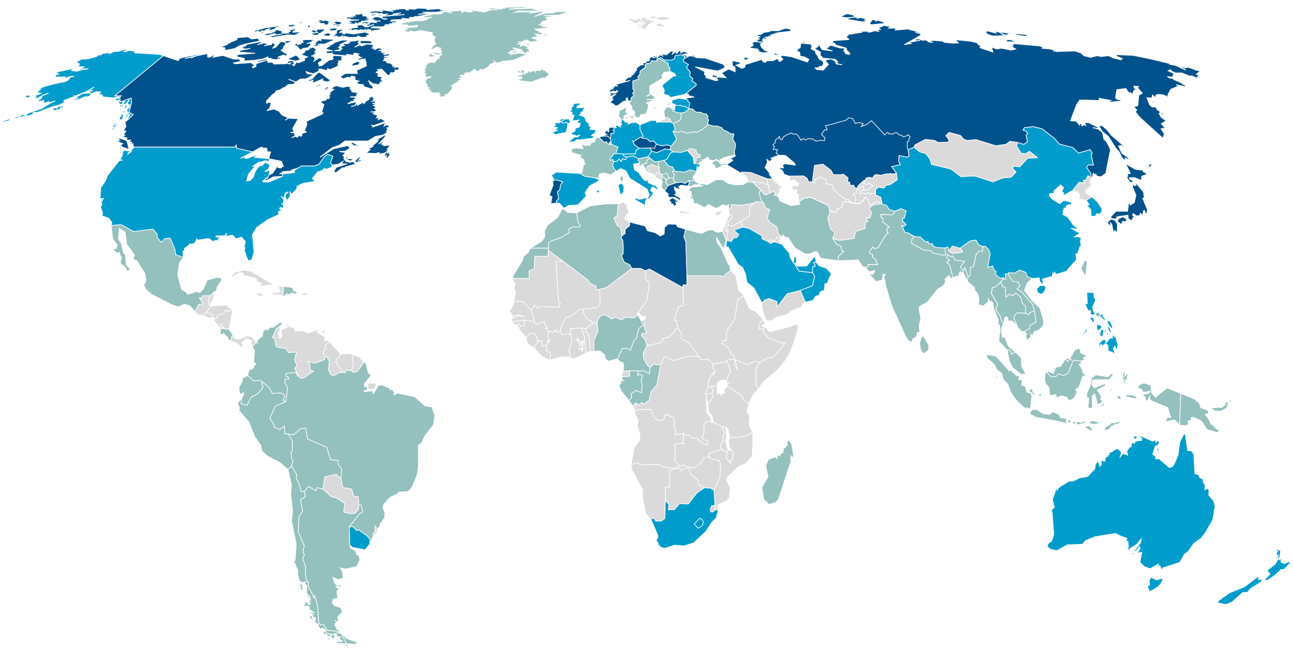
1. Source: https://www.gsma.com/spectrum/wp-content/uploads/2019/10/mmWave-5G-benefits.pdf

Progress So Far

The transition from 4G to 5G is well underway and picking up speed. In fact, the 5G revolution is happening faster than the transition to any previous access technology. Operators around the world are investing in spectrum and next-generation mobile network infrastructure. (See Exhibit 1.) At the time of writing this report, 348 operators in 119 countries have made some sort of investment in 5G, 77 operators have deployed 5G technology in their networks and 49 have launched a commercial service compliant with the 3GPP standard.[2]

EXHIBIT 1

5G INVESTMENT AND LAUNCHES AROUND THE WORLD AS OF DECEMBER 2019



Launched 5G

Actively deploying 5G

Investing in 5G tests and trials

2. Source: GSA, January 2020, "5G Market Snapshot - January 2020"

Spectrum and Infrastructure

Auctions for 5G spectrum are well underway globally. (See Exhibit 2.) The early focus in most countries has been on the 3 GHz band, but in some—most notably the US—operators are rolling out 5G using mmWave spectrum. The bands in this range getting the most interest are 26, 28 and 40 GHz.

EXHIBIT 2

COMPLETED, ONGOING AND PLANNED SPECTRUM AUCTIONS (AS OF DECEMBER 2019)

	COMPLETED			PLANNED
	2017	**2018**	**2019**	**2020**
EMEA	Ireland, Czech Republic, Slovakia	Finland, Latvia, Italy, Oman, Spain, UAE, Italy, UK	Qatar, Austria, Germany, Saudi Arabia, Switzerland	Hungary, Luxembourg, France, Netherlands, Israel, Norway, Poland, Slovenia, Sweden, Greece, Czech Republic, Portugal, Belgium, Estonia, Romania, Bulgaria, UK
AMERICAS			US, Canada	Mexico, US, Brazil, Peru, Ecuador
ASIA		Australia, South Korea	Japan, Singapore, China, Hong-Kong	New Zealand, Thailand, India

Source: "Roadmap for C-band spectrum in ASEAN" – GSMA; Press search

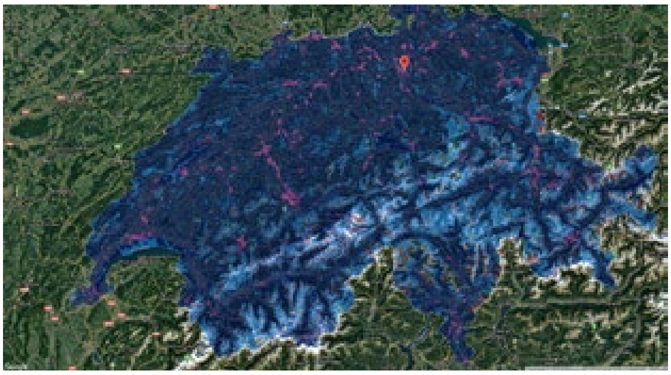
Operators have focused their available capital on investments that promise the largest and quickest returns, and that protect and strengthen their core businesses. Operators are typically pursuing deployments in 3 GHz spectrum in cities, which they combine with coverage deployments in lower spectrum bands. In some geographic regions and markets, operators are offering fixed wireless access (FWA).

In metropolitan areas and data consumption hotspots (such as malls, train stations, and airports), operators are densifying networks with both macro and small cells. T-Mobile US, for example, has recently covered much of Manhattan with 5G small cells. (See Exhibit 3.) The availability of large amounts of bandwidth in new spectrum bands (predominantly the 3 GHz band in Europe and Asia, and mmWave in the US) allows operators to provide higher throughputs and lower latency, resulting in outstanding user experience.

Because of the challenging radio propagation properties of higher frequency bands, however, these bands are being deployed only to a limited extent outside of metropolitan areas. For suburban and rural 5G deployments, operators typically leverage lower frequency bands and use techniques such as dynamic spectrum sharing (DSS) to achieve a wider 5G footprint. With DSS, operators can quickly achieve broad 5G outdoor and indoor coverage at relatively low cost. In Switzerland, for example, Swisscom achieved 90% population coverage with 5G by the end of 2019.

EXHIBIT 3

LEFT: EXAMPLE FOR DENSIFICATION OF METROPOLITAN AREAS WITH HIGH-BANDWIDTH HIGH-FREQUENCY SPECTRUM—5G COVERAGE WITH MMWAVE (28 GHZ) BY T-MOBILE IN NEW YORK CITY'S MANHATTAN BOROUGH.[3] RIGHT: SWISSCOM'S REPORTED 5G COVERAGE IN SWITZERLAND – ACHIEVED WITH DSS.[4]



3. Source: https://www.t-mobile.com/coverage/5g-coverage-map?filter=new-york
4. Source: https://scmplc.begasoft.ch/plcapp/pages/gis/netzabdeckung.jsf

The Early Consumer Response

Consumers so far are receptive. In South Korea, one of the first nations to launch 5G, the number of subscribers to 5G plans reached 4 million in October 2019, only six months after commercial launch. GSMA Intelligence expects 5G to attract 200 million connections in North America (46% of the total) by 2025. In China, Japan, and South Korea, 5G connections will account for more than 40% of the total. In Europe about 30% of connections will be to 5G networks.[5]

A maturing device ecosystem will help drive 5G adoption. In a recent study in South Korea, approximately one third of all respondents cited the bundling of 5G to a specific device as the main reason for them to sign up for a 5G plan.[6] In 2019, after two years of stagnation, the global smartphone market is growing again, partially driven by the advent of 5G.[7] The number of 5G devices on the market jumped more than fivefold from 35 (including 10 smartphones) to 199 (63 smartphones) from March to December 2019.[8] In 2020, when Apple is expected to launch its first 5G device, total shipments are expected to reach 160 million units. By 2024, there should be more than 1 billion 5G mobile devices in circulation.[9]

Operators are adopting three types of market propositions with their early 5G launches. In order to demonstrate the value of 5G subscriptions with high data allowances and large throughputs, some operators are bundling their plans with exclusive content, ranging from exclusive videos, movies, and games to live sports and augmented reality. In South Korea, for example, all three major operators (SK Telekom, KT, and LG U+) offer access to certain content, such as 5G-powered in-stadium experiences for professional baseball exclusively with 5G plans. Other operators are offering access to specific devices that are in high demand exclusively in combination with 5G plans. In the US, Verizon offered access to Samsung's S10 smartphone only in combination with a subscription to a 5G service. In other cases, the novelty of 5G and the substantial media attention on the technology itself has developed a certain marketing caché. Operators are exploiting this with targeted advertising campaigns highlighting their nationwide 5G coverage. Swisscom in Switzerland, for example, markets its 90% population coverage.

5. Source: The Mobile Economy North America 2019, GSMA, 2019
6. Source: 5G user study conducted by Doitsurvey research company in June 2019
7. Source: https://telecoms.com/500669/global-smartphone-market-returns-to-growth-driven-entirely-by-samsung-and-huawei/
8. Source: GSA, December 2019, "5G Device Ecosystem – December 2019"
9. Sources: https://www.ccsinsight.com/wp-content/uploads/2019/02/CCS_Insight_5G_Forecast_Sample.pdf; https://www.ericsson.com/4acd7e/assets/local/mobility-report/documents/2019/emr-november-2019.pdf

Initial Lessons from South Korea

The frontrunner in global 5G deployment, South Korea, is on track to reach 12 million 5G subscribers in 2020, according to analysts, and 36 million—or 90% penetration—by 2026. The commercial launch strategies used by the country's network operators may offer some lessons for others as well as some early indications on the resulting impact on market dynamics.

All three major operators bundled new ways of consuming local content directly with their 5G plans which, combined with subsidised 5G devices, has supported the faster-than-expected 5G adoption rate. Offers have included free innovative content, such as AR, VR, and sports experiences. (See Exhibit 4.) The strategy has proved effective at attracting early adopters to higher tier 5G data plans, which typically sell at higher prices than other plans. As a result, all South Korean operators have reversed declining ARPUs. Early evidence even point towards slight ARPU increases. Operators hope to be able to kick off another multi-year period of continuous ARPU increase similar to South Korea's successful 4G launch. (See Exhibit 5.)

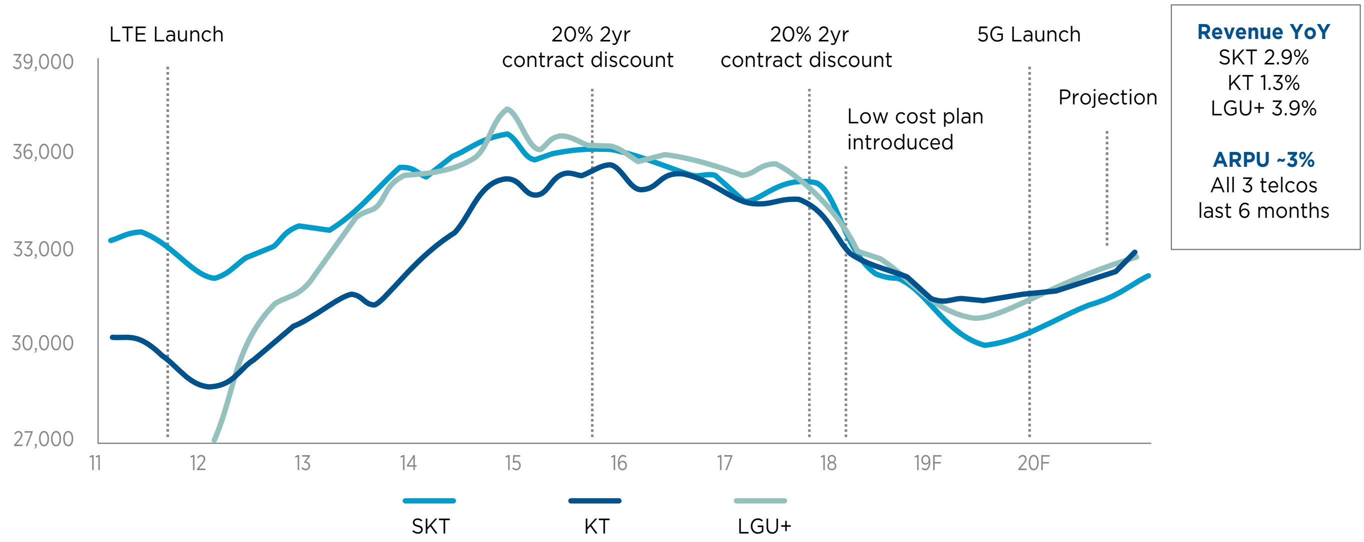
EXHIBIT 4

EXAMPLE OF CONTENT OFFERS BY SOUTH KOREAN OPERATORS

5G VR	5G AR	5G Baseball	5G Golf	5G Idol
Cirque du Soleil, Queen concert, virtual world tour, yoga, movie contents is in service	4K AR Studio is built collaborated with '8i' a renowned F/X company	360 degree game playing, rewind scoring scene, stadium zoom-in, hot player exclusive contents	Panoramic view, Course 3D broadcasting, ball tracking, 360 swing movie	Virtual date, virtual concert, dance lesson with the most popular K-pop artist is in service

EXHIBIT 5

THE LAUNCH OF 4G LTE STARTED SEVERAL YEARS OF CONTINUOUS ARPU INCREASES FOR SOUTH KOREAN OPERATORS; EARLY MARKET SIGNS INDICATE THAT 5G COULD KICK OFF ANOTHER PERIOD OF ARPU GROWTH



There is reason to be optimistic about the South Korean 5G business case. While it is too early to conclude for how long the trend towards higher ARPUs can be sustained, analysts expect ARPU growth to continue at least until the end of 2020 supported by further increases in adoption from more 5G-exclusive services and new, more affordable 5G plans.[10]

In the long term, operators hope that new content services can provide additional revenue streams. Operators expect to be able to utilise network slices or leasing edge infrastructure to offer new propositions to service providers, especially for latency-sensitive use cases that require high quality of service can be assured. For example, SKT has entered into an exclusive partnership with Microsoft for their cloud gaming service, xCloud.[11]

10. Source: Industry report by KB Research – "Telecom Services – 5G Services and Revenues Set to Grow"
11. Source: https://news.microsoft.com/apac/2019/09/04/sk-telecom-and-microsoft-announce-plans-for-joint-5g-based-cloud-gaming

Realising the Full 5G Vision

Each market is progressing toward 5G deployment and uptake at its own rate, but just about everywhere the business case contains multiple challenges. The major hurdles are the monetisation of 5G investments for operators and ensuring sufficient infrastructure investment and deployment to meet the full 5G vision for both B2B and B2C uses. At the moment, the lack of clear ROI for operators hinders the case for the infrastructure investment necessary to accelerate full 5G deployment.

Business Case Uncertainties

Despite early indications from South Korea, network operators around the world remain skeptical about the positive bottom-line impact of 5G. As witnessed during the transition from 3G to 4G, simple price premiums for new technology plans are not sustainable. Consumers have become used to a certain average price for their mobile subscription and are generally unwilling to pay more.

The business case for B2B services looks more promising, given that a growing number of industrial companies are considering investment in IoT as part of their digital transformation. From a technical standpoint, features such as network slicing support new business and partnership models with content providers and vertical enterprises.

However, securing a portion of the value pool requires large investments outside of the operators' main area of expertise. Operators face tough questions because many B2B use cases are still in their infancy.

Private networks, where industrials build their own 5G networks with spectrum carved out by the government, also introduce additional uncertainties. These networks would limit the monetisation potential of nationwide networks operated by operators, but operators could benefit from building and operating private networks on behalf of industrial clients.

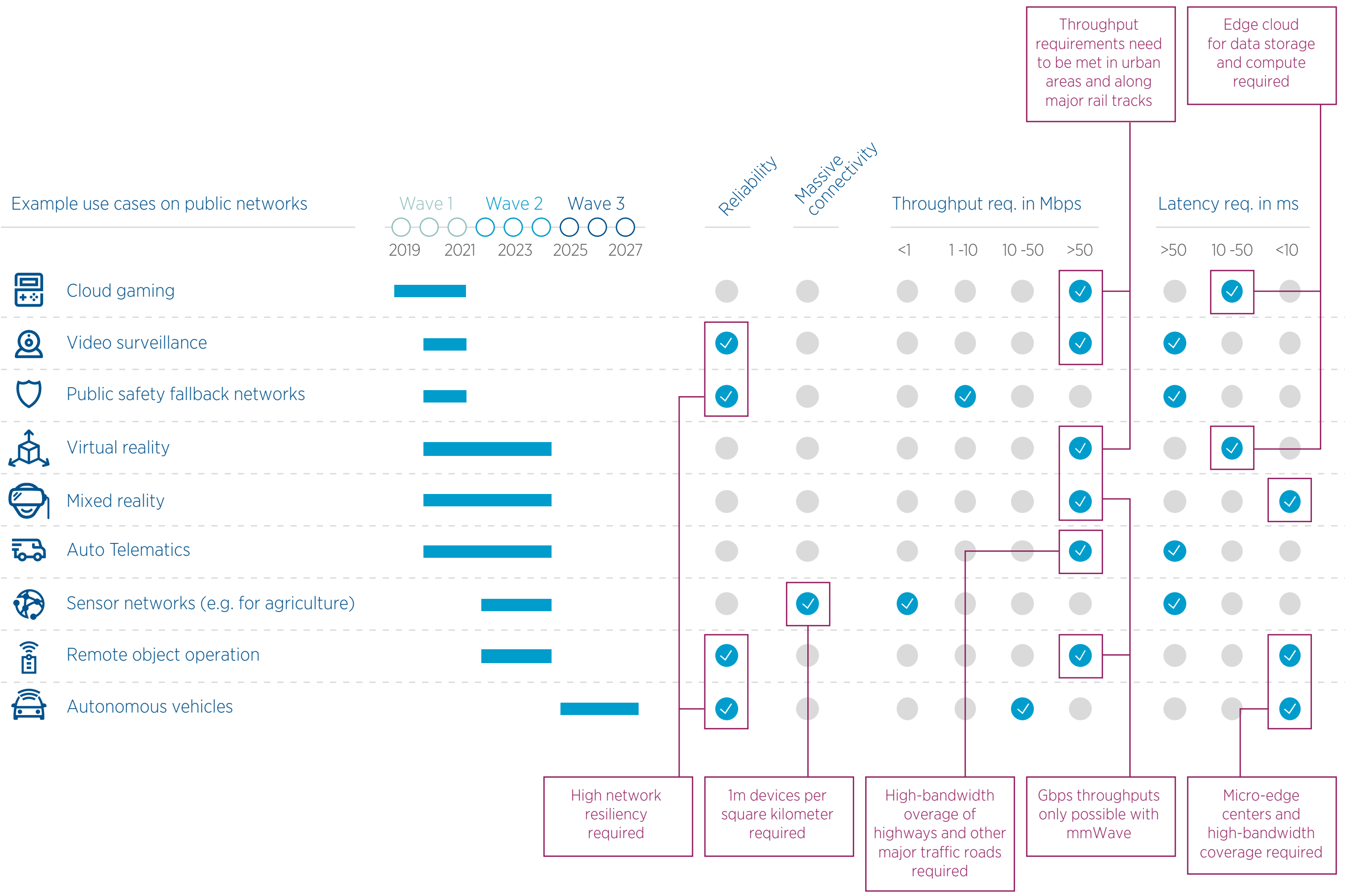
All in all, 5G business uncertainties remain a challenge.

The Need for Continuing Investment in Infrastructure

Initial 5G network deployments have focused on supporting B2C uses such as eMBB. They will not suffice for future use cases that demand better latency, reliability, and security, among other factors. Exhibit 6 summarizes some of the most heavily anticipated uses that are expected to run on 5G infrastructure along with the anticipated shortfalls. Additional uses that are not currently envisioned but that will have similar or even more stringent requirements are expected to emerge once 5G technology matures.

EXHIBIT 6

INFRASTRUCTURE NEEDS TO REACH THE FULL 5G VISION



To reap the full socio-economic benefits of 5G, operators must continue to invest in new infrastructure capabilities. For example, for some ultra-low latency use cases, processing and storage need to be moved from today's centralised data centers to the network "edge". Network resiliency has to be increased, e.g., with battery power backups for cell sites, redundant backhaul capability. Transit routes need to be covered with 5G deployments to enable such applications as in-car or in-train entertainment systems in the short and intermediate term and autonomous driving in the long run. Eventually, high bandwidth 5G deployments also need to reach rural areas and inner cities need to be densified with mmWave small cells in the intermediate term to deliver the full 5G experience.

Three Waves of Investment

Infrastructure is expensive, and the necessary investments cannot and will not happen all at once. They need to be phased in sequence with the commercialisation of the uses they should unlock. The timelines presented below are approximations and should not be considered as a playbook for an 'ideal' 5G infrastructure deployment strategy. They represent a hypothetical rollout by a representative operator with the ambition to realise the full 5G vision from a mobile network capability perspective by 2027. Actual timelines will of course vary from market to market, depending on such factors as spectrum release and local geographic and demographic conditions. They will also depend on how quickly and effectively 5G uses are commercialised and made available to the general public.

Wave 1: Laying the Ground (2019–2021)

During Wave 1, operators invest in capacity-driven inner-city roll-out with new 5G bands reflecting the rollout pattern we are currently observing. Additionally, edge data centers need to be installed to enable the first low-latency use cases, such as cloud gaming and early applications of mixed and virtual reality. Operators also need to start to build resiliency and redundancy into the network for the first generation of use cases with high-reliability requirements.

Wave 2: Expansion (2022–2024)

This wave 2 will extend the reach of 5G as operators start to cover major transit routes (highways and rail tracks) to enable the first generation of (semi-) autonomous vehicles (such as autonomous trucks). Depending on spectrum availability, we will start to see mmWave densification in inner cities and hot spots (shopping centers, train stations, and sports arenas, for example). Additionally, we expect high-bandwidth networks to start penetrating rural towns, although it is unlikely that the rural rollout will be completed by the end of Wave 2.

We also expect to start to see a more strongly distributed network of micro-edge computing centers. Each of these smaller centers will have more limited storage and computing capabilities than the larger centers that were deployed in Wave 1. However, they will be deployed in close proximity to the users they support.

Wave 3: Full Vision (2025 – 2027)

In Wave 3, the deployments of micro-edge computing centers, as well as rural deployments and mmWave densification will be completed. In addition, street-by-street coverage will expand to second tier transit routes—regional roads, in particular.

Estimating the Investment Required

To quantify the amount of additional 5G investments a typical operator needs to make, BCG ran simulations using its proprietary geo-based simulation software and using representative network operator data. (See the sidebar, About Shannon by BCG).

EXHIBIT 7

MODEL COUNTRY CHARACTERISTICS

Fundamental characteristics

Population: 10 M

Area: 100'000 km^2

Realistic population distribution

Realistic street and rail network

Geography & demographics

85% rural area with 30% of population

15% urban and suburban area with 70% of population

One metropolitan area of type "sprawling metropolis" with 30% of population

Telecommunications & spectrum availability

Three large mobile operators

Realistic existing telecommunication networks

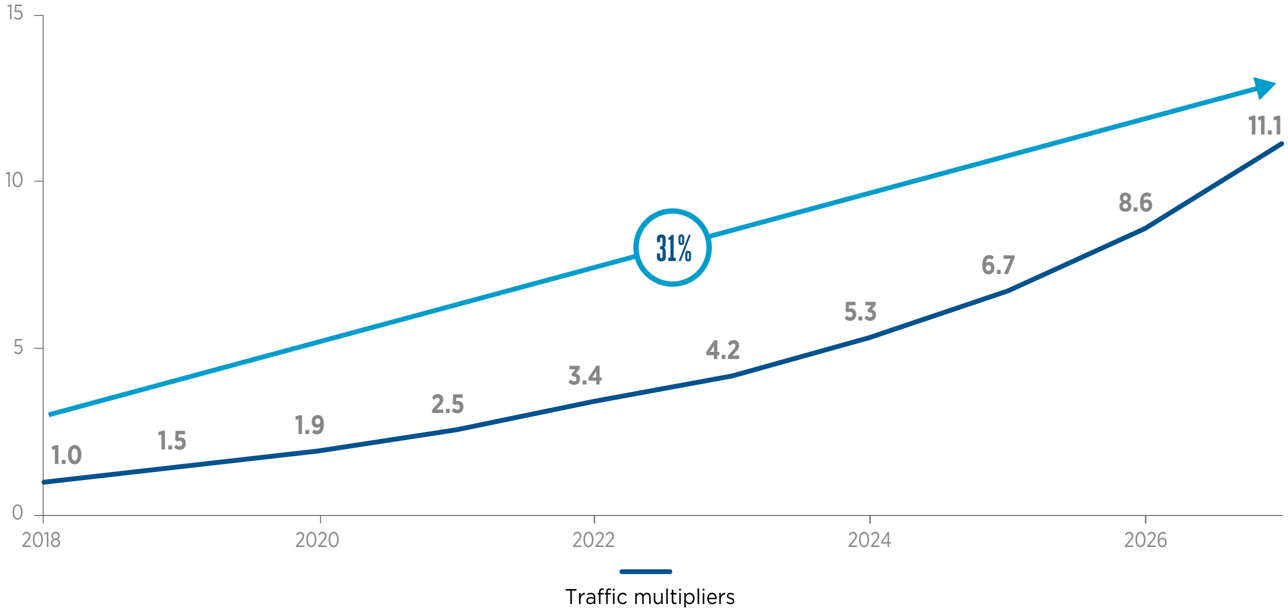
Realistic spectrum allocation with 300 MHz newly allocated mid-band spectrum (100 MHz per MNO)

BGC ran a series of 10 simulations. The base scenario represents a continuation of the 5G network rollout strategy currently observed all around the world (urban densification and rural DSS). Successive cases add more network requirements and corresponding complexity.

In the base case, capex is entirely driven by the need for network densification from increasing traffic. (See Exhibit 8). It was assumed that network traffic would increase by a factor of about 11 over the course of the simulation timeline, from 2019 to 2027. The same traffic forecast was used for all simulations. In subsequent scenarios the addition of key infrastructure components required to boost and extend capacity and performance to full 5G levels was factored in. (See Exhibit 9.) As these simulations build on each other, some deployment cost synergies can be expected (such as between coverage of highways and roads and rural areas).

EXHIBIT 8

TRAFFIC EXPECTED TO GROW BY A FACTOR OF ~11X UNTIL 2027



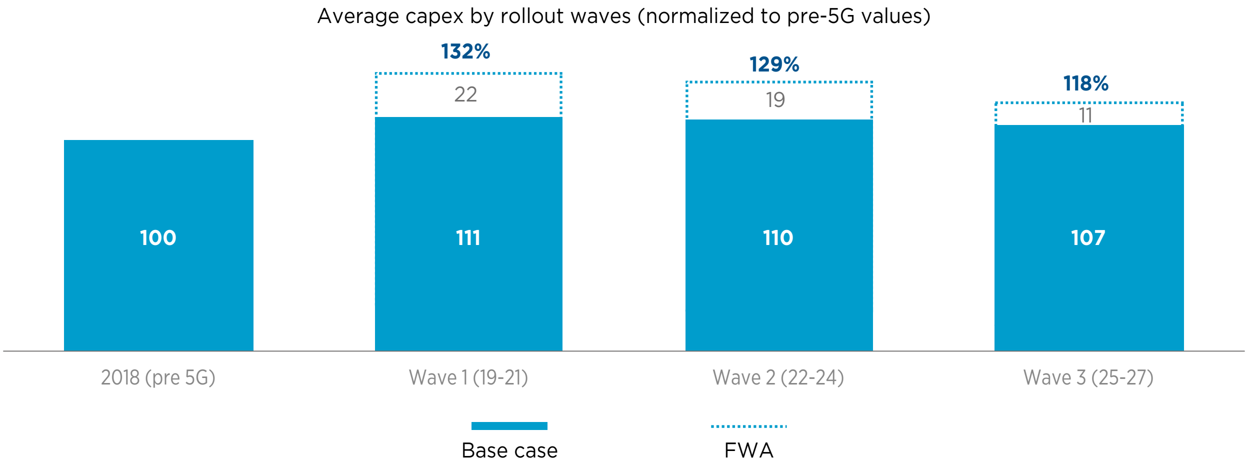
For all simulations, a traditional network architecture was assumed (specifically no centralised or cloudified RAN). Unit costs for deployments of 5G band, new macro sites and small cells were based on international benchmarks from BCG case work.

In a separate simulation, Shannon by BCG was used to estimate the costs of FWA deployments covering roughly 20% of the suburban households. FWA was considered separately as its deployment depends strongly on local market conditions and its rollout should be based on an individual business case, such as new connectivity revenue paying for the investments in suburban FWA coverage.

Simulations showed that capex can be kept roughly at pre-5G levels, requiring only about a 10% increase over the three 5G waves, for the base case. (See Exhibit 9.)

EXHIBIT 9

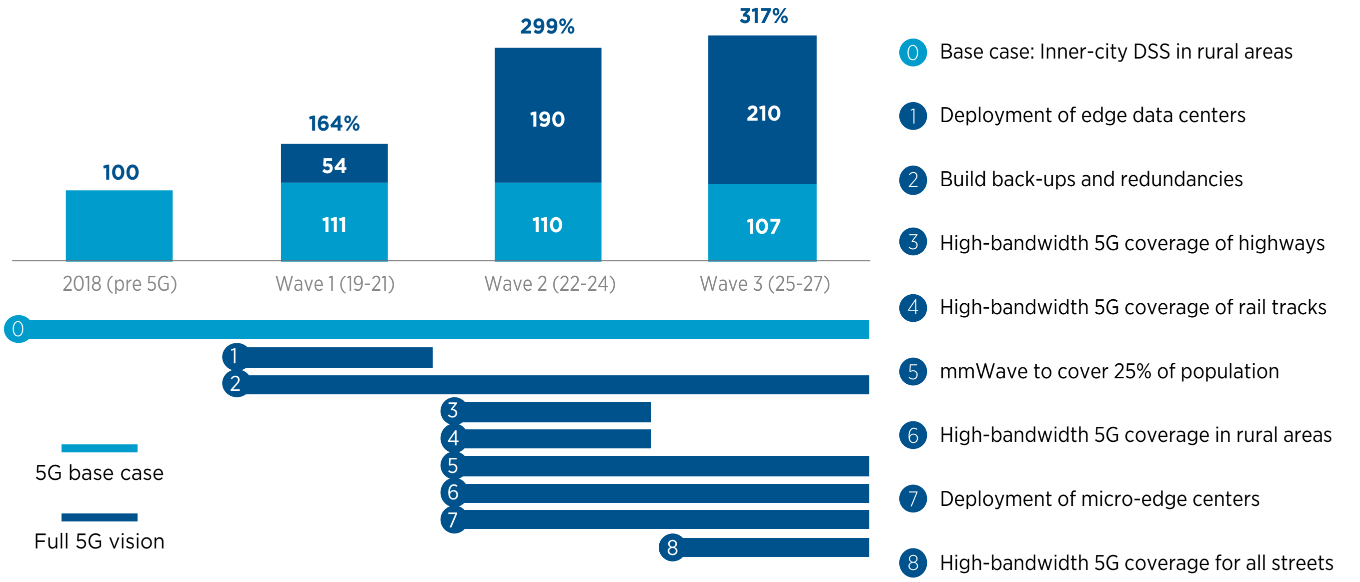
CAPEX ENVELOPE CAN BE KEPT MOSTLY FLAT IN BASE CASE



Adding the requirements for the incremental scenarios, the results become increasingly sobering. Compared with the base case, enabling the full 5G vision will require approximately 2.4 times the capital expenditures over the course of the simulation period (2019 to 2027). Capex can be expected to be higher from the outset compared with pre-5G levels and could reach roughly three times pre-5G levels. (See Exhibit 10.) Operational expenses will also increase, but not as fast. Overall TCO can be expected to be 1.7 times higher than in the base case and two to three times more than pre-5G levels in wave 2 and 3.

EXHIBIT 10

EXPECTED CAPEX BY ROLLOUT WAVE NORMALIZED TO PRE-5G LEVELS



To a large extent, these costs are driven by the coverage requirements for transit routes and rural areas, and the ultra-dense deployment of small cells in the metropolitan region.

All of these costs exclude investments in spectrum licenses and content rights.

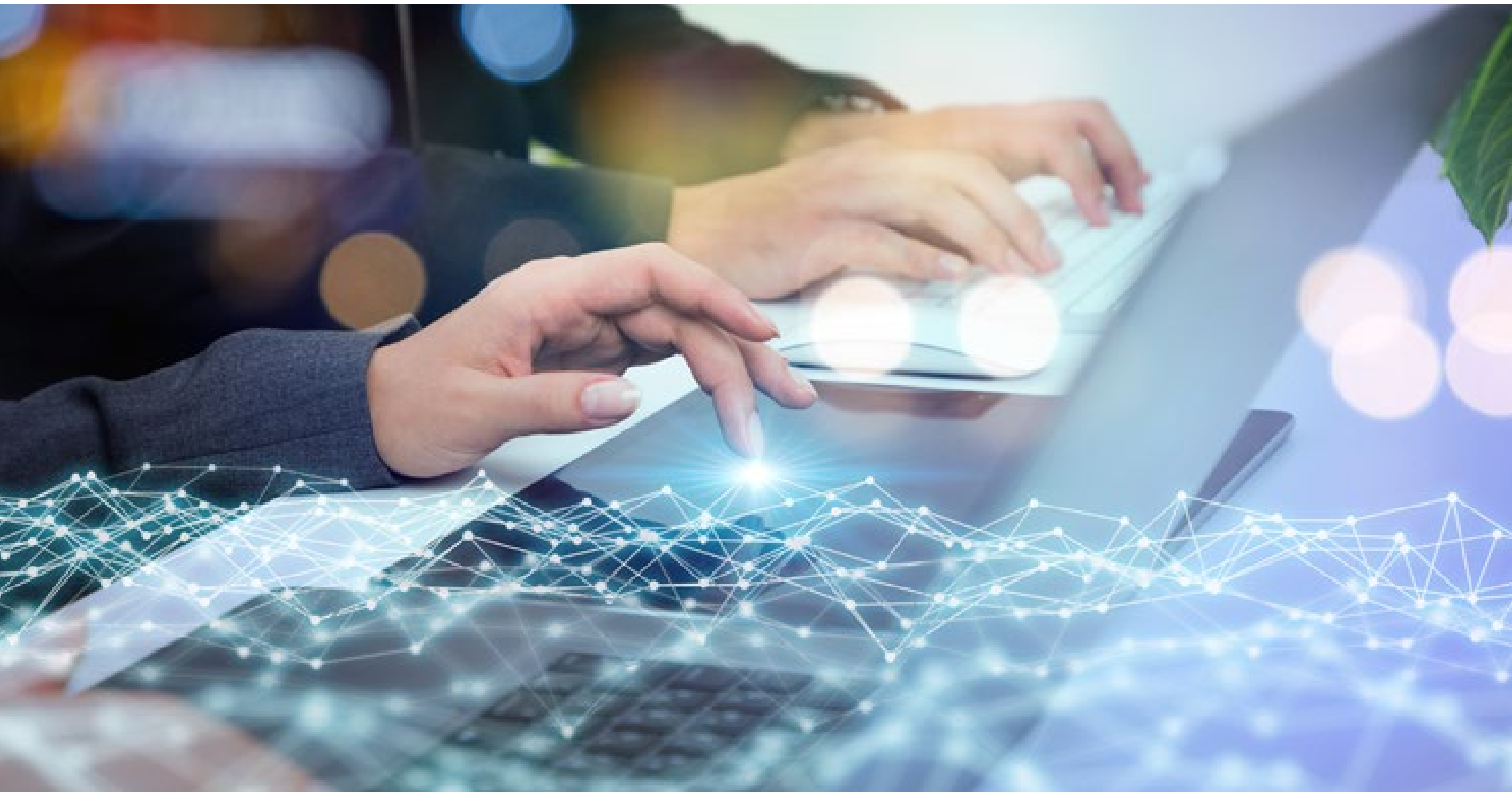
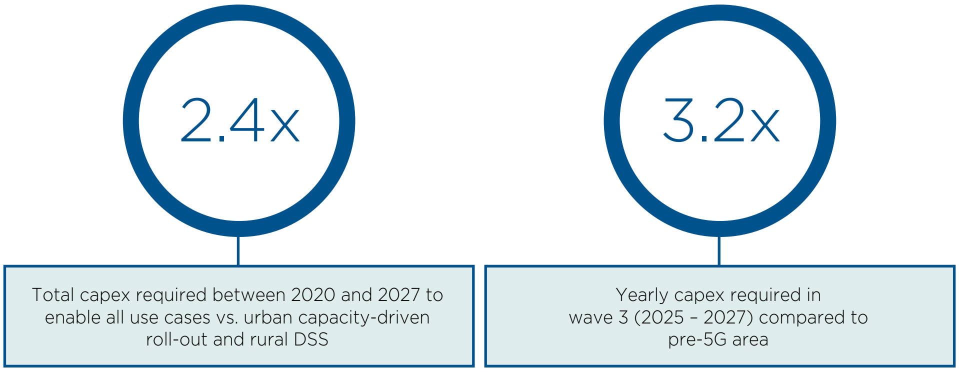


EXHIBIT 11

MASSIVE INCREASE IN REQUIRED INVESTMENTS DRIVEN BY NEED FOR LARGE NUMBER OF ADDITIONAL MACROS AND SMALL CELLS



Operators will be hesitant to deviate from their current capex trajectories, which support continued traffic growth at the same revenue levels. Investments to deliver the full 5G vision will likely be deferred until there are tangible signs that the revenue growth required to sustain such capex levels can be achieved. This means that realisation of the socio-economic benefits of 5G may be delayed. If consumers, businesses, and society are to reap the benefits of full 5G deployment, network operators and policy makers need to change the fundamentals of the current 5G business outlook.

About *Shannon* by BCG

Shannon by BCG is a proprietary BCG software platform for simulation of the development, expansion, densification, and costing of mobile networks; the impact on customer experience in any given location; and the impact on market positions. The software can be fed with real operator data, such as geo-coordinates of site locations, as well as sector-level network equipment and measured traffic. On a geo-spatial grid, *Shannon* by BCG then forecasts traffic demand in the network and simulates corresponding network enhancements (such as densification with macros and small cells, deployment of new spectrum bands, and MIMO upgrades) based on flexible, customizable rollout strategies.

Overcoming the Challenges

Operators need to both tap new sources of revenue growth and optimise their cost structure to meet the substantial increase in investment required to bring the full socio-economic vision for 5G to life.

Strengthen the Consumer Proposition

Operators need to think more innovatively about how they build a B2C case for their 5G offerings and capture value from new 5G use cases and higher consumption of content through the mobile network. As we have seen, South Korea's network operators have been successful at increasing ARPUs with 5G. But it remains to be seen whether marketing initiatives involving bundled content and access to advanced capabilities can be translated into increased revenue streams in a sustainable manner.

Fixed Wireless Access (FWA). Because of 5G's step change in capabilities, operators have an opportunity to strengthen the core business by extending their connectivity offerings. It will soon be a viable alternative for operators to widen their footprint for home broadband plans in a cost-effective way. While the upsides for operators clearly depend on such factors as individual geographies, competition, and existing footprint, FWA can generate topline benefits in the short term and help fund the 5G journey.

Smart Connectivity & Content Partnerships. An integrated offering of smart 5G connectivity and high-quality local content provides opportunities for operators to accelerate 5G adoption and increase the value proposition. For example, Vodafone recently signed a two-year partnership with German Football Association (DFL) to bring real-time statistics to fans using mixed reality technology.[12]

Another application is mobile cloud gaming whose ultra-low latency requirements requires access to edge data and computing infrastructure. We are already seeing partnerships between operators and tech companies, such as SKT and Microsoft in South Korea and Sunrise and Gamestream in Switzerland.[13]

Certain AR and VR use cases are likely to require service level guarantees for a seamless user experience, which will make network slicing a persuasive proposition. Similarly, mission-critical use cases on public networks with high reliability and low latency requirements such as autonomous driving are likely to require dedicated slices.

Vertical Partnerships

Operators have multiple opportunities to identify promising verticals and find partners that can help deliver high-value, data-centric products or services to be distributed over the 5G network.

Many industries are experiencing an explosion of IoT-enabled offers. By collaborating with industry partners, operators can help form new data ecosystems. These ecosystems give their participants access to valuable collective data assets as well as the capabilities and domain expertise necessary to develop the assets into new data-driven products and services.[14] In the US, for example, AT&T and Magic Leap, a spatial computing startup, have partnered to build solutions for the manufacturing, retail and health care industries.

Partnership models are powerful ways to build strong relationships, expand the operator's own 5G enterprise capabilities through experimentation, and fill capability gaps in areas outside of the telco's core competencies. Lessons learned from early B2B deployments will help expand the product and services offering and increase the enterprise footprint. In Japan, NTT DOCOMO is providing a showcase example for successful implementation of such a B2B strategy. While industry partners get exclusive access to 5G test environments, NTT DOCOMO can leverage its network to co-develop use cases and build its expertise.

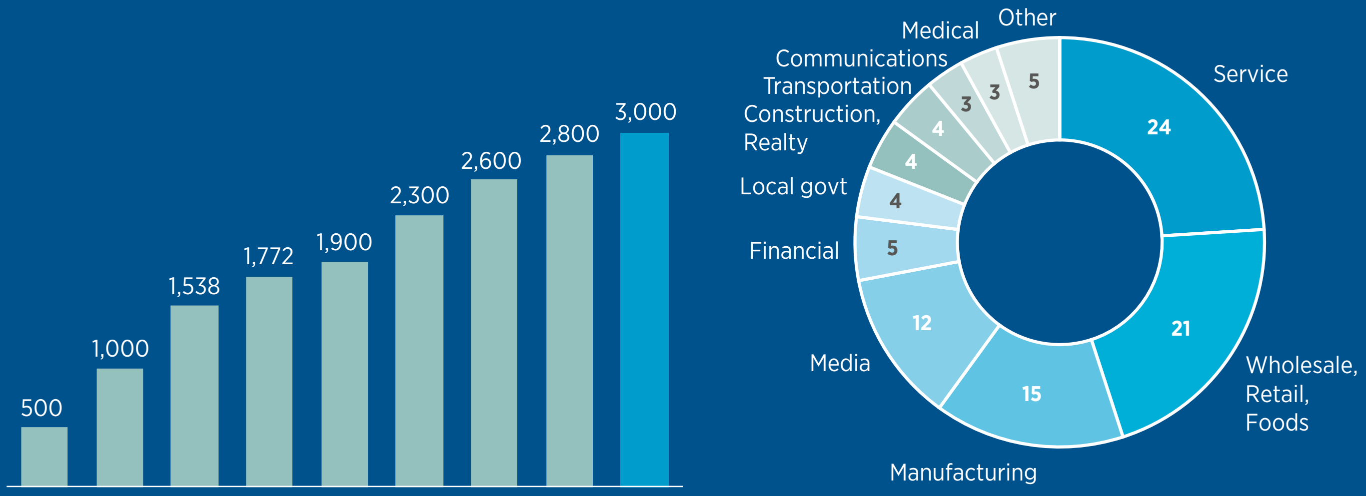
12. Source: https://www.forbes.com/sites/stevemccaskill/2019/07/15/bundesliga-uses-5g-to-power-real-time-ar-statistics-app-for-fans-in-the-stadium/#299a72b955d6
13. Source: https://gamestream.biz/events/sunrise-and-gamestream-launched-the-first-world-cloud-gaming-service-up-to-4k-resolution
14. Source: https://www.gsma.com/futurenetworks/wiki/5g-era-mobile-network-cost-evolution/

NTT DOCOMO's Growing Ecosystem

There are many reasons to believe that much of the new 5G value will be generated in B2B applications. In Japan, NTT DOCOMO has set an example for implementing a successful B2B strategy, building a network with some 3,000 enterprise partners as of November 2019. The ambition is to reach 5,000 by 2022.

EXHIBIT 12

NTT DOCOMO HAS ESTABLISHED SOME 3,000 PARTNERSHIPS WITH ENTERPRISES AND SMES ACROSS MANY DIFFERENT INDUSTRY SECTORS.



NTT DOCOMO has partners in industries ranging from health care to transportation to communication. Together, they explore 5G industry use cases in dedicated testing facilities (both indoor and outdoor). Besides early access to real 5G deployments, NTT DOCOMO provides an open cloud platform to its partners (including an AI software suite) so they can test the 5G uses deemed most relevant for their respective business operations.

Examples of trials conducted with industry partners include remote training of technicians using VR, video monitoring to detect abnormalities in processes, wide-area monitoring using connected drones, live streaming from remote areas, and remote-control of outdoor vehicles equipped with HD cameras. For all trials, data was transmitted through NTT DOCOMO's 5G test networks.

In addition, NTT DOCOMO acts as intermediary to connect individual industry partners with each other, so that they can exchange ideas and experiences and expand development of the broader ecosystem.

For NTT DOCOMO, this strategy is one way to build a reputation as trusted 5G partner for industry customers. At the same time, NTT DOCOMO receives immediate industry feedback on which use cases are particularly relevant to enterprises. Jointly with partners, it can develop expertise and industrial IoT capabilities. Some successful ventures can be productised and offered to other partners as a service.

In pursuing this strategy, NTT DOCOMO has a long legacy to draw on. In 1999, using 2G technology, NTT DOCOMO launched i-mode, a content provider and handset vendor platform. Supported vendors developed handsets for i-mode under the NTT DOCOMO brand while content and service providers used the i-mode platform to distribute their content. The platform skyrocketed and early skepticism over mobile data services melted. Over time, NTT DOCOMO built strategic alliances for services from mobile credit cards to mobile insurance, mobile customer relationship management, and mobile advertising. A few years later, in 2002, NTT DOCOMO was able to repeat a similar success with a mobile payment platform, "Osaifu Keitai", based on the IC chip FeliCa which was co-developed with Sony.

NTT DOCOMO has learned important lessons from its earlier successes. First of all, it has become a trusted partner for many major industry players in Japan, which helped it to establish partnerships for 5G. At the same time, it gained experience on how to build and scale powerful networks operationally. In addition, and potentially more important, NTT DOCOMO's past successes have built trust within the company that platform business models work. This makes it uniquely positioned to take important strategic decisions early and build partnership networks rapidly.

Optimise Network Costs

Several factors combine to push up capital expenditures, including densification of the radio access network (RAN) in cities with macros and small cells, higher backhaul capacity requirements, and deployment of new infrastructure such as mobile edge data centers.

While some increases are hard to avoid, operators can pull a number of levers to optimise TCO for their networks. An initial assessment by BCG indicates that a reduction of about 40% in TCO is possible with actions on several fronts. But doing so requires fundamental changes in the way networks are built and run, necessitating further changes in skillsets, partners, and operating models. We outline some of these actions below.

Value-Based Deployment Strategies. Resources are limited, and operators should make careful assessments on the value of infrastructure deployments. For each 5G use case requiring its own technology, equipment, or software, operators need to develop a clear view on the return on investment of each single network action – using big data analytics and AI algorithms. These insights can then be used to prioritize roll-outs.

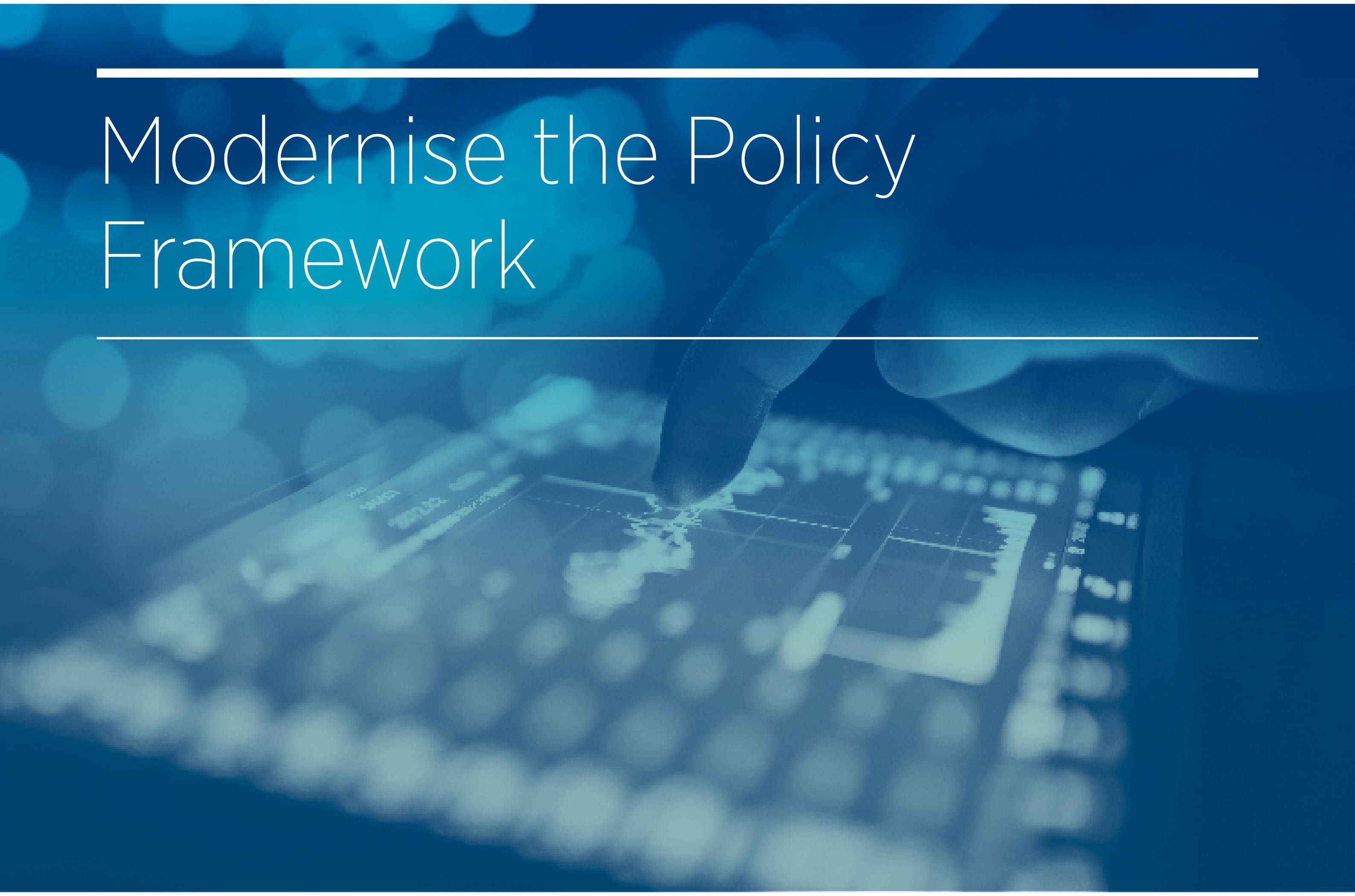
Network-Sharing Agreements. While the strategic considerations have to be weighed on a case-by-case basis, infrastructure sharing with other operators has the potential to reduce network costs significantly. A recent study by the GSMA, the results of which are supported by own project work, has shown that it can reduce infrastructure costs by up to 40%.[15] The magnitude of the savings depends on the type of agreement, which can range from sharing of passive infrastructure such as towers to shared operation of active components (radio units, for example) and spectrum. The last year has seen a rapid rise of network sharing agreements.

Network Virtualisation and Centralisation. Virtualisation of networks allows the development of new, more cost-efficient network architectures, thus reducing network spending and broadening the network infrastructure ecosystem. Virtualisation is also a key enabler for network slicing. Rakuten, the Japanese retail giant, which plans to launch its own telecommunications service in April 2020, will build its network with more than 3,000 sites based on a cloud architecture with OpenRAN.[16] The network deployment will be supported by a large diversity of vendors across the RAN, backhaul, core and operating systems. In November 2019, Vodafone announced plans to seek tenders to cover its entire European footprint (more than 100,000 sites in 14 countries) with OpenRAN equipment.[17]

Automation and Self-Organising Networks. Configuration, management, and operation of mobile networks are complex tasks and there is substantial potential to automate these processes. Near term, programmable, rules-based automation of network processes can lead to massive savings. In the intermediate and long term, machine learning and artificial intelligence can help network components learn from data to achieve fuller optimisation and realise the vision of self-organising networks (SON).

15. Source: https://www.gsma.com/futurenetworks/wiki/5g-era-mobile-network-cost-evolution/
16. Source: https://www.japantimes.co.jp/news/2019/09/06/business/corporate-business/rakuten-delay-mobile-service-six-months/#.XeoZU-hKg2w
17. Source: https://www.mobileworldlive.com/featured-content/home-banner/vodafone-offers-europe-up-to-openran/?ID=a6g1r000000xdpuAAA&JobID=320367&HE=62f669ecada2f74671ac28582b1cfd31ba2fd3ed8ab1ef68e063253a4cea981b&utm_source=sfmc&utm_medium=email&utm_campaign=MWL_20191113&utm_content=https%3a%2f%2fwww.mobileworldlive.com%2ffeatured-content%2fhome-banner%2fvodafone-offers-europe-up-to-openran%2f

Modernise the Policy Framework



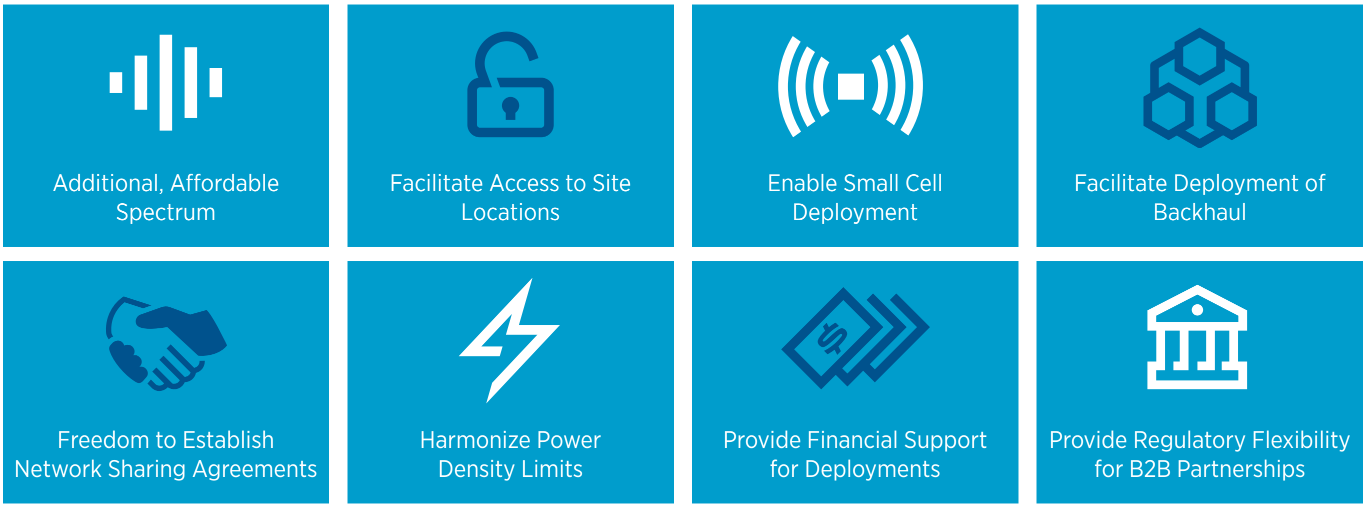
While the industry must explore opportunities for new revenue streams and optimising infrastructure, policy makers and regulators also play a critical role in unlocking the vast potential of 5G. The GSMA has long argued that policy makers and regulators must strike a balance between incentivising competition and keeping prices low for consumers and supporting industry investment in next generation infrastructure. Incentivising investment, furthering technical progress, and enabling innovation are all essential to a sustainable telecommunications market.

In our 2018 report on *Delivering the Digital Revolution,* we identified six regulatory levers to foster infrastructure investment.[18] Governments around the world have taken concerted steps in most of these. But they will need to do more to stimulate full 5G deployment. Continuation of the current pace of regulatory change will not enable the industry to realise the 5G vision. We explore these regulatory levers and additional actions below. (See Exhibit 13.)

18. Delivering the Digital Revolution: Will mobile infrastructure keep up with rising demand?, GSMA, February 2018.

EXHIBIT 13

REGULATORY LEVERS TO ACCELERATE 5G INFRASTRUCTURE



Additional, Affordable Spectrum

Spectrum is the scarce resource that the mobile communication network is built on. Making additional spectrum available in a timely and affordable fashion is a top priority for accelerating advanced network deployment. Early release is only one aspect of constructive, enabling spectrum regulation. Policymakers also have to strike an appropriate balance among sometimes competing objectives, such as maximising proceeds from spectrum auctions, fostering competition to keep consumer prices low, and enabling build-out of new mobile broadband infrastructure. In addition, they also have to consider other spectrum users, e.g., military or satellite applications.

It's encouraging that spectrum auctions for the mid-band and high-band spectrum bands are well underway in many countries. Korea made 280 MHz of the 3.5 GHz and 2400 MHz bands available in 2018. The US Federal Communications Commission (FCC) developed a "5G FAST" plan to make auctioning high-band spectrum a priority. Auctions have already been concluded for the 28 GHz and 24 GHz bands, with the 37 GHz, 39 GHz, and 47 GHz being auctioned at the time of writing this report. In Singapore, the IMDA plans to release licenses for both 3.5 GHz and mmWave spectrum together.

To make the most of 5G, all governments should be thinking about the release of the next wave of spectrum bands in the pipeline across low-, mid-, and high-band spectrum. Regulators should aim to make available 80-100 MHz of contiguous mid-band spectrum (such as 3.5 GHz) per operator. This spectrum is at a balancing point between coverage and capacity. To drive 5G innovation and make the highest 5G speeds possible, mobile operators also need access to spectrum above 6 GHz. In particular, 1 GHz of contiguous mmWave spectrum should be assigned per operator in bands such as 26 GHz, 40 GHz, or even higher.

How spectrum is awarded also has an impact on the future success of networks. Best practice includes publishing spectrum roadmaps. For countries that decide to award spectrum using auctions, getting the design and price right is key. A good example is Finland where regulators split the crucial mid-band spectrum (3.4–3.8 GHz) into three equally sized blocks of 130 MHz. In China, the government assigned 5G spectrum at no cost, in order to speed up the rollout of networks.

Facilitate Access to Site Locations

5G presents an increasing need for densification, particularly in hotspots such as shopping centers, transport hubs, public facilities, and stadiums, where small cells are often the only viable solution to provide additional capacity. In many markets, local regulations make gaining access to site locations difficult, but some policy makers are now moving to make access easier.

The IMDA in Singapore has required "mobile installation spaces"—typically rooftop spaces reserved for telecommunication equipment—be provided to network operators by building developers and owners free of charge.[19] In Japan, operators can install 5G base stations on 208,000 traffic lights across the country.[20] Moreover, the Japanese government has proposed that the costs of using the traffic lights for 5G deployments be shared between operators and local administrations.[21] In a move to further its smart city infrastructure, the government also plans to equip traffic lights with communication functions for traffic data collection and processing and emergency communication. The UK's Electronic Communications Code facilitates operators' access to macro and small cell infrastructure on public and private land.

Granting access to public buildings and street "furniture," such as bus stop shelters, lamp posts or traffic lights, owned by municipalities, at low or no cost removes a significant hurdle to site deployment. New street infrastructure that is manufactured and installed deployment-ready means operators can attach their equipment and connect to backhaul and energy networks.

Enable Small Cell Deployments

Cumbersome bureaucratic approval processes typically inhibit timely large-scale deployment of small cells. Some regulators are moving to facilitate next-generation infrastructure investments by streamlining approval processes. These measures include simplified, transparent, and standardised application and review processes for small cell siting, exempting small cells that meet certain set criteria from reviews of environmental and historic site preservation organisations; and accepting declarations of compliance for network operators without requiring routine post-installation measurement of power density.

In 2018, the US FCC issued infrastructure rules aimed at streamlining and removing barriers at the federal, state, and city levels.[22] These include the establishment of two new "shot clocks" for the reviewing of small wireless facilities deployments: 60 days for collocation on pre-existing structures and 90 days for new construction. Similarly, the EU has launched a consultation on light deployment regime for small cells, which will likely lead to regulation updates in the intermediate term.[23] The Danish Energy Agency is exploring guidelines (including best practice examples) for public authorities on how to deal with applications for permission to set up telecommunications infrastructure.[24]

19. Source: https://www2.imda.gov.sg/-/media/Imda/Files/Regulation-Licensing-and-Consultations/Consultations/completed-consultations/consultation-papers/12/COPIF-2018-Industry-briefing-on-7Dec2018-cleanpptx.pdf?la=en
20. Source: https://www.japantimes.co.jp/news/2019/06/14/business/tech/japan-install-5g-network-relay-devices-traffic-signals/#.XclwHDNKg2w
21. Source: https://asia.nikkei.com/Spotlight/5G-networks/Japan-to-greenlight-5G-base-stations-on-200-000-traffic-signals
22. Source: https://www.fcc.gov/document/fcc-facilitates-wireless-infrastructure-deployment-5g
23. Source: https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2018-5660684_en
24. Source: https://ens.dk/sites/ens.dk/files/Tele/5g_action_plan_for_denmark.pdf

Facilitate Deployment of Backhaul

With the massive data rates enabled by 5G, and the resulting increase in mobile data traffic, backhaul for network sites is becoming more important than ever. Policy changes that facilitate the rollout of new fibre backhaul and other backhaul technologies, and encourage sharing of facilities and costs, can help to reduce the overall costs of backhaul.

Governments are looking at the arrival of 5G as an opportunity to promote fibre infrastructure. In the UK, for example, regulators in 2018 granted "Relief from Non-Domestic [Tax] Rates" (i.e., lower business tax rates) for fiber rollouts in England and Wales, aiming to "support and incentivise the rollout of broadband and 5G services."[25]

Another example is India, where a "Fibre First Initiative" was launched in 2018.[26] It promotes collaboration models for shared duct infrastructure and incentivises fibre connectivity for all new developmental construction and at least 60% of mobile network towers, citing the need to "accelerate migration to 4G/5G" as one of the main ambitions.

Freedom to Establish Network Sharing Agreements

As we have seen, the deployment of 5G puts an enormous capex and opex burden on mobile operators. Operators in many markets are, therefore, entering into network sharing arrangements to bring down each company's costs and achieve economies of scale.

Orange Belgium and Proximus have recently signed a network sharing agreement, which the operators' hope will "allow a quicker and more comprehensive 5G roll-out."[27] Similarly, Vodafone and Telecom Italia Group have established a network sharing partnership, also citing the enablement of a "faster deployment of 5G over a wider geographic area" as the primary motivation.[28] According to their respective press releases, all of these operators expect several hundred million Euros in synergies and investment savings. In April 2019, Orange and Vodafone Spain entered into an active sharing agreement for mobile infrastructure on 14,800 masts and backhaul components, including joint use of 5G sites.[29]

In China, the three mobile network operators, China Telecom, China Unicom, and China Mobile, co-own the tower company China Tower Corp. Because of heavy investment requirements for 5G deployments, China Telecom and China Unicom are now going one step further—not only sharing their site locations but also the active RAN equipment. The deal is expected to save the partners a total of $28 billion to $38 billion in capex. China Mobile may join the team in order to benefit from the massive savings potential from active network sharing.[30]

It is vital for the wider success of 5G that such cooperative agreements do not run into regulatory roadblocks. A growing number of regulators are taking steps to permit, or even encourage, shared deployment, especially for small cells, recognising that network operators need the flexibility, to share infrastructure assets.

25. Source: http://researchbriefings.files.parliament.uk/documents/CBP-8392/CBP-8392.pdf
26. Source: http://dot.gov.in/sites/default/files/EnglishPolicy-NDCP.pdf
27. Source: https://www.orange.com/en/Press-Room/press-releases/press-releases-2019/Network-sharing-agreement-in-Belgium-between-Orange-Belgium-and-Proximus
28. Source: https://www.vodafone.com/news-and-media/vodafone-group-releases/news/network-sharing-partnership-with-telecom-italia
29. Source: https://www.rcrwireless.com/20190425/5g/vodafone-orange-sign-network-sharing-agreement-spain-including-5g
30. Source: https://www.fiercewireless.com/5g/china-s-carriers-to-build-a-shared-5g-network

Harmonise Power Density Limits

Overly strict power density limits (PDLs) for the radio signals transmitted by network antennas undermine the ability of network operators to speed up deployment of next-generation infrastructure. Radio spectrum cannot be effectively used and, therefore, goes to waste. Modern approaches to site compliance assessment based on realistic parameters should be adopted otherwise new mobile technologies, such as massive MIMO, cannot be deployed, negating the value of technology advances. New sites or colocations are rendered unavailable for deployment.

Policies regarding power density limits should be evidence-based and harmonised in line with recommendations by expert bodies such as the World Health Organization (WHO) and the International Telecommunication Union (ITU).

Both these organisations recommend the human exposure guidelines developed by the International Commission on Non-Ionizing Radiation Protection (ICNIRP), which are designed to provide protection against all established health hazards. They are reviewed on a regular basis.

Some countries retain restrictive limits as a political response to public concern and perceived scientific uncertainty. A Swiss report in 2019 estimated that if the country's restrictive PDLs are not amended it will take more than 30 years and require 46,500 additional macro sites to provide nationwide 5G but even with this investment, indoor coverage requirements would not be met.[31] One country, Poland, recently replaced its strict standards for electromagnetic field exposure with the ICNIRP public limits, based on a proposal by the Health Ministry. But overall, movement in this area has been slow, perhaps owing to the emotional nature of the issue. More fact-based discussion is needed.

Provide Financial Support for Deployments

Delivering mobile coverage everywhere continues to remain a challenge, and our analysis shows that rolling out 5G to all areas will require very significant investments. Rural areas are challenging for operators to cover commercially due to the limited additional revenues, relatively high deployment costs and barriers to accessing suitable locations and supporting infrastructure for deployment. To unlock the full value of 5G for the entire country, governments should consider providing financial support to achieve the widest coverage.

Several financial incentive models are taking shape. In the UK, operators agreed with the government to build a shared rural network with financial contributions from both industry and government.[32]

Not all subsidies are for rural deployment. The city administration in Shenzhen is offering CNY10,000 for every standalone 5G base station constructed, up to 15,000 base stations or a total of CNY150 million.[33] Moreover, 5G sites are eligible for electricity cost subsidies for three years.[34]

31. Source : https://www.bafu.admin.ch/dam/bafu/de/dokumente/elektrosmog/fachinfo-daten/bericht-mobilfunk-und-strahlung.pdf.download.pdf/Bericht_MobilfunkStrahlung.pdf
32. Source: https://www.ft.com/content/cd83abc8-f70c-11e9-a79c-bc9acae3b654
33. Source: https://www.mobileworldlive.com/asia/asia-news/shenzhen-offers-5g-subsidies/
34. Source: https://www.lightreading.com/partner-perspectives-(sponsored-content)/why-are-governments-around-the-world-subsidizing-5g/a/d-id/754298

Provide Regulatory Flexibility for B2B Partnerships

5G is designed to enable a variety of services that have different connectivity needs, and connections optimised for multiple services will be a core feature and business driver of 5G networks. These types of services, optimised to meet specific use cases — for example, the IoT, connected cars and virtual reality — will become more prevalent as many sectors embrace digitalisation and connectivity. Network slicing will enable operators to create products for different verticals that can be customised for the enterprises. The customisable network capabilities include data throughput, latency, reliability, security, and service optimisation.

Operators should have the freedom to innovate as 5G networks take shape, in order to realise the technology's full potential. They should have the confidence in the regulatory environment to explore new deployment models and service propositions for consumers and businesses. Regulatory authorities should acknowledge the dynamic nature of 5G networks and services and that optimised connectivity built on network slicing is compatible with the open internet principle.

How Fast? How Soon?

Over the next few years, hundreds of millions of people around the world ought to be able to enjoy the benefits of enhanced mobile broadband. Some will finally get high-speed internet access in their homes thanks to 5G FWA technology. But seizing the full macroeconomic opportunity requires concerted commitments from policy makers and the industry.

5G is not necessarily a race, but countries that move more quickly will deliver greater benefits to consumers, businesses, and their own economies sooner.

At the same time, in many other countries, there is a risk of getting stuck in a vicious cycle. (See Exhibit 14.) Network infrastructure deployments are expensive and rollouts are delayed. This slows down use case innovation, because uses that demand advanced network capabilities cannot be tested under real-life conditions or deployed at scale. In turn, a lack of use case innovation adds to operators' skepticism over the prospects for monetisation—and prevents them from investing more optimistically and aggressively.

EXHIBIT 14

Targeted regulation that helps operators to reduce costs and explore new revenue opportunities can help break the cycle. Regulatory reform is difficult, but necessary. Finding the right balance that serves the interests of many stakeholders is hard, and it can be a lengthy process. That said, the rapid transition to a global mobile and digital society isn't slowing down. If network operators, regulators and policy makers can work together to achieve the necessary improvements in efficiency and effectiveness, operators can be counted on to build the infrastructure of the future. A productive regulatory environment that encourages investment, just as it incentivises competition, can be the deciding factor in the transition to a more mobile and digital society.

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