McKinsey&Company

Japan at a crossroads – The 4G to 5G (r)evolution

How Japan can leverage next-generation networks to boost industries, spur innovation, and regain technology leadership for a prosperous telecommunications sector

Research report January 2018

Preface

Japan's telecommunications industry is in the midst of a significant transition, as it scrambles to keep pace with rapid technological change. By 2020, Japanese operators will roll out 5G, the next-generation mobile network, in time to host the Olympic and Paralympic Games. Japan will, once again, be one of the first movers to deploy a next-generation network. Preparations are already ongoing, and changes, such as a potential introduction of spectrum auctioning and a possible new fourth operator, will affect all players in the industry. Operators, device, and equipment vendors, need to act now to avoid missing the desired timetable.

The authors of this report aim to provide a view on how stakeholders in Japan's telecom industry could successfully navigate the network transition to create a thriving, profitable and sustainable ecosystem. We believe a world-class infrastructure can help Japan remain at the forefront of technological development, enabling the country's export industry to scale globally as the network evolves.

The report analyze the business challenges and opportunities for the various stakeholders in the telecom industry. It does not provide technical specifications for the next-generation networks.

* * *

This report is the result of collaboration between McKinsey's Japan office and the Firm's global Telecom, Media and Technology (TMT) practices. We are grateful for the advice and input of many McKinsey colleagues, including Ferry Grijpink, Gustav Grundin, Ken Kajii, Masahiro Komatsubara, Richard Lee, Suraj Moraje, Roi Shigematsu, Freddie Södergren, Taro Umemura, and Ole Jørgen Vetvik. We also want to thank the following colleagues, Pauline Arnold, Bijeta Joshi, Mats Lindelöw, Michele Manigart, Hanako Muto, Yumiko Oka, Lorraine Salazar, Aya Sekiguchi, and Saki Takasu for their support in creating and producing this report.

André Andonian
Senior Partner, Tokyo
Managing partner of the Japan office

Axel Karlsson
Senior Partner, Hong Kong
Head of Telecom, Media and Technology in APAC

Kenji Nonaka
Partner, Tokyo
Head of the research effort

January 2018

Contents

Executive summary

Japan has been a global leader in mobile communications for the past four decades. Its landmark innovations include the first commercial mobile browser-based web service, the first mobile email, and the first handsets with cameras. A culture of innovation has created a thriving ecosystem and fueled a successful expansion of Japanese industry.

However, in recent years, Japan's leadership has been increasingly challenged. Its networks are starting to show signs of capacity constraints, the domestic vendor landscape has been disrupted by global innovations, such as the iPhone, and industries are not able to fully benefit from new features such as the Internet of Things (IoT). Japan now faces an inflection point that will define its future competitiveness in mobile communications.

As we speak, mobile networks are evolving toward 5G, which will bring substantial improvements in terms of speed, capacity, and latency. This network evolution provides a significant opportunity for Japan for several reasons. First, it will help operators alleviate capacity constraints and handle the exponential growth in data traffic and connections. Second, it will generate new opportunities in high-growth areas such as artificial and virtual reality, which to date are less dominated by global competitors. Third, it will enable the industry to innovate and stay competitive in areas such as autonomous vehicles and robotics. Fourth, it will give the government and its citizens access to new value-adding services, such as remote patient monitoring and disaster alerts. Finally, the value at stake is massive, estimated to be $4 to $11 trillion globally in 2025 from IoT alone. Altogether, leaning in on the network evolution should be a priority for Japan.

To capture this opportunity, stakeholders should consider three strategic imperatives:

1. Operators[1] need to build the next-generation infrastructure and offerings based on the best of global products and services: By using solutions from the global innovation ecosystem and limiting customization, operators will be able to reduce time to market for new features, limit vendor lock-in, and deploy more cost-effective solutions for their networks. Striving for global standards and developing procurement capabilities will help this process.

2. Subscale mobile telecom equipment vendors need to build alliances and find new pockets of growth: By refocusing their portfolios, limiting customization, and building alliances, network equipment and handset players can tap into 5G growth opportunities and combat increasing development costs.

3. Industry, government, and regulators need to collaborate with operators and mobile telecom equipment vendors and embrace the new technology: By actively engaging with the telecom industry to shape the next-generation networks, the private and public sector can enable new products and services that can be scaled globally, thus regaining technology leadership.

By following these imperatives, Japan can regain mobile communications leadership, boost its export industries, and spur innovation that will benefit all of society. However, time is of the essence. An early deployment will result in first-mover advantages. A failure to act now could let other countries reap the benefits, and hold Japan back.


CLR
5,980

1. Historical context – Leaders in mobile communications

The genesis of mobile internet was i-mode. The application allowed the user to easily access mobile webpages on a phone.

The launch of i-mode in 1999 cemented Japan's position as a leader in mobile technology[5], allowing users to access desktop HTML sites, as opposed to Wireless Application Protocol (WAP), which defined a new markup language where content makers had to learn how to make content with it.[6]

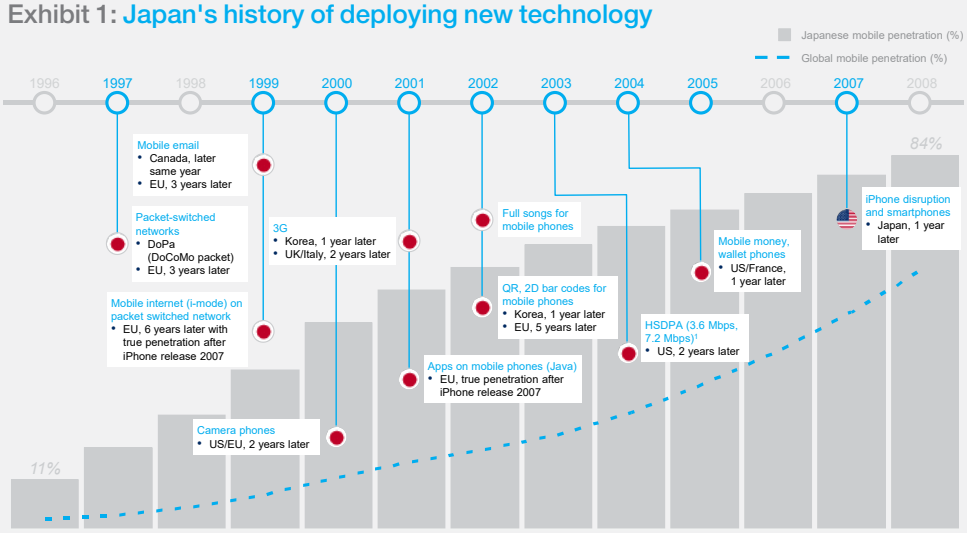
While i-mode was hugely popular in Japan, it failed to gain traction overseas, despite being launched in several countries, and has since been replaced by more modern technologies.[7]

Historically, Japan has been a leader in mobile technology, with a reputation for developing innovative wireless applications and devices, and introducing next-generation standards. Since Nippon Telegraph and Telephone's (NTT) launch of the first mobile telecommunications network in 1979, Japanese companies have introduced innovation after innovation, including mobile email and internet technology with i-mode, the mobile handset with built-in camera, and the mobile wallet.[2] Other countries struggled to keep pace, taking years to deploy the same types of features. During that time, mobile penetration in Japan was one of the highest in the world, growing from 11 percent to 84 percent between 1996 and 2008; only a handful of other countries surpassed it.[3] (Exhibit 1)

In addition to leading the market in innovation, Japan's telecom manufacturers and operators also experimented with developing customized offerings and mobile network standards, rather than collaborating on one set of global applications or standards with other countries. For example, the network standard, Personal Digital Cellular (PDC), was used almost exclusively in Japan, compared with the Global System for Mobile Communications (GSM) with far broader reach. Another example was i-mode (see inset "i-mode"), which was a great success in Japan, but never gained traction overseas.[4]

An environment of innovation and early adoption created a thriving ecosystem, centered on mobile network operators (MNOs). With an impressive product development track record and strong technical capabilities, several large mobile handset and network equipment manufacturers were able to scale. The Japanese market grew fast and was large enough to sustain companies without the need to expand abroad.

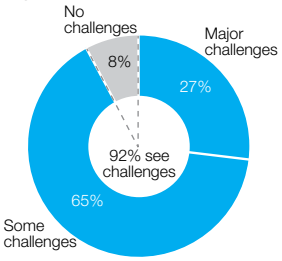
Exhibit 1: Japan's history of deploying new technology



1 Mbps = Megabits per second
Source: Expert interviews; Ovum, World Cellular Information Service (WCIS), September 2017; press search

2. Current reality – Falling behind

Survey 1:
More than 90% see challenges in the current mobile network
n=52[1]

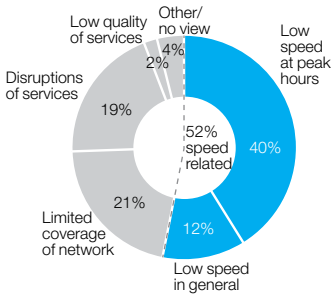


1 How would you describe the challenges with the current Japanese mobile networks?
Source: McKinsey survey to Japanese telecom industry managers, September 2017

On the surface, Japan still has one of the most developed telecom infrastructure systems in the world. Communications service providers (CSPs) are financially healthy and the network infrastructure ranks among the highest in the world for availability, with 93 percent of the population having access to LTE networks.[8]

Despite these indicators of success, Japan's penchant for domestic innovation may now be holding the country back from maintaining its global leadership position and keeping pace with increasing demands on mobile networks. Specifically, by pioneering its own standards, rather than collaborating internationally, Japan has created a somewhat fragile ecosystem. Further, the network is starting to face capacity and usage constraints, due to densely populated cities and high mobile penetration. Managers in the industry also see potential challenges in the network infrastructure, as indicated by 52 telecom industry managers surveyed in Japan (Survey 1).[9]

Survey 2:
Low speed is considered the main user pain point of current LTE network
n=52[1]

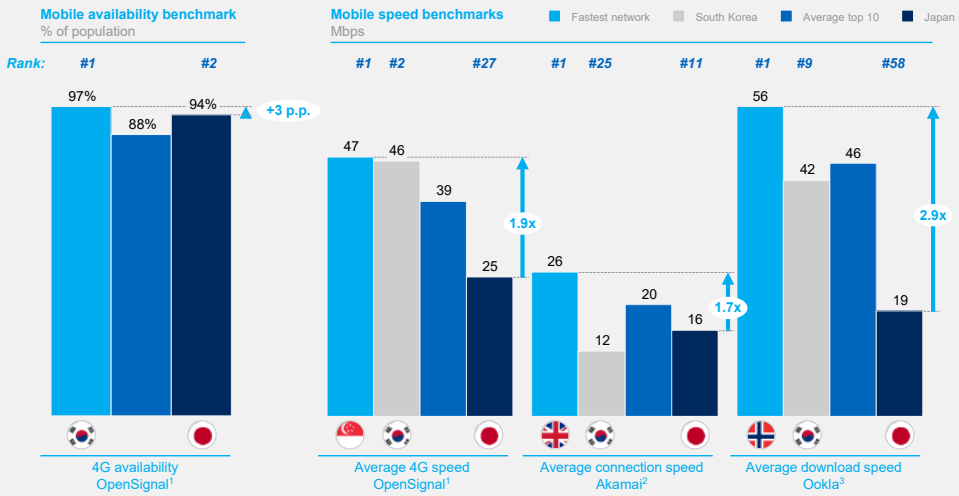


1 What is the main user pain point of the current LTE network in Japan today?
Source: McKinsey survey to Japanese telecom industry managers, September 2017

2.1 Capacity and usage constraints

Japan has invested heavily in infrastructure over the past 20 years. As a result, it has one of the densest networks in the world and consumers generally enjoy high levels of coverage. However, rising demand from densely populated cities means that connection speed, especially at peak hours, shows some strain. According to McKinsey's Japanese telecom survey, more than half of the respondents believe the main pain point of the current network either is low speed in peak time or low speed in general (Survey 2). This finding is supported by an international speed benchmark that shows average network speed in Japan is slower than other global leaders and, as two out of three benchmarks indicate, other densely populated countries such as South Korea (Exhibit 2). Several factors may skew the results, for example, extensive usage of mobile phones in subways or a network optimized for a particular type of usage rather than speed. However, an ever increasing mobile data traffic will put additional strain on the networks over time.

Exhibit 2: Japan has very high 4G availability but lags behind in speed



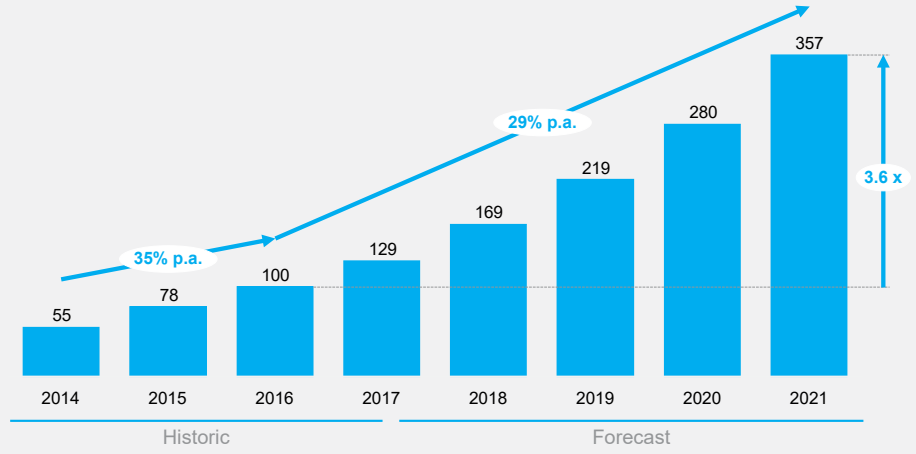
1 Results from ~50 billion measurements and ~3.8 million smartphone and smart devices during July 1st – October 1st 2017, during normal usage of users with OpenSignal's apps. Availability measured as proportion of time the user has access to a particular network, Speed measured as average download connection speed with LTE or LTE Advanced
2 Average connection speeds on mobile networks (IPv4) based on usage data from smartphones, tablets, computers, and other devices that connect to the Internet through mobile network providers
3 Average download speed from hundreds of millions of tests taken by real people using Speed test every month. At least 670 unique user result needed to be included in the index
Source: OpenSignal, June 2017; Akamai, Q1 2017; Ookla (Speedtest), August 2017

Over the years, Japan has had consistent data traffic growth of nearly 30 percent a year (Exhibit 3). This rate is forecast to continue, underpinned by a shift toward more high-quality videos (Exhibit 4). Rising demand risks further clogging networks, especially during peak hours, and will affect end-users' experience, and put pressure on operators' revenues, as less data generated to customers will mean lower net sales.

Considerable additional capacity will be required to cope with the predicted growth, and with current technology this will be very costly, especially in a city like Tokyo, where high densification is required and new sites are expensive.

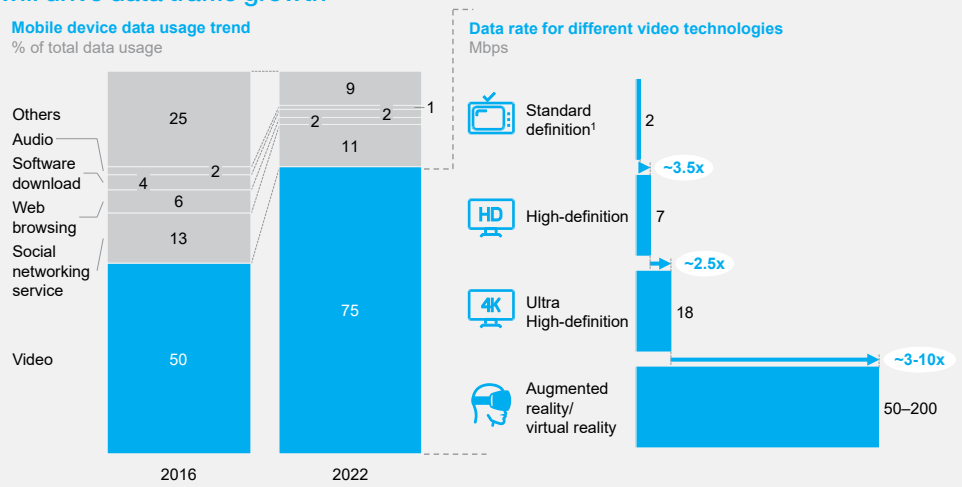
Exhibit 3: Mobile device data traffic is expected to more than triple in Japan between 2016 and 2021

Mobile device data traffic growth in Japan, total mobile consumer data traffic indexed for 2016



Source: Cisco VNI Global Mobile Data Forecast, accessed December 12, 2017, cisco.com

Exhibit 4: Video usage and shift toward more demanding technologies will drive data traffic growth



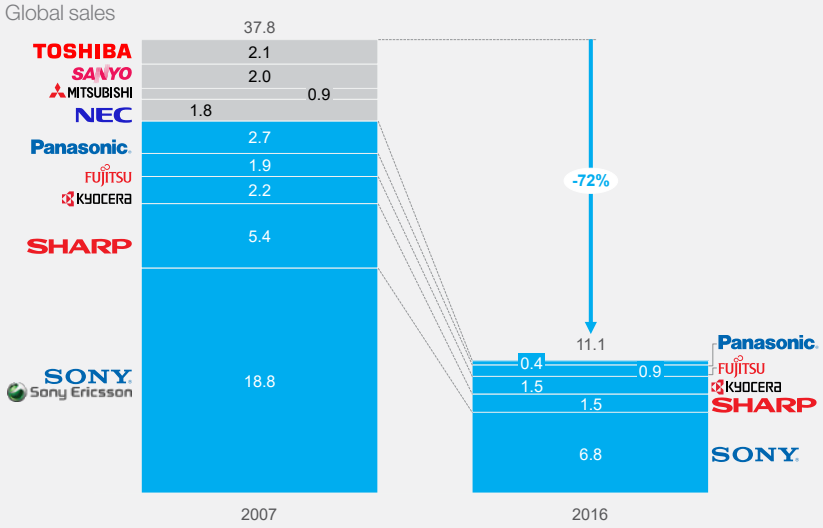
1 TV signal types: 576i for PAL systems; and 480i on NTSC system
Source: Expert interviews; Ericsson mobility report, June 2017, ericsson.com; McKinsey analysis

2.2 Pressure from global competition in the mobile telecom equipment market

In network equipment, competition from global players has truly disrupted the Japanese ecosystem, and many domestic companies have left the market. This upset is especially apparent for mobile handset manufacturers (Exhibit 5). In 2007, when the iPhone was released, there were nine large Japanese companies making devices. Mitsubishi, NEC, Sanyo, and Toshiba were no longer in the market by 2016, and in 2017 the media reported that Fujitsu is also set to off-load its mobile handset business.[10]

Exhibit 5: Consolidation of Japanese mobile handset manufacturers, 2007 to 2016

USD bn, Global sales



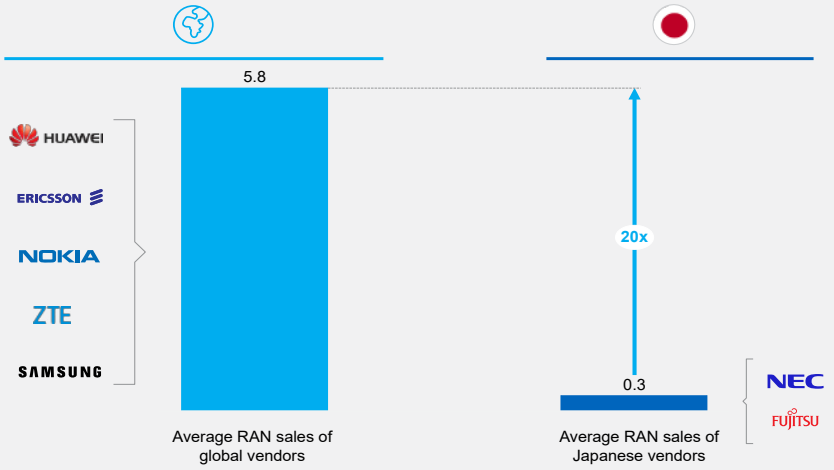
Source: IDC quarterly mobile phone tracker - final historical, Q3 2017

Given Japan's large domestic market, customized networks, and operator specific devices, most manufactures have historically not managed to get traction overseas, with the exception of Sony, which gained traction overseas through an alliance with Ericsson. International handset manufacturers have rapidly gained market share in Japan, while Japanese manufacturers had only 31 percent of the domestic market in 2016.[11]

Similarly, Japanese network equipment manufacturers are struggling to compete with global players. The revenues of global network equipment manufacturers such as Ericsson, Huawei, and Nokia Networks are almost 20 times those of their Japanese counterparts (Exhibit 6) for radio access network equipment. The sector is also going through a period of consolidation (Exhibit 7), and domestic players, such as NEC and Fujitsu are likely to face challenges to compete with global players given the difference in scale. The sheer size of global companies allows them to fund massive development efforts for network equipment many times more than a local player could afford. This scale advantage becomes especially evident every ten years when the next-generation network is in development and forces companies to fund investments in new technologies at the same time as sustaining research on the previous generation, while cutomers reduce their overall investments. This cyclicality is not new, and it has pressured large network equipment providers, such as Lucent, Nortel Networks, and Siemens to become acquired by others. In this generation, the scale game will be even more pronounced as regional standards are converging toward a single global standard, and much of the development among the different companies will be focused on the same area.

Exhibit 6: Japanese network equipment vendors are at a significant scale disadvantage

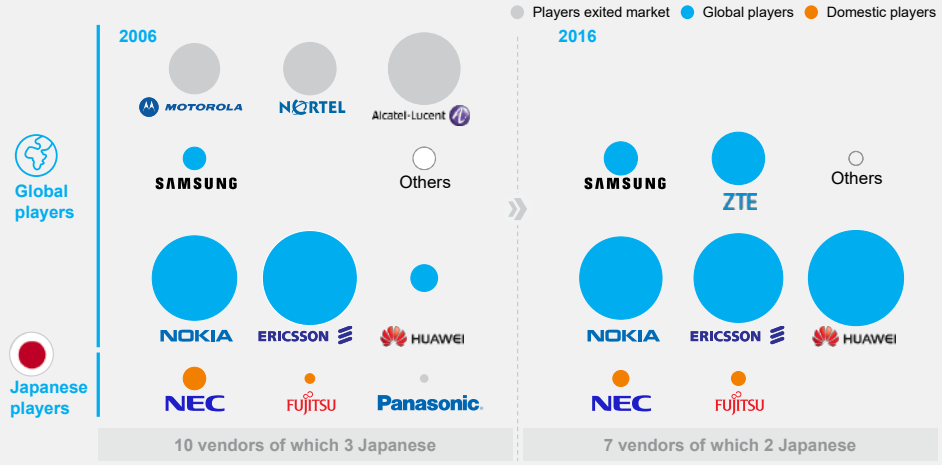
USD bn, radio access network (RAN) sales 2016



Source: Dell'Oro, mobile radio access networks, 2016

Exhibit 7: Consolidation of the global radio access network equipment market, 2006 to 2016

Area of bubble represents total radio access network sales



Source: Dell'Oro, mobile radio access networks, 2016

The three major Japanese telecom operators, KDDI, NTT DOCOMO, and SoftBank, still perform well financially. The operators have a high monthly average revenue per user (ARPU) of $38, compared with $20 for operators in Europe, and still manage to have a low monthly churn of 0.7 percent, compared with 1.9 percent in Europe.[12] This situation is unique globally, and if the rest of the world is anything to learn from, then operators in Japan could face a more challenging future. When customers increasingly want Apple or Samsung, not operator specific, handsets available among all operators, the differentiation becomes limited and more focused on price and performance. This will in turn puts pressure on the profitability, and cost leadership will become important as the trend evolves.

* * *

The current situation presents an increasing set of challenges for the Japanese telecom market, and is a new reality for a country accustomed to being a leader in mobile communications. However, this moment can also act as a transition point to find ways to regain competitive advantage and renew its historic leadership.

3. The network evolution opportunity – Why it matters to Japan

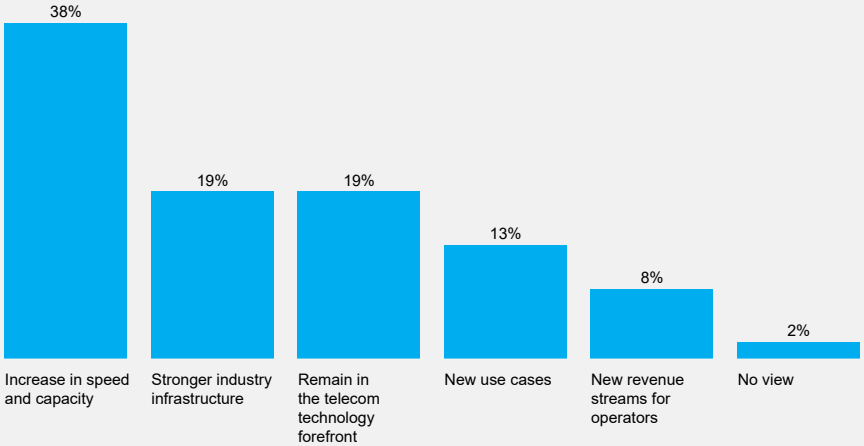
The future deployment of next-generation networks, such as LTE Advanced and 5G, puts Japan at a crossroads. The economic impact of 5G is expected to be significant. According to a recent estimate, the global impact from 5G will be $12.3 trillion by 2035 (similar to China's GDP in 2017, and 4.6 percent of estimated global real output in 2035).[13] The planned capabilities of 5G will provide the infrastructure necessary for new technologies, such as augmented reality, to break through and become mainstream. These technologies will create opportunities for companies to develop innovative, disruptive technology, much like during the rise of the iPhone following the launch of 4G networks. This development will have significant benefits for Japan as a country.

3.1 Substantial performance improvements and proliferation of use cases

Evolving the network to 5G is inevitable given the predicted growth in data traffic. 5G infrastructure will transmit data at a lower cost than 4G, given additional spectrum, as well as increased spectrum efficiency enabled by technologies such as coordinated multipoint and massive multi-user multiple-input multiple-output (MIMO). Japanese telecom managers believe increases in speed and capacity will be the key benefit of 5G, rather than new use cases and additional revenue streams (Exhibit 8). As scaling capacity with legacy equipment becomes too costly and unsustainable, this increase in efficiency through 5G will be a necessity.

Exhibit 8: Increase in speed and capacity considered to be the main benefit for Japan with the deployment of 5G

Main benefit of 5G network deployment[1], n=52



1 What is the main benefit for Japan with the deployment of 5G networks?
Source: McKinsey survey to Japanese telecom industry managers, September 2017

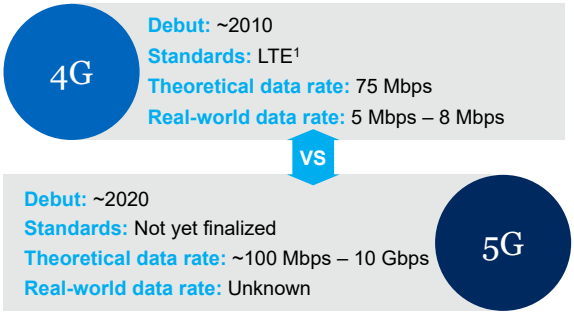
Speed will not be the only network improvement, the increased number of connections and significantly lower latency will be as important to reveal the full benefits with 5G. These new technical standards will cater to a far more diverse set of use cases than before, including enhanced mobile broadband, massive IoT and mission critical control applications (See inset "5G specifications and requirements", and exhibit 9).

5G specifications and requirements

The telecommunication standardization organization 3rd Generation Partnership Project (3GPP) is developing technical standards for 5G networks, with completion for commercial deployment expected in 2019.[14] The initial plan is for the network to deliver substantial performance improvements compared to LTE, which includes the following items:

- Higher data speed: The speed will have a theoretical limit 100x faster than 4G, delivering fixed broadband-like speed and providing gigabits per second (Gbps) speed in certain areas.
- Ultralow latency: The response time will be reduced to 5:1 of that with 4G networks, and latency will have a theoretical response rate of 1 millisecond.
- Massive number of connections: The number of connections per radio base station will be 100 times higher than for 4G, supporting the expected increase in IoT devices.
- Other requirements:
  - Ultrahigh reliability: The network should have a reliability of 99.999 percent or higher for use cases that demand it.
  - Device power efficiency: Battery life should be significantly increased to more than ten years for an IoT device.

Differences between 4G and 5G



Other requirements of 5G

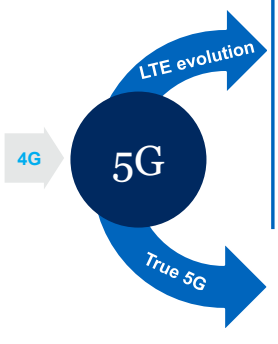
- Energy consumption reduced to 10:1 of today's
- Ten times longer battery life for IoT devices
- Ultrareliable (99.999% reliability)
- Latency reduced of ~1 ms

1 LTE is evolving to LTE Advanced and LTE Pro with data rates up to 1 Gbps
Source: Expert interviews; "5G White Paper," Next Generation Mobile Networks (NGMN), 15 February, 2015, ngmn.org; "Augmented and Virtual Reality: The First Wave of 5G Killer Apps," Qualcomm, 1 February, 2017, qualcomm.com

The evolution to the next-generation network will be a collection of different technologies that will need to integrate to achieve the significant increase in performance across the different dimensions. A few of these technologies will be on the new radio front end, leveraging for example Massive MIMO and millimeter wave spectrum, Modulation/Waveforms with spectral sharing technologies.

The technology will also build on collaboration between macro and micro sites, on which the macro sites will further leverage the LTE base stations as they continuously become more efficient and include new features branded as LTE Advanced. Hence, 5G will follow an evolutionary path and use technology and features already in market as part of LTE and LTE Advanced. In this report we will refer to 5G or network evolution to describe the features that are not yet available in the network, even though they may not be labelled as 5G on a stand-alone basis.

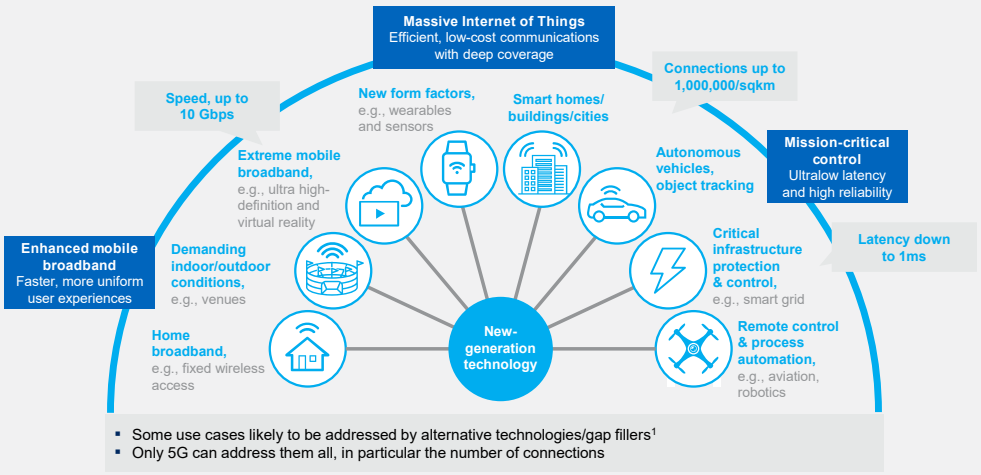
Currently, there are multiple initiatives being pursued towards developing "true 5G"



	Short description	Examples
LTE Advanced	Deployment of LTE Advanced features already in LTE roadmap defined by 3GPP	Nokia 5G solution for 2017 for last-mile hop based on MIMO/active antennas and branded as 5G
New sub-6GHz spectrum	Deployment of LTE interfaces in higher bands including unlicensed spectrum	Vodacom and Huawei achieved 1 Gbps speed using 5.8 GHz unlicensed band in June 2016
Use of millimeter wave spectrum	Use of very high-band spectrum (>6 GHz to ~100 GHz) in conjunction with new network architectures	SK Telecom currently piloting millimeter wave systems in 28 GHz band under the brand 5G
New-generation wireless system	The new generation wireless system introducing a step change in data speed and end-to-end latency	AT&T, Sprint, and T-Mobile US holding out on 5G technology until industry standards are created

Source: Expert interviews, GSMA, SKT website, McKinsey analysis

Exhibit 9: Next-generation technology will open up new types of use cases



1 LTE Advanced, Wi-Fi, terrestrial networks
Source: Expert interviews; "5G white paper," Next Generation Mobile Networks (NGMN), 15 February, 2015, ngmn.org; Qualcomm

- Enhanced mobile broadband: Enhanced mobile broadband will further push the boundaries on technological capabilities and requirements. Enhancements will significantly increase speed and will enable, among other things, massive 4K video streaming and fixed wireless (fiber-like speed to homes). Multiplayer gaming is also expected to move to mobile devices when latency improves with the next generation.

- Massive IoT: Massive IoT refers to the explosion of new devices that connect to the Internet, beyond handsets, including wearables, and smart homes. 5G networks will be able to handle a significant increase in the number of connected devices for each base station.

- Mission critical control: Mission critical control is about improving the reliability and latency of the network infrastructure. With ultrahigh reliability and low latency, autonomous vehicles, and remote-control processes (e.g., remote mobile robots) are expected to become new use cases relying on the network.

The relative importance of each use case depends on the country. Many of the US operators are focused on maximizing the value of fixed wireless networks as part of enhanced mobile broadband, but this is less attractive in Japan, where fiber networks are already extensively deployed. For Japan, the increase in capacity with enhanced mobile broadband is particularly compelling to address constraints in usage and speed, especially in high-density areas such as central Tokyo. While the total value of these use cases for Japan has not been properly assessed, the impact will most likely have enormous benefit for society. One example is IoT, including technologies such as Low Power Wide Area (LPWA), which McKinsey Global Institute estimates the potential global economic value to be $4 trillion to $11 trillion a year in 2025.[15]

3.2 Critical for the competitiveness and future success of Japanese industry and society at large

The performance improvements and proliferation of use cases that come with the next-generation network will not only be important for the telecom sector but will also be essential for many other industries, and for Japanese society as a whole. While Japan's current infrastructure is adequate, failing to remain in the forefront could have a significant impact and put industries at a disadvantage against international peers.

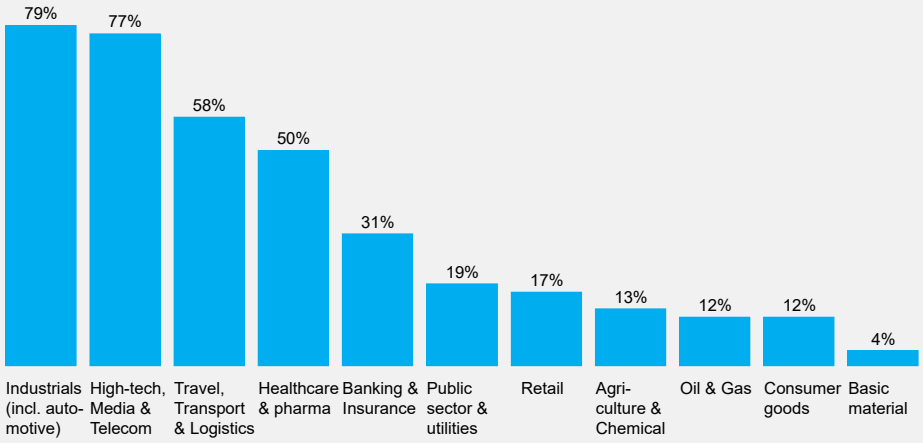
For operators, the new technologies will provide improvements to help alleviate capacity constraints, which will become ever more prevalent due to an exponential growth in data traffic. The previously mentioned performance improvements will also enable operators to improve their offering to end users, as well as open up new potential revenue sources with additional use cases more suitable for B2B.

Mobile device manufacturers and network equipment vendors will also benefit from an infrastructure that allows new types of technologies to scale. Much as iPhone and other smartphone devices gained traction from LTE networks, 5G may allow for similar types of innovation related to new use cases. With an evolved network, Japanese companies within electronics and industrial engineering may be able to find new areas that can become their future growth engine.

In addition, the success of many industries outside the telecom sector will depend on a mobile network that is at the forefront. For companies to remain in the leading edge of innovation, they will need a globally competitive infrastructure on which to build their future products . As connectivity becomes ever more ingrained in society, mobile networks will become the infrastructure on which industries will base their new products and services. This will be crucial for important exporting industries, such as automotive and robotics, which are expected to be among the main beneficiaries of 5G, according to the surveyed telecom mangers (Exhibit 10). Japan's reliance on exports from high-tech industries means their success will also have an impact on the overall national economy.

Exhibit 10: Industrials such as automotive expected to be one of the main beneficiaries from 5G

n=52[1]

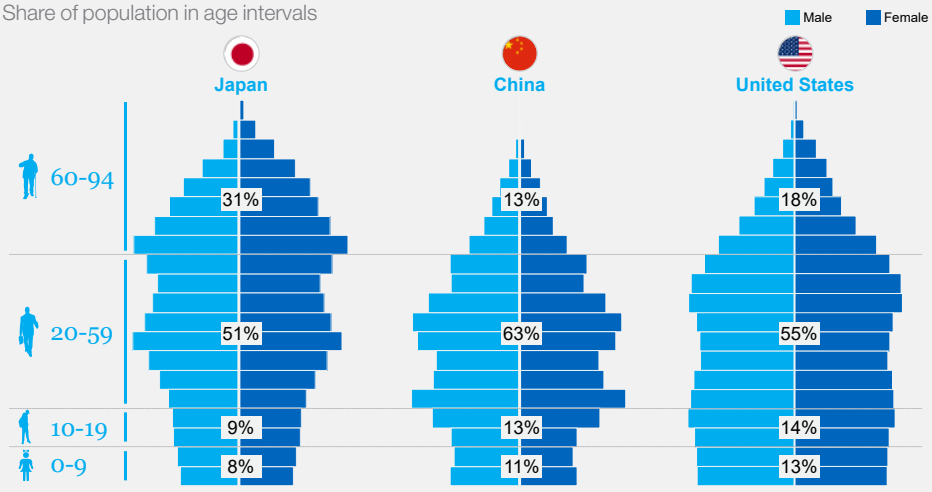


1 Which Japanese industries are likely to benefit the most from accessing 5G infrastructure? Select all that apply.
Source: McKinsey survey to Japanese telecom industry managers, September 2017

Lastly, there are huge benefits for the Japanese government and society at large. With an aging population and a challenging demographic outlook, productivity and more efficient healthcare will be key in order for Japan to reduce economic impact and sustain quality of life for its citizens. Currently, 31 percent of the population in Japan is older than 60 years of age, compared with 13 and 18 percent in China and the United States respectively (Exhibit 11). Technologies enabled by the next-generation networks will be integral in handling this impending change. Healthcare is one area where such technologies will be important. Use cases include as diverse things as sensors, monitoring health conditions in real time through LPWA, surgeries done in rural hospitals with remote-controlled robotics, or robots taking care of household chores and delivering food or medicine to the elderly.

Exhibit 11: Japan will need to handle a significantly larger share of old population compared with other countries

Share of population in age intervals



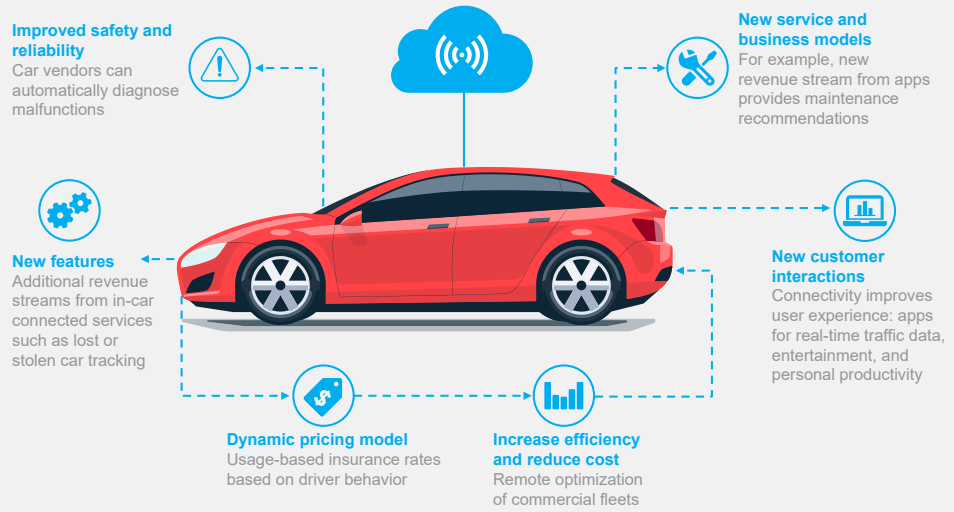
SOURCE: United Nations, Demographic and social statistics, 2006-2016, latest year available

Additionally, education and disaster protection are other areas where the next-generation networks will have a positive impact for the government and society. With an ultrareliable network infrastructure, disaster alerts can be improved to provide even more reliable and timely warnings, as well as information to help guide people to safety. Education is also an area that could be improved through better connectivity. Use cases include remote collaboration through video telepresence, usage of AR and VR as interactive tools in vocational training or for simulating dangerous environments, and IoT applications to improve classroom experience by, for example, providing real-time feedback to lecturers on the content.

Case study one – The automotive industry

The automotive industry is especially important for the Japanese economy. It accounts for 16 percent of exports[16] and employs more than 800,000 people in production alone.[17] Internet connectivity will become integral to the car of the future, given technological advances in GPS, automated driving, and other features. The network-enabled car may even disrupt the landscape and introduce new business models for car companies to handle (Exhibit 12). To remain competitive globally, it is crucial that the automotive industry is supported by a network that helps shape the future of connected cars.

Exhibit 12: The connected car could bring new business models



Source: *The Internet of Things: Mapping the Value Beyond the Hype*, McKinsey Global Institute, June 2015

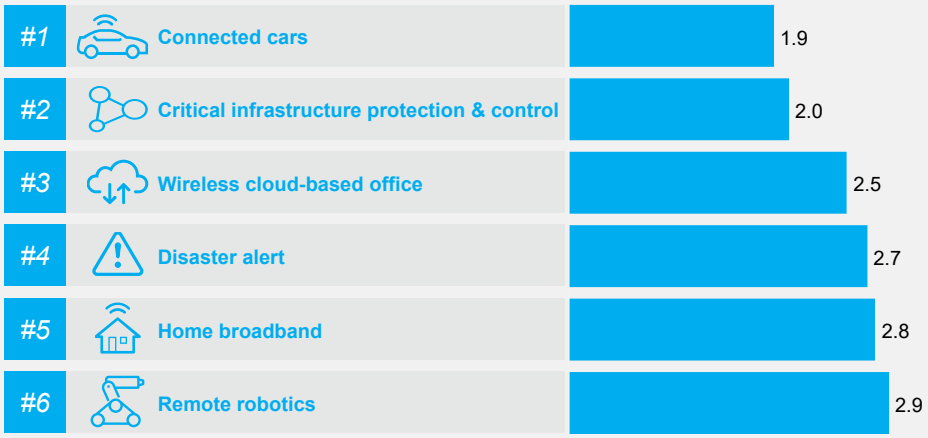
While some cars already rely on the mobile network to, for example, calculate the fastest routes, significant growth is still expected. The total potential economic impact from autonomous vehicles and condition-based maintenance is estimated to be around $210 billion to $740 billion in 2025,[18] and to capture this opportunity, many car manufacturers and operators are already collaborating to build features for connected cars.

One of the main use cases pointed out for 5G is autonomous vehicles, which was confirmed in McKinsey's survey to Japanese telecom industry managers (Exhibit 13). Although car manufacturers are still in the early stages of development on self-driving cars, they are making significant progress, and cars are already able to drive themselves for extensive periods without human intervention.[19] Until fully autonomous vehicles are in final development phases, the extent to which they will rely on 5G features, such as mission-critical reliability or ultralow latency, remain unclear. However, it is safe to say they will continue to increase demand on mobile networks both from cross-car communications over the network, and from downloading and uploading data for navigation and entertainment systems. With the driver required to spend less time focusing on traffic, data consumption for high-quality streaming is also likely to rise. Next-generation networks will be much more capable of delivering data to objects moving at high speeds, such as cars.

Embracing the new technology the networks will offer early on will be crucial for Japanese auto companies. With cars becoming more reliant on connectivity and software, scale will become even more important, with increasing network effects. One example is self-driving cars that can improve functions through machine learning. Companies with scale will have an advantage by analyzing different scenarios and integrating user feedback. With large amounts of data, the car's software will be able to strengthen its capabilities more quickly and effectively.

Given Japanese automakers' significant presence in the global market (exporting nearly four million cars in 2015), they are in a good position to capture the opportunities presented by next-generation vehicles.[20]

Exhibit 13: **Experts rate connected cars as the number one 5G use case**



1 Please rank the following 5G use cases in order of importance, with 1 being most important.
Source: McKinsey survey to Japanese telecom industry managers, September 2017

Collaborative robots[24] or "cobots" are robots designed to work alongside and in partnership with humans.

Cobots learn from and interact with humans – for example in assembling products. A collaborative workspace is possible thanks to various safety concepts designed to protect the humans if the robot malfunctions.

Advances in technologies, such as sensors, and motion control, have made them a viable option for many work environments. The market for cobots has started to take off, and is predicted to see accelerating growth as workplace safety and performance improves.

Case study two – The robotics industry

Technological advances in robotics have long been synonymous with Japan. Since the 1980s, industrial robots have been an increasingly common sight on factory floors. This occurrence is mainly because Japan's many successful automotive and electronic manufacturing companies have needed to increase labor productivity. The increased penetration of industrial robots has fueled the growth of a domestic robotics industry, with Yaskawa and Fanuc as market leaders. It has also placed Japan at the forefront of robotic technology globally, with exports of almost $2.7 billion in 2016 and 52 percent of the global supply of industrial robots.[21]

The government has played an important role in realizing and maintaining Japan's leadership in robotic technology. In 2015 the government launched a vision and action plan called "Robot revolution" intended to establish Japan as a robotics superpower and to "lead the world by intensive utilization of robots in a data-driven era."[22] The effort includes staying ahead in the ongoing transition from mature industrial manufacturing machine type of robots to new collaborative type of robots for the service industry (see inset "Collaborative robots").

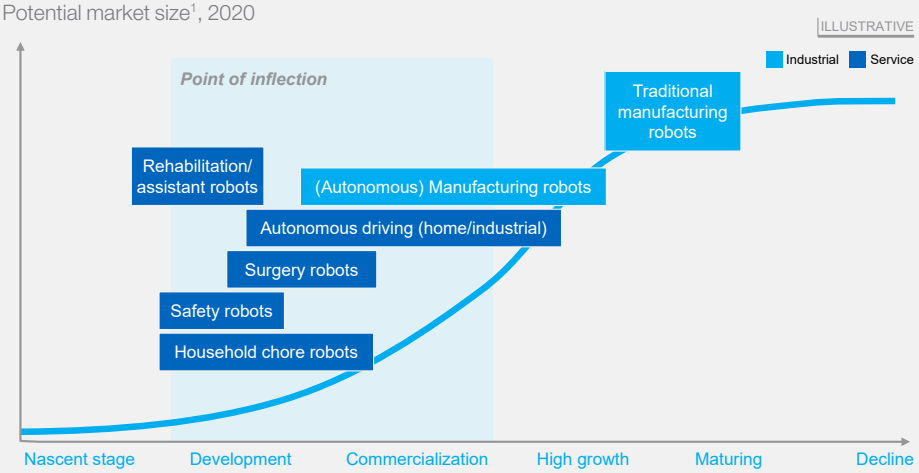
The development is not only important to sustain exports of robotic products but also to maintain productivity and to provide care for the elderly, as the workforce experiences a significant shift towards retirement. In the current population, there are almost twice as many 60- to 64-year-old individuals as 0- to 4-year-old children, making Japan one of the first advanced countries to experience this dramatic demographic change.[23] New robotic technology will be one of the main tools to handle this transition and dampen the economic effects on the country as a whole.

As technology advances, new types of robots more focused on service rather than industrial applications are approaching the inflection point for large-scale deployment (Exhibit 14). As these robots become more and more mobile and autonomous in the future, wireless

connectivity will be essential. More specifically, 5G will play a central role in creating the next-generation of mobile robotics (for example, automated guided vehicles and remote-controlled robots). Low latency, high data capacity, and ultra-high reliability will all be crucial.

Exhibit 14: Based on recent innovations, robotics for services are likely to reach a point of commercialization and high growth in the near future

Potential market size[1], 2020



1 Preliminary market sizing based on expert interviews.
Source: Expert interviews, McKinsey analysis

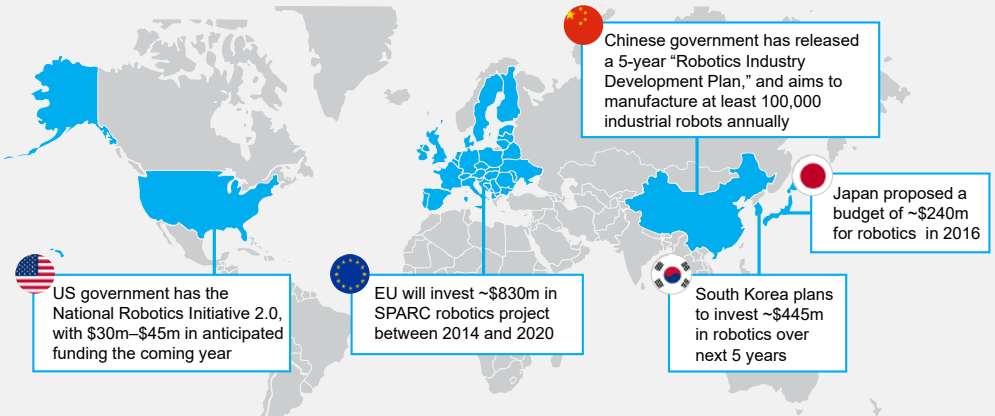
First, one of the main requirements for remote-controlled robotics is very low latency, as a delay of just a few tenths of a millisecond between the input and action makes controlling the robot very difficult. LTE networks have previously not been able to effectively manage very low latency.

Second, substantial data traffic will be generated. Even autonomous robots, with machine learning capabilities, are expected to rely on mobile networks for some time to come, as they encounter situations that the internal image processing and recognition will not be able to handle alone. They will also generate substantial data traffic when transmitting and receiving data to and from a central server to further build their capabilities and learn from each other. With more and more reliance on image recognition and an increase in image quality, high-speed data transfer will be essential.

Last, for industries and service functions to build their offerings with robots relying on mobile networks, the uptime of the network will be critical, something the specifications for 5G promise to deliver. This advancement will be especially critical in areas where robots are in close proximity of and interacting with human beings, for example, during surgery, in a cobot production line, or at home.

As a leading nation in robotic technology, and with a good mobile network infrastructure, Japan has a good shot at achieving its ambitions. Still, many other countries are making good progress and have set out ambitious targets for their robotics industry. Governments in China, the European Union, South Korea, and the United States are all making substantial investments into this area (Exhibit 15), and hope to benefit from them.

Exhibit 15: Governments' focus in robotics is fueling R&D investment in the technology



Source: "NSF Releases Solicitation for National Robotics Initiative 2.0" Rutgers Research Portal, February 2, 2017, researchportal.rutgers.edu; Frank Tobe, "EU's Horizon 2020 has funded $179 million in robotics PPPs," The Robot Report, May 24, 2016, therobotreport.com; Trevor Mogg, "South Korea is about to spend big money on making better robots", Digital Trends, October 12, 2016, digitaltrends.com; Andrew Zaleski, "China's blueprint to crush the US robotics industry," CNBC September 6, 2017, cnbc.com; "Current Status of New Robot Strategy", (Robot Revolution Initiative, June 2017)

* * *

All in all, the next generation of mobile networks will have a hugely beneficial impact, similarly to previous generations. When 2G replaced 1G, Short Message Service (SMS) was not predicted to be the huge revenue generator it became. Equally, when 3G replaced 2G, the technology was not immediately clear on how data capabilities would be monetized. When 4G replaced 3G, there was uncertain about why the additional capacity was necessary. Looking back, demand always rose to meet additional capacity and eventually led to enormous economic benefits. 5G will most likely play out in similar fashion.


溜池 新橋
Tameike Shinbashi
品川
Shinagawa
15
芝浦
Shibaura
海岸通り
羽田まで
20分

4. The way forward: How Japan can regain its leadership position

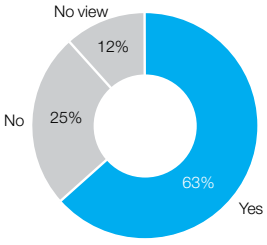
To capture the opportunity presented by 5G deployment, re-establish Japan as a global leader, and build a new foundation on which industries can create next-generation technologies, Japanese telecom operators, equipment vendors, the private sector, the government, and regulators should consider three strategic imperatives:

1. Operators need to build the next-generation infrastructure and offerings based on the best of global products and services: By using solutions from the global innovation ecosystem and limiting customization, operators will be able to reduce time to market for new features, limit vendor lock-in, and deploy more cost effective solutions for their networks. Going for global standards and developing procurement capabilities will help this process.

2. Subscale mobile telecom equipment vendors need to build alliances and find new pockets of growth: By refocusing their portfolios, limiting customization, and building alliances, network equipment and handset players can tap into 5G growth opportunities and combat increasing development costs.

3. Industry, government, and regulators need to collaborate with operators and mobile telecom equipment vendors, and embrace the new technology: By actively engaging with the telecom industry to shape the next generation networks, the private and public sector can enable new products and services that can be scaled globally, and regain technology leadership.

Survey 3:
A majority of respondents think Japan will follow global 5G standard (3GPP) with limited customization
n=52[1]



1 Is Japan likely to follow the global 5G standard (3GPP) with limited customizations?
Source: McKinsey survey to Japanese telecom industry managers, September 2017

4.1 Operators need to build the next-generation infrastructure and offerings based on the best of global products and services

In a market where innovation takes place at a global pace, telecom operators need to provide consumers with access to new products and services from around the world. Innovation is happening at lightning speed, further accelerated with a shift from hardware to software development, and can completely disrupt an industry and change the competitive landscape in a few years. Examples include LINE, a communications application, which launched in 2011 and had more than 400 million users in three years, replacing a lot of standard text messaging.[25] In the other direction, Nokia handsets (i.e. not to be confused with Nokia Networks) was market-leading in 2007 and a few years later sold off to Microsoft.[26] With ever-increasing connectivity and an expanding marketplace, more products and services are consumed globally. Alignment with global standards and limited customizations are key enablers to tap into this global ecosystem and provide a cost-efficient infrastructure. There is already a relatively broad consensus that this will happen in Japan, where some 63 percent of industry managers believe 5G will be deployed with limited customization (Survey 3).

The benefits of going for a closer harmonization with the rest of the world are many, but to capture them, operators have to take three sets of actions:

1. Reduce time to market for new features.

2. Limit vendor lock-in and allow for a flexible network roadmap.

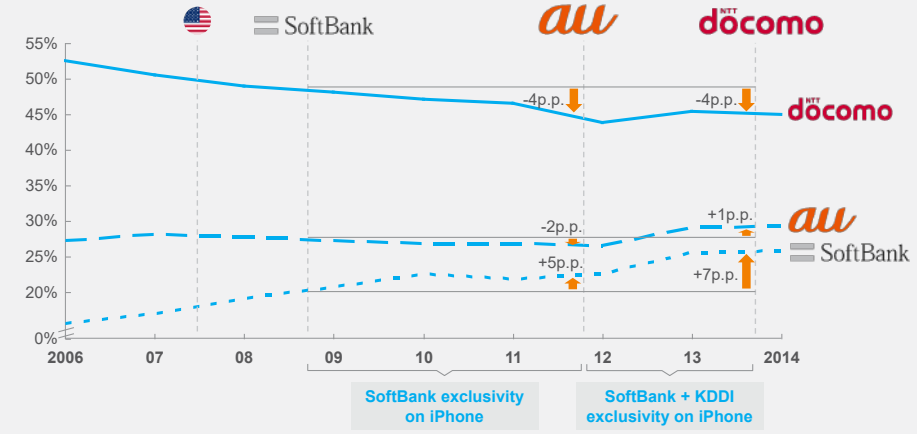
3. Deploy more cost-effective solutions.

Reduce time to market for new features

To get in advance of competitors and improve offerings and services to end-users, operators need to reduce the time required to release new features. For example, by moving quickly and offering the iPhone to consumers ahead of competitors, SoftBank was able to attract a substantial share of subscribers (Exhibit 16). Telecom operators that introduce the latest innovations and features in Japan will have the upper hand in attracting subscribers and winning market share.

Exhibit 16: iPhone had a big impact on the subscriber rate among Japanese operators

Share of suscribers per year[1], Japan



1 Historical subscribers include acquired companies: KDDI (au) includes TU-KA; Docomo includes NTT Docomo (PHS); and SoftBank includes Vodafone and eMobile.
Source: Historical subscriber data, Telecommunications Carriers Association (TCA), 2017, McKinsey analysis

It is likely that there will be new areas where a head start will bring a competitive advantage. This will not only be true for mobile devices, where augmented reality could be the next big thing, but also for value-added services or network features. By releasing features, such as nationwide NB-IoT coverage or mission critical control, operators could attract new customers and businesses (see inset "Low Power Wide Area (LPWA)").

Limit vendor lock-in and allow for a flexible network roadmap

To allow for a flexible roadmap and to be able to quickly roll out new features in the network, operators will need to find ways to limit lock-in from vendors. The evolved network will see a proliferation of use cases that require new capabilities and technological expertise, making it difficult for vendors to cater to all of them. As a result, technology leadership may shift depending on the area, and flexibility will be important.

The network equipment market is also consolidating, and there are now only a handful of major players offering radio-access network products. As the number of players continue to decline, it will be even more important to limit lock-in and add flexibility. For example, there are several solutions being developed around IoT. With flexible network evolution roadmaps, operators can pick and choose the solutions that suit them best, such as Cat-M1 or NB-IoT.

Low Power Wide Area (LPWA) is a type of low-cost wireless communication designed for IoT applications that use low power and a low data rate, and require long battery life – for example to operate in remote locations. Some of the use cases include smart utility metering, smart parking, and environmental monitoring systems.

LPWA includes three key competing technologies:

1. 3GPP IoT uses licensed LTE spectrum with standards, such as Cat-M1 and NB-IoT; it is mainly used for high value and critical use cases.[27]
2. Sigfox is a proprietary solution using unlicensed spectrum; it has low cost and targets low criticality use cases.[28]
3. LoRa is also a proprietary solution using unlicensed spectrum for use cases in between NB-IoT and Sigfox.[29]

Deploy more cost-effective solutions

Another benefit of utilizing global scale in innovation is unmatched price and performance. As products are developed for global use, the amount of reuse rises, and marginal cost for feature development falls. This outcome can significantly reduce costs compared with feature development in a completely customized setup.

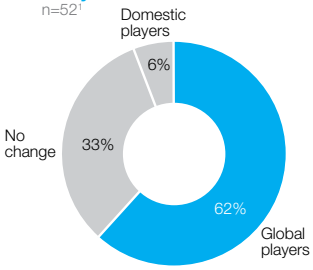
At the same time, performance can be improved by an unrivalled supply of innovations and features. By relying on the combined global innovation community, operators can choose from the most attractive combination of price and performance and deploy more cost-effective solutions without compromising network performance.

To capture these benefits, operators also need to build capabilities in their procurement functions. As the supply of products and services continue to expand, and the relative competitiveness of equipment vendors can quickly change, operators need to constantly monitor and evaluate the supplier landscape and select the most suitable suppliers.

Operators that limit customized equipment and software, and use off-the-shelf products can maintain both lower R&D costs and capex. As an example, South Korean operators, who reduced their customization of CDMA networks in 2001, now have 10 to 15 percent capex to revenue ratio, compared with 15 to 20 percent for Japanese operators.[30]

Survey 4:
A majority of respondents believe global network equipment providers are likely to take share

n=52[1]



1 As the competitive landscape for network vendors evolves, which players are likely to gain share?
Source: McKinsey survey to Japanese telecom industry managers, September 2017

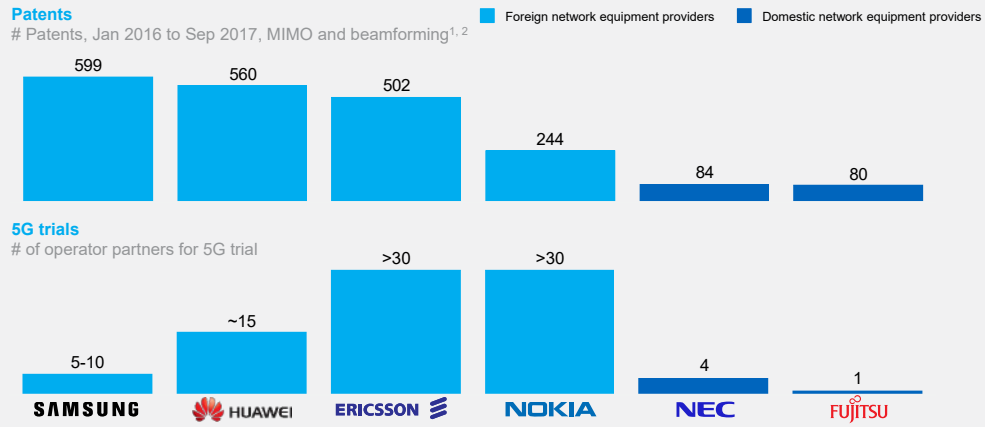
4.2 Subscale mobile telecom equipment vendors need to build alliances and find new pockets of growth

In recent years, Japan has seen an influx of new devices and services offered by global network equipment and device manufacturers. While end users have benefited from this increased competition, through handsets like iPhone and services such as Twitter and Instagram, Japanese device manufacturers, are rapidly losing market share.[31] Network equipment vendors have a minor share of the market and based on our survey, telecom managers believe they will further lose market share in the future, suggesting vendors must recalibrate to survive in the face of global competition (Survey 4). If vendors refocus their portfolios, limit customization, and seek alliances, they will have the opportunity to find pockets of growth not only in Japan but also globally.

Japanese network equipment vendors are currently subscale. If they in the future lose market share they will struggle to fund the research and development necessary to deliver solutions needed for the impending network evolution, including Massive MIMO, millimeter waves and beamforming network technologies. Global competitors are already outpacing Japanese vendors in R&D, evidenced by the number of patents held in key wireless radio 5G technologies (Exhibit 17). The major global incumbent network vendors, including Ericsson, Nokia Networks, and Huawei, have made no secret of their ambition to capture a significant share of 5G deployments and are already conducting 5G trials across the globe.

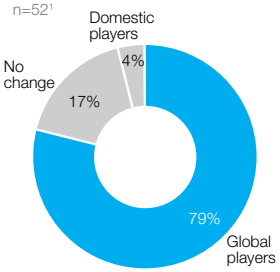
Success in the development race will depend not only on the availability of investment capital but also on market access and relationships with operators worldwide. Given that most Japanese network vendors focus mainly on domestic growth, Japanese players will have to substantially change how they do business, in order to survive.

Exhibit 17: Global vendors outpace the domestic player in number of patents for key 5G technologies and 5G trials



1 MIMO and beamforming under H04W (Wireless communication networks), H04B (Transmission) and H04L (Transmission of digital information) categories; patents from Jan 2016 to Sept 2017.
2 Includes patents from mobile devices for vertically integrated companies.
Source:Innography, accessed October 2, 2017; Ovum, September 2017; Company homepages; McKinsey analysis

Survey 5: A significant majority of respondents believe global mobile handset manufacturers are likely to take share

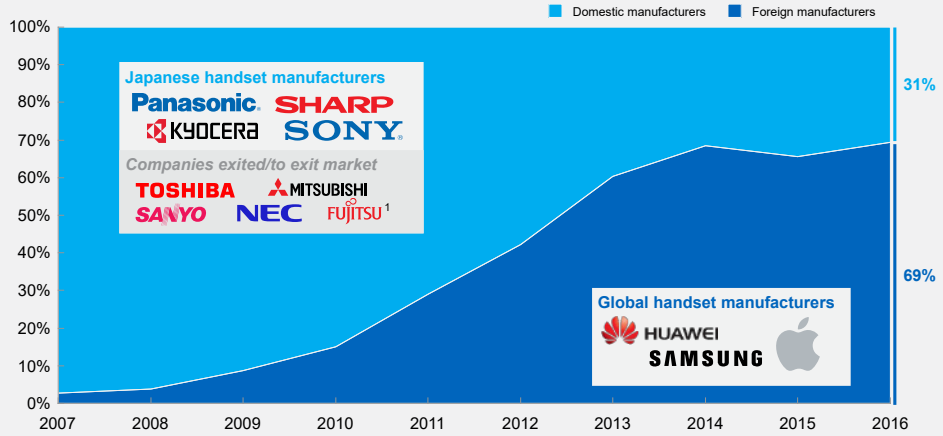


1 As the competitive lanscape for network vendors evolves, which players are likely to gain share?
Source: McKinsey survey to Japanese telecom industry managers, September 2017

Mobile device manufacturers also face tough competition from international players, and an even larger majority of survey respondents believe that domestic players will continue to lose market share to their global counterparts (Survey 5). With increasing network effects from comprehensive systems such as Apple's iOS and Google's Android OS, scale will become more important. In addition, the majority of Japanese manufacturers are currently restricted by their domestic focus. This course of action shows that they are mainly cannibalizing each other, rather than global leaders such as Apple and Samsung (Exhibit 18).

Exhibit 18: Foreign handset manufacturers have completely disrupted the Japanese market

Mobile device sales in Japan by manufacturer, % of market, Japan



1 In 2017, Fujitsu announced the withdrawal of their handset operations.
Source: IDC quarterly mobile phone tracker - final historical, Q3 2017, "Fujitsu putting mobile phone business on the block," Nikkei Asian Review, August 22, 2017, asia.nikkei.com

To rebuild in the face of global competition, vendors should consider three key actions:

1. Refocus portfolios and innovate to achieve profitable growth.

2. Limit customization and increase reuse of solutions to build scale.

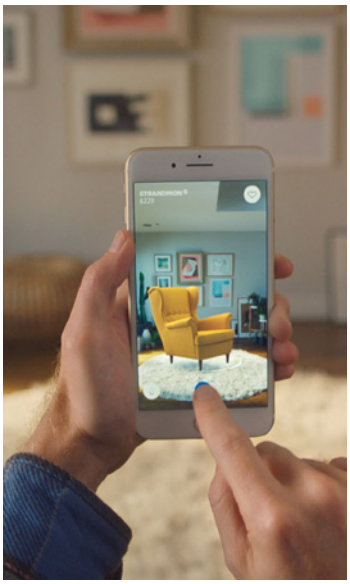
3. Build alliances to fill gaps in portfolios and stay relevant.

Refocus portfolios and innovate to achieve profitable growth

To compete with global players, device and equipment manufacturers need to refocus their portfolios on products or services that can still capture a substantial share of the market. This could, for example, be in already strong segments such as System Integration, or within new segments that will come from an expanded set of use cases, for which products are not yet developed and where incumbent manufacturers have less of a grip. The experience of recent years shows companies (such as Apple and Samsung) can disrupt the market quickly, while others (for example Nokia handsets, Motorola, and HTC) quickly can lose out.

In a world with next-generation networks, rather than iterating on handsets alone, device manufacturers should focus their R&D on areas where they are already present and if it is realistic to build global top-three position over the coming three to seven years. In addition, they should seek opportunities presented by new network infrastructure that can become the future growth engine, for example, in augmented reality, virtual reality, or smart homes. While there is no certainty which use case will generate the largest value, augmented reality seems ripe for development at scale, especially given the expected advances in the technical capabilities of the new network infrastructure (see inset "Augmented reality (AR) may be the next mass-market hit").

Augmented reality (AR) may be the next mass-market hit



Handsets are already entering the area of AR. More and more applications use the video functionality of the phone to overlay pictures in real time, adding information or adjusting in some way. The most notable example is Pokémon Go, which was released in 2016 and had more than 65 million active users in April 2017.[32] Another is Google Translate. Apple's latest operating system, iOS 11, released in September 2017, promises AR capabilities through its ARKit technology. The kit will allow developers to build AR applications for the iPhone, and companies like IKEA have already released applications using the platform.[33]

Phones are not the only devices that use AR. Many companies have experimented with integrating AR into eyewear. Google, with Glass, and Microsoft with HoloLens are both testing AR devices. While AR has not yet come into mainstream use, there are many niche examples where it is already applied. One use case is in warehouses, where pickers use the technology to help them locate and pick the correct items. With a more advanced network infrastructure, the number of areas where AR can cater for a significant market will likely increase.

Limit customization and increase reuse of solutions to build scale

Scale is critical for vendors to generate enough funds to cover product development costs, and customizations should therefore be limited. Global competitors have a significant advantage when it comes to scale, as they will be able to spread the cost of development among many more customers than domestic players can.

Scale becomes easier to achieve with a focus on the reusability of solutions. Historically, Japanese handset manufacturers have created parallel product lines, one for the Japanese market (or even one for each operator), and another for the international market. This development has limited their ability to realize economies of scale and grow.

The same is true on the network equipment side, where vendors commonly customize products to fit the Japanese operators' specific needs. Going forward, if an adaptation is necessary, vendors should make sure to integrate it into the overall product roadmap to make the general offering even stronger.

Build alliances to fill gaps in portfolios and stay relevant

By focusing their portfolios and limiting customization, vendors will be in a better position to achieve profitability. However, to stay relevant with their customers and cope with their R&D investments, they will need to enter partnerships or consider M&A options. By collaborating, through alliances or joint ventures, Japanese vendors can build scale and obtain a stronger position in the face of global competition, offering a wider range of products, and at the same time refocus their R&D resources to pockets of growth.

Network equipment vendors will likely not have the resources necessary to invest in the R&D needed for a full 5G offering on their own, and risk becoming obsolete in the face of global competition. To survive, they should build alliances with global peers, bringing their local expertise to the partnership while broadening their product portfolios.

The transition point may be imminent, as 5G development is already under way. The need for interworking between 4G and 5G puts an additional burden on the network equipment vendors. By drawing on their local knowledge and close bonds with customers, and codeveloping solutions, network equipment providers can find ways to remain relevant and retain R&D centers in Japan, while forming alliances with global players. The Nokia-Panasonic Network partnership, and later acquisition, is one example where such an alliance was built.[34]

4.3 Industry, government, and regulators need to collaborate with operators and mobile telecom equipment vendors and embrace the new technology

The export industry is critical to the nation's economy. To support exporters, the operators, government, and regulators all need to work for accelerated deployment of the mobile infrastructure and ensure that the industries can keep pace with the rest of the world.

In addition, there needs to be a stronger connection between the industry and telecom operators, so the network infrastructure deployed can truly serve as a competitive advantage. Other stakeholders, such as government and regulators, should also take an active role to prioritize a mobile network that increases the competitiveness of exporters.

As the focus moves to greater partnership between industry, operators, and the broader stakeholder community, players should consider the following actions:

1. Industry leaders need to collaborate with operators to ensure a fit-for-purpose next-generation network.

2. Government should make next-generation networks a strategic priority.

3. Regulators should enable faster adoption of innovation.

Industry leaders need to collaborate with operators to ensure a fit-for-purpose next-generation network

To make next-generation networks an enabler of innovation, industry leaders need to participate actively in the planning and creation of future infrastructure, helping operators understand which features and technical requirements they should focus on. For example, seamless interoperability between 5G and LTE can become critical for self-driving cars when they switch between a wide area LTE coverage to urban 5G networks.

Collaboration will benefit the industry and help operators, which have a good opportunity to increase B2B revenue with the arrival of 5G. With a more focused approach to working with industries, operators will be able to increase their B2B sales. This relationship will be even more important with 5G, since it will primarily create a large value pool for industry players. By strengthening their relationships now, operators should be able to capture some of this value.

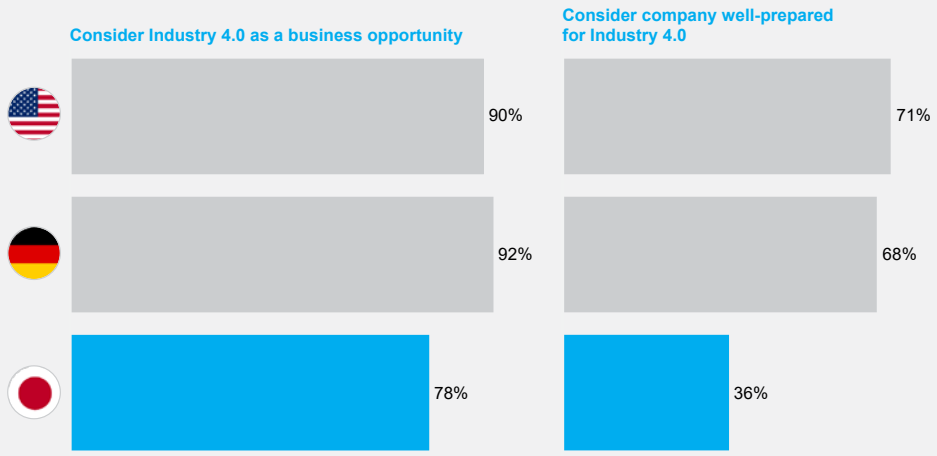
Looking at industry 4.0 (see inset "Industry 4.0"), including IoT, Japanese industries see a significant opportunity, but do not believe they are prepared to seize it (Exhibit 19). Companies in Germany and the United States are much better positioned. However, by participating in the evolution of the network, companies can take positive steps toward developing the innovations and solutions of the future.

Industry 4.0[35] is defined as the next phase in the digitization of the manufacturing sector, driven by four disruptions:

1. Big data: Huge rise in data volumes, computational power, and connectivity arising from IoT
2. Advanced analytics: Emergence of analytics and business-intelligence capabilities
3. Human-machine interfaces: New forms of human-machine interaction such as augmented-reality systems
4. Digital-to-physical transfer: Improvements in transferring digital instructions to the physical world, such as 3-D printing

Exhibit 19: Japanese companies do not feel ready to exploit industry 4.0 and IoT

Response from 300 companies



Source: McKinsey Digital Industry 4.0 Survey, 2016

Government should make next-generation networks a strategic priority

Japan's exporting industries are hugely important to the country with the automotive industry alone generating $131 billion in net exports as of 2016.[36] As connectivity becomes more important for exporting industries, the government should make a leading next-generation telecom network a strategic priority. In addition to economic benefits, new network infrastructure will bring social rewards, for example, in supporting surgery in rural hospitals, surveillance for crime prevention, disaster alerts, and education, among others.

Japan has embraced the potenial of going digital with their concept of Society 5.0 (see inset "Society 5.0"). Building on Industry 4.0, Japan aims to harness digital technologies and data from devices, such as household equipment, sensors, and mobile devices, to create a smart

Society 5.0[37] is a concept created by Japan in 2016 to describe their vision on how to reform their economy and society with the use of new technologies.

The "super smart" society is enabled by advances in robotics, growth of connected sensors, accumulation of data, and developments in artificial intelligence. It will realize a new economy and society, which focuses on individuals. Society 5.0 specifically lays out three areas of improvement:

1. Reform of individuals: Ensure people, including elderly, can live safe, secure, and healthy lives.
2. Reform of companies: Improve productivity through digitization and reform of business models.
3. Solving social issues: Solving social issues, such as aging population and natural disasters, through overseas expansion and new businesses and services.

society that can handle an aging population. To put the concept into reality an extensive collaboration between government and industry will be needed.

There are numerous ways that government can support the development of a new infrastructure. For example, the government can support research in the years ahead, as standards will not be finalized until 2019 and deployment will continue over many years beyond.[38] Use cases are still being trialed and tested, and some can have a significant impact on how critical infrastructure will operate in the future. With additional focus on research, Japan can maintain its capabilities in telecoms and regain its technological leadership.

Regulators should enable faster adoption of innovations

Another important stakeholder group when creating a purpose-built infrastructure and realizing innovations is regulators. This is especially true for future network infrastructure as it will rely on new, unassigned, frequency bands and enable use cases that can transform industries. By collaborating with both operators, equipment vendors, and industry stakeholders, regulators can remove barriers and help deploy 5G as quickly as possible.

Allocation of frequency spectrum is one area of importance for 5G where regulators play a central role. The performance and global interconnectivity of the mobile network depends on the assignment of the spectrum range. For 5G, three key frequency ranges will be needed[39] to deliver the essential speed and coverage for the different use cases:

- Sub-1 GHz, to achieve wide coverage and IoT use cases
- 1 GHz to 6 GHz, to achieve a good mix of speed and coverage suitable for urban areas
- Above 6 GHz, to achieve ultrahigh broadband speeds, while having limited range

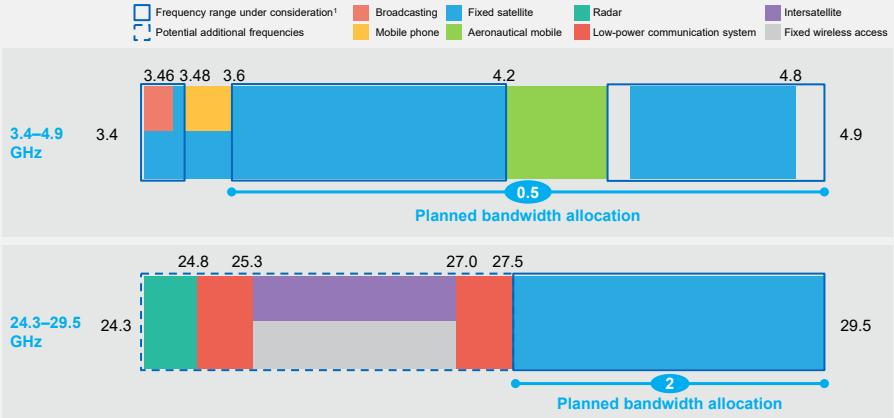
Across the world, most of the useful frequency bands have already been allocated to different kinds of technologies, especially in the sub-1 GHz end of the spectrum. Making room for additional spectrum for mobile networks is a challenging process, especially when trying to achieve as close a standardization as possible across the world. To support an efficient mobile infrastructure with high performance, regulators should ensure that 5G frequency bands will be sufficient for operators' needs and are as harmonized as possible with the international standards set by the International Telecommunication Union (ITU).

Below 1 GHz, spectrum has not yet been allocated specifically to 5G, and is currently used for LTE, however, these bands can also be used for 5G in the future. To ensure good coverage and high performance, the spectrum range needs to be wide enough to also handle the future data traffic increase. Regulators can help operators by ensuring that enough spectrum in this range will be available in the future. In higher frequency ranges, Japan is considering allocating a total of 500 MHz between 1 GHz and 6 GHz, and 2 GHz in the range above 6 GHz. The frequencies under consideration are currently used by other radio systems, such as radio astronomy, radar, broadcasting, and satellite communications, and a lot of spectrum will need to be freed up from other less critical technologies (Exhibit 20). Regulators need to form a clear, accelerated plan for how to achieve this outcome as early as possible, as equipment manufacturers need time to develop new devices and other equipment. They should also allocate large continuous frequency bands (that is, not chopped up) to provide the best possible performance to the operators. Recent plans have

shown that the regulators are accelerating this effort and Japan is shifting toward a more common practice to auction instead of allocating spectrum via beauty contest. This shift may also provide an opportunity for a possible fourth entrant to enter the Japanese market (see inset "Disruptions on the horizon for operators driving the cost imperative")

Exhibit 20: Currently different types of technologies are using the spectrum under consideration for 5G

Current usage of example candidate frequency bands in Japan[1], GHz



1 Also considering other high-frequency spectrum, 40.5 GHz to 43.5 GHz compatible with EU, and 37 GHz to 40 GHz compatible with the United States.
Source: Expert interviews; Spectrum Charts and allocation, Ministry of Internal Affairs and Communications, June, 2017, tele.soumu.go.jp

Another area where regulators can play a vital role in helping industries accelerate innovation is by promoting laws and regulations benefitting new use cases. For example, in Germany, regulators and the government are legalizing self-driving cars to allow the automotive industry to innovate and build new products.[40] This implementation will be relevant in Japan as well, and there will be other areas, such as the robotics industry, where regulation may need adjustment to bring new use cases and products to the public as quickly as possible.

Disruptions on the horizon for operators driving the cost imperative

Introduction of spectrum auctions

Japan has, up until today, not used spectrum auctions as a means of allocating radio frequencies. As such it stands out from the other 35 OECD nations.[41] Over the past two decades competitive bidding has become the global standard for awarding spectrum because it ensures that spectrum is distributed to the players that can generate the greatest economic impact and guarantees that the public gets fairly compensated for this scarce resource.

The Ministry of Internal Affairs and Communication (MIC) is currently conducting a substantial review of Japan's spectrum policy, the results of which are due to be published in April 2018, and which will govern the access to the 3.7 GHz and millimeter wave bands in 2019. Although, there is still uncertainty about how the spectrum regime will evolve, publicly stated objectives include increasing transparency of decision criteria and increasing the element of competition in applications.

Just how far Japan will go towards traditional price-based auctions and to what extent coverage obligations and business objectives will be weighed against spectrum fees remains unclear. However, Japanese operators need to prepare for a potential future where they will have to pay for what was previously given to them free of charge.

The possibility of a fourth entrant

Japan has been a stable three player market for a long time. Attempts to launch alternative networks have had limited long-term effect on market dynamics.

The upcoming allocation of 1.7 GHz and 3.4 GHz in March 2019 could very well change this. In the guidelines provided by the MIC, new entrants are given slightly preferential treatment (access granted if they fare as well as competitors on the other scoring criteria, e.g., coverage ambitions).[42] Rakuten, the e-commerce conglomerate that is also Japan's largest mobile network virtual operator (MVNO), has already announced plans to apply for an MNO license to operate on these bands.[43]

The introduction of fourth entrants have played out very differently in various markets. In many cases (such as in Spain), new players struggle to gain scale, and remain below 5 percent market share five years after launch.[44] In other instances, they create a severe market disruption and reach a solid position above the 15 percent mark, as in France and Poland.[45] Almost without exception, the introduction of an additional network causes prices to decline. In the most extreme cases, such as in France, market ARPUs have dropped as much as 50 percent over a five-year period following the launch.[46]

Ultimately, the effect of a potential new entrant in the Japanese market will depend on many factors. However, there are two facts that should be a cause for concern among established operators:

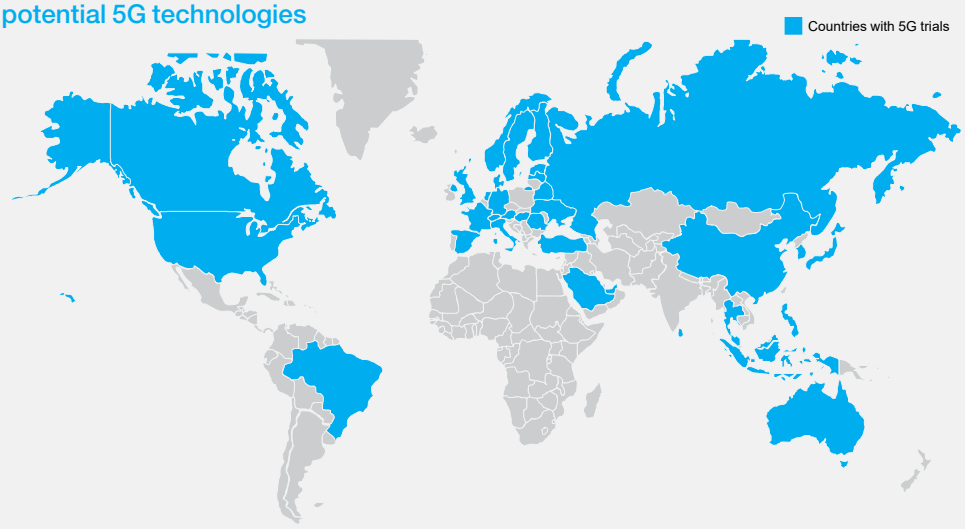
- Technology penetration: The high penetration of 4G capable handsets means that an attacker can credibly operate a 4G-only Voice over IP-based network (e.g., Jio in India),[47] without need for national roaming arrangements with existing MNOs. This penetration increases the addressable market and translates to a real cost advantage that reduces the scale required to break even.
- Current price levels: Japan has some of the highest mobile prices in the world, with ARPUs being almost two times higher than the Western European average.[48]

With the possibility of having to pay 'market prices' for spectrum access in the future and the risk of substantial ARPU erosion associated with a fourth entrant, Japanese operators could face a situation in a few years where they need to aggressively address their cost base (in particular network cost) to be able to pay the dividends to which their shareholders have become accustomed.

5. A vision for the future – Why Japan needs to accelerate the transition

As of today, operators from more than 40 countries are already in various phases of 5G testing (Exhibit 21). Japanese companies have already committed to investing more than $45 billion in 5G deployment and plan to start rolling it out in time for the 2020 Summer Olympic Games. However, Japan must move more quickly if it is to gain both the direct and indirect benefits of a first-mover advantage.[49]

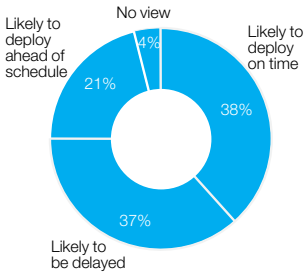
Exhibit 21: Countries where operators are demonstrating, testing, or trialling potential 5G technologies



Source: : "5G Update – Global Market Trials," GSA, September, 2017

Survey 6: There is a mixed view on the deployment timing for 5G

n=52[1]



1 What is the likely scenario for the committed 5G deployment in 2020?
Source: McKinsey survey to Japanese telecom industry managers, September 2017

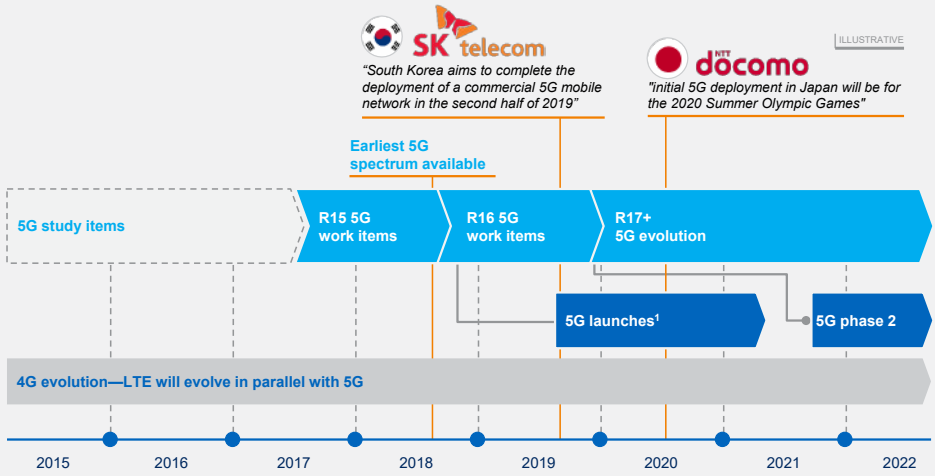
With its current commitment, Japan will be one of the first countries to deploy the new network. However, South Korea is likely to make commercial launch in 2019, a full year ahead of Japan (Exhibit 22), and China plans a massive deployment from 2020, targeting a penetration of more than 400 million 5G connections by 2025.[50] Telecom managers in Japan also have mixed views of whether 5G will be deployed on time (Survey 6). Japan needs to ensure that the 4G to 5G transition will be fast and successful to avoid further weakening Japan's competitiveness compared with China and South Korea.

Direct benefits among industries, end users, and operators

Countries that rapidly deploy next-generation networks and ensure interoperability will establish a strong foundation for companies to develop and test new products, giving them a chance to launch quickly onto the global market.

Speed matters. When 3G was launched in 2001, Japan deployed the Freedom of Mobile Multimedia Access (FOMA) standard, which was not fully compatible with the widely used Universal Mobile Telecommunications System (UMTS) protocol.[51] It took three years to achieve full compatibility for mobile handsets. At the same time, South Korea was able to deploy a commercial network with CDMA2000 that had a higher adoption rate and was compatible with countries such as the United States. Subsequently, companies such as LG Electronics and Samsung developed compelling handset propositions that were internationally scalable.

Exhibit 22: South Korea is likely to deploy commercial 5G one year ahead of Japan



Note: Estimated commercial dates;
1 Forward compatibility with R16 and beyond
Source: Expert interviews; 3GPP; Qualcomm; Press search

If Japan moves quickly and adopts international standards, the new network will bring substantial benefits to the industry. In addition, end users will enjoy higher connection speeds, more capacity, and better reliability, helping them access new applications in areas such as health monitoring and autonomous vehicles. Finally, by accelerating the launch, operators could more quickly relieve network congestion and increase profitability, as the new technology will be less costly per added unit of data capacity.

Indirect benefits for the whole of Japanese society

Getting a head start on 5G deployment will also benefit society more broadly. An improved infrastructure will serve as the basis for entrepreneurs and companies to develop new ventures and business models, generating growth.

In the previous generation of networks, China made massive investments into LTE, which helped create and scale companies such as Alibaba, now one of the world's most valuable tech companies, with more than 500 million active mobile users monthly across its platforms.[52] The United States is another example. The country benefited from the invention and commercial launch of the Internet and managed to build a culture of innovation that led to the creation of some of the fastest-growing and most profitable companies in the world, including Facebook, Amazon, Netflix, and Google.

* * *

Japan was able to take a leadership position in mobile communications in the 1980s by embracing new technology and has since had a very impressive list of successful telecommunications companies, including network equipment providers, mobile handset manufacturers, and mobile operators. By embracing the network evolution and following the imperatives described above, Japan has a chance to boost its industries, spur innovation, and regain technology leadership for a prosperous telecom sector.

However, time is of the essence. Early deployment will result in first-mover advantages across society and lay the foundation for regained technology leadership. Failure to act now could let other countries reap the benefits and hold Japan back for the foreseeable future.

Glossary

3GPP	3rd Generation Partnership Project (3GPP) is a collaboration between groups of telecommunications associations to develop and maintain mobile communications standards
4G	Fourth generation telecommunications network
5G	Fifth generation telecommunications network
AR	Augmented reality is a technology that overlay computer-generated visuals and intelligence on the real-world view seen by a user
ARPU	Average revenue per user
Beamforming	Beamforming is technology for directional transmission of wireless signals
CatM1	Competing standard to NB-IoT that enable different devices, typically IoT device, and services to be connected thought the mobile telecommunications networks
CDMA 2000	Competing third generation standard to UMTS used in Japan, Europe, and China
Churn	Churn is the percentage of subscribers to a service that discontinue their subscriptions to that service within a given time period
Cobot / Collaborative robot	Cobot or collaborative robot is a robot that shares workspace and is intended to physically interact with humans
Coordinated multipoint	Coordinated multipoint or cooperative MIMO is an advanced technology to improve cell-edge user data rate and spectral efficiency
Core	Core is the backbone of the telecom network, namely, the core part that interconnects the different nodes of the network
CSPs	Communications service provider
Evolved network	Path from LTE to 5G, including LTE Advanced and technologies with mobile network technologies such as IoT
FCC	Federal Communications Commission
FOMA	Freedom of Mobile Multimedia Access is W-CDMA-based third-generation mobile services offered by NTT DoCoMo
GSM	Global System for Mobile communications is a standard developed for second-generation mobile telecommunications system
i-mode	Technology that enables connection of mobile devices to internet utilizing packet switched networks
IoT	Internet of Things is a term to describe devices connected to the internet or with the ability to transfer data over a mobile telecommunications network without requiring human interaction
ITU	International Telecommunication Union is an United Nations agency that co-ordinates usage of wireless spectrum and technical standards globally
Latency	Time delay in signal transmission
LPWA	Low Power Wide Area (LPWA) is a type of low-cost wireless communication, designed for IoT applications that use low power, low data rate, and require long battery life
LTE	Long-Term Evolution is a 4G telecommunication standard that allow high speed communication
LTE Advanced	An enhancement of the LTE standard that will bring data speeds theoretically up to 1Gbps

M&A	Mergers and acquisitions is a term to describe consolidation of companies or assets
Massive MIMO	Massive multiple-input and multiple-output is large scale antenna systems
Millimeter wave	High frequency wave that occupy spectrum from 30 GHz to 300 GHz
MIMO	Multiple-Input and Multiple-Output is an antenna technology for wireless communications that uses multiple antennas to transmit and receive data in order to increase the spectral efficiency
MNO	Mobile network operator is a provider of wireless communications services
MVNO	Mobile network virtual operator is a virtual provider of wireless communications services that uses an existing operator's infrastructure
Modulation	Modulation is the process of modifying a waveform to overlay information on a carrier signal
Multiuser MIMO	Multiuser MIMO is a multiple input and multiple output technology that uses multiple antennas to transmit and receive signals to and from multiple users
NB-IoT	Narrow Band Internet of Things is a low-power radio technology standard developed to enable different devices, and services to be connected thought the mobile telecommunication networks
SDN	Software Defined Networking technology enables deployment of agile and flexible mobile network through cloud architecture
SMS	Short Message Service is text messaging service
UMTS	Universal Mobile Telecommunications System is a third-generation network standard based on the GSM standard
WAP	Wireless application protocol is a technical standard to access information over the telecommunication networks

Footnotes

1 The scope of this report is network operators and does not cover satellite operators.

2 NTT Network Innovation Laboratories, accessed December 12, 2017, ntt.co.jp.

3 Ovum, World Cellular Information Service (WCIS), September 2017.

4 Mayumi Negishi, “Long before Apple pay, Japan had ‘mobile wallet’"*The Wall Street Journal*, September 11, 2014, wsj.com.

5 Akky Akimoto, “In the battle with smart phones is i-mode dead?,” *Japan times*, April 20, 2011, japantimes.co.jp.

6 Programming WebLogic Server for Wireless Services, accessed December 12, 2017, Oracle.com.

7 Negishi, Ibid.

8 *The state of LTE*, OpenSignal, June 2017, opensignal.com.

9 McKinsey survey to Japanese telecom industry managers, September 2017. Proprietary survey conducted during September 2017 with 52 respondents of Japanese telecom managers. Figures may not total to 100%, because of rounding.

10 "Fujitsu putting mobile phone business on the block," *Nikkei Asian Review*, August 22, 2017, asia.nikkei.com.

11 IDC quarterly mobile phone tracker - final historical, Q3, 2017.

12 Ovum, WCIS, Ibid.

13 Results based on IHS Markit, *The 5G economy: How 5G technology will contribute to the global economy* whitepaper. Information is not an endorsement of McKinsey & Company. Any reliance on these results is at the third party's own risk. Visit www.technology.ihs.com for more details.

14 On 20 December 2017, 3GPP announced its ratification of Non-Standalone (NSA) 5G New Radio (NR) specifications that will form the basis of first commercial 5G deployments by 2019. NSA 5G NR will utilize the existing LTE radio and core network while adding a new 5G carrier. Specifications for a Standalone (SA) 5G NR that utilizes a 5G next-generation core network architecture (5G NGC), are expected to be completed in June 2018 as part of 3GPP Release 15. Global mobile industry leaders expressed support for these development. See Monica Alleven, “3GPP declares first 5G NR spec complete,” *FierceWireless*, 20 December 2017, fiercewireless.com. See also 3GPP “Industry support for 3GPP NR announcement,” 21 December 2017, 3gpp.org.

15 Mckinsey Global Institute, *The Internet of Things: Mapping the value beyond the hype*, June 2015, on McKinsey.com.

16 *Japan's International Trade in Goods*, Japan External Trade Organization, 2016, jetro.go.jp.

17 *The motor industry of Japan 2016*, Japan Automobile Manufacturers Association, 2016, jama.org.

18 McKinsey Global Institute, Ibid.

19 "Empty cars with no steering wheel could soon be driving in California," *Guardian*, March 10, 2017, theguardian.com.

20 *The motor industry of Japan 2016*, Japan Automobile Manufacturers Association, 2016, jama.org.

21 *Robots: Japan delivers 52 percent of global supply,* International Federation of Robotics (IFR), Nov 23, 2017, ifr.org.

22 “*Summary of Japan's robot strategy: Its vision, strategy and action plan,*" updated March 2, 2015.

23 *Demographic Yearbook 2015*, United Nations and DESA, United Nations Publications, 2017.

24 *Cobots: the rise of the collaborative robot (cobot) – what you need to know*, i-SCOOP, i-scoop.eu.

25 *LINE Surpasses 400 Million Registered Users*, Line corporation, April 2, 2014, linecorp.com.

26 James Surowiecki, "Where Nokia went wrong," *New Yorker*, September 3, 2013, newyorker.com.

27 *3GPP Low Power Wide Area Technologies*, GSMA, 2016, gsma.com.

28 SigFox Technology Overview, accessed December 12, 2017, sigfox.com.

29 Semtech, accessed December 12, 2017, semtech.com.

30 Ovum, *Communications Provider Revenue & Capex Tracker*, 3Q17.

31 IDC, Ibid.

32 Matt Weinberger, "The fad may be over, but Pokémon Go still has 65 million monthly active players," *Business Insider*, April 4, 2017, businessinsider.com.

33 "IKEA launches IKEA Place, a new app that allows people to virtually place furniture in their home," IKEA, September 14, 2017, ikea.com.

34 "Nokia buys part of Panasonic's network business," *Reuters*, July 31, 2014, reuters.com.

35 See Cornelius Baur and Dominik Wee, "Manufacturing's next act," " June 2015 on McKinsey.com. See also "Industry 4.0 after the initial hype: where manufacturers are finding value and how they can best capture it," April 2016 on McKinsey.com.

36 Japan External Trade Organization (JETRO), 2016

37 *Society 5.0*, Cabinet Office, 2016, cao.go.jp.

38 Lorenzo Casaccia "3GPP agrees on plan to accelerate 5G NR – the global 5G standard – for 2019 deployments," March 9, 2017, qualcomm.com.

39 *5G spectrum: Public policy position,* GSMA, November 2016, gsma.com.

40 "Germany adopts self-driving vehicles law," *Reuters*, May 12, 2017, reuters.com.

41 "Japan to invite new faces to 5G party," *Nikkei Asian Review*, November 28, 2017.

42 See http://www.soumu.go.jp/main_content/000517622.pdf.

43 "Rakuten announces intent to enter mobile network operator (MNO) business," December 14, 2017, global.rakuten.com.

44 Ovum, WCIS, Ibid.

45 Ibid.

46 Ibid.

47 Kevin Murnane, "If you build it they will come: 4G LTE network launch in India has an immediate worldwide impact," *Forbes*, October 7, 2016.

48 Ovum, WCIS, Ibid.

49 "Nationwide 5G mobile coverage coming to Japan in 2023," *Nikkei Asian Review*, June 7, 2017, asia.nikkei.com.

50 *5G in China: Outlook and regional comparisons,* GSMA Intelligence, June 2017, gsmaintelligence.com.

51 Jo Best, "The race to 5G: Inside the fight for the future of mobile as we know it," TechRepublic, December 14, 2014, techrepublic.com.

52 Paul Mozur, "The world's biggest tech companies are no longer just American," New York Times, August 17, 2017, nytimes.com.