

Benchmark 5G in Japan



The background of the page is a light gray abstract design. It features several overlapping, wavy, concentric lines that resemble topographic map contours or signal waves. These lines are more prominent on the left side and fade towards the right. Scattered throughout the background are small, faint dots, some of which are connected by thin, light gray lines, suggesting a network or data flow.

Authors

Fabrice Clari, INNO and Global5G.org
partner

Lisa Poucher, INNO and Global5G.org
partner

Editors

John Favaro, Trust-IT Services and Deputy
Global5G.org coordinator

Stephanie Parker, Trust-IT Services and
Global5G.org coordinator

Graphic Design

Gianluca Savini, Trust-IT Services

Overview

This report aims at analysing 5G deployment in Japan. As it was the case for 3G, the ambition of Japan is to be a leading country in 5G networks deployment. The country wishes to once again become a global leader as it was until the dawn of China and the US. In Japan, the research and development of 5G is highly driven by the historical culture of innovative technology in the country. This innovative culture first developed in the 1970s when the Japanese government activated the specialization of the country towards telecommunication and more generally, with cutting edge technologies. Ever since, the country put efforts into remaining a global leader in technology advancement. Today, Japan occupies the fourth position in the global 5G race. Tests in several cities have already been implemented, but mainly with other telecommunication actors or in specific conditions such as

in stadiums, in trains or in cars. The next step will be to focus on the security of Japanese citizens' telecommunication system. By 2020, after the Tokyo Olympics and Paralympics Games, the goal will be to turn those tests into commercial offerings. 5G in Japan focuses on areas where there is potential for creating new applications and markets: automotive and public transport, smart manufacturing and cybersecurity, wireless cloud-based office and healthcare. The Japanese strategy of relying on the know-how of its main operators to carry out a large-scale deployment of 5G across the country is enabling an evolution of the already dense 4G infrastructures towards 5G. Japan is advancing on its objective to deploy 5G for the Olympic Games 2020, and on a large scale afterwards. However, this deployment can be jeopardized by several issues (environmental, political, etc.).

Table of contents

Overview.....	1
Glossary of Terms	3
Executive Summary	5
Introduction.....	7
5G market in Japan	9
Telecommunication market overview	9
5G in Japan.....	11
5G implementation	13
Market Size & Growth.....	15
Pestel Analysis.....	17
Political	17
Economic	18
Societal.....	20
Technological	21
Environment.....	22
Legal.....	23
Key market trends impacting 5G.....	24
Ageing of population.....	24
Connectivity	26
High Tech and Manufactural Industry.....	27
Applications of 5G : Verticals.....	28
Automotive	28
Autonomous vehicles	29
Connected cars.....	29
Infrastructural Security.....	29
Cyber-security	30
Wireless cloud-based office.....	30
Robotics	31
Healthcare.....	31
Implementation Strategy: Key vendors	33
NTT DOCOMO	34
KDDI.....	35
Softbank.....	36
Challenges for the 5G Market in Japan.....	37
Efficient coverage of the territory	37
The Cyber-security	38
Conclusions.....	39

Glossary of Terms

3GPP	3 rd Generation Partnership Project
4G	Fourth Generation of mobile network technology
5G	Fifth Generation of mobile network technology
AI	Artificial Intelligence
AR	Augmented Reality
ASIC	Application-Specific Integrated Circuit
CAGR	Compound Annual Growth Rate
CEO	Chief Executive Officer
C-RAN	Centralized Radio Access Network
CU	University of Colorado Boulder
EPB	Electronic Parking Brake
FC	Fiber Channel
FCC	Federal Communications Commission
GBps	Gigabits per second
GDP	Gross Domestic Product
GHz	Gigahertz
IoT	Internet of Things
ITS	Institute for Telecommunication Sciences
LTE	Long-Term Evolution
M2M	Machine-to-Machine
MEC	Multi-access Edge Computing
MHz	MegaHertz
MIMO	Multiple Input, Multiple Output
mmWave	Millimetre Wave
MSOD	Measured Spectrum Occupancy Database
NFV	Network Functions Virtualization
NIST	National Institute of Standards and Technology
NL	Nonlinear
NSF	National Science Foundation

NTIA	National Telecommunications and Information Administration
ONF	Open Networking Foundation
ONRC	Open Networking Research Center
QAM	Quadrature Amplitude Modulation
RAN	Radio Access Network
RFIC	Radio Frequency Integrated Circuit
SASAC	State-owned Assets Supervision and Administration Commission
SDN	Software-Defined Networking
TMT	Technology, media and telecoms
URLLC	Ultra-reliable low latency communications
USCIB	United States Council for International Business
VR	Virtual Reality
WTO	World Trade Organisation

Executive Summary

5G is the next telecommunication generation, the fifth generation. It succeeds the 4G systems and should meet the needs of society for increasing data and connectivity. 5G should be faster (10 times more than 4G), enable low latency and high reliability, allow to connect more people and more devices, able to use more connected objects (such as IoT devices), and it should be more cost-effective. Major innovations are expected to come from vertical industries, from automotive and transport to health and energy. The key element of the 5G technology is the use of high frequencies in the spectrum, which are more powerful but have less reach than previous telecommunication generations (4G, 3G). Therefore, a significant number of

cellular sites must be implemented.¹

Today, 5G is in the development phase: no country has yet implemented 5G at a national scale except Switzerland. Yet, some countries like South Korea, USA, Germany, Spain, Italy, Bahrain, the Lesotho, Finland and Estonia, have launched it in some areas. All major world economies are aiming at an early and strong implementation of 5G in their country, they are either competing or collaborating on this topic. Multiple countries are implementing diverse strategies for the 5G development and launch – whilst some focus on acquiring the largest amount of licences and spectrum, others aim at a wide-spread integration in different applications.

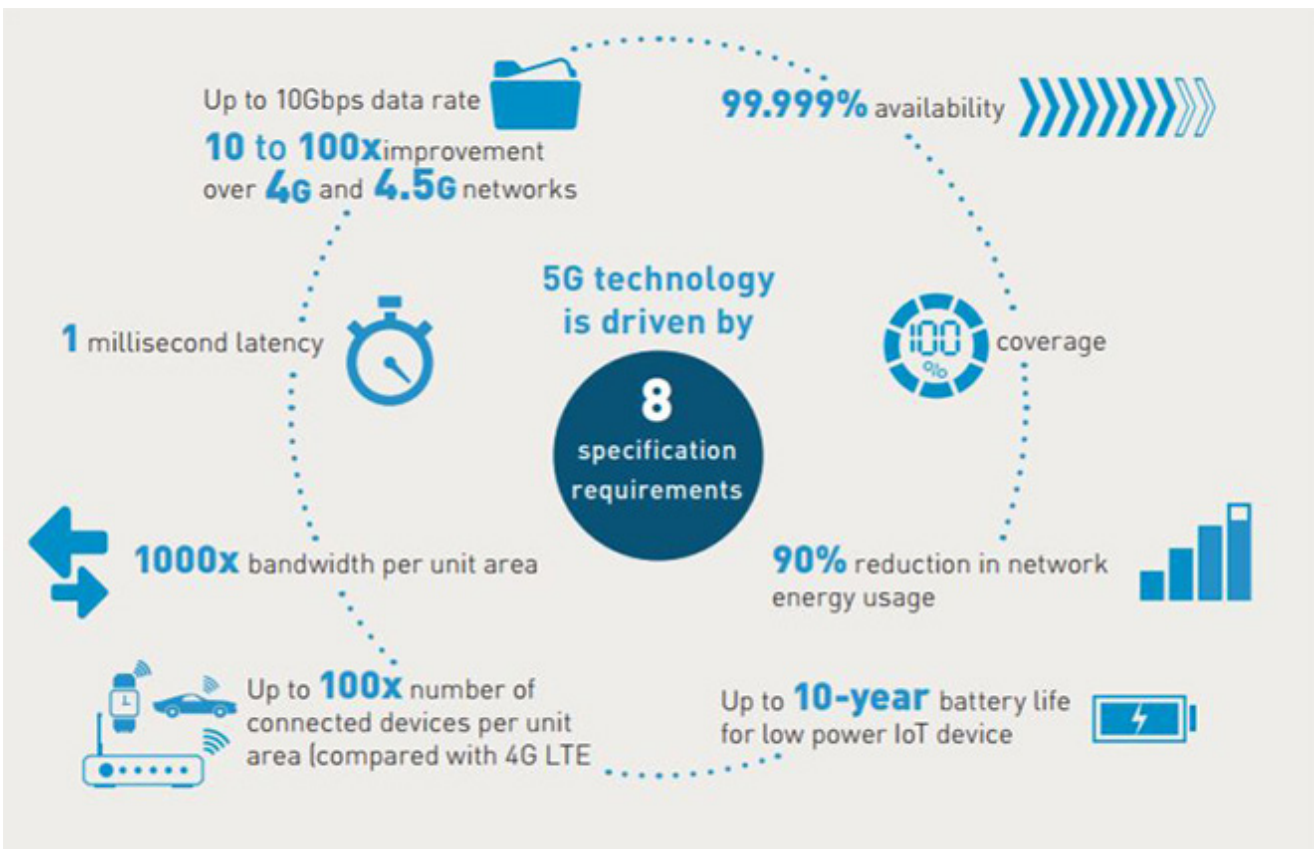


Figure 1: 5G characteristics (Source: Gemalto.com)

¹ The 5G era in the US (2018) GSM Association.

The Global5G.org project is dedicated to international technology advances in 5G, with a focus on standardization, regulations, market verticals and identification of existing gaps in technology. Whilst the project particularly supports the implementation of EU-supported 5G projects and their collaboration and outreach, it also looks at international initiatives: as seen above, the 5G development is a global one. In addition to the Global5G Mapping Tool released on the project's website, benchmarks are undertaken on the 5G Network in selected countries in order to compare their strategies and implementation modes to those in the EU. In this context, the information gathered in this benchmark is relevant for the project because it allows the identification of some good practices and important information related to the 5G implementation in China. More specifically, this analysis allows you to:

- › Identify the potential benefits and advantages the 5G's implementation will enable in the next years;
- › Understand how the development process of this technology is defined in a country, such as Japan;
- › Have an overview of the 5G's driving forces (trends, public authorities, industrial players and Universities) in Japan;
- › Identify the verticals prioritized by the Japanese government and which applications of the 5G are foreseen;
- › Understand the link between vertical industries, standardisation and research in an important country as Japan;
- › Understand how the implementation of 5G is enabled, which are the key actors of this implementations and what is their strategy;
- › Understand the potential challenges of this technology's development and implementation;
- › Identify which aspects could potentially be applicable in Europe.

Introduction

From the 1G to the now widely used 4G and the debut of 5G, a lot has changed, notably in the way people work, live and play. The following figure gives an overview of the shifts and changes across the various generations.

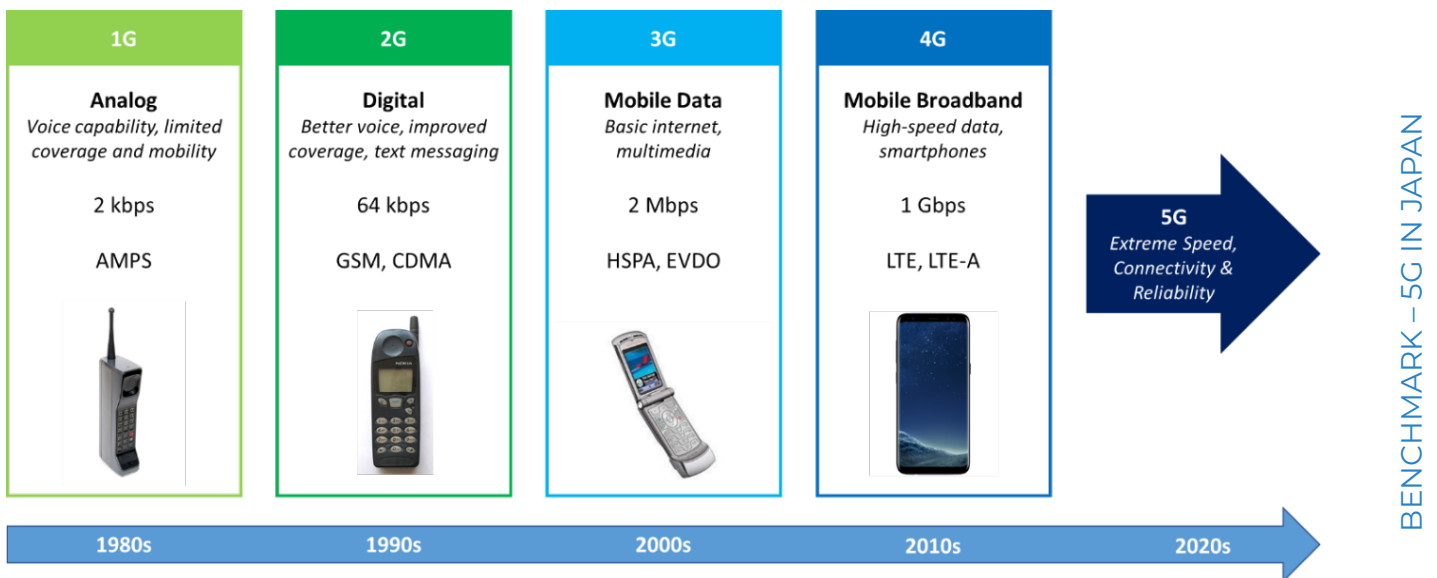


Figure 2: Evolution and key development in cellular technology from 1G to 5G (Source: 5G Americas)

With the arrival of 3G came the possibility to use basic mobile Internet service. Further mobile equipment improvements capitalized this Internet service and text messages (through phone displays of higher quality, advanced chipsets, digital cameras integration). 4G has capitalized on smartphones and increased consequently the data speeds. Moreover, it enabled the development of a mobile broadband service which is capable of delivering streaming video and multimedia experiences.

Post 4G, a new area is about to arrive: the 5G Network. The ambition of the future 5G Networks is to increase usage, speed

and services of telecommunication whilst reducing energy consumption. 5G should allow:

- › 1,000 times more capacities
- › 10 to 100 times more connected objects
- › 5 times more responsiveness
- › 90% energy savings
- › Everywhere the same efficiency²

The various countries are at different levels of 5G development. The ambition of Japan is to be a leading country in 5G commercial services, like it was until 3G. The country is currently well positioned as showed by the table hereafter.

² 5G PPP Video: <https://youtu.be/bfNmiYtG9Cg> (accessed 19/08/2019)

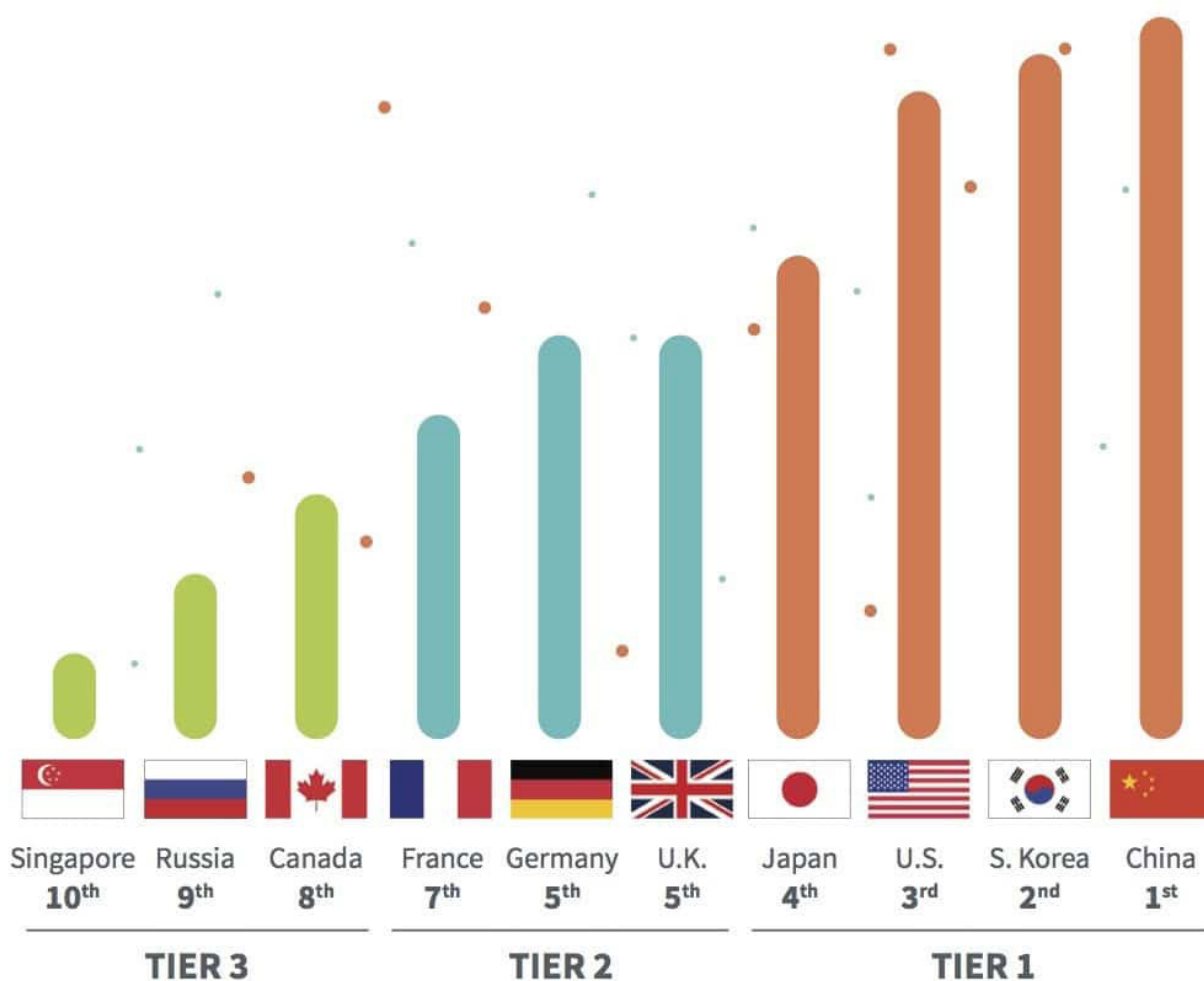


Figure 3: Winning countries in the race for 5G (Source: Analysys Mason)

NTT Docomo, KDDI and Softbank, the three main mobile operators in Japan, some of the main telecommunication operators in the world, already committed completely in the race launched by the Japanese government and have undertaken actions to implement 5G by 2020. Indeed, the Olympics 2020 in Japan should be the official launch of 5G in Japan. The commercialisation of 5G phones will be ready in 2020 and by then – NTT Docomo, KDDI and Softbank will provide mobile 5G services.

In the first part, this document will describe the 5G market in Japan followed by an analysis of the Japanese market environment through a PESTEL analysis. A third part will

describe the Japanese market trends using 5G and the projected increase through the nationalisation usage of 5G. The driving forces of 5G in Japan will be explained in a fourth part, including the initiatives from the public authorities and the industry that offers to 5G a favourable environment for development. The fifth part will focus on 5G implementation strategy of the Japanese key telecom providers. The challenges that will have to be faced regarding 5G implementation will be discussed in a sixth part. Finally, a conclusion will allow to identify the differences regarding 5G between Japan and other countries. Good practices will be presented throughout the whole document.

5G market in Japan

The Japanese telecommunication industry is at a crossroad. While sectors of telecom are increasingly converging, new technology domain like Internet of Things (IoT) and Artificial intelligence (AI) are moving towards mainstream adoption. This convergence is coupled with technological progress that offers opportunities for innovation, growth and productivity improvements. Over the next decade, 5G will be the instrument of these major trends' development. 5G is expected to:

- › Deliver increasingly integrated video on mobiles;
- › Spur further developments and scale in IoT;
- › Support growth in augmented reality, virtual reality (VR), industrial automation and AI;

Telecommunication market overview

Japan has been a leader in the information and communication technology (ICT) sector for many years. Until the mid-1990s, the country was behind on the wireless market but implemented high-speed networks' in the late 1990s. The rapid deployment of the second and the third telecommunication generation, supported by the Japanese government gave the country a central place in the global telecommunication market. Japan was even one of the first country in the world to implement 3G at a large scale. However, the country lost its leading position in the mid 2000s, due to two main factors: the choice of their cellular standards, and their domestic market dynamic. These two specific reasons caused the country's loss of competitiveness since Japan failed:

- › On one hand, to follow the general dynamic of the digital cellular standards, by the creation of a single and specific cellular standard for the 3G deployment;
- › On the other hand, to have the means to get the manufacturing access to develop sophisticated devices as was doing the rest of the world.

- › Increasingly serve as an alternative for fixed broadband connectivity.

The Japanese environment provides good assets for the development of the 5G:

- › The Japanese government continuously supports the 5G progress through allocation of new spectrum, infrastructure and employment;
- › World-class events are planned in the years to come like the Rugby World Cup 2019 and the Olympics 2020, which are good opportunities to display 5G advancements;
- › Existing infrastructures which density favouring new types of technologies.

This loss in leadership was initially due to incentives from the Japanese government, which developed strong Research and Development resources and capabilities since the 1970's. The monopoly of the Japanese government over infrastructures and R&D vanished with the Japan telecommunication laws in the mid 1980's, which opened the telecommunication sector to the international market³. It also marked the arrival of new equipment and services, and the beginning of Japanese specialisation in telecommunication technologies. Japanese telecommunication carriers developed rapidly and became leaders on the global telecommunication market within twenty years. They lost their leading position when came the third and the fourth generation, because they failed to overcome the challenge posed by global major players in terms of network equipment. Japan notably deployed the Freedom of Mobile Multimedia Access (FOMA) standard, which was not fully compatible with the widely used Universal Mobile Telecommunications System (UMTS) protocol.⁴

³ Reform of Japanese Telecommunications Law: Panacea or Placebo, D.W.Colber, 1987.

⁴ Jo Best, "The race to 5G: Inside the fight for the future of mobile as we know it," TechRepublic, December 14, 2014, techrepublic.com

The Figure below highlights the chronology of the new technology deployment in Japan:

BENCHMARK – 5G IN JAPAN

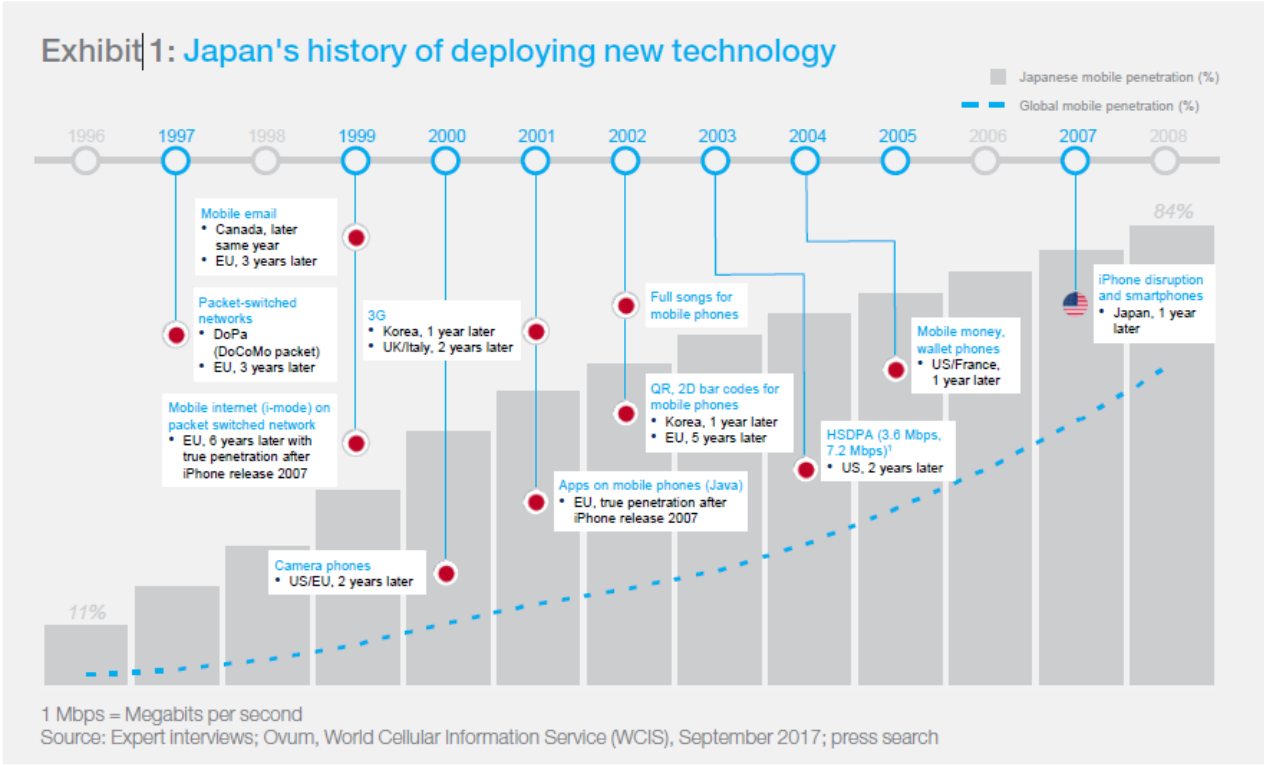


Figure 4: Deployment of new technology in Japan (Source: Expert interviews, Ovum, World Cellular Information Service)

As shown in the figure, the Japanese market has grown quickly over the years and was large enough to sustain companies without the need to expand abroad. The domestic mobile penetration was higher than in the rest of the world and Japan was ahead of the global telecommunication market until the arrival of the iPhone. With the iPhone, Apple came with a brand-new concept of telephone, capable of displaying videos, maps and act like an iPod music player. Its touchscreen and its power, enabled by a new range of standards, contributed to the substitution of computers through iPhones. This technological revolution had a massive impact on the global market, to which the Japan didn't not successfully adapt to.⁵

Moreover, the country has some of the best indicators regarding telecommunication (system viability, network density, carriers'

financial health, high know-how in innovation technologies, number of subscriptions) according to sources such as OECD or Statista, but it falls behind in the global race to telecommunication leadership. One of the main causes is because the domestic telecommunication policy has become a constraint: the density of the Japanese network is leading now to serious connexion speed issues notably during peak hours, and Japan's lack of technical means to adapt to the new global telecommunication framework⁶ (not because of a technological delay, but because of the specificities of its telecommunication infrastructures). Data traffic growth is one of the main drivers for the implementation of 5G. Moreover, if Japan wants to stay competitive in the telecommunication industry, it will have to follow its evolution.

5 Forbes.com.

6 <https://www.recode.net/2017/6/26/15821652/iphone-apple-10-year-anniversary-launch-mobile-stats-smart-phone-steve-jobs>

Nevertheless, the situation can be reversed as the Japanese telecommunication giants

are economically stable and willing to invest in the next telecommunication generations.

5G in Japan

As technology is evolving in domains like the Internet of Things (IoT) or Artificial Intelligence (AI), it offers opportunities for innovation, growth and productivity improvements. As Japan has been behind regarding the 5G's implementation (compared to the US and China) in the past years, the Japanese government has decided to create incentives with the aim to reposition Japan as one of the telecommunication leaders.

As 5G is expected to support growth in the mobile video, the IoT, the AR, the VR, the automation and the AI markets, the Japanese government wants to make the necessary efforts to reach excellence in these areas. On the one hand, because the economic impact of 5G is expected to be significant. Indeed, according to a recent estimate, the global economic impact of 5G will be USD12.3 trillion generated by 2035 (similar to China's GDP in 2017, and 4.6 percent of estimated global real output in 2035)⁷. Such financial stakes justify the race to a strategic position in the global market share of 5G. On the other hand, the planned capabilities of 5G will provide the infrastructure necessary for the

new technologies (augmented reality or artificial intelligence for instance) to break through and to become mainstream. These new technologies represent development opportunities for Japanese companies: through the development of innovative and competitive technologies and services which could have significant outcomes for the Japanese economy.

Nevertheless, the following indicators show that Japan remains competitive on the telecommunication market:

- › Japan is the third country with the largest R&D expenditures (behind the US and China): USD169,554 M R&D spending per year. It accounts for 3.4% of Japan's GDP.
- › Japan is one of the world leaders in new technologies, it is the world reference in industrial robotics.⁸
- › Japan has an existing dense network which will be upgraded through investments of USD14 billion in new telecommunication networks (forecasted by Japanese carriers). Already, it represents the densest network in the world as illustrated in the following figure (even though the country would need a greater infrastructure according to the market's needs).

⁷ 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

⁸ Estimated from a report of the International Federation of Robotics which states that Japan provides 52% of the global robotic supply.

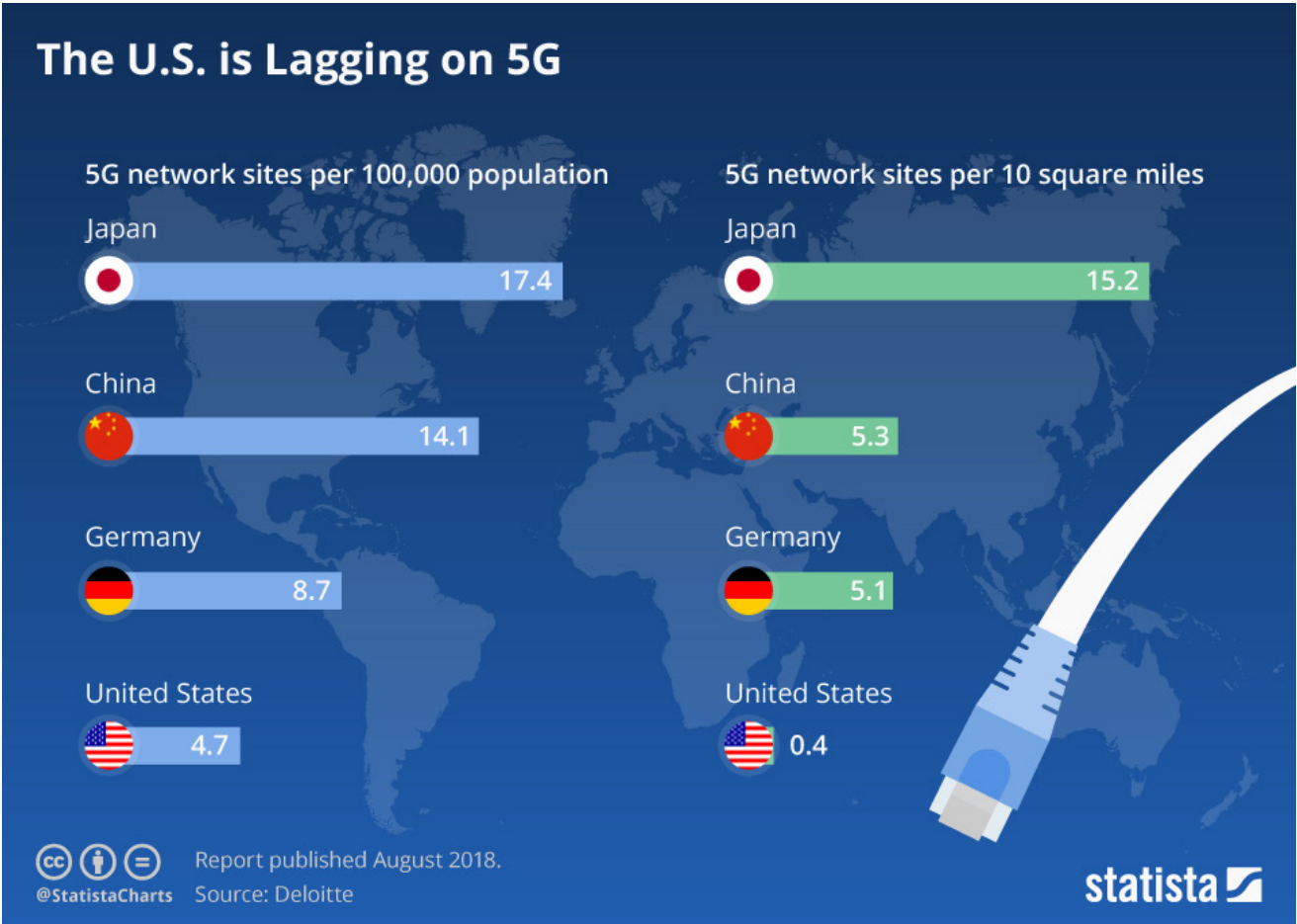


Figure 5: 5G network density (Source: Deloitte)

5G implementation

Japanese telecom providers intend to implement 5G by the end of 2019. The Japanese government expects the fifth generation to be available for the 2020 Summer Olympics in Tokyo. This idea has been submitted at the Broadband World

Forum (BBWF) 2013 by NTT Docomo. In 2014, the 5GMF (Fifth Generation Mobile Communications Promotion Forum) issued a roadmap for the 5G implementation in Japan (illustrated in the following figure).

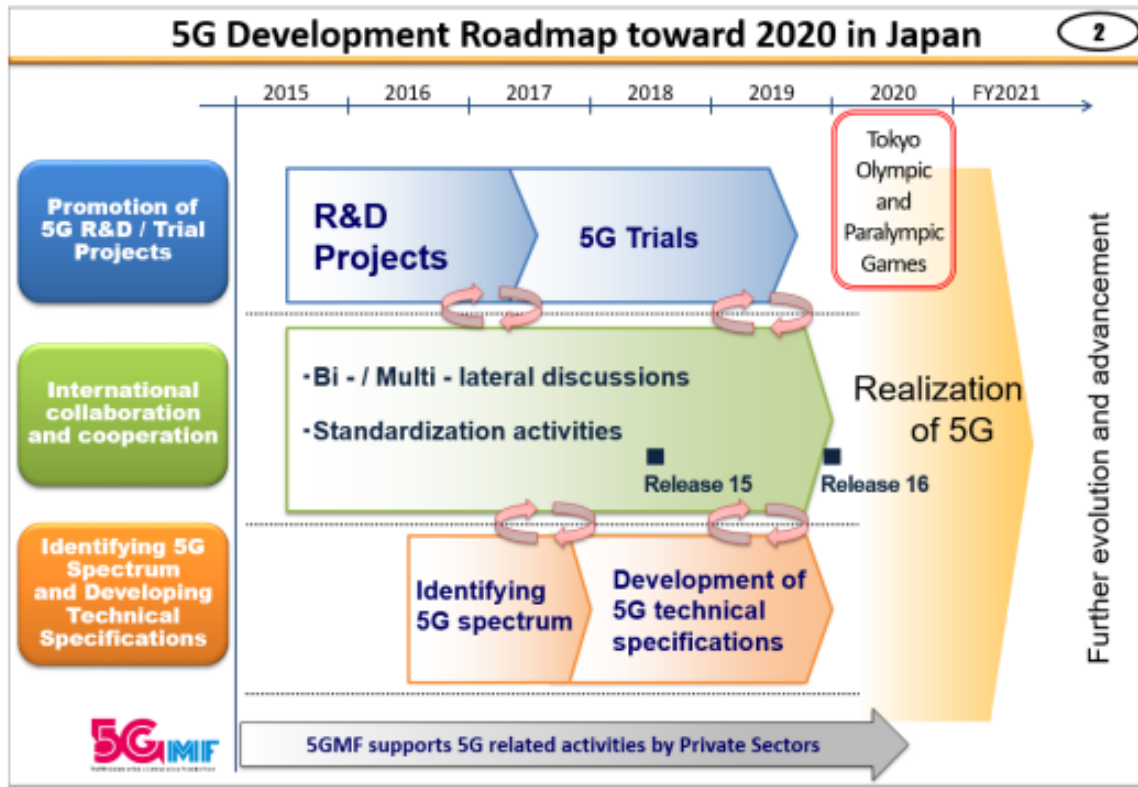


Figure 6: 5G development roadmap towards 2021 (Source: MIC)

The plan established by Japanese carriers (on behalf of the Japanese government) in

relation to the 5G development is divided into several phases:

Until 2020: Implementation

Research and development, new build sites (complementing the densified small cells sites) and cooperation

Internal: Promotion of R&D projects

Since 2016, the main Japanese mobile operators have carried out several 5G system trials with other telecommunication operators such as Huawei or Nokia.

Around 300 million USD have been dedicated by the Japanese authorities to promote the industrial IoT and related technologies such as big data, artificial intelligence and robotics.

External: International collaboration and cooperation

Japan and European authorities have signed a collaboration agreement: they will collaborate with European carriers as Ericsson and Nokia for 5G trials.

Technical: Identification of the spectrum and developing technical specifications

Trials carried out on specific fields (automotive, robotics)

Beyond 2020: Commercialisation

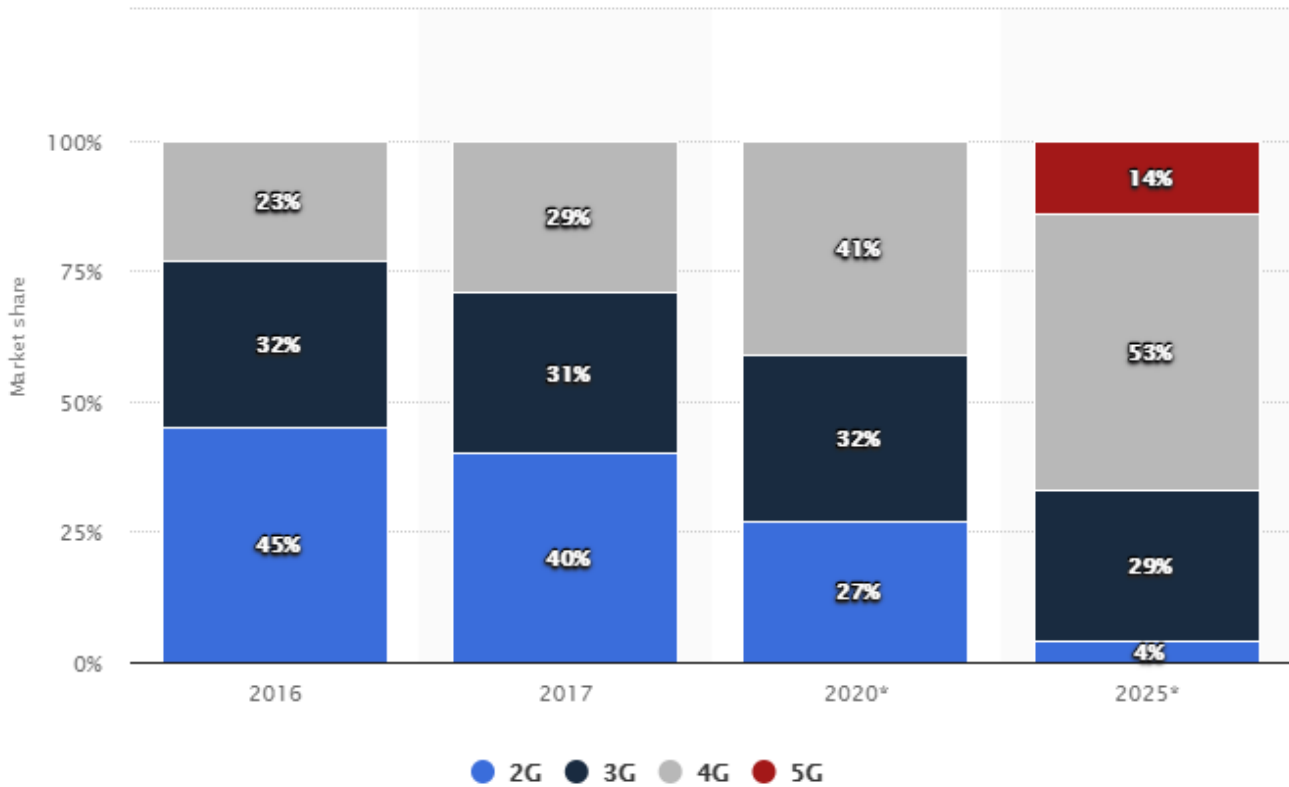
The Tokyo Olympic Games are expected to showcase the Japanese 5G advancement and the launch of 5G at a large scale.

Market Size & Growth

Worldwide, 5G is expected to yield a rapidly growing market share. According to Statista, the worldwide market share of 5G is expected to be of 14% in 2025, whereas 4G will have a market share of 53%, 3G of 29%

and 2G of 4%.⁹

The following figure illustrates the fast evolution of the mobile telecommunication technologies worldwide.



BENCHMARK – 5G IN JAPAN

Figure 7: Market share of mobile telecommunication technologies worldwide from 2016 to 2025 by generation (Source: Statista)

Japan is expected to follow the worldwide trend. The share of mobile connections from all other generations are expected to decrease, whereas the share of 5G is expected to increase rapidly. It is predicted

that in Japan, 5G connections will reach 88 billion of all national mobile connections by 2025 which represents 7.2% of all 5G connections worldwide, as shown in the graph below.

⁹ <https://www.statista.com/statistics/740442/worldwide-share-of-mobile-telecommunication-technology/>.

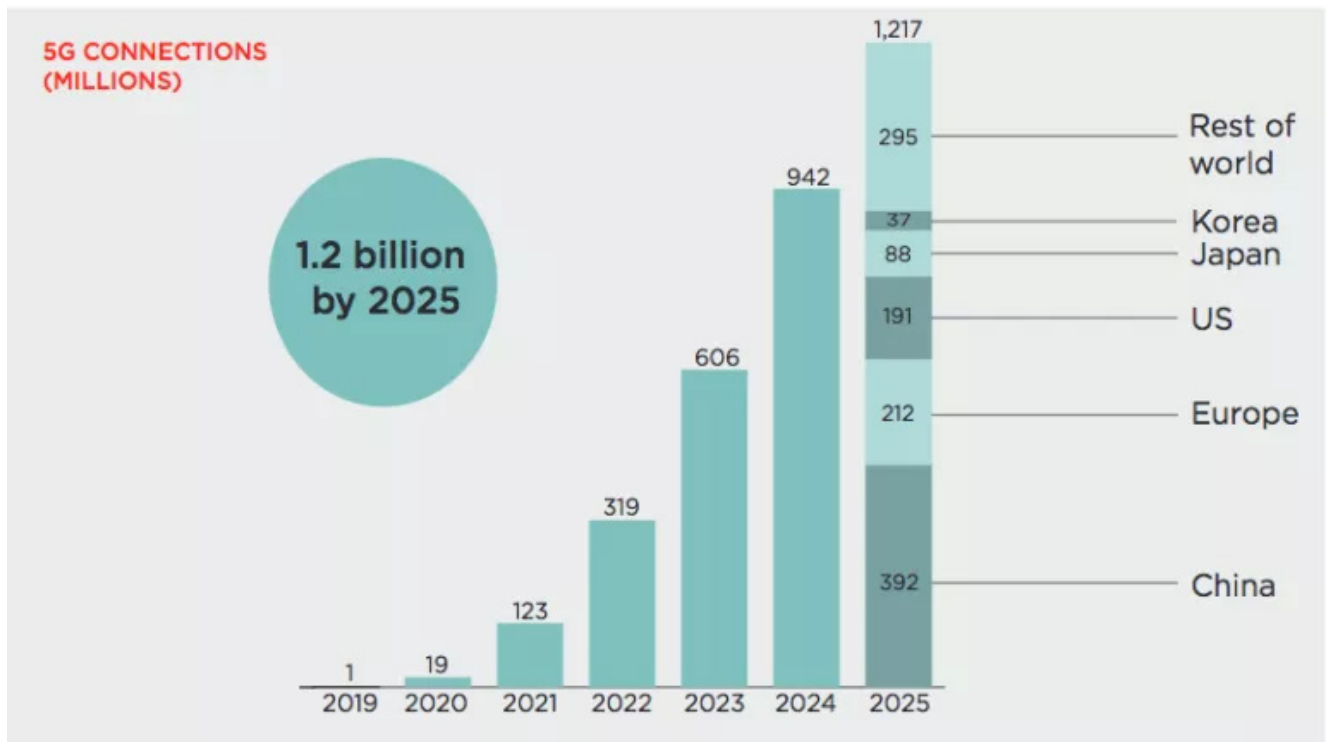


Figure 8: Forecast of 5G connections in 2025 (Source: GSMA.com)

Pestel Analysis

A PESTEL analysis allows you to identify the environment in which 5G research and deployment in Japan are evolving. The analysis includes

the description of the political, economic, social, technological, environmental and legal aspects in Japan.

Political

The political environment is full of risks for the telecommunication sector. The traditional political risks are those related to regulations, network licensing, national radio spectrums.

In the case of Japan, a key aspect is the strong involvement of the Japanese government in the development strategy of the country's telecommunication sector. The Japanese government has quickly established tight links with the main Japanese telecommunication carriers.

Japan has seen significant developments during the second half of the 20th century and has become a leader in some cutting-edge technologies. It was the first non-Western country to include western technological and scientific traditions. Therefore, the country developed into a super-power in advanced technologies. The government's incentives and policies regarding science and technology have played an important role in this industrial development¹⁰.

Japan's specialisation in science and technology was focused specifically on the information technology sector, which played a key role in the Japanese industrial development in the 1970s. The country is now one of the leaders of the telecommunication industry, and notably of the wireless telecommunication industry, thanks to massive investments in R&D. But still, compared to the significant expansion of China as well as the advancement of the USA in R&D, Japan is lagging behind in terms of technological advancement. This

delay stresses multiple political issues:

- › Within the country: Japan's telecommunication infrastructure's specificities led the country to a dominant position but became a burden several years later as the country failed to follow the evolution of the global telecommunication framework. Now, Japan have to negotiate with strategic partners (i.e. India and Europe) to develop a strategy for the next generation of cellular telecommunication. This strategy already relies on a high standard organizational structure of the Japanese market, led by NTT Docomo which fosters the catching up process initiated with western economies, leading the country towards more openness and more standardization, notably regarding 5G telecommunication implementation.
- › The economic clash between US and China puts Japan in a difficult situation because of the importance that both giants have in the Japanese economy. Japan has always had tense relations with China (due to historical rivalry) and that rivalry has become even more intense lately as China replaced Japan as the political and economic leader in Asia. Nevertheless, maintaining close relations with Beijing is important for Tokyo for two reasons:
 - › China remains Japan's main trading partner;
 - › Neither China nor Japan wish to start a political conflict.

Nevertheless, Japan has decided to seize the opportunity represented by 5G to

¹⁰ SCIENCE AND TECHNOLOGY POLICY IN JAPAN, Fukasaku

reimpose itself as the leading country in the telecommunication sector. The Japanese government puts a lot of efforts in Science & Technology investments with the aim to lead the 5G market in the next few years, making telecom industry one of its main levers for economic development. The data traffic growth and the global competitive environment may also explain this initiative. On February 2019, Japanese Prime Minister

Abe held a speech during the G-20 summit, highlighting the importance of data for the future of Japanese economy and the necessity to enhance the quality and intensity of data regulation, particularly in the frame of a significative raise in the data flow. Abe also showed his support for a model called Data Free Flow with Trust: the governance of data should be a “*great gap buster*”¹¹.

Economic

The Japanese GDP oscillates between 0% and 2% since the end of the 2008 economic crisis. It has been increasing constantly over the past few years and reached 2.4% in the second semester of 2018 (as illustrated in the figure below), a rate which is still below the US and the Chinese GDPs. Nevertheless, this

economic health represents a favourable environment for the consumer spending on telecommunication products and services as in general the stronger the economy of one's country is, the higher will be the consumer spending on telecommunication products or services.

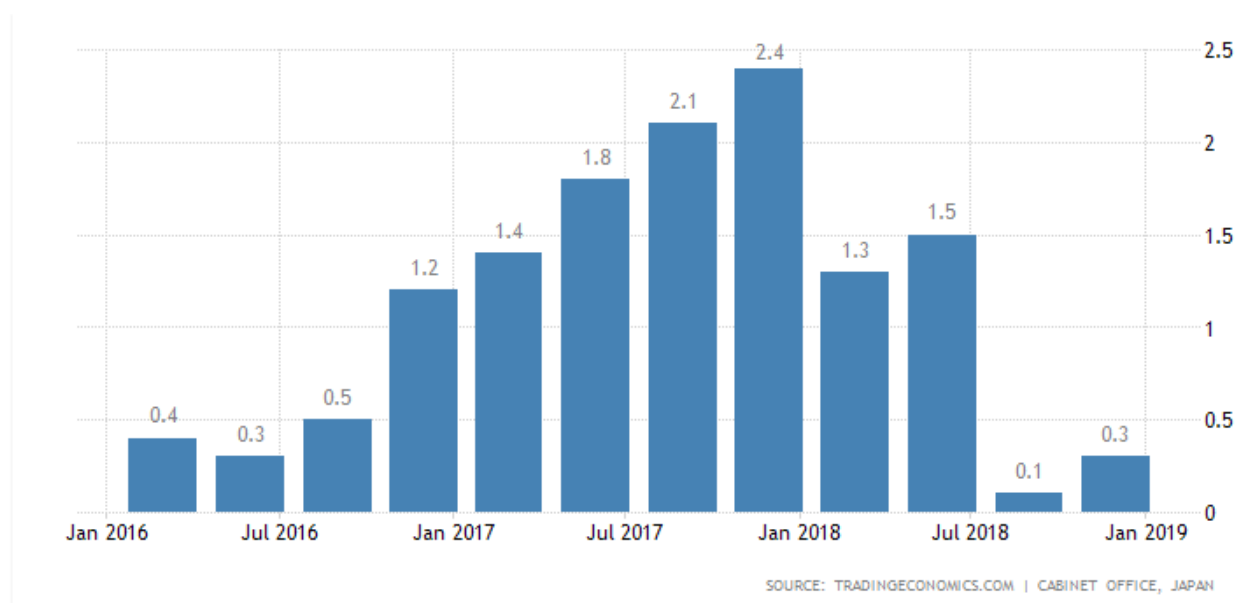


Figure 9: GDP Annual Growth Rate in Japan (Source: tradingeconomics.com)

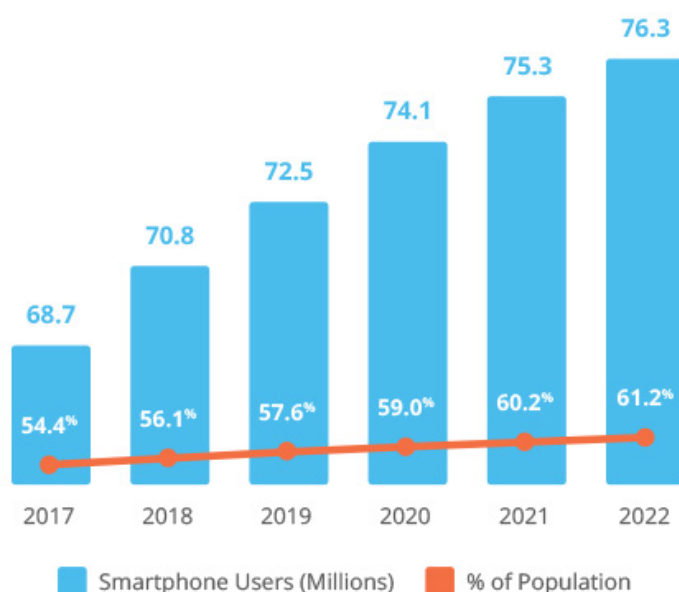
Moreover, the number of smartphone users increased from 2017 with 68.7 million to 70.8 million in 2018 and is expected to grow to 76.3% in 2022 (as shown by the figure below). These figures represent a growth from 2017 to 2022 of 11.8%. Regarding the penetration rate of smartphone users, an

increase can also be observed. Indeed, in 2017 the percentage of the population which were smartphone users was of 54.4% and in 2022 it was expected to reach 61.2%, which represents a growth of 12,98%. In 2018, the smartphone users and penetration rate in Japan was the 7th highest worldwide¹².

¹¹ <https://thediplomat.com/2019/02/japan-calls-for-global-consensus-on-data-governance/>.

¹² <https://newzoo.com/insights/rankings/top-50-countries-by-smartphone-penetration-and-users/>.

Smartphone Users and Penetration in Japan



Source: eMarketer, April 2018

Figure 10: Smartphone users and penetration rate in Japan (Source: eMarketer)

In addition, some other indicators show a profitable environment for the development of telecommunication technologies in Japan. Indeed, the mobile device data

traffic is expected to more than triple in Japan between 2016 and 2021 as illustrated in the following figure.

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

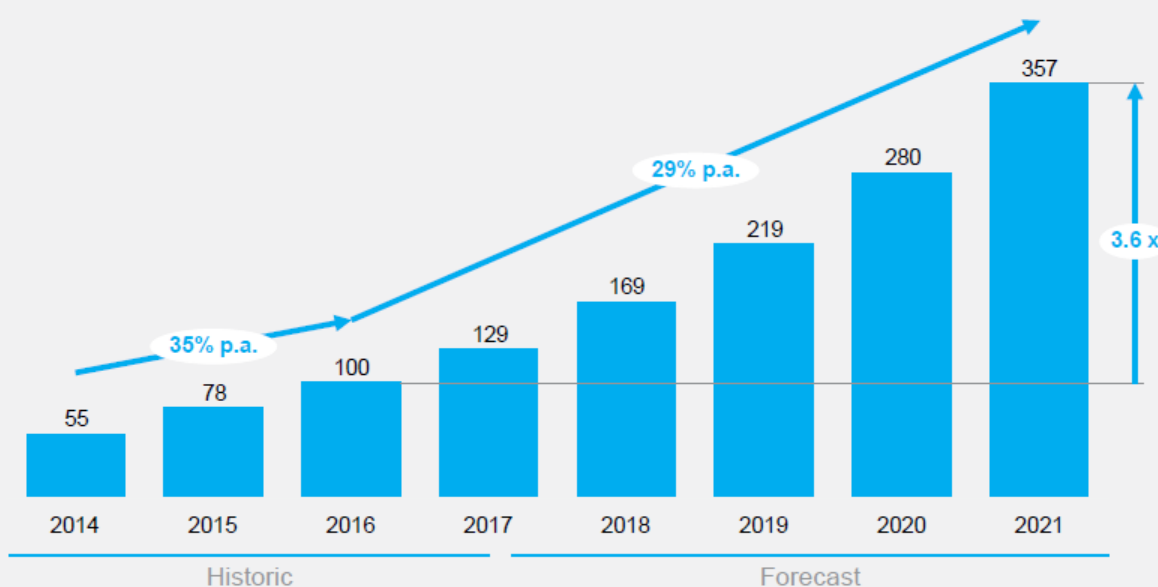


Figure 11: Mobile device data traffic in Japan between 2016 and 2021 (Source: GSMA)

Societal

Globally, the use of internet-based services has grown. People are now using them to various purposes:

- › **Entertainment.** The enhancement of the quality of telecommunication devices coupled with the 4G expansion enabled a significant raise in the use of smartphones to access television or entertainment via platforms like YouTube or Netflix;
- › **Business.** Internet-based services lead to new opportunities of business development. The use of a new panel of services like streaming, videos broadcasting or mobile computing was eased by technological enhancement and created new ranges of work methods and jobs (i.e. the “Youtubers” phenomenon allowing some of them to earn a good wage¹³);
- › **Social.** The advent of Facebook and other social medias gave the

opportunity to people to connect each other. The phenomenon accelerated as technological devices gained in efficiency and sophistication. Today, social medias are important in people’s everyday life and are also used as political tools¹⁴.

Overall, these trends show the key role played by internet-based services which could be enhanced through the implementation of 5G.

Japan is one of the countries with the most of mobile internet users with 66.6 million in 2018.¹⁵ This figure is projected to rise to 71.9 million in 2023. Regarding the use of social medias, in Japan social media has become an important part in people’s everyday life: in 2018, approximately 51.3 million people actively used social media¹⁶ which represent a 40% social media infiltration rate (as shown by the graph below). In 2023, this figure is projected to reach about 61.8 million social network users.

13 <https://www.forbes.com/sites/natalierobehmed/2018/12/03/highest-paid-youtube-stars-2018-markiplier-jake-paul-pewdiepie-and-more/#4cd665ee909a>.

14 Facebook Use in the 2012 USA presidential campaign, Social Media in Politics: Case Studies on the Political Power of Social Media, Bogdan Patrut & Monica Patrut, 2014.

15 <https://www.statista.com/statistics/239086/forecast-of-mobile-internet-users-in-japan/>.

16 <https://www.statista.com/statistics/278994/number-of-social-network-users-in-japan/>.

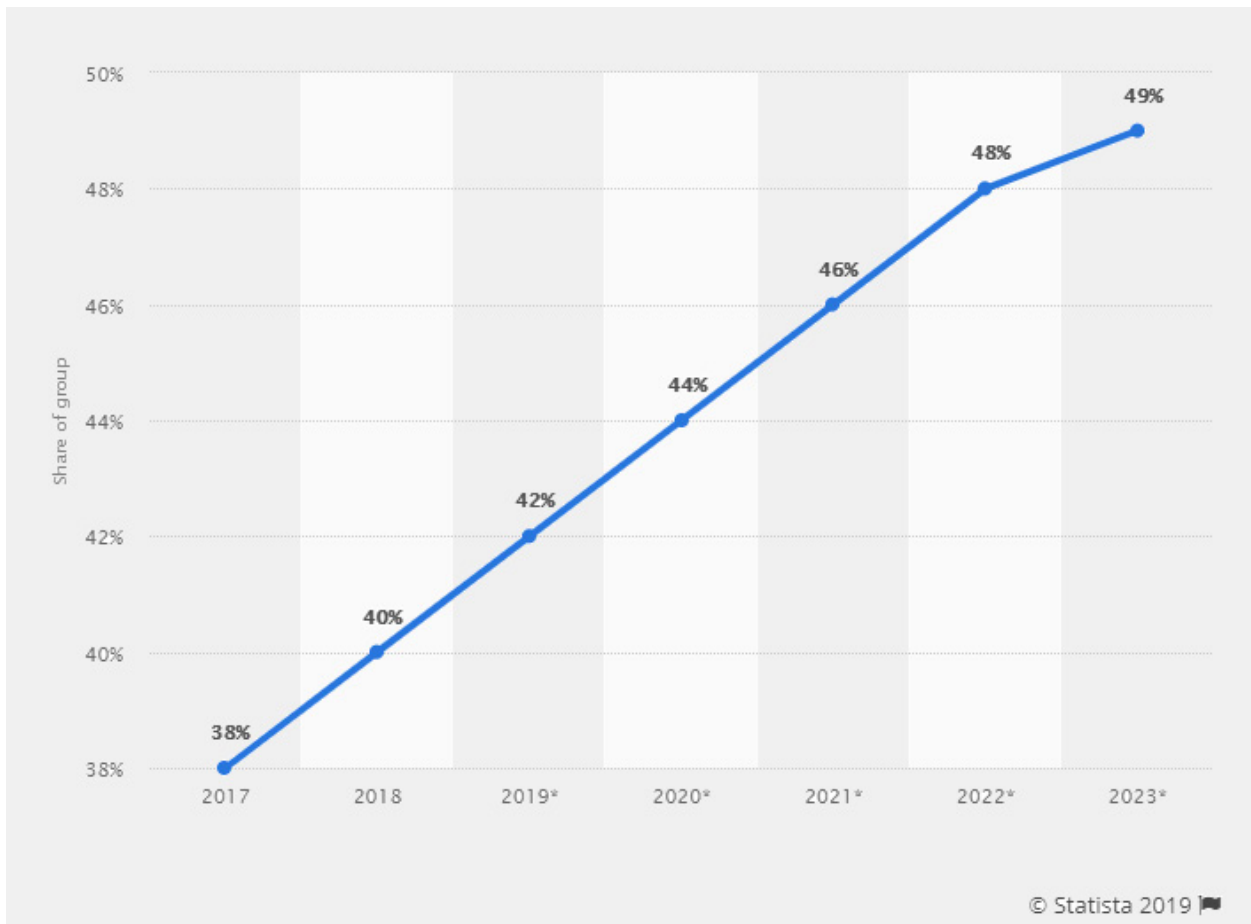


Figure 12: Social network user penetration in Japan from 2017 to 2023 (Source: Statista)

In 2017, 92.08%¹⁷ of the Japanese population had a daily internet access. It is the second highest rate of the Asian area after South Korea, and one of the highest rates in the world. This high figure can be explained by the quality and the density of the Japanese telecommunication infrastructure, and it shows the excellence of Japan on technological advancement.

In contrast, the share of smartphone users in the overall population, is lower in Japan than in Western countries. As showed by the graph below, the overall number of smartphone users accounts for 57.6% of the population in 2019 (see figure 10). In the US for instance, smartphone users account for 77% of the population¹⁸.

Technological

Japan has been specialized in science and technology since the second half of the 20th century. The arrival of the Japanese telecommunication industry enabled major technological advancements, making Japan a world leader in several sectors such as automotive or robotics. But Japan's excellence addresses other

aspects of technological sectors like autonomous driving, IoT, connected cars, smart homes and businesses and smart cities, which will rely on the next generation telecommunication system to work efficiently.

Regarding advancement expected on the telecommunication aspect, 5G will play a

¹⁷ https://data.worldbank.org/indicator/it.net.user.zs?name_desc=false.

¹⁸ <https://www.pewinternet.org/fact-sheet/mobile/>.

key role in the smartphone sector. The trend of smartphone sales in Japan is increasing, notably with Apple dominating the market, with more than 50% of the market share¹⁹.

Japanese sales are still expected to grow in the next years, with the wide-scale implementation of 5G network and devices.

Environment

As time goes on, environmental consciousness progresses. European countries seem to be the keenest to tackle environmental issues but Japan also considers seriously the question, notably regarding the recent history of the country (Fukushima nuclear reactor explosion, tsunami in 2011), and its tricky relation with nature in general (a country familiar with earthquakes). The growing cost of extreme weather hazard forces politicians to reflect better on solutions regarding the environment.

In 2018, the Japanese Prime Minister Shinzo Abe during a UN General Assembly urged nations to put ‘promises into practice’ to avoid

climate disaster. He also positioned Japan as a potential leader for climate change and repeatedly highlighted the need to abandon the massive production of greenhouse gases. Indeed, as shown in the figure below, the concentration of greenhouse gases in Japan is high²⁰ – although not as much as the US and China. Moreover, the country suffers from an important waste management problem. With the economic and demographic growth of the 20th century came an increase of waste in Japanese modern society and the growing shortage of lands rapidly posed a challenge regarding waste management in Japan.

ANNUAL CO₂ EMISSIONS PER COUNTRY (MILLIONS OF TONS OF CO₂, 2017)

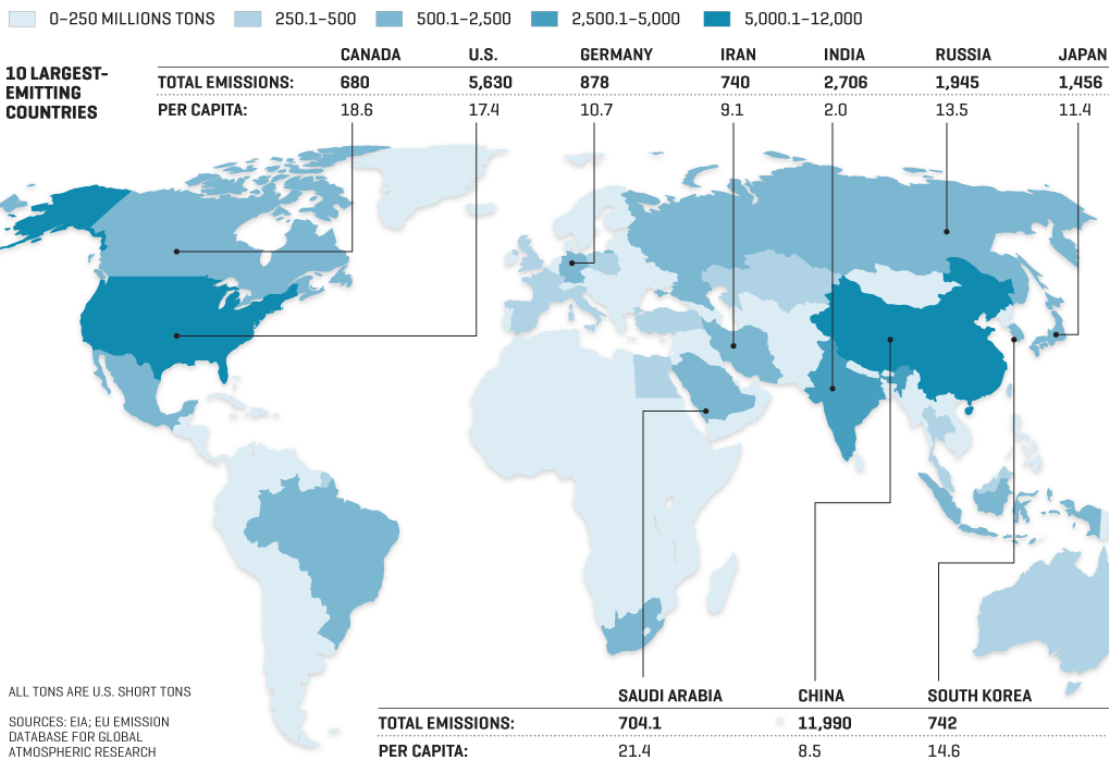


Figure 13: Annual CO₂ emissions in 2016 (Source: fortune.com²¹)

¹⁹ According to a Canalsys study issued on February 2019.

²⁰ <https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions>.

²¹ <https://fortune.com/longform/global-co2-emissions-2018/>.

To tackle these environmental issues, Japan has chosen the path of technology. Whether through the innovation of its automotive industry²² or of its recycling technologies²³, 5G combined with IoT is expected to bring a substantial help in implementing more efficient facilities to deal with environmental problems Japan is facing, such as highly connected factory which should be widely

implemented in Japan²⁴. These new kinds of factories will integrate more and more the environmental management aspect at every stage of products' life cycle. It will notably contribute to the decrease of factories' footprint. Moreover, through their expected rationalisation, connected factories will help to accelerate the cycle of recycling.

Legal

The Telecommunication Business²⁵ Laws and the Nippon Telegraph and Telephone Corporation Act in 1985 marked the opening of the Japanese telecommunications system to the global market, and the arrival of supergiant telecommunication actors like NTT Docomo.

Nonetheless, on the eve of 5G wide-scale implementation, Japan has established a legal framework in which 5G would be implemented and developed. Operators are free to deploy 5G throughout the country, but the Japanese government ask for some minimum requirements regarding regulation.

Regarding network coverage, the Ministry of Telecommunications has divided the country into 4,500 parcels, and operators are asked to cover at least 50% with base transceiver stations (BTS) by 2025.

The Ministry also incorporated some conditions in the deployment framework of 5G on the territory. In addition to the 50%

coverage required, the following conditions have been mentioned:

- › The expansion of optical fibre networks;
- › The improvement of safety measures to reduce outage risks during natural disasters;
- › The improvement of prevention measures against interferences between existing radio licensees;
- › The improvement of cybersecurity measures.

These conditions established by the Japanese government, gave a framework to the three main telecommunication carriers – NTT Docomo, KDDI and Softbank - and to Rakuten to deploy 5G networks in 2020. In practice, each carrier is awarded 400MHz spectrum on the 28GHz frequency. The three main carriers are awarded 200MHz on 3.7GHz, except Rakuten, which has requested 100MHz.

22 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, McKinsey&Company.

23 <https://www.env.go.jp/en/recycle/smcs/attach/swmrt.pdf>.

24 https://www.meti.go.jp/english/publications/pdf/journal2015_05a.pdf.

25 http://www.soumu.go.jp/main_sosiki/joho_tsusin/eng/Resources/laws/2001TBL.pdf.

Key market trends impacting 5G

Ageing of population

Japan is one of the world's countries with the highest rate of elderly people. Indeed, 25 percent of its population is aged 65 or more. By 2040, this ratio is estimated to rise to an unprecedented level of 36 percent. The Japanese population has nearly tripled in the 20th century, peaking at 128 million in 2010. But with a falling birth rate, one of the world's longest life expectancies, and a close to zero net immigration, the country is heading for not

only a high ratio of seniors but also a sharp downturn in its total population as showed by the graph hereafter. From roughly 126 900 000 citizens in 2019, this figure is expected to decrease to 110 000 000 by 2050. An accumulation of reasons may put increasing pressure on Japan's ability to manage its rising debt and social security obligations, and could trigger a growing shortages of skills²⁶.

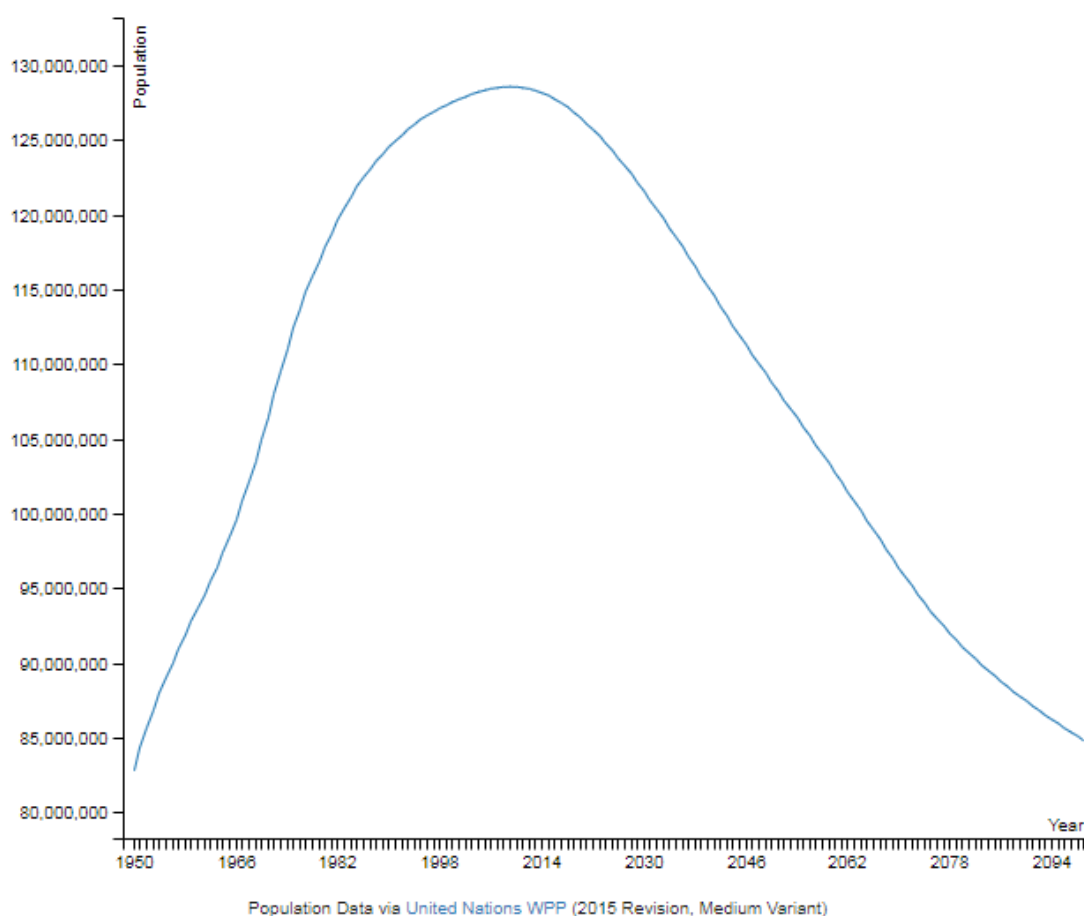


Figure 14: Projection of the Japanese population (Source: United Nations WPP)

26 <https://www.japantimes.co.jp/opinion/2019/01/10/editorials/face-challenges-shrinking-aging-population/#.XLmG4jAzaUk>.

The Abe administration has vowed to address this national issue by launching initiatives to support young couples in having children, as for example making preschool education free. The Abe administration has also set a target of raising the fertility rate back to 1.8 by 2025 and anticipates welcoming up to 345,000 foreign workers in five years under the fertility programme that started in April 2019.

The ageing population and declining birth rate are fundamental aspects to consider when addressing the future of 5G in Japan. The “silver market”²⁷ will be significant in Japan within the next few years and will influence the 5G’s development in the country. Indeed, experts in economics and social sectors consider ageing population in Japan as an economic opportunity to

seize. The country is already implementing several devices relying on IoT in order to face this demographic challenge. Mitsufuji for instance, a Tokyo based company, developed a wearable clothing brand which products are made of silver-metalized conductive fibres and filled with sensors. Aimed primarily at elderly persons, these products have been on the market since 2016 and are used to monitor health information (such as breathing and heart rate, temperature, humidity) through sensors²⁸.

Considering that more efficient healthcare will be the key for Japan to reduce the economic impact of ageing population and to maintain the quality of life for its citizens, Japan seeks to be a frontrunner who can provide solutions answering to the challenges presented by ageing population.

²⁷ Referring to the recent concept of “silver economy”. The Silver Economy refers to the economical markets, activities and stakes related to people aged 60 or more.

²⁸ <https://www.tematicaresearch.com/japan-is-harnessing-iot-technology-to-support-its-aging-population/>.

Connectivity

In recent years, Japanese networks are starting to show signs of capacity constraints. Moreover, the domestic vendors' landscape has been disrupted by global innovations and they have difficulties to fully adapt and benefit from new features such as the Internet of Things. It materialises in people's

everyday life: the capacity constraints and exponential growth in data traffic and connections have considerably slowed the speed capacity of telecommunications in highly dense Japanese areas and especially at peak hours, as illustrated in the graph below.²⁹

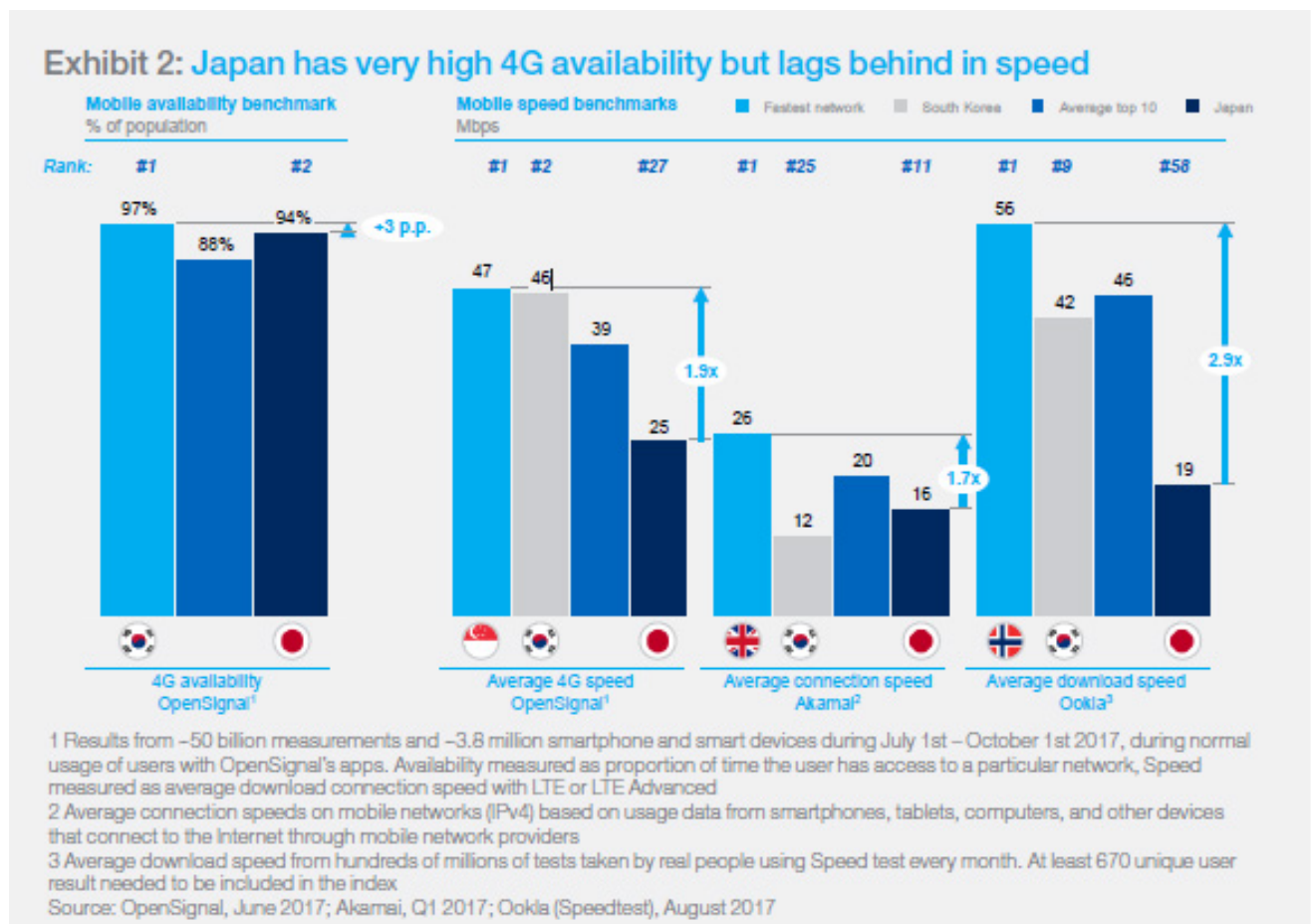


Figure 15: Japan 4G ability and speed: the country has a very high 4G availability but lags in speed (Source: Japan at crossroads, p9³⁰)

Softening the data traffic congestion in Japanese major cities will be a key driver of 5G development in Japan. Congested networks, especially during peak hours affects end-users' experience and for the main Japanese carriers, providing the best

technological experience through a more efficient telecommunication network is the challenge they want to tackle – in order to get a return on the important investments made for the deployment of 5G.

²⁹ 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.

³⁰ <https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/japan-at-a-crossroads-the-4g-to-5g-revolution>.

High Tech and Manufacturing Industry

5G will be important for the telecom sector but it will also have an impact on the entire Japanese industry. For decades, Japan has focused on high precision manufacturing and high-tech items such as hybrid vehicles, robotics, and optical instruments. These sectors are strategic for Japan and 5G is expected to help the country maintain its vigour.

Of the ten Japan's largest companies, seven are either related to electronics or to

the manufacturing industry. For example, Toyota, an important manufacturing company is the largest Japanese company in terms of turnover, and the 12th largest in the world, with an annual profit of USD22.5 billion in 2018. Sony, an important player in the electronics and robotic sector made an annual USD 4.4 billion profit in 2018 and is the 7th largest Japanese company.

The table below highlights the importance of these sectors in the Japanese economy.

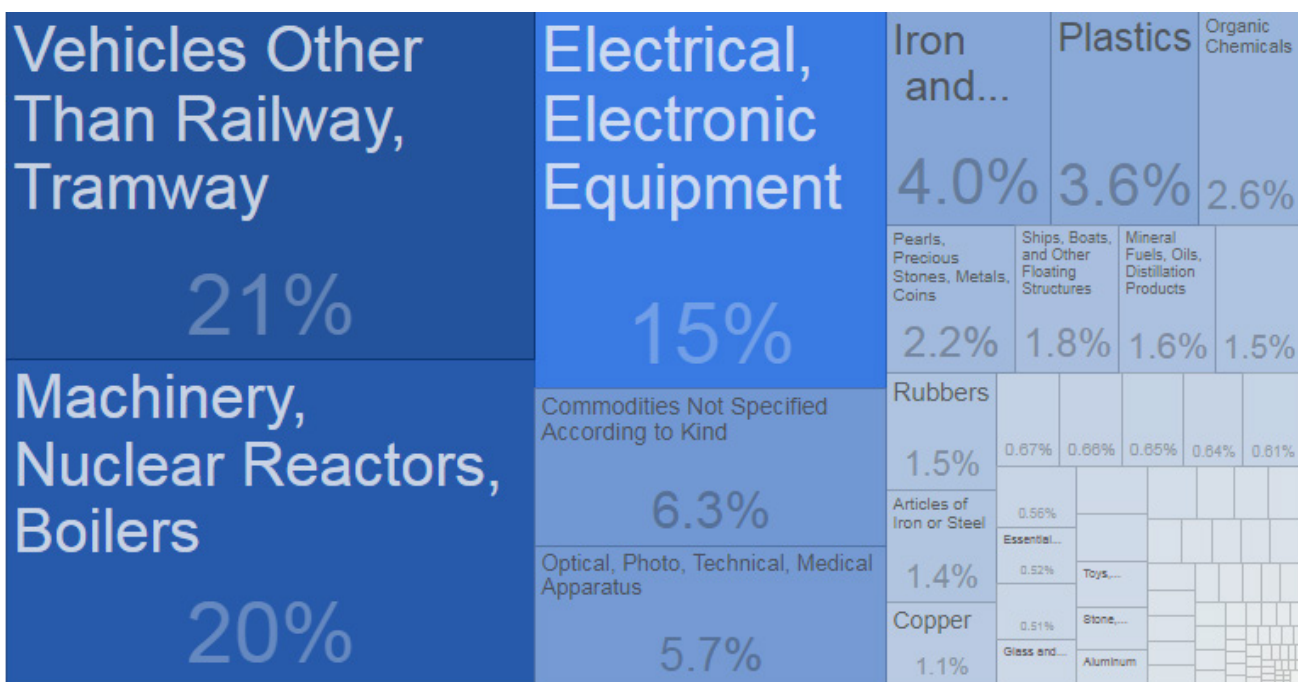


Figure 16: Japan export by category (Source: Tradingeconomics.com)

Japan is currently in second position in the world in terms of automation according to the Automation Readiness Index³¹. But according to the same index, it is the first in the potential of its favourable environment for Research & Innovation³², meaning that it has the tools necessary to deploy innovations and in consequence is one of the front runners to for example take the lead in Automation in the future. Nevertheless, for companies to remain in

the leading edge of innovation, they will need a globally competitive infrastructure on which to build their future products and competitiveness. Connectivity becoming even more implemented in society, mobile networks may be one of the core infrastructures on which industries will base their new products and services. Therefore, the success of many industries outside the telecommunication sector will depend on the mobile network infrastructure.

³¹ <http://www.automationreadiness.eiu.com/>.

³² <http://www.automationreadiness.eiu.com/#overview>.

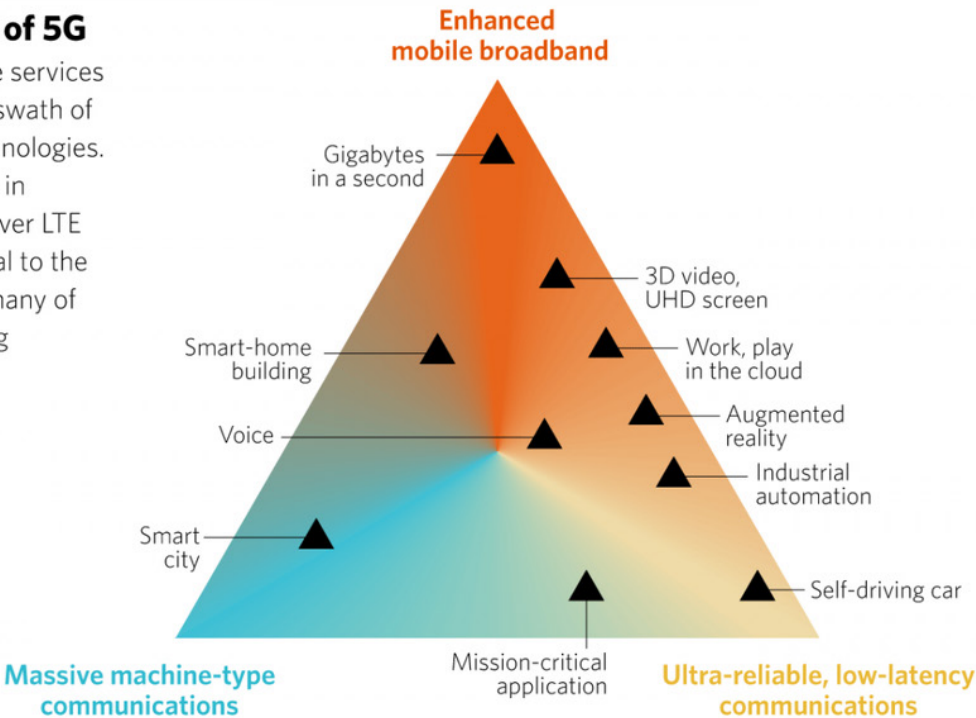
Applications of 5G : Verticals

The implementation of 5G will result in a lot of transformation. 3G and particularly 4G increased the use of mobile devices and brought an all new range of possibilities. 5G will allow the transformation of several vertical industries. Moreover, 5G will offer ultra-reliability which aims at effectively eliminating any element

of risk but also low latency which should enable people to control objects remotely, ensure the ultra-rapid responsiveness of objects and a lot more. The following figure show what the 5G is expected to enable and which verticals will emerge through these opportunities.

Future Use of 5G

5G will provide services across a wide swath of disruptive technologies. Improvements in performance over LTE will be essential to the future use of many of these emerging applications.



Copyright Stratfor 2018

Figure 17: Future use of 5G (Source: Stratfor 2018)

Automotive

For years now, Japan has been focusing on the advanced automotive industry and hosted some of the most cutting-edge automobile technologies (notably, at Toyota). For the Japanese economy, the automotive industry is a crucial asset. It accounts for 16 percent of exports³³ and employs more than 800,000 people in production alone³⁴. 5G and IoT are expected

to boost these figures. Internet connectivity should become integrated to the car of the future and should bring technological advancements in GPS, automated driving, and other features. New manufactural and business models are expected and coming with it, as are new jobs and business opportunities. Japanese automakers' significant presence on the global market

³³ Japan's International Trade in Goods, Japan External Trade Organization, 2016, jetro.go.jp.

³⁴ The motor industry of Japan 2016, Japan Automobile Manufacturers Association, 2016, jama.org.

(exporting nearly four million cars in 2015), puts them in a strategic position to capture these opportunities.

Autonomous vehicles

Although the development of self-driving cars is still in the early stages, car manufacturers are making significant progress: creating cars able to drive themselves for extensive periods without human intervention. Considered as the future of driving, autonomous vehicles present a significant expectation in Japan: enabling vehicles to communicate with the outside world could result in considerably

Two main use cases of 5G have been identified among automotive industry³⁵:

more efficient and safer use of existing road infrastructure. If all the vehicles on a road were connected to a network incorporating a traffic management system, they could potentially travel at much higher speeds and within greater proximity of each other without risk of accident³⁶. Autonomous cars are expected to reduce the potential for human error.

Connected cars

Connected vehicles are expected to enhance significantly functionalities of vehicles, notably for the remote-control key aspects of everyday life (i.e. control of household functionalities). Besides, some concrete initiatives have been launched in the sector of connected cars. Toyota for instance launched Toyota T-Connect, which

is a service which provides drivers in Japan with real-time traffic information and lets them book a restaurant via a human concierge. Nissan announced in 2018 that the company would offer connectivity for all new Nissan, Infiniti and Datsun cars sold in key markets by 2022.

Infrastructural Security

All over the world, governments have taken infrastructural security into consideration and 5G is expected to bring more security for infrastructures at the cyber-level, but also at physical level (i.e.: better control over seismic risk) levels which is crucial for Japan. For Japan, such an implication is crucial considered two aspects:

- › The country nuclear reliability: 5G would bring more security in nuclear installations thanks to an enhanced control enabled by connected factories, able to rapidly communicate information. In the frame of the “Society 5.0”, the Japanese Government have already announced the development of “Connected Industries”. This new industrial concept combined with global evolution toward “industries of the future” is expected to solve a

significant number of problems³⁷(in terms of environmental issues).

- › Seismic risk: This use case is particularly important for Japan as earthquakes are very frequent. The country being located at the intersection of four tectonic plaques, Japanese authorities have to take into consideration this factor. 5G should provide better means to address such issues in the future.

Japan is unfortunately well known for disasters, whether they have natural origins (earthquakes, typhoons...) or human origins (the nuclear explosion of Fukushima for example), Japan is not spared by catastrophes. The country's population is already familiar with extreme conditions, and the country has developed infrastructures adapted to face natural

³⁵ <https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/japan-at-a-crossroads-the-4g-to-5g-revolution>

³⁶ Understanding 5G: Perspectives on future technological advancements in mobile, GSMA Intelligence, 2014.

³⁷ https://www.meti.go.jp/english/policy/mono_info_service/connected_industries/index.html.

disasters. The Japanese society will benefit from possibilities brought by 5G in security management, like the dramatic reduction of the latency period for an information transmission from a place to another. The Japanese government already provides its citizens with alerts across TV, radio and mobile phones. These alerts are managed by the main telecommunication carriers (NTT Docomo, KDDI and Softbank). Softbank for instance is well advanced on

disaster management: they have deployed across Japan mobile power supply vehicles to provide power to base stations in case of power shutdown after a disaster³⁸ and systems for warning people just before the arrival of seismic waves are already used. But these existing systems are often not fast enough. 5G should mitigate this issue, through the significant increase in the telecommunication speed.³⁹

Cyber-security

The strengthening of cybersecurity has become a real priority as the growing amount of data is becoming more difficult to manage for companies and industries. The rising number of cyberattacks proves that the digitality can also be used as a weapon.

Japan has been falling behind in terms of cyber-security for decades due to cultural, governmental and organizational reasons. Famous for its public-safety and its preference to avoid risk, Japan missed the opportunity to foster home cyber-security policies. Nonetheless, in 2017, the Ministry of Internal Affairs and Communications

(MIC) launched the Cybersecurity Action Program, aiming to accelerate the reinforcement of national cyber-security. A National Cyber Training Centre was also established, to train new skilled and young professionals specialized in cyber-security and national defence⁴⁰.

The significant raise in data brought by 5G triggers an enhancement of need for cybersecurity policies, in order to prevent any hypothetical threat for National security or individuals. Considered the delay accumulated by Japan over the years, catching up with most advanced countries is a genuine challenge.

Wireless cloud-based office

As technological development comes with new means to increase the efficiency of companies' working process, a wide range of opportunities are appearing. Cloud computing introduces a significant shift in how technology is obtained, used, and managed. It also shifts how organizations budget and pay for technology services. The advantages of using the cloud includes: the growth of data storage and of computing power it offers, coupled with a decline of servicing costs. Cloud networking will

have a significant impact on the Japanese economy when considering the cost-efficiency this change in working habits should bring.

Japan is already ranked as the second largest cloud computing market amongst the top markets⁴¹, and it will seek to maintain its position thanks to 5G. Indeed, 5G will increase the possibilities of the cloud to carry out business tasks and for the storage and the use of data.

³⁸ <https://www.softbank.jp/en/corp/csr/reconstruct/restoration/>.

³⁹ <https://eandt.theiet.org/content/articles/2018/10/japanese-researchers-develop-machine-learning-technique-for-natural-disaster-detection/>.

⁴⁰ <https://wisdom.nec.com/en/technology/2017120601/index.html>.

⁴¹ 2016 Top Markets Cloud Computing Report, US Department of Commerce

Robotics

Since the 1980s, industrial robots have been increasingly common in factories. The increasing development of robotics has also fuelled the growth of the domestic robotics industry, with Yaskawa and Fanuc as market leaders. The robotic sector is important in Japan and 5G could have a significant impact on several strategic aspects.

Exports

With exports of almost USD2.7 billion in 2016 representing 52 percent of the global supply of industrial robots⁴², Japan is one of the most important robotic technology exporters.

The government has played an important role in establishing and maintaining Japan's leadership in robotic technologies. It launched in 2015 a vision and action plan called "Robot revolution". This plan intends to "establish Japan as a robotics superpower and to lead the world by intensive utilization of robots in a data-driven era"⁴³. Hence, the robotics industry plays a key role in the present and the future of Japan's economy. With 5G, more and more robots are expected to be used in the industry and therefore, the exports of Japanese robots are expected to grow accordingly.

Healthcare

The Japanese government has set up numerous measures in the past few years intending to boost the Japanese healthcare industry. It introduced Jisedai Iryo-kiban Ho, translated as "next-generation medical infrastructure law", which provides external researchers access to data related to diseases. This law aims to facilitate medical research using patient records stored at medical institutions⁴⁶. The use of this data

Industrial applications

The growing demand for new services due to the ageing population motivated the development of a strategy regarding applications of robotics in services. It can also free people from some tasks and allow the redistribution of workers towards jobs jeopardized by ageing and waves of retirements.⁴⁴

Service applications

As technology advances, new types of robots that are more focused on services rather than on industrial applications are approaching the inflection point for large-scale deployment. These new robots have other uses and they have the ability to be more and more mobile and autonomous. 5G will play a central role in creating the next generation mobile robotics (for example, automated guided vehicles and remote-controlled robots), and to enhance their in-depth application in Japanese workplaces. But workplaces may be followed by private places. Indeed, this advancement will be especially critical in areas where robots are in proximity and interaction with human beings in private spheres like in homes for instance⁴⁵. Moreover, robots can be alternatives to employees in care services to the elderly people.

is expected to help develop new kinds of treatments thanks to the generalized database access to researchers, the large quantity can be a constraint for those who wish to get access to them. The accelerated flow enabled by 5G will facilitate the large-scale data use. However, some drawbacks can be pointed out, such as the need to enhance the control over this enlargement of database access⁴⁷.

⁴² Robots: Japan delivers 52 percent of global supply, International Federation of Robotics (IFR), Nov 23, 2017, ifr.org.

⁴³ "Summary of Japan's robot strategy: Its vision, strategy and action plan," updated March 2, 2015.

⁴⁴ Japan at a crossroads p22

⁴⁵ <https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/japan-at-a-crossroads-the-4g-to-5g-revolution>

⁴⁶ <https://www.japantimes.co.jp/news/2017/05/15/reference/medical-big-data-pooled-disease-research-drug-development-japan/#.XNwXERQzaUk>.

⁴⁷ <https://healthcareasiamagazine.com/healthcare/news/japan-build-10-ai-based-hospitals-2022>.

Furthermore, on practical aspects, 5G should bring new applications in the field of Healthcare: sensors, health conditions monitoring, remote surgeries (i.e. in rural hospitals with remote-controlled robots), household caring or food and medicine deliveries⁴⁸. With the population ageing phenomenon, healthcare will be a challenge

for Japanese in the next decades. With 31% of the population aged 60 or more, the number should be even more important the future. Maintaining an efficient healthcare policy will be essential for the Japanese economy, notably regarding the need for elderly caring by the state which should be reduced with a good healthcare situation.

48 Japan at a crossroads p19.

Implementation Strategy: Key vendors

There are three main telecommunication operators in Japan: NTT Docomo, KDDI and Softbank. NTT Docomo is the largest player, with a 45.1 % market share. KDDI (via its subsidiary “au”) is the second

largest with 31.3% followed by Softbank with 23.6% market share. The following figure illustrates the subscribers market share per telecommunication operators.

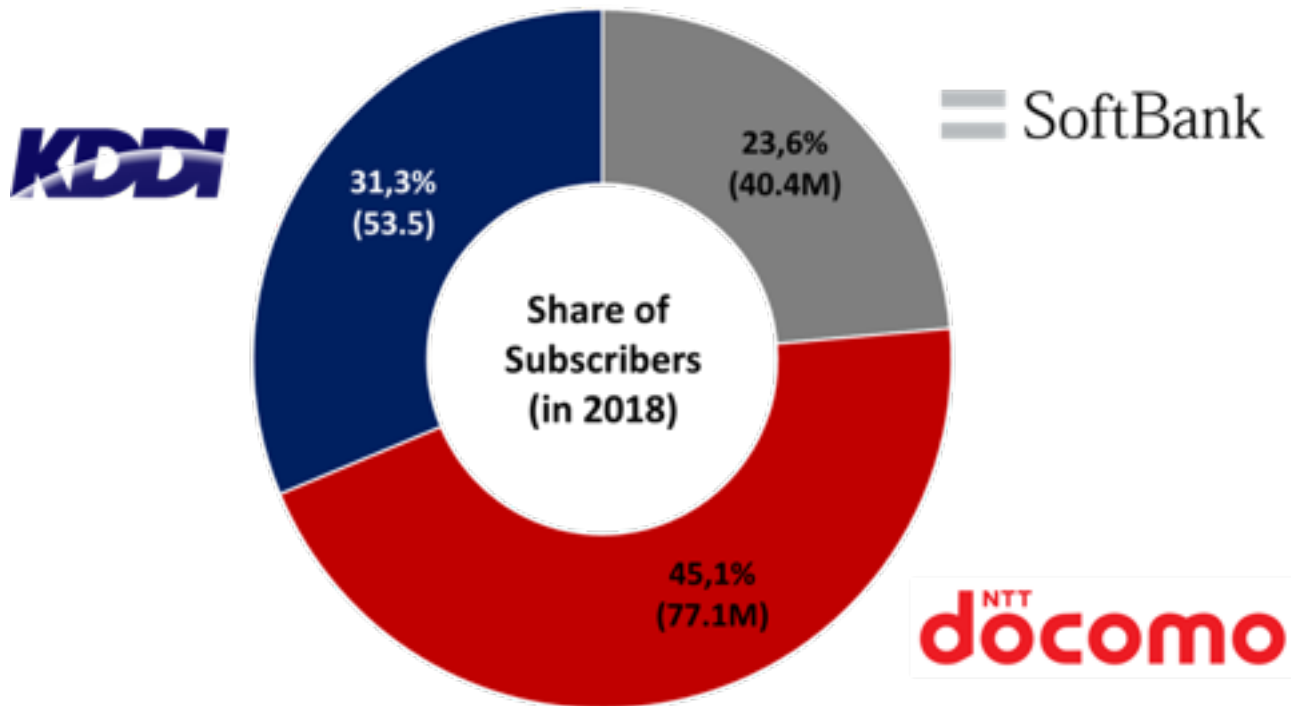


Figure 19: Share of Subscribers in 2018 in Japan
(Source: Telecommunication Carriers Association)

Japanese companies hope to deploy 5G very soon, they have targeted the 2020 Olympics as the official launch of 5G in Japan. This objective has already been settled during the 5GMF (Fifth Generation Mobile Communications Promotion Forum) forum taking place in 2015. This forum gathered members of the government, the

main Japanese carriers (NTT Docomo, KDDI and Softbank) and major stakeholders of industrial and technological innovation. At this occasion, the roadmap for the implementation of 5G was showcased, and the main Japanese carriers settled their objectives (which are described later in this chapter).

NTT DOCOMO

NTT Docomo is the largest telecommunication carrier in Japan and the fifth largest in the world⁴⁹. Founded in Japan, Nippon Telegraph & Telephone Corporation (NTT) had a market value estimated at USD81.564 billion in February 2019. Fibre connections are highly valued in Japan, and Japanese companies are known to invest a lot to obtain the newest Internet technology. The dense fibre network in Japan has helped boost Nippon Telegraph & Telephone Corporation's prevalence. With 5G, NTT Docomo is looking to expand both its sales of cloud computing services and its customer base.

Following the 5GMF Forum, NTT Docomo carried out several trials of 5G technologies by engaging its know-how with other major telecommunication companies such as Sony or Nokia, Ericsson or Qualcomm. These collaborations were established in order to expand the mobile ecosystem toward rapid validation and commercialization of 5G at the national scale. NTT Docomo and Sony worked together on a driverless vehicle, relying on the New Concept Cart SC-1 which leverages 5G for multifunctional remote operations⁵⁰. This concept car is an innovative vehicle incorporating artificial-intelligence (AI) and robotics technologies.

A major achievement of NTT Docomo was accomplished with NS Solutions. They showcased their 5G humanoid assistant robot at the 2018 Mobile World Congress. The human-like robot imitates the movements of a human being. It works via a 5G network carrying signals from sensors put all over a person's body⁵¹.

NTT Docomo for now exclusively carried out joint trials, and intends to collaborate more closely with Ericsson, Intel and Toyota for the phase of commercialisation.

NTT Docomo and Huawei previously completed several joint field trials for 5G

mobile communications over a long distance using the 39GHz mmWave band in Yokohama, Japan and experienced some achievements. For instance, during a trial, the downlink data transmission achieved a maximum speed of more than 2 Gbps on a test vehicle⁵².

NTT Docomo also achieved trials outside of Japan. It was particularly active in Guam (Philippines) where it collaborated with several partners for different 5G use cases⁵³:

- ▶ With Guam Power Authority (electricity utility): NTT Docomo led a 5G virtual-reality training and a 5G monitoring programme using AI technology;
- ▶ With University of Guam Office of Information Technology: it led a 5G education and 5G monitoring programme using AI technology;
- ▶ With ARLUIS Wedding Guam: it conducted a trial on 5G live streaming of multi-screen videos;
- ▶ With United Airlines Guam Marathon Organizer: NTT Docomo carried out several trials on 5G sports, 5G drones, 5G tourism, 5G AI robotics.

On 10th April 2019, the Japanese Ministry of Internal Affairs and Communications announced the frequencies the different carriers will be granted to rollout 5G services. NTT Docomo was awarded 400MHz spectrum on the 27.4-27.8 GHz frequency and 200MHz spectrum on 3.6-3.7 GHz and 4.5-4.6 GHz frequencies. Most of the trials operated in Japan are on mid-band 4.5GHz spectrum as well as on 28GHz millimetre wave spectrum. NTT Docomo will use them as part of their global ecosystem.

This ecosystem should cover over 90% of the country within 5 years, according to the company's objective. NTT Docomo committed to invest USD7.1 billion in their 5G networks to reach this objective.

49 <https://www.investopedia.com/articles/markets/030216/worlds-top-10-telecommunications-companies.asp>.

50 https://www.nttdocomo.co.jp/english/info/media_center/pr/2019/0327_00.html.

51 <https://www.businessinsider.com/this-5g-humanoid-robot-could-complete-dangerous-tasks-for-humans-2018-2?IR=T>.

52 <https://www.rcrwireless.com/20180503/5g/state-5g-trials-japan-tag23-tag99>.

53 https://www.nttdocomo.co.jp/english/info/media_center/pr/2019/0327_01.html.

KDDI

The company was formed in 2001 due to the merger of DDI Corp. (Daini-Denden Inc.), KDD (Kokusai Denshin Denwa) Corp., and IDO Corp. It is the second largest domestic Japanese telecommunication carrier, with an estimated market value of USD65.5 billion in 2018. Its main concurrent at the local level is Softbank (although more important at the international level in terms of market share and profit). KDDI also expects to expand its sales and implementation in Japan, by covering 90% of the territory by 2025, like NTT Docomo.

KDDI started effective actions towards 5G in 2017. KDDI and Ericsson signed in September 2017 an agreement to test a proof of concept in the 4.5GHz frequency band in some cities across Japan.

As for NTT Docomo, KDDI was awarded the 400MHz spectrum on the 3.7-3.8 GHz and 4.0-4.1 GHz frequency and 200MHz spectrum on the 3.7GHz frequency.

The company started to use these frequencies for several trials like those made with Samsung Electronics. One focused on adapting 5G to trains in Japan: the two companies have completed a test using 28 GHz to transmit 4K ultrahigh-definition (UHD) surveillance video on a train platform in Tokyo. The goal was to increase train passengers' safety notably by detecting dangers in advance. Samsung also partnered with KDDI, to complete the first 5G demonstration on a moving train traveling at over 100km/hour. The test was carried out in the city of Saitama in Japan, near Tokyo over two days in 2017 (17th October to 19th October). This test used the firm's commercial end-to-end solution, which includes a 5G router (CPE), radio access unit (5G Radio), virtualized RAN and virtualized core⁵⁴.

KDDI and Samsung also successfully partnered to complete a 5G multi-device trial at a professional baseball stadium in Okinawa, Japan (on the 28GHz band). The trial showcased a live 4K video content downloaded and streamed simultaneously on 5G tablets designed to support the millimetre wave spectrum. This is the first 5G performance test relying on 5G tablets in Japan⁵⁵. This trial was a major advancement to enable the use of 5G at the Olympics 2020, as the event will be watched by billions of people over the world.

KDDI was also active with other European telecommunication technology providers like Ericsson. They announced that they were planning to carry out many tests across a wide range of use cases using the 4.5 GHz and 28 GHz frequency bands, including interworking between 5G and LTE technologies⁵⁶.

At the local level, the company teamed up with Rakuten. This agreement, which was signed in April 2018, gives Rakuten access to KDDI's 4G network for the provision of mobile services. The agreement will enable Rakuten to offer a nationwide LTE service. The services will be provided until March 2026, which will give them time to deploy their own telecommunication network (mainly 4G and 5G). In return, Rakuten should provide payments as well as its logistics expertise.

Regarding deployment, KDDI committed to invest USD4.1 billion in its 5G networks. It has also set up a fund in partnership with the venture capital company Global Brain to invest USD186 million over the next five years in companies which can boost its 5G ambitions.

54 <https://www.sammobile.com/2017/12/01/samsung-completes-first-5g-demonstration-moving-train/>.

55 <https://www.sammobile.com/news/samsung-and-kddi-conduct-5g-trial-in-japan-with-prototype-tablets/>.

56 <https://www.ericsson.com/en/news/2017/8/ericsson-and-softbank-trial-5g-in-4.5ghz-band>.

Softbank

Softbank is the third largest domestic carrier in Japan behind KDDI and NTT Docomo, but it is the sixth largest telecommunication carrier in the world⁵⁷, in front of KDDI. The Softbank Group Corporation was created in 1981 as a software provider and has since created a domestic telecommunications segment that includes Japan's mobile communication, device, and broadband needs. The company's market value was of USD\$ 98.79 billion in February 2019. The company began an important business expansion policy in build-up to 5G. In early 2019, Softbank further expanded its holdings through the acquirement of 84,7% of the US phone service provider Sprint shares. It also manages Yahoo! Japan. In 2015, Softbank purchased IBM's licensing for its robot "Watson" to create a Japanese Android called "Pepper", with plans to sell the robot to retail customers⁵⁸.

The company has undertaken many business actions in the last few years to be in a position which will allow the company to profit from 5G. Before receiving the standard frequencies allocated by Abe's administration to rollout 5G (400 MHz spectrum on the 29.1-29.5 GHz frequency and 200MHz spectrum on 3.9-4.0 GHz frequency), Softbank carried out many trials, on the 4.5 GHz, 15 GHz and 28 frequencies.

Softbank notably carried out trials with Ericsson. The Japanese company teamed up with the Swedish Company for a 5G trial using the 4.5 GHz band in urban areas of Tokyo, in 2017. The 5G trial included two new radios, virtualized radio access network and evolved packet core RAN, beamforming, massive MIMO functionality and support services.

In 2017, Softbank collaborated with Chinese operators such as ZTE and Wireless City Planningtouse for several 5G trials in Nagasaki, Japan. But due to international political tensions, the trials stopped. Yet, these trials led to the achievement of a massive download of data at a rate of 956 Mbps on a 20 MHz channel.

These trials should be useful to cover 64 % of the country by 2025. Softbank is planning to cover less territory than its Japanese main counterparts which forecasted each to cover 90% of the country. This lack of domestic presence will be balanced by its significant presence abroad.

Softbank are committed to investing USD1.8 billion in their 5G networks, which is less than its opponents, but its strategy is also different as it will focus on a large-scale penetration of IoT⁵⁹ and more on abroad than on the domestic market.

57 <https://www.investopedia.com/articles/markets/030216/worlds-top-10-telecommunications-companies.asp>.

58 2016 Press released of SoftBank Robotics, <https://www.softbankrobotics.com/corp/pressroom/20160107a/>.

59 <https://group.softbank/en/corp/irinfo/message/miyauchi/>.

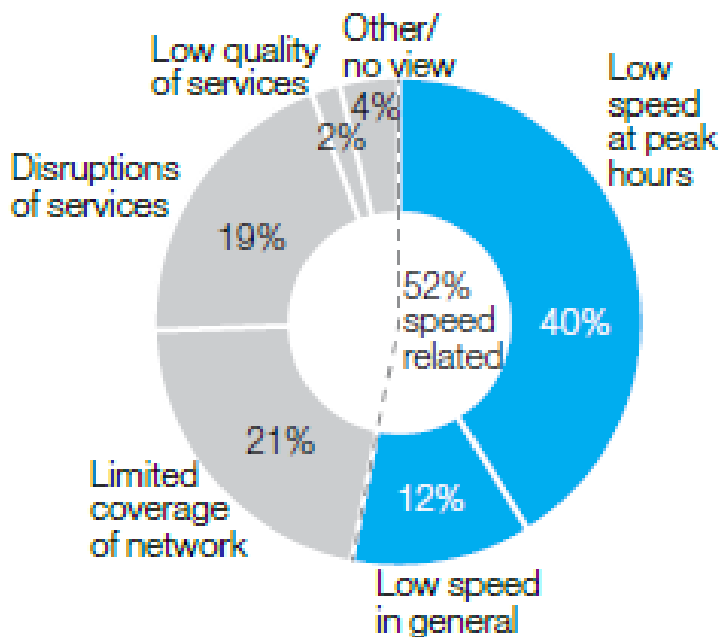
Challenges for the 5G Market in Japan

Next generation of telecommunication is unavoidable, and Japan is one of the leading countries in the race to 5G. But some aspects of this change in

telecommunication paradigm may come with a bundle of problems, if Japan miss the opportunity to address them efficiently.

Efficient coverage of the territory

Survey 2:
Low speed is considered the main user pain point of current LTE network
n=52¹



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

Figure 20: Main user pain point of current Japanese LTE network: low speed is considered as the main concern according to Japanese telecom industry managers (Source: McKinsey survey to Japanese telecom industry managers, "Japan at crossroads" p9⁶⁰)

⁶⁰ <https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/japan-at-a-crossroads-the-4g-to-5g-revolution>.

The previous graph illustrates the results of a national survey carried out among the Japanese telecom industry managers by the McKinsey agency. They were asked what is the “main pain point of the current LTE networking in Japan today”. A majority (52%) pointed out a low-speed problem. Moreover, some highlighted the limited coverage of network (21%) and others the disruption of services (19%). These issues are due to the inefficient coverage of the territory with LTE network due to probably

the large amount of data consumption in Japan.

Nevertheless, these issues will probably be tackled by the deployment of 5G as there is a need for 5G to work efficiently to increase the telecommunication infrastructure and to multiply the deployment of small cells. Moreover, 5G is expected to be used on a wider frequency spectrum and in consequence will allow more data to be navigated without a decreased speed.

The Cyber-security

The geopolitical tensions between the US and China have triggered a division between those who will use Chinese equipment for their future 5G network and those who will not. NTT Docomo, KDDI and SoftBank, planned to follow the government’s move by not using equipment from the Chinese companies in their current networks and upcoming 5G gear. This decision has political reasons and may have practical consequences on 5G in Japan.

At the cybersecurity level, risks of cyberattacks are always considered as imminent. As 5G brings ultra-fast speed, it also comes with an increase in opportunities for cyber-criminals, who will get the ability to steal data even more quickly via wireless devices.

To tackle this issue, the Japanese government decided to act preventively: it

approved a law amendment on 25th January 2019 allowing government workers to hack into people’s IoT devices⁶¹. This action is part of an unprecedented wide scale “survey” of unsecure IoT devices. This law aims to compile a list of unsecure devices with easy-to-guess passwords. These devices will be transmitted to authorities and to the relevant internet service providers, in order to take measures on the devices’ security⁶². These procedures have been recurrent these last months as the government wants to protect the 2020 Olympics from cyberattacks like those that occurred in Pyeongchang (South Korea) Winter Olympics⁶³ (during the opening ceremonies, a massive cyberattack had temporarily paralyzed IT systems, shutting down display monitors, Wi-Fi, and the Olympics website). This amendment, aiming to control IoT devices’ security is motivated by the global context as well.

⁶¹ <https://www.zdnet.com/article/japanese-government-plans-to-hack-into-citizens-iot-devices/>.

⁶² <https://www.japantimes.co.jp/news/2019/01/29/business/japan-survey-200-million-gadgets-cybersecurity-push-ahead-tokyo-2020-olympics/#.XMrDwRQzaUk>.

⁶³ <https://www.wired.com/story/olympic-destroyer-malware-pyeongchang-opening-ceremony/>.

Conclusions

As it was the case for 3G, the ambition of Japan is to be a leading country in the 5G deployment. The country wishes to once again become a global leader as it was until the dawn of China and the US. According to a study led by Analysys Mason, in terms of readiness, the first major player in 5G is China thanks to proactive government policies and industry momentum. China started trials in 13 major cities at the end of 2018. Additionally, China has 5G commercial licences and spectrum and plans to propose the 5G services on a large scale and for commercial application by 2020. South Korea is also in one of the top positions. It has been one of the world's first nation to offer commercial 5G services in March 2019. The country has already tested its 5G technology during the Winter Olympics in February 2018 with self-driving cars, virtual reality games and a motion detection system to ward off menacing wild boars.

Japan occupies the fourth position in the global 5G race. Tests in several cities have already been implemented, but mainly with other telecommunication actors or in specific conditions such as in stadiums, in trains or in cars. The next step will be to focus on the security of Japanese citizens' telecommunication system. By 2020, after the Tokyo Olympics and Paralympics Games, the goal will be to turn those tests into commercial offerings. Other large countries/regions are targeting a commercial 5G roll out within the next two years: Russia and Europe plan to introduce commercial 5G in 2020 and India in 2022. This race for 5G is motivated by the will to be the first country to implement 5G.

In Japan, the research and development of 5G is highly driven by the historical culture of innovative technology in the country.

This innovative culture first developed in the 1970s when the Japanese government activated the specialization of the country towards telecommunication and more generally, with cutting edge technologies. Ever since, the country put efforts into remaining a global leader in technology advancement.

In the past few years, Japan teamed up with Europe to compete against the US and China in the race to 5G. In Europe, the situation regarding 5G is different from Japan since there are many different telecom operators (up to 3 or 4 in some countries) which causes issues regarding the investment capacity of each one for a large-scale 5G and small cells deployment⁶⁴. The research and development of 5G should be driven by the European Union as numerous countries and operators should work together if they want to compete with countries like the US, Japan or China. But the European technological advancement represents an opportunity for Japan to develop their 5G implementation and technologies. Moreover, to address investment issues, Japan relies on its operators, which have the economic power to invest massively in new infrastructures. NTT Docomo, KDDI and Softbank are ready to invest respectively 7.1, 4.1 and 1.8 billion dollars in new infrastructures for the 5G implementation. These investments are expected to be cost-effective, as the profit coming from 5G is expected to be significant as well.

5G in Japan focuses on areas where there is potential for creating new applications and markets: automotive and public transport, smart manufacturing and cybersecurity, wireless cloud-based office and healthcare⁶⁵. Moreover, research and development of 5G in Japan is moving rapidly and numerous

⁶⁴ <https://www.usine-digitale.fr/article/5g-pourquoi-la-chine-et-les-etats-unis-sont-loin-devant-l-europe-selon-nokia-N658174>.

⁶⁵ <https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/japan-at-a-crossroads-the-4g-to-5g-revolution>.

trials have been announced and launched. Nevertheless, the complicated political context with China, Japan has started collaborations on 5G with several countries, notably with the European Union.

To conclude, the Japanese strategy of relying on the know-how of its main operators to carry out a large-scale deployment of 5G across the country is enabling an evolution of the already dense

4G infrastructures towards 5G. Japan is advancing on its objective to deploy 5G for the Olympic Games 2020, and on a large scale afterwards. However, this deployment can be jeopardized by several issues (environmental, political, etc.). Nevertheless, the 5G large-scale deployment in Japan is expected by 2020 and Japan may return on the foreground of the major technological actors.



The work described in this document has been conducted within the project Global5G.org. This project has received funding from the European Union's Horizon 2020 (H2020) research and innovation programme under the Grant Agreement no. 761816. This document does not represent the opinion of the European Union, and the European Union is not responsible for any use that might be made of its content.

