Ministry of Internal Affairs and Communications, JAPAN

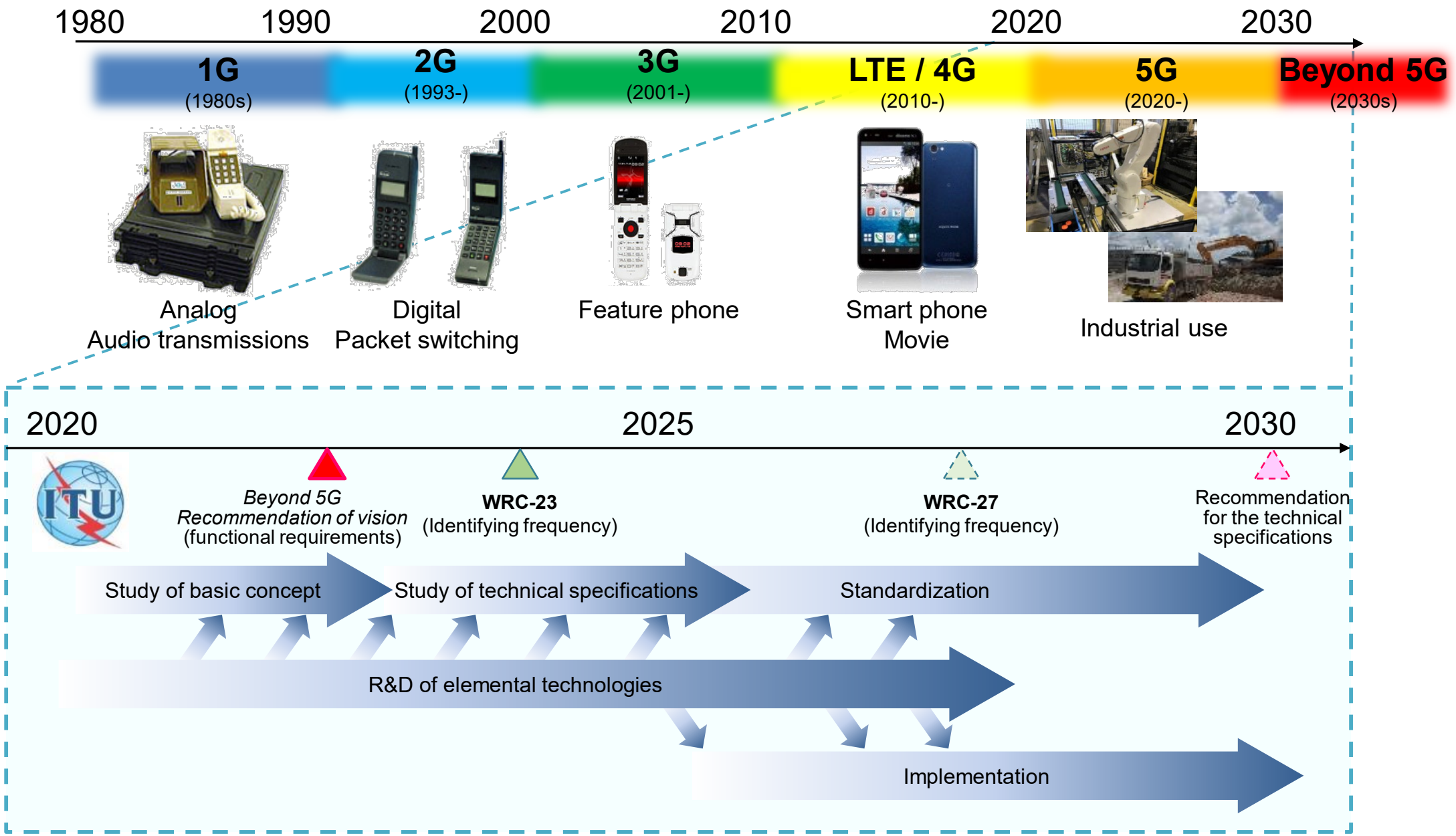
Vision toward Beyond 5G

November, 2021

Vice-Minister for Policy Coordination
TAKEUCHI Yoshiaki

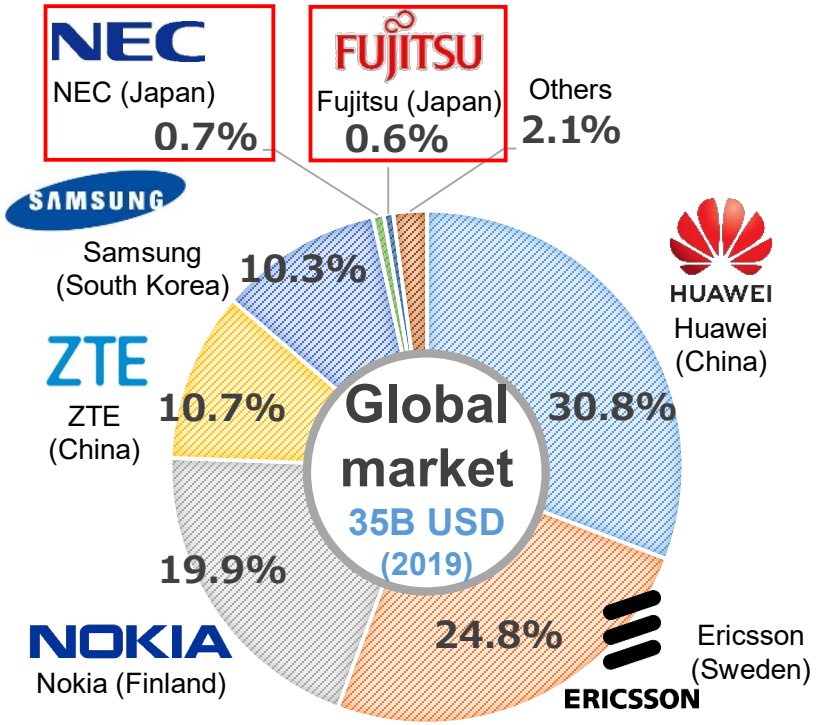
I. Vision of Beyond 5G

What is Beyond 5G ?



Global share of 5G base station

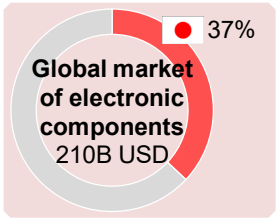
About the global share of mobile base station in 2019, the sum of five companies in China, Europe, and South Korea accounts for 97% but **Japanese companies account only 1.5%.**



Ref. Informa PLC.'s data sheet

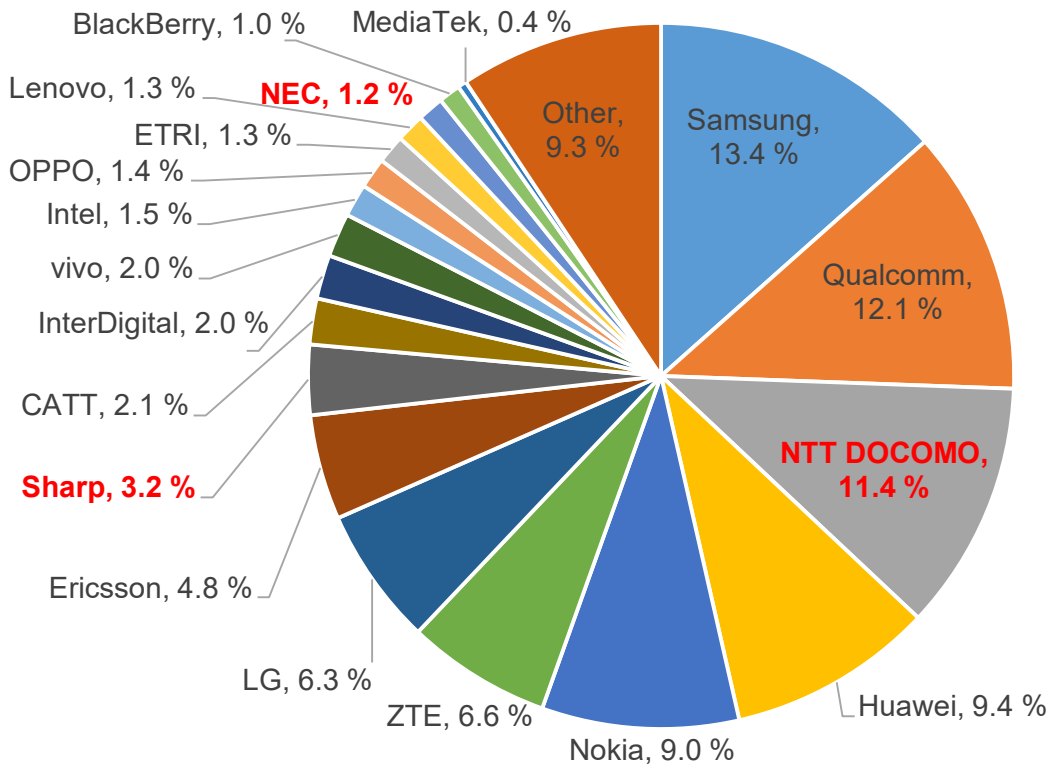
From the perspective that the share of Japanese companies in the global market of electronic components accounts for 40% (70% for some specific products), Japan has international competitiveness toward Beyond 5G potentially.

Ref.: JEITA Statistical Handbook 2020-2021



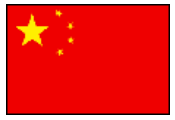
Standard essential patents for 5G

Japanese companies hold approximately 15% of standard essential patents for 5G, however, NTT DOCOMO, a MNO, holds almost all of them and **the Japanese vendors hold a few.**

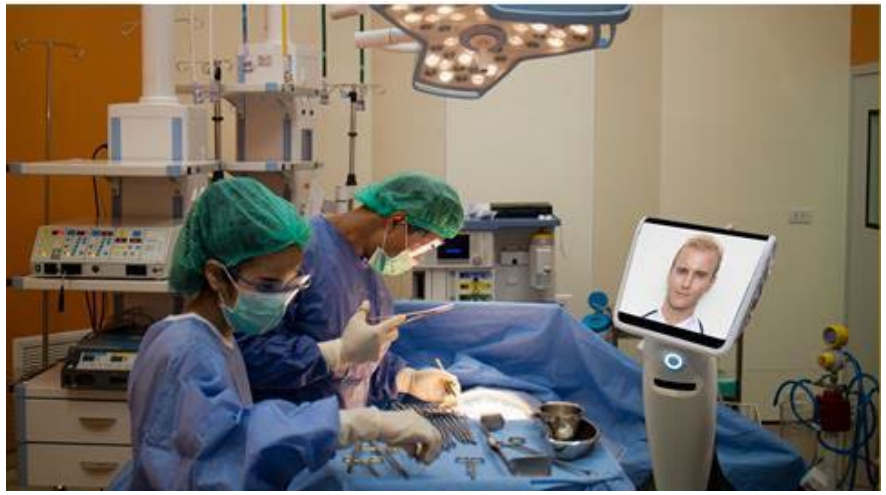


Ref.: Cyber Creative Institute Co., Ltd.. Press Release (April 2nd, 2021)

Government R&D Investment on 5G/B5G

	5G	Beyond 5G (6G)
EU	• Invested an R&D budget of 700 million euros (approx. **85 billion yen**) in a 5G-related R&D project under the EU's R&D program Horizon 2020 (2014 through 2020).	• Investing an R&D budget of 900 million euros (**approx. 120 billion yen**) in a 6G-related R&D project under Horizon EU, a next R&D program (2021 through 2027) (since March 2021).
		• Germany has been investing an R&D budget of 700 million euros (**approx. 85 billion yen**) in a 6G-related R&D project (since April 2021).
	• (Finland invested 100 million euros (approx. **13 billion yen**) in R&D under 5th Gear, a next-generation network technology project (2014 through 2019).)	• Finland has been investing **approx. 30 billion yen** in 6 Genesis, a research project of the University of Oulu, Nokia, and others (2018 through 2026).
United States	• Invested 400 million dollars (approx. **40 billion yen**) in the R&D of Advanced Wireless Research Initiative (AWRI), a research program related to 5G networks.	• Investing an increase of 300 billion dollars over four years in the R&D of advanced technologies under Biden's campaign pledge.
Korea	• Invested 410 billion won (approx. **40 billion yen**) in Giga Korea, a high-speed network R&D project (2013 through 2020).	• Investing 220 billion won (approx. **22 billion yen**) in a 6G-related R&D project over five years based on the 6G R&D promotion strategy.
 China	• **Unknown** government investment figures.	• **Unknown** government investment amount (In November 2019, the government-led 6G Technology R&D Promotion Activity Team and others were launched.)

Solving social problems



- *The pandemic of COVID-19 is expanding, causing a serious impact on the economy, environment and society. Under the 'Stay-Home' policy,* ***physical flows of people have dramatically decreased***
- *For social issues such as regional revitalization, aging society with fewer children and labor shortage,* ***B5G will provide wide range of solutions, such as telework, remote control, telemedicine, distance education and autonomous operation of various equipment including cars****.*

Communication between humans and things

- ***IoH (Internet of Human) and IoA (Internet of Abilities)****, where humans, abilities, things and events are connected.*
- ***Human Augmentation and brain-related communication****, which enhances human abilities in terms of physical strength, perception, cognition and presence.*
- ***Multisensory communication*** *to make use of tactile, gustatory and olfactory senses of the five senses.*
- ***Wearable devices such as XR (VR, AR, MR) devices*** *and* ***real and rich communication*** *utilizing 8K or higher-definition images and holograms.*

Example of Beyond 5G service #2

Expansion of communication environment

- ***Communication will become fundamental infrastructure just like the air***
- ***Our activity domains will be extended*** *to buildings, drones, flying cars, airplanes, ships, and space.*
- ***Communication needs to cover unmanned factories and unmanned construction site*** *with various sensor networks*
- *As a result,* ***communication services need to cover all areas, such as the ground, sky, sea and space****.*

Sophistication of cyber-physical fusion

- ***Ultimately, the cyberspace and physical space will be fused into one domain with no gaps.***
- ***Cyberspace will support human thinking and activity on a real-time*** *through wearable devices or micro devices with brain-ICT and other technologies.*
- ***All things will connect to cyberspace****, such as vehicles, construction machines, machine tools, security cameras etc. to provide safety and security, solve social problems and support affluent human lives.*

➢ *Cultivate several new life styles of 2030* ***through the evolution of ICT*** *, such as* ***“food,” “purchasing,” “health,” and “lifestyle”*** *from among material needs, and* ***“learning,” “play,” “communication,” “work styles,” and “rest”*** *from psychological needs*

(a) Automatic purchase of food and drink using sensors

(b) Counseling by a virtual human

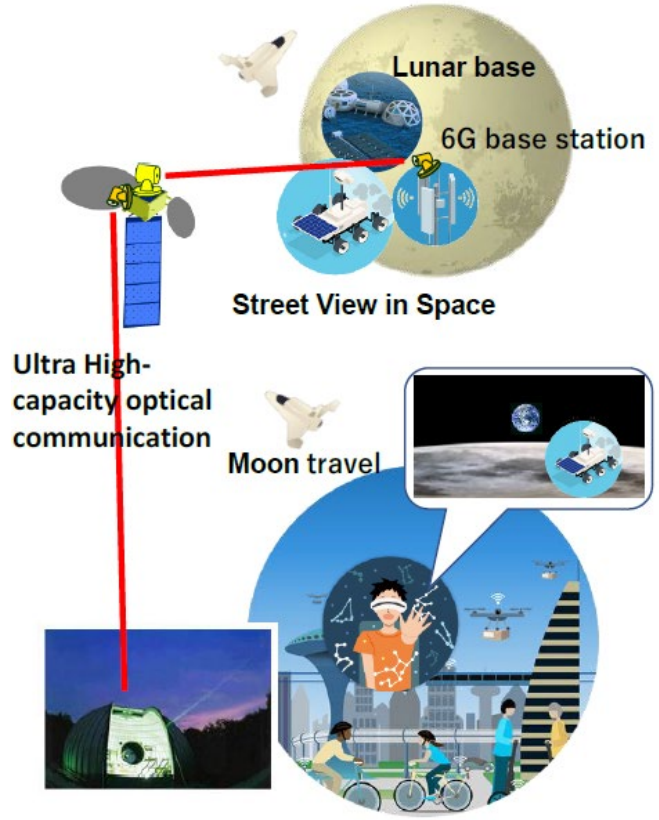
(c) Automatic delivery by robot

(d) 3D animation using point cloud data

Scenarios based on an image of social life in the years from 2030 to 2035

- ***A nursing-care support avatar (AI or robot) reads verbal, non-verbal and brain information*** *of the elderly and the physically challenged, and assists them with their wishes and feelings.*
- ***Caregivers can also remotely control the nursing-care support avatar*** *to provide assistance*

- ***Instantly move around the world with 3D avatars*** *while staying at home.*
- ***Meetings with people overseas are made easy with XR and simultaneous multilingual interpretation****.*
- ***Take care of parents living far away while working****.*



A user on the earth controls avatar on the lunar surface in real-time*.*

Key Features for Beyond 5G

*Green words are the example of areas where Japan has advantages or is actively engaged in.

Synchronization of Physical and Cyber Spaces

Beyond 5G

THz Communications

Sensing

Ultra Fast and Large Capacity

- Network Access: **10x Faster than 5G**
- Core Network Access: **100x Faster** than now

Ultra Low Latency

- Latency: **1/10 of 5G**
- Advanced Synchronization with CPS
- High Level of Synchronization with Complementary Network

Ultra Numerous Connectivity

- Simultaneous Connectivity: **10x more than 5G**

All-Photonics Network

Ultra low power consumption

- Power Consumption: **1/100 lower** than now

*Without reduction measures, IT-related power consumption would reach to 36x tha now (1.5x of total consumption than now.).

Low Power Consumption Semiconductor

Further Upgrade of 5G Features

eMBB | URLLC | mMTC

5G

New features contribute to generate sustainable and new values

Ultra security and resiliency

- Always Ensuring Cybersecurity
- Instant Recovery from Disaster/Failure

Quantum Cryptography

HAPS

Inclusive Interface

Autonomy

- Autonomous coordination among devices without manual intervention
- Construction of optimized network highly integrating wired and wireless connection

Complete Virtualization

Scalability

- Seamless Connection with Satellites and HAPS (incl. space and ocean)
- Transforming various interfaces such as terminals and windows into base stations
- Ubiquitous connections through coordination between devices

Beyond 5G Promotion Strategy

Mission

Early and Smooth introduction of Beyond 5G

Strengthen the international competitiveness of Beyond 5G

Basic Principles

Global First

Ecosystem Driving Innovation

Focused Resource Allocation

Three pillars

R&D

Intensive investment for advanced technology and drastic opening spectrum

World-class R&D Environment

Establish Core Technologies from around 2025

IP & Standardization

Strategic promotion of openness/defactization and collaboration with international strategic partners

Game Change

Reducing supply chain risk and creating market entry opportunity

Above 10% Share of Essential Patent to Beyond 5G

Deployment

Deploying networks throughout society and promoting industrial/public use through demonstration of 5G solutions

Beyond-5G-Ready Environment

New Value Added of 44T JPY* by FY2030

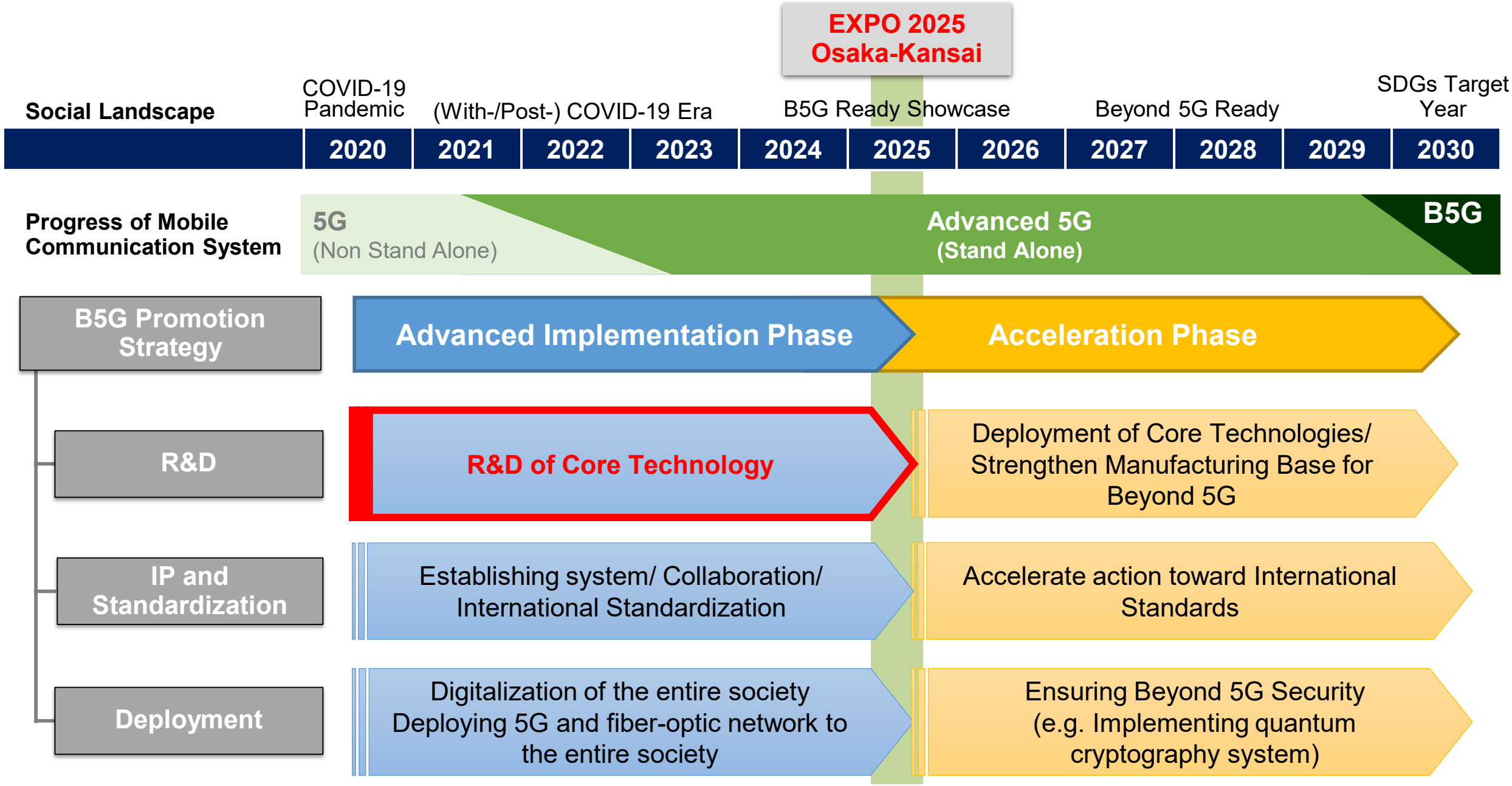
*400B USD (1USD=110JPY)

Promoting through industry-academia-government collaboration

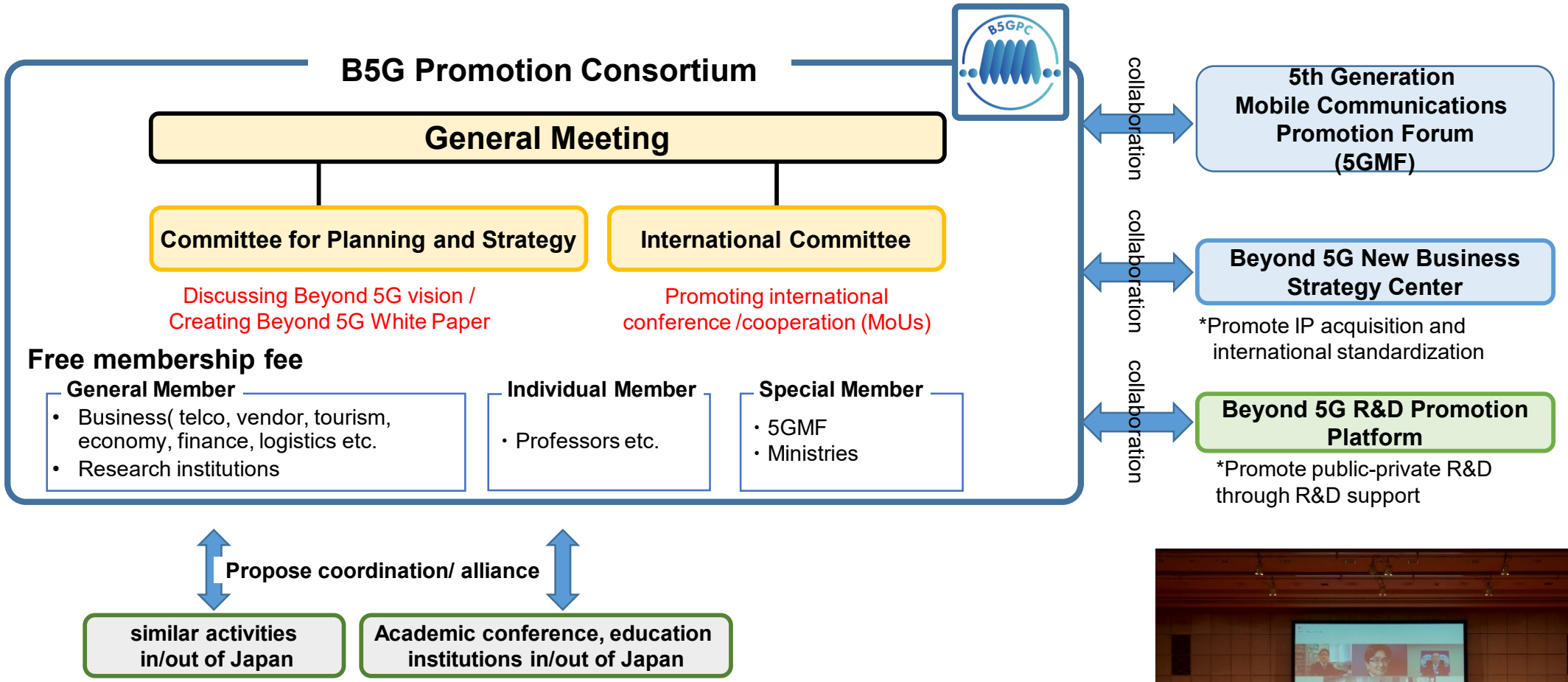
Beyond 5G Promotion Consortium

Holding an international conference for international cooperation, Discussing among stakeholders to create the vision for Beyond 5G, etc.

B5G Roadmap


EXPO 2025
Osaka-Kansai
Social Landscape
COVID-19 Pandemic
(With-/Post-) COVID-19 Era
B5G Ready Showcase
Beyond 5G Ready
SDGs Target Year
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
Progress of Mobile Communication System
5G
(Non Stand Alone)
Advanced 5G
(Stand Alone)
B5G
B5G Promotion Strategy
Advanced Implementation Phase
Acceleration Phase
R&D
R&D of Core Technology
Deployment of Core Technologies/ Strengthen Manufacturing Base for Beyond 5G
IP and Standardization
Establishing system/ Collaboration/ International Standardization
Accelerate action toward International Standards
Deployment
Digitalization of the entire society
Deploying 5G and fiber-optic network to the entire society
Ensuring Beyond 5G Security
(e.g. Implementing quantum cryptography system)

B5G Promotion Consortium



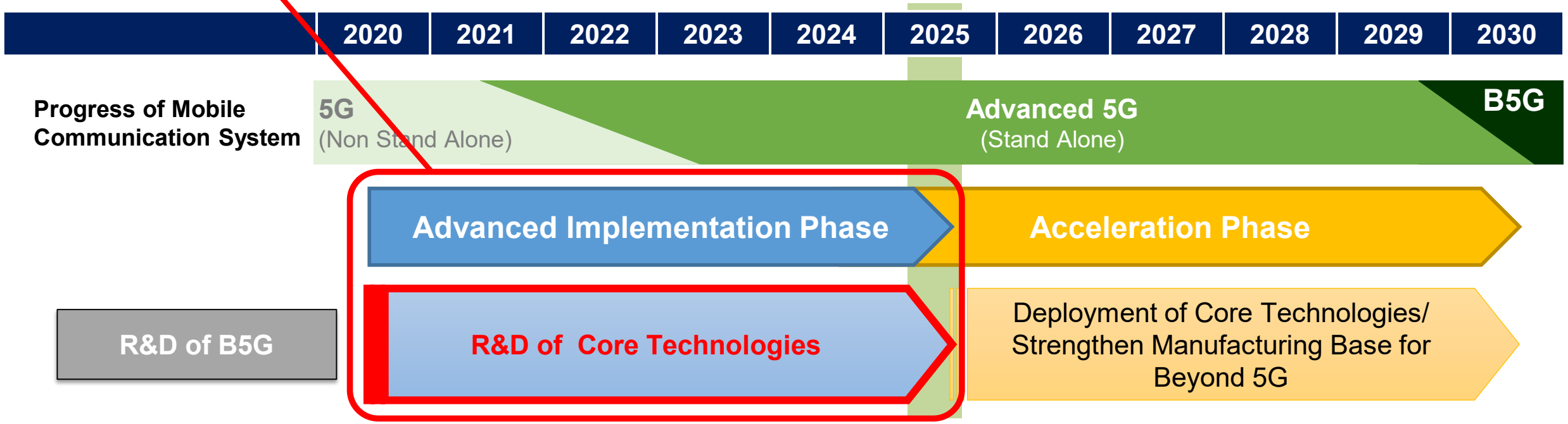
President	GONOKAMI Makoto (Professor and 30th President, the University of Tokyo)
Vice-President *Alphabetical order	Il Motoyuki (President and Chief Executive Officer, NTT DOCOMO, INC.) MIYAKAWA Junichi (President and Chief Executive Officer, SoftBank Corp. SAWADA Jun (President and Chief Executive Officer, Nippon Telegraph and Telephone Corporation (NTT)) TAKAHASHI Makoto (President, KDDI Corporation) TOKUDA Hideyuki (President, National Institute of Information and Communications Technology (NICT)) TOKURA Masakazu (Chairman, KEIDANREN (Japan Business Federation)) YAMADA Yoshihisa (President, Rakuten Mobile, Inc.) YOSHIDA Susumu (Chairman, The Fifth Generation Mobile Communications Promotion Forum (5GMF))

General assembly for the establishment
@Imperial Hotel, Tokyo,
December 18th, 2020

The National Institute of Information and Communications Technology (NICT)

- Launched “Beyond 5G R&D fund” to grant R&D projects of research organizations in Japan such as private companies/universities *[apx. 300M USD]*, and
- Building research environment (facilities/equipments) for Beyond 5G R&D *[apx. 200M USD]*.

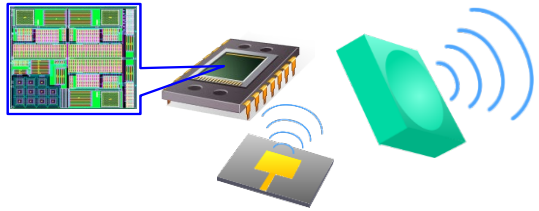
⇨ **Within the next five years**, in order to strengthen the international competitiveness, MIC aims to **invest one billion USD**, including Spectrum User Fees, that is one of the largest budget in the world.



Example of elemental technologies toward Beyond 5G

Ultra Fast and Large Capacity

[Terahertz and millimeter waves]
• High-frequency bands such as terahertz/millimeter waves, which are unexploited radio waves.



Ultra Low Latency

[Transmission media conversion]
•Optimization of processing delay and flexible network configuration by seamlessly interconverting optical and radio signals.

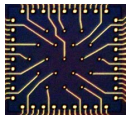
Photoelectric conversion device

Ultra Numerous Connectivity

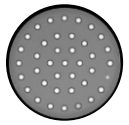
[Multiple simultaneous connection]
• Interference control between multiple antennas that realizes high-capacity simultaneous transmission of multiple user terminals

Ultra Low Power Consumption

[All photonics network]
•All photonics communications from network to terminals, low-power consumption devices by introducing optical technology into a chip, etc.



Integrated light receiving device



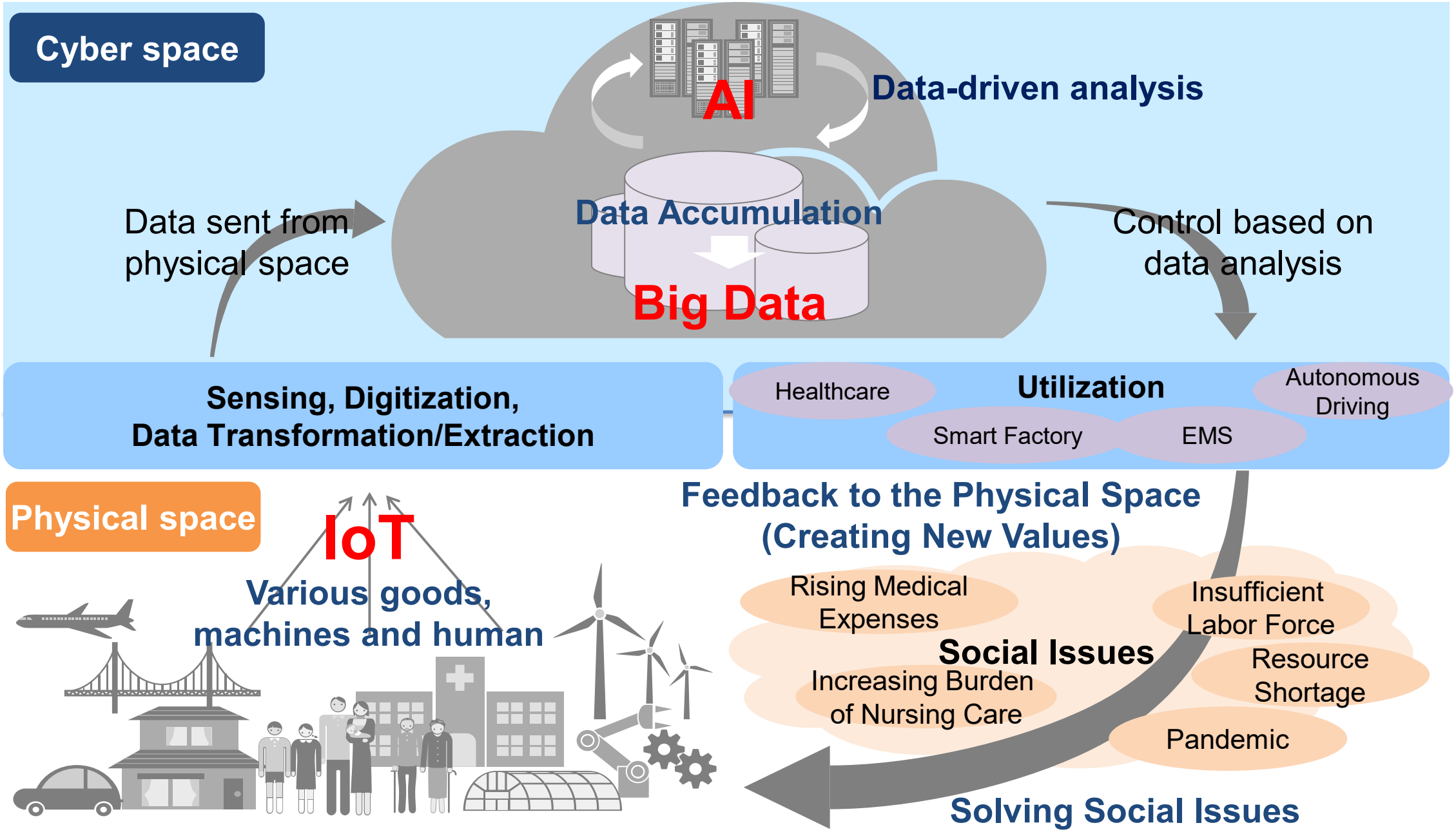
Multicore Optical fiber

Ultra security and resiliency

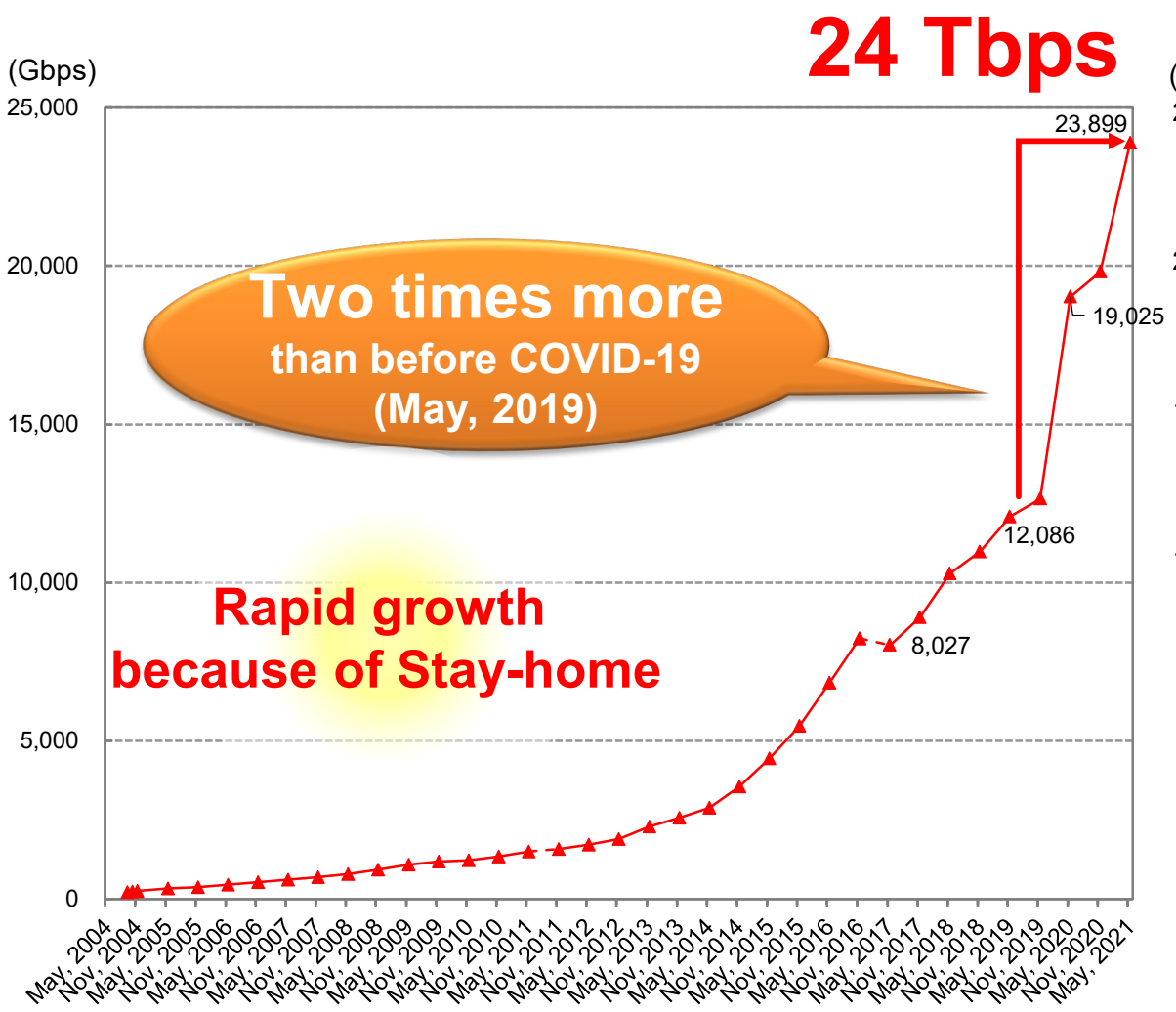
[Quantum cryptography]
•Secure communications where wiretapping is theoretically impossible by transmitting cryptographic keys on photons

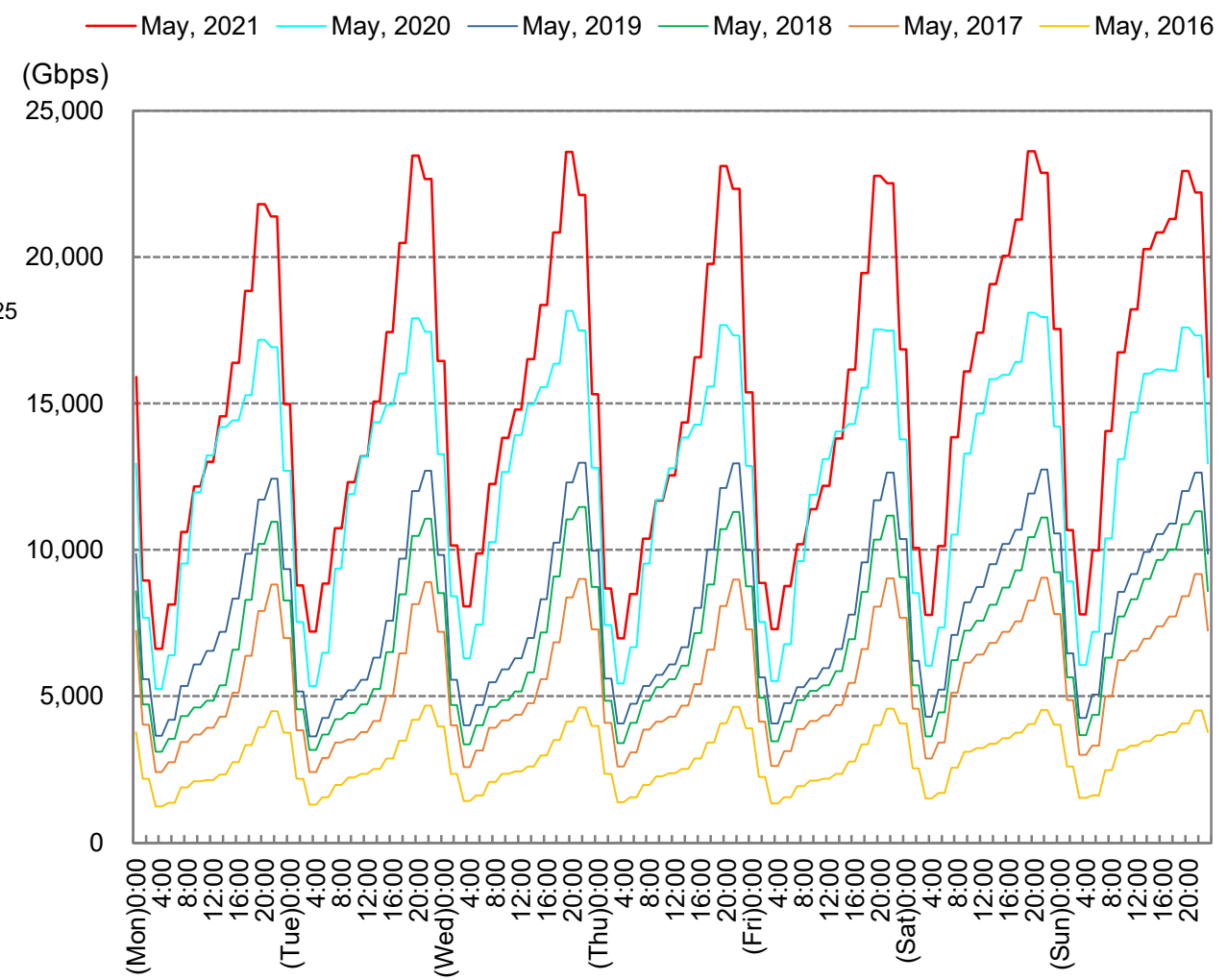
Quantum communication

II. Deployment of Infrastructure to realize Beyond 5G


Cyber space
AI
Data-driven analysis
Data sent from physical space
Data Accumulation
Big Data
Control based on data analysis
Sensing, Digitization, Data Transformation/Extraction
Utilization
Healthcare
Autonomous Driving
Smart Factory
EMS
Physical space
IoT
Various goods, machines and human
Feedback to the Physical Space (Creating New Values)
Rising Medical Expenses
Insufficient Labor Force
Social Issues
Resource Shortage
Increasing Burden of Nursing Care
Pandemic
Solving Social Issues

Rapid growth of the Internet traffic under COVID-19 pandemic





Group Policy (1) Multi-stakeholders' reinforced response to traffic growth

- Establishing **a mechanism to share information on large-scale event traffic in advance from content providers** to telecommunications carriers.
- **Reinforcing the cooperation ammong related businesses** in CONECT* (involvement of content industry organizations, small- and medium-sized telecommunications carriers, etc.).
- **Periodic post-event monitoring, analysis, and announcement of Internet traffic** by MIC and CONECT.
- **Ongoing capital investments** of telecommunications carriers.

* **CO**uncil for **N**etwork **E**fficiency by **C**ross-layer **T**echnical members (CONECT): Established in April 2020 as a technical cooperation system for telecommunications carriers, content providers, etc.

Group Policy (2) Addressing issues related to users' Internet access.

- Collection, dissemination, and commendation of good examples (best practices) of awareness-raising activities for users regarding Internet access improvements.
- **Establishment of a quality measurement method for fixed broadband services.**
- Establishment of a consultation system by telecommunication carriers etc. for improvements in the communications environments of homes and housing complexes.
- **Studying and promoting the model measures to eliminate communications bottlenecks caused by on-site wiring and Wi-Fi use in housing complexes.**

Regular follow-up

Group Policy (3) Regional decentration of data traffic (elimination of inefficiencies in the network structure)

- **Horizontal development and expansion of demonstration projects for regional decentration of data traffic** to help eliminate communications quality disparities between regions.
- **Decentration of IX, mainly concentrated in Tokyo and Osaka currently**, and **promotion of building domestic data centers especially in regional areas while considering geopolitics and international competitiveness**.
- Efforts promoted by telecommunications carriers and content providers to **maintain communications and other services** by using detour routes **when disaster occurred in the Tokyo metropolitan area**.

Group Policy (4) Dealing with other issues that require attention.

- **Migration of IPv6 addresses to solve communication bottlenecks during telework** by companies, and **to solve problems in content usage due to IPv4 address exhaustion**, and other initiatives.

Regular follow-up

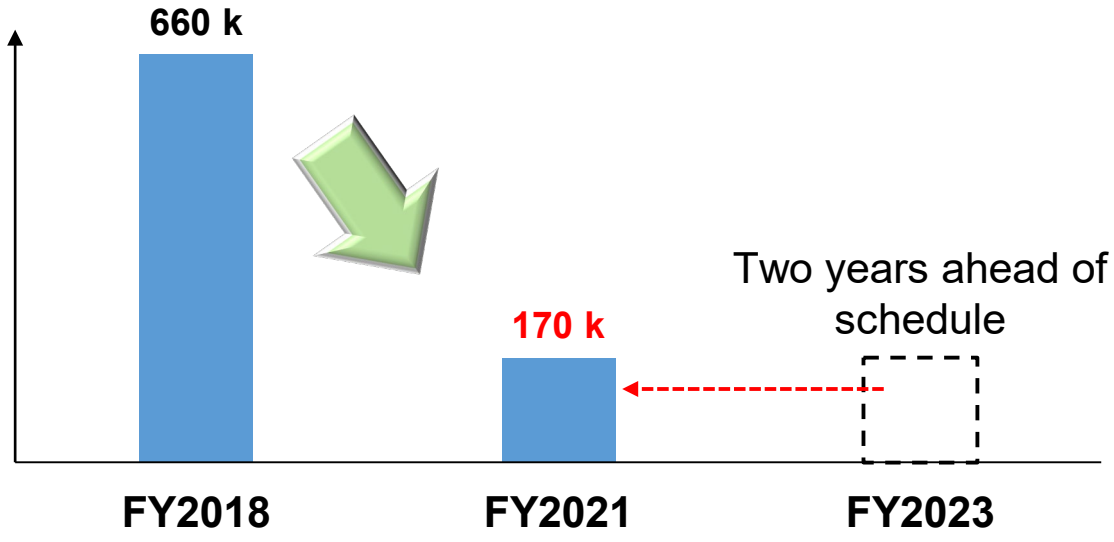
- **Digitalization enables everything, regardless of location: telework; healthcare; entertainment; government procedures.**
- **Digitalization contributes to Green/carbon neutral. Digitalization and green are the keys to economic growth in the New normal post COVID-19 era.**
- **High-speed internet connection is essential to digitalization. MIC is working on developing and maintaining high-level ICT infrastructure, such as 5G, FTTH.**

- FTTH: Reducing uncovered households to 170 thousand by FY2021
- 4G (LTE): Covering all residential areas by FY2023
- 5G: Deploying 280 thousand base stations by FY2023, 4x of initially planned

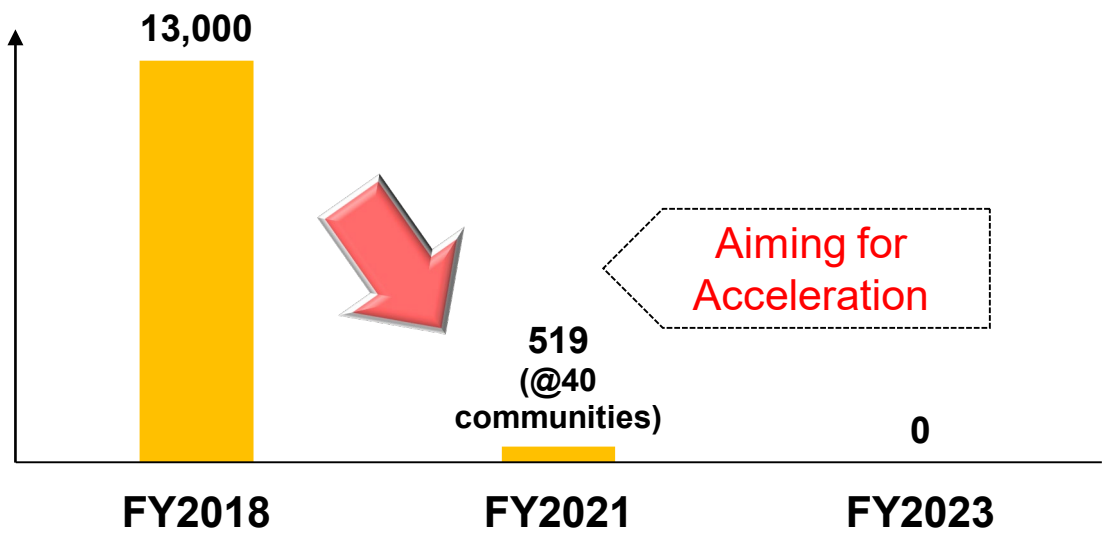
} essential requirements for 5G deployment

- Maintaining infrastructure including rural areas and tunnels
- Promoting Local 5G (Private 5G) system implementation

Households outside FTTH coverage

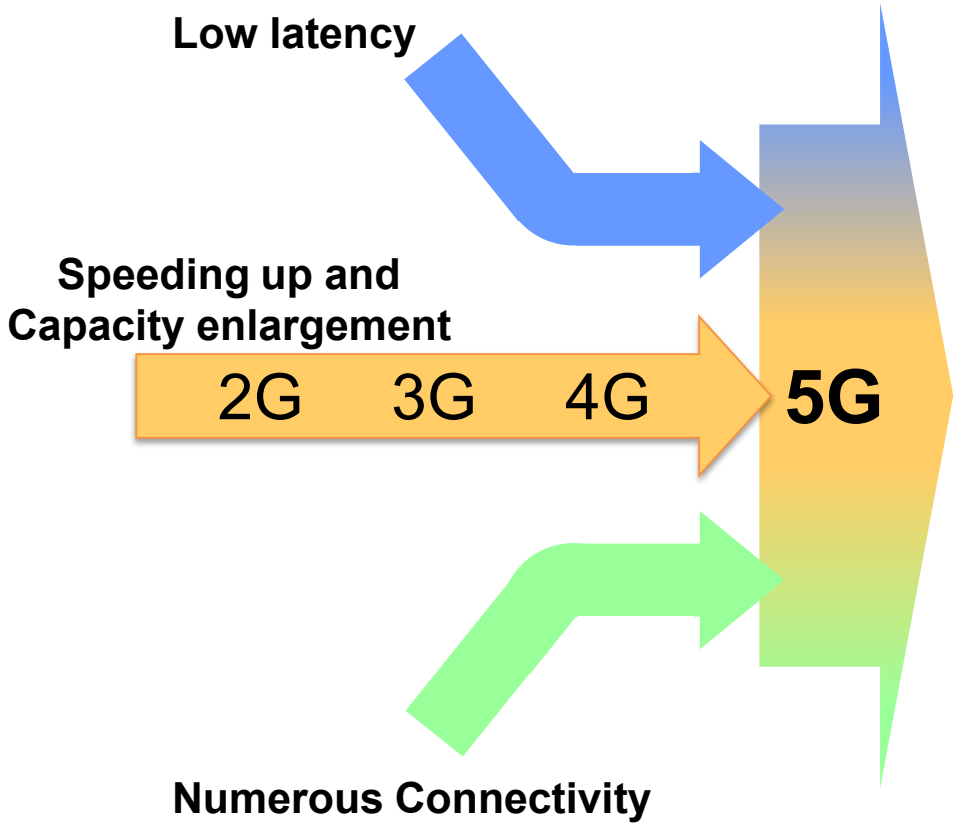


People outside 4G (LTE) coverage



[Performances of 5G] Very high speed → Maximum transmission speed: 10 Gbps
Very low latency → Latency: about one millisecond
Numerous Connectivity → Capacity: One million units per square kilometer

5G is the ICT base for AI/IoT era



Very high speed

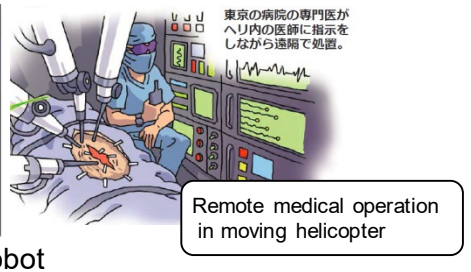
Providing broadband services 100 times faster than the current mobile communications systems

⇒ *A two-hour movie* ***can be downloaded in*** *three seconds.* (*cf. five minutes with LTE*)

Very low latency

The operator can control robots remotely in real time, without being conscious of delay.

Remote control of robot

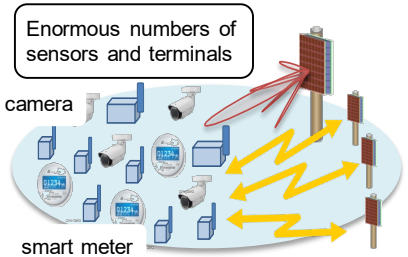


Remote medical operation in moving helicopter

⇒ *Real-time communication* ***enables*** *high-precision operation* ***of robots.***
(*10 times more precise than LTE*).

Numerous Connectivity

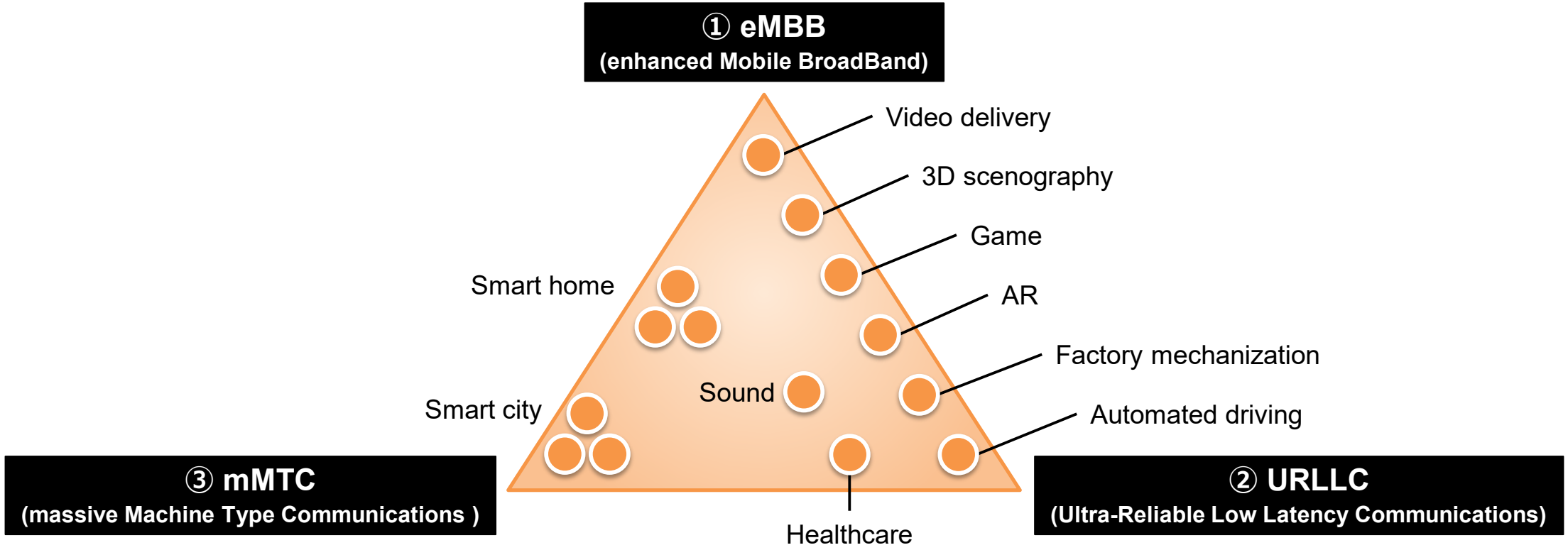
Any types of personal devices, such as smartphones and PCs, are connected to the Internet.



⇒ *About 100 terminals and sensors at home are connected to the Internet.*

5G Standalone enables these features.

5G major performance and use case

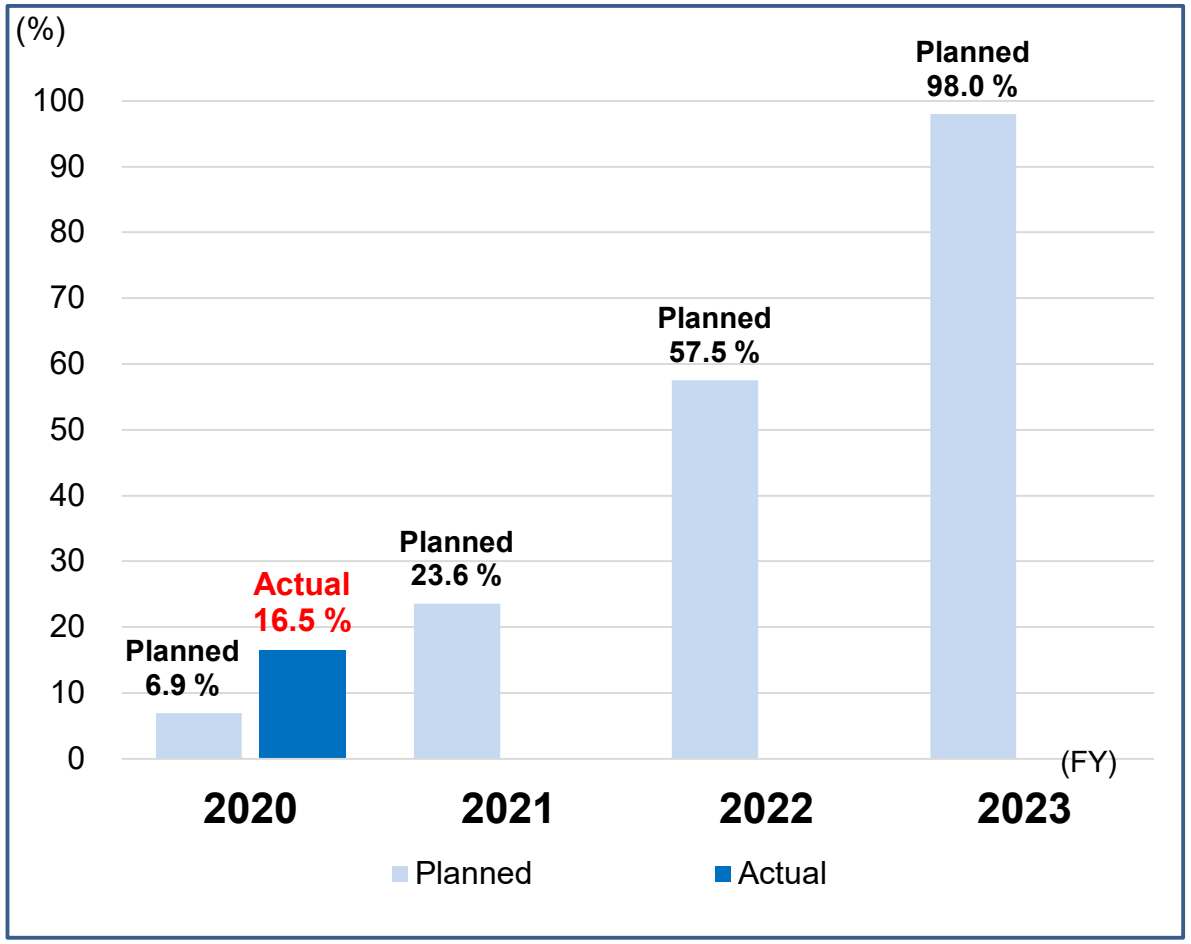


	4G/LTE		5G
Data rate	100 Mbps	100 times	**10 Gbps**
Latency	30-50 msec	1/30~1/50	**1 msec**
Connected device	10 thousand/km^2	100 times	**1 million/km^2**

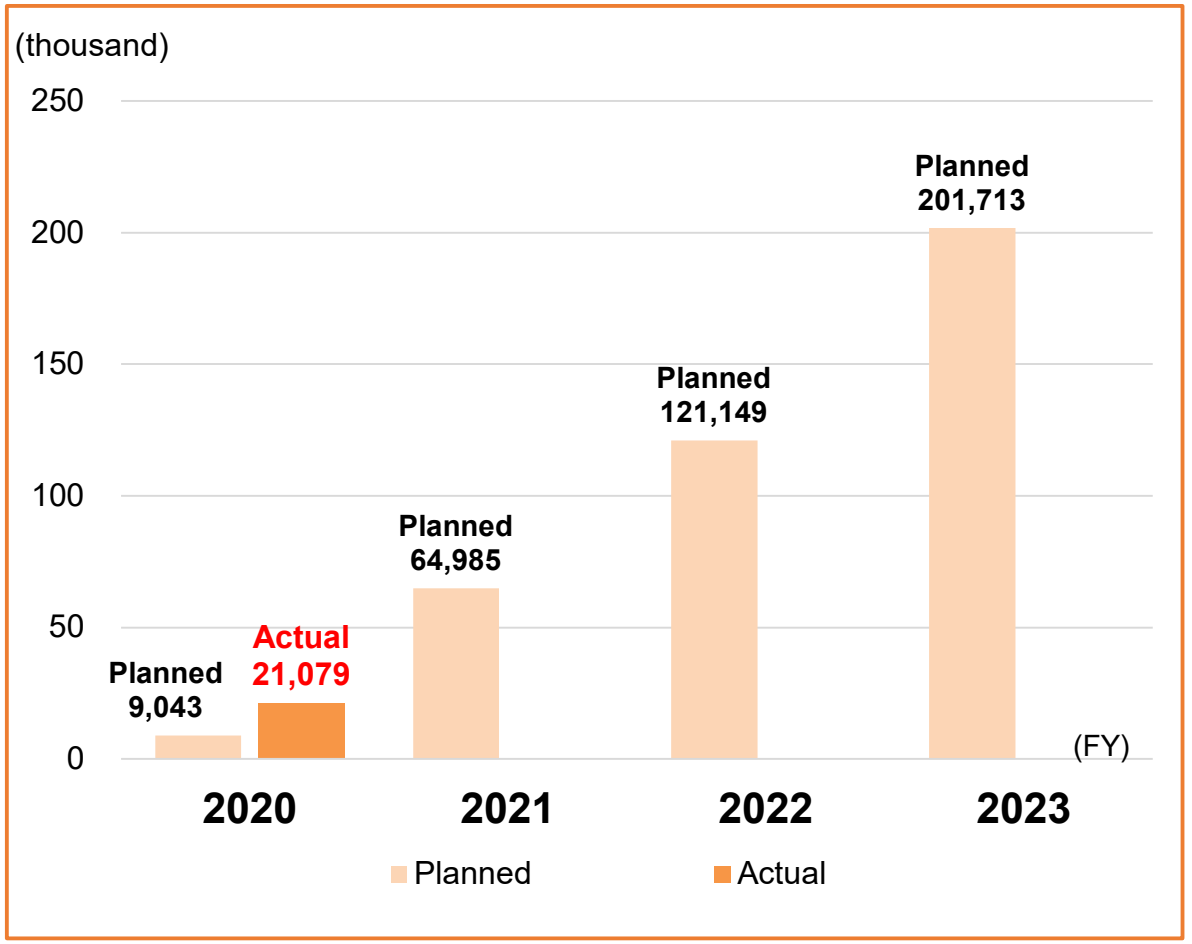
Deployment situation of 5G base stations

- By the end of March 2021, four mobile network operators launched 5G commercial service in all prefectures.
- Rate of 5G base station nationwide is **16.5%**. *(cf. the planned value: 6.9%)*
- Total number of 5G base stations is **21,079**. *(cf. the planned value: 9,043)*

Rate of 5G base station nationwide



Total number of 5G base stations



- Local 5G enables the following:
  - **Establishment of customized networks with flexible specifications** that meet local needs
  - **Establishment of 5G systems prior to area coverage by mobile carriers**
  - **Operation of networks less vulnerable to communication failures and disasters**.

Use cases of Local 5G

Connected terminal

Tele-medicine

4K/8K movie

Smart construction

Smart factory

Remote work

River monitoring

Sensor, 4K/8K

Farming automation

Tax Break System for Promoting Investments in 5G

Specified Advanced ICT Utilization System Intro. Plan

Competent Minister → Accreditation

(Accreditation Criteria)
- Security / Trustworthiness
- Stability of Supply
- Openness (International Alliance)

(Supporting Measures)
- Special Provisions for Taxation
- Financial Support such as “Two-Step Loan”

Special Provisions for Taxation

Competent Minister → Accreditation

(Standards for Early Dissemination and Stability of Supply)
- Base stations introduced ahead of Installation Schedule of nationwide 5G carriers
- Higher Stability of Supply

(Important Equipment)
- Advanced Equipment for base stations in nationwide 5G
- Important Equipment to build system

1. Corporate Tax / Income Tax

*Tax Deduction is for at most 20% of the corporate tax in each fiscal year.

Target Entities	Facilities	Tax Deduction	Special Depreciation
Nationwide 5G Carriers	Machinery, etc.	15%	30%
Local 5G Licensees	Machinery, etc.	15%	30%

2. Fixed Property tax (limited to Local 5G licensees)

Cut tax base by 1/2 for three years

Ensuring interoperability

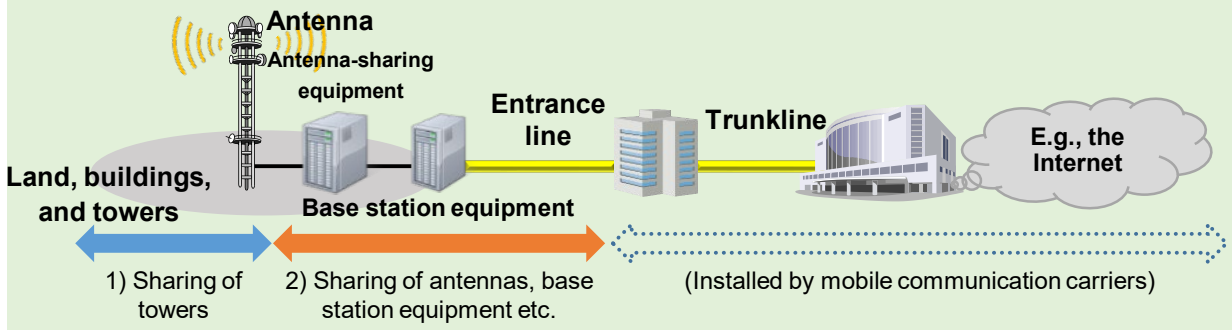
Open Radio Access Network (O-RAN)

- Mobile network without depending a specific vendor, enabling to establish with multi-vendor, open and smart design.
- O-RAN Alliance, joined by major operators and vendors, working on establishing global standard of RAN.

- **Developing testbed for interoperability test** of RAN base stations from different vendors (2021-2022)
- **Planning to establish test center (OTIC)** to provide functions for interoperability tests and issue certifications/budges.

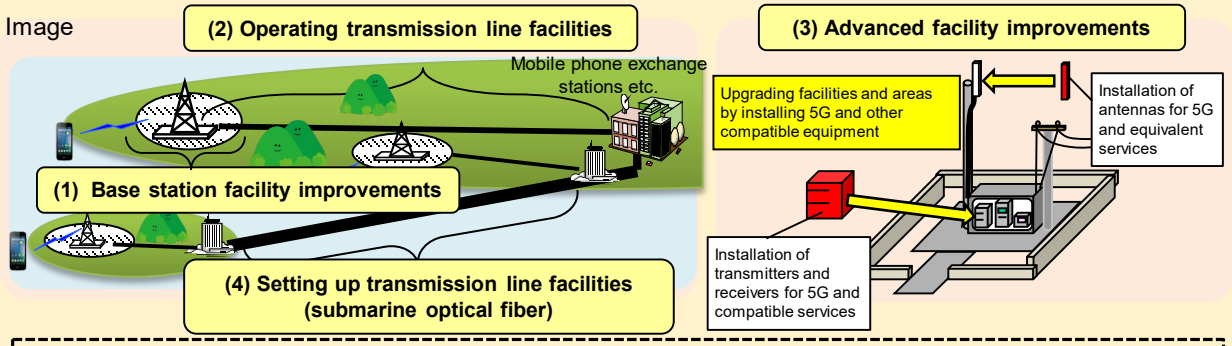
Promoting 5G development through infrastructure sharing

(1) Formulation of the Guidelines on Application Relationships of Telecommunications Business Act and Radio Act concerning Infrastructure Sharing in the Mobile Communications Field



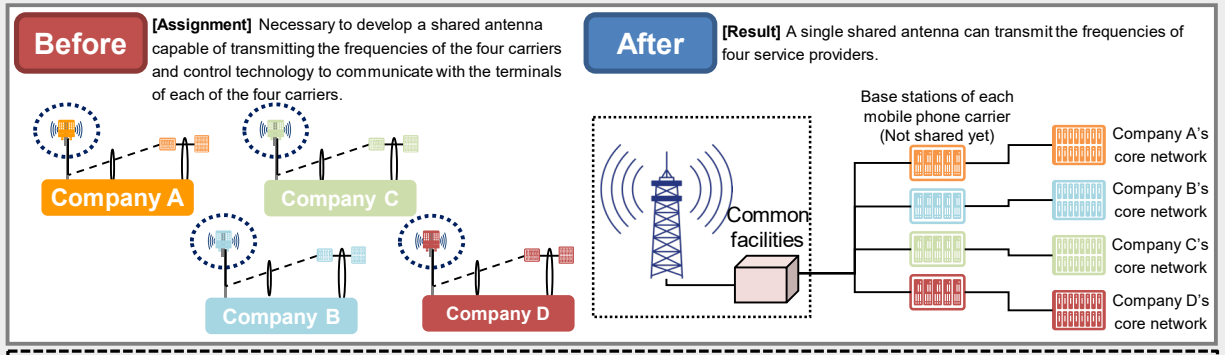
➢ The Guidelines were formulated in December 2018 to clarify the application relationship between the Telecommunications Business Act and the Radio Act.

(2) Development project for mobile phone and other terminal service areas



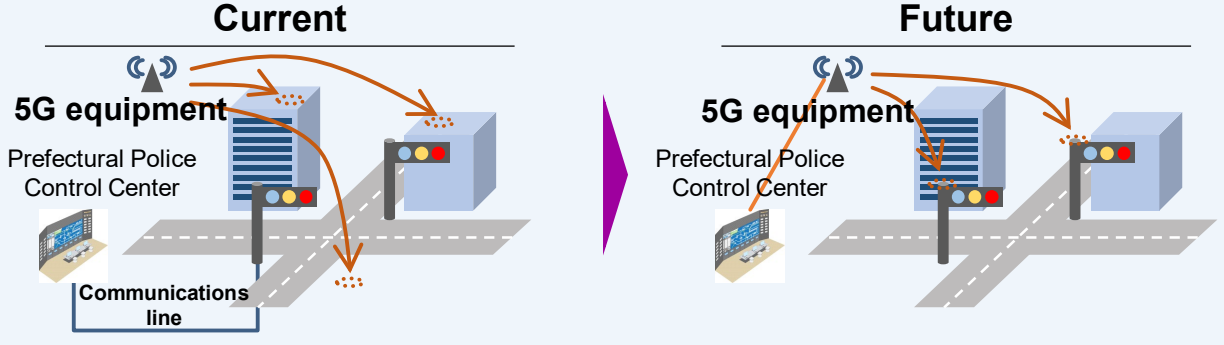
➢ Enabling deployment of mobile network services in geographically disadvantaged areas (depopulated areas, remote areas, remote islands, peninsulas, etc.) and promoting advanced services, including 5G.

(3) R&D of 5G base station sharing technology



➢ A single radio station's frequency range of simultaneous emission will become wide when sharing a base station. Therefore, the sharing of radio stations requires compatible equipment and technology for controlling radio waves for multiple companies.

(4) Construction of 5G network utilizing traffic light pole

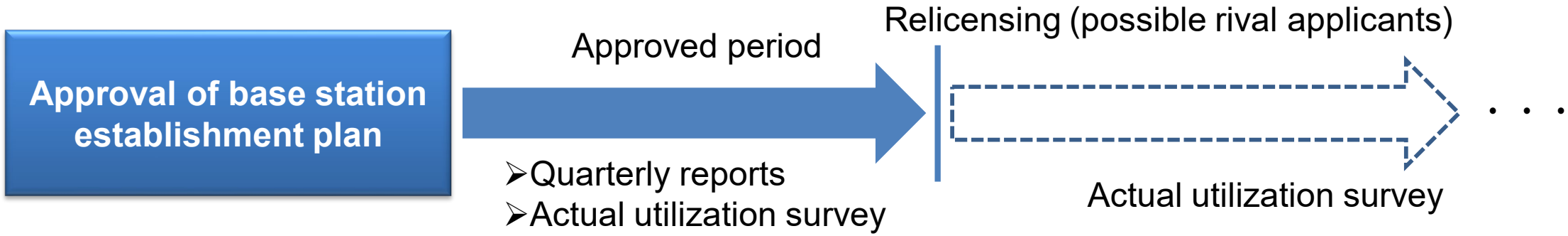


➢ Creating a method to maximize installation value, including a reference architecture that will enable the low-cost and flexible development of 5G areas and secure digitization and networking of traffic signals toward 5G area expansion by installing 5G base stations on traffic signals and the promotion of the centralized control of traffic signals.

- **The Japanese Government set carbon-neutrality as a prioritized policy target.**
  - PM Policy Speech to Diet: “I have declared that Japan would realize carbon-neutrality by 2050.”
- **MIC promotes policies for achieving Beyond 5G which has the feature of ultra low power consumption.**
  - Without reduction measures, in 2030, IT-related power consumption would reach to 36x than now. (1.5x of total consumption than now)
  - Beyond 5G Power Consumption: 1/100 lower than now
- **Greening data center facility as a measure for Green of Digital.**

Introducing frequency reallocation for mobile phones

- As for allocated frequencies for expired establishment plans for specified base stations, the government should **introduce a mechanism to reallocate such frequencies** through comparison of existing license owners and new license applicants by setting license deadlines for existing license owners in such cases where the utilization of the allocated frequencies is insufficient or the existing license owners face competition from new license applicants.
- However, it must be noted that the introduction of the mechanism does not seek equality of the results but aims to secure equality of the opportunity and provide a fair competitive environment to acquire frequencies.



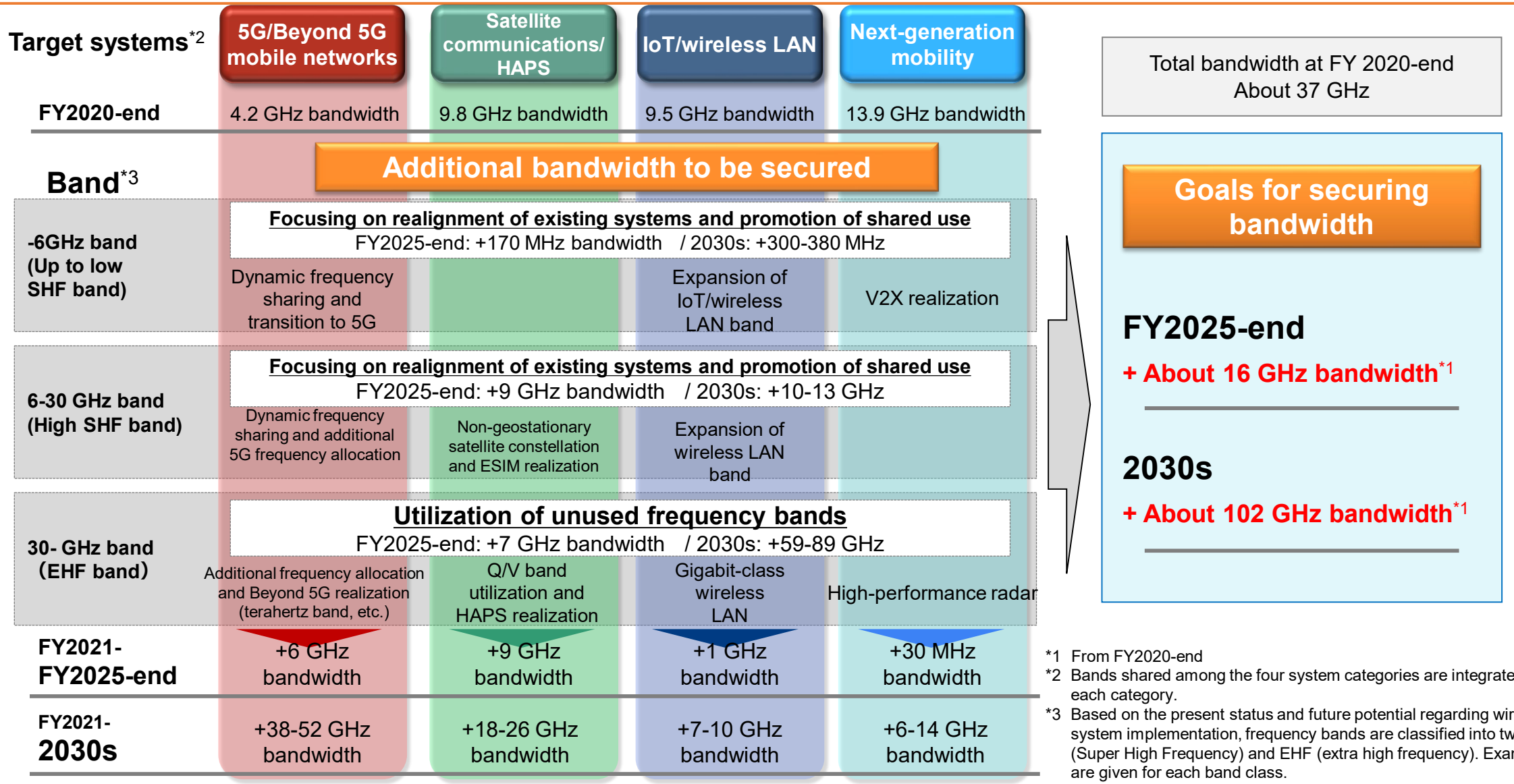
① Effective use is insufficient,
② Rival applicants emerge,
③ Necessary for other effective use purposes

In any of the three cases

Reallocation through comparison of license holders and new license applicants

Establishment of goals for securing bandwidth by the 2030s

- Seek to secure **a total increase of about 16 GHz bandwidth by the end of FY2025**[*1] in preparation for the expansion and diversification of radio utilization needs
- Seek to secure **a total increase of about 102 GHz bandwidth by the 2030s**[*1] toward future Beyond 5G services



*1 From FY2020-end
*2 Bands shared among the four system categories are integrated for each category.
*3 Based on the present status and future potential regarding wireless system implementation, frequency bands are classified into two: SHF (Super High Frequency) and EHF (extra high frequency). Examples are given for each band class.

Organizing a study group on frequency allocation methods for new mobile phone

- From the perspective of Article 1 of the Radio Act: *The purpose of this Act is to promote the public welfare by ensuring the fair and efficient utilization of radio waves.*), a fundamental review of Japan's mobile phone frequency allocation system will be conducted. This review will realize a frequency allocation system that further reflects economic value while ensuring the conditions that must be achieved (area coverage etc.).
- To this end, a new study group will be organized to conduct a broad survey and analysis of frequency allocation methods in other countries and to compile measures to deal with the merits and demerits of auction methods and related issues. (The first report is scheduled to be compiled by the end of fiscal 2021.)
- Studying a new allocation system for mobile phone frequencies in Japan, based on the merits of the mobile phone frequency allocation systems in other countries, in response to the first round of the report. (The second report is scheduled for July 2022.)

Main Topic

1. Verification of the frequency allocation method for mobile phones in Japan
2. Survey and analysis of frequency allocation methods for mobile phones in other countries
   (1) Survey and analysis of frequency allocation methods in other countries
   (2) Sorting out the advantages of the auction system and related conditions
   (3) Sorting out the measures to deal with the disadvantages of the auction system and related conditions
3. Considering a new allocation system for mobile phone frequencies in Japan in response to 1 and 2, based on the merits of other countries' mobile phone frequency allocation systems.
4. Others

III. Promotion of B5G R&D and standardization through cooperation with like-minded countries

①Signing of MoU on Beyond 5G / 6G

Beyond 5G Promotion Consortium

6G FLAGSHIP UNIVERSITY OF OULU

Beyond 5G Promotion Consortium
(Japan)

Signing of MoU

First MoU of Beyond 5G Promotion Consortium
(June 2021)

6G Flagship
(Finland)

Areas of Cooperation

1. **Exchange of Information and Publications**
2. **Personnel Exchange**
3. **Collaborative Research and Development Projects**

②U.S.-Japan Joint Leaders' Statement (April 17, 2021)

U.S.-JAPAN GLOBAL PARTNERSHIP FOR A NEW ERA

- ✓ *"The United States and Japan recognize that **digital economy and emerging technologies** have the potential to **transform societies** and bring about **tremendous economic opportunities**."*
- ✓ *"President Biden and Prime Minister Suga affirmed their commitment to **the security and openness of 5th generation (5G) wireless networks** and concurred that it is important to **rely on trustworthy vendors**."*
- ✓ *"The United States and Japan will engage with others through **our enhanced Global Digital Connectivity Partnership** to catalyze investments and to provide training and capacity building to promote vibrant digital economies."*

U.S.-Japan Competitiveness and Resilience (CoRe) Partnership

- ✓ ***"Advance secure and open 5G networks**, including Open Radio Access Networks ('OpenRAN'), by fostering innovation and by promoting trustworthy vendors and diverse markets."*
- ✓ *"Strengthen competitiveness in the digital field by **investing in research, development, testing, and deployment of secure networks and advanced ICT including 5G and next-generation mobile networks ('6G' or 'Beyond 5G')**. The United States has committed $2.5 billion to this effort, and **Japan has committed $2 billion**."*
- ✓ *"**Build on successful U.S.-Japan cooperation in third-countries** and **launch a Global Digital Connectivity Partnership** to promote secure connectivity and a vibrant digital economy while building the cybersecurity capacity of our partners to address shared threats."*
- ✓ *"Strengthen **collaboration and information exchange** between U.S. and Japanese ICT experts in **global standards development**."*
- ✓ *"Cooperate on **other areas that contribute to climate change mitigation, [...] including ICT technology (such as smart cities, power saving ICT infrastructure, and digital solutions to infrastructure management)** [...]."*

Joint Statement

- ✓ *"We are determined to harness **the benefits of data and digital transformation** for society, the environment and the economy, while upholding fundamental rights."*
- ✓ *"We will collaborate to promote **global standards and comprehensive, including regulatory**, approaches for **digital policies and technologies**, notably on cybersecurity, **secure 5G, 'Beyond 5G' / 6G technologies**, block chain, and **safe and ethical applications of artificial intelligence** while **encouraging an innovative environment**."*
- ✓ *"This collaboration will also cover **open and interoperable network architectures**."*
- ✓ *"We underline our joint commitment to high standards of protection for personal data, based on the already high degree of convergence between our systems. We undertake to continue cooperation on **'Data Free Flow with Trust'** with a view to facilitating safe and secure cross-border data flows through enhancing security and privacy. This will help us harness **the benefits of the digital economy**. We will strive to reach a consensus-based solution on digital taxation by mid-2021 within the OECD."*
- ✓ *"We will work on **strengthening Japan-EU digital cooperation** to support an inclusive, sustainable, human-centric digital transformation."*

ANNEX Japan and the EU will take action forward on

- ✓ *"Promoting **cooperation in the digital economy**, in areas such as cybersecurity, artificial intelligence, platforms, data and 5G and 'Beyond 5G' / 6G, through **the Japan-EU ICT Policy Dialogue** and **the Japan-EU ICT Strategy Workshop**."*
- ✓ *"Establishing **a cooperation roadmap for 'Beyond 5G' / 6G technologies**, including issues such as R&D, standardization and secure 5G deployment."*

Status of Overseas Beyond 5G/6G initiatives

Europe

Hexa-X Project
- Launched in January 2021. A project to conduct research and development on 6G over the next two years and a half.
- A total of 25 companies and universities participated, including **Nokia and Ericsson**, and others.

5G Infrastructure Association (5G IA)
- The organization represents the private side of the 5GPPP, a research program that is part of Horizon 2020.
- European ICT businesses, including **Nokia and Ericsson**, participated.

6G Innovation Centre (6G IC)
- Established by the University of Surrey in November 2020. Conducting research focused on advanced telecommunications engineering that integrates the physical and virtual worlds. More than 70 companies and universities are participating.

Finland

MoU

6G Flagship Project
- A project on 6G R&D led by the University of Oulu (with cooperation from Nokia and others). A plan to invest approximately 250 million euros (approximately 33 billion yen) over eight years from 2019 through 2026.
- The white paper *Key Drivers and Research Challenges for 6G Ubiquitous Wireless Intelligence* was released in September 2019. White papers on all 12 areas, including elemental technologies and use cases, were issued in June 2020.

United States

Next G Alliance

In October 2020, the Next G Alliance was launched, led by the North American industry (Alliance for Telecommunications Industry Solutions, ATIS for short). Corporations, including **Intel and Cisco**, are participating. Created a Next G Roadmap and promoting discussions on standardization for 6G realization.

Platforms for Advanced Wireless Research (PAWR)

An advanced wireless communications research platform (testbed) built by the National Science Foundation (NSF) in four cities. About 30 companies, including Intel and Qualcomm, participated in the construction.

Korea

Ministry of Science and ICT (MSIT)

Issued the 6G R&D Promotion Strategy in August 2020. Invested 200 billion won (approximately 20 billion yen) in core technology development over five years. Also provided companies and research institutions with a package of funding and strategies to secure standard patents.

Germany

6GKom Project
- The first project in Germany, funded by the Federal Ministry of Education and Research of Germany (October 2019 through September 2023). The design of the hardware infrastructure for 6G is underway.
- The Fraunhofer IZM Institute took the lead, and several universities participated.

China

Ministry of Industry and Information Technology (MIIT)
- In January 2020, MIIT announced that IMT-2020, the main driver of 5G in China, was expanded to IMT-2030 and that research on next-generation standards was on the way.

Ministry of Science and Technology (MoST)
- In November 2019, MoST announced the start of 6G R&D. At the same time, two organizations were established: A governmental organization to be responsible for promoting 6G research and a technical organization consisting of 37 universities, research institutes, and companies.

Utilizing the framework of the MoU to promote specific collaboration with like-minded countries

- In the ITU (WP5D) , discussions on **IMT-2030 (Beyond 5G)'s Report (Future Technology Trends (FTT)) and Recommendation (Vison of Beyond 5G)** were started.

→ Start of international standardization process for Beyond 5G

ITU-R Report "Future Technology Trends (FTT)" working document

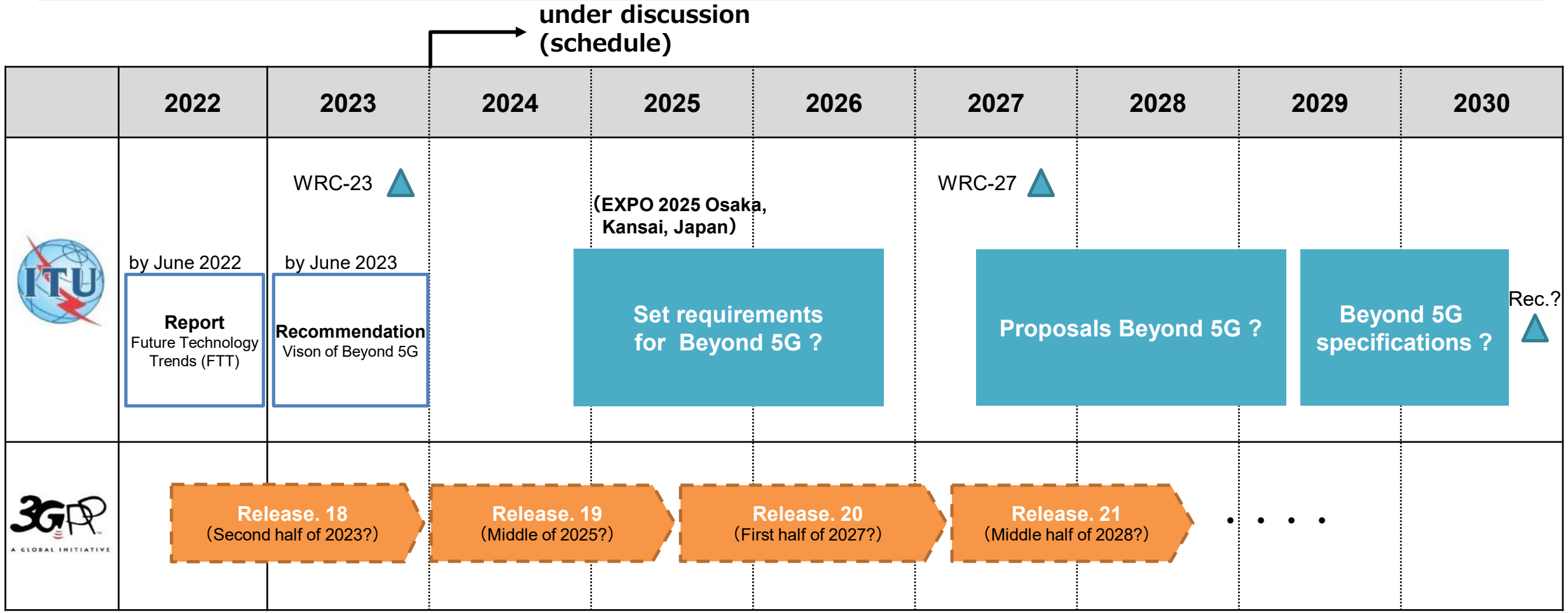
1 Introduction
2 Scope
3 Related ITU-R documents
4 Overview of emerging services and applications
[Editors note: This section is under discussion for its applicability to this report. It was discussed in the meeting of SWG Radio Aspects that this might be more applicable to the VISION report]
4.1 New services and application trends
4.2 Motivation on driving factors for future technology trends towards 2030 and beyond
5 [Emerging] Technology Trends and Enablers
5.1 Technologies for native AI based communication
5.2 Technologies to enhance RAN privacy
5.3 Technologies for integrated sensing and communication
5.4 Technologies for integrated access and super sidelink communications
5.5 Technologies to enhance adaptability and sustainability
5.6 Technologies for efficient spectrum utilization [Editors note: This section may be moved back to section
5.8 Technologies to enhance energy efficiency and low power consumption
5.9 Technologies to support enhanced services and applications
5.9.1 [RAN Based Mobile edge computing]
5.10 Technologies to natively support real-time communications
5.11 Technologies to support the convergence of communication and computing
5.12 Technologies to support extreme low latency
5.13 Quantum Technology with respect to the RAN
6 Technologies to enhance the radio interface
6.1 Advanced modulation, coding and multiple access schemes
6.2 Advanced Antenna Technologies
6.2.1 Advanced/Extreme MIMO
6.2.1.2 AI-aided MIMO

6.3 Co-frequency Co-time Full Duplex (CCFD) communications
6.4 Multiple physical dimension transmission
6.5 Tera-Hertz (THz) communications
6.6 Visible light communication (Light communication as bearer platform)
6.7 [Tbps modem Technologies]
6.8 Ambient Backscatter Communication (AmBC)
6.9 Coverage and capacity extension and spectral efficiency improvement
6.10 Interference cancellation techniques
6.11 Transmission techniques
6.12 [High-precision Positioning Technology/Support ultra-high accuracy positioning/Technologies to support localization]
6.13 Support for flexible channel bandwidths
7 Technology enablers to enhance the radio network
7.1 RAN slicing for Massive-Broadband URLLC RAN
7.2 Massive-Broadband URLLC RAN
7.3 [Enhanced resiliency and QoS guarantees/Technologies to support resilient and soft network and guaranteed QoS
7.4 Stand-alone support of voice services
7.8 [Ultra-dense IAX network]
7.9 Technologies to enhance radio network performance and precision
7.10 [New radio architecture to support new operation and business models]
7.11 [Technologies to support Digital Twin Network]
7.12 Technologies for interconnection/[integration] with non-terrestrial networks
7.13 Support for ultra-dense radio deployments
8 Technology enablers for terminal technologies
8.1 Battery and charging technologies
9 Summary and conclusion
10 Acronyms, Terminology, Abbreviations

THz communications
Visible light communication
AI
Interference cancellation
High-precision Positioning
RAN slicing
Efficient spectrum utilization
Enhance radio network performance and precision
low power consumption
Real-time communications
Digital Twin NW
MIMO

International standardization schedule for Beyond 5G

- In the ITU (International Telecommunication Union), international standardization of IMT-2030 (Beyond 5G) is ongoing.
- 3GPP's technical specifications will be proposed to the ITU.
- It is necessary for advancing R&D (Beyond 5G elemental technologies, etc.) and reflecting the results into international standardization process.



Support for international collaborative research on Beyond 5G/ 6G - Beyond 5G/6G R&D Promotion Project

- MIC has been implementing “Beyond 5G R&D Promotion Project” to support research and development of key technologies necessary for the realization of Beyond 5G/6G.
- MIC’s basic policy of this project is to “**global first**” as well as to “build an ecosystem that generates innovation” and "concentrate resources". MIC supports international collaborative research using the R&D fund established in this project.

Beyond 5G/6G R&D Promotion Project

Founded by 総務省 NICT

Beyond 5G R&D Fund

Core facilities for Beyond 5G R&D

Private companies, Universities, etc.

Support R&D of cutting-edge elemental technologies of Beyond 5G/6G

Further advancement of 5G's characteristic features
- Ultra High Speed & Ultra High Capacity
- Ultra Low Latency
- Ultra Massive Connectivity

Adding sustainable features that contribute to the creation of new value
- Ultra Security and Ultra Reliability
- Autonomy
- Scalability
- Ultra Low Power Consumption

1. Core Research Program
R&D program for core technologies to realize the functions required for Beyond 5G/6G

2. International Joint Program
R&D program for advanced technologies through international collaboration with strategic partners

3. Program for Technology Idea Creation
R&D program to generate innovation through technological seeds

R&D in progress

- **R&D of Terahertz Bands Channel Models and Applications to Support Beyond 5G Ultra-high Capacity Wireless Communications**
  (Japan) **Sharp Corp.**, Kyoto Univ., Univ. of Tokyo
  (US) US carriers, US research institute

- **R&D of 300 GHz Bands Terahertz Networks**
  (Japan) **Gifu Univ.**, Waseda Univ., Chiba Inst. of Tech.
  (EU) TU Braunschweig, Fraunhofer IFA, Lille Univ. of Sci. and Tech./IEMN, Univ. of Stuttgart, VIVID Components Ltd.*
  **Research collaborators*

- **R&D of Open and Secure Beyond 5G Mobile Data Offloading using Next Generation Public Wireless LAN Roaming**
  (Japan) **Kyoto Univ.**, Local24 Inc., Tohoku Univ., NII
  (EU) GÉANT*
  * *GÉANT is an organization composed of the NRENs (National Research and Education Network) of European countries. With the support of the European Commission, it provides a pan-European and global network and services for research and education.*

Joint Statement from Quad Leaders

"In partnership with industry, ***we are advancing the deployment of secure, open, and transparent 5G and beyond-5G networks, and working with a range of partners to foster innovation and promote trustworthy vendors and approaches such as Open-RAN****.*

Acknowledging the role of governments in fostering an enabling environment for 5G diversification, ***we will work together to facilitate public-private cooperation and demonstrate in 2022 the scalability and cybersecurity of open, standards-based technology****.*

With respect to the development of technical standards, we will establish sector-specific contact groups to promote an open, inclusive, private-sector-led, multi-stakeholder, and consensus-based approach. We will also coordinate and cooperate in multilateral standardization organizations such as the International Telecommunication Union."

Fact Sheet

The Quad will:

- Establish Technical Standards Contact Groups: The Quad will establish contact groups on Advanced Communications and Artificial Intelligence focusing on standards-development activities as well as foundational prestandardization research.
- Support 5G Deployment and Diversification: To support the critical role of Quad governments in fostering and promoting a diverse, resilient, and secure telecommunications ecosystem, **the Quad has launched a Track 1.5 industry dialogue on Open RAN** deployment and adoption, coordinated by the Open RAN Policy Coalition. **Quad partners will jointly facilitate enabling environments for 5G diversification, including with efforts related to testing and test facilities**.

MIC strongly promotes
B5G realization
under international cooperation.