



Roadmap for the Realization of Beyond 5G

October 2022

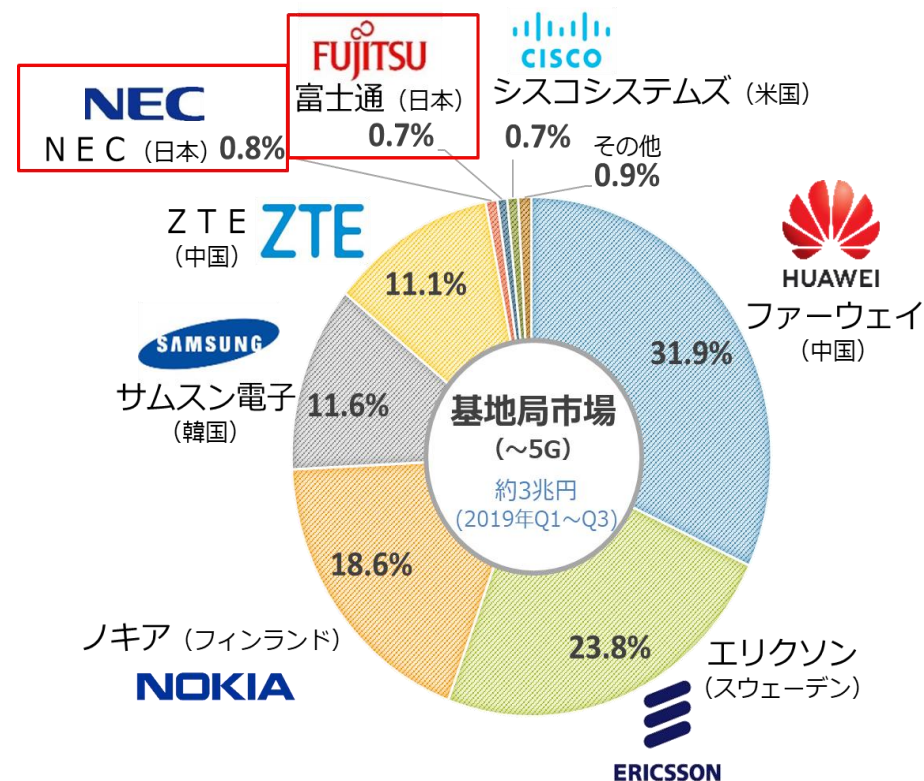
Vice-Minister for Policy Coordination

TAKEUCHI Yoshiaki

- **The time for discussion is past;
now is the time to make decisions and take action**
- **This is the right time to build and implement a cooperative
framework for the realization of Beyond 5G**

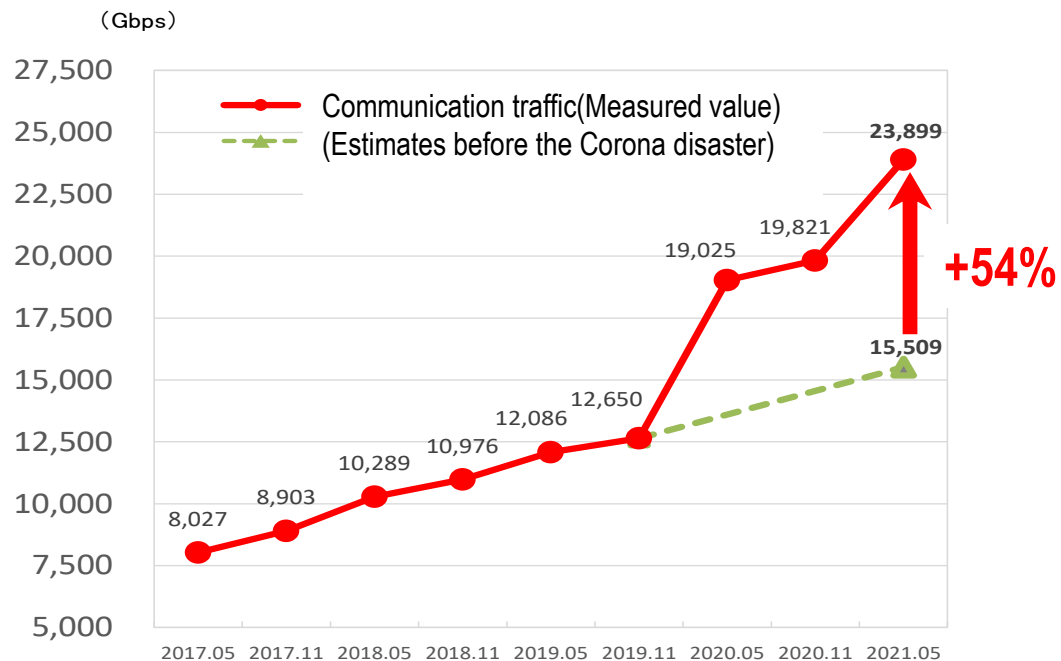
- Japanese vendors are trailing behind in the international market for 5G base stations
- While Japanese companies have outstanding technical capabilities in the **Beyond 5G field**, they face challenges regarding international competitiveness and market acquisition

<Market share for 5G base stations (2019)>

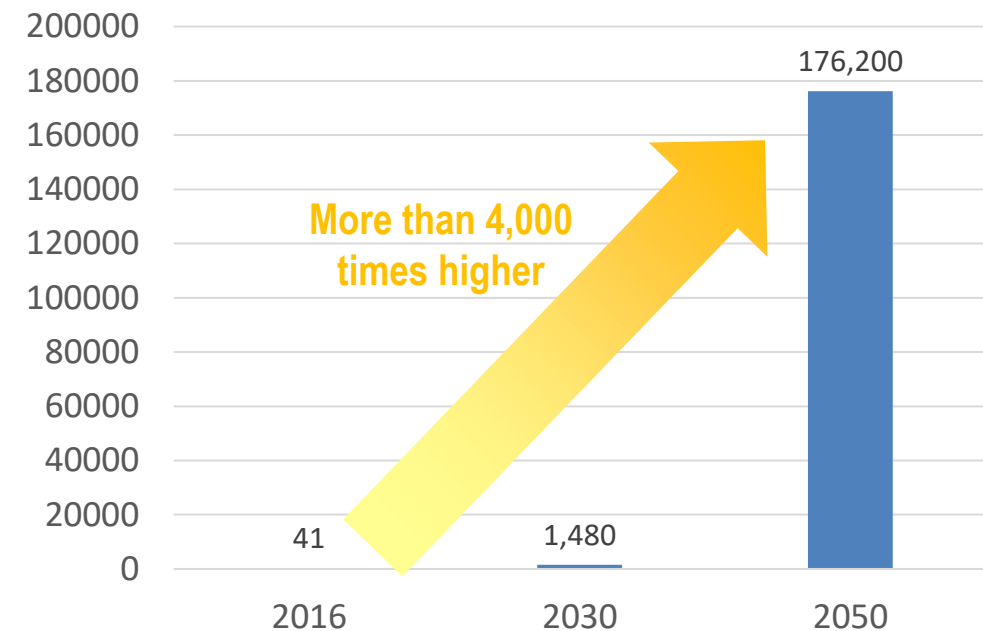


- Due to lifestyle changes triggered by the pandemic, **communication network traffic and electric power consumption are on the rise**
- **Without technological innovation, further upsurges are forecast, making the goal of carbon neutrality hard to achieve**

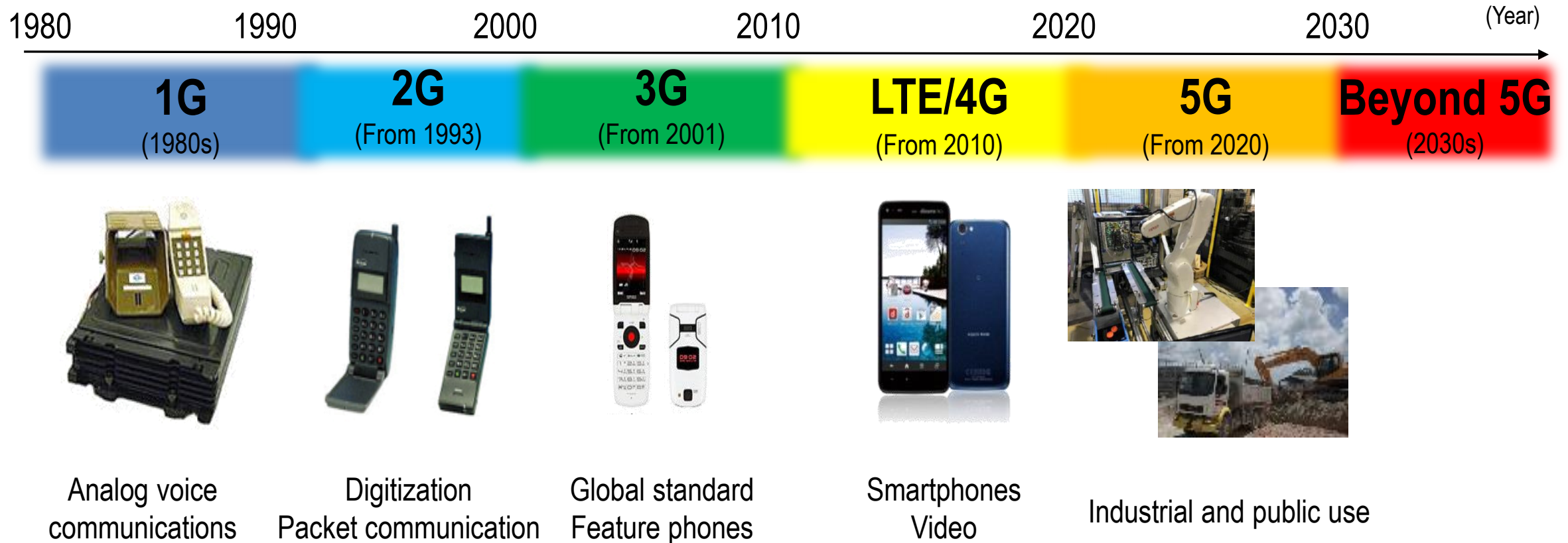
<Changes in communications traffic in Japan>



<Projected ICT-related power consumption>



- There is a **need for a national strategy implemented by the government as a whole**, under which relevant ministries and agencies work in close partnership to **deliver the benefits of Beyond 5G to the public** by expanding functions beyond 5G, with the aim of **achieving digitization that allows everyone to flourish and leaves no one behind**



A society where everyone
can flourish
Inclusive



Vision for a Digital Garden City Nation

Health and medical care, extending social longevity

Work style reform

Vision for society in the
2030s
A robust and vibrant society



(Beyond 5G Promotion Strategy)

A society growing
sustainably
Sustainable



Greener environment and energy

Greening of ICT by 2040
Greening of ICT by 2050

**Bolstering international
competitiveness, achieving
economic growth**

An open and fair Beyond 5G market
environment, etc.

A society where people
can undertake activities
with peace of mind

Dependable



Economic security

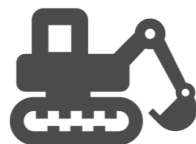
Mid- and post-pandemic society

**Disaster prevention, mitigation,
and national resilience**

Realization of Society 5.0



Finance



Construction and real estate



Logistics and transportation



Information and communications



Media



Energy and resources



Motor vehicles

Beyond 5G as the basis for all industrial and social activities in the 2030s

- Ultra-fast, high-capacity services
- Services requiring ultra-low latency
- Services offering simultaneous connectivity of numerous IoT sensors
- Liberation from constraints of time and place
- Stable, secure provision of the service quality demanded by users



Machinery, electrical machinery, factories



Food and agriculture



Distribution, retail, and wholesale



Medical care



Public services, government, and education



Disaster risk reduction and the regions



Space and HAPS

Further Upgrade of 5G Features

(1) Ultra High Data Rate

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

(2) Ultra Low Latency

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

(3) Ultra Numerous Connectivity

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

New features contribute to generate sustainable and new values

(1) Ultra low power consumption

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

(2) Autonomy

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

(3) 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

(4) Ultra security and resiliency

- Always Ensuring Cybersecurity
- Instant Recovery from Disaster/Failure

Challenge 1

All photonics network technology

Ultra-fast, high-capacity, ultra-low latency

Ultra-low power consumption

Challenge 2

Open network technology

Autonomy

Ultra-security and resiliency

Challenge 3

Device technology

Ultra-fast, high-capacity, ultra-low latency

Ultra-low power consumption

Challenge 4

Network orchestration technology

Autonomy

Ultra-low power consumption

Challenge 5

Wireless network technology

Ultra-fast, high-capacity, ultra-low latency

Ultra-numerous connectivity

Challenge 6

NTN (HAPS/satellite network) technology

Scalability

Ultra-security and resiliency

Challenge 7

Quantum network technology

Ultra-security and resiliency

Challenge 8

Terminal and sensor technology

Ultra-fast, high-capacity, ultra-low latency

Ultra-numerous connectivity

Challenge 9

E2E virtualization technology

Autonomy

Ultra-security and resiliency

Challenge 10

Beyond 5G service and application technology

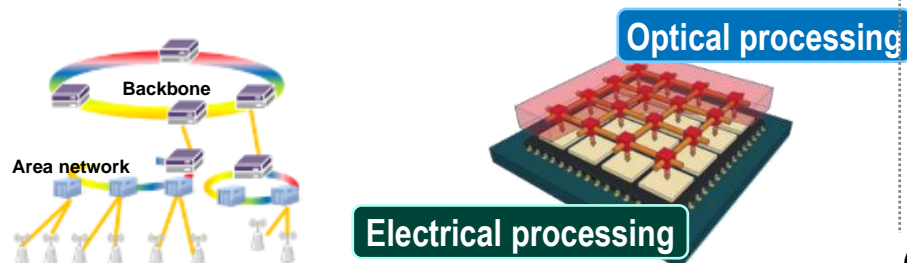
Scalability

● Designating priority R&D programs on which the government should focus

- Prioritizing technologies where Japan's strengths lie, and which can be combined to enable Japan to become a world leader

(1) All photonics network technology

Creating ultra-fast, energy-efficient communications infrastructure

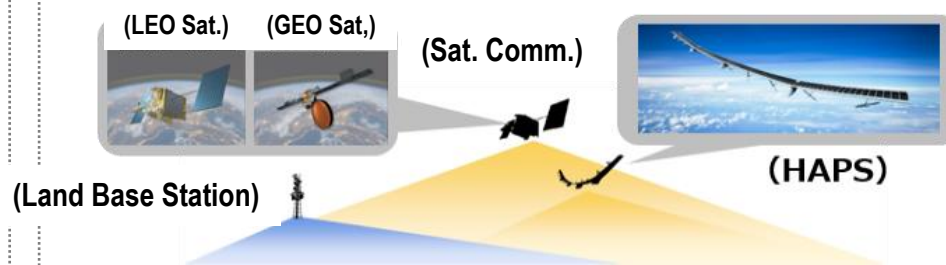


(Optical network technology)

(Photonics-electronics fusion technologies)

(2) Non-terrestrial network technology

Expanding communications coverage to seamlessly link land, sea, and air



(3) Secure virtualization and integrated network technology

Creating a secure, highly dependable communications environment for users

- Need to powerfully expedite R&D through intensive investment by the government
- Creation of a framework allowing for a multi-year budget would be necessary

- The ITU Telecommunication Standardization Sector (ITU-T) is gaining even greater importance as the **international organization responsible for the standardization of the cutting-edge technologies required for Beyond 5G.**



International Telecommunication Union (ITU)



ONOE Seizo Director-Elect of the ITU-T

Current post: Chief Standardization Strategy Officer (CSSO),
Nippon Telegraph and Telephone (NTT) Corp.

- Cultivating personnel who will promote IP and standardization at companies

- Training for younger corporate talent with executive potential (Leaders' forum)
- Efforts to promote company-wide understanding of IP and standardization activities (standardization awareness guidebook)
- Support for HRD through international conferences



Beyond 5Gで203X 日本が変わる

Beyond 5Gリーダーズフォーラム、Aチーム
2022.3.16

Open / closed strategy

(1) All Photonics network (APN)

(2) Non-Terrestrial Networks(NTN)

(3) Secure virtualization and integrated networks

[International standardization strategy] (Open strategy)

- Standardization based on the results of demonstrations.
- Promote the international deployment from FY2026 onwards.

- International spectrum allocation (WRC-23, 27).
- Deliver world-leading communications services.

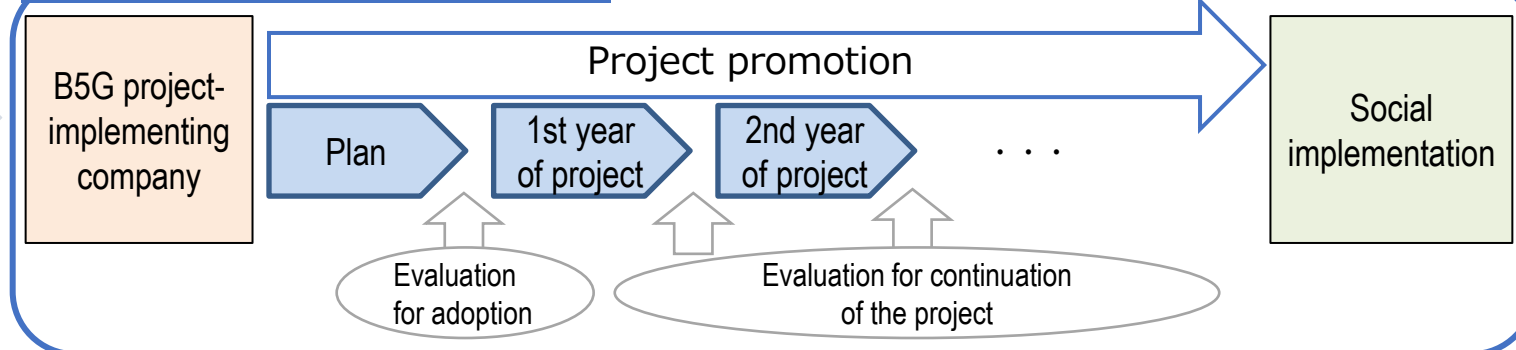
- Promote R&D by FY2025.
- Take the initiative virtualization of Open RAN virtualization technology.

[IP strategy] (Closed strategy)

- Tailoring patent applications to standardization to establish standard-essential patents
- Filing applications for intellectual properties(ex.patents) or ensuring complete concealment

Consider open/closed strategy in the adoption process

Beyond 5G R&D Promotion Project



Presentation of strategies

● Starting social implementation early

The outcomes of priority R&D programs will begin to be implemented progressively in domestic networks and launched onto the market in 2025

● Identifying scenarios for migration to Beyond 5G

[From FY2024]

- Verifying technology at public institutions and other advanced user areas, combining all photonics network technology with secure virtualization and integrated network technology

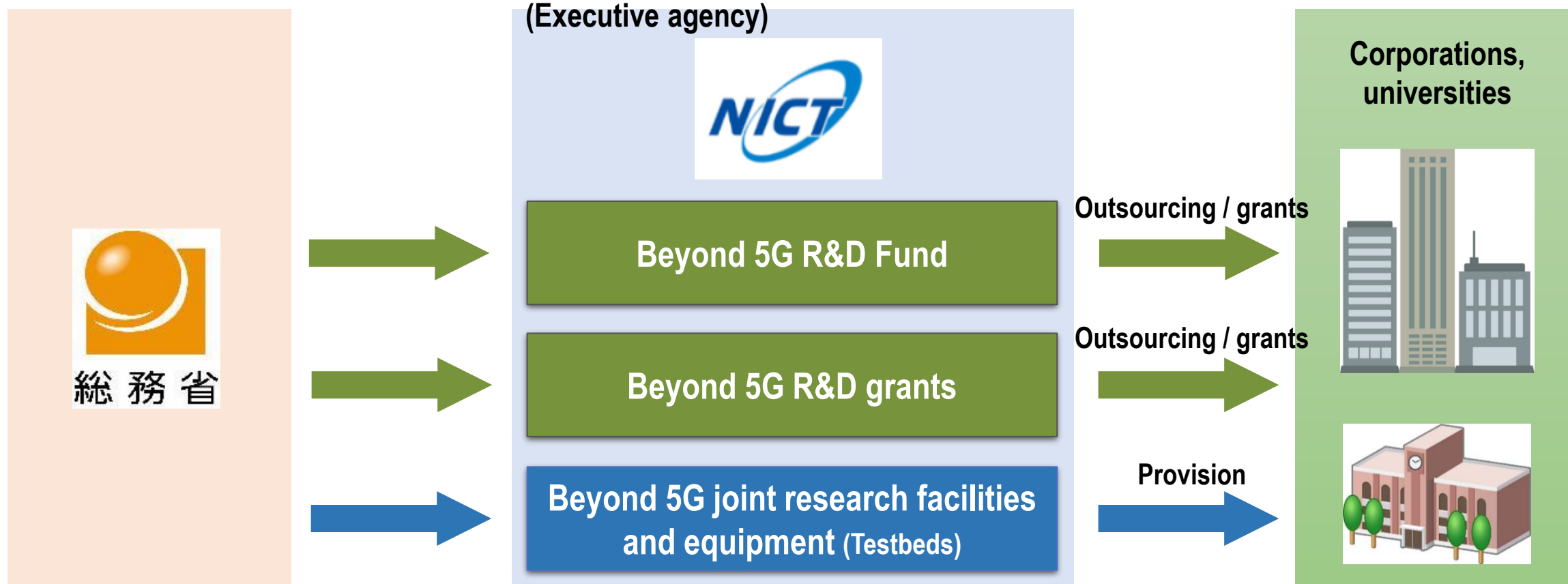
[From FY2025]

- Integrated effort by industry, academia, and government to spread the word about the aforementioned outcomes worldwide via Expo 2025 Osaka, Kansai

[From FY2026]

- Augmenting the functions of all photonics network technology and secure virtualization and integrated network technology, and implementing a phased expansion of the areas served
- Expanding the areas served to cover the whole of Japan and the rest of the world, in combination with non-terrestrial network technology

- **Encouraging the introduction of Global Beyond 5G Key Technologies by communications carriers overseas**
 - **While working in partnership appropriately with major global vendors, we will promote the introduction of the outcomes of our priority R&D programs by communications carriers overseas**



(1) R&D Fund

Third supplementary budget for FY2020: ¥30 billion

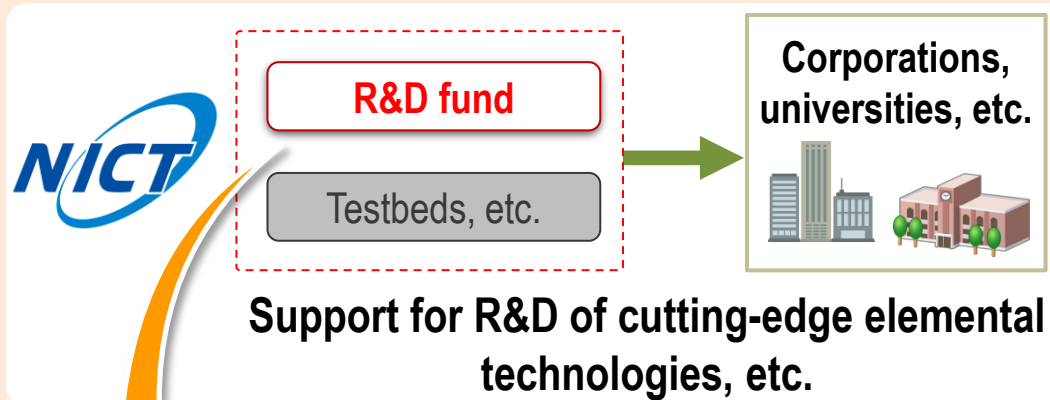
(2) R&D grants

Supplementary budget for FY2021: ¥20 billion, Initial budget for FY2022: ¥10 billion

(3) Facilities and equipment

Third supplementary budget for FY2020: ¥20 billion

|| Beyond 5G R&D Promotion Project



(1) Beyond 5G Function Realization Program

(2) Beyond 5G International Joint R&D Program

(3) Beyond 5G Seeds Creation Program

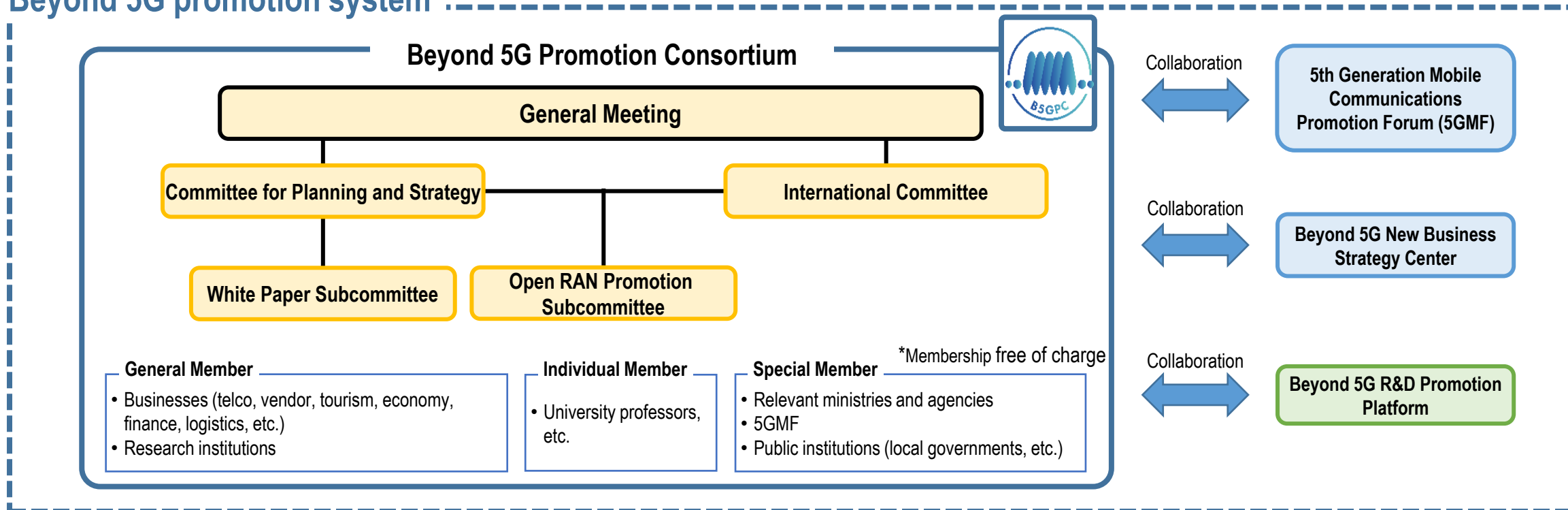


- R&D of terahertz band channel models and applications to support Beyond 5G's ultra-high-capacity wireless communications
(JP) Sharp, Kyoto University, University of Tokyo
(U.S.) U.S. communications providers and research institutes
- R&D of floating cyber-physical systems and wide-area cooperation to achieve low latency and autonomy
(JP) Kyushu Institute of Technology, KDDI Research
(U.S.) City College of New York



- R&D of a terahertz network working at 300 GHz, undertaken in collaboration with the EU
(JP) Gifu University, Waseda University, Chiba Institute of Technology
(EU) Technical University of Braunschweig, Fraunhofer Institute for Applied Solid State Physics, University of Lille Institute of Electronics, etc.
- Open and secure Beyond 5G mobile data offloading using next-generation public wireless LAN roaming
(JP) Kyoto University, Local 24, Tohoku University, Research Organization of Information and Systems National Institute of Informatics
(Overseas organizations) GÉANT
- Ecosystem for self-propagating sustainable digital twins to support City as a Service
(JP) Waseda University, Shibaura Institute of Technology, Tokyo University of Technology, Gaiax, Fukuoka University
(EU) Dipartimento di Ingegneria Elettronica, Università degli Studi di ROMA "Tor Vergata", Italy

Beyond 5G promotion system



President	GONOKAMI Makoto (President, RIKEN (Institute of Physical and Chemical Research))
Vice-President (Alphabetical order)	II Motoyuki (President & CEO, NTT DoCoMo), MIYAKAWA Junichi (President & CEO, Softbank), SAWADA Jun (Chairman, NTT), TAKAHASHI Makoto (President, KDDI), TOKUDA Hideyuki (President, NICT), TOKURA Masakazu (Chairman, Keidanren (Japan Business Federation)), YAZAWA Shunsuke (President, Rakuten Mobile) YOSHIDA Susumu (The Fifth Generation Mobile Communications Promotion Forum (5GMF))

- Published a white paper (March 2022) that summarizes ways of using Beyond 5G, along with performance targets. The updated Version 1.5 of the white paper was published in September 2022.
- Proposed the usage scenarios and performance targets as a topic for discussion relating to the international standardization of Beyond 5G at the International Telecommunication Union (ITU) (June 2022)

<Beyond 5G White Paper>

- Beyond 5G: vision for society and usage scenarios (XR, autonomous driving, use in health care)
- Performance targets required of Beyond 5G (ultra high speed, more than 10 times faster than 5G (at least 100 Gbps); ultra-low latency, etc.)
- Beyond 5G elemental technologies (terahertz, antenna technologies, photonic communication technology, etc.)



<Beyond 5G usage examples>

Entertainment using virtual spaces



Source:
<https://about.fb.com/news/2021/10/facebook-company-is-now-meta/>

Advanced medical care



Source: AMED (Information about outcomes)

<Key performance indicators (KPIs) for Beyond 5G>

Quantitative requirements	Outcomes of deliberations by the Beyond 5G Promotion Consortium
Ultra-fast, high-capacity	100 Gbps or more
Ultra-low latency	0.1 millisecond
Ultra-numerous simultaneous connectivity	$10^6 - 10^7$ devices/km ²
Ultra-low power consumption	One-hundredth of that of 5G
Coverage	Over a radius of dozens to hundreds of kilometers

Outline of policies and implementation

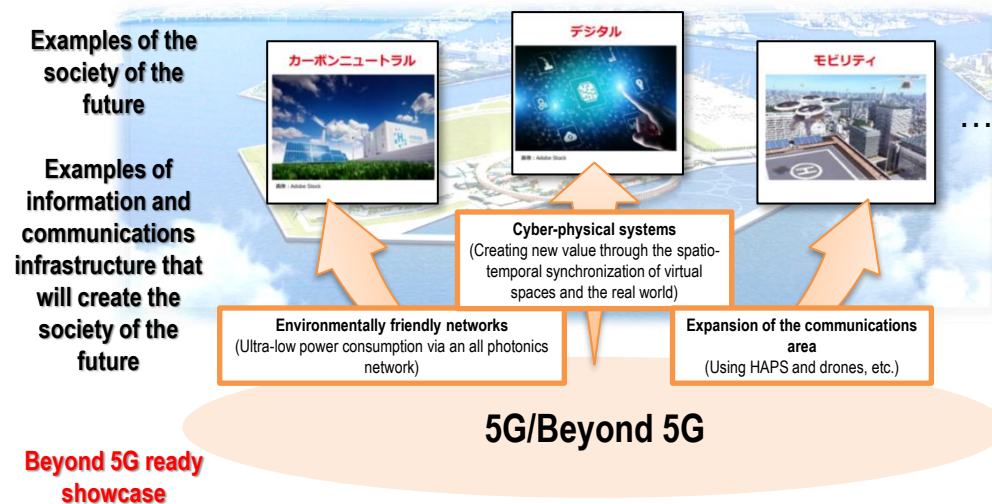
Efforts to realize Beyond 5G and deploy it worldwide will be expedited by creating the Beyond 5G ready showcase to highlight the outcomes of R&D conducted in the priority phase through to 2025, displaying and demonstrating these technologies to a global audience, and using the showcase as a springboard for efforts to expedite subsequent initiatives.

Status of deliberations aimed at implementation

(Timing) During Expo 2025

(Location) At the Expo 2025 venue

(Responsible organizations) Private sector business operators, etc. are expected to take the lead

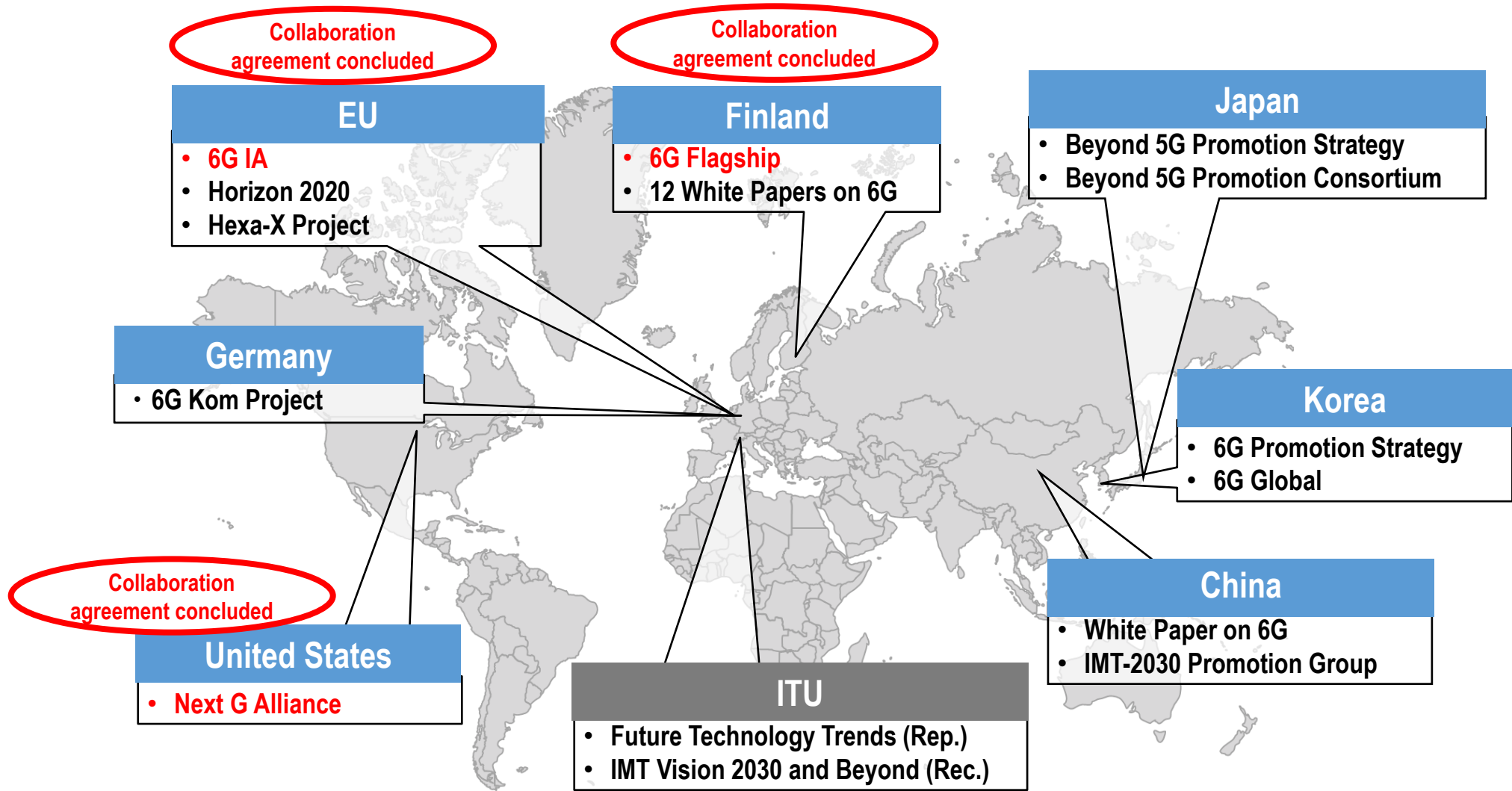


The advanced technologies of the 2030s can be implemented and promoted to the world

FY2021	FY2022	FY2023	FY2024	FY2025
Deliberations on the Vision for the Beyond 5G ready showcase				Exhibited/demonstrated at Expo 2025 Osaka Kansai
	Deliberations on an exhibition and demonstration plan			
	Design and production of content to be exhibited and demonstrated			

Efforts on Beyond 5G/6G

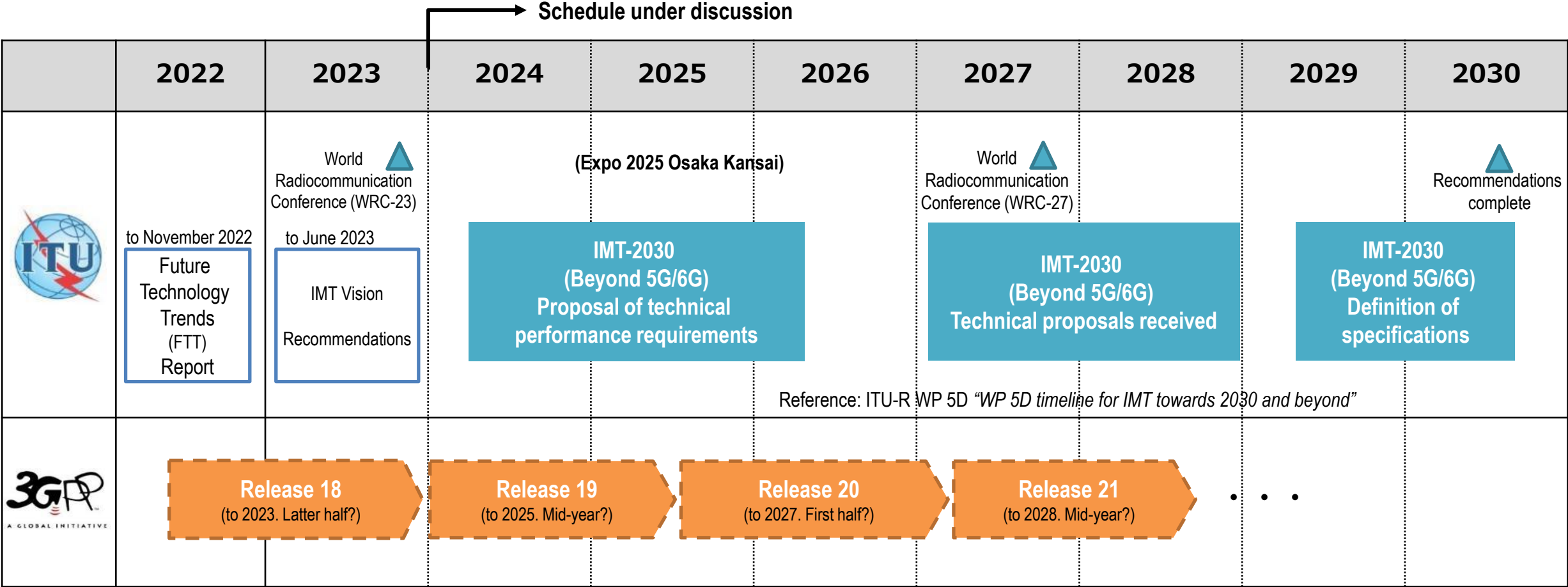
- Many countries have issued 6G white papers and have started to conduct R&D on 6G.
- ITU has started discussing standardization for IMT-2030 (Beyond 5G/6G).



	<ul style="list-style-type: none">● In the U.S., the Secure 5G and Beyond Act has been passed (March 2020)● In the U.S.-Japan Joint Leaders' Statement, the U.S. committed to investing \$2.5 billion in next-generation mobile networks (with the two countries committing to invest a total of \$4.5 billion) (April 2021)● The U.S. has passed the CHIPS and Science Act of 2022, which will provide \$20 billion in support for development of the next-generation communications standard (6G) and other advanced technology (August 2022)
	<ul style="list-style-type: none">● Under the next-generation R&D program Horizon Europe (2021-2027), the EU has decided to invest 900 million euros in 6G R&D (March 2021), and has already contributed 240 million euros to a work program (2021-2022) (December 2021)● The Hexa-X 6G R&D project is underway (January 2021 - June 2023)
	<ul style="list-style-type: none">● Germany has committed to investing 700 million euros by 2025 (April 2021)
	<ul style="list-style-type: none">● The 6Genesis project has got underway in Finland (January 2019) 250 million euros will be allocated to the budget for 6G R&D over the 8 years from 2019 to 2026
	<ul style="list-style-type: none">● China has established the 6G promotion organization IMT-2030 (6G) and has embarked on 6G R&D (January 2020)● It has announced a policy of intensive support for innovative activities by the private sector (December 2021), and has positioned this as a key task in the 14th Five-Year Plan (January 2022)
	<ul style="list-style-type: none">● South Korea has announced a 6G R&D implementation plan (June 2021). It intends to invest 220 billion won over the life of the plan, which runs to 2025

Schedule for international standardization regarding Beyond 5G

- Efforts toward the international standardization of IMT-2030 (Beyond 5G/6G) are underway at the International Telecommunication Union (ITU)
- 3GPP technical specifications will be reflected to the ITU, and established as recommendations (standardization)



ITU-R SG5 WP5D is beginning deliberations on the **Technology Trends Report (June 2022)** and **Recommendations for Vision 2030 (June 2023)**, aimed at the standardization of IMT-2030 (Beyond 5G/6G).

ITU-R Future Technology Trends Report (Draft)

- 1 Introduction
- 2 Scope
- 3 Related ITU-R documents
- 4 Overview of emerging services and applications
 - 4.1 New services and application trends
 - 4.2 Drivers for future technology trends towards 2030 and beyond
- 5 Emerging technology trends and enablers
 - 5.1 Technologies for native AI based communication **Effective use of AI**
 - 5.2 Technologies for integrated sensing and communication
 - 5.3 Technologies to support convergence of communication and computing architecture
 - 5.4 Technologies for device-to-device communications **Efficient use of frequencies**
 - 5.5 Technologies to efficiently utilize spectrum
 - 5.6 Technologies to enhance energy efficiency and low power consumption **Low power consumption**
 - 5.7 Technologies to natively support real-time services and communications
 - 5.8 Technologies to enhance trustworthiness **Spatio-temporal synchronization**
- 6 Technologies to enhance the radio interface
 - 6.1 Advanced modulation, coding and multiple access schemes
 - 6.2 Advanced antenna technologies **E(Extreme)-MIMO**
 - 6.3 In-band full duplex communications
 - 6.4 Multiple physical dimension transmission **Terahertz communications**
 - 6.5 THz communications
 - 6.6 Technologies to support ultra-high accuracy positioning
- 7 Technology enablers to enhance the radio network
 - 7.1 RAN slicing **RAN slicing**
 - 7.2 Technologies to support resilient and soft networks for guaranteed QoS
 - 7.3 New RAN architecture
 - 7.4 Technologies to support digital twin network **Digital twin network**
 - 7.5 Technologies for interconnection with non-terrestrial networks
 - 7.6 Support for ultra-dense radio network deployments **Non-terrestrial communications**
 - 7.7 Technologies to enhance RAN infrastructure sharing
- 8 Conclusion
- 9 Acronyms, Terminology, Abbreviations

U.S.-Japan Joint Leaders' Statement: "U.S.-JAPAN GLOBAL PARTNERSHIP FOR A NEW ERA" (April 16, 2021)



- The United States and Japan will: 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**.
- Strengthen **collaboration and information exchange** between U.S. and Japanese ICT experts in **global standards development**.

(Annex 2: U.S.-Japan Competitiveness and Resilience (CoRe) Partnership, section on Competitiveness and Innovation)

Japan-EU Summit 2022 Joint Statement (May 12, 2022)



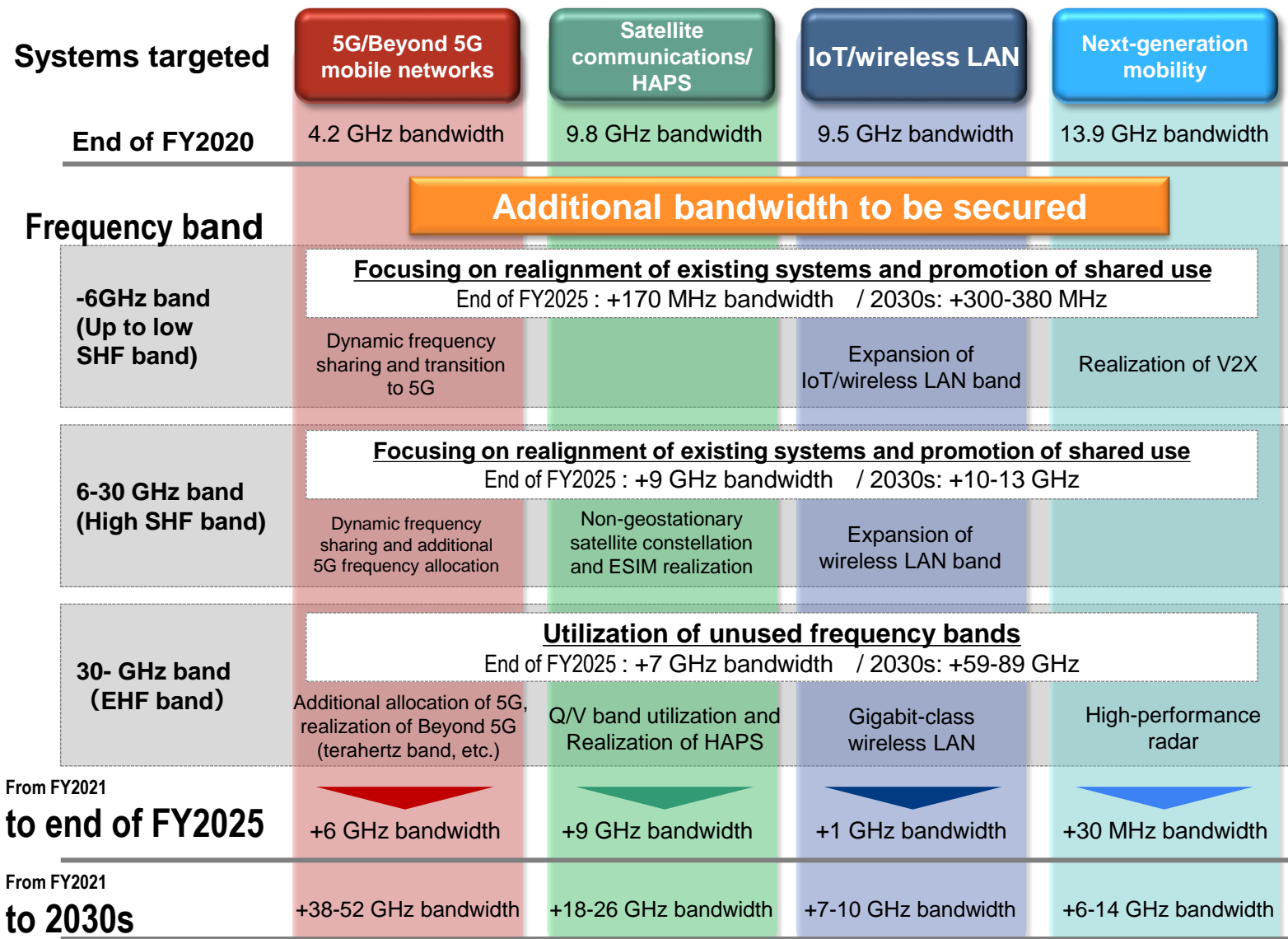
- **We also stress** the importance of an open and competitive marketplace in the supply of ICT technology and services as well as **a secure, diversified and resilient telecommunication infrastructure, such as 5G and beyond 5G**.
- We launch the Japan-EU Digital Partnership in order to advance cooperation on a wide range of digital issues to foster economic growth and achieve a sustainable society through an inclusive, sustainable, human-centric digital transformation based on our common values. [...] Our Partnership will reinforce the existing dialogue on these issues with a view to delivering concrete results, notably on **secure 5G, "Beyond 5G" / 6G technologies**, safe and ethical applications of artificial intelligence and the resilience of global supply chains in the semiconductor industry, while **encouraging an open and innovative environment**.
- As part of this joint vision, both sides should **continue and enhance their on-going cooperation** to: (i) promoting these standards globally through initiatives like the INDICO partnership, (ii) **achieve common goals and vision for 5G (including security), Beyond 5G/6G**, Internet of Things, Artificial Intelligence and digital identities and (iii) cooperate on standardisation from the early stages of research and innovation (R&I).

Japan-Australia-India-U.S. (Quad) Summit: Joint Statement (September 24, 2021)



- [Regarding 5G] 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^{*1}**. 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.
- [Regarding technical standardization] 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**.

*1 Open RAN: A wireless network composed of secure, open, and transparent networks by combining multiple vendors, rather than relying on a specific vendor

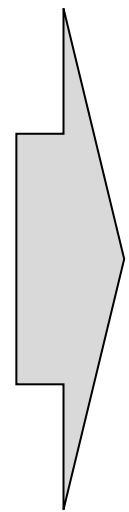


Total bandwidth at the end of FY2020
Approx. 37 GHz bandwidth

Targets for securing bandwidth

End of FY2025
+ approx. 16 GHz bandwidth

2030s
+ approx. 102 GHz bandwidth



- **Beyond 5G is important social infrastructure that will support society in the 2030s.**
- **Through partnership and cooperation with like-minded countries, Japan will speed up the pace of R&D and contribute to international standardization.**
- **Let's give it our all!**