

Beyond 5G/6G

<https://beyond5g.nict.go.jp/en/index.html>

 B5G
White
Paper

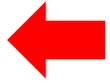


R&D on Beyond 5G/6G and future communication technologies



National Institute of Information and Communications Technology

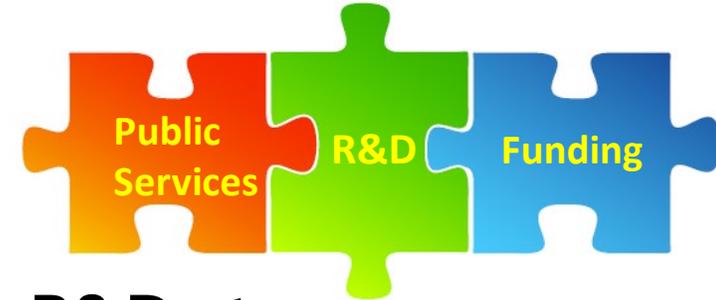
Japan's only public research institute specialising in ICT



MIC

■ Primary Work:

- ◆ Cutting-edge ICT R&D
- ◆ Determining and broadcasting JST, Space weather forecasting etc.
- ◆ Supporting private and academic sector R&D etc.



■ Location: HQ in Koganei, Tokyo

■ Number of Employees: Approx. 1,200 incl. 700 Ph.D. holders

■ Budget: ¥28 billion (€207million, @€/¥=140) in operational grants

■ Established: 1st April 2004

(A research institute (CRL) and a funding agency (TAO) were joined)

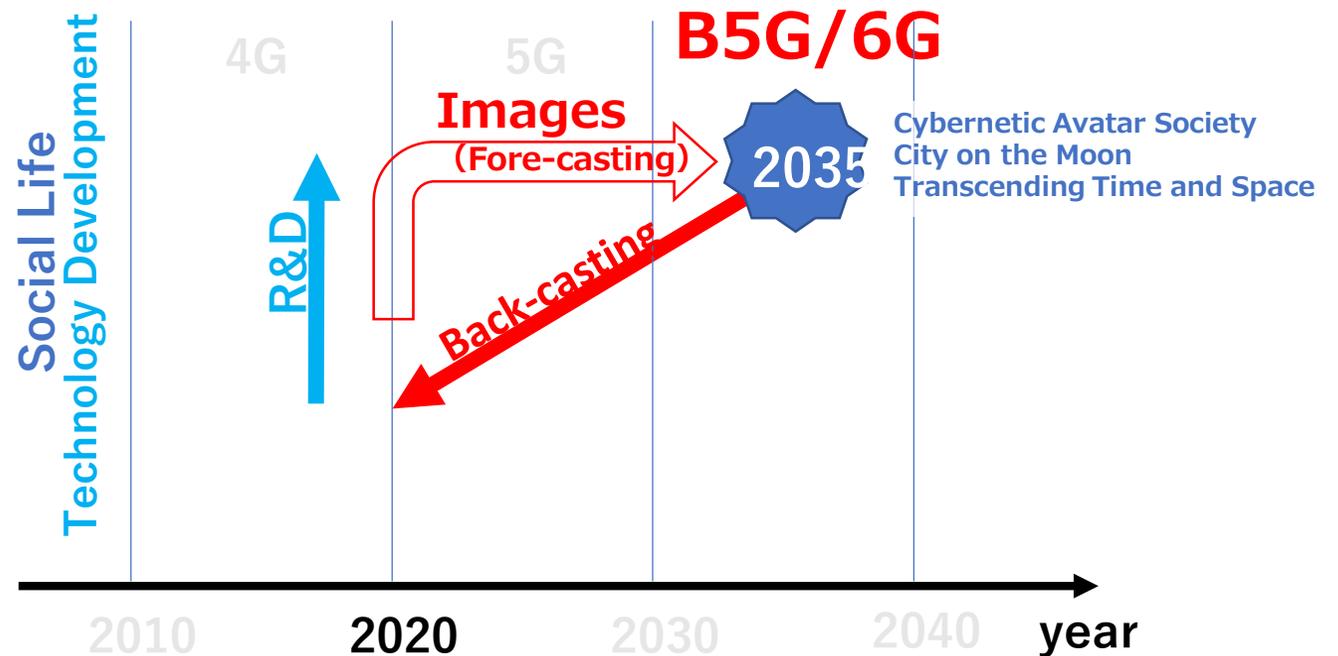
■ Mid-to-Long Term Plans (5 years): **5th April 2021 – March 2026**

Beyond 5G/6G White Paper

- English version 2.0 -

June 2022

- We created four scenarios,
 - [Scenario 1] **Cybernetic Avatar Society**,
 - [Scenario 2] **City on the Moon**,
 - [Scenario 3] **Transcending Time and Space** and
 - [Scenario 4] **Light and Shadow of the Cyber world**,which are images of social life around 2035, and identified the necessary key technologies by back casting from the future society described in these scenarios.
- It summarizes the scenarios, the use cases that appear in the scenarios, the key technologies and requirements to realize them, the R&D roadmap , and the deployment strategy

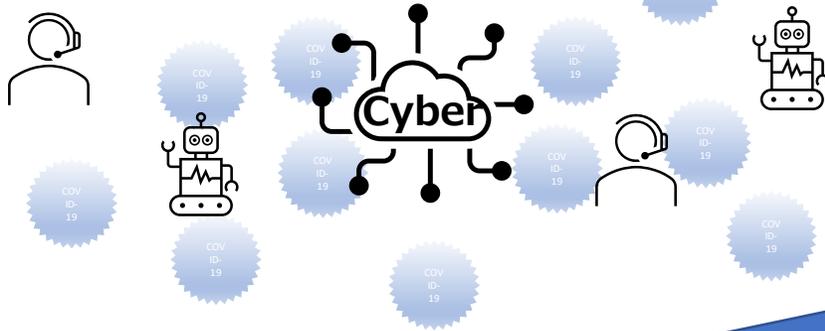


Technology Vision for Beyond 5G / 6G in Physical Space

Urgent issues: Economic growth under the new-normal → Non-contact society by utilizing ICT
 ~ "Society 5.0"

Keys are the development of the Beyond 5G / 6G, together with the realization of the Cyber-Physical System (CPS)

Spatially dispersed individuals are connected through advanced networks (B5G / 6G) to collaborate with others, robots and avatars through cyberspace, creating value at any time.

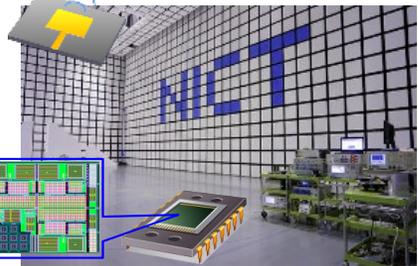


Realization of a "cyber-physical system" that measures real-world phenomena (big data), projects them into cyber-space, finds solutions (optimal solutions), and actuate the real world.



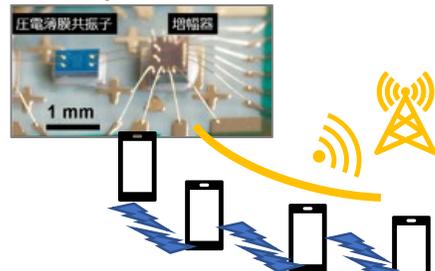
Seeds of Techs @NICT

Terahertz



Achieves 100 Gbit/s class ultra-high-speed wireless communication on mobile phones. Mobile Back/Fronthaul can communicate at 100 Gbit/s over 1 km outdoors.

Space-time synchronization



With an ultra-compact atomic clock, the phase of radio waves can be controlled freely, and cooperation between terminals and base stations, non-GPS Location-based services are also available

Radio emulators



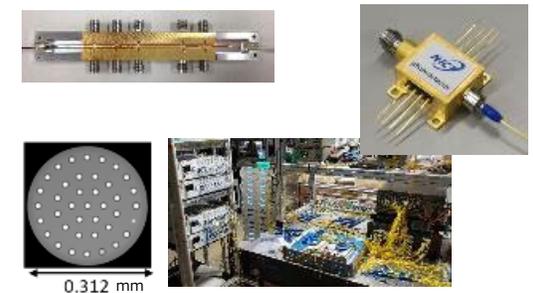
Provides an environment for designing, evaluating, and verifying various radio wave systems, from infrastructure to applications, in a virtual space

Extension to NTN NTN (Non-Terrestrial Network)



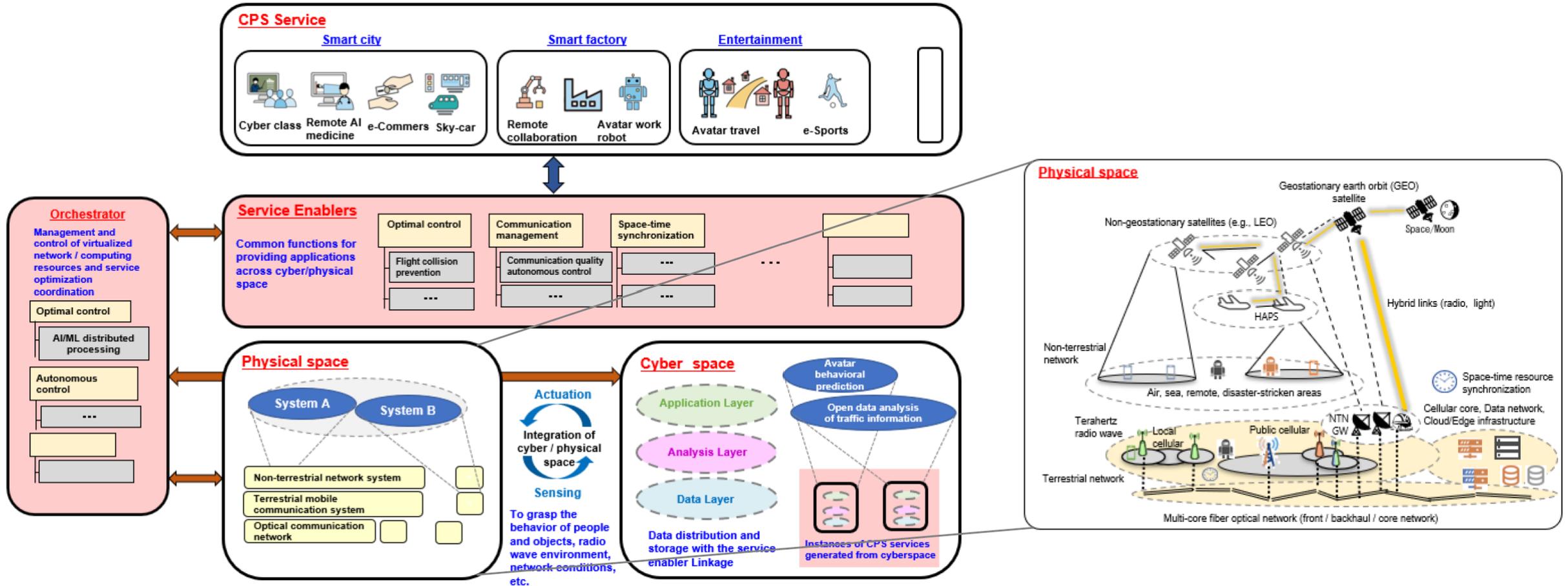
Fundamental Technologies for Seamlessly Integrated, Multilayered Networks for Aerospace and Ocean

Ultra-high capacity optical network



Early commercialization of large-capacity backbone communication systems and dynamic network control technology to support the realization of terahertz radios

B5G Architecture for open service framework



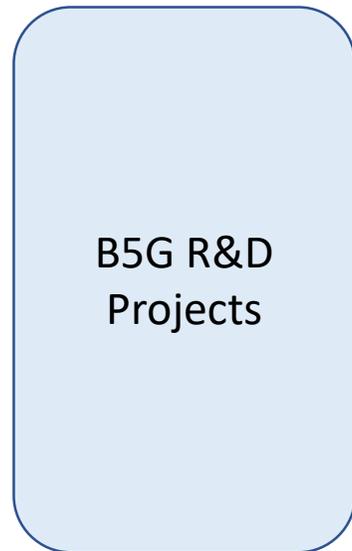
An open platform is expected to **accommodate various systems** and **promote flexible service creation** where ICT and other technologies are optimally integrated.

Beyond 5G R&D Promotion Programs (FY2020 - 2022)

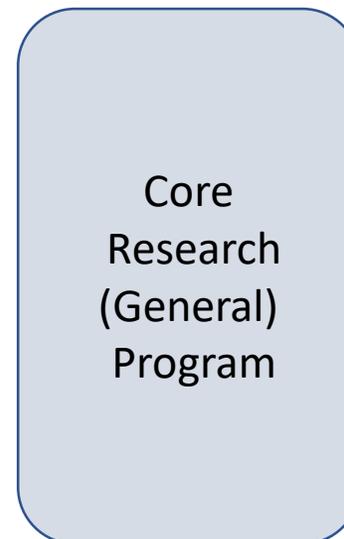
NICT R&D
Laboratories

Beyond 5G R&D Promotion Programs

FY2020-FY2025: Call 1(2020/2021)、Call2(2022)、Call3(2022)、...



+



6 projects (2020/2021)
4 projects (2022)
2 projects (2022)
Budget : 0.5B~x.0Byen/year
R&D Period: 3-5 years

20 projects (2021)
6 projects (2022)
3 projects (2022)
0.3B~0.5Byen/year
3-5 years

3 projects (2021)
2 projects (2022)
50M~100M yen/year
2-3 years

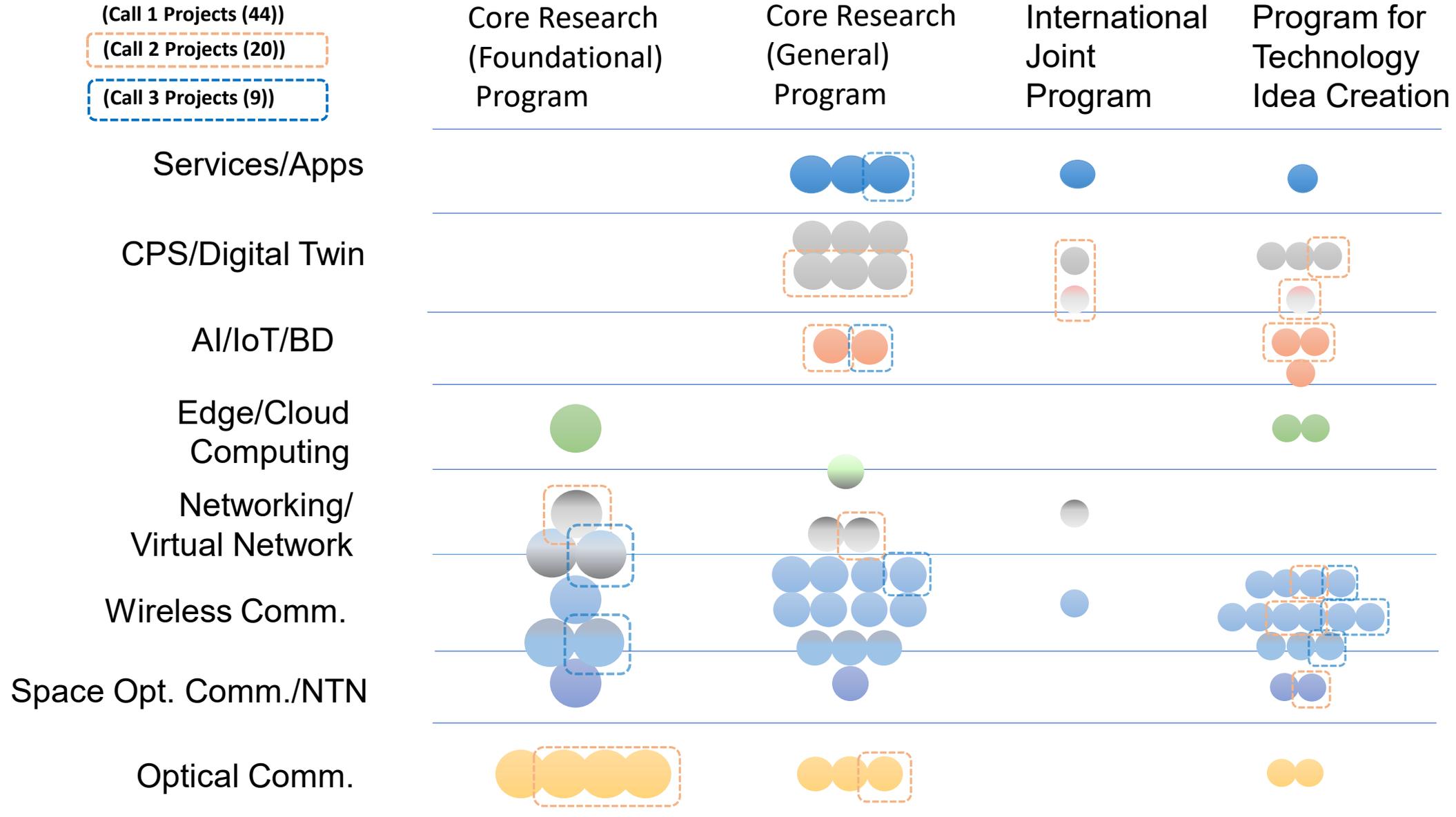
15 projects (2021)
8 projects (2022)
4 projects (2022)
50M~100Myen/year
2-3 years

(as of Jan. 2023)

※NICT gives detailed research plans with specific development goals for the public invitation

Beyond 5G R&D Promotion Programs (FY2020 - 2022)

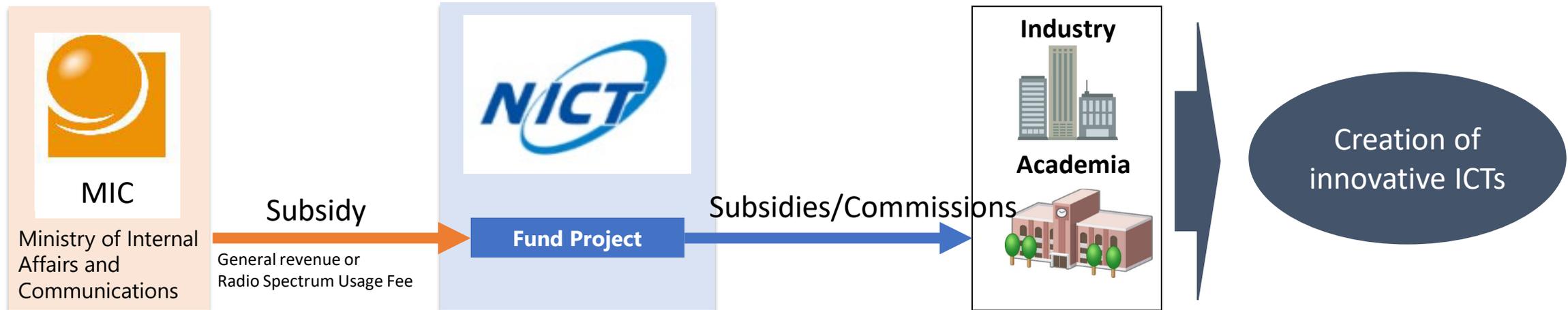
Call 1,2,3 Portfolio (as of Jan. 2023)



Innovative Information and Communication Technologies (Beyond 5G (6G)) Fund Project (From FY2023 -)

- With regard to the next generation of information and communications infrastructure, Beyond 5G (6G), which is expected to be introduced in the 2030s, we aim to develop technologies that originate in Japan, implement them in society, and deploy them overseas in order to strengthen our international competitiveness and ensure our economic security.
- NICT will establish a permanent fund to promote research and development of innovative information and communication technologies and support research and development by private companies and universities on key technologies for Beyond 5G (6G).

※The Radio Spectrum Usage Fee Fund budget is used to research and develop technologies that contribute to the efficient use of radio waves.



- **Supplementary budget for FY2022: 66.2 billion yen (including 3.5 billion yen from spectrum usage fees)**
- **Initial budget for FY2023: 15.0 billion yen (spectrum usage fees)**

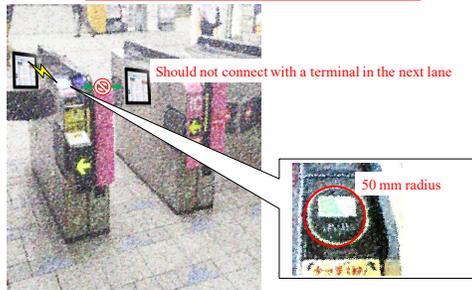
Coordinated standardization activities
towards global standards for future
communication technologies

IEEE802.15.3d : World first Standard for THz Band and 100 G

- IEEE 802.15.3d using the 300 GHz band was published in Sep. 2017.
- Ultra-High-speed wireless assuming 100 Gbps utilizing wide band width.
- Distance is assumed to be from close proximity to short/medium.
- Beam Switchable Point to Point.

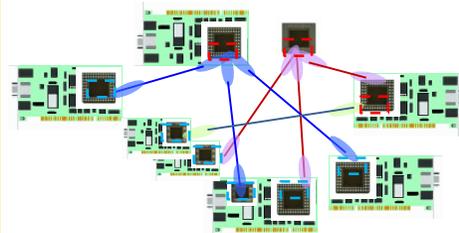
Chair : Thomas Kürner (TU Braunschweig)
 Vice-chair: Iwao Hosako (NICT)
 Technical Editor: Monique Brown (NICT)
 Secretary: Ken Hiraga (NTT)

Close Proximity P2P



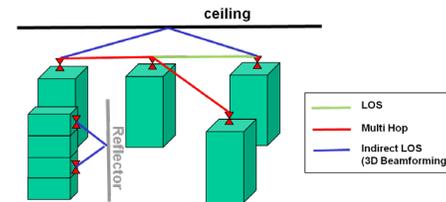
File downloading at toll gates in a train station

Intra-Device Communication



Wireless board to board communication

Data Center



<https://terapod-project.eu/>

Horizon 2020

IEEE STANDARDS ASSOCIATION



IEEE Standard for High Data Rate
 Wireless Multi-Media Networks

Amendment 2: 100 Gb/s Wireless
 Switched Point-to-Point Physical
 Layer

IEEE Computer Society

Sponsored by the
 LAN/MAN Standards Committee

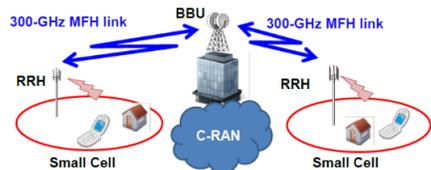
IEEE
 3 Park Avenue
 New York, NY 10016-5997
 USA

IEEE Std 802.15.3d™-2017
 (Amendment to
 IEEE Std 802.15.3™-2016
 as amended by
 IEEE Std 802.15.3d™-2017)

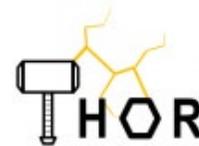
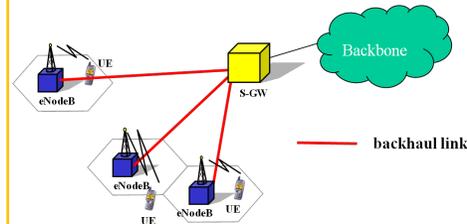
“R&D for expanding radio resources” in JP

<https://www.tele.soumu.go.jp/j/sys/fees/purpose/kenkyu/>

Wireless Fronthaul



Wireless Backhaul



<https://thorproject.eu/>

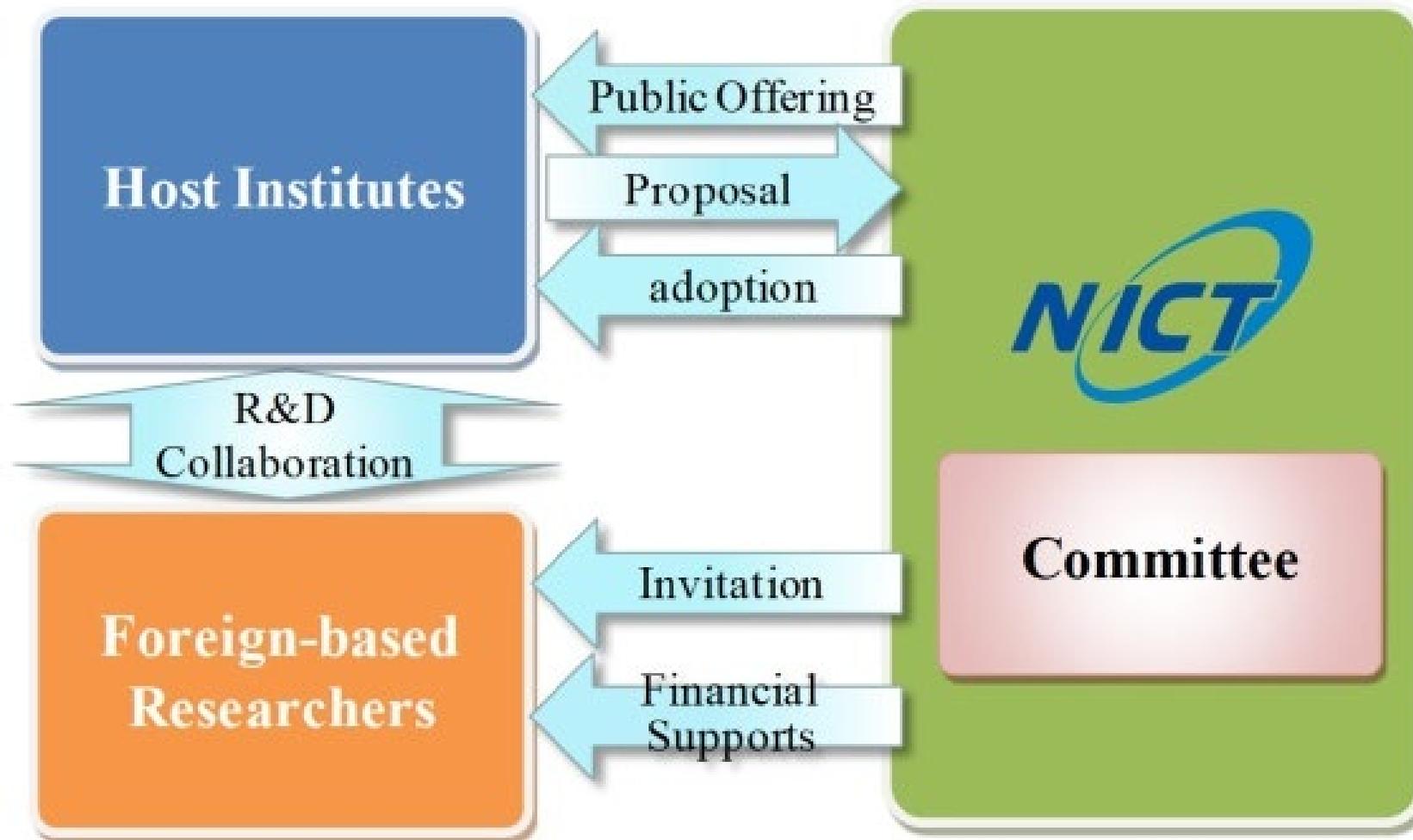
Horizon 2020 & NICT

Exchange of excellent scientists

For researchers outside NICT

Invitation programs for foreign-based researchers to Japan 2024

<https://www.nict.go.jp/en/deploy-support/invitation.html>



Invitation Programs of Foreign-based Researchers

For researchers at NICT

International Collaboration and Deployment Fund

This fund supports the efforts to promote the international collaboration and deployment of NICT's R&D. The following points will be taken into consideration when accepting proposals.

- Four strategic areas (Beyond 5G, AI, Quantum Information Communications, Cyber Security)
(Applications outside of the strategic area are also accepted.)
- Proposals that plan to use external competitive funds
- Efforts to promote the ASEAN IVO (ICT Virtual Organization of ASEAN Institutes and NICT) projects
- International deployment of R&D results that are close to practical use
- Social implementation through licensing to companies
- Incorporating NICT's R&D results into international projects
- Exhibit the results of NICT's R&D at international exhibitions and demonstration experiments in foreign countries, etc.

Acceptance of international internship trainees, etc.

- One person from RWTH is coming to Japan to study at the Beyond 5G R&D Promotion Unit, scheduled for April-September 2023.

Joint workshops and scientific exchange

The 1st Germany-Japan Beyond 5G/6G Research Workshop

- Purpose
 - An event for Japanese and German B5G/6G related researchers to introduce their research to each other and to discuss the direction of Japan-Germany collaboration, as well as matching for the start of joint research, etc.
- Dates & Locations
 - April 24-25, 2023 @ NICT Headquarters (Bldg. 3, 1F)
- Participants
 - Germany
 - More than 20 people from universities and companies from 4 research hubs (6G-Life, 6G-RIC, 6GEM, Open6GHub) and 6G Platform
 - Japanese
 - More than 50 people from NICT researchers, contract researchers, B5G consortium, telecom-operators, vendors, and chairs of relevant study groups of academic societies
- Program Overview
 - Lectures, Poster Presentations, Panel Discussions
 - Networking dinner @ new building (evening of 1st day)



The 1st Germany-Japan Beyond 5G/6G Research Workshop
Co-organized by NICT and the 6G Platform Germany

GOAL

Research and development projects on Beyond 5G/6G are quite active in Germany and Japan. To strengthen global collaborations and promote joint activities from fundamental technologies to demonstrations, a research workshop on Beyond 5G/6G is going to be held between Germany and Japan. Any participants who are interested in Beyond 5G/6G research activities are welcome to join. Also, poster presentations are appreciated to seek for research partners and potential collaboration topics.

DATE

Apr. 24-25, 2023

VENUE

Headquarters of National Institute of Information and Communications Technology (NICT)
Address: 4-2-1 Nukui-kitamachi, Koganei, Tokyo 184-8795
[Check here for the access info.](#)

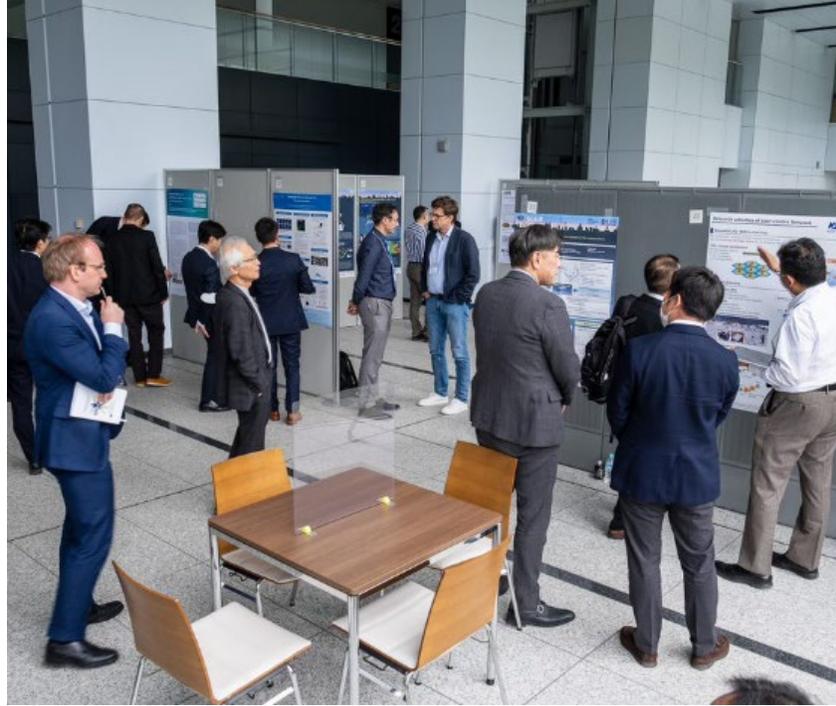
PROGRAM

Day 1 April 24(Mon) 9:30 - 19:00

9:30 - 9:45	Opening & Greetings - Dr. Tokuda Hideyuki (President of NICT)	15 min
9:45 - 10:30	Overview of Germany/Japan B5G/6G projects - Prof. Hans Schotten (6G Platform Germany)	45 min

<https://beyond5g.nict.go.jp/en/event/20230424Germany-Japan-Workshop.html>

Lecture by the president of NICT
(Dr. Hideyuki Tokuda)



Dr. Michael Meyer (Ericsson)





Day1 April 24 (Mon.) 9:30 – 19:00	
9:30-9:45	<u>Opening & Greetings</u> - Dr. Hideyuki Tokuda (President of NICT)
9:45-10:30	<u>Overview of Germany/Japan B5G/6G projects</u> “Introduction of the German 6G Program and the 6G Platform Germany” - Dr. Michael Meyer (Ericsson) “Updates on 5G Evolution and 6G in Japan” - Dr. Takehiro Nakamura (NTT DOCOMO)
10:30-11:00	Break
11:00-12:00	<u>Highlighting 6G technologies 1</u> “5G and 6G to Realize Super Smart Society” - Prof. Kei Sakaguchi (Tokyo Institute of Technology) “6G-RIC Research and Innovation Cluster” - Prof. Slawomir Stanczak (TU Berlin) “Digital Twin as a use case of B5G/6G and Digital Twin as an enabler of B5G/6G” - Prof. Hideyuki Shimonishi (Osaka univ.)
12:00-13:00	Lunch break
13:00-13:30	<u>Academic research activities in Japan</u> “Activities of IEICE Technical Committee on Smart Radio” - Prof. Suguru Kameda (Hiroshima Univ.) “Introduction of R&D Activities for B5G/6G in IEICE Technical Committee on Radio Communicarion Systems (RCS)” - Prof. Kenichi Higuchi (Tokyo Univ. of Science)
13:30-14:00	<u>Lightning talks</u>
14:00-15:30	<u>Poster session</u>
15:30-16:30	<u>Highlighting 6G technologies 2</u> “6G Architecture: building blocks” - Dr. Simone Redana (Nokia) “The Road to 6G” - Dr. Michael Meyer (Ericsson) “6G technologies” - Dr. Hanako Noda (Anritsu) “High-Speed and Energy-Efficient Stream Processing with Direct Data Transfer between Accelerators” - Mr. Ken Iizawa (Fujitsu)
16:30-17:00	Break
17:00-19:00	<u>Networking Dinner</u>

Day2 April 25 (Tue.) 9:30 – 16:30	
9:30-11:30	<u>Introduction of outstanding global activities in Japan</u> “Global Collaboration for 5G/Beyond5G R&D” - Prof. Akihiro Nakao (Univ. of Tokyo) “Wireless Challenges for the Evolution of Mobile Communications: ~ Past and Future ~” - Prof. Fumiyuki Adachi (Tohoku univ.) “R&D activities on Non-Terrestrial Networks (NTNs) toward 5G/Beyond 5G in Wireless Networks Research Center” - Dr. Morio Toyoshima (NICT) “NICT’s R&D and Promotion Activities on the Testbed Development and Evolution toward Beyond 5G/6G Systems and Services” - Dr. Fumihide Kojima (NICT)
11:30-13:00	Lunch Break
13:00-14:00	<u>Highlighting 6G technologies 3</u> “Towards THz Communications in 6G: Combining electronic and photonic technologies” - Dr. Taro Eichler (Rohde & Schwarz) “Proposal of Error-Free Plastic Optical Fiber for Beyond 5G Society” - Prof. Yasuhiro Koike (Keio univ.) “The journey towards resilient 6G: The 6GEM Hub paradigm” - Prof. Aydin Sezgin (Ruhr Univ. Bochum) “New lifestyles and technologies toward 6G” - Dr. Satoshi Konishi (KDDI)
14:00-14:30	Break
14:30-16:00	<u>Panel on future research collaborations</u> (Moderator : Dr. Naoto Kadowaki (NICT)) - Dr. Simone Redana (Nokia) - Prof. Christian Wietfeld (TU Dortmund Univ.) - Prof. Haris Gačanin (RWTH Aachen) - Dr. Satoshi Konishi (KDDI) - Prof. Tetsuya Kawanishi (Waseda Univ.)
16:00-16:30	<u>Closing remarks</u> - Dr. Iwao Hosako (NICT) - Way forward to future actions - Dr. Michael Meyer (Ericsson) - Invitation to the 2nd workshop in Berlin

Berlin 6G Conference

- The Annual Networking Event of the German 6G Program -

Organized by the 6G Platform Germany

colocated with

The 2nd Germany Japan Beyond 5G/6G Research Workshop

Co-organized by NICT and the 6G Platform Germany

Berlin Congress Center (bcc), 27-29 June 2023

PROGRAM	Monday June 26, 2023	Tuesday June 27, 2023	Wednesday June 28, 2023	Thursday June 29, 2023
Session AM1 9:00 – 10:30	Exhibition Setup	Tue-AM1 Welcome note/Keynotes Plenary C 01	Wed-AM1 Keynotes/Industry Plenary C 01	Thu-AM1 Technical Sessions
Coffee Break 10:30 – 11:00				
Session AM2 11:00 – 12:30		Tue-AM2 Keynotes/EU-Programs Plenary C 01	Wed-AM2 Technical Sessions	Thu-AM2 Technical Sessions
Lunch Break 12:30 – 14:00				
Session PM1 14:00 – 15:30	Mon-PM1 Internal Project Meetings	Tue-PM1 Technical Sessions	Wed-PM1 Keynotes Plenary C 01	Thu-PM1 Jap-Ger Working- Session & Technical Sessions
Coffee Break 15:30 – 16:00				
Session PM2 16:00 – 18:00	Mon-PM2 Internal Project Meetings	Tue-PM2 Technical Sessions	Wed-PM2 Jap-Ger Working- Session & Technical Sessions	Thu-PM2 Summary & Conclusion Plenary C 01
Evening Networking Event 18:00 – 21:00		Networking Reception		Exhibition Dismantling

Harmonization and alignment of R&D activities

B5G/6G Development in Japan

	2021	2022	2023
MIC	<ul style="list-style-type: none"> ■ International Symposium on B5G (11/9) 	<ul style="list-style-type: none"> ■ International Symposium on B5G (10/25) 	
B5G Promotion Consortium	<ul style="list-style-type: none"> ■ 2nd B5G Promotion Consortium General Meeting (03/21) 	<ul style="list-style-type: none"> ■ B5G Promotion Consortium White Paper v1.0 (03/22) ■ 3rd B5G Promotion Consortium General Meeting (03/22) 	<ul style="list-style-type: none"> ■ B5G Promotion Consortium White Paper v2.0 (03/23)
Germany-Japan	<ul style="list-style-type: none"> ■ Prof. Dr. Ina Schieferdecker 's presentation (11/9) 	<ul style="list-style-type: none"> ■ Prof. Dr. Ina Schieferdecker 's presentation (10/25) ■ BMBF-NICT meeting (10/25) 	<ul style="list-style-type: none"> ■ MOU between NICT and RWTH Aachen Univ. on B5G (06/13)
NICT	<ul style="list-style-type: none"> ■ NICT Open Summit on B5G/6G (01/20) ■ NICT B5G White Paper v1.0 (03/21) 	<ul style="list-style-type: none"> ■ B5G Testbed Symposium (01/22) ■ B5G R&D Workshop (02/22) ■ B5G Open Discussion (03/22) ■ NICT B5G White Paper v2.0 (03/22) ■ NICT B5G SIG meeting (05/22) ■ MOU between NICT and Oulu Univ. on B5G (08/31) 	<ul style="list-style-type: none"> ■ NICT B5G White Paper v3.0 (03/23) ■ MOU between NICT and I2R on B5G (03/17) (I2R: Singapore) ■ MOU between NICT and RWTH Aachen Univ. on B5G (06/13) ■ MOU between NICT and INRIA on B5G (06/16) ■ Joint WS between NICT and INRIA on B5G (TBD)
B5G R&D Projects	<ul style="list-style-type: none"> ■ B5G R&D Projects Call 1.0(01/29) ■ B5G R&D Projects Call 1.1(04/30) ■ B5G R&D Projects Call 1.2(06/30) ■ B5G R&D Projects Call 1.3(07/16) ■ B5G R&D Projects Call 1.4 (SBIR) (09/30) 	<ul style="list-style-type: none"> ■ B5G R&D Projects Call 2.0(04/22) ■ B5G R&D Projects Call 2.1(04/28) ■ B5G R&D Projects Call 2.2 (SBIR) (06/22) ■ B5G R&D Projects Call 3.0(09/08) ■ B5G R&D Projects Call 3.1(10/13) 	

Overview of MOU with German Institutes

institute	Start	Finish
<i>Effective</i>		
(ifak) Institut für Automation und Kommunikation e.V. / Institute for Automation and Communication e.V. /	2022/3/2	2026/3/31
(DFKI) Deutsches Forschungszentrum für Künstliche Intelligenz / German Research Center for Artificial Intelligence	2017/3/20	2026/3/31
(KIT) Karlsruher Institut für Technologie / Karlsruhe Institute of Technology /	2016/11/29	2026/12/31
<i>Finished</i>		
(Fraunhofer IAO) Fraunhofer-Institut für Arbeitswirtschaft und Organisation / Fraunhofer Institute for Industrial Engineering /	2020/11/26	2022/9/30
(Fraunhofer IPA) Fraunhofer-Institut für Produktionstechnik und Automatisierung / Fraunhofer Institute for Manufacturing Engineering and Automation	2020/11/26	2022/9/30
SAP SE	2019/10/23	2022/12/31
(Fraunhofer IAF) Fraunhofer-Institut für Angewandte Festkörperphysik / Fraunhofer Institute for Applied Solid State Physics	2015/7/1	2020/7/1
(Fraunhofer HHI) Fraunhofer-Institut für Nachrichtentechnik, Heinrich-Hertz-Institut / Fraunhofer Institute for Telecommunications	2015/7/1	2020/7/1
(DLR) Deutsches Zentrum für Luft- und Raumfahrt e.V. / German Aerospace Center	2014/4/16	2017/4/15
(UDE) Universität Duisburg-Essen / The University of Duisburg-Essen	2012/4/1	2016/3/31

MOU: Memorandum of Understanding

Based on the activities described so far and others, the following activities will take place in the future.

- **R&D collaborative projects with the participation of relevant stakeholders from Japan and Germany.**

Thank you for your attention!



Some of the web-links

- NICT (English)
(Japanese)
- NICT Channel

[NICT - National Institute of Information and Communications Technology](#)
[NICT-情報通信研究機構](#)
[NICTchannel - YouTube](#)

- Beyond 5G R&D Promotion Unit
- Beyond 5G / 6G White Paper

[TOP - Beyond 5G/NICT](#)
[B5G White Paper - Beyond 5G/NICT](#)

- Beyond 5G R&D Promotion Program

[Beyond 5G R&D Promotion Project \(nict.go.jp\)](#)