Accelerating Beyond 5G/6G R&D in NICT

February 2, 2024

Hideyuki Tokuda, Ph.D.
President, National Institute of Information and Communications Technology
Vice President, Beyond 5G Promotion Consortium
Professor Emeritus, Keio University

NICT
National Institute of
Information and Communications Technology

Japan's only public research institute specialising in ICT

NICT Personnel and Budget

- Location: HQ in Koganei, Tokyo
- Personnel: ~ 1380
- Researchers: ~730
- Budget: ~28.68 Billion Yen + α (2023)
- 5th Mid-to-Long Term Plan: April 2021 – March 2026

Public Services:

- Japan Standard Time
- Space Weather Forecast
- Wireless Equipment Testing & Calibration
- Cybersecurity Training

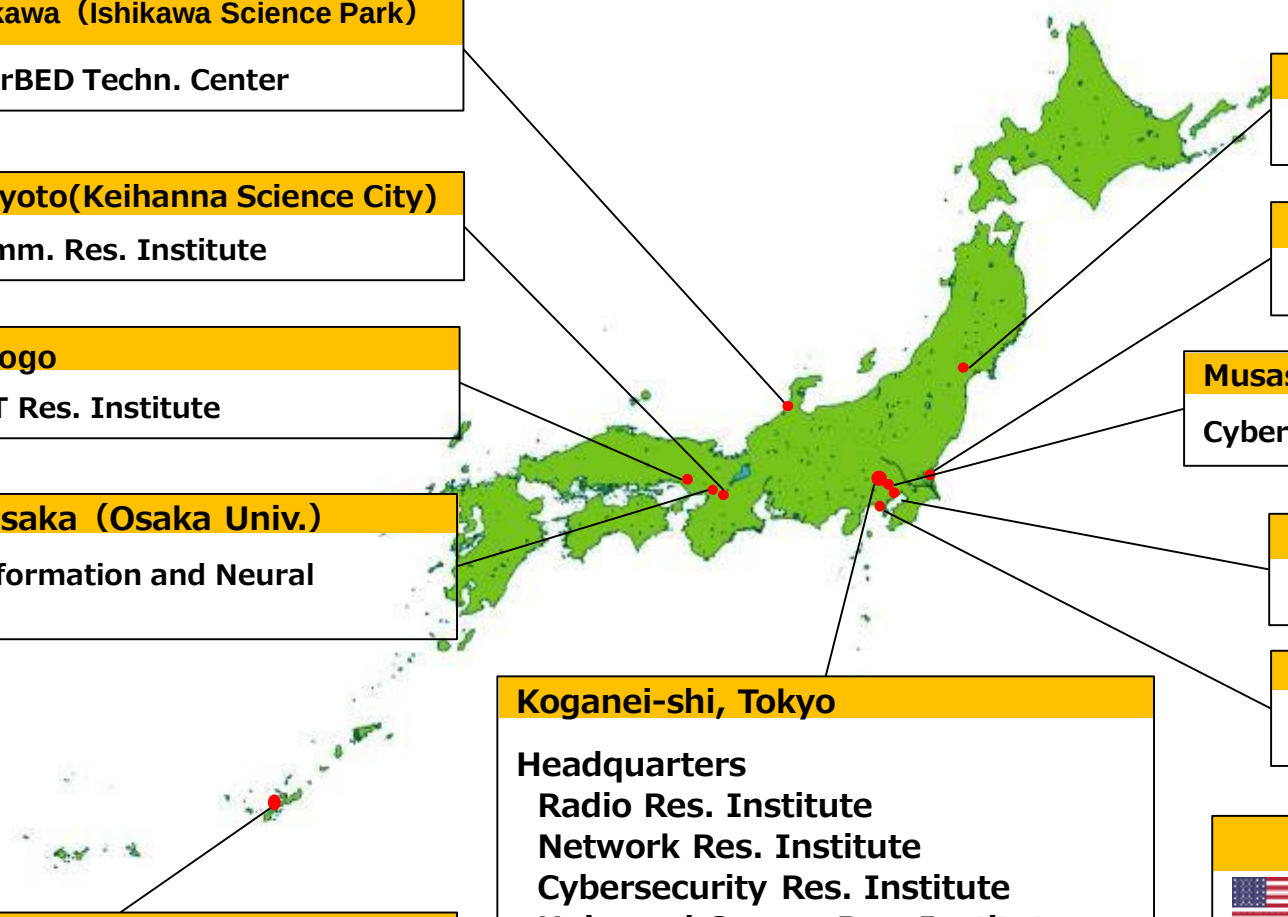
5 Main Research Areas

- Advanced Electromagnetic Wave Technology
- Innovative Networks
- Cybersecurity
- Universal Communication
- Frontier Science

Funding Agency:

- B5G R&D Project / Domestic ICT Projects
- US-Japan Projects
- EU-Japan Projects
- ASEAN-IVO Projects
- Taiwan-Japan Projects

NICT Facilities



Nobi-shi, Ishikawa（Ishikawa Science Park）
x
Hokuriku StarBED Techn. Center

Seika-Cyo, Kyoto(Keihanna Science City)
Universal Comm. Res. Institute

Kobe-shi, Hyogo
Advanced ICT Res. Institute

Suita-shi, Osaka（Osaka Univ.）
Center for Information and Neural Networks

Onna-son, Okinawa
Okinawa Electromagnet Techn. Ctr.

Sendai-shi, Miyagi（Tohoku Univ.）
Resilient ICT Research Ctr.

Kashima-shi, Ibaraki
Kashima Space Techn. Ctr.

Musashino-shi, Tokyo
Cybersecurity Recurrent Evolution . Ctr.

Chuo-ku, Tokyo
Innovation Ctr.

Yokosuka-shi, Kanagawa（YRP）
Wireless Network Res. Ctr.

Koganei-shi, Tokyo

Headquarters
- Radio Res. Institute
- Network Res. Institute
- Cybersecurity Res. Institute
- Universal Comm. Res. Institute
- Advanced ICT Res. Institute
- Beyond 5G R&D Promotion Unit
  - Terahertz Technology Res. Ctr.
- Quantum ICT Collaboration Center
- Open Innovation Promotion HQs.
  - ICT Testbed R&D Promotion Ctr.

Oversea Centers

- North-America Center (Washington D.C., U.S.)
- Europe Center (Paris, France)
- Asia Center (Bangkok, Thailand)

*Silicon Valley Representative (Sunnyvale, U.S.)

The 5th Mid-to-Long Term Plan (Apr. 2021 – Mar. 2026)

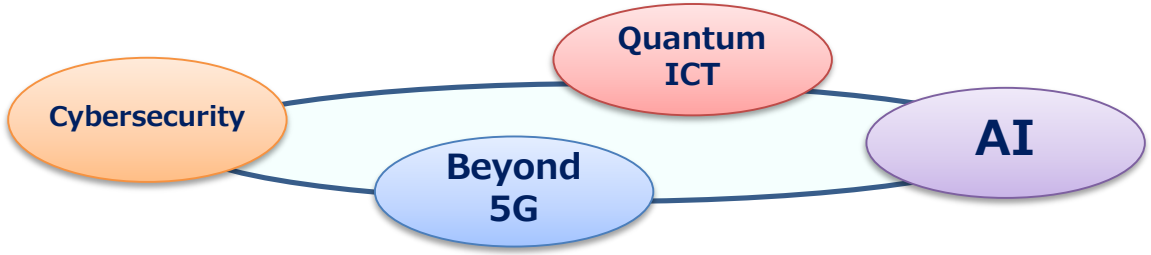
Shaping the society of the future…

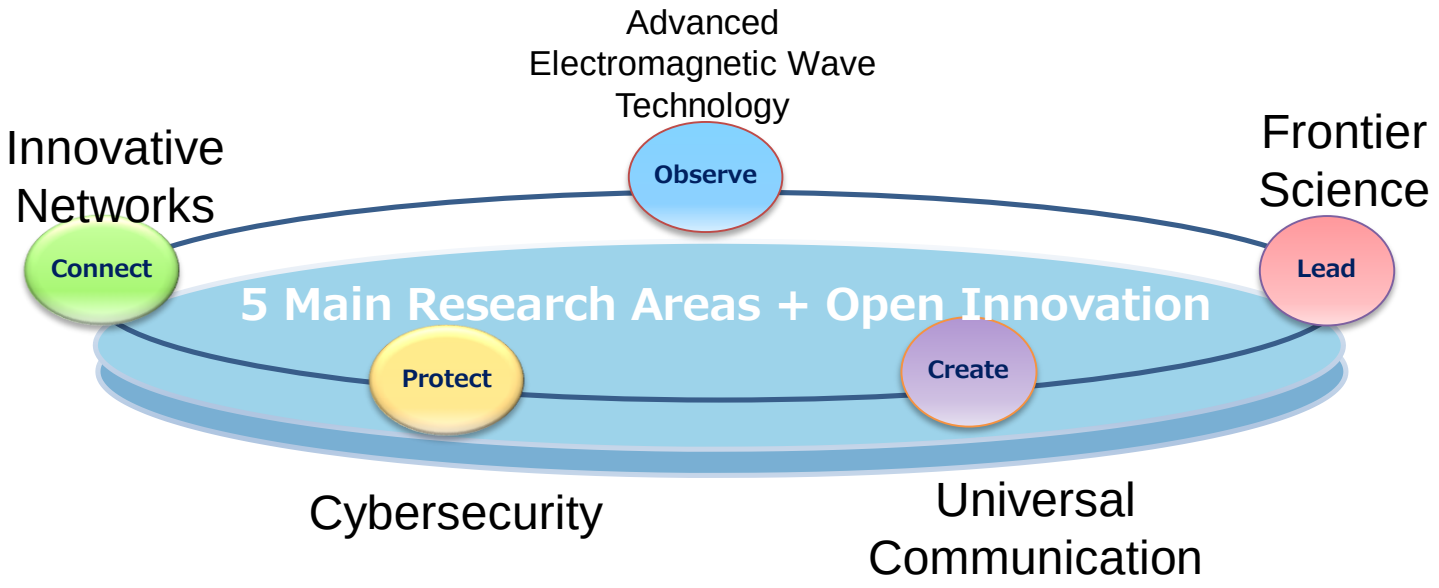
- Realising Society 5.0 and cyber-physical systems
- Achieving SDGs and a carbon neutral society
- **Core philosophy: Human-centered (co-creation between Human and AI), Sustainability, Inclusiveness**
- Realize a prosperous society that can create diverse lifestyles and create new values by transforming the industrial structure and working environment with a new social infrastructure.

New ICT Strategies for the Beyond 5G Era

From the Information and Communications Council, ICT Strategy Council

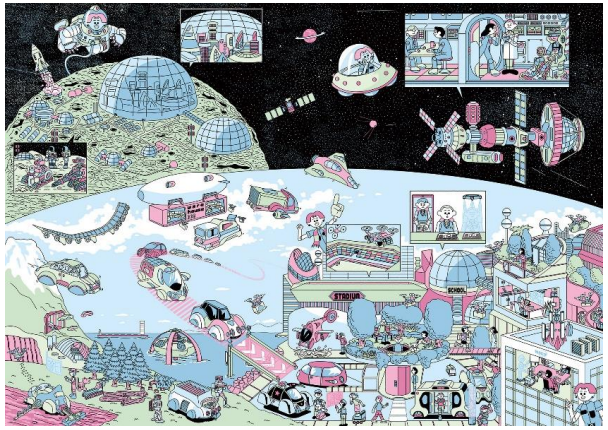
The four strategic fields





Highlights in the Four Strategic Fields

Beyond 5G

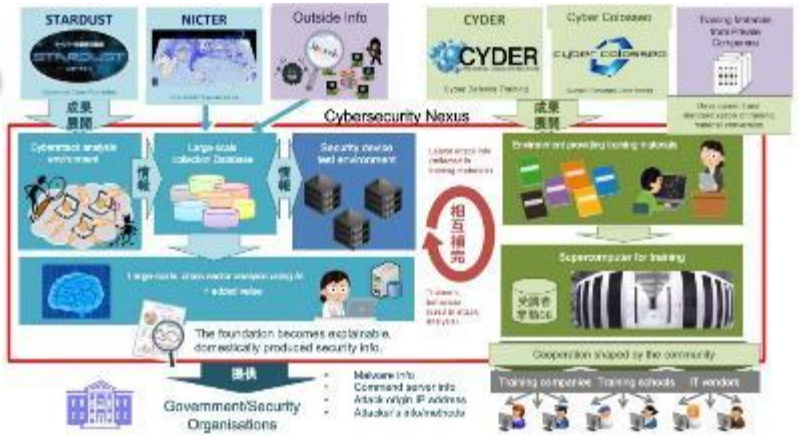


- NICT's R&D (Teraherts Wireless Comm., Multi-Core, Multi-Moder Fiber, Space-time Synchronization, etc.)
- B5G establishment of open testbeds
- International collaborations on B5G/6G development
- B5G R&D HUB (Industry-academia-government)
- B5G public call R&D funds

Quantum ICT

- Quantum security hub in Koganei
- NICT Quantum Camp for young students and professionals

Cybersecurity



- Establishment of Cybersecurity Nexus
- R&D hub for industry-academia-government collaboration for information gathering, analysis and personnel development

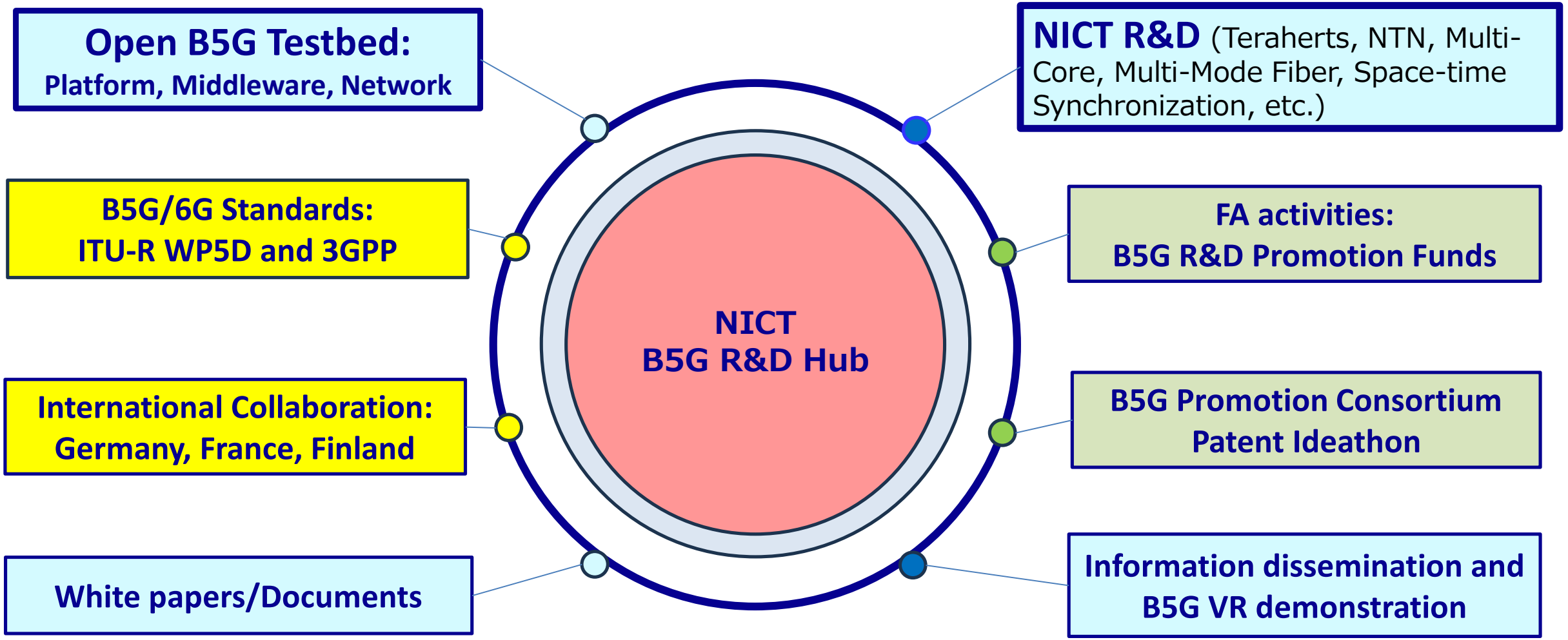
AI

- Establish AI (for language processing) computing facilities in the Keihanna region

Beyond 5G/6G, AI, Quantum ICT, and Cyber Security
will drive innovation in all aspects of daily life, industry, medical care, education, disaster prevention and the environment. These are an extremely important foundation for human-centered, sustainable, and inclusive society.

NICT Beyond 5G/6G R&D Status

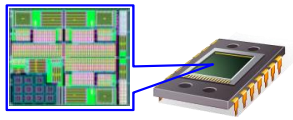
NICT's Activity in 2023



NICT R&D for Beyond 5G/6G

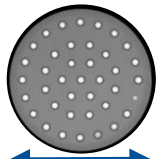
Teraherts Wireless Comm.:
Increasing the capacity of wireless communications

THz Band Silicon Semiconductor

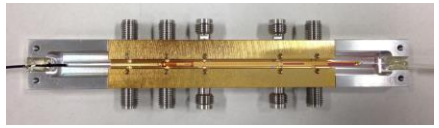


THz Band Compact antenna

Multi-Core, Multi-Mode Fiber
Increasing the capacity of the core network
Multi-core fiber, multi-mode fiber, etc.



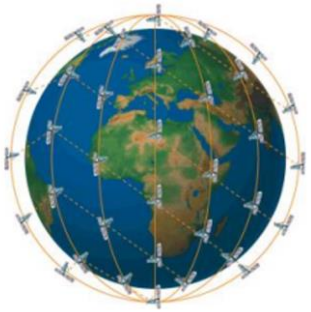
0.312mm

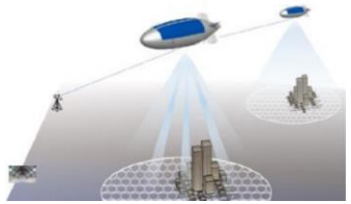


70mm

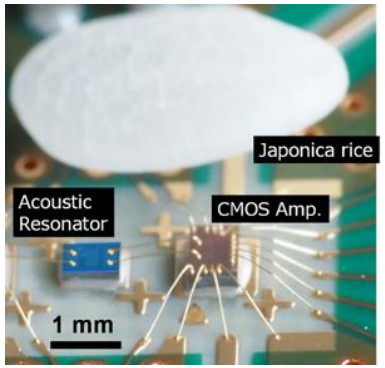
20mm

NTN: Coverage expansion
Satellite constellations, HAPS, etc.

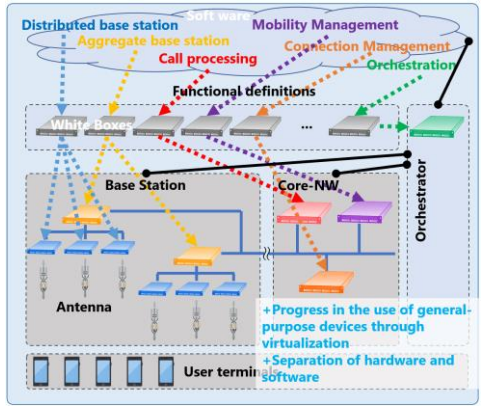




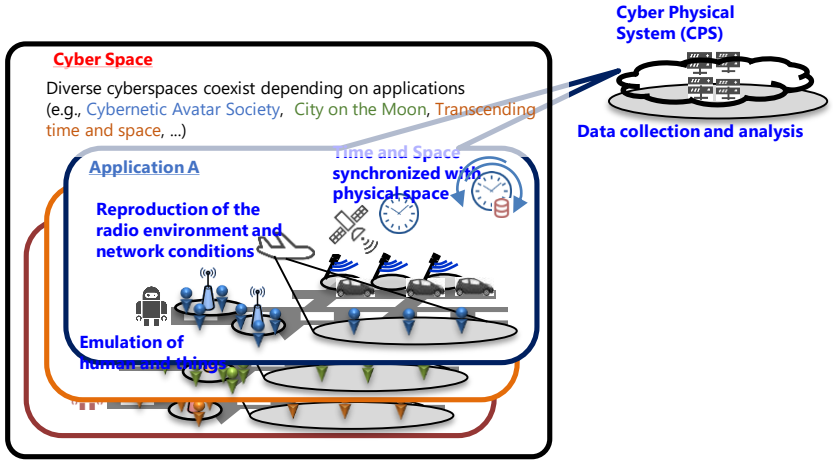
Space-time synchronization
+Inter terminal coordination
+Non-GPS location
+Remote synchronization



Virtualization
+Cloud native
+Highly available resource allocation
+Network Control with AI
+Autonomic networks



Network slicing
Network functions and resources can be dynamically managed and flexibly selected.



Space laser communication technologies applied for multi-layered networks in Beyond 5G

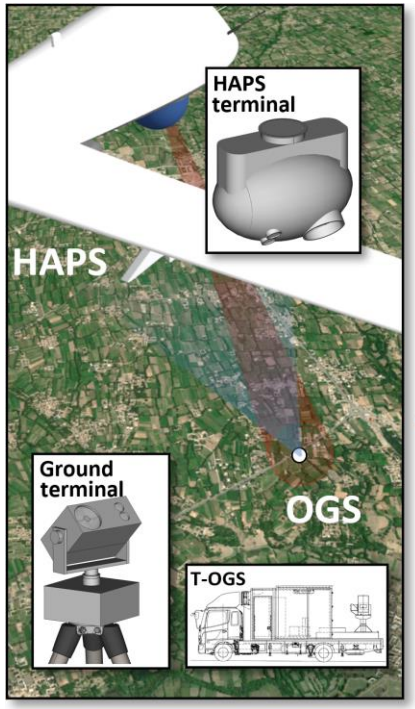
Compact optical communication terminals that can be utilized for any mobile platforms realize "ultra-high speed, large capacity" and “scalability" of Beyond 5G networks.

Overview

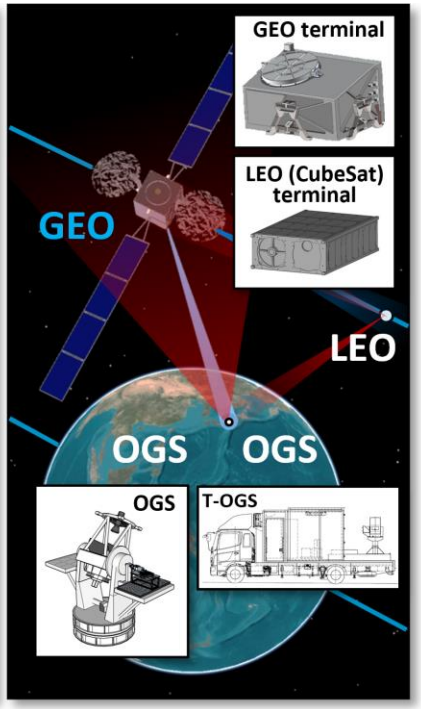
NICT aims for a variety of next-generation optical link scenarios:

GEO : Geostationary Earth Orbit　LEO : Low Earth Orbit
OGS : Optical Ground Station　T-OGS : Transportable-OGS
HAPS : High Altitude Platform Station

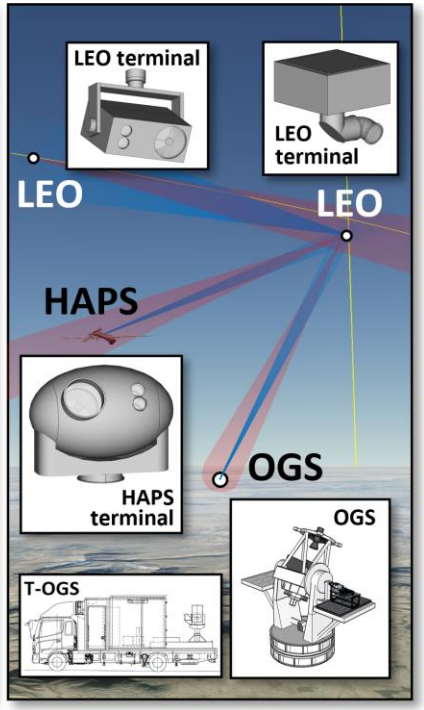
HAPS-OGS scenario



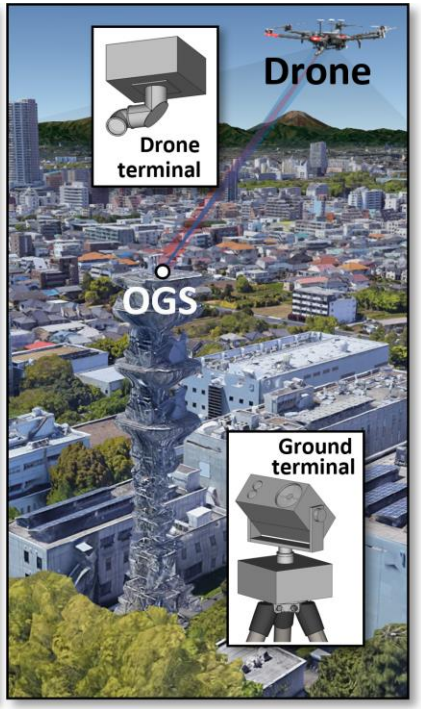
GEO-LEO/OGS scenario



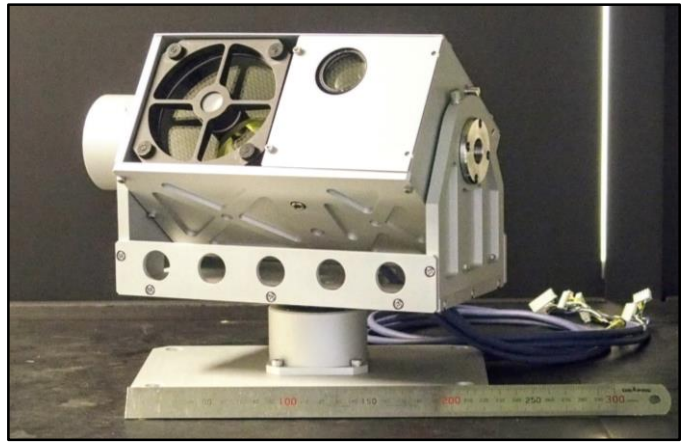
LEO-HAPS/OGS scenario



Drone-OGS senario



Prototype model of the optical terminal developed by NICT:



Examples:

- Space-Space (LEO-GEO): 1 Gbps
- Space-Space (LEO-LEO): 5 Gbps
- Space-Air (LEO-HAPS): 5 Gbps
- Space-Ground (LEO-OGS): 10 Gbps
- Air-Air (HAPS-HAPS): 2 Tbps

Feature

- Small optical terminals operate on space/aerial platforms
- Low SWaP (size, weight & power) with high performances
- Optical communication links between various platforms

Future

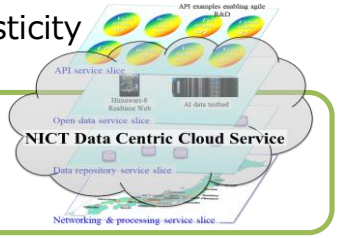
Verification of HAPS-ground, HAPS-HAPS, space-to-ground optical communication using 6U size CubeSat

Open B5G R&D Testbed

■ Extend and improve testbed environment to accelerate B5G R&D and promotion

- **B5G/IoT testbed with high-reliability and high-elasticity**
  - **The evaluations employing wired/wireless infrastructure as well as data analysis functions and wireless emulation functions**
- **Beyond 5G/6G Transmission Infrastructure Technology Development Environment**
- **Ultra-high-speed optical communication technology development facilities supporting Beyond 5G/6G**

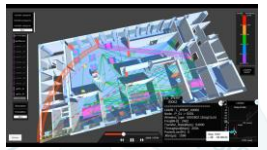
B5G/IoT testbed with high-reliability and high-elasticity



4. DCCS (Data Centric Cloud Service):
The environment for developing services on B5G era that utilize various data via the B5G network

Platform Layer

3. CyReal Proof Test Environment:
CyReal environment on STARBED harmonizing simulation, emulation and physical events



Middleware Layer

JGN

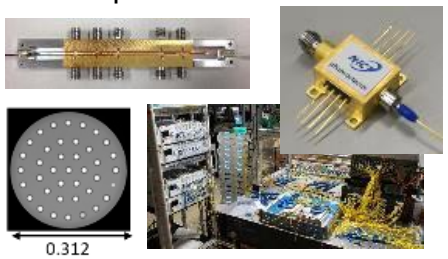
Network Layer

2. B5G Mobile Environment:
Verification environment on DU/CU and core parts with B5G hardware and software

1. B5G Reliable Virtualization Environment:
Virtual computing environment that utilizes HW resources extensively and prevents network service failures

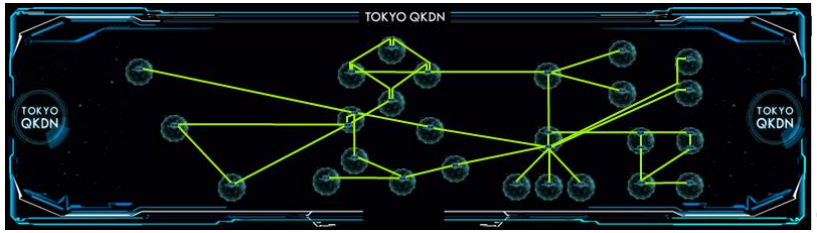
Terahertz Testbed

Ultra High Volume Optical Network

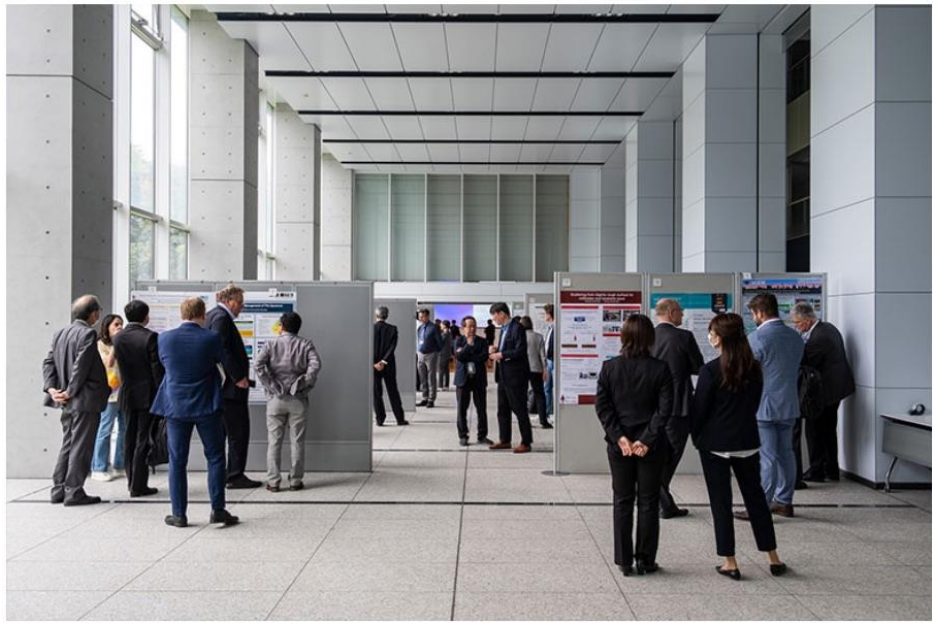


Optical Comm. Testbed

QKD Network



1st Germany-Japan Beyond 5G/6G Workshop
(April 24-25, 2023 @ NICT)



INRIA-NICT Workshop 2023 and new MoU

(INRIA-NICT Workshop @ 12/4-5/2023)

(INRIA-NICT MOU Signing Ceremony @ 6/16/2023/)

Information dissemination and demonstrations

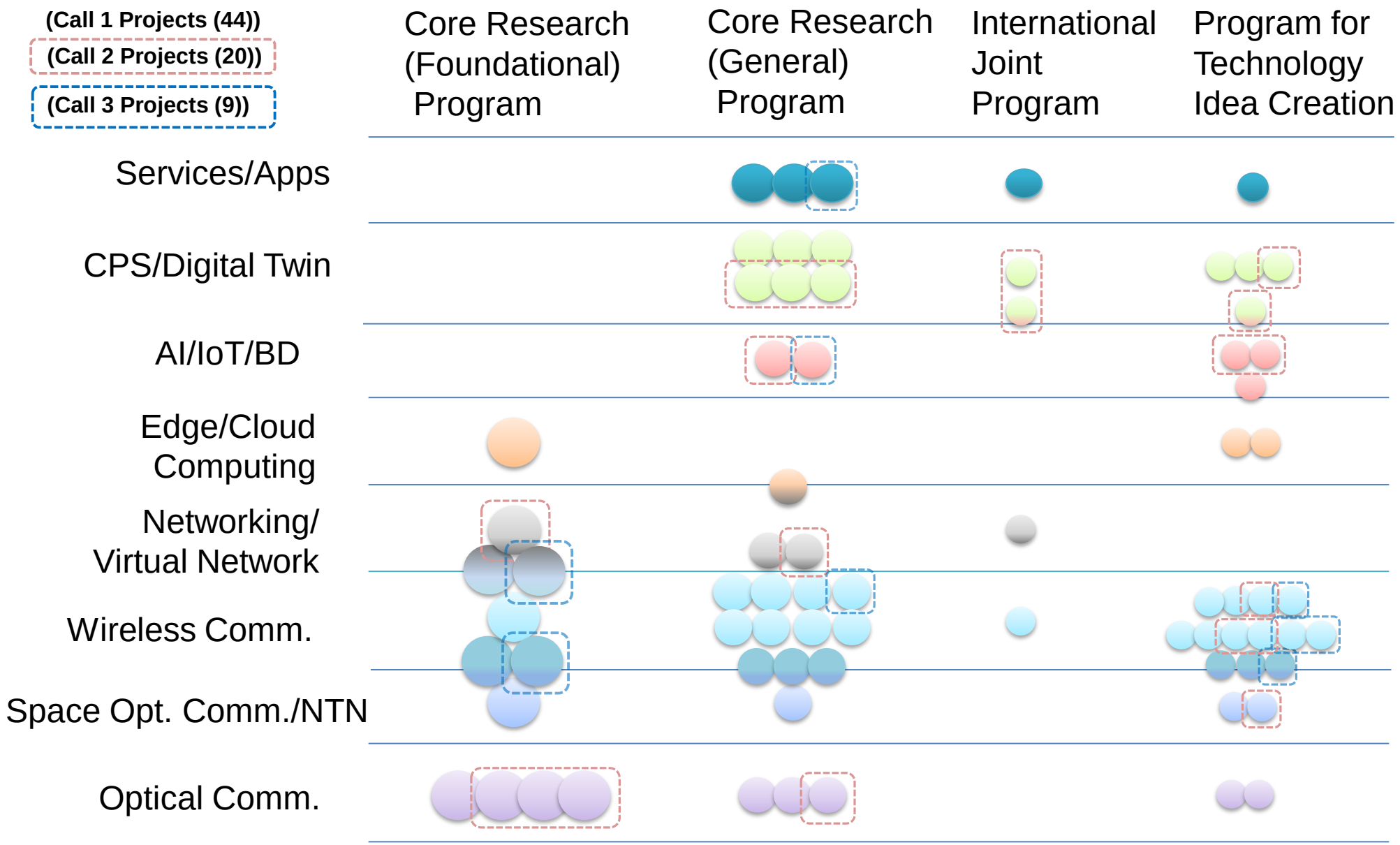
CEATEC2023: B5G Architecture, Terahertz demo, and Robots Applications

G7 Digital Ministerial Meeting in Takasaki: B5G VR Demo

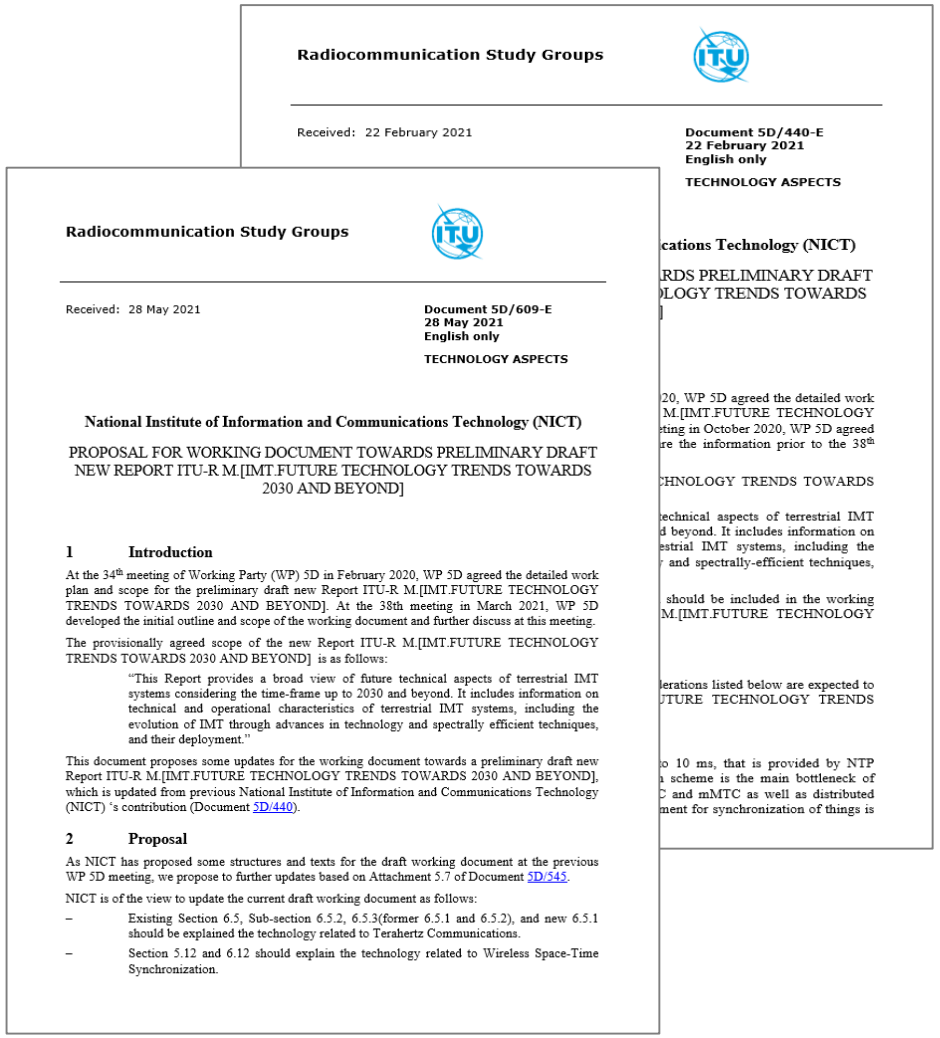
B5G Ideathon: B5G Zerogravity Meeting

Beyond 5G R&D Promotion Programs
Call 1,2,3 Portfolio (as of Jan. 2023)

(Call 1 Projects (44))
(Call 2 Projects (20))
(Call 3 Projects (9))



Proposal documents from NICT



Radiocommunication Study Groups

Received: 22 February 2021

Document 5D/440-E
22 February 2021
English only

TECHNOLOGY ASPECTS

cations Technology (NICT)

RDS PRELIMINARY DRAFT
LOGY TRENDS TOWARDS

Radiocommunication Study Groups

Received: 28 May 2021

Document 5D/609-E
28 May 2021
English only

TECHNOLOGY ASPECTS

National Institute of Information and Communications Technology (NICT)

PROPOSAL FOR WORKING DOCUMENT TOWARDS PRELIMINARY DRAFT NEW REPORT ITU-R M.[IMT.FUTURE TECHNOLOGY TRENDS TOWARDS 2030 AND BEYOND]

1 Introduction

At the 34th meeting of Working Party (WP) 5D in February 2020, WP 5D agreed the detailed work plan and scope for the preliminary draft new Report ITU-R M.[IMT.FUTURE TECHNOLOGY TRENDS TOWARDS 2030 AND BEYOND]. At the 38th meeting in March 2021, WP 5D developed the initial outline and scope of the working document and further discuss at this meeting.

The provisionally agreed scope of the new Report ITU-R M.[IMT.FUTURE TECHNOLOGY TRENDS TOWARDS 2030 AND BEYOND] is as follows:

"This Report provides a broad view of future technical aspects of terrestrial IMT systems considering the time-frame up to 2030 and beyond. It includes information on technical and operational characteristics of terrestrial IMT systems, including the evolution of IMT through advances in technology and spectrally efficient techniques, and their deployment."

This document proposes some updates for the working document towards a preliminary draft new Report ITU-R M.[IMT.FUTURE TECHNOLOGY TRENDS TOWARDS 2030 AND BEYOND], which is updated from previous National Institute of Information and Communications Technology (NICT) 's contribution (Document 5D/440).

2 Proposal

As NICT has proposed some structures and texts for the draft working document at the previous WP 5D meeting, we propose to further updates based on Attachment 5.7 of Document 5D/545.

NICT is of the view to update the current draft working document as follows:

– Existing Section 6.5, Sub-section 6.5.2, 6.5.3(former 6.5.1 and 6.5.2), and new 6.5.1 should be explained the technology related to Terahertz Communications.

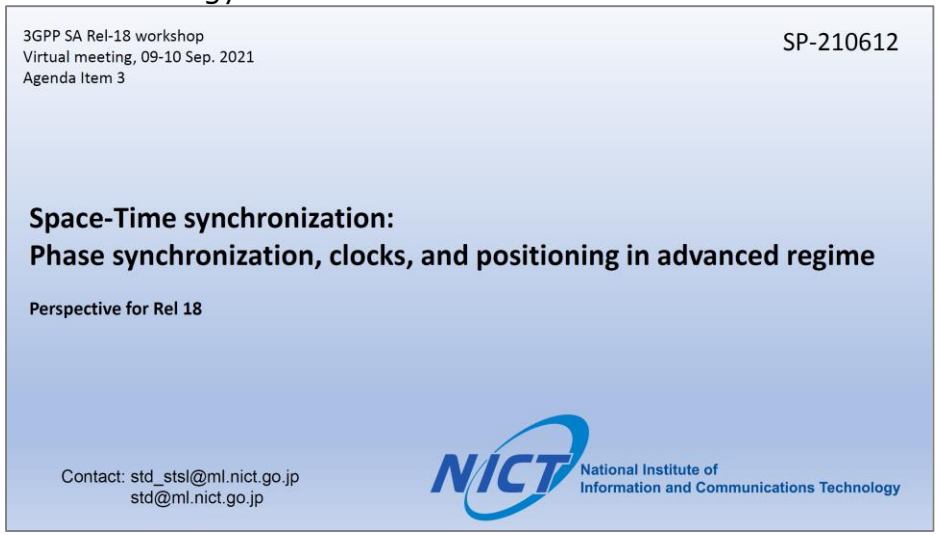
– Section 5.12 and 6.12 should explain the technology related to Wireless Space-Time Synchronization.

◀ Contributions to ITU-R WP5D (5D/440, 5D/609)

Proposals for the realization of Beyond 5G / 6G for Terahertz, Space-Time synchronization, and Non-Terrestrial Network (NTN).

▼ Contribution to 3GPP SA Rel.18 Workshop (SP-210612)

Proposal of ultra-low latency and high-precision positioning technology by Space-Time synchronization technology.



3GPP SA Rel-18 workshop
Virtual meeting, 09-10 Sep. 2021
Agenda Item 3

SP-210612

Space-Time synchronization:
Phase synchronization, clocks, and positioning in advanced regime

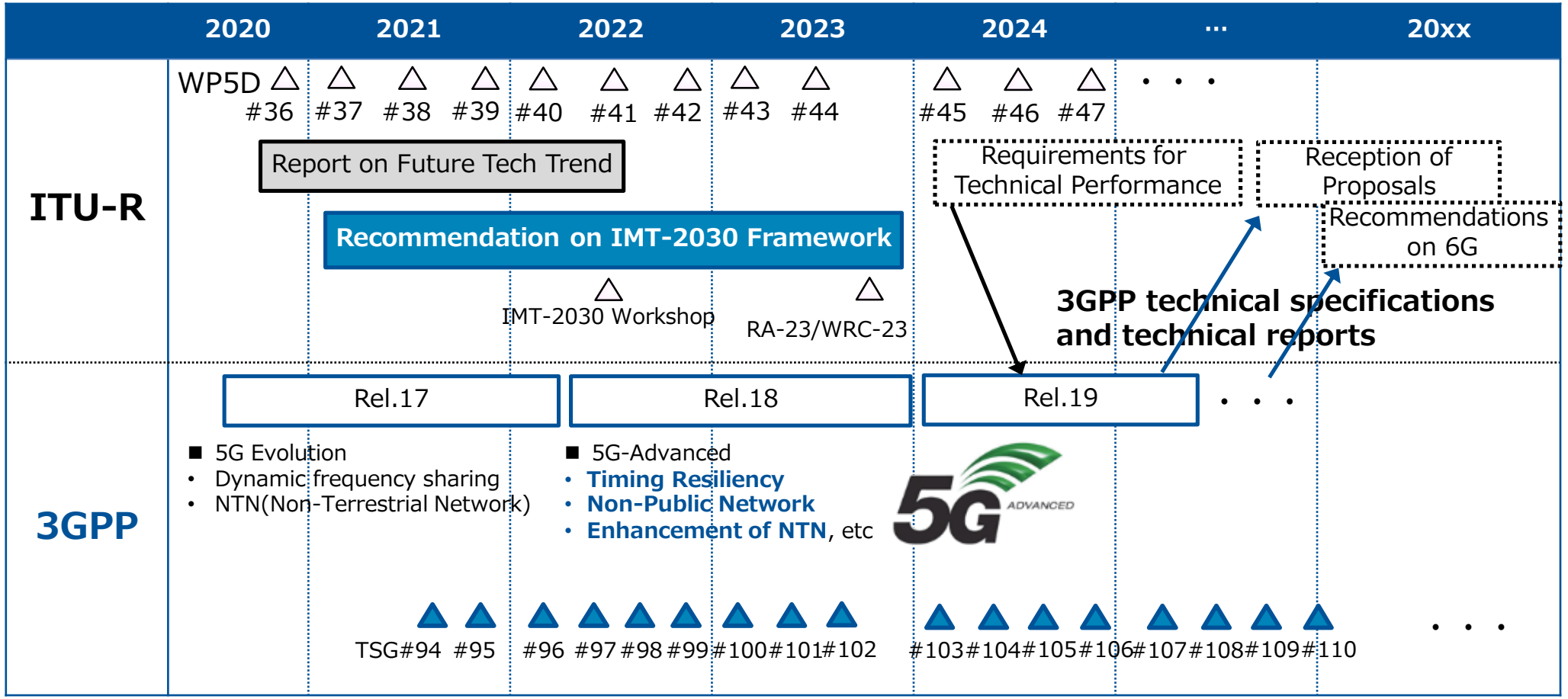
Perspective for Rel 18

Contact: std_stsl@ml.nict.go.jp
std@ml.nict.go.jp

National Institute of Information and Communications Technology

Standardization Activities on Beyond 5G/6G

- ITU-R SG5 WP5D completed the Report on Future Technology Trend for IMT-2030 in 2022.
- ITU-R approved the Recommendation on IMT-2030 Framework (M.2160) in November 2023.
- NICT proposed Terahertz (THz), Space-time synchronization and Non-Terrestrial Network (NTN) as technological seeds for Beyond 5G, and they were incorporated in the recommendation.



ITU-R Framework for IMT-2030 (M.2160)

- M.2160 recommends usage scenarios and capabilities of IMT-2030 (International Mobile Telecommunications), also known as 6G.
- The draft recommendation was agreed in WP5D, June, and in SG5, September, and approved in Radiocommunication Assemblies (RA) in November 2023.

1 Introduction

2 Trends of IMT-2030

2.1 Motivation and societal considerations

2.2 User and application trends

2.3 Technology trends

2.4 Studies on technical feasibility of IMT in bands above 100 GHz

2.5 Spectrum implications

3 Usage scenarios of IMT-2030

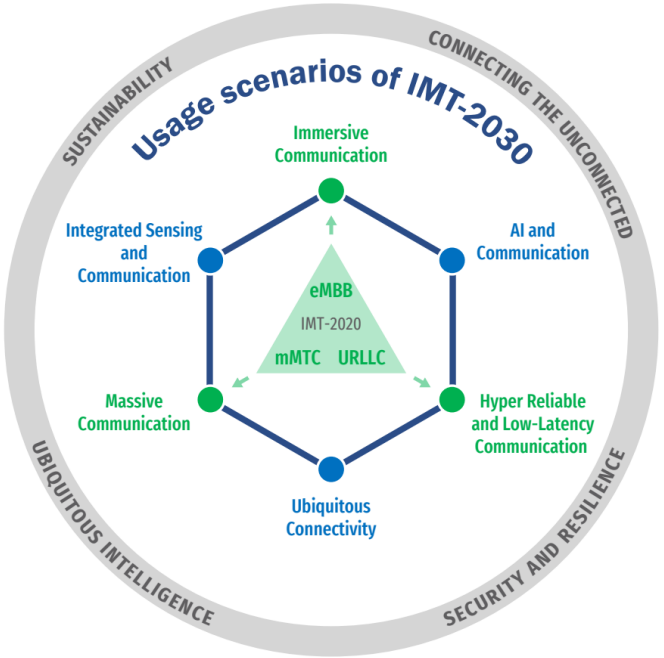
4 Capabilities of IMT-2030

5 Considerations of ongoing development

5.1 Relationships

5.2 Timelines

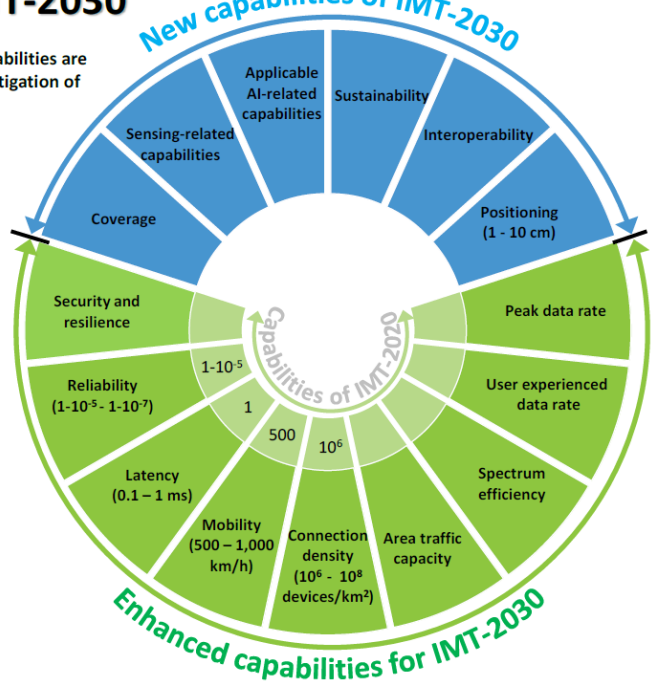
5.3 Focus areas for further study



Usage scenarios and overarching aspects of IMT-2030

Capabilities of IMT-2030

NOTE: The range of values given for capabilities are estimated targets for research and investigation of IMT-2030.



Capabilities of IMT-2030

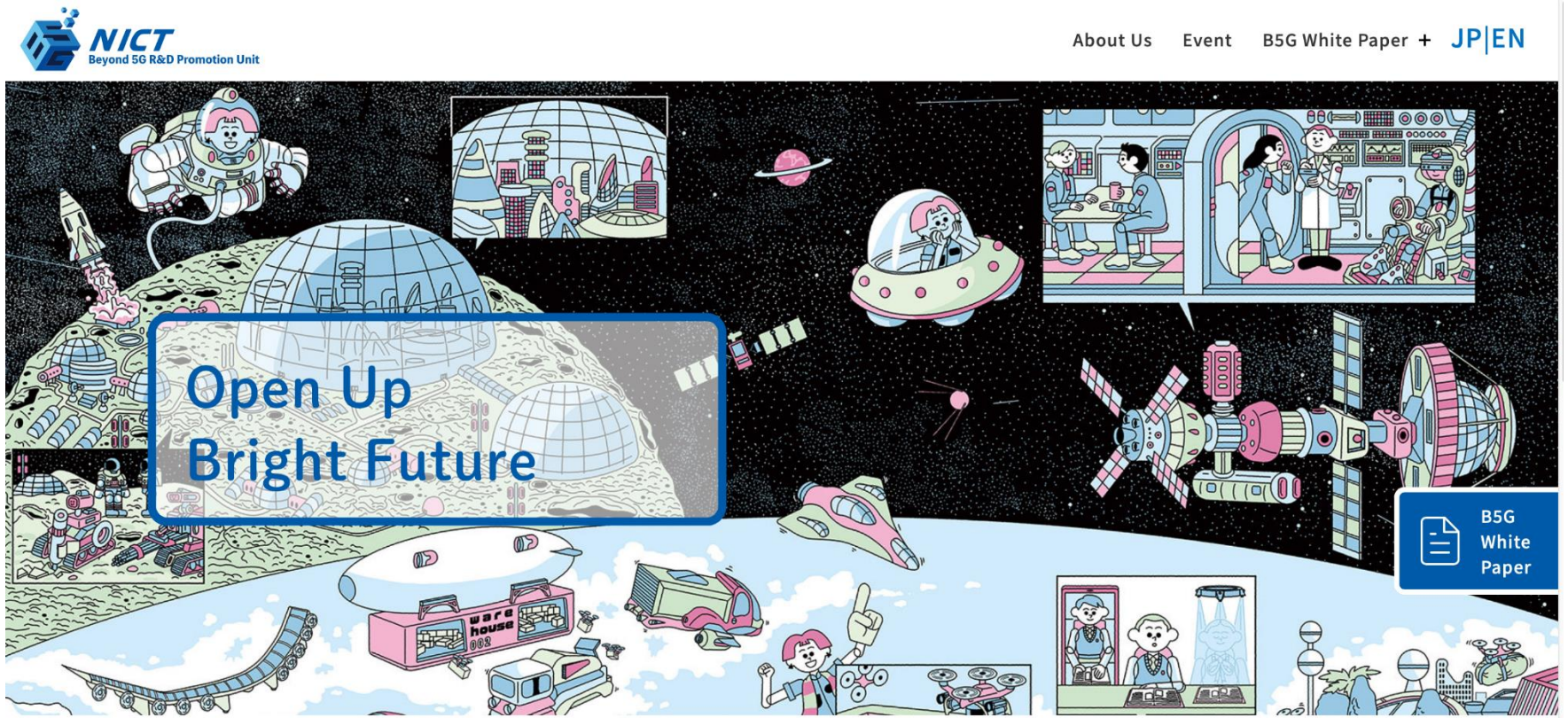
Beyond 5G/6G Trials/Demos in 2025

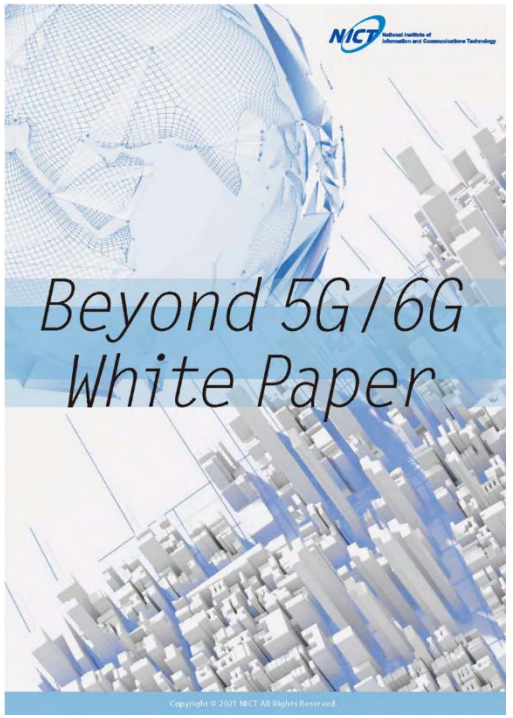
- **Connected B5G/6G testbed**
  - Development of radical 6G use cases in both testbed
  - Testing and Verifying 6G capabilities with these testbed

- **Joint Demonstrations**
  - **Expo 2025 Osaka, Kansai, Japan**
  - Demonstration of B5G/6G Interoperability
  - Demonstration of radical 6G use cases with interoperability

NICT B5G R&D promotion unit

(https://beyond5g.nict.go.jp/en/index.html)





Ver. 3.0 (June 2023)

https://www2.nict.go.jp/idi/#whitepaper

Thank you

NICT will continue to contribute to create a better society by ICT

www.nict.go.jp