Research and Development of Satellite-Terrestrial Integration Technology in Beyond 5G

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In "Beyond 5G" (i.e., the future generation of wireless technology that will succeed the current 5G networks), "Non-Terrestrial Networks" (NTN) are attracting attention from the perspective of scalability and wide coverage. An NTN connects different spaces—including space, air, and sea—through a multi-layered, diverse communication infrastructure consisting of satellites, high-altitude platform stations (HAPS), drones, and other equipment. Each component of the communication infrastructure that composes the NTN has different communication characteristics in terms of latency and stability, and it is expected that flexible communication links will be established according to the application. Moreover, standardization of NTNs has gained pace at the 3rd Generation Partnership Project (3GPP); in particular, the initial NTN specifications in Release 17 have been completed, and the further improvements from Release 18 onwards are being considered. In accord with these trends, efforts toward the commercialization of integrated satellite links and 5G/Beyond 5G networks are intensifying both domestically and internationally.

In 2019, the National Institute of Information and Communications Technology (NICT) established the "Study Group on the Collaboration between Satellite Communications and 5G/Beyond 5G." Including a wide range of organizations, including domestic satellite operators, terrestrial mobile operators, satellite-related manufacturers, universities, research institutions, and standardization organizations, this study group focused on effective use cases, technical challenges and solutions, evaluation and demonstration, and standardization related to the collaboration between satellite communications and 5G/Beyond 5G[1].

Moreover, with the aim of strengthening Japan-Europe cooperation in the NTN field, NICT has signed a Letter of Intent (LoI) with the European Space Agency (ESA) and is promoting research and development of NTN technology from a global perspective and continuing efforts toward implementing communication infrastructure.

Under these circumstances, NICT launched the research project "Research and Development of Satellite-Terrestrial Integration Technology in Beyond 5G" under its commissioned research and development program for advanced communications and broadcasting, and it promoted the project from 2020 to 2024 in collaboration with Japan Radio Co., Ltd., SKY Perfect JSAT Corporation, and The University of Tokyo[2]. In this project, under a Japan-Europe cooperation framework based on the aforementioned LoI with the ESA, the Japanese and European partners collaborated on the demonstration experiments described below.

In the first phase of the project, Phase 1 (FY2020-FY2021), a Japan-Europe joint experiment on integrated satellite-5G control, including a geostationary (GEO) satellite link—Japan's first such experiment—was conducted from January to February 2022 [3][4]. In this experiment, a Japan-Europe joint trial testbed was constructed and used to demonstrate the transmission of 4K video and Internet of Things (IoT) data. Specifically, the experiment demonstrated that communication sessions could be established by using control signals between the customer-premises equipment (CPE, i.e., 5G-enabled gateway) in Japan and the 5G core in Europe even under the influence of delays associated with long-distance transmission using satellite links and Japan-Europe terrestrial links. It also confirmed that data

acquired by 4K cameras and IoT sensors on the Japanese side could be transmitted to laptops and data servers on the European side, and the operability of the satellite-5G network was evaluated by measurements of network quality in each transmission section.

In the second phase of the project, Phase 2 (FY2022-FY2024), following up on the basic demonstrations performed in Phase 1, a disaster use case connecting a GEO satellite link, low Earth orbit (LEO) satellite links, and local 5G was demonstrated. To evaluate the interoperability of satellites and 5G-control technology, a proof-of-concept experiment using path control, satellite Quality of Service (QoS) control, and slicing technology was conducted, and the results of the experiment demonstrate that dynamic backhaul-path switching and QoS control were successful[5].

This special feature details the results obtained from the demonstration experiments conducted in Phase 2 of this commissioned research project. SKY Perfect JSAT will provide an explanation titled "Demonstration and Evaluation of Local 5G with GEO/LEO Backhaul: Implementing High Reliability and High Capacity," and the University of Tokyo will explain "Enhancing Local 5G Resilience through Satellite-Terrestrial Integrated Backhaul and Adaptive Resource Control."

Aiming to Implement a three-dimensional network that connects land, sea, air, and space in a multi-layered manner, NICT will further deepen its collaborations with domestic and international companies, universities, and research institutions to promote the research, development, and implementation of satellite-to-terrestrial integration technology and NTN technology in the Beyond 5G era from a global perspective.

References

[1] Report of the Study Group on the Collaboration between Satellite Communications and 5G/Beyond 5G, https://www2.nict.go.jp/wireless/sat5g-scl.html (in Japanese)
[2] NICT: Research and Development of Satellite-Terrestrial Integration Technology in Beyond 5G, Commissioned Research on R&D of Advanced Communications and Broadcasting, https://www.nict.go.jp/collabo/commission/k_21901.html (in Japanese)
[3] NICT Press Release: Successful Japan-Europe Joint Experiment on Integration of Satellite Links in Japan-Europe Long Distance 5G Network (June 8, 2022), https://www.nict.go.jp/en/press/2022/06/08-1.html
[4] Keisuke Saito et al., "Evaluation of Network Performance for 4K Video Streaming with Satellite and 5G interconnection in Japan-Europe Joint Experiment," 39th International Communications Satellite Systems Conference (ICSSC2022), 2022.
[5] NICT Press Release: Proof-of-Concept Achieved for Satellite-5G Networks Utilizing Adaptive Routing and Quality Management (October 9, 2025), https://www.nict.go.jp/en/press/2025/10/09-1.html

Cover Art

The Pride of Tokyo's Twelve Months: June, Morning Glories at Iriya

Tsukioka Yoshitoshi
(1839-1892)

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