FY2024

XG Mobile Promotion Forum Report of Working Activities on NTN Promotion Project in FY2024

31 March 2025

XG Mobile Promotion Forum

NTN Promotion Project

Contents

Chapter 1 Introduction

1.1 Purpose of the NTN Promotion Project

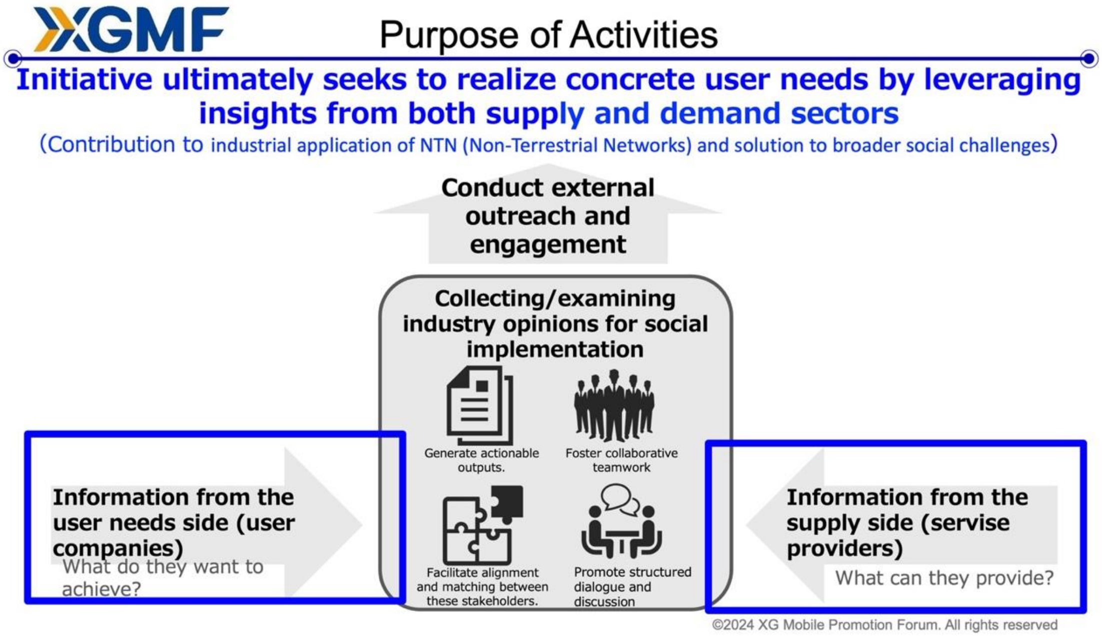
In Chapter 2 of the Integrated Innovation Strategy 2023, set by the Cabinet on June 9, 2023, the goal is established to achieve a transformation towards a sustainable and resilient society that ensures the safety and security of the people. The goal is to "complete the 'Data Strategy' and transform society into one where cyber and physical spaces create a dynamic virtuous cycle, allowing anyone, anywhere, at any time, to safely utilize data and AI to create new value." In line with this, the development and research of next-generation infrastructure and data and AI utilization technologies suitable for the digital society are being promoted.

According to the 2024 Information and Communications White Paper, "The rapid proliferation of Artificial Intelligence (AI) and the expansion of the use of digital technologies such as robotics have led to an increased demand for instantaneous processing and decision-making. As societal needs for such capabilities rise, the requirements for information and communication networks are becoming even more stringent, with elements such as low latency, reliability, and resilience being of increasing importance. In particular, new approaches, such as 'AI Constellations' — decentralized AI systems where multiple AIs collaborate through networks — have emerged. To realize such systems, there is a need for the establishment of more advanced network functions and the deepening of collaboration between computing resources and networks.

The Ministry of Internal Affairs and Communications' "Strategy for Information and Communication Technology Toward Beyond 5G" identifies all-optical network technology and Non-Terrestrial Network (NTN) technology as critical technological areas. NTN technology, in particular, is expected to significantly contribute to the realization of advanced communication capabilities beyond 5G. As a new communication method that does not depend on terrestrial communication infrastructure, NTN technology holds the potential to surpass traditional communication domains by utilizing space and the stratosphere.

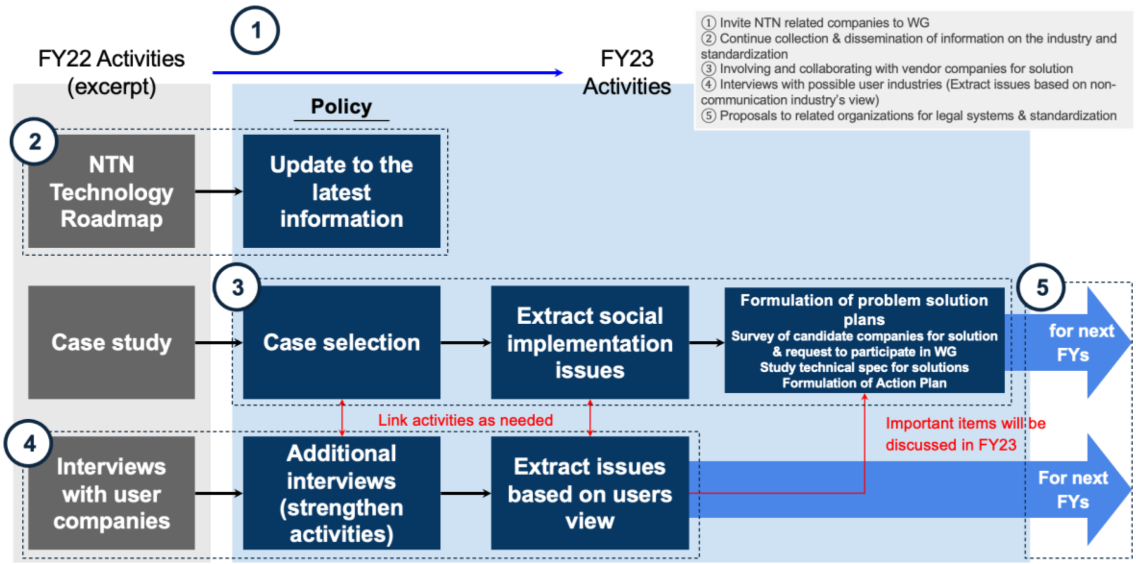
As part of the efforts to advance NTN technology, the Beyond 5G Promotion Consortium's Scalability Working Group under the XG Mobile Promotion Forum has actively engaged in discussions and activities to contribute to the spread of NTN, working with NTN stakeholders from various industries. The "FY2023 Scalability Working Group Report" was finalized on March 31, 2024, and the working group was subsequently dissolved in an evolving manner. In response, the NTN Promotion Project Working Group was newly organized on April 1, 2024, to further advance NTN technology and move to the next phase.

The main objectives of the NTN Promotion Project can be divided into two areas. The first is to accelerate the deployment of information and communication networks by leveraging NTN technologies, including High Altitude Platform Stations (HAPS) and satellite communications. To achieve this, the project aims to provide opportunities for dialogue and value sharing with potential users, clarify technical requirements based on user needs, and contribute to solving industrial and societal challenges through the examination of use cases. The second objective is to promote global collaboration and build a co-creation cycle for NTN. This includes sharing common challenges of NTN, exploring solutions, and promoting the dissemination of NTN technology while ensuring Japan takes international leadership in NTN technology. Furthermore, the project seeks to strengthen collaboration with other initiatives, promote cooperation across different fields, and contribute to international cooperation and standardization activities.



1.2 Efforts Up to Last Year

The participating companies from the previous year included Ericsson Japan, SoftBank, VIAVI Solutions, Huawei Technologies Japan, and Rakuten Mobile. Under the leadership of Mr. Toyoshima (NICT), active efforts were made for information exchange between the participating companies, updating the landscape map, and promoting NTN dissemination activities. The detailed division of roles is as follows.



Activities	Initiatives	Kickoff 8/30	① 9/19	② 10/31	③ 11/21	④ 12/19	⑤ 1/30	⑥ 2/20	GM 3/8
① Invite NTN companies to WG	Recruitment to join the WG at international Committee								
	Individual briefing for applicants								
② Continue collection & dissemination of information on the industry and standardization	Information exchange among participants		★	★	★	★	★	★	
	Update NTN Technology Roadmap			Update as needed					
	Creation and publication of WG activity reports					➡ ★	➡ ★	⇨ ☆	
	Posting on website (Including derivatives from other activities & English translation)								◆
③ Involving and collaborating with vendor companies for solution	Select use cases	◎	➡ ★	⇨ ☆					
	Extract social implementation issues		◎	➡ ★	⇨ ☆				
	Survey of candidate companies for solution			◎	➡ ★	⇨ ☆	Jan 23		
	Request candidates to participate in WG				→	→→ →	→→		
	Formulation of technology specifications & Action Plan				◎	➡ ★	➡ ★	⇨ ☆	
④ Interviews with possible user industries (Extract issues)	Select interviewee and interview contents	◎	➡ ★	⇨ ☆	Update as needed				
	Interview request and execution			→→ →	★⇨ ☆	➡ ★	⇨☆		
	Extract issues based on the results and addition of use cases				◎	➡ ★	➡ ★	⇨ ☆	
⑤ Proposals to related organizations for legal systems & standardization	Summary on required legal development			Record discovery through activities accordingly (consider legal system/standardization schedule)					
	Summary on required standardization								

【Note】◎:Policy decision ➡:Study; ★:Presentation, discussion, interview →:Coordination ⇨ summarization; ☆Check summary

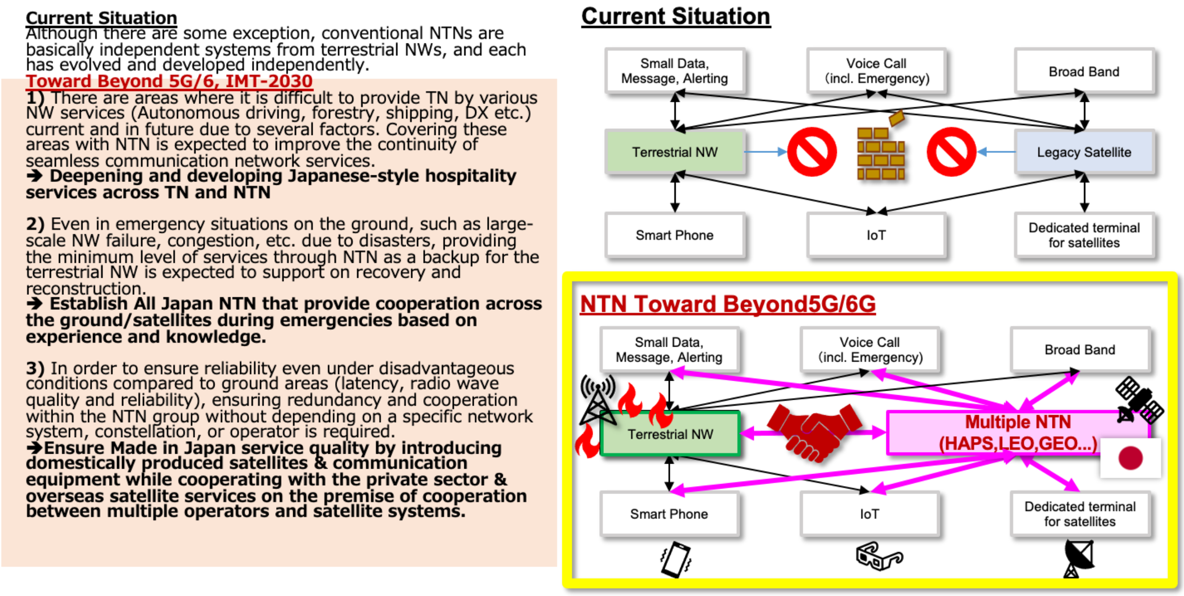
Activities	Initiatives	Coordinators
① Invite NTN companies to WG	Recruitment to join the WG at international Committee	-
	Individual briefing for applicants	-
② Continue collection & dissemination of information on the industry and standardization	Information exchange among participants	Secretariat［Data collection & projection at Regular Meeting］
	Update NTN Technology Roadmap	Rakuten Mobile
	Creation and publication of WG activity reports	VIAVI Solutions
	Posting on website (Including derivatives from other activities & English translation)	Secretariat［Data collection (Including format adjustment)］
③ Involving and collaborating with vendor companies for solution	Select use cases	Softbank
	Extract social implementation issues	Softbank
	Survey of candidate companies for solution	VIAVI Solutions
	Request candidates to participate in WG	-
	Formulation of technology specifications & Action Plan	Huawei Japan
④ Interviews with possible user industries (Extract issues)	Select interviewee and interview contents	Ericsson Japan
	Interview	Ericsson Japan
	Extract issues based on the results and addition of use cases	Space Compass (HAPS), KDDI (satellite)
⑤ Proposals to related organizations for legal systems & standardization	Respond as needed in ②-④ activities	WG leader

Observers	Tokyo Metropolitan University (Professor Shoken Ishii), NTT Docomo, Nokia

1.3 Issues Identified Through Last Year's Activities

Through the activities of the Scalability Working Group in the previous year, several key points emerged. Discussions with industry sectors on the use cases of HAPS and satellite communications, as well as debates on the image of NTN, highlighted the challenge of how Japan should engage internationally in the NTN field. It was recognized that, in order to realize an "All Japan" approach, further identification of issues and continued efforts to discover new services are essential. The following points were identified as common understandings for achieving "All Japan":

- Reliance on devices that can only be used with specific LEO constellations presents a high risk.
- Full dependence on overseas satellite operators is concerning. It is desirable for Japan to also possess its own independent network.
- It would be beneficial if the same device could utilize services from different LEO constellations.
- Furthermore, it would be advantageous if the same device could connect to GEO, LEO, HAPS, and terrestrial networks.
- To realize this, standardization on both the device side and the network provider side is necessary (though it is not guaranteed that entities like Starlink will comply).
- Devices will likely be standardized in three major categories: small IoT devices (low power consumption), mobile devices (e.g., smartphones), and large devices (for high-speed communication).
- It is necessary for Japan to prepare for network construction with these developments in mind.
- Given Japan's geographical characteristics (with 70% of the land being mountainous or hilly, possessing the world's sixth-largest Exclusive Economic Zone (EEZ), and being a disaster-prone country), there will be numerous opportunities for utilizing NTN. It is desirable to continue the development of services tailored to specific use cases.

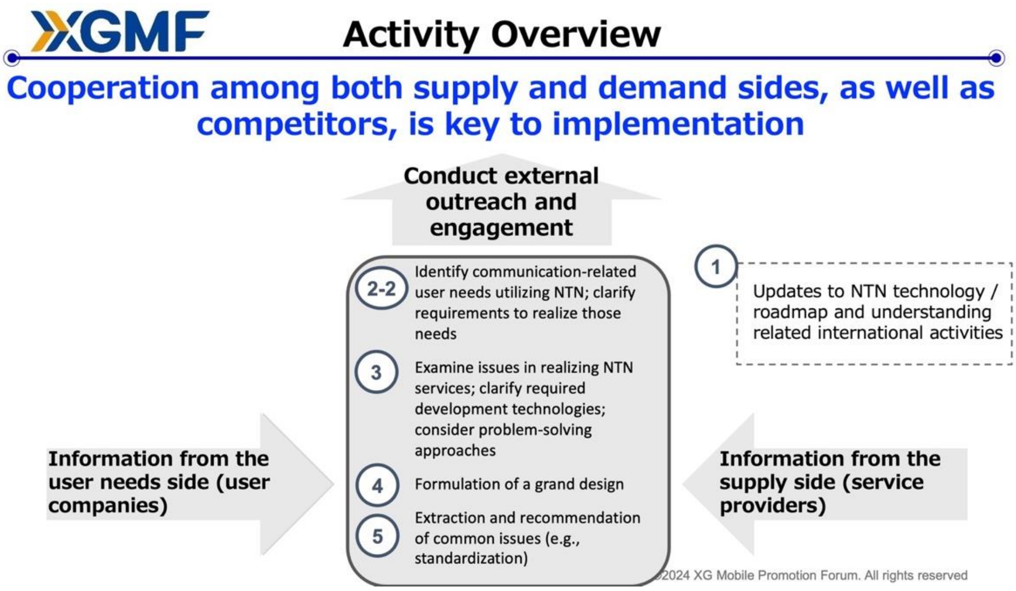


Chapter 2 Activities Policy for This Year

Based on the activities and challenges identified in the previous year, the following activities were carried out in the current year, including eight meetings, one of which was an exchange of views with users in the maritime sector. The activity report will be presented in the following chapters.

- Update of the NTN Technology Roadmap (updating with the latest information and primarily revising the HAPS section)
- Monitoring of relevant activities in foreign countries (investigating 6G-NTN activities, understanding the situation in South Korea, etc.)
- Identification of user needs related to communications utilizing NTN and clarification of the requirements needed for realization (held discussions with ten users involved in the maritime sector. Examined the requirements and challenges necessary to fulfill the identified needs and considered existing technologies/services that could be utilized)
- Examination of the challenges to realizing NTN services, clarification of technologies to be developed, and consideration of solutions/responses (referencing the opinions from the exchange meetings, organized the challenges and solutions necessary to realize services. Reviewed the requirements for detailed design of inter-company collaboration architecture through TN-NTN integrated control technology)
- Development of a Grand Design (discussed a future vision that overlooks the technologies and solutions expected for next-generation NTN)
- Extraction and proposal of common challenges beyond industry boundaries (discussed common institutional challenges identified from user needs)

In relation to last year's efforts, the meeting schedule, and the companies responsible for summarizing each challenge are listed below. As with last year, discussions were actively conducted with the lead of the project, Dr. Toyoshima (NICT), and the summarizing companies, with participation from all members.



Overall Schedule

【Legend】◎: Planning approach; ➡: Review; ★: Presentation/Discussion;
→: External Coordination; ⇨: Summarization; ☆: Summary Review;
■: Opinion Exchange,
and Yellow background: Activities initiated after opinion exchange meetings

Activities	Initiatives	Kickoff 7/25	① 8/27	② 10/3	③ 11/7	④ 12/19	⑤ 1/16	⑥ 1/30	⑦ 2/27	GM March
①Updates to NTN technology / roadmap and understanding related international activities	a. Update of the NTN technology roadmap［↑⇦］		Update as necessary							
	b. Identification of related international activities［↑⇦］		◎	Update as necessary						
②Identify communication-related user needs utilizing NTN; clarify requirements to realize those needs	a. Understanding user needs (continued opinion exchange meetings)［➡］※ **with/without being constrained by industry boundaries**	◎	➡ ★	⇨☆→	→→■	Marine sectors			→→■	Other related sectors
	b. Presentation of applicable existing technologies［⇦］					◎➡	★⇨	☆	Update as necessary	
	c. Invited lectures from groups conducting R&D related to NTN［⇦］		NICT★	As appropriate						
	d. Clarification of requirements necessary to meet user needs［●］					◎➡	★⇨	☆	Update as necessary	
③Examine issues in realizing NTN services; clarify required development technologies; consider problem-solving approaches	a. Examination of issues in realizing NTN-based services and identification of technologies required for development［●］						◎➡	★⇨	☆	
	b. Consideration of solutions and countermeasures for key challenges［●］						◎➡	★⇨	☆	
	c. Examination of inter-company collaboration architecture［●］		Define	◎➡	As appropriate				☆	
④Formulate a grand design	Formulation of a grand design［●］	◎	➡ ★	⇨☆			◎➡	★⇨	☆	
⑤Extract and recommend common industry-agnostic issues (e.g., standardization)	Identification and proposal of cross-industry issues (e.g., standardization)［●］		As appropriate					As appropriate		
⑥External Engagement	a. Implementation of solutions and countermeasures［↑］		As appropriate							
	b. Participation in and organization of relevant events［↑］									
Activity repot	Preparation of materials for website updates on meeting activity status		Preparation						Preparation	
	Preparation of the final report									Preparation

Detailed overview of activities and consolidation

Activities	Initiatives	Products	Coordinator
XGMF project office	a. Meeting Planning (Scheduling, Venue Arrangement, Online Setup, Invitations, Attendance Management)	Notice of meeting	Softbank
	b. Preparation of Meeting Materials and Facilitation	Projection materials	Softbank
	c. Meeting Minutes	Meeting Notes	Rakuten Mobile
① Updates to NTN technology / roadmap and understanding related international activities	a. Update of the NTN technology roadmap［↑⇦］	NTN technology roadmap (Latest Version)	Rakuten Mobile
	b. Identification of related international activities［↑⇦］	Summary of international activities	Huawei Japan
② Identify communication-related user needs utilizing NTN; clarify requirements to realize those needs	a. Understanding user needs (continued opinion exchange meetings)［➡］※ **with/without being constrained by industry boundaries**	Grand design	Softbank
	b. Presentation of applicable existing technologies［⇦］	Grand design	Softbank
	c. Invited lectures from groups conducting R&D related to NTN［⇦］	Presentation materials	NICT
	d. Clarification of requirements necessary to meet user needs［●］	Grand design	SAHRP
③ Examine issues in realizing NTN services; clarify required development technologies; consider problem-solving approaches	a. Examination of issues in realizing NTN-based services and identification of technologies required for development［●］	List of challenges	Space Compass
	b. Consideration of solutions and countermeasures for key challenges［●］	List of challenges	Space Compass
	c. Examination of inter-company collaboration architecture［●］	Interface-related documents	NICT
④ Formulate a grand design	Formulation of a grand design［●］	Grand design	NOKIA
⑤ Extract and recommend common industry-agnostic issues (e.g., standardization)	Identification and proposal of cross-industry issues (e.g., standardization)［●］	List of challenges connecting to Grand design	Space Compass
⑥ External Engagement	a. Implementation of solutions and countermeasures［↑］	As appropriate	NTT Communication
	b. Participation in and organization of relevant events［↑］	As appropriate	NTT Communication
⑦ Activity repot	Preparation of materials for website updates on meeting activity status	Documents for home page	NICT
	Preparation of the final report	Report (JP/EN)	Tokyo Metropolitan Univ.

Chapter 3 Update of the Technology Roadmap and Global Trends

3.1 Key News After 2024

Satellite Broadband

Geostationary Satellite

- SKY Perfect JSAT Signs Procurement Agreement with Thales Alenia Space for Full Digital Satellite JSAT-31. (SKY Perfect JSAT, May 27)
- The first Viasat-3 started service on August 5, 2024 (capacity degraded due to antenna deployment failure). (Viasat, August 5)
- SKY Perfect JSAT signs communications satellite procurement contract with Thales (France, March 11, 2025)

LEO Constellation

- Starlink launches new D2C-enabled satellite. (SpaceX, June 4)
- Amazon announces that Project Kuiper's initial service launch will be delayed to 2025 (Space News, June 27)
- AST Space Mobile Obtains Commercial Satellite Launch Permit From FCC (AST SpaceMobile, August 5)
- Softbank announced to initiate Eutelsat OneWeb service on December 2024 (SoftBank, September 3)
- Hawaiian Airlines Launches In-Flight Wi-Fi Offering by using Starlink (Hawaiian Airlines, September 24)
- Starlink has over 4 million subscribers. (Starlink, September 27)
- Constellation Chiho by China's Shanghai Kakinobu Satellite Technology (SSST) launches its first 18 satellites on August 6 (Space News, August 6) and launches next 18 satellites on October 15 (Space News, October 15)
- SKY Perfect JSAT and Planet Labs Collaborate to build Low-Orbit Satellite Constellation with USD 230 Million (SKY Perfect JSAT, February 5, 2025)
- Communications NBN considers entering low-Earth satellite market (Australia, February 14, 2025)
- Amazon launches first Kuiper internet satellite (CNBC, April 28, 2025)

Satellite Mobile Direct

- AT&T, AST Space Mobile Officially Sign Partnership. (AT&T, May 15)
- Verizon teams up with AST Space Mobile for Satellite Communications Services (AST SpaceMobile, May 29)
- AST Space Mobile announced Satellite and Mobile Phone Direct Communications Details

(AST SpaceMobile, July 1)

- Emergency SOS via satellite by iPhone 14 or later models starts on July 30 in Japan. (Apple, July 30)
- Verizon announces alliance with Skylo. Efforts to launch satellite text sending and receiving service using 3GPP R-17 IoT-NTN compliant devices (Verizon, August 28).
- AST SpaceMobile successfully launched five commercial satellites on September 12. (AST, September 12) In October, Phased Array Antenna was successfully deployed. (AST, October 26)
- iOS 18 can send and receive text via satellite on iPhone 14 and later models (US and Canada only). (Apple, September 16)
- 3GPP accepts Iridium's request to extend NB-IoT for NTN as an official work item in 3GPP Release 19 (Iridium, September 25)
- FCC permit provisionally to use Starlink Direct to Cell in U.S. Hurricane Disaster Areas. (SpaceX, October 9)
- KDDI successfully transmits and receives SMS by direct communication between au smartphone and Starlink satellite in an experimental environment on Kumejima, Okinawa. (KDDI, October 24)
- Apple invests $1.5 billion in Globalstar to build new constellation (Via satellite, November 1)
- FCC Allows Conditional Commercial License for Starlink Direct to Cell Services in the U.S. (SpaceX, November 27)
- One NZ Launches Starlink Direct to Cell Service in New Zealand (One NZ, December 19)
- KDDI Obtains permission to launch Radio wave emission for Starlink Direct to Cell Service (KDDI, December 25)
- Vodafone Releases World's First Test of Satellite Video Calls, Connects Satellites and Smartphones directly to call in Regions Where Mobile Phones can't Reach (Vodafone, January 29, 2025)
- T-Mobile will start offering services that connect satellites and cell phones directly from July (T-Mobile, February 9, 2025)
- au launches "au Starlink Direct," a direct communication service between satellites and smartphones, covering the entire country of Japan (KDDI、Okinawa Cellular Telephone, April 10, 2025)

Satellite IoT

- Hubble Network successfully connects by Bluetooth from space (Hubble Network, April 29)
- OQ Technology launches two additional satellites. The number of satellites are total 10. (OQ Technology, March 10)
- Sateliot launches four additional satellites on August 16. (Sateliot, August 17)
- Solacom launches NTN IoT service compliant with 3GPP Rel-17 using Skylo's network (available in North America, Europe, and Oceania). (Soracom, July 17)

HAPS

- Succeeded in 5G communication experiment, simulating HAPS using small aircraft (4 business operators, SKY Perfect JSAT, NTT DoCoMo, NICT, Pana HD). (WING, May 29)
- NTT DoCoMo and Space Compass announce launch of HAPS service in 2026 (Space Compass, June 3)
- SoftBank successfully demonstrates null-forming technology that enables frequency sharing between HAPS and terrestrial base stations. (Softbank, June 26)
- Sunglider, a large unmanned aircraft for stratospheric communication platforms (High Altitude Platform Station, HAPS), successfully flew in the stratosphere. (SoftBank, October 2)
- Successful demonstration of data communication to a smartphone via HAPS flying in the stratosphere at an altitude of approximately 20 km above Kenya (Space Compass, NTT Docomo, March 3, 2025)

Others

- SES announces Intelsat acquisition; Deal expected to complete in second half of 2025. (SES, April 30)
- SES Space & Defense Demonstrates First Multi-Orbit, Multi-Band Commercial LEO Relay (SES Space & Defense, June 5)
- Italy's Telespazio teams up with US company Starlink. (NNA, June 10)
- Adtran and Iridium Enhance PNT Resistance in Europe and Asia-Pacific with Satellite Time and Location Technology (Adtran, June 24)
- Starlink launches "Starlink Mini" in the United States. (SpaceX, July 11)
- SpaceX’s proposal to ease PFD restrictions was met with opposition from companies.(FCC, August 12)
- The wireless communications and satellite industries don't match on U.S. position at WRC. (FCC, August 20)
- Intelsat and Intelsat start joint technology verification for realization of ubiquitous network. In the future, terrestrial and satellite communication networks will be seamlessly connected based on 5G standard specifications. (SoftBank, September 17)
- Eriksson will participate in the Mobile Satellite Service Association (MSSA) and will conduct a study on direct NTN satellite connection using the satellite frequency L/S band. (September 18)
- Mitsubishi Heavy Industries launch satellite with Eutelsat. (France, September 19)
- SpaceX plan to invest in Vietnam with $1.5 Billion (Vietnam, September 27)
- Commerce Department begins beta test of space transportation adjustment system. (NOAA, September 30)
- Interstellar Technologies completes financing for series E round totaling 3.9 Billion Yen (PR TIMES, October 24)
- SKY Perfect JSAT Yokohama Satellite Control Center has established the “Universal NTN

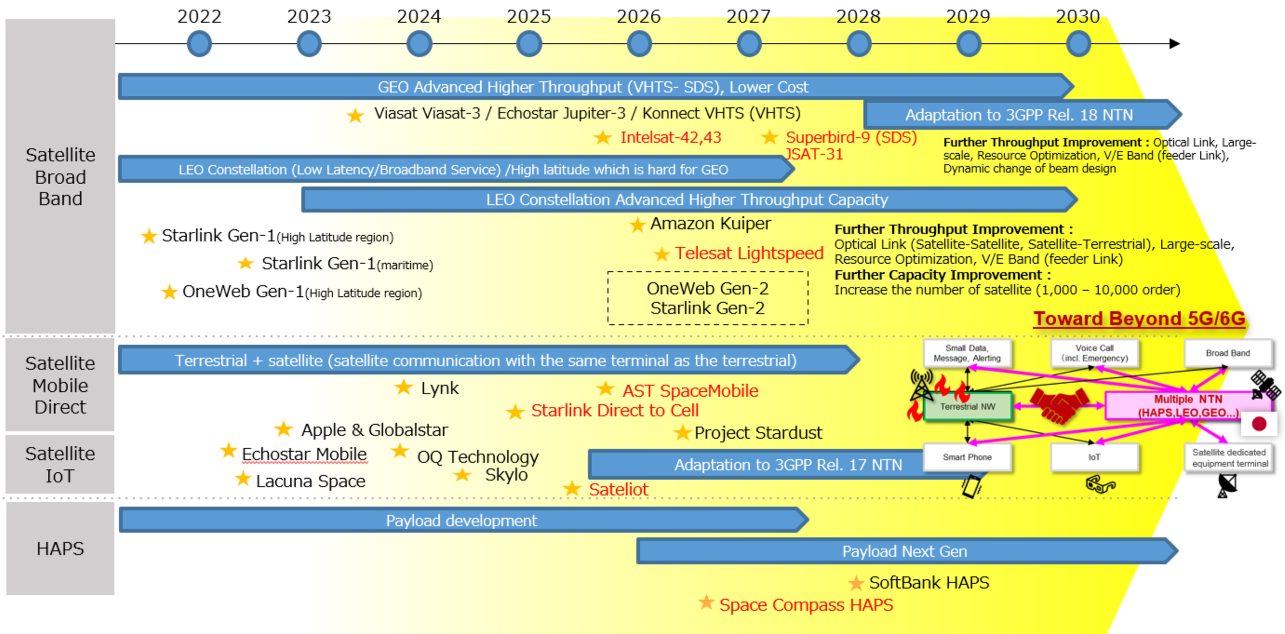
Innovation Lab" and started testing using non-terrestrial networks and 5G technologies. (Sky Perfect JSAT, November 25)

- ESA to establish European satellite communications with 10.6 billion euros. (EU, December 18)
- Rosenwarthel, Chairman of the FCC, proposed to assign additional frequencies to space launches. (FCC, December 19)
- Remote sensing by satellite mega-constellation. (Fraunhofer, January 2, 2025)
- World's First Success in Transmission of Ultra-Large-capacity Mission Data Using 1.5-µm Inter-satellite Optical Communications - JAXA and NEC's Initiatives for Optical Communications in Space - (JAXA, NEC, January 23, 2025)
- Marble Visions, NTT Data, Pasco, Canon Electronics, and NTT Data have agreed to form a capital and business alliance to develop a high-resolution, high-frequency optical satellite observation system. (NTT Data, February 25, 2025)
- China successfully launches communications technology test satellite No. 15 (AFP, March 10,2025)
- Space Compass to demonstrate satellite communications with ESA (EU、March 26, 2025)
- The U.S. State Department has urged allies to cut off contact with Chinese satellite communications companies (NEXTGOV, April 21, 2025)

3.2 Technology Roadmap

The technology roadmap was established and updated as well as the previous one. The description was updated while maintaining the framework of satellite broadband, satellite mobile direct, satellite IoT, HAPS, and framework classifications for the aeronautics and oceans sectors.

Satellite Broadband	The use of Starlink continues to expand, and as of January 2025, the number of subscribers worldwide exceeded 4.6 million. Smaller and lighter terminals have also been released, and convenience has also been improved. In addition to ship services, the company began offering aircraft services in September 2024. OneWeb has also started services, and services by Project Kuiper are scheduled to start in the future, and competition by LEO Constellation is expected to intensify further. Efforts are progressing to comply with the 3GPP standard of the VSAT system and to support multi-orbit satellites of terminals with flat-type antennas, and it seems that integration of terrestrial mobile communication networks and satellite communication networks, multi-orbit support will be advanced in the future.
Satellite Mobile Direct Satellite IoT	Direct communication between satellite and smartphone is already available in some models, areas, both iPhone and Android, and services available on existing smartphones are also becoming available with Starlink D2C. AST SpaceMobile has also started launching commercial satellites and will soon begin beta service. Although it is often time-consuming to send and receive texts at present, it is expected that performance and communication opportunities will be improved by increasing satellite constellations in the future. 3GPP Rel-17 NTN compliant terminals are also emerging, and usage is expected to expand in the future.
HAPS	The development and testing of the system continues. It is expected that mobile network coverage will expand, including in remote islands, mountainous regions, and by sea and in the air, not to mention in the event of a disaster. In terms of the system, the revised version RR was enforced from January 1, 2025, which made the 1.7 GHz and 2.6 GHz bands worldwide, and the 700-900 MHz band was specified worldwide, excluding some Asian countries. As the test development phase progresses, it is likely that domestic institutionalization will proceed in parallel.



		2023	2024	2025	2026	2027	2028	2029	2030
Aviation	Broadband Communications (In-flight Wi-Fi, etc.)	GEO Higher speed (VHTS, SDS), lower cost LEO Constellation: Higher speed / larger capacity In the aviation field, the use of in-flight Wi-Fi service (IFC) with geostationary satellite as a backhaul is expanding. Starlink is also beginning to offer in-flight Wi-Fi, and services are becoming faster and less expensive.							
	Mobile Direct IoT	Regarding in-flight Wi-Fi, there may be demands in the future for improved speed and stability, and for a wider coverage, but for satellite mobile direct, due to aviation safety reasons, many countries do not permit LTE or 5G communications on board aircraft. So, for the time being, its use in the aviation sector is unlikely to progress.							
Marine Field	Broadband Communications (In-flight Wi-Fi, etc.)	GEO Higher speed (VHTS, SDS), lower cost LEO Constellation: Higher speed / larger capacity In ships, internet access for crews and passengers is becoming essential, and Starlink's use of LEO satellites is also promoted. There are problems related to charges and congestion during access concentration. In the future, LEO constellations will become more powerful and sophisticated, and prices are expected to fall by increasing users and competition operators. In addition, miniaturization of user terminals and simplification of installation are progressing, and it is expected that usage in small ships will increase in the future.							
	Mobile Direct IoT VDES	Transition from satellite communication system to 3GPP Rel. 17 NTN compliant service, integration with terrestrial mobile service Sophistication of navigation support by transitioning from AIS to VDES For small ships and boats that are difficult to use the above-mentioned satellite broadband, it is expected that the use of direct communication between satellites, HAPS, and smartphones will be utilized. In Japan, a demonstration experiment of VDES, which can provide bidirectional communication at high transmission rates, is planned from 2024 to 2027, and after that, global demonstrations are planned.							

3.2.1 Satellite Broadband

In addition to geostationary satellites (GEO), the development of low orbit satellites (LEO) that will intensify in the future will include updated information on the situation.

		VHTS・SDS (Geostationary Satellite)	OneWeb	Starlink	Amazon Kuiper	Telesat Lightspeed
Satellite		GEO	LEO	LEO	LEO	LEO
Service link frequency		Ku-band, Ka-band	Ku-band	Ku-band, Ka-band (from GEN-2)	Ka-band	Ka-band
terminal		Dedicated Terminal (VSAT, etc.) 60 cm ~ 1.2 m Parabolic	Dedicated Terminal ~1.2m Parabolic 50 x 45cm (flat)	Dedicated Terminal (flat) 29.85cm x 25.9cm 59.4cm x 38.3cm 57.5cm x 51.1cm	Dedicated Terminal (flat) 17.8 cm x 17.8 cm 28.9 cm x 28.9 cm 48.3 cm x 76.2 cm	Parabolic, Flat
Throughput		~150Mbps(Down)	~ 195 Mbps (down)	~220Mbps (down) ~25Mbps (up)	~ 1Gbps (down)	~7.5Gbps
Latency		~600ms (Alt.35,000km)	70ms (Alt. 1,200km)	20~40 ms (Alt. 500km)	~50 ms? (Alt. 600km)	~ 70 ms? (Alt. 1,015 km, 1,325 km)
Coverage		Depending on the position of the satellite. Polar regions coverage is difficult.	Global	Global	Global	Global
Features		The existing ground-based system for geostationary satellites can be used. Cost reduction due to expanding capacity and optimization of coverage due to flexible beams.	Inter-satellite optical link (not included in initial constellation)	Inter-satellite optical link	Inter-satellite optical link	Replay relay method Inter-satellite optical link
Related Systems	Wireless Communications Rules	Available at existing FSS distribution frequencies (Ku/Ka/Q/V band, etc.)	Available in existing FSS distribution frequencies (Ku/Ka band)	Available in existing FSS distribution frequencies (Ku/Ka band)	Available in existing FSS distribution frequencies (Ka band)	Available in existing FSS distribution frequencies (Ka band)
	When introduced in Japan	Available within the system of allocated FSS frequency	Gen-1 is institutionalized	Gen-1 is institutionalized	In order to introduce it, it is necessary to develop a system	In order to introduce it, it is necessary to develop a system
	Standards	DVB-S2X (ETSI standard) 3GPP Rel-18	European Standard, ECC Report 271, ECC Decision (18)05, ETSI EN 303 980	European Standard, ECC Report 271, ECC Decision (18)05, ETSI EN 303 981	–	–
Use Case		Rural area, broadband for ships and aircraft, mobile backhaul, backup line for disaster	The basic use case is the same as the service by geostationary satellite (VHTS · SDS). Although it is considered advantageous due to latency, throughput, cost, and ease of terminal installation, it is assumed that there are many cases where it is difficult to use because the outlook condition is more severe than the GEO satellite.			

VHTS (Very High Throughput Satellite)

Satellite Overview		A satellite with a capacity of several tens of times more than a conventional geostationary satellite by arranging a number of spot beams and reusing frequency is called HTS, but a next-generation satellite with an further larger capacity is called VHTS. In 2024, Viasat-3 service (Ka band) started. GSAT-20 (India, Ka band, 70 Gbps), Telekomsat-113 BT (Indonesia, C / Ku band, > 32 Gbps) were launched and those are currently being tested.
Technology		Having High Power (20 kW) to supply Thousands of Beams. Also after launch, the band can be reassigned from less demanded areas to more demanded areas in a flexible manner
Terminal		VSAT, ESIM (available on existing geostationary satellites) Throughput: > 100Mbps
Use Case		Broadband, mobile backhaul, and disaster backup lines for ships and aircraft in the rural area. Available in a wider range and at a lower cost than ever before.
Related Systems	Wireless Communications Rules	Available at existing FSS distribution frequencies (Ku/Ka/Q/V band, etc.)
	Introduced in Japan	Available within the system of allocated FSS frequency
	Standards	DVB-S2X (ETSI standard), 3GPP Rel-18
Others		

SDS (Software Defined Satellite)

Satellite Overview		Unlike conventional satellites, the beam design can be changed after the launch of the satellite. Beam placement, size, bandwidth and power can be dynamically changed. SKY Perfect JSAT Superbird-9, JSAT-31, Intelsat IS-42, IS-43, IS-41, IS-44, Inmarsat GX 7, 8, 9, etc. are planned. Use Ku and Ka bands in service link. GX7, 8, and 9 can simultaneously place thousands of beams.
Technology		Thousands of beams can be dynamically repositioned with the latest digital processing and phased array antennas
Terminal		VSAT, ESV, ESIM (available on existing geostationary satellites) Throughput: > 100Mbps
Use Case		Broadband, mobile backhaul, and disaster backup lines for the are available in a wider range and at a lower cost than ever before.
Related Systems	Wireless Communications Rules	Available at existing FSS distribution frequencies (Ku/Ka/Q/V band, etc.)
	Introduced in Japan	Available within the system of allocated FSS frequency
	Standards	DVB-S2X (ETSI standard), 3GPP Rel-18
Others		

OneWeb

Satellite Overview		Constellation of 588 satellites at an orbital altitude of 1,200 km (Gen-1) Global Coverage (including sea)
Technology	Communication	Not implemented in Gen-1. Expected implementing an optical link between satellites in Gen-2.
	frequency	Service link: Ku band, Feeder link: Ka band * V / E band (under consideration in Gen-2)
	Ground station	40-50 locations will be set up worldwide. The license for Japanese earth station(gateway) was given on August 6, 2024.
Terminal		855 x 374 mm (fixed/portable), 895 x 895 mm (fixed/movable/sea)
Use Case		BCP/Remote/Land Mobile Broadband Communication Ship/Aircraft Broadband Communication
Related Systems	Wireless Communications Rules	Available in existing FSS distribution frequencies (Ku/Ka band)
	Introduced in Japan	Gen-1 is institutionalized
	Standards	European Standard. ECC Report 271, ECC Decision (18)05, ETSI EN 303 980
Possibility of international collaboration		Solar panel technology, debris removal technology

Starlink

Satellite Overview		SpaceX has launched more than 7,000 satellite constellations (alt. 550 km). The FCC has granted 12,000 launches. Downlink maximum throughput of 220 Mbps. The service link uses the Ku band (Ka band and V band are also planned for Gen-2 and later). The Gen-2 constellation plans to launch 30,000 satellites (altitude of about 330 km to 610 km).
Technology		Adopted the latest digital processing and phased array antennas. Adopting the inter-satellite laser link (ISL) enables communication service even at a distance from the gateway.
Terminal		Starlink dedicated terminals. Manufactured by SpaceX. Phased Array Antenna
Use Case		Broadband for the Rural Area, Ships, and Aircraft, Mobile Backhaul, and Disaster Backup
Related Systems	Wireless Communications Rules	Available in existing FSS distribution frequencies (Ku/Ka band)
	Introduced in Japan	Gen-1 is institutionalized
	Standards	European Standard. ECC Report 271, ECC Decision (18)05, ETSI EN 303 981
Possibility of international collaboration		

Amazon Kuiper

Satellite Overview		Satellite (LEO) Constellation by Amazon. The FCC has given permission to launch up to 3,236 satellites. These satellites will be located between an altitude of about 590 km and 630 km, with service expected to begin in the later half of 2025. The company conducted the launch of two prototypes in 2023, and is testing things like 4K Video Streaming and two-way video communication. In addition, tests of inter-satellite communication at 100 Gbps were conducted for the adoption of inter-satellite laser link (ISL).
Technology		By adopting inter-satellite laser link (ISL), communication services can be provided even at a distance from the gateway.
Terminal		Kuiper dedicated terminal. Three models (phased array antenna) will be provided: Ultra-compact (~100 Mbps), high-performance (~400 Mbps), and high-bandwidth design(~1 Gbps).
Use Case		Rural area, backup line for disaster. It is expected that the service will streamline data processing and storage in conjunction with Amazon's cloud services (AWS).
Related Systems	Wireless Communications Rules	Available in existing FSS distribution frequencies (Ka band)
	Introduced in Japan	In order to introduce it, necessary system must be established.
	Standards	—
Possibility of international collaboration		Debris Removal Technology

Telesat Lightspeed

Satellite Overview		Telesat's satellite (LEO) constellation. It is scheduled to launch 298 satellites in the Gen-2 Constellation. The 198 units of the initial launch were ordered to MDA. Operation on both polar and tilted orbital surfaces enables polar-to-pole communication. Plan to deliver 1Mbps to several Gbps throughput to a single site. The launch is scheduled to begin in 2026.
Technology		Combined with phased array antenna and beam hopping technology, several Gbps transmission can be concentrated spot-wise. Space-based IP NW was constructed by Inter-Satellite Laser Link (ISL). Improved link performance by digital modulation and demodulation on satellite.
Terminal		Phased array (aviation), flat panel (corporate), single dual dish antenna (ship), etc.
Use Case		Backhaul of air, shipping, fixed carriers, or companies
Related Systems	Wireless Communications Rules	Available in existing FSS distribution frequencies (Ka band)
	Introduced in Japan	In order to introduce it, necessary system must be established.
	Standards	—
Possibility of international collaboration		Debris Removal Technology

3.2.2 Satellite Mobile Direct

Regarding satellite mobile direct (communication via satellite directly from communication terminals such as smart phones without having a dedicated terminal that is responsible for communication with satellites), update information is described for each company's service development.

		AST SpaceMobile	Lynk	Starlink Direct to Cell	Apple & Globalstar	Skylo
Satellite		LEO	LEO	LEO	LEO	GEO
Service link frequency		3GPP Frequency (Mid-band, Low-band) Partner MNO Frequency	3GPP Frequency (Low-band) Partner MNO Frequency	3GPP frequency (Mid-band) Partner MNO frequency	(L-band/S-band) using global star frequency	L-band (n255) S-band (n256)
Terminal		Existing mobile phone terminals (prior to 3GPP Rel 17)	Existing mobile phone terminals (prior to 3GPP Rel 17)	Existing mobile phone terminals (prior to 3GPP Rel 17)	iPhone 14 series or later	3GPP Rel17 NTN IoT-compatible Terminal (Google Pixel 9 Series, Samsung Galaxy S25 Series)
Services		Text, voice, broadband	Text (Voice, data in the future)	Text (Voice, data in the future)	Emergency SOS, Text (US, Canada only)	Emergency SOS Text
Coverage		Global, but the range of frequency that can be used by partner MNOs	Global, but the range of frequency that can be used by partner MNOs	Global, but the range of frequency that can be used by partner MNOs	17 countries (as of Jan-2025) (May be used in the coverage of Global Star in the future.)	Global except polar regions
Features of each technology		Large Phased Array Antenna Vent Pipe System Compensating for Doppler, Delay on Ground	Phased array antenna with 1m ~1.5m. Installed eNodeB, EPC in satellite. Can transmit/receive text with store and forward communication even if it is away from the gateway.	2.7m x 2.3m Phased Array Antenna. Installed eNodeB in satellite. Doppler Correction Inter-satellite Optical Communication	Utilizes Global Star's Satellite Communications Function	Extend coverage using existing geostationary satellites (Inmarsat, Ligado, Echostar)
Related Systems	Wireless Communications Rules	Additional distribution of MSS to the frequency used. Article 4.4 is Applied. Due to using frequencies that are not assigned to mobile satellite operations	Additional distribution of MSS to the frequency used. Article 4.4 is Applied. Due to using frequencies that are not assigned to mobile satellite operations	Additional distribution of MSS to the frequency used. Article 4.4 is Applied. Due to using frequencies that are not assigned to mobile satellite operations.	Available in existing MSS distribution frequency (L/S band)	Available at existing MSS distribution frequencies
	When introduced in Japan	In order to introduce it to Japan, necessary system must be established.	In order to introduce it to Japan, necessary system must be established.	Institutionalized	Institutionalized	Since rules are established for each system, necessary system must be established.
	Standards	2G, 4G, 5G	2G, 4G, 5G	3GPP Rel-8 or later (LTE)	Unknown.	3GPP Rel 17 NTN
Use Case		Message services, calls, and data communications outside mobile coverage	Message services outside mobile coverage	Message services outside mobile coverage (calls, data communications)	Emergency Text Send/Receive Outside Mobile Coverage.	Emergency Text Send/Receive Outside Mobile Coverage.

AST SpaceMobile

Satellite Overview		AST Space Mobile's Satellite Constellation Provides Direct Communication Services to Existing Mobile Phones (Text, Voice, Broadband Communications). Using MNO Partner Frequencies (3GPP Frequency Low-band and Mid-band). Demonstration experiment in 2023 achieved voice calls and downlink throughput of 14Mbps. Launched five Block 1 BlueBird satellites in September 2024.
Technology		Phased array antenna with large diameter. Vent pipe system (eNB is located on the ground). Doppler shift and delay correction.
Terminal		Existing mobile phone terminal (3GPP terminal)
Use Case		Significant expansion of mobile network coverage. Restoring mobile networks in the event of a large-scale disaster
Related Systems	Wireless Communications Rules	Additional distribution of MSS to the frequency used. Article 4.4 is Applied. Due to using frequencies that are not assigned to mobile satellite operations.
	Introduced in Japan	Necessary system must be established.
	Standards	2G, 4G, 5G
Others		

Lynk

Satellite Overview		Lynk's satellite constellation (altitude of 500 km). Provides direct communication services to existing mobile phones (text). Using MNO partner's frequency (3GPP frequency Low-band). Three commercial satellites have been launched. Two additional satellites were launched in 2024 (5 satellites are currently in operation). Commercial service started in June 2023.
Technology		1-1.5m Phased Array Antenna. The eNB and EPC are installed on the satellite. Store and forward communication is possible even in a location away from the gateway. Doppler Shift and Delay Correction.
Terminal		Existing mobile phone terminal (3GPP terminal)
Use Case		Emergency Communications in dead area zones Emergency Communications in the case of a Large-Scale Disaster
Related Systems	Wireless Communications Rules	Additional distribution of MSS to the frequency used. Article 4.4 is Applied. Due to using frequencies that are not assigned to mobile satellite operations.
	Introduced in Japan	In order to introduce it, necessary system must be established.
	Standards	2G, 4G, 5G
Others		

Starlink Direct to Cell

Satellite Overview		Starlink satellite constellation for direct communication with mobile phones. Usually, the Starlink satellite is about 500 km in altitude, but the direct communication satellite is orbiting at 340 km. Provides direct communication services to existing mobile phones (originally text, future voice, data communication) Utilizing the frequency of MNO partners (3GPP frequency Mid-band) Successfully sent and received texts by launching six satellites in January 2024. The service is scheduled to begin in Japan in the spring of 2025.
Technology		2.7m x 2.3m Phased Array Antenna. eNodeB is installed on satellite. Connected to existing Starlink constellations via laser backhaul (no dedicated gateway required). Doppler shift and delay correction.
Terminal		Existing mobile phone terminal (3GPP terminal)
Use Case		Emergency Communications in dead area zones Emergency Communications in the case of a Large-Scale Disaster
Related Systems	Wireless Communications Rules	Additional distribution of MSS to the frequency used. Article 4.4 is Applied. Due to using frequencies that are not assigned to mobile satellite operations.
	Introduced in Japan	Institutionalized
	Standards	4G
Others		

Apple & Globalstar

Satellite Overview		Utlize Global Star's satellite (LEO) constellation, which is 32 satellites deployed at an altitude of approximately 1,440 km.
Technology		Utilize Global Star's Satellite Communications Function
Terminal		Existing mobile phone (iPhone 14 or later) terminals. The satellite connectivity function will be implemented in Apple Watch Ultra in 2025. It can send and receive emergency SOS messages (texts) and send location information on iPhone 14 and later.
Use Case		Emergency SOS
Related Systems	Wireless Communications Rules	Available in existing MSS distribution frequency (L/S band)
	Introduced in Japan	Institutionalized
	Standards	4G
Others		—

3.2.3 Satellite IoT

Satellite IoT is a network configuration that communicates directly with satellites from IoT terminals, similar to mobile direct. Although there is no significant difference in the development of services from last year, there is a lot of movement in Constellation, and we will focus on this and provide updated information.

		Skylo	OmniSpace	Echostar Mobile	Lacuna Space	OQ Technology	Sateliot
Satellite		GEO	LEO	GEO	LEO	LEO	LEO
Service link frequency		L-band (n255) S-band (n256)	L-band (n255) S-band (n256)	S-band Licensed Frequency	S-band Licensed Frequency	S-band (n256)	S-band (n256)
Terminal		GPP Release 17 NTN IoT-compatible terminals	GPP Release 17 NTN IoT-compatible terminals	Lora terminal for LR-FHSS	Antenna for Lora terminal + with LR-FHSS	GPP Release 17 NTN IoT-compatible terminals	GPP Release 17 NTN IoT-compatible terminals
Services		Direct satellite communication from 5G IoT terminals	Direct satellite communication from 5G IoT terminals	Direct Satellite communication from Lora terminal	Direct Satellite communication from Lora terminal	Direct satellite communication from 5G IoT terminals	Direct satellite communication from 5G IoT terminals
Coverage		Global except polar regions	Services by Global LEO Constellation	Europe-only service with EchoStar XXI (geostationary satellite: 10.25° E)	Service by Global LEO Constellation (approximately 500 km)	Services by Global LEO Constellation	Services by Global LEO Constellation
Features of each technology		Integrate with your network on the ground to expand 5G IoT coverage	Integrate with your network on the ground to expand 5G IoT coverage	Integrate with LoRa networks on the ground to increase coverage	Integrate with LoRa networks on the ground to increase coverage	Integrate with your network on the ground to expand 5G IoT coverage	Integrate with your network on the ground to expand 5G IoT coverage
Related Systems	Wireless Communications Rules	Available at existing MSS distribution frequencies	Available at existing MSS distribution frequencies (S-band)	Available in existing MSS distribution frequency (S band)	Available in existing MSS distribution frequency (S band)	Available in existing MSS distribution frequency (S band)	–
	When introduced in Japan	Since rules are established for each system, necessary system must be established.	Since rules are established for each system, necessary system must be established.	Since rules are established for each system, necessary system must be established.	Since rules are established for each system, necessary system must be established.	Since rules are established for each system, necessary system must be established.	Since rules are established for each system, necessary system must be established.
	Standards	3GPP Rel 17 NTN	3GPP Rel 17 NTN	LR-FHSS	LR-FHSS	3GPP Rel 17 NTN	3GPP Rel 17 NTN
Use Case							

Skylo

Satellite Overview		Utilize Existing satellites (Satellites of Inmarsat, Ligado Networks, Echoster) Direct communication service to 5G terminals. Frequency is used 3GPP bands n255 and n256
Technology		Provide Skylo NTN coverage by roaming with MNO, MVNO.
Terminal		3GPP Rel-17 NTN (NB-IoT) compatible terminals (Google Pixel 9, etc.)
Use Case		Emergency SOS, Text, IoT
Related Systems	Wireless Communications Rules	[No issues] Available with existing MSS distribution frequency
	Introduced in Japan	In order to introduce it, necessary system must be established.
	Standards	3GPP Rel-17 NTN(NB-IoT)
Others		

OmniSpace

Satellite Overview		OmniSpace's satellite constellation. It plans to provide initial service in 2026 with 300 LEO satellites. Provides direct communication services to 5G terminals. Frequency is using 3GPP band n 256 (S band). Test satellite Spark-1, Spark-2 has been launched (April and May 2022). These satellites are for NB-IoT.
Technology		Details not disclosed
Terminal		3GPP Rel.17 compliant. Band n256 compatible terminal
Use Case		IoT use case general (asset tracking, etc.)
Related Systems	Wireless Communications Rules	[No issues] Available for existing MSS distribution frequency (S band)
	Introduced in Japan	[Issues] Since rules are established for each system, necessary system must be established.
	Standards	3GPP Rel-17 NTN(NB-IoT)
Others		

EchoStar Mobile

Satellite Overview		Using EchoStar XXI (geostationary satellite: 10.25° E) Using the licensed frequency of the S band. Providing direct communication services for Lora Terminals in Europe in July 2022.
Technology		Available for integration with LoRa networks on the ground.
Terminal		Lora terminal for LR-FHSS
Use Case		IoT Use Case General (Asset Tracking, etc.) Lora IoT Service Coverage Expansion
Related Systems	Wireless Communications Rules	Available in existing MSS distribution frequency (S band)
	Introduced in Japan	Since rules are established for each system, necessary system must be established.
	Standards	LR-FHSS
Others		

Lacuna Space

Satellite Overview		Lacuna Space's Satellite Constellation (approximately 500 km). Using Cubesat. Provides direct communication services to Lora terminals. Frequency is S-band (2GHz band). Commercial satellites are being launched (7 satellites have been launched (6 are in operation), total 32 satellites launch are planned)
Technology		Store and forward communication. Available in integration with LoRa network on the ground.
Terminal		Lora Module for LR-FHSS + Dedicated Antenna
Use Case		IoT Use Case General (Asset Tracking, etc.) Lora IoT Service Coverage Expansion
Related Systems	Wireless Communications Rules	Available in existing MSS distribution frequency (S band)
	Introduced in Japan	Since rules are established for each system, necessary system must be established.
	Standards	LR-FHSS
Others		Announced collaboration with OminiSpace (March 2021). OminiSpace's S-band frequency will be used for services

OQ TECHNOLOGY

Satellite Overview		OQ TECHNOLOGY's satellite constellation (plans to launch 60 units). Provides direct communication services to 5G IoT terminals. Frequency is S-band (2 GHz band). Commercial service has started in June 2023. 10 satellites have been launched. An additional 20 satellites are scheduled to be deployed by the end of 2025.
Technology		Details not disclosed. A patent was granted for "wake-up" technology that efficiently uses power only when a private terminal is communicating with a satellite.
Terminal		3GPP R17 IoT-NTN support
Use Case		IoT use case general (asset tracking, etc.)
Related Systems	Wireless Communications Rules	Available in existing MSS distribution frequency (S band)
	Introduced in Japan	Since rules are established for each system, necessary system must be established.
	Standards	3GPP Rel-17 NTN(NB-IoT)
Others		

Sateliot

Satellite Overview		Sateliot's satellite constellation (250 launches planned). The first satellite was launched in April 2023, and the additional 4 satellites were launched in August 2024. Plan to deploy 100 satellites in orbit by 2028 and provide real-time global coverage. Direct communication service for and 5G NB-IoT terminals. Commercial service to be started in 2025
Technology		Details not disclosed
Terminal		3GPP R17 IoT-NTN support
Use Case		IoT use case general (asset tracking, etc.)
Related Systems	Wireless Communications Rules	—
	Introduced in Japan	Since rules are established for each system, necessary system must be established.
	Standards	3GPP Rel-17 NTN(NB-IoT)
Others		

3.2.4 HAPS

HAPS is one of the forms of NTN, an architecture form in which communication terminals such as unmanned airplane (UAV) and smart phones flying into the stratosphere directly communicate. This paper summarizes the outline of Space Compass, SoftBank, which is currently planning to expand its services.

		Softbank (software)	Space Compass(Phase1)	Space Compass (Phase 2-)
Satellite		HAPS	HAPS (Fixed Blade Type, Small)	HAPS (Fixed Blade Type, Small to Medium)
Service link frequency		3GPP Frequency PartnerMNO Frequency	3GPP frequency (2GHz FDD band)Using the frequency band of partner MNO	3GPP frequency (2GHz FDD/TDD band, etc.) partnerMNO frequency band *TDD band usage policy is under consideration
Feeder link frequency		ITU-R HAPS FeederLink Frequency (Either 6.5GHz, 21GHz, 26GHz, 28GHz, 31GHz, 38GHz, 47GHz)	38-39.5GHz band	38-39.5GHz band, etc.
Terminal		Existing mobile phone terminal (3GPP)_LTE/5G	Existing mobile phone terminal (LTE/5G SA)	Existing mobile phone terminal (LTE/5G SA)
Services		Text, voice, broadband	Text, voice, broadband	Text, voice, broadband
Coverage		200km diameter	100km diameter	Diameter 100-200 km
Features of each technology		Footprint Fixation Technology	Vent pipe method HAPS flight-compatible technology (feeder link tracking, footprint fixing, Doppler shift correction, etc.) Portable GW station	Vent pipe method/Regenerative repeater method HAPS flight support technology (feeder link tracking, footprint fixing, Doppler shift correction, etc.) Portable GW station, Feeder link MIMO via satellite, high-speed capacity enhancing technology by multi-beam, etc.
Related Systems	Wireless Communications Rules	1.7GHz band, 2GHz band and 2.6GHz band have been specified as the frequency used in the whole world. 700-900MHz band is specified for feeder link worldwide except for some Asian countries: 6.5GHz, 21GHz, 26GHz, 28GHz is specified for some regions and countries, 31GHz, 38GHz, 47GHz is specified for worldwide use	Specified as the frequency used in ITU-R	
	When introducing domestic	Necessary system must be established as a radio station different from existing mobile phone base stations	Initiatives to Install Institutionalized Services in Japan for 2026	Implement domestic institutionalization as necessary
	Standards	3GPP (HAPS BS standard)	3GPP (HAPS BS standard)	
Use Case		Significant expansion of mobile network coverage Restoration of mobile networks in the event of large-scale disaster Migration support to next-generation communications. Realization of low-latency communications	Expansion of mobile network coverage according to needs, such as remote islands and mountain area. Restoration of mobile networks in the event of large-scale disaster. Low-latency communication (industrial use, etc.)	Significant expansion of mobile network coverage including sea and air. Restoration of mobile networks in the event of large-scale disaster (More rapid, large-capacity system recovery) Low-latency communication (industrial use, etc.), , Temporary industry/event use etc, using TDD band.

HAPS

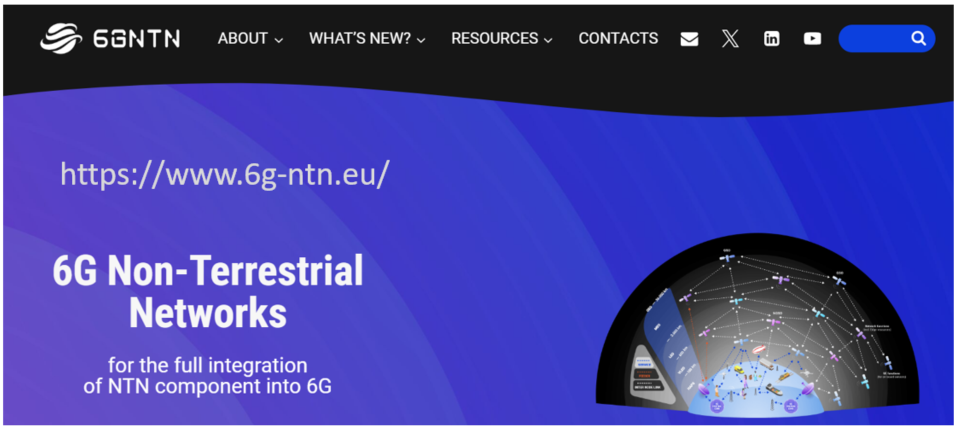
Overview		Providing communications services over a wide area by operating unmanned aerial vehicles (UAVs) such as aircraft flown in the stratosphere as communication base stations. The onboard radio will emit radio waves toward the ground to provide connectivity to communication networks such as LTE and 5G.
Technology	Payload	Development of optical wireless for FeederLink (Establishment of fine tracking and coarse tracking technology/improvement of accuracy) Development of radio wave management technology assuming ground station interference/prohibited areas (footprint fixing, radio wave propagation model/simulation) Establishment of Inter-HAPS technology (Stratospheric mesh configuration/improvement of operation rate) Multi-cells/large capacity
	Battery	Higher density / lighter weight (all solid batteries). Battery life improved / cycle number increased (next-generation resin foil). Safety improved under stratospheric environment.
	Solar Panel	Module development for stratospheric environments. Lightweight/high efficiency
Use Case		Rural / Remote island area / 3D coverage, Disaster communication, IoT, Sensing service (camera etc.)
Related Systems	Wireless Communications Rules	1.7GHz band, 2GHz band and 2.6GHz band have been specified as the frequency used in the whole world. 700-900 MHz band has been specified worldwide, excluding some Asian countries. Feeder link frequency: 6.5 GHz, 21 GHz, 26 GHz, 28 GHz are specified in some regions/countries, 31 GHz, 38 GHz, 47 GHz are specified as the worldwide use frequency
	Introduced in Japan	A system needs to be established for radio stations that are different from existing mobile phone base stations (SoftBank). Currently working on domestic institutional arrangements in preparation for service launch in 2026 (Space Compass)
	Standards	3GPP (HAPS BS standard)
Possibility of international collaboration		Promotion of various institutional adjustments (ICAO, FAA, EASA, CASA). International Frequency (ITU, 3GPP)

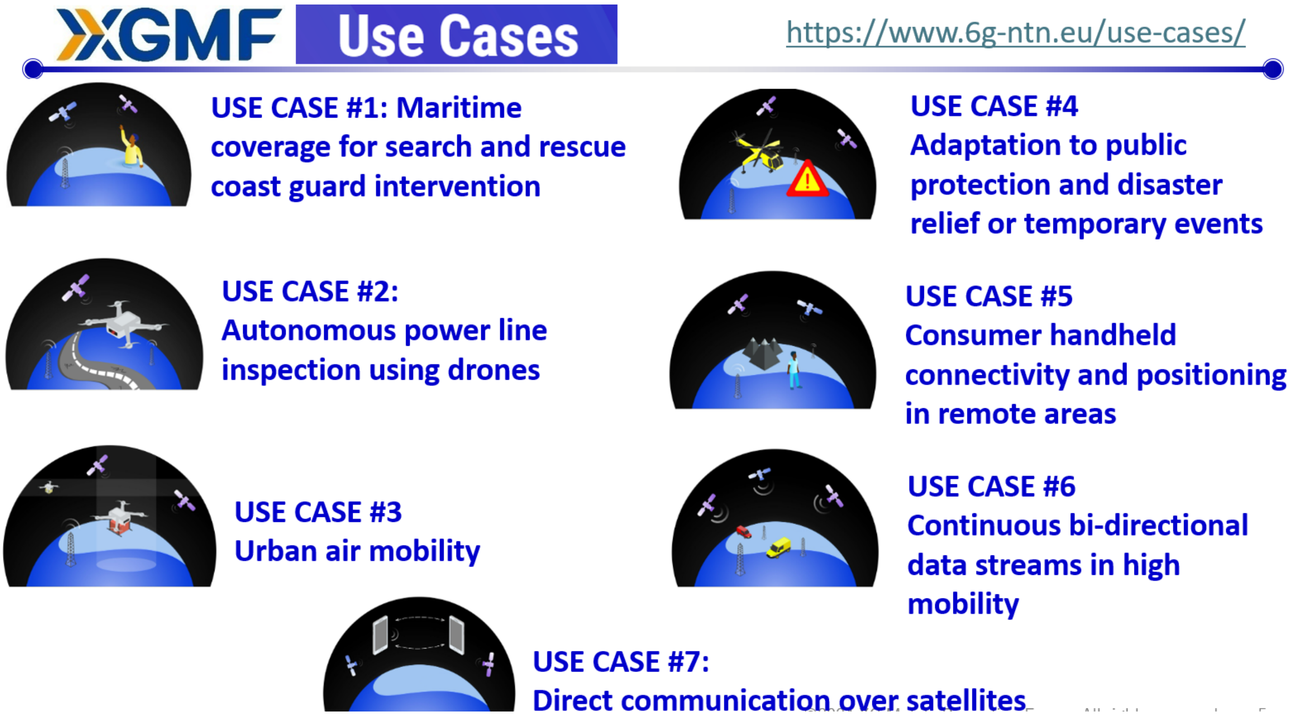
3.3 Related Activities in Overseas Countries (EU-6G-NTN Project)

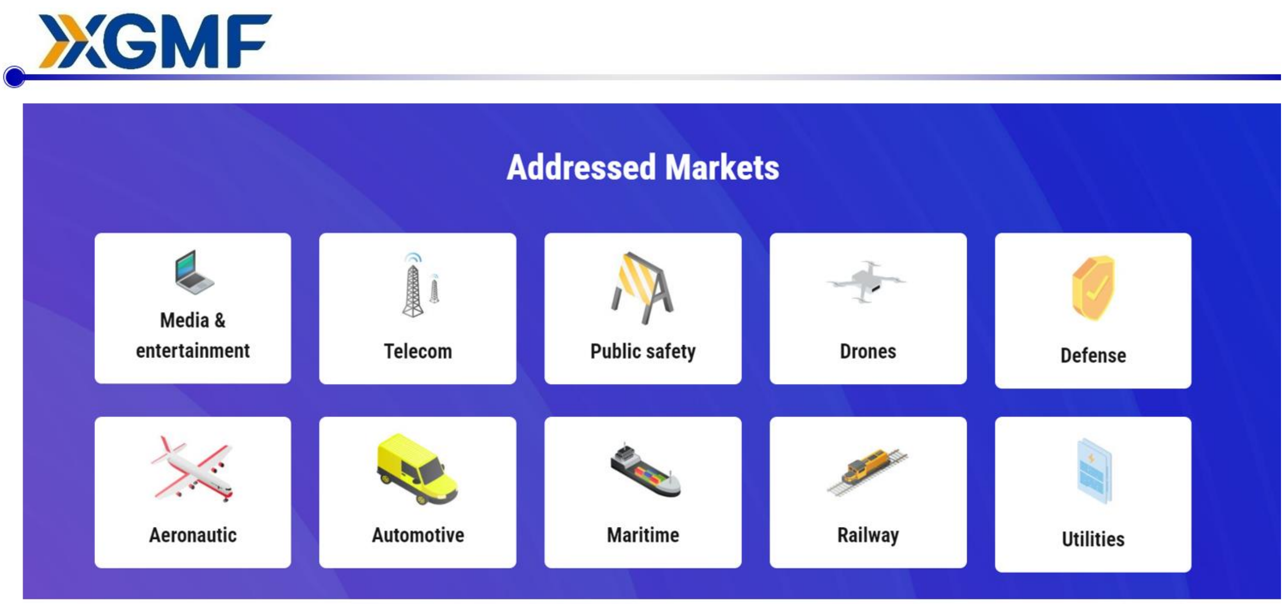
This year, for related activities in overseas countries, EU 6G-NTN's activities through the Web-HP (https://6g-ntn.eu/) was investigated to understand the so far conducted their research activities. 6G-NTN is one of the major European Union's 6G research project on NTN, which is having financial supports from the parent organization, 6G-SNS (Smart Network & Services).Also, we considered this activity is a major overseas NTN research activity in EU therefore, we focused it as the subject of our survey. Following shows our survey implementation details and observations on the 6G-NTN EU Project.

XGMF **Task(1)b: Reviewing 6G-NTN works**

This task tries to identify 6G-NTN work status specifically focuses on;
(1)Use-cases (Case study)
(2)Technical Landscape (Technology information & 3GPP trends)
(3)Seeking Solutions (Industrial Cooperation & Technical Challenges)

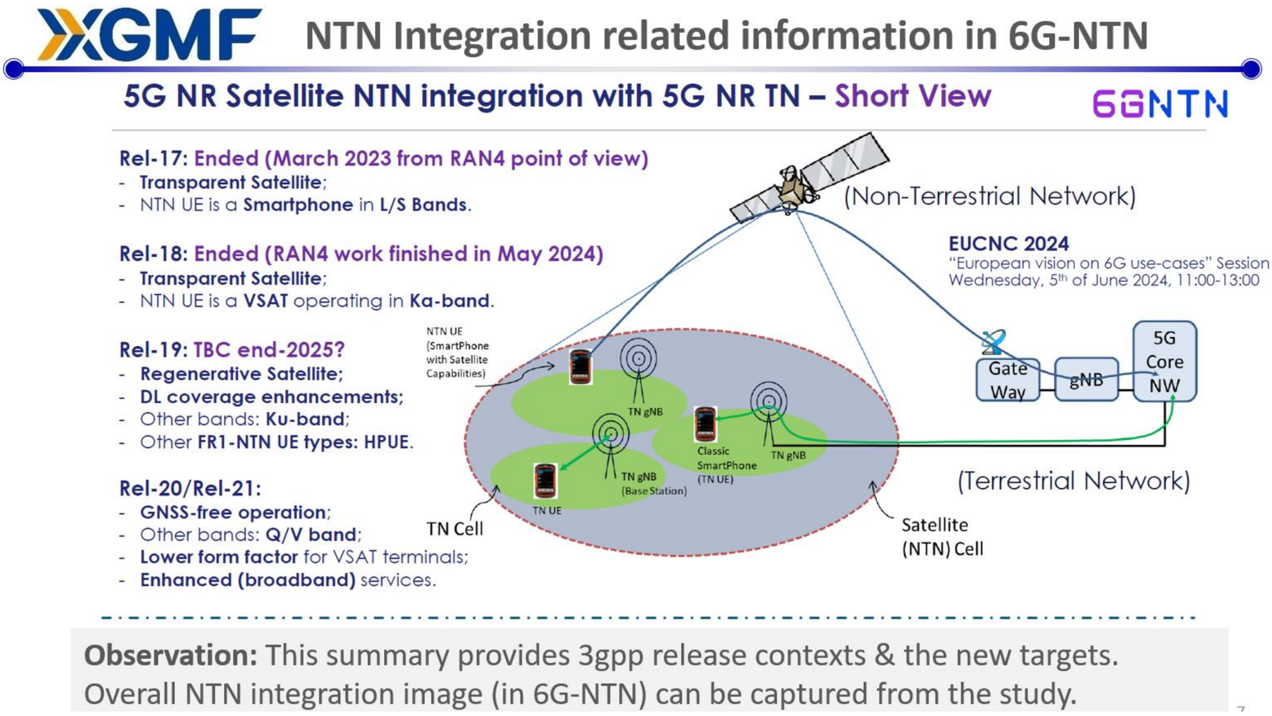






Observation: These fields indicated as main target markets that 6G-NTN focuses on. Detail survey can be found in each (see next page), worthwhile to observe.


THALES
Building a future we can all trust
6G NTN Use-Cases
EUCNC 2024
"European vision on 6G use-cases" Session
Wednesday, 5th of June 2024, 11:00-13:00
Dorin Panaitopol
THALES SIX FRANCE
6G NTN Use-Cases
Presentation by Thales Six France | EUCNC & 6G Summit 2024 – "European vision on 6G use-cases" Session | 05.06.2024 | PDF
https://www.6g-ntn.eu/download/6g-ntn-use-cases/


NTN Integration related information in 6G-NTN
5G NR Satellite NTN integration with 5G NR TN – Short View
6GNTN
Rel-17: Ended (March 2023 from RAN4 point of view)
- Transparent Satellite;
- NTN UE is a Smartphone in L/S Bands.
Rel-18: Ended (RAN4 work finished in May 2024)
- Transparent Satellite;
- NTN UE is a VSAT operating in Ka-band.
Rel-19: TBC end-2025?
- Regenerative Satellite;
- DL coverage enhancements;
- Other bands: Ku-band;
- Other FR1-NTN UE types: HPUE.
Rel-20/Rel-21:
- GNSS-free operation;
- Other bands: Q/V band;
- Lower form factor for VSAT terminals;
- Enhanced (broadband) services.
(Non-Terrestrial Network)
EUCNC 2024
"European vision on 6G use-cases" Session
Wednesday, 5th of June 2024, 11:00-13:00
NTN UE
(SmartPhone
with Satellite
Capabilities)
TN gNB
Classic
SmartPhone
(TN UE)
TN gNB
TN gNB
(Base Station)
TN UE
TN Cell
Gate
Way
gNB
5G
Core
NW
(Terrestrial Network)
Satellite
(NTN) Cell
Observation: This summary provides 3gpp release contexts & the new targets.
Overall NTN integration image (in 6G-NTN) can be captured from the study.

NTN Integration related information in 6G-NTN

Trends: Standardization, Implementation and Research (takeaways)

6GNTN

IRIS² (approach under construction):

Support implementation of **5G NTN standards** defined in 3GPP domain
- to the maximum extent possible and
- through a gradual implementation approach

Future roadmap, in order to support **5G/6G NTN-TN convergence**:

> Satellite with **regenerative** payload: starting from **Rel-19**;

> Evolution towards **6G New Radio:**

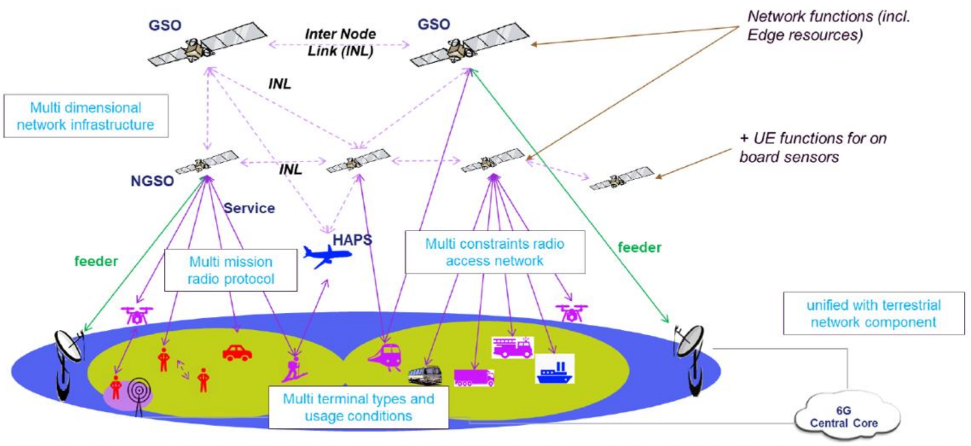
- **Increasing Non-Terrestrial Network (NTN) capacity**:
  - Introducing **more Satellite** frequency **bands for increased capacity;**
  - **Integration of TN and NTN 5G/6G towards 3D (mesh) communications.**
- **Simulation and testing capabilities:**
  - **6G WaveForm (WF)** abstraction **toolbox;**
  - **Channel Model** for satellite communication;
  - Evaluate **PAPR**, **resilience to Doppler & timing errors** of various WaveForms.

Observation: it can be observed 6G-NTN also has high-level requirements in TN-NTN integration with various analysis.

NTN System Overview image in 6G-NTN

6G-NTN SNS Project: Key Design Principles

6GNTN



Observation: an image of design principles is provided.
Could be referred as our study of Grand-Design.

Technical Information & Challenges

Public Deliverables

This page gives you the opportunity to download all public deliverables developed within the scope of the 6G-NTN project. As the evaluation and approval process by the European Commission is ongoing, some of the content may change.

Work package	Del. #	Title	Delivery date (month)
WP 1	D1.1	DMP	M5
WP 2	D2.1	Use case report	M3
	D2.2	Report on user requirements	M6
	D2.3	Report on system requirements	M9
	D2.4	Report on business model metrics and analysis	M24
	D2.5	Report on regulatory requirements	M12
WP3	D3.1	Report on 3D multi layered NTN architecture (1st version)	M7
	D3.2	Report on terminals (1st version)	M18
	D3.3	Report on software defined payload and its scalability (1st version)	M18
	D3.4	Report on vLEO space segment (1st version)	M18
	D3.5	Report on 3D multi layered NTN architecture (2nd version)	M12
	D3.6	Report on 3D multi layered NTN architecture (3rd version)	M24
	D3.7	Report on 3D multi layered NTN architecture (final version)	M36
	D3.8	Report on terminals (final version)	M30
	D3.9	Report on software defined payload and its scalability (final version)	M30
	D3.10	Report on vLEO space segment (final version)	M30
WP4	D4.1	Report on unified and data driven airinterface for 6G-NTN (1st version)	M17
	D4.2	Report on 6G-NTN radio controller (1st version)	M17
	D4.3	Open datasets for 6G-NTN data driven radio access networks	M8
	D4.4	Spectrum regulation analysis for 6G NTN scenarios (1st version)	M8
WP5	D5.1	Report on reliable and high accuracy positioning solutions for 6G-NTN	M36
	D5.2	Initial report on orchestration and monitoring solutions and cybersecurity threats for 6G-NTN	M18
	D5.3	Final report on orchestration solutions and cybersecurity framework for 6G-NTN	M36
WP6	D6.1	Dissemination and Communication Strategy and Plan	M4
	D6.2	Impact Creation Mid-Term Report	M18
	D6.3	Standardisation, Exploitation and Sustainability Strategy and Plan	M18
	D6.4	Impact Creation Final Report	M36
	D6.5	Standardisation, Exploitation and Sustainability Final Roadmap	M36

Produced Materials

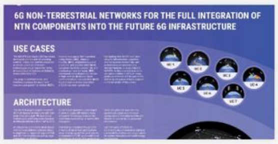
Poster – EUCNC & 6G Summit 2024

Enablers for E2E integration in 6G-NTN

DOWNLOAD

Poster – The ETSI Conference "NTN, a Native Component of 6G"

6G-NTN project overview



DOWNLOAD

Brochure

Architecture & use cases brochure

DOWNLOAD

Flyer

About 6G-NTN – Introductory Flyer

DOWNLOAD

XGMF **Enablers for E2E integration in 6G-NTN** Poster – EUCNC & 6G Summit 202

https://www.6g-ntn.eu/wp-content/uploads/sites/94/2024/06/EuCNC_6G_NTN_WP5_poster-1.pdf

6G NON-TERRESTRIAL NETWORKS FOR THE FULL INTEGRATION OF NTN COMPONENTS INTO THE FUTURE 6G INFRASTRUCTURE

Enablers for E2E integration in 6G-NTN

Reliable Positioning

Positioning objectives

UE positioning is integral for 6G NTN operations, gaining prominence with 3GPP Rel.17's introduction [1]. NTN, pivotal for emergency services, explores explicit positioning via single or multiple LEO satellites in scenarios with weak or unavailable GNSS signals. Various methods, including TOA, TDOA, RTT, two-way TOA, and FDOA based on delay and Doppler measurements, are discussed. Method choice hinges on system requirements and available resources. For instance, TOA and RTT need high bandwidth for resolution, RTT requires bidirectional signaling, and TDOA has a trade-off with DOP [2]. This paper explores positioning techniques in 6G NTN, focusing on LEO satellite constellations in diverse configurations and deployments to propose suitable NTN positioning methods.

[1] Technical Specification Group Services and System Aspects; Location Services (LCS); Service description; Stage 1," 3GPP TS 22.071, version 17.0.0.J.
[2] M. L. Psiaki, "Navigation using carrier Doppler shift from a LEO constellation: TRANSIT on steroids," Navig. J. Inst. Navig., vol. 68, no. 3, pp. 621 – 641, Sep. 2021.

State of the art for positioning

NR-positioning involves two key processes: measurement and position estimation based on these measurements. The positioning procedures in 5G-NR are categorized as UEassisted, UE-based, and Network-based, offering flexibility in implementation. In terms of measurements, 5G provides timing measurements (DL-RSTD, UL-RTOA, Rx-Tx time difference) and receive-power measurements (DL PRS-RSRP, UL SRSRSRP, AoA, Zenith-AoA, SSB, and CSI-RS). Numerous 3GPP evaluation studies on these schemes are documented in 3GPP 38.855 [3] and 38.859 [4], providing valuable insights into their performance in the context of NR-positioning. The following highlights the main challenges in LEO-NTN based positioning:

By comparing the results among the different considered scenarios, we have observed the following:

- The best positioning accuracy was achieved in FR2 with highestfrequency of operation (i.e., 78 GHz) and with the highest subcarrier spacing (i.e., 240 kHz).
- The achievable positioning accuracy is indeed below 1m. However, using FR1 and sub-carrier spacing between 15 kHz and 60 kHz, the accuracy is above 1 m and below 6 m.

Dynamic Orchestration and Autonomous Monitoring

ML for VNF orchestration

- **A virtualized and cloud native architectures for the 6G core network** capable to cope with ad-hoc satellite constellations of 6G through a dynamic orchestration of the service-based architecture.
- In TN/NTN scenarios, the orchestrator leverages insights from the **AI management platform to dynamically adjust resources**, ensuring that sufficient resources are allocated to meet each user's specific requirements.
- **Pre-emptive resource allocation** to mitigate costs and prevent waste of energy associated with overprovisioning while simultaneously avoiding degradation of service quality due to under provisioning.

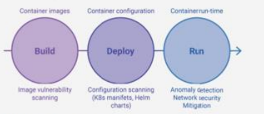
Cyber Security

Context and technical problem

Security of cloud computing infrastructures

It is a de facto standard to deploy complex applications of micro-services. Kubernetes is an open-source orchestration engine of containers on clusters of servers. It's very flexible but with some drawbacks:

- Security risks induced by virtualization
- Security to rethink compared to traditional deployments (mental model)
- Security configurations complex and difficult to implement correctly
- Little visibility on what is implemented



Technical solution

Building a microservice deployment model using a topological graph $\mathcal{G}(\mathcal{N},\mathcal{E})$ and assessing its security

- Nodes ($\mathcal{N}$): pods (or deployments) and containers

XGMF Presentations & Talks

https://www.6g-ntn.eu/presentation-talks/

6G NTN Use-Cases

Presentation by Thales Six France | EUCNC & 6G Summit 2024 – "European vision on 6G use-cases" Session | 05.06.2024 | PDF

NTN-TN Convergence for 5G/6G Networks – Use Cases & Challenges

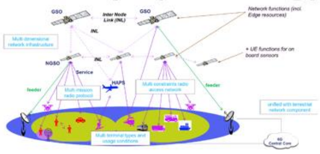
Presentation by Thales Six GTS France| Thematic days on NTN communications Organised by the CNRS GDRs RSD & ISIS | 19/20.10.2023 | PDF

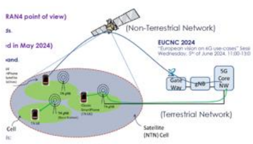
XGMF Observation Summary of 6G-NTN Activities

Intensive studies are observed in 6G-NTN Activities, such as including

(1) On Use Cases: 7-fields of key Use-cases.

(2) On Technical Landscape (Technology information & 3GPP trends)





(3) On Seeking Solutions: Plenty number of Deliverables (Technical Challenges)

Public Deliverables

This page gives you the opportunity to download all public deliverables developed within the scope of the 6G-NTN project. As the evaluation and approval process by the European Commission is ongoing, some of the content may change.

Produced Materials

Poster – EUCNC & 6G Summit 2024

3.4 Summary

For the technology roadmap, as last year conducted, the main news from FY2024 onwards we surveyed following three categories of NTN related information, which is satellite broadband, satellite mobile direct, satellite IoT, and HAPS. We updated the comparison table and detailed information of each company's services in accordance with the status of the service deployments. Although there were no noticeable updates, future plans for satellite constellation and radio communication regulations are still in place. It observed that preparations were underway for the these service deployments.

For related activities in overseas NTN related research, this year EU 6G-NTN's activities through the Web-HP (https://6g-ntn.eu/) was investigated. We were able to observe, the key use cases, technical information and 3GPP trends & technical issues, etc., eventually we were enable to capture their outline of the work status via this survey.

Chapter 4 Identifying the Needs and Requirements of Users Interested in Utilizing NTN

4.1 Identifying the Needs of Users Interested in Utilizing NTN

4.1.1 Implementation of Opinion Exchange Sessions

Continuing from last year, our project conducted activities to identify user needs. This year, we focused on identifying the demands and challenges in the "marine" sector and organized the opinon exchange sessions as described below. Invitations were extended to institutions and companies associated with our project members (hereinafter referred to as "guests"). The participating guests introduced the activities of their respective organizations and also took part in a pre-session questionnaire.

- Title: Opinion Exchange Session on Communication Services Using Satellites and HAPS in Marine Sector
- Date and Time: November 7, 2024 (Thursday), 15:00–17:30 (JST)
- Venue: Conference room at the Association of Radio Industries and Businesses and Online (Hybrid Format)
- On-site Participants:

  Guests:
  - Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
  - Nippon Kaiji Kyokai (ClassNK) / Ship Data Center Co., Ltd.
  - NAIKEN R&D / SIM-SHIP Co., Ltd.
  - Infracom Corporation
  - Oceanic Constellations, Inc.
  - MOL Sunflower Ltd.
  - BANYANS Inc.
  - FURUNO ELECTRIC CO., LTD.
  - NYK CRUISES CO., LTD.
  - Lighthouse Inc.

  Project Members:
  - National Institute of Information and Communications Technology (NICT)
  - Sharp Corporation

- Space Compass Corporation
- Softbank Corp.
- Nokia Solutions and Networks Japan G.K.
- Rakuten Mobile, Inc.
- ITOCHU Techno-Solutions Corporation
- Internet Initiative Japan Inc.
- VIAVI Solutions Inc.
- Keysight Technologies Japan K.K.
- KDDI CORPORATION

4.1.2 Summary of the Opinion Exchange Session

The specific examples (activity introductions, Q&A, and contents of the pre-session questionnaire) provided by the guests were consolidated, and a list of demands and challenges was compiled based on each example. The following trends were frequently observed. For specific details, please refer to Section 4.2.

- Pricing plans (balance between price and data capacity, etc.)
- Communication quality (latency, connection stability, etc.)
- Communication coverage
- Legal and regulatory framework
- Communication terminals and equipment

4.1.3 Titles of Activity Introductions (Reference Information)

Each guest introduced their organization's activities with the following titles. As these were based on a closed meeting within XGMF, the detailed contents are omitted. (Specific examples collected are included in the content consolidated in Section 4.1.2)

XGMF Introduction to Activities from Each Organization/Company

No.	Organization / Company Name	Title
1	Japan Agency for Marine-Earth Science and Technology (JAMSTEC)	Current Status and Challenges of Satellite Communication in Offshore Unmanned Observation Platforms
2	Nippon Kaiji Kyokai (ClassNK) / Ship Data Center Co., Ltd.	Examination Towards Remote Operation for Autonomous Ships
3	NAIKEN R&D / SIM-SHIP Co., Ltd.	Future Brought by Automation and Mass Production - Proposing a New Shape for Coastal Vesseles
4	Infracom Corporation	Safety Measures System for Mountain and Marine Leisure
5	Oceanic Constellations, Inc.	Communication Needs in Forming Networks between USVs (Unmanned Surface Vehicles)
6	MOL Sunflower Ltd.	Use Cases of Marine DX and Low-Earth Orbit Satellite Communication at MOL Sunflower Ltd.
7	BANYANS Inc.	Company Introduction of BANYANS Inc.
8	FURUNO ELECTRIC CO., LTD.	Marine DX Promoted by FURUNO
9	NYK CRUISES CO., LTD.	Case Study of NTN Utilization in ASUKA Cruises
10	Lighthouse Inc.	Business Introduction of Lighthouse Inc.

4.1.4 Questions in the Pre-event Survey (Reference Information)

Below questions were used for the pre-session questionnaire, and responses were collected from the guests. As these were based on a closed meeting within XGMF, the content of the responses is omitted. (Specific examples collected are included in the content consolidated in Section 4.1.2)

Q1. Are you currently using NTN? If yes, could you tell us any challenges you are facing?
Q2. Have you ever had to give up on something due to communication issues? If yes, could you share the reasons if possible?
Q3. What are your expectations for NTN?
Q4. If you could use NTN, what would you like to use it for? Please provide potential uses and needs.
Q5. Are there any challenges, considerations, or issues that need to be solved for using NTN? Either industry-specific matters or communication environments is fine.
Q6. Is there anything you think would make NTN more convenient or encourage you to use it more actively?
Q7. Do you have any other concerns or issues regarding fees, subscription contracts, or legal matters?
Q8. Do you have any expectations or requests for the NTN promotion project?

4.2 Presenting Solutions Using Existing Technologies

The content from the activity introductions, Q&A, and pre-session questionnaire were consolidated, and potential solutions that users might not have recognized were flagged against the demands and challenges listed in Section 4.1.2.

Flagging Criteria:

(A) Feasible using existing technologies or combinations thereof.
(B) Feasible using forthcoming technologies in the near future or combinations thereof.
(C) Not feasible with existing technologies.

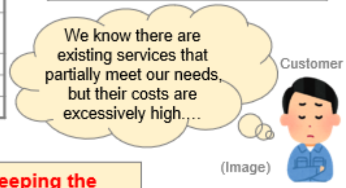
When summarized for each flag, the following results were obtained. The most notable group is the "(A)" group. It was to become apparent that despite existing solutions capable of addressing operational issues and demands, users (demand side) were unable to adopt them due to various reasons. Hence, focusing solely on technological challenges will not solve the demands and challenges.

XGMF Potential for Problem Solving with Existing Technologies: Summary (1/4)

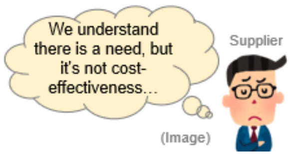
[Group A] Solution Already Available / Improvement Expected with Existing Technologies

Requests/Challenges	Solutions
Low Latency (at Vesseles/Ferries)	Low latency, high capacity, and low cost are being realized through satellite broadband communication with LEO satellite constellations like Starlink Business, Eutelsat OneWeb, Amazon Kuiper project, etc. (Eutelsat OneWeb also offers performance guarantees), and further improvements are expected in the future.
Simplification of Receiver Installation	Flat type antennas make the installation easier compared to conventional movable antennas.
Expansion of Terrestrial Communication Area	Coverage Area Expansion is possible with NTN (except for polar regions).
Low Latency	Implementation of Communication Using MEC.
High Capacity	High-capacity plans are already available.
Ensuring Security	There are already services that can add security features.

Other Requests
Request for low-cost services.
Request regarding Regulations.
Request for simplified procedures.
Request for information sharing.
Request for a trial environment.



It's tough to meet operational challenges and customer demands while keeping the service providers' businesses viable.
If we only focus on tech issues, it's impossible to solve everything.



Requests/Challenges	Bottlenecks
Various type of service plan such as offering area and data allowance	Depends on the decision for service providers based on cost-effective.
Various option of communication devices	Depends on the decision for device venders based on cost-effective.
High data allowance plan	Although a high data allowance plan are offered, the significant expense are necessary to utilize it.

XGMF Potential for Problem Solving with Existing Technologies: Summary (2/4)

[Group B] Potential for Resolution with Alternative Services / Solutions Expected to Emerge in the Future

Requests/Challenges	Solutions
Marine Observation: The options are limited (The requirements for Devices: small size, low power; The requirements for Communication Methods: data capacity, coverage area)	If the coverage requirements can be met, the following solutions may be applicable. Iridium, Globalstar, Inmarsat, Orbcomm
High Capacity	Low latency, high capacity, and low cost are being realized through satellite broadband communication with LEO satellite constellations like Starlink Business, Eutelsat OneWeb, and Amazon Kuiper project, etc. (Eutelsat OneWeb also offers performance guarantees), and further improvements are expected in the future. *There is room to explore the potential for improvements through the combination with QoS.
Low-Cost Satellite Communication Solutions for USVs	The following solutions may be applicable. Iridium, Globalstar, Inmarsat, Orbcomm
Increase in Communication Capacity (for Image Data Transmission)	The following solutions may be applicable. Starlink Business for Maritime
Implementation of TN/NTN Interworking System	Possible if standardization by 3GPP and the development of RR, etc., progress.
Seamless Handover	It may be possible with the use of SD-WAN equipment. *Excluding international legal frameworks
Marinization of Antenna Equipment	Development of ocean-proof terminals seems possible (however, depending on cost-effectiveness criteria of equipment developers).
Communication Environment Equivalent to Terrestrial	Development of hybrid terminals is anticipated in the future.
Stable Connectivity	Using the bandwidth guarantee option of Eutelsat OneWeb could provide more stable connectivity than best-effort lines.
Provision of D2D Services	Solutions enabling communication with existing terminals, like Starlink D2C and AST mobile, are planned to be released in the future. Subsequently, standardization of TN/NTN dual-compatible terminals complying with 3GPP Release17 NB-IoT/18 NR-NTN is also anticipated to proceed.

XGMF Potential for Problem Solving with Existing Technologies: Summary (3/4)

[Group C] Resolution is difficult due to natural laws/coverage limitations and legal obligations.

Requests/Challenges	Solutions/Bottlenecks
Marine Observation: Flexibility in Choosing Communication Means (for Communication Coverage Area) Vesseles/Ferries: Expansion of Communication Area (for Remote Control from Terrestrial)	Currently, only Iridium MSS service supports small terminals globally. Orbcomm, Globalstar, and geostationary satellites lack coverage in polar regions.
Marine Observation: Flexibility in Choosing Communication Means (Communication Capacity)	It is expected that communication capacity will increase with IoT services provided by Starlink D2C and AST SpaceMobile. (However, the area is limited to the territorial waters of the serviced country.)
Marine Observation: Balancing Miniaturization and Low Power	As transmission capacity and power consumption are proportional, it is challenging to achieve both high communication capacity and energy efficiency. If the performance of satellite transceivers improves, it might be possible to increase communication capacity without raising the power consumption of terminals. However, specific plans are unknown. High-speed communication with VSAT is difficult to achieve with small antennas because of the need to capture geostationary satellites.
Mountain/Marine Leisure: Difficulty in Rescue/Search in Areas Outside Communication Coverage	Improvements are expected with satellite SOS by iPhone and LTE area coverage expansion by Starlink D2C and AST SpaceMobile. (Reportedly, Apple Watch Ultra 3 will support text messaging via satellite.) In valleys, even NTN might not ensure communication, but obtaining location information and confirming positions during searches using Globalstar SPOT terminals (which requires user possession) might be somewhat replaceable by beacon systems like COCOHELI.
Vesseles/Ferries: Reduction of Service Price, Implementation of TN/NTN interworking Systems, Stability/High Capacity/Performance Assurance	Satellite broadband communication using LEO satellite constellations such as Starlink Business, Eutelsat OneWeb, and Amazon Kuiper project is realizing lower latency, high capacity, and lower prices (Eutelsat OneWeb also offers performance assurance), and further improvements are expected in the future.
Regulatory: Reduction of NTN usage fees	There is potential for further reduction in the cost of satellite broadband with LEO satellite constellations in the future.One possible bottleneck is the difficulty in obtaining GMDSS certification for satellite broadband systems.

XGMF Potential for Problem Solving with Existing Technologies: Summary (4/4)

[Group C] Resolution is difficult due to natural laws/coverage limitations and legal obligations.

Requests/Challenges	Solutions/Bottlenecks
Data Linkage Necessary for Safe Navigation: Provision of D2D Services	D2D services available on existing terminals by Starlink D2C and AST SpaceMobile cannot be used in waters beyond territorial seas due to regulations. Responding to the traffic demand of cruise ships with D2D services, including others, is challenging in terms of capacity.
Cruise Ships: High-Speed, High Capacity, Low Latency	Due to the high number of passengers on cruise ships, capacity issues are frequent. Expected alleviation of capacity issues with the increase in the number of constellation satellites and use of Ka-band in the future.
High Latitudes: Expansion of Communication Coverage Area	In high-latitude regions, due to generally low traffic demand, the number of satellites in orbits that cover high latitudes is relatively low in constellation plans. Expected alleviation of capacity issues with the increase in the number of constellation satellites and use of Ka-band in the future.
Balancing Communication Capacity / Throughput and Miniaturization / Energy Efficiency	Trade-off between the two.
Low Solar Power Generation in Mid-High Latitudes During Winter	Correlation between sunlight hours, solar radiation, and solar power generation.

4.3 Clarification of Requirements Necessary to Meet User Needs

For the requests and issues listed in section 4.1.2, the following results were obtained by summarizing the requirements necessary for realization.

Summary of clarification of requirements needed to realize needs

category	requirement	Technology, services, etc. required to solve the problem
Communication stability	bandwidth	Expansion of allocated bandwidth Utilization of multiple bands (Ku, Ka, Q, V, etc.)
	jitter	(Difficult to resolve due to NTN characteristics?)
	delay	Communication using MEC Utilization of satellites in relatively low orbit such as LEO/MEO (but difficult to solve fundamentally due to the characteristics of NTNs)
	communication speed	Variable DL/UL Ratio Spatial multiplexing technology
	E2E Orchestrator	E2E Orchestrator E2E Orchestrator Implementation Obstacles to Implementing E2E Orchestrator Radio Laws, etc.
	SLA-based QoS management	SLA-based QoS management
	network slicing	network slicing
	coverage area	TN/NTN coordination LEO/MEO/GEO/HAPS multi-orbiting high latitude communications satellite deployment
	Jitter reduction during handover	(Difficult to resolve due to NTN characteristics?)
	Packet Loss Reduction	(Difficult to resolve due to NTN characteristics?)
TN/NTN coordination	TN/NTN inter-domain orchestrator	Implementation of TN/NTN inter-domain orchestrators
	Seamless handover	Providing TN/NTN hybrid terminals Providing communication plans for TN/NTN hybrid terminals
	regulation adjustment	Standardization of linkage between TN/NTN in 3GPP
	QoS guarantee considering NTN line characteristics (bandwidth, jitter, delay)	QoS settings for TN/NTN
Communication Reliability	Reliable communication channel	Providing bandwidth reservation services
	security	quantum cryptography
	Network Conduciveness	Combined service of multiple satellite communication networks Coordination between TN/NTN LEO/MEO/GEO/HAPS multi-orbiting
Expansion of communication capacity	high capacity communication plan	Offer inexpensive unlimited capacity plans
IoT device support	Communication Plans for IoT	Providing communication plans for IoT
communications device	Satellite Communication Terminal Specifications	Wide range of satellite terminals (small, power-saving to large, high-speed communications)
	Communication standards for IoT devices	Standardization of communication standards for IoT devices
	D2D service support	Providing of D2D-compliant satellites communication plans for D2D
Standardization of terminals for offshore use	Product size	Establishment of unified standards for offshore terminals and mounting jigs
	Mounting Method	

4.4 Summary

Through the opinion exchange sessions, the demands and challenges in the marine sector were identified, and the feasibility of solutions using existing technologies was examined. For unresolved issues, necessary requirements to meet these needs were considered. It became apparent that operational challenges and demands from the user's side (demand side) confront the business feasibility of the service provider side (supply side), and focusing only on technological challenges does not ensure resolution.

It was perceived that to achieve widespread adoption of NTN, reducing usage costs is necessary. This indicates that procurement costs for satellites and HAPS are key issues. Forming a global ecosystem aimed at reducing NTN costs in parallel with technological advancements deemed essential.

Chapter 5 Efforts to Solve Challenges for Realizing NTN Services

5.1 Examination of Challenges for Realizing NTN Services

By the end of the last fiscal year (FY 2023), as an activity to raise interest in NTN, which is an important element of Beyond 5G, we formulated use cases. By disseminating examples that make it easy to imagine that what cannot be done with 5G until now can be done with Beyond 5G, and by conveying the appeal of NTN, we aimed to bring to light the needs and problems of users, and to provide opportunities for collaboration with companies that possess technologies. As a result, 19 examples were formulated from 2 different viewpoints, namely, from the technical viewpoint that overviews the whole NTN, and from the industry viewpoint that expresses concrete application contents.

In addition, from these examples, we examined them from the viewpoint of the examples that should be most realized as Beyond 5G, and selected examples to be taken up as initiatives to solve problems for social implementation. Those with an asterisk (*) at the end of each case name are applicable.

- Technical Perspective
    - NTN and TN Integration (*)
    - Broadband communication outside of TN coverage (*)
    - IoT communication outside of TN coverage (*)
    - High-Precision Positioning &Navigation (*)
    - Sensing and Communication Service Integration
- Industry Perspective
    - Observation of River Water Level & Snow Accumulation
    - Herd management
    - Collaboration between Disaster Medical Sites and Hospitals (*)
    - Provision of Power Supply and Communication to Disaster Areas
    - Mobility
    - Communication Methods in Mountainous Areas (*)
    - Unmanned delivery (by HAPS)
    - Advanced Airport Control
    - Disaster Detection in Mountainous Areas
    - Public Safety LTE
    - Sensing

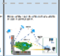
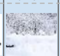
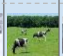
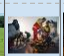
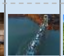
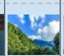
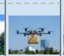
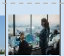
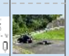
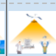
- Complementary Service by NTN
- Unmanned delivery (by Satellite) (*)
- BCP for Cellular Communication

In this fiscal year (FY 2024), as described in the previous chapter, we took up marine communication use cases, such as ships and ocean observations, as new applications of NTN services, and discussed issues and solutions to realize social implementation through discussion meetings with related companies. In addition, with regard to HAPS, which is aimed at early commercialization in Japan in particular, we updated the examination of utilization cases from a technical perspective, including HAPS, in the integration of NTN and TN, and additionally examined utilization cases from a new industry perspective that utilizes the features of HAPS.

As a result, the following three new cases were examined through this year's activities.

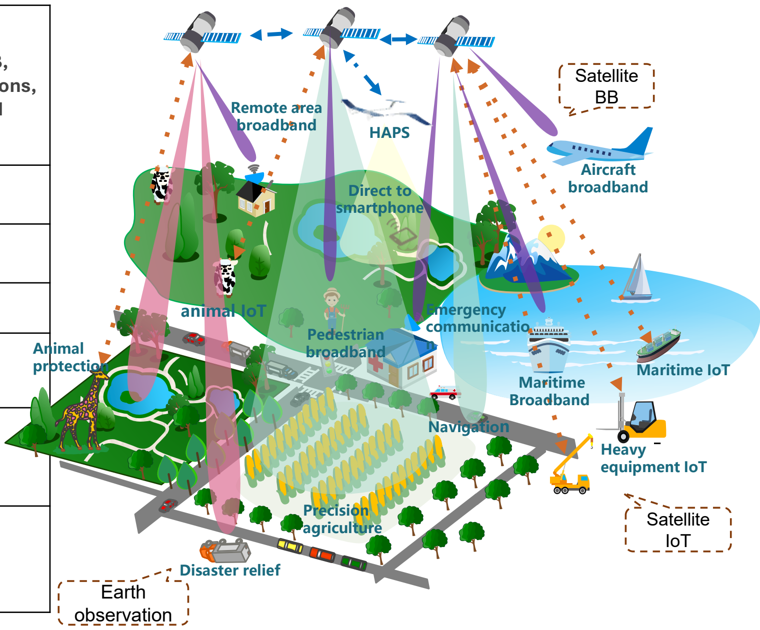
- Additional cases (Industry Perspective)
    - Mobility in the Ocean (*)
    - Disaster Countermeasures (by HAPS)
    - Video Transmission from Remote Areas and Drones (by HAPS)

In the following sections, a total of 22 NTN use cases are presented, including 3 new cases added this year.

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Case	NTN and TN Integration	Broadband Communication Outside of TN Coverage	IoT Communication Outside of TN Coverage	High-Precision Positioning & Navigation	Sensing and Communication Service Integration	Observation of River Water Level & Snow Accumulation	Herd Management	Collaboration between Disaster Medical Sites and Hospitals	Provision of Power Supply and Communication to Disaster Areas	Mobility	Communication Methods in Mountainous Areas	Unmanned Delivery (by HAPS)	Advanced Airport Control	Disaster Detection in Mountainous Areas	Public Safety LTE	Sensing	Complementary Service by NTN	Unmanned Delivery (by Satellite)	BCP for Cellular Communication	Mobility in the Ocean	Disaster Countermeasures (by HAPS)	Video Transmission from Remote Areas and Drones
Image																						
Broadband	●	●	-	-	-	-	-	●	●	●	-	-	-	-	-	-	-	-	●	-	-	-
Mobile Direct	-	-	-	-	-	-	-	-	-	-	●	●	-	-	-	-	●	-	-	●	-	-
IoT	●	-	●	-	-	●	●	-	-	●	-	●	-	●	-	-	-	●	-	-	-	-
HAPS	●	-	-	-	-	-	-	-	-	●	●	●	●	-	-	-	-	-	-	●	●	●
Sensing /Location	●	-	-	●	●	-	-	-	-	●	-	●	●	-	-	●	-	●	●	-	-	-
Mobility	-	-	-	●	-	-	-	●	●	●	-	-	-	-	-	-	-	●	●	●	-	-
NTN-TN Integration	●	●	●	●	●	-	-	-	-	-	-	-	-	-	●	●	●	●	-	●	-	-

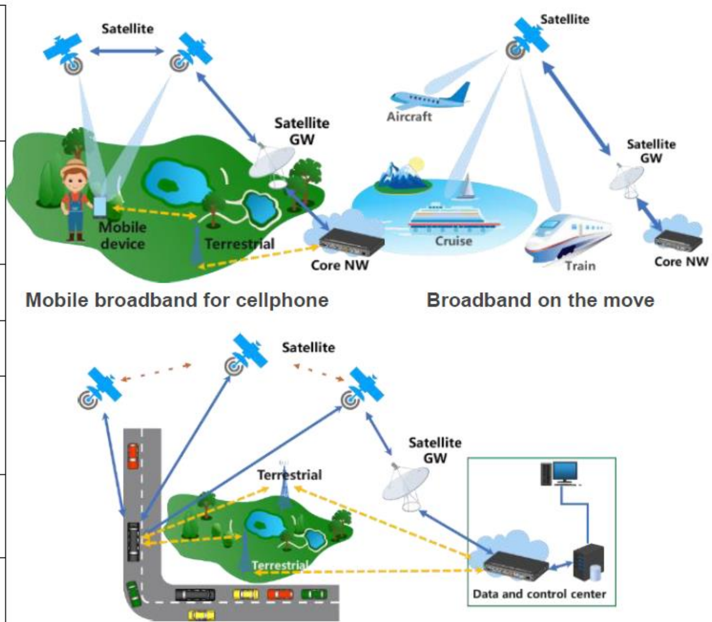
5.1.1 Integration of NTN and TN

Use case overview		This shows an overall NTN-TN convergence image. Satellite BB, Satellite IoT, Satellite Observations, and HAPS are integrated with TN communication.
KPI	**Throughput**	>100Mbps
	Latency	<20ms
	Coverage	Rural areas, ocean, etc.
Terminal type		Dish terminal(fixed) Mobile phone
Frequency		Ku Ka S sub-6G
Expected Service Provided Timing		Year 2025~30



5.1.2 Broadband Communication in TN Coverage-Limited Areas

Use case overview		Connectivity to conventionally unconnected objects with Satellite-broadband. (convergence of TN and NTN-BB)
KPI	**Throughput**	• >100Mbps for moving platforms • >10Mbps for cellphone • >1Mbps for first responder
	Latency	• <20ms
	Coverage	• Rural areas, ocean, etc.
Terminal type		• Dish terminal on platforms • Handset type mobile phone
Frequency		• Ku Ka for dish terminals • Sub-6GHz for mobile phones
Expected Service Provided Timing		Year 2025~30

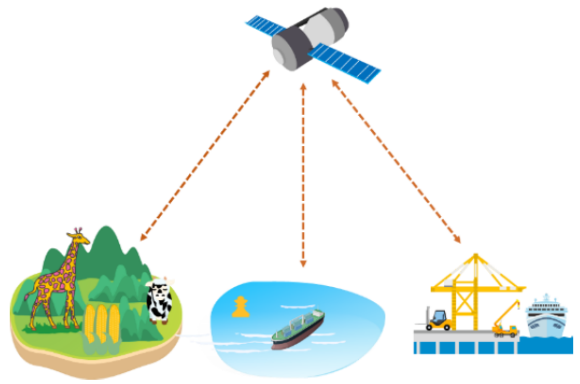


First Responder communication and disaster relief

5.1.3 IoT Communication in TN Coverage-Limited Areas

Use case overview		Expand IoT service coverage, collecting information in conventionally TN unconnected, such as buoys, containers and animals in forests. (convergence of TN and NTN IoT services)
KPI	Throughput	Kbps level
	Latency	No requirement
	Coverage	Rural areas, ocean, etc.
Terminal type		Portable
Frequency		Low band (such as L ,S, etc.)
Expected Service Provided Timing		Year 2025~30

Lower band-width, extremely wide-range coverage



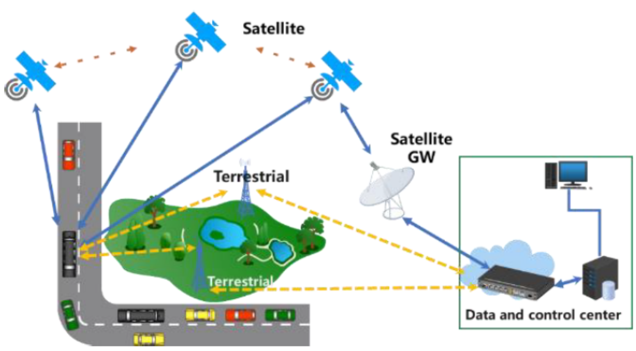
Technical Challenges and issues/difficulties to overcome this scenario includes;
1. Unified Protocol and Multi-Connection Technology for IMT and satellite
2. Intelligent High Dynamic Routing and Inter-satellite Optical Interconnection Tec.
3. Satellite-Ground Network O&M and Resource Management
4. Unified terminal for IMT and satellite communication

Highly expected international cooperation to overcome such challenges/issues.

5.1.4 High-Precision Location Information and Navigation

Use case overview		Integration of positioning and navigation for critical applications, such as remote driving, precise agricultural applications. (convergence of GNSS and communication)
KPI	Throughpu t	No requirement
	Latency	<20ms
	Coverage	Full coverage of earth
Terminal type		Convergent terminal for positioning and communication
Frequency		No requirement
Expected Service Provided Timing		Year 2025~30

High accuracy required scenario with Low Latency in Satellite communication.



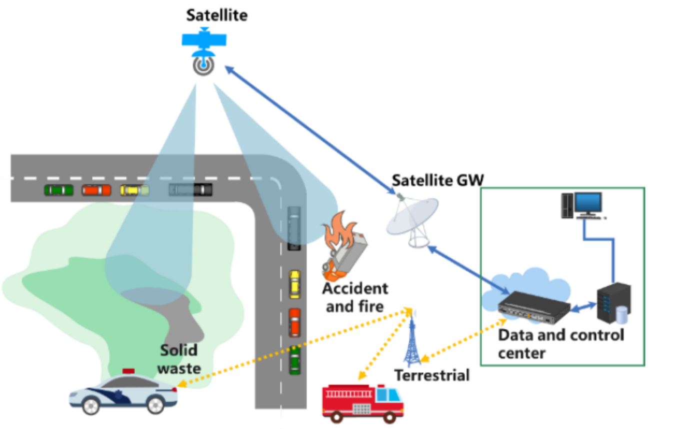
Technical Challenges and issues/difficulties to overcome this scenario includes;
1. Unified Protocol and Multi-Connection Technology for IMT and satellite
2. Intelligent High Dynamic Routing and Inter-satellite Optical Interconnection Tec.
3. Satellite-Ground Network O&M and Resource Management
4. Unified terminal for IMT and satellite communication

Highly expected international cooperation to overcome such challenges/issues.

5.1.5 Sensing and Communication Service Integration

Use case overview		Remote sensing and data transferring by the same satellite node. (convergence of Earth observation and Communication)
KPI	Throughput	>100Mbps for data transfer xx resolution for earth observation
	Latency	<20ms
	Coverage	Full coverage of earth
Terminal type		Dish terminal Mobile terminal
Frequency		Ku Ka and Low band
Expected Service Provided Timing		Year 2025~30

Sensing and Communication Service Integration



Technical Challenges and issues/difficulties to overcome this scenario includes;
1. Unified Protocol and Multi-Connection Technology for IMT and satellite
2. Intelligent High Dynamic Routing and Inter-satellite Optical Interconnection Tec.
3. Satellite-Ground Network O&M and Resource Management
4. Unified terminal for IMT and satellite communication

Highly expected international cooperation to overcome such challenges/issues.

5.1.6 Observation of River Water Level and Snow Accumulation

Tech to be used	GEO or LEO + Image analysis		
Use case	Remote monitoring of river water level and snow accumulation around railways, combining with NTN and single-board computer.		
UC Overview	To realize the measurement of water level and snow depth through the analysis of images or videos taken by the cameras installed near the river.		
Existing solution	None		
KPI	Throughput	Latency	Coverage
	Several Mbps	-	Remote area
Challenge	1. Inability to carry out measurements due to lack of personnel. 2. Personal injury accidents caused by working in hazardous areas. 3. Inability of measuring personnel to reach the site due to heavy snowfall.		
Expected Benefit	1. Acquisition of observation data regardless of weather 2. Supplementing staff shortages and reducing operating load by using data analysis		
Expected Service Provision Timing	Year 2023-2025		

Although there is a tendency for snow accumulation to decrease as global warming progresses, various natural disasters have been seen due to recent extreme weather. Working near rivers under such conditions is dangerous and may lead to the worst-case scenario. Mechanizing surveying operations such as image analysis allow us to avoid hazards as well as eliminating variations in measurement result caused by manual work. As a disaster-prone country, there are high expectations for data preservation, and it is expected to use for sharing information not only to Japan but also to other countries.

5.1.7 Herd Management

Tech to be used	GEO or LEO + LPWA		
Use case	Cow's herd count management integrated with LPWA		
UC Overview	By attaching LPWA tags to cows, we can achieve the automation of headcount management for cows moving around on the vast ranch.		
Existing solution	None		
KPI	Throughput	Latency	Coverage
	Several Mbps	-	Suburban area
Challenge	1. Reducing personnel operating cost at public ranch 2. Reducing the workload of patrolling vast ranch		
Expected Benefit	Reducing operating costs and time, and mitigating labor shortages		
Expected Service Provision Timing	Year 2023-2025		

Walking around a vast ranch is physically taxing and managing each numbered cow is not easy. As an initial introduction, reduced operating costs and workload in herd management are expected. In future, collaboration with the ranch's own physical condition management system (requires LTE communication) will be expected. There is also the possibility of technology diversion to other livestock. Demand is also expected in overseas countries (US, Australia etc.) where grazing area is larger than Japan.

5.1.8 Collaboration between Disaster Medical Sites and Hospitals

Tech to be used	LEO		
Use case	Means of communication among disaster medical sites and hospitals		
UC Overview	Provides collaboration among disaster sites and hospitals, and access to EMIS by installing antennas on emergency medical vehicles		
Existing solution	None		
KPI	Throughput	Latency	Coverage
	Tens of Mbps	-	Urban/suburban area
Challenge	Due to communication disruption at the disaster site ; 1. Unable to contact nearby hospitals（unable to cooperation） 2. Unable to access to EMIS（unable to system cooperation）		
Expected Benefit	1. Time saving for deciding on treatment methods and transport destinations 2. Smooth information sharing among field responders by communication equipment		
Expected Service Provision Timing	Year 2023~2025		

In addition to providing medical treatment at the disaster site and a means of communication with hospitals, it enables to access to EMIS (Emergency Medical Information System), which enables appropriate treatment and transportation by checking the operating status of nearby hospitals. It enables to provide optimal treatment by linking with a platform that centrally manages health information (medical history, hospital visit history, etc.).This use case is expected to be as an advanced initiative for the promotion of NTN, which combines both aspects of communication as a means of contact and as a means of accessing data.

5.1.9 Provision of Power Supply and Communication to Disaster Areas

Tech to be used	LEO + EV		
Use case	Providing power supply and communication through electric vehicles in the event of a disaster.		
UC Overview	Provides power supply and communication services in disaster areas by installing antennas on electric vehicles.		
Existing solution	None		
KPI	Throughput	Latency	Coverage
	Tens of Mbps	-	Urban/suburban area
Challenge	Ensuring power supply and communications in evacuation shelters		
Expected Benefit	With availability of communication; 1. Sharing information using safety confirmation and collection of damage data by local governments 2. Reduction of mental stress 3. Obtain surrounding information (damage, distribution of supplies, etc.)		
Expected Service Provision Timing	Year 2023～2025		

Source：https://www.softbank.jp/corp/news/press/sbkk/2022/20220214_01/

Telecommunications, now indispensable in daily life, is expected to be used especially for information gathering and communication during disasters. Many disaster victims become anxious when their daily communications become unavailable during a disaster, and the system is expected to reduce their stress. This case can be used not only during disasters, but also for special events, and is expected to be used as an alternative to wired communications, which take time to prepare.

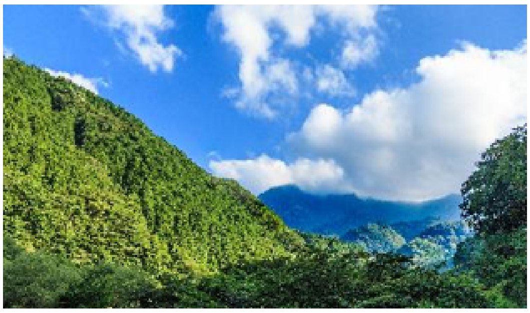
5.1.10 Mobility

Tech to be used	LEO/HAPS + Connected car		
Use case	Standardization of eCall at Connected cars		
UC Overview	By equipping vehicles with communication devices, it is possible to realize the rescue of accident vehicles using eCall.		
Existing solution	None		
KPI	Throughput	Latency	Coverage
	Tens of Mbps	-	Urban/suburban area
Challenge	1. In case of the accident in dead zones, it is unable to call for help 2. If the passenger cannot call, it will lead to a delay in rescue		
Expected Benefit	1. Expansion of the areas where rescue is possible using eCall even outside of cellular coverage. 2. Communication-based IoT collaboration and updating of vehicle-mounted systems		
Expected Service Provision Timing	Year 2025-2030		

Since April 1st, 2018, it is mandatory to equip new vehicles sold within the European Union with eCall. While advancements in autonomous driving technology focus on "safe driving," there is also an expected demand for the implementation of eCall services that prioritize post-accident response. As there are still areas without cellular network coverage, there is anticipation for satellite communications to compliment the coverage. Additionally, by integrating with IoT, there is the potential for applications such as reassessing insurance premiums based on accumulated driving information and detecting vehicle maintenance timings.

5.1.11 Communication Methods in Mountainous Areas

Tech to be used	HAPS		
Use case	Means of communication in mountainous areas		
UC Overview	Emergency communication methods for forestry workers		
Existing solution	None		
KPI	Throughput	Latency	Coverage
	Tens of Mbps	-	Suburban /mountainous area
Challenge	In mountainous areas, where communication is not available, there is a risk of life-threatening situations as contacting for rescue becomes impossible in the event of workers getting injured.		
Expected Benefit	1. Life saving of the injured in mountains 2. Communication among workers and remote responders 3. Improve work efficiency by sharing on-site photos of tree growth conditions		
Expected Service Provision Timing	Year 2025-2030		



According to MAFF data, number of forestry workers in 2015 are decreased to 45,000 (11,000 people are 65 years and over) compared to those in 1990 by 55,000 （decreased 3,000 people of 65 years and over). It is expected to be used as a means of emergency communication to protect current workers and promoting IoT in view of the declining workforce and aging of the industry. With the "Green Employment" project that started in 2003, a certain number of inexperienced workers are finding employment, and remote monitoring and work instructions are expected to be a great help.

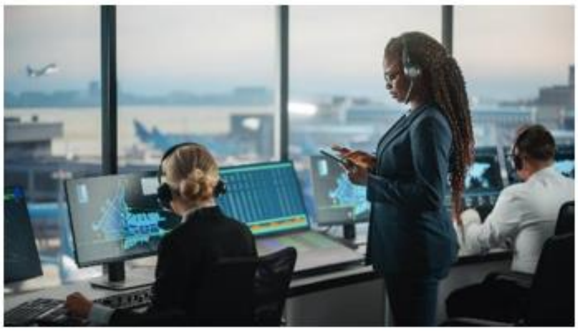
5.1.12 Unmanned Delivery (Using HAPS)

Tech to be used	HAPS + Location data		
Use case	Delivery by small drone		
UC Overview	By equipping small unmanned drones with location data, unmanned delivery to specific locations is made possible.		
Existing solution	None		
KPI	Throughput	Latency	Coverage
	Several Mbps	-	Urban/suburban area
Challenge	1. Shortage of delivery staff due to increased demand by popularity of food delivery and flea market application 2. Increased cost on the transportation industry due to free shipping etc. 3. Increased operations due to redelivery 4. Development of laws for air mobility		
Expected Benefit	1. Reduction of delivery burden for small-sized packages 2. Digital transformation (DX) of the transportation industry in data management		
Expected Service Provision Timing	Year 2025-2030		

Delivery demand has been rising due to new services and impact of COVID-19. The issue that stands out is the shortage of delivery staff. The service by equipping small drone with location data and enables unmanned delivery to unique locations have benefits including operation/fuel reduction for transportation industry, and same day delivery for users by shipping from nearby logistics center. It can also be used for transporting supplies during disasters. However, there is currently no established system for small drone to conduct aerial deliveries. It is anticipated that the development of regulations will enable smooth and efficient aerial delivery services.

5.1.13 Advancement Airport Control

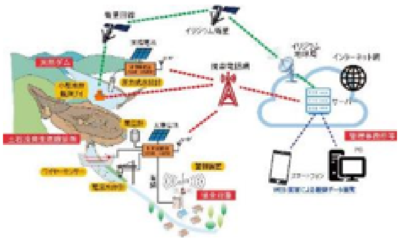
Tech to be used	HAPS + Sensing + Location data		
Use case	High-density operations through advanced control management		
UC Overview	Combining connectivity and sensing to achieve optimization of operation and routes.		
Existing solution	None		
KPI	**Throughput**	**Latency**	**Coverage**
	Tens of Mbps	Several milliseconds to tens of milliseconds	Urban/Suburban Maritime
Challenge	1. Prolonged waiting time for takeoff/landing 2. Data acquisition for flight path judgment		
Expected Benefit	1. Shortened waiting time for takeoff/landing through the utilization of location and sensing data 2. Determining flight path based on more detailed weather data than before than before 3. Reduction of CO_2 emissions through optimal flight path		
Expected Service Provision Timing	Year 2030 and later		



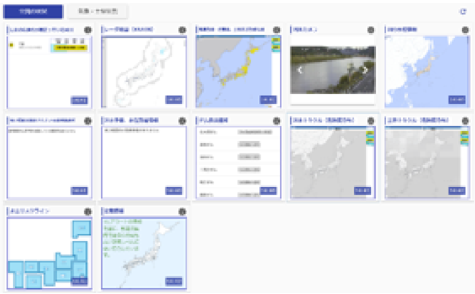
According to the International Air Transport Association (IATA), global aviation demand has shown signs of recovery as of June 2022. The total revenue passenger kilometers (RPK) increased by 76.2% compared to the same month last year, surpassing 70% of pre-pandemic levels. It is also forecasted to reach 101% of pre-pandemic levels by 2025. Prolonged waiting times during takeoff/landing not only create a negative impression for passengers but also require optimization from the perspective of smooth flight management. Detailed weather data obtained from the stratosphere enables better understanding and prediction of weather conditions, providing valuable insights for determining and modifying flight path. Additionally, flight path optimization is expected to contribute towards achieving a carbon-neutral world.

5.1.14 Disaster Detection in Mountainous Areas

Use case overview		To reduce damage by detecting signs of landslide occurrence and promptly warning downstream areas • Monitoring of landslide morphologies • Monitoring of natural dam water level • Detection of debris flow (wire sensor) Although this technology already exists, it is currently difficult to secure low-cost communication methods in mountainous areas. Satellite NB-IoT enables monitoring at lower cost over the wider areas.
KPI	**Throughput**	kbps level
	Latency	<600ms
	Coverage	Mountainous area
Terminal type		NB-IoT
Frequency		L-band, S-band
Expected Service Provision Timing		Year 2025~30



https://www.takuwa.co.jp/case/case3.html



https://www.river.go.jp/portal/?region=80&contents=multi

5.1.15 Public Safety LTE

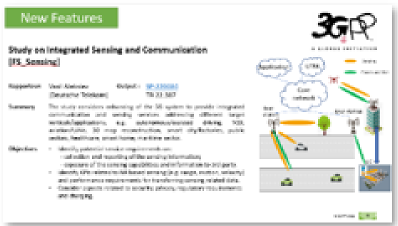
Use case overview		To Provide seamless Public Safety LTE service for areas outside cellular coverage or in the event of base station failure due to disaster by using satellite lines. ------- Public Safety LTE: A shared-use mobile communication network that enables high-speed data communication as well as voice communication using LTE. MIC aims to establish a verification system for the basic functions of PS-LTE, conduct functional verification in actual fields in cooperation with related organizations, and study operational issues and measures for social implementation in FY 2020, with the aim of starting full-scale operation in FY 2022.
KPI	Throughput	
	Latency	
	Coverage	Areas outside of terrestrial LTE coverage
Terminal type		Normal UE Compliant to 3GPP
Frequency		3GPP Band
Expected Service Provision Timing		Year 2025~30

https://www.soumu.go.jp/johotsusintokei/whitepaper/ja/r04/html/nd243420.html

5.1.16 Sensing

Use case overview		The use of sensing data provided by earth observation satellite is increasing in specialized areas such as weather observation and military. On the other hand, research and development of sensing technology for private-sector applications is also progressing, and in 3GPP Rel-19, a study item on sensing using mobile networks and base stations for terrestrial and indoor applications has been started, and discussions on use cases and network services are ongoing.In the future, mutual integration of sensing data between TN and NTN is expected to improve the accuracy of analysis and expand to various private services.
KPI	Throughput	N/A
	Latency	N/A
	Coverage	Nationwide (Ground + Sea)
Terminal type		N/A
Frequency		
Expected Service Provision Timing		Year 2030 and later

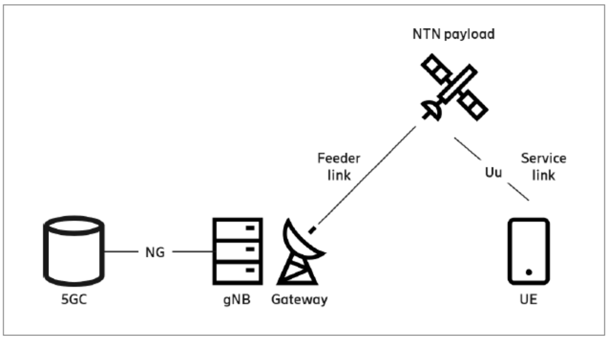
リモートセンシングと放射伝達 – JAXA 第一宇宙技術部門 Earth-graphy



https://www.3gpp.org/ftp/tsg_sa/TSG_SA/TSGS_96_Budapest_2022_06/Docs/SP-220661.zip

5.1.17 Complementary Services by NTN

活用技術 Tech to be used	LEO, 5GNR		
ユースケース Use Case	-5G Service at TN outside coverage -TN Backup to big NW failure/disaster -Reinforcement of government NW		
ユースケース概要 UC Overview	Global connectivity for transportation, energy and health sector 5G use case		
既存ソリューション Existing Solution	None		
KPI	Throughput	Latency	Coverage
	DL:10-15Mbps UL: ～1Mbps	25-42ms (max. RTD)	Outside of TN Coverage
課題 Challenge	1.Doppler effect 2.Latency/Delay 3.Inter-system connection 4.Install functionalities to smart phone		
想定 メリット・効果 Expected Benefit	1. Large ecosystem of standard products and components		
実現可能時期	2025年または2026年		



The 5G NTN business opportunity:
- Dedicated satellite network for national or regional security and sovereignty in addition to terrestrial fixed and mobile networks
- A supporting complement to the existing 5G cellular networks for additional coverage at lower costs (roaming partner solution to existing MNOs)
- An emergency fall-back system if parts, or all, cellular systems fail to function (resiliency)

Eco-System:
Reuse of the mass market 5G smartphone ecosystem and CSP subscriber base for satellite communication is what sets 5G NTN aside from anything else on the market.

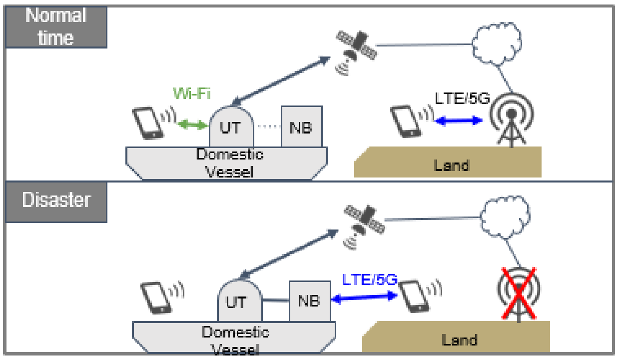
5.1.18 Unmanned Delivery (by Satellites)

Tech to be used	LEO		
Use case	Unmanned delivery		
UC Overview	Automated delivery by smart mobility (self-driving car and drone etc.)		
Existing solution	None		
KPI	Throughput	Latency	Coverage
	<1Mbps	-	Suburban/ urban area
Challenge	• Establishment of flight operations including autonomous driving • Cooperation between cellular and satellite communications • Installing the satellite terminal onto the drone • Legal development		
Expected Benefit	• Efficient delivery • Solution for labor shortage		
Expected Service Provision Timing	Year 2025~2030		

In 2030, Japan will face a labor shortage due to a rapidly shrinking population. Particularly mountainous areas and its surrounding area will see increased number of shopping refugees due to reduced public transportation and retailers. It is important to build an automatic delivery system that utilizes smart mobility such as self-driving cars & drones as counter measures.

5.1.19 Business Continuity Plan for Cellular Communication

Tech to be used	LEO+ Domestic vessel + Base station		
Use case	To provide communications for mobile phones from domestic vessels at the time of disaster		
UC Overview	Cellular base stations equipments are installed on board domestic vessels to provide cellular communications from the vessels by using satellite communications as a backhaul line. In the event of a disaster, this contributes to rapid restoration in areas where restoration is difficult. During normal times, Wi-Fi is provided for crew members.		
Existing solution	Cable laying vessel "KIZUNA"		
KPI	Throughput	Latency	Coverage
	-	-	-
Challenge	1. Communication failure due to collapse of base station in the event of disaster 2. Prolonged communication recovery time due to damage to the land route 3. Delay in safety confirmation due to communication disruption		
Expected Benefit	1. Swift communication restoration 2. Early safety confirmation 3. Reduction of mental stress 4. Obtain surrounding information (damage, distribution of supplies, etc.)		
Expected Service Provision Timing	Year 2023~2025		

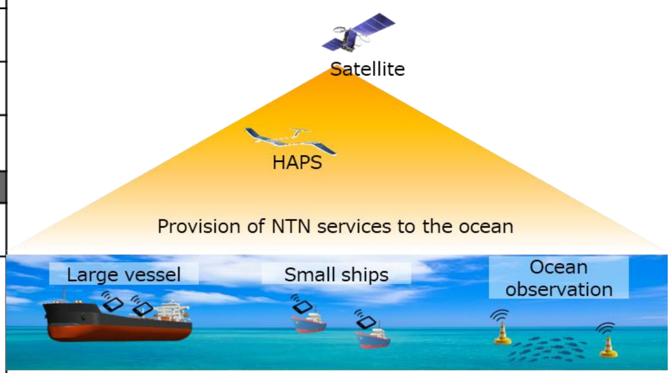


UT : User terminal for satellite communication NB : Cellular base station equipment

Cellular communication has become an essential infrastructure for daily life, swift recovery is required in the event of communication disruption due to a disaster. It is necessary to have BCP measures throughout Japan as it is essential not only for confirming safety in disaster-stricken areas, but also as a medium for communicating and gathering information. The solution of approaching from the sea using a "shipboard base station" that was operated during the Noto Peninsula earthquake in 2024 has proven to be technically feasible. Increased numbers of such stations will enable to respond quickly and flexibly. Price reduction might be possible if it could be introduced to all existing (approx.7,000) vessels.

5.1.20 Mobility in the Ocean

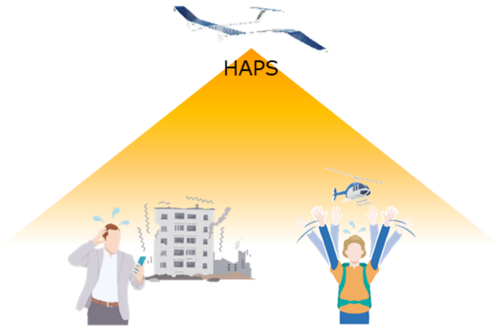
Tech to be used	LEO or HAPS + Mobile direct		
Use case	Ocean observation, communication provision to ships and ferries, safe operation system for small ships, etc.		
UC Overview	Offering seamless NTN mobile direct communication services in the ocean for various use cases		
Existing solution	Satellite phone service, etc.		
KPI	Throughput	Latency	Coverage
	Several kbps to several Mbps	-	Ocean
Challenge	1. Network: Implementation of TN/NTN linkage system, seamless handover, land-sea seamless, provision of D2D services, etc. 2. Terminals: Sea specification of antenna equipment, compatibility of communication capacity/speed with compact size and power saving, etc. 3. Communication quality: Same communication environment as on the ground, stable connectivity, etc.		
Expected Benefit	In the conventional satellite phone service in the ocean, a dedicated terminal is required, and communication speed and capacity are limited. Mobile direct by LEO/HAPS is expected to realize a faster and larger capacity service using the same mobile terminal as on the ground, such as a smartphone.		
Expected Service Provision Timing	Year 2025-2030		



It is expected to provide a seamless mobile direct communication service by NTN in the ocean and use it for various use cases such as ocean observation, communication provision to ships/ferries, and safe operation system for small ships. Different services require a wide range of communication speeds and required costs, and flexible service provision is required.

5.1.21 Disaster Management (by HAPS)

Tech to be used	HAPS		
Use case	Rapid restoration of mobile communications services (LTE/5G) in the event of a disaster		
UC Overview	Provides direct communication services (LTE/5G) to mobile terminals by utilizing highly mobile HAPS in areas where terrestrial communication services are difficult to provide in the event of a disaster (To improve the mobility of HAPS, use portable GW stations or backhaul lines via satellites.)		
Existing solution	Large zone base stations, transportable base stations by vehicles or ships, etc.		
KPI	Throughput	Latency	Coverage
	Several Mbps	-	Disaster area
Challenge	In some disaster-stricken areas, it may be difficult to move portable base stations, and it may take time to restore mobile communications services.		
Expected Benefit	Faster recovery of mobile communications services compared to existing solutions, especially in disaster-stricken areas where mobile base stations are difficult to move.		
Expected Service Provision Timing	Year 2025-2030		



Recently, a number of natural disasters have occurred in Japan, such as the Noto Peninsula Earthquake. Expectations for the practical application of HAPS as a means of disaster countermeasures are growing among telecommunications carriers. The direct communication service to mobile terminals by HAPS does not depend on the 3GPP NTN standard and has the advantage of being compatible with a wide range of existing terminal models, leading to the ability to provide a lifeline service to a larger number of users, especially in use cases such as disaster countermeasures.

5.1.22 Video Transmission from Remote Area and Drone

Tech to be used	HAPS		
Use case	Video transmission via mobile communications services (LTE/5G) from remote areas and drones		
UC Overview	Real-time video transmission from a terminal mounted on a drone, etc., using high-speed uplink data communication via HAPS from remote areas or airborne areas where terrestrial communication services are out of range		
Existing solution	LTE airspace plan, etc.		
KPI	Throughput	Latency	Coverage
	Several Mbps	-	Remote or airborne areas
Challenge	1. In some areas, it may be difficult to provide communication services to drones using existing terrestrial networks (such as LTE airspace plan) 2. In NTN, future technological development is required to realize uplink high-speed data communication from mobile terminals with limited transmission power.		
Expected Benefit	1. It is possible to transmit images using mobile terminals from areas outside the range of terrestrial networks, and can be used for various use cases such as broadcasting, surveillance, life-saving search, etc. 2. It is possible to realize seamless real-time transmission of drone aerial images by supplementing existing communication services via terrestrial networks.		
Expected Service Provision Timing	Year 2025-2030		

The direct communication service to mobile terminals by HAPS has the feature of realizing high-speed data transmission, especially on uplink where terminal transmission power is severely limited. Therefore, it is possible to realize not only services such as text messages and voice calls, but also services that require high-speed communication, such as video transmission from remote areas using drones and buoys on the sea, etc. It is expected to be used as a use case especially for industry.

5.2 Examination of Solutions and Countermeasures for the Issues

In the last fiscal year (FY 2023), we mapped each of the use cases shown in the previous section and the categories included therein and examined them from the perspective of the cases that should be most realized as Beyond5G. As a result, we selected seven application cases to be taken up as subjects for extracting issues for social implementation, and examined the technologies and solutions considered necessary for solving the issues.

In the current fiscal year (FY 2024), discussions were held mainly on cases of NTN utilization in the ocean, such as ships and ocean observation. As a result, mobility in the ocean was newly selected, and issues and technical requirements that need to be developed for social implementation of NTN services were examined.

5.2.1 NTN and TN Integration

No.	課題 Challenge	詳細(細分化) Details (Subdivision)	課題解決に向けた協力依頼先となる業種 Target industries for cooperation to resolve issues	技術的な挑戦と困難/課題解決案 ※現時点で見えているものがあれば Technical challenges/Solution idea *If it is currently known	備考 Remarks
1	想定ユースケースにおける必要通信要件の確認 Confirmation of required communication requirements for target use cases	標準化/業界団体動向 Standardization/industry group trends	業界団体 （5GAA等） Industry group (5GAA etc.)	利用者ニーズに即した標準化 Standardization in line with user needs	全事例に共通 災害対策の重要度が上がっている Common to all cases. Disaster countermeasures become more important
		利用事業者動向 User company trends	想定利用事業者 （自動車OEM等） Target user (Automotive OEM etc.)	利用者ニーズに即した標準化 Standardization in line with user needs	
2	TN/NTN NW統合の仕組み Mechanism of TN/NTN NW integration	［SD-WAN方式］ ・UTと網側で通信ベアラの切替、トラヒックのBonding/Blendingを行う上での仕様の統一化 [SD-WAN] ・Unification of specifications for communication bearer switching and traffic bonding/blending between UT & network side	・SD-WANベンダー ・SD-WAN vendor	TN/NTN事業者の網間接続方式の定義と各ベンダーの仕様統一化 Definition of TN-NTN carrier network connection method & unification of vendors' specifications	現在は、各ベンダー独自実装 →UT側・NW側が同一ベンダーである必要有 Currently, each vendor has its own implementation → UT side and NW side must be from the same vendor.
		［TN-NTN事業者 網間接続方式］ ・網間インタフェース/プロトコルの共通化 －認証方式 －Handover －不整合がある場合のコンバーター [TN-NTN carrier network connection method] ・Unification of network interfaces/protocols -Authentication method -Handover -Converter in case of inconsistency	・NTN事業者 ・TN事業者 ・Global MVNO ・通信NW機器メーカー ・NTN operators ・TN operator ・Global MVNO ・Communication NW equipment manufacturer		ローミング方式ならびにShare RAN方式あり HAPSとGEO/LEOの連携を検討（NTNノード間連携） Roaming and Share RAN methods Considering collaboration between HAPS and GEO/LEO(NTN inter-node cooperation)
		［HAPSと衛星の連携方式］ ・HAPSと衛星によるシームレスなNTNサービス提供 ・HAPSへのフィーダリンク回線を衛星経由で提供する方式等 [HAPS & satellite cooperation method] ・Seamless NTN service provision using HAPS & satellites ・Method of providing feeder link line to HAPS via satellite, etc.	・NTN事業者 ・TN事業者 ・NTN operator ・TN operator		
3	TN/NTN両対応端末の開発 Development of terminal compatible with both TN/NTN	・チップセット/SIM/アンテナ等の統一化 Unification of chipset/SIM/antenna etc.	・UTベンダー ・UT vendor	チップセット/SIM/アンテナ等の統一化 Unification of chipset/SIM/antenna etc.	各部品選定の主導権はUTベンダーにあるため、まずは部品メーカーではなく、UTベンダーの巻き込みがよいと考える UT vendor holds the initiative in selecting each component. Involve the UT vendor first, rather than the component manufacturer.
		・ユースケースに合わせた形状のアンテナ開発 Developing antennas with shapes tailored to use cases	・UTベンダー ・UT vendor	アンテナの小型化 Antenna miniaturization	
4	顧客PFの開発 Development of customer PF	・TN/NTN統合に際する請求システム統合 Billing system integration for TN/NTN integration	・NTN事業者 ・TN事業者 ・Sier ・NTN operator ・TN operator ・Sier	技術的には実現可能であると想定 Assumed to be technically feasible	
		・利用状況等の可視化システムの設計/開発 Design/development of visualization system for usage status, etc.	・NTN事業者 ・TN事業者 ・SIer	技術的には実現可能であると想定 Assumed to be technically feasible	
		・回線管理システムの設計/開発 Design/development of line management system	・NTN事業者 ・TN事業者 ・SIer	技術的には実現可能であると想定 Assumed to be technically feasible	
		・通信最適化システムの設計/開発 Design/development of communication optimization system	・NTN事業者 ・TN事業者 ・通信NW機器メーカー ・NTN operator ・TN operator ・Communication NW equipment manufacturer	技術的には実現可能であると想定 Assumed to be technically feasible	

No.	課題 Challenge	詳細(細分化) Details (Subdivision)	課題解決に向けた 協力依頼先となる業種 Target industries for cooperation to resolve issues	技術的な挑戦と困難/課題解決案 ※現時点で見えているものがあれば Technical challenges/Solution idea *If it is currently known	備考 Remarks
5	制度化に向けての技術的検討 Technical consideration for institutionalization	＊理想となる各NW（TN/NTN）のインターワークの仕組み定義 *Definition of ideal interwork mechanism for each NW	・NTN事業者 ・TN事業者 ・Global MVNO ・通信NW機器メーカー ・NTN operator ・TN operator ・Global MVNO ・Communication NW equipment manufacturer	利用者ニーズに即したインターワークの仕組み定義 Definition of interwork mechanism in line with user needs	アーキテクチャ定義の前段として顧客ニーズの把握が必要 e.g. ・Mobilityの自律運転 ・EEZ外でも使える通信回線 Requires understanding of customers needs to define architecture as a first step. e.g. ・Mobility autonomous driving ・Communication lines that can be used outside of the EEZ
		＊NW統合する最適な手段の検討 （考えられる案） －SD-WAN －事業者間ローミング －その他 *Examining the optimal means of NW integration (possible idea) －SD-WAN －Inter-operator roaming －Others	・NTN事業者 ・TN事業者 ・Global MVNO ・通信NW機器メーカー ・NTN operator ・TN operator ・Global MVNO ・Communication NW equipment manufacturer	利用者ニーズに即したインターワークの仕組み定義 Definition of interwork mechanism in line with user needs	顧客要件を満たす切り替え時間を実現する必要有 HAPSによる端末への直接通信とGEO/LEOによる大容量固定系通信がメインと想定 Need to achieve changeover times that meet customer requirements. It is assumed that direct communication to terminals using HAPS and large-capacity fixed-line communication using GEO/LEO will be the main ones.
6	既存制度の適応範囲の検討 Consideration of the application scope of existing systems	社会実装したいシステム連携（インターワーク）に応じた、TN基準の踏襲可否の検討・判断 （認証方式、周波数、通信機器） Consider & determine whether TN standards can be followed in line with the system collaboration (interwork) planned to be implemented in society (Authentication method, frequency, communication equipment)	・各標準機関 ・総務省 ・SDOs ・MIC	利用者ニーズに即したインターワークの仕組み定義 Definition of interwork mechanism in line with user needs	
7	カバレッジ連携 Collaborative Coverage	カバレッジ拡大 Coverage enhancement	ベンダー＆オペレーター Vendor& Operator	端末と衛星間の直接通信のサービスエリア拡大とインターワークの機能 Enhancing coverages & interworking to support direct connection between cellphones and satellites	（RP-232669）3GPP RAN1-Rel18にて議論されている In-discussion（RP-232669）3GPP RAN1-Rel18
		デュアルカバレッジ/マルチ接続 Dual coverage/multi connections	ベンダー＆オペレーター Vendor& Operator	衛星ネットワークと地上ネットワークのデュアル接続のカバレッジ拡大 Extending dual connection coverages of satellite and terrestrial networks	3GPPにおいて議論未実施 Not discussed yet In 3GPP
8	端末移動時の管理 Mobility Management	セルの管理 Cell Management	ベンダー＆オペレーター Vendor& Operator	異なるネットワーク間のシームレスなローミングをサポートするインターワーキングの強化 Interworking enhancement to support seamless roaming between different networks	3GPP RAN2 (RP-232669)にて議論されている Discussed in 3GPP RAN2 (RP-232669)
		ハンドオーバー Handover	ベンダー＆オペレーター Vendor& Operator	ハンドオーバー時のリンクの安定性向上 Improve link stability while during handover process	

No.	課題	詳細(細分化)	課題解決に向けた 協力依頼先となる業種	技術的な挑戦と困難/課題解決案 ※現時点で見えているものがあれば	備考
9	ルーティングの管理 Routing management	ダイナミック・トポロジー Dynamic Topology	ベンダー＆オペレーター Vendor& Operator	ネットワーク・トポロジーをリアルタイムで取得または更新する新しいメカニズム等の導入（NTT様同様の検討有り） Introduce new mechanisms to obtain or update the network topology in real time	衛星は移動し、時間によってトポロジーが変化するため、地上NWよりも難しい More difficult than terrestrial, because the satellites moves, the topology changes by time
		ルーティングプロトコル Routing Protocols	ベンダー＆オペレーター Vendor& Operator	TCP/IPなどのプロトコルを改良し、移動する衛星をとらえる Improved protocols such as TCP/IP to catch up moving satellite target	
10	衛星間通信 Inter satellite communication	高キャパシティー＆安定したリンク High capacity & stable link	光通信 Optical communication	最大100Gbps（リンクあたり）の衛星間通信に対応 Up to support 100Gbps (per-link) inter-satellites	衛星間通信への帯域割当 Inter-satellites bandwidth allocation
		搭載機器の交換 On Board exchange	データ処理（チップスピード） Data processing (Chip speed)	光スイッチングや処理装置の進化に基づく技術課題 Technical challenge based on the evolution of optical switches and processors on boarded.	
11	電波の調整 Spectrum coordination	電波の管理 Spectrum management	規制当局とオペレーター Regulators and Operators	周波数割り当てと複数システムの多重化に関する規制 Regulations on Frequency Allocation and Multiplexing for Multiple Systems	スペクトルの分離またはスペクトラム共有（ITU-Rおよび3GPP RP-232669） Spectrum isolation or Spectrum sharing (ITU-R and 3GPP RP-232669) HAPSでは地上NWと同じ周波数を共用することが大きな課題
		干渉検知 Interference detection	オペレーター Operators	優れた干渉検知と評価メカニズム Intelligent Interference Detection and Evaluation mechanism	
12	運用＆保守 O&M	リソース管理の統一化 Unified resource management	オペレーター Operators	異なるネットワーク間のリソースを調整し、ユーザーの接続要件を満たす課題 Coordinates resources between different networks to meet user connection requirements.	オペレーターによる運用＆保守機能の向上が期待される Operators improved O&M features are expected
		ユーザー管理の統一化 Unified user management	オペレーター Operators	充電方式、端末、決済の統一化 One charging mode, one terminal, and unified settlement	
13	アンテナ Antennas	衛星側のアンテナ Satellite antennas	アンテナメーカー Antenna manufactures	デジタルフェーズドアレイによる柔軟なビームステアリングとリソース割り当て課題 Digital phase array to support flexible beam steering and resource allocation	衛星アンテナの無線技術の向上が期待される Expected improved Radio technology on Satellite Antennas
		端末側のアンテナ Terminal antennas	アンテナメーカー Antenna manufactures	安価な電気式ステアリングアンテナ/携帯電話用小型端末アンテナ化への挑戦 Low cost electrical steering antenna/ compact size terminal antenna for cell phones	

5.2.2 Broadband Communication Outside of TN Coverage

No.	課題 Challenge	詳細(細分化) Details (Subdivision)	課題解決に向けた 協力依頼先となる業種 Target industries for cooperation to resolve issues	技術的な挑戦と困難/課題解決案 ※現時点で見えているものがあれば Technical challenges/Solution idea *If it is currently known	備考 Remarks
1	モバイル ダイレクトの高速化 Acceleration of Mobile Direct	・衛星－スマートフォン通信で >10Mbpsの下り速度を実現できるか。一方で上り速度に対しては1Mbpsを下回るのではないか。 ・Cell範囲が大きいことによるキャパシティにも懸念あり ・Can download speeds of >10Mbps be achieved with satellite-smartphone communication? With upload, the speed may be less than 1Mbps. ・There are also concerns of capacity due to the large cell range.	・LEO事業者 ・LEO Operator	アンテナの大型化（ただし、利便性とトレードオフ） Larger antenna (However, trade-off with convenience)	要件［Throughput：>10Mbps for cellphone］よりモバイルダイレクトの事例と判断して記載。前段として要件の精緻化が必要。 HAPSによるモバイルダイレクトの高速大容量化を検討. LEOはビーム数が多いと想定され、フィーダリンクの実現性も懸念 Determined as Mobile Direct case based on the requirement［Throughput：>10Mbps for cellphone］.Requirements need to be refined as a first step. Considering increasing the speed & capacity of mobile direct using HAPS. LEO is expected to have a large number of beams, and there are concerns about the feasibility of feeder links.
2	エアー・インターフェース Air interface	同期 synchronization	ベンダー＆オペレーター Vendor& Operator	衛星通信における伝送遅延とドップラー効果の影響を克服するため、共通なTA計測とGNSSによる位置測位はこの問題を軽減する技術になり得ると考える。 To over come the Impact of Transmission Delay and Doppler Effect in satellite communication, common TA (Timing Advance) and GNSS positioning may mitigate the issue.	3GPP RAN1 38.213-4.2；38.211-4.3.1
		ランダムアクセス Random access	ベンダー＆オペレーター Vendor& Operator	新たなプリアンブルシーケンス、ランダムアクセス手順の簡素化 New preamble sequence, Simplified random access procedure	3GPPにおいて議論未実施 Not discussed in 3GPP yet
		マルチユーザーMIMO MU-MIMO	ベンダー＆オペレーター Vendor& Operator	スペクトル効率の向上、複数の衛星をどのように同期させるかが課題 Improve the spectrum efficiency, the difficulty is how to synchronize multiple satellites	3GPPにおいて議論未実施 Not discussed in 3GPP yet
3	MACプロトコル MAC protocols	ビームホッピング Beam hopping	ベンダー＆オペレーター Vendor& Operator	カバレッジの需要に適合するためのビーム リソース割り当てメカニズム Beam resource allocation mechanism to make sure match the coverage demands	すでにGEO衛星通信システムで使用されている Already used in GEO satellite communication systems
		リソースの割当 Resource allocation	ベンダー＆オペレーター Vendor& Operator	高スループットの要件を満たすための電力、キャリアリソース割当て、帯域幅の割当てに関する課題 Power, carrier resource allocation and bandwidth assignment to meet requirement of high throughputs	地上ネットワークと同様 Similar to terrestrial networks

No.	課題 Challenge	詳細(細分化) Details (Subdivision)	課題解決に向けた 協力依頼先となる業種 Target industries for cooperation to resolve issues	技術的な挑戦と困難/課題解決案 ※現時点で見えているものがあれば Technical challenges/Solution idea *If it is currently known	備考 Remarks
4	ユーザー端末 User terminal	消費電力 Power consumption	チップメーカー＆標準プロトコル Chip manufacturing & protocol standard	低消費電力デバイス、5Gよりも低い送信電力 Low power consumption devices, low transmit power than 5G	ユーザー端末のEIRPについては 3GPP RAN1で議論されている EIRP of user terminal discussed in 3GPP RAN1
		アンテナ小型化 Antenna miniaturization	アンテナメーカー Antenna manufacturing	ブロードバンドのための携帯電話のビームステアリングアンテナ Beam steering antenna in mobile phone for broadband	アンテナパラメーターは3GPP RAN1 Rel16 (TR38.821)で議論されている Antenna parameter of user terminal discussed in 3GPP RAN1 Rel16 (TR38.821)
		端末小型化 Device miniaturization	端末メーカー Device manufacturing	ハンドセット端末またはポータブルデバイスへのダイレクト接続をサポートする機能 Support direct connection to handset-UE or portable devices	小型化はデバイスメーカーとユースケースシナリオにも依存 miniaturization may depend on device manufacturers and usage scenarios.
5	衛星ペイロード Satellite payload	搭載プロセッサ Onboard processor	チップメーカー Chip manufacturing	デジタル式ペイロードにより遅延を削減し、より柔軟なサービスを提供する Digital payloads, reduce time delay and provide more flexible service	3GPP RAN1で議論されている Discussed in 3GPP RAN1
		電源 Power supply	衛星ベンダー Satellite manufacturing	設備の低コスト化 Low-cost Equipment	高容量電源供給は既存技術制約の1つ High-capacity power supply is one of the technical limitations so far.

5.2.3 IoT Communication Outside of TN Coverage

No.	課題 Challenge	詳細(細分化) Details (Subdivision)	課題解決に向けた協力依頼先となる業種 Target industries for cooperation to resolve issues	技術的な挑戦と困難/課題解決案 ※現時点で見えているものがあれば Technical challenges/Solution idea *If it is currently known	備考 Remarks
1	TN/NTN統合の定義 Definition of TN/NTN integration	・既にNTN IoT技術は実現している ⇒TNと統合が必要となる場合、想定されるユースケースを踏まえた統合の定義づけから必要 ⇒「対象事例名：NTN-TN interworking」の議論へ NTN IoT technology has already been realized. →If integration with TN is required, it is necessary to define the integration based on the expected use case. →Discuss "Target case: NTN-TN interworking"		利用者ニーズに即したユースケースの把握 Understanding use cases that meet user needs.	
2	エアー・インターフェース Air interface	同期 synchronization	ベンダー＆オペレーター Vendor& Operator	衛星通信における伝送遅延とドップラー効果の影響を克服するため、共通なTA計測とGNSSによる位置測位はこの問題を軽減する技術になり得ると考える。 To overcome the Impact of Transmission Delay and Doppler Effect in satellite communication, common TA (Timing Advance) and GNSS positioning may mitigate the issue.	3GPP RAN1 38.213-4.2；38.211-4.3.1
		ランダムアクセス Random access	ベンダー＆オペレーター Vendor& Operator	新たなプリアンブルシーケンス、ランダムアクセス手順の簡素化 New preamble sequence, Simplified random access procedure	3GPP RAN1にて議論されている Discussed in 3GPP RAN1
		Redcap （小型で低消費電力のIoT機器を、5Gで接続しやすくするための拡張機能）	ベンダー＆オペレーター Vendor& Operator	低消費電力、低ランク変調、低複雑度 Low power consumption, low modulation rank, low complexity	3GPP RAN1にて議論されている Discussed in 3GPP RAN1
		IoTプロトコル IoT protocols	ベンダー＆オペレーター Vendor& Operator	NB-IoT, LoRa, Sigfoxなど3種類の異なるプロトコルの収容スキーム Diversified three different protocols, such as NB-IoT, LoRa and Sigfox are exist, how should they be accommodated?	NB-IoTは3GPP RAN1にて議論されている、LoRaとSigfoxはプライベートプロトコル NB-IoT is discussed in 3GPP RAN1, LoRa and Sigfox are private protocols
3	MACプロトコル MAC protocols	リソースの固定割り当て Fixed resource assignment	ベンダー＆オペレーター Vendor& Operator	通信衝突を避けるためにユーザ毎に時間と周波数の固定リソースを割り当てる手法（NB-IoT） Allocating fixed time-frequency resources to users may contribute to avoid collisions(NB-IoT)	3GPP RAN1にて議論されている Discussed in 3GPP RAN1
		リソースのランダム割り当て Random resource assignment	ベンダー＆オペレーター Vendor& Operator	異なる(時分割・周波数分割)リソース割当手法は、スペクトル効率とエネルギー効率の向上寄与の可能性(LoRa およびSigFox) Allocating different (time & frequency) domain resource mechanism may improve spectral and energy efficiency (LoRa and SigFox)	プライベートプロトコル Private protocols
4	ユーザー端末 User terminal	消費電力 Power consumption	チップメーカー＆標準プロトコル Chip manufacturing & protocol standard	低消費電力デバイス、5Gよりも低い送信電力 Low power consumption devices, low transmit power than 5G	ユーザー端末のEIRPについては3GPP RAN1で議論されている EIRP of user terminal discussed in 3GPP RAN1
		端末小型化 Device miniaturization	端末メーカー Device manufacturing	端末またはポータブルデバイスへのダイレクト接続をサポートする機能 Support direct connection to UE or portable devices	小型化はデバイスメーカーとユースケースシナリオにも依存 miniaturization may depend device manufacturers and usage scenarios.
5	衛星ペイロード Satellite payload	搭載プロセッサ Onboard processor	チップメーカー Chip manufacturing	デジタル式ペイロードにより遅延を削減し、より柔軟なサービスを提供する Digital payloads, reduce time delay and provide more flexible service	3GPP RAN1で議論されている Discussed in 3GPP RAN1
		電源 Power supply	衛星ベンダー Satellite manufacturing	設備の低コスト化 Low-cost Equipment	高容量電源供給は既存技術制約の1つ High-capacity power supply is one of the technical limitations so far.

5.2.4 High-Precision Positioning and Navigation

No.	課題 Challenge	詳細(細分化) Details (Subdivision)	課題解決に向けた協力依頼先となる業種 Target industries for cooperation to resolve issues	技術的な挑戦と困難/課題解決案 ※現時点で見えているものがあれば Technical challenges/Solution idea *If it is currently known	備考 Remarks
1	位置測位の高精度化 High precision positioning	・Mobilityの自動運転を可能にする位置測位精度の明確化 Clarification of positioning accuracy for enabling self-driving Mobility	・自動車メーカー ・農耕機メーカー ・ドローンメーカー ・Auto manufacturer ・Agricultural machinery manufacturer ・Drone manufacturer	利用者ニーズに即したユースケースの把握 Understanding use cases that meet user needs.	HAPSでの光学センサー等によるセンシングも有望 Sensing using optical sensors etc. in HAPS is also promising.
		・高精度位置測位技術の開発 Development of High precision positioning technology	・通信機器メーカー ・Communication equipment manufacturer	利用者ニーズに即したユースケースの把握 Understanding use cases that meet user needs.	※cm測位(RTK測位)のSOLは存在 ※ cm-positioning (RTK positioning) SOL exists
2	低遅延（Latency：<20ms）の定義 Definition of low latency (Latency：<20ms)	①衛星側に処理能力を置く場合の実現可否検討 Consideration of feasibility when placing processing power in satellite side	・衛星通信事業者 ・Satellite operator	利用者ニーズに即したユースケースの把握 Understanding use cases that meet user needs.	前段として要件の精緻化が必要 Requirements need to be refined as a first step
		②HAPSを利用する場合の実現可否検討 Consideration of feasibility when using HAPS	・HAPSオペレーター ・HAPS operator	利用者ニーズに即したユースケースの把握 HAPSでは、RANの遅延について大きな課題はない認識だが、E2Eでの低遅延化にはMECの適用等が必要（TNと同じ）	
3	見通し影響 LOS impact	・衛星通信を前提とした際、LOS(見通し)が取れない場面があるが、そこを踏まえた自動運転シナリオとなっているか With satellite communication, there are situations where LOS (line of sight) cannot be obtained. The autonomous driving scenario should take this into account.	・自動車メーカー ・農耕機メーカー ・ドローンメーカー ・Auto manufacturer ・Agricultural machinery manufacturer ・Drone manufacturer	利用者ニーズに即したユースケースの把握 Understanding use cases that meet user needs.	セルラー圏外かつLOS取れない場面を想定 Target situation is where it is out of cellular service and cannot obtain LOS.
4	エアー・インターフェース Air interface	同期 synchronization	ベンダー＆オペレーター Vendor& Operator	衛星通信における伝送遅延とドップラー効果の影響を克服するため、共通なTA計測とGNSSによる位置測位はこの問題を軽減する技術になり得ると考える。 To over come the Impact of Transmission Delay and Doppler Effect in satellite communication, common TA (Timing Advance) and GNSS positioning may mitigate the issue.	3GPP RAN1 38.213-4.2；38.211-4.3.1
		ランダムアクセス Random access	ベンダー＆オペレーター Vendor& Operator	新たなプリアンブルシーケンス、ランダムアクセス手順の簡素化 New preamble sequence, Simplified random access procedure	3GPP RAN1にて議論されている Discussed in 3GPP RAN1
		位置測位 Positioning	ベンダー＆オペレーター Vendor& Operator	単一衛星による測位、GNSS測位の強化 single satellite positioning enhancement based on GNSS	3GPP RAN1にて議論されている Discussed in 3GPP RAN1
		センシング Sensing	ベンダー＆オペレーター Vendor& Operator	センシングと通信を同時に行う波形 Waveform support sensing and communication at the same time	3GPPでは議論されていない、ISACと同様、2つの機能を同時にサポートする波形を検討する必要あり Not discussed in 3GPP, similar to ISAC, need to consider the same waveform to support two functions

No.	課題 Challenge	詳細(細分化) Details (Subdivision)	課題解決に向けた協力依頼先となる業種 Target industries for cooperation to resolve issues	技術的な挑戦と困難/課題解決案 ※現時点で見えているものがあれば Technical challenges/Solution idea *If it is currently known	備考 Remarks
5	MACプロトコル MAC protocols	ビームホッピング Beam hopping	ベンダー＆オペレーター Vendor& Operator	高スループットの要件を満たすための電力、キャリアリソース割当て、帯域幅の割当てに関する課題 Power, carrier resource allocation and bandwidth assignment to meet requirement of high throughputs	すでにGEO衛星通信システムで使用されている Already used in GEO satellite communication systems
		リソースの割当 Resource allocation	ベンダー＆オペレーター Vendor& Operator		地上ネットワークと同様 Similar to terrestrial networks
6	ユーザー端末 User terminal	消費電力 Power consumption	チップメーカー＆標準プロトコル Chip manufacturing & protocol standard	低消費電力デバイス、5Gよりも低い送信電力 Low power consumption devices, low transmit power than 5G	ユーザー端末のEIRPについては 3GPP RAN1で議論されている EIRP of user terminal discussed in 3GPP RAN1
		アンテナ小型化 Antenna miniaturization	アンテナメーカー Antenna manufacturing	ブロードバンドのための携帯電話のビームステアリングアンテナ Beam steering antenna in mobile phone for broadband	アンテナパラメーターは3GPP RAN1 Rel16 (TR38.821)で議論されている Antenna parameter of user terminal discussed in 3GPP RAN1 Rel16 (TR38.821)
		端末小型化 Device miniaturization	端末メーカー Device manufacturing	携帯電話またはポータブルデバイスへのダイレクト接続をサポート Support direct connection to mobile phone or portable devices	デバイスメーカーとユースケースシナリオによる Depend on device manufacturer and usage scenarios
7	衛星ペイロード Satellite payload	搭載プロセッサ Onboard processor	チップメーカー Chip manufacturing	デジタル式ペイロードにより遅延を削減し、より柔軟なサービスを提供する Digital payloads, reduce time delay and provide more flexible service	3GPP RAN1で議論されている Discussed in 3GPP RAN1
		電源 Power supply	衛星ベンダー Satellite manufacturing	設備の低コスト化 Low-cost Equipment	高容量電源供給は既存技術制約の1つ High-capacity power supply is one of the technical limitations so far.

5.2.5 Collaboration between Disaster Medical Sites and Hospitals

No.	課題 Challenge	詳細(細分化) Details (Subdivision)	課題解決に向けた 協力依頼先となる業種 Target industries for cooperation to resolve issues	技術的な挑戦と困難/課題解決案 ※現時点で見えているものがあれば Technical challenges/Solution idea *If it is currently known	備考 Remarks
1	可用性の確保 (降雨減衰対策) Ensuring availability (Rain attenuation measures)	降雨減衰対策 ①周波数帯域（Ku、Ka等）の特性を考慮した運用が必要 場合によっては、S/L帯のGEOとの冗長性を持たせるかなど Rain attenuation measures ①Requires operation considering characteristics of frequency bands（Ku、Ka etc.） In some cases, consider the needs of redundancy with GEO in S/L bands etc.	・LEO事業者 ・LEO Operator	①周波数帯域（Ku、Ka等）の特性を考慮した運用が必要 場合によっては、S/L帯のGEOとの冗長性を持たせるかなど ①Requires operation considering characteristics of frequency bands（Ku、Ka etc.） In some cases, consider the needs of redundancy with GEO in S/L bands etc.	既にUSなどでユースケースあり。どこまでユーザビリティの向上を求めるか？の議論が必要。 フィーダリンク（Q帯）の可用性向上はHAPSでも大きな課題 There are already use cases in the US etc. Discussion on how much the usability can be improved is necessary. Improving the availability of feeder links (Q band) is a major issue for HAPS as well.
		降雨減衰対策 ②UT（アンテナ）・衛星の通信能力(受信/送信)の向上 Rain attenuation measures ②UT (antenna)・Improving satellite communication capabilities (reception/transmission)	・LEO事業者 ・LEO Operator	②UT（アンテナ）・衛星の通信能力(受信/送信)の向上 ②UT (antenna)・Improving satellite communication capabilities (reception/transmission)	
		降雨減衰対策 ③ISL(Inter Satellite Link)を前提とした地上GW局(エリア)の冗長 Rain attenuation measures ③Redundancy of ground GW station (area) based on ISL (Inter Satellite Link)	・LEO事業者 ・LEO Operator	③ISL(Inter Satellite Link)を前提とした地上GW局(エリア)の冗長 ③Redundancy of ground GW station (area) based on ISL (Inter Satellite Link	
2	可用性の確保 （見通しのない災害現場における代替手段） Ensuring availability (Alternatives for the disaster sites lacking line-of-sight conditions)	見通しのない災害現場における代替手段・他NWとの連携検討 ・Consider collaboration with other NWs	・LEO事業者 ＋TN/NTN統合議論 ・LEO Operator ＋TN/NTN integration discussion	・他NWとの連携検討 ・Consider collaboration with other NWs	
3	可用性の確保(接続性) Ensure Availability (Connectivity)	他のNTNシステムとの連携 Cooperate with other NTN systems	LEO/MEO/GEO/（HAPS）事業者 LEO/MEO/GEO/（HAPS) Operator	他NWとの連携による遅延増加を最小限に抑える Minimize Latency increase due to collaboration	
		海上（日本領域外での使用） Maritime (use outside Japanese territory)	LEO事業者、（総務省=政府） LEO operator, (MIC=government)	現在、一部の LEO サービスは日本の領域外では利用できない Currently, some LEO services may not be available outside of the Japanese territory.	HAPSでも足元に地上GW局が必要な制約があり、海上等での運用に課題あり HAPS also has the restriction of requiring a terrestrial GW station at its feet, which poses challenges for operation at sea, etc.
4	キャパシティの確保 Ensure capacity	①帯域保証サービスの提供 ①Provide bandwidth guarantee services	・LEO事業者 ・LEO Operator	技術的には実現可能 Technically feasible	既にUSなどでユースケースあり。どこまでユーザビリティの向上を求めるか？の議論が必要。 There are already use cases in the US etc. Discussion on how much the usability can be improved is necessary.
		②衛星のキャパシティ向上 －衛星基数を増やす －高周波数（V-bandなど）を使う ②Improve satellite capacity －Increase satellites －Use high-frequency（V-band etc.）	・LEO事業者 ・LEO Operator	高周波数を使うとさらに降雨減衰の影響を受ける Using higher frequencies is further affected by rain attenuation.	
5	信頼性の確保 Ensure Reliability	帯域保証サービスの提供 Provide bandwidth guarantee services	LEO事業者 LEO operator		
		再送制御、高性能FEC、他のNTNとの連携、アンテナ数の増加 Retransmission control, high performance FEC, coordination with other NTNs, increase number of antennas	標準化、NWおよび端末ベンダー Standardization, NW and UE vendor		
6	低遅延化 Reduce Latency		TN/NTN事業者 TN/NTN operator	エッジ サーバーなど。NTNはTNより遅延が大きいため、より注意する必要有り Edge servers, etc. NTNs, where Latency is more pronounced, need to be more aware than TNs.	

5.2.6 Communication Methods in Mountainous Areas

No.	課題 Challenge	詳細(細分化) Details (Subdivision)	課題解決に向けた協力依頼先となる業種 Target industries for cooperation to resolve issues	技術的な挑戦と困難/課題解決案 ※現時点で見えているものがあれば Technical challenges/Solution idea *If it is currently known	備考 Remarks
1	可用性の確保 （救助連絡に使うため、常時利用できる必要有) Ensuring availability （Must be available anytime to contact rescue personnel)	①自律運転を含めた運航オペレーションの確立 救助連絡に使うため、常時利用できる必要有 ①Establishment of flight operations including autonomous driving (Must be available anytime to contact rescue personnel)	・HAPS Alliance参加企業 －機体メーカー －HAPSオペレーター ・HAPS Alliance members - Aircraft manufacturers - HAPS operators	①自律運転を含めた運航オペレーションの確立 ①Establishment of flight operations including autonomous driving	
		②長期飛行を実現するための要素技術開発 （充電／蓄電など） ②Elemental technology development for long flight （charging／storage battery etc.）	・HAPS Alliance参加企業 －機体メーカー －各種メーカー ・HAPS Alliance members - Aircraft manufacturers - Several manufacturers	②長期飛行を実現するための要素技術開発 （充電／蓄電など） ②Elemental technology development for long flight （charging／storage battery etc.）	緯度、季節、夜間等の影響も課題 Challenges include effects of latitude, season, nighttime, etc.
2	可用性の確保 （山間部となると地上局設置が難しい可能性有) Ensuring availability （Possible difficulty of installing a ground station in mountainous area)	①InterHAPS通信の実現 山間部となると地上局設置が難しい可能性有 ①Realizing InterHAPS communication (Possible difficulty of installing a ground station in mountainous area)	・HAPS Alliance参加企業 －HAPSオペレーター －通信機器メーカー ・HAPS Alliance members - HAPS operators - Communication equipment manufacturer	①InterHAPS通信の実現 ①Realizing InterHAPS communication	HAPS間光通信を要検討（衛星BHとの比較も必要） Optical communication between HAPS needs to be considered (comparison with satellite BH is also necessary)
		②衛星通信のバックホール利用 山間部となると地上局設置が難しい可能性有 ②Usage of satellite communications as backhaul (Possible difficulty of installing a ground station in mountainous area)	・HAPS Alliance参加企業 －HAPSオペレーター －通信機器メーカー ・衛星通信事業者 ・HAPS Alliance members - HAPS operators - Communication equipment manufacturer ・Satellite operator	②衛星通信のバックホール利用 ②Usage of satellite communications as backhaul	HAPSにおいて、足元に地上GW局が必要な制約を緩和する手法として検討中 Currently considers as a method for easing the constraints that require a terrestrial GW station at the base of HAPS.
3	セルラーNW電波との干渉対策 Measures against interference with cellular NW radio waves	①専用周波数の確保 ①Ensuring dedicated frequency	・政府 Government	①専用周波数の確保 ①Ensuring dedicated frequency	基本的にはビームで干渉を絞ったり、必要に応じてTNと周波数を分ける運用が必要 2GHzのTDDバンド（Band 34）をHAPS専用周波数の有力候補として検討中 対衛星についても同様の課題が想定される Basically, it is necessary to narrow down the interference with beams and separate the frequency from TN as necessary. The 2GHz TDD band (Band 34) is currently being considered as a promising candidate for the HAPS dedicated frequency. Similar issues are expected for satellites.
		②ビームフォーミング ②Beam forming	・通信機器メーカー ・Communication equipment manufacturer	②ビームフォーミング ②Beam forming	
		③キャンセラー技術等 ③Canceller technology etc.	・通信機器メーカー ・MNO ・Communication equipment manufacturer ・MNO	③キャンセラー技術等 ③Canceller technology etc.	

5.2.7 Unmanned Delivery (by Satellites)

No.	課題 Challenge	詳細(細分化) Details (Subdivision)	課題解決に向けた協力依頼先となる業種 Target industries for cooperation to resolve issues	技術的な挑戦と困難/課題解決案 ※現時点で見えているものがあれば Technical challenges/Solution idea *If it is currently known	備考 Remarks
1	可用性の確保 （救助連絡に使うため、常時利用できる必要有） Ensuring availability （Must be available anytime to contact rescue personnel）	①自律運転を含めた運航オペレーションの確立 救助連絡に使うため、常時利用できる必要有 ①Establishment of flight operations including autonomous driving (Must be available anytime to contact rescue personnel)	・HAPS Alliance参加企業 －機体メーカー －HAPSオペレーター ・HAPS Alliance members - Aircraft manufacturers - HAPS operators	①自律運転を含めた運航オペレーションの確立 ①Establishment of flight operations including autonomous driving	
		②長期飛行を実現するための要素技術開発 （充電／蓄電など） ②Elemental technology development for long flight （charging／storage battery etc.）	・HAPS Alliance参加企業 －機体メーカー －各種メーカー ・HAPS Alliance members - Aircraft manufacturers - Several manufacturers	②長期飛行を実現するための要素技術開発 （充電／蓄電など） ②Elemental technology development for long flight （charging／storage battery etc.）	緯度、季節、夜間等の影響も課題 Challenges include effects of latitude, season, nighttime, etc.
2	可用性の確保 （山間部となると地上局設置が難しい可能性有） Ensuring availability （Possible difficulty of installing a ground station in mountainous area）	①InterHAPS通信の実現 山間部となると地上局設置が難しい可能性有 ①Realizing InterHAPS communication (Possible difficulty of installing a ground station in mountainous area)	・HAPS Alliance参加企業 －HAPSオペレーター －通信機器メーカー ・HAPS Alliance members - HAPS operators - Communication equipment manufacturer	①InterHAPS通信の実現 ①Realizing InterHAPS communication	HAPS間光通信を要検討（衛星BHとの比較も必要） Optical communication between HAPS needs to be considered (comparison with satellite BH is also necessary)
		②衛星通信のバックホール利用 山間部となると地上局設置が難しい可能性有 ②Usage of satellite communications as backhaul (Possible difficulty of installing a ground station in mountainous area)	・HAPS Alliance参加企業 －HAPSオペレーター －通信機器メーカー ・衛星通信事業者 ・HAPS Alliance members - HAPS operators - Communication equipment manufacturer ・Satellite operator	②衛星通信のバックホール利用 ②Usage of satellite communications as backhaul	HAPSにおいて、足元に地上GW局が必要な制約を緩和する手法として検討中 Currently considers as a method for easing the constraints that require a terrestrial GW station at the base of HAPS.
3	セルラーNW電波との干渉対策 Measures against interference with cellular NW radio waves	①専用周波数の確保 ①Ensuring dedicated frequency	・政府 Government	①専用周波数の確保 ①Ensuring dedicated frequency	基本的にはビームで干渉を絞ったり、必要に応じてTNと周波数を分ける運用が必要 2GHzのTDDバンド（Band 34）をHAPS専用周波数の有力候補として検討中 対衛星についても同様の課題が想定される Basically, it is necessary to narrow down the interference with beams and separate the frequency from TN as necessary. The 2GHz TDD band (Band 34) is currently being considered as a promising candidate for the HAPS dedicated frequency. Similar issues are expected for satellites.
		②ビームフォーミング ②Beam forming	・通信機器メーカー ・Communication equipment manufacturer	②ビームフォーミング ②Beam forming	
		③キャンセラー技術等 ③Canceller technology etc.	・通信機器メーカー ・MNO ・Communication equipment manufacturer ・MNO	③キャンセラー技術等 ③Canceller technology etc.	

5.2.8 Mobility in the Ocean

No.	課題 Challenge	詳細(細分化) Details (Subdivision)	課題解決に向けた協力依頼先となる業種 Target industries for cooperation to resolve issues	技術的な挑戦と困難/課題解決案 ※現時点で見えているものがあれば Technical challenges/Solution idea *If it is currently known	備考 Remarks
1	ネットワークの課題 Network issues	①地上通信エリアの拡張 Expansion of terrestrial communications areas	・NTN事業者 ・TN事業者 ・NTN operator ・TN operator	NTNでカバー可能（極地以外） Can be covered by NTN except in polar areas	既存の解決策あり Existing solution available
		②TN/NTN連携システムの実装 Implementation of TN/NTN linkage system	・NTN事業者 ・TN事業者 ・NTN operator ・TN operator	3GPP等での標準化、RRの整備、等が進めば可能 Possible if standardization by 3GPP, etc., and development of RR, etc.	D2DサービスではTN-NTN間のシームレスハンドオーバーが実現可能 D2D services enable seamless TN-NTN handover
		③シームレスハンドオーバー Seamless handover	・NTN事業者 ・TN事業者 ・NTN operator ・TN operator	衛星用端末の場合、SD-WAN機器を用いれば可能？ （国際的な法整備は技術課題以外） For satellite terminals, SD-WAN devices can be used? (International legal development is other than technical issues)	
		④D2Dサービスの提供 Providing D2D Services	・NTN事業者 ・TN事業者 ・NTN operator ・TN operator	今後、HAPS、Starlink D2CやAST mobile等、既存端末で通信が可能となるソリューションがリリースされる予定。その後も、3GPP Release17 NB-IoT/18 NR-NTNに準拠したTN/NTN両対応端末の標準化が進んでいく予定。 In the future, HAPS, Starlink D2C, AST mobile and other solutions that enable communication with existing devices will be released. After that, standardization of both TN and NTN compatible terminals in compliance with 3GPP Release17 NB-IoT/18 NR-NTN will continue.	
		⑤冬場の中高緯度におけるソーラー発電量の少なさ Low solar power generation in mid- and high-latitude areas in winter	・NTN事業者（HAPS） ・NTN operator (HAPS)	日照時間,日射量とソーラー発電量の相関関係 Correlation of solar power generation with sunshine duration and solar radiation	HAPS機体の大型化やソーラーパネル/バッテリーの技術向上によって将来的には改善される見込み Expected to improve in the future due to larger HAPS aircraft and improved solar panel/battery technology
2	端末の課題 Terminal issues	①アンテナ設備の海仕様化 Ocean specification of antenna equipment	・NTN事業者 ・端末メーカー ・NTN operator ・Device manufacturing	海仕様端末の開発は可能と思われる （機器開発ベンダーの費用対効果基準次第） It seems possible to develop a marine terminal (Depends on equipment development vendor's cost-effectiveness criteria)	D2Dサービスでは既存端末が利用可能 Existing terminals are available for D2D services
		②通信容量/速度と小型省電力化の両立 Combine communication capacity/speed with compact power saving	・NTN事業者 ・端末メーカー ・NTN operator ・Device manufacturing	両者のトレードオフ Trade-off between the two	

No.	課題 Challenge	詳細(細分化) Details (Subdivision)	課題解決に向けた協力依頼先となる業種 Target industries for cooperation to resolve issues	技術的な挑戦と困難/課題解決案 ※現時点で見えているものがあれば Technical challenges/Solution idea *If it is currently known	備考 Remarks
3	通信品質の課題 Communication quality issues	①低遅延化 low latency	・NTN事業者 ・NTN operator	MECを用いた通信の導入 Introduction of communication using MEC	既存の解決策あり Existing solution available
		②大容量化 High capacity	・NTN事業者 ・NTN operator	既存の大容量プランあり B5G時代には技術発展によりさらなる大容量化にも期待できる Existing high-capacity plan available In the B5G era, further capacity can be expected due to technological development	既存の解決策あり Existing solution available
		③セキュリティの担保 Security assurance	・NTN事業者 ・NTN operator	セキュリティサービスを追加できるサービスは存在 Service exists to add security service	既存の解決策あり Existing solution available
		④地上と変わらない通信環境、陸⇄海シームレス化 Seamless land-to-sea communication environment	・NTN事業者 ・TN事業者 ・NTN operator ・TN operator	今後、ハイブリッド端末の開発が見込まれる Hybrid handsets are expected to be developed in the future	D2DサービスではTN-NTN間のシームレスハンドオーバーが実現可能 D2D services enable seamless TN-NTN handover
		⑤安定した接続性 Stable connectivity	・NTN事業者 ・NTN operator	Eutelsat OneWebの帯域確保のオプションを利用すれば、ベストエフォート回線よりも安定した接続性を提供できる可能性あり。 Eutelsat OneWeb's bandwidth options may provide more stable connectivity than best-effort lines.	HAPSでは特定のエリアに高品質な通信サービスを提供可能 HAPS can provide high quality communication services to specific areas
4	技術以外の課題 Issues other than technology	①選択肢の柔軟性（エリア、通信容量） Choice flexibility (area, communication capacity)	・NTN事業者 ・サービス提供者 ・NTN operator ・Service provider	サービス提供側の費用対効果基準に左右される To depend on the cost-effectiveness criteria of the service provider	HAPSでは特定のエリアをスポット的にカバー可能 HAPS allows for spot coverage of specific areas
		②機器の選択肢の柔軟性 Flexibility in equipment choices	・NTN事業者 ・サービス提供者 ・NTN operator ・Service provider	機器開発ベンダーの費用対効果基準に左右される Subject to equipment vendor cost-effectiveness criteria	
		③通信容量の増加（価格） Increased capacity (price)	・NTN事業者 ・サービス提供者 ・NTN operator ・Service provider	通信容量が大きいサービスはあるが高価格になる There are services with high capacity, but they are expensive.	

5.3 Examination of Architecture Required for Inter-Enterprise Collaboration

In the future, the world's communication traffic will increase, and the era of global traffic control will come. It will be necessary to realize a network that provides high-quality services by utilizing communication resources available anywhere on the planet. Taking disasters as an example, even if the data traffic of a certain business operator is congested, if the system is globally interconnected through inter-operator cooperation, it will lead to the relief of users. In the construction of such terrestrial and non-terrestrial networks, it is important to control traffic and network resources on a global scale that transcends the boundaries of the domains of operators. In this project, we will solve this problem by proposing an architecture that links networks with different specifications and enables global resource control among operators, rather than simply connected for data transmission.

Terrestrial networks (TN) and non-terrestrial networks (NTN) integration requires a close cooperation between TN and NTN network operators and service providers. TN/NTN convergence or integration requires the involvement of multiple TN segments such as terrestrial mobile core networks (CN) and data networks (DN) as well as multiple NTN segments such as Geostationary Earth Orbit (GEO) and low Earth orbit (LEO) satellites and High-Altitude Platform Station (HAPS). In most use cases involving TN-NTN integration, a single operator may not be able to provide both TN and NTN network segments. It is likely that many operators require to collaborate to one another to have their network segments interconnected both in the control plane and the data plane. Therefore, to interconnect TN and NTN segments, it is essential to develop new mechanisms and interfaces.

The network operators and service providers can collaborate on the basis of established standard framework such as one developed by the International Telecommunication Union (ITU). ITU has developed a framework architecture for TN-NTN integration, also known as fixed, mobile and satellite convergence (FMSC). ITU-T Y.3207 (2024) “Fixed, mobile, satellite convergence – Integrated network control architecture” specifies the framework of TN-NTN convergence, where TN and NTN network segments have their own individual network controllers to monitor their performances and control their resources. These individual network controllers are connected to the integrated network control system through interfaces. Through the interfaces, which are yet to be developed and standardized, the integrated network control system can collect the monitoring data of TN and NTN segments as well as transmit control commands/parameters to them.

This report describes a scenario of TN and ITN integration, TN-NTN integrated network control architecture (INCA), and required interfaces to be standardized.

5.3.1 Scenario of TN and NTN integration

Figure shows the scenario of TN and NTN integration through the integrated network control system. The TN segments are data networks, cellular core networks, and access networks. Data networks are composed of the Internet, cloud computing infrastructure, data storage, and application servers. The cellular core network is composed of functions for user authentication, mobility management, resource management, session management, etc. of cellular networks as defined and specified in 3GPP standards. Similarly, NTN segment includes satellites and HAPS in space and satellite operation center (SOC), network operation center (NOC), ground stations (GST), non-terrestrial network and terrestrial network gateways (NTN-TN GW), and NTN terminals on earth. The radio frequency (RF) or free-space optical (FSO) links are used to communicate between GST and satellites/HAPS or among satellites and HAPS. Similarly, NTN-TN GWs can be connected to the cellular core network or directly to data networks if cellular core functions are not required by the radio access network connected to NTN terminals

The access network can be a fixed access network (e.g., fiber-to-the-home) to connect fixed terminals (e.g., computers and smart devices in home or office) or a radio access network (e.g., cellular wide-area network (WAN) consisting of radio access network (RAN) central units and radio heads) to connect mobile user equipment (e.g., smartphones). The fixed access networks (not shown in figure) are usually connected to data networks, while a RAN is connected to the cellular core network through high-speed, multi-core optical fiber networks so that seamless mobility of mobile users from a TN to an NTN can be supported. Similarly, the cellular RAN including local Beyond-5G and 6G access networks and various types of wireless access points installed on ground, airplanes or ship can be connected to NTN though an NTN terminal such as a VSAT (Very Small Aperture Terminal) acting as a gateway between the terrestrial RAN and NTN.

In the control plane, each network segment is managed by its own network controller. Although different kinds of NTN networks (e.g., GEO satellites, LEO satellites, and HAPS) are shown collectively managed by a single NTN controller in Figure 1, each NTN segment or domain operating at a different altitude may be controlled and managed by a different network controller operated by a different operator.

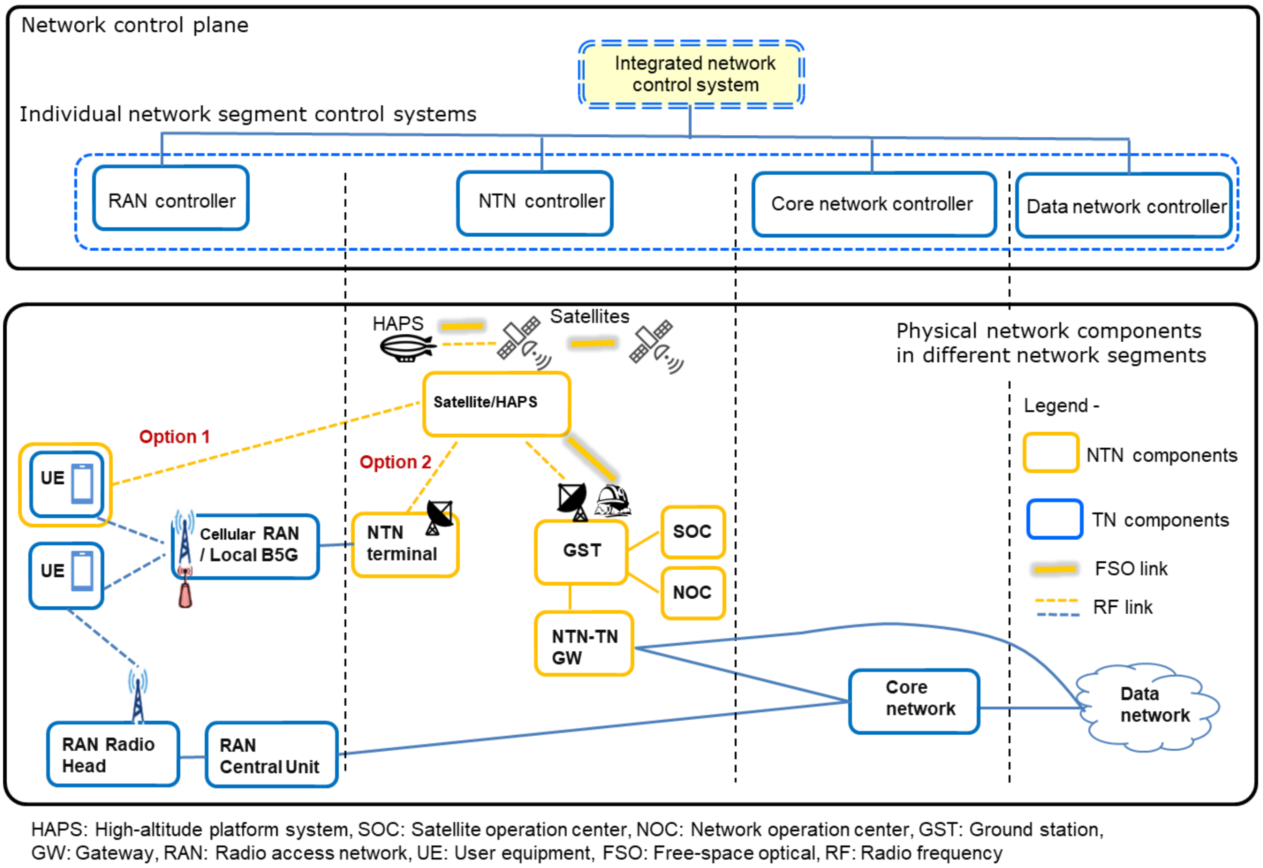


Figure Scenario of TN and NTN integration

5.3.2 TN-NTN integrated network control architecture (INCA)

This section describes the functional components of TN-NTN integrated network control architecture.

Figure shows the functional architecture of integrated network control system [ITU-T Y.3207]. The major components of integrated network control architecture are: (1) integrated network control interfaces, (2) integrated control data service, (3) end-to-end (E2E) network status analysis, (4) application requirements and user intent analysis, (5) E2E resource allocation, management, and optimization, and (6) integrated control and orchestration functions.

The integrated network control interfaces communicate with the network control external interfaces of individual network segments (e.g., radio access, NTN, cellular core, and data networks) controllers to collect control data from them and send control commands to them. The interfaces also contain functions to collect control data in different granularity of time scales and details as required.

The collected control data from various network segments are managed by the integrated control data service functions. The data service functions are responsible to manage the data consistency and provide control data in dynamically adjustable granularity to E2E network status analysis function through on-demand and streaming data services.

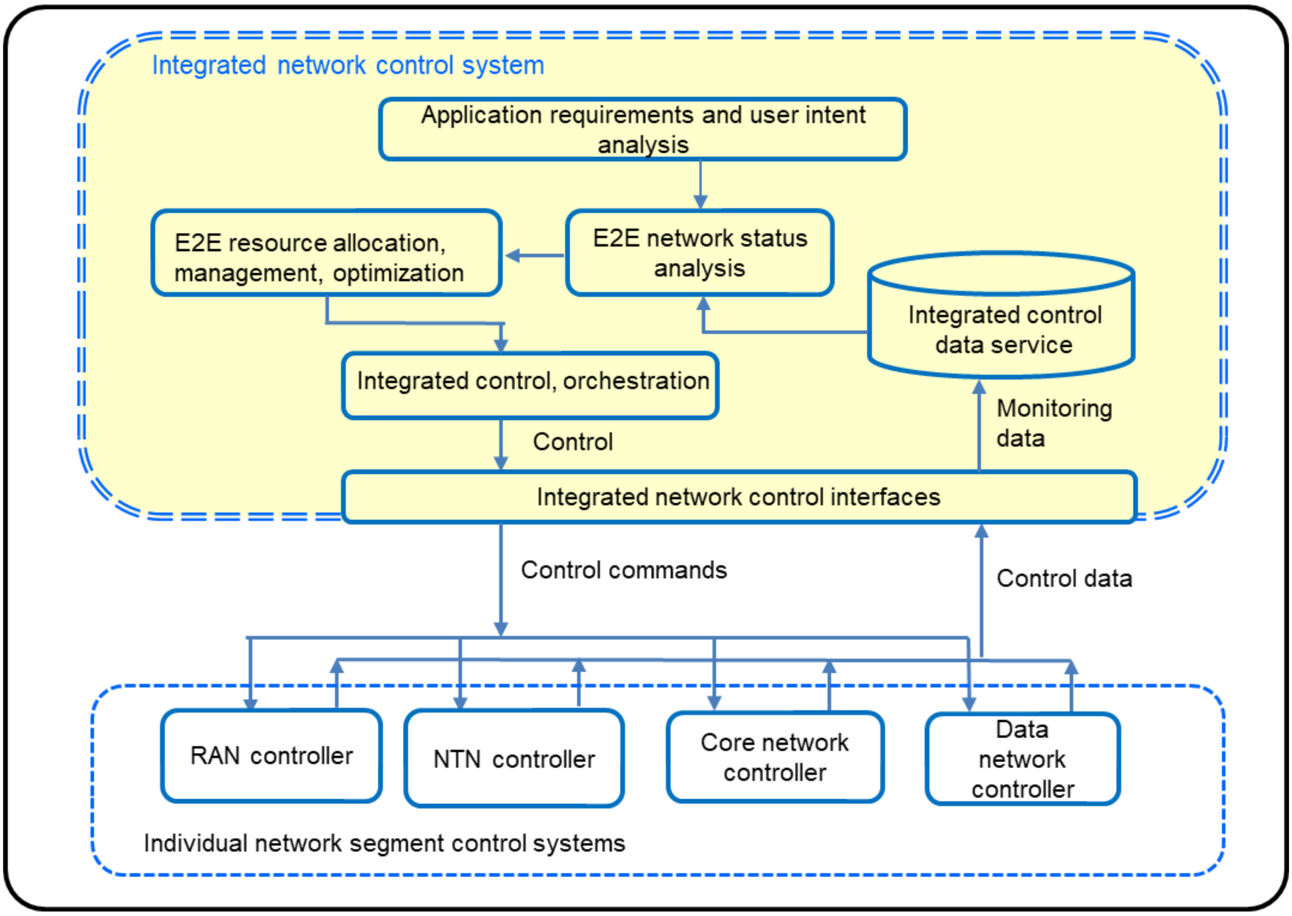


Figure Architecture framework of integrated network control system (ITU-T Y.3207)

The E2E network state analysis function processes control data to assess the status of end-to-end network services by analysing the status of resource utilization and performances of all involved network segments. It also uses the output coming from the application requirements and user intent analysis component to judge the network service quality with respect to service level agreements. The application requirements and user intent analysis component includes necessary functionalities to interpret the user and service provider expectations expressed in abstract policies (called intents) and convert them into the control system-understandable parameters that can be mapped into well-defined service configuration templates.

The E2E resource allocation, management and optimization functions formulate optimal control decisions on the basis of the current and predicted future network states of network segments involved in an end-to-end communication service, together with the prediction on the fluctuation of available resources and their demands. Different kinds of network segments can have different kinds of resources in demand. For example, data networks may demand more computational (e.g., virtual machines, CPU, GPU, memory) and storage resources, while the NTN may demand more RF bandwidths for feeder and service links or replacement of RF links by FSO links due to changes in weather conditions and user traffic demands. Different combinations of resource allocation strategies can be considered as feasible candidate solutions and evaluated them for their fitness by using mathematical optimization models and/or machine learning models. The optimal resource allocation and control decisions are provided to the integrated control and orchestration function.

The integrated control and orchestration function executes the control decision by generating lists of appropriate resource control parameters and commands for each network segment involved in the end-to-end network service and sending the lists to the network segments through integrated network control interfaces.

5.3.3 Use cases scenarios of INCA

The following are prominent use-case scenarios of INCA in Beyond-5G and 6G network environments. It is not an exclusive list.

1. INCA as an Enabler for Multi-Operator Network Services over TN-NTN Integrated Environments

A virtualized network domain with slicing capabilities can be shared by multiple operators. Each operator manages its allocated resources through a dedicated INCA instance and can create multiple slices for different services (e.g., URLLC, eMBB, mIoT). This scenario is illustrated in Figure.

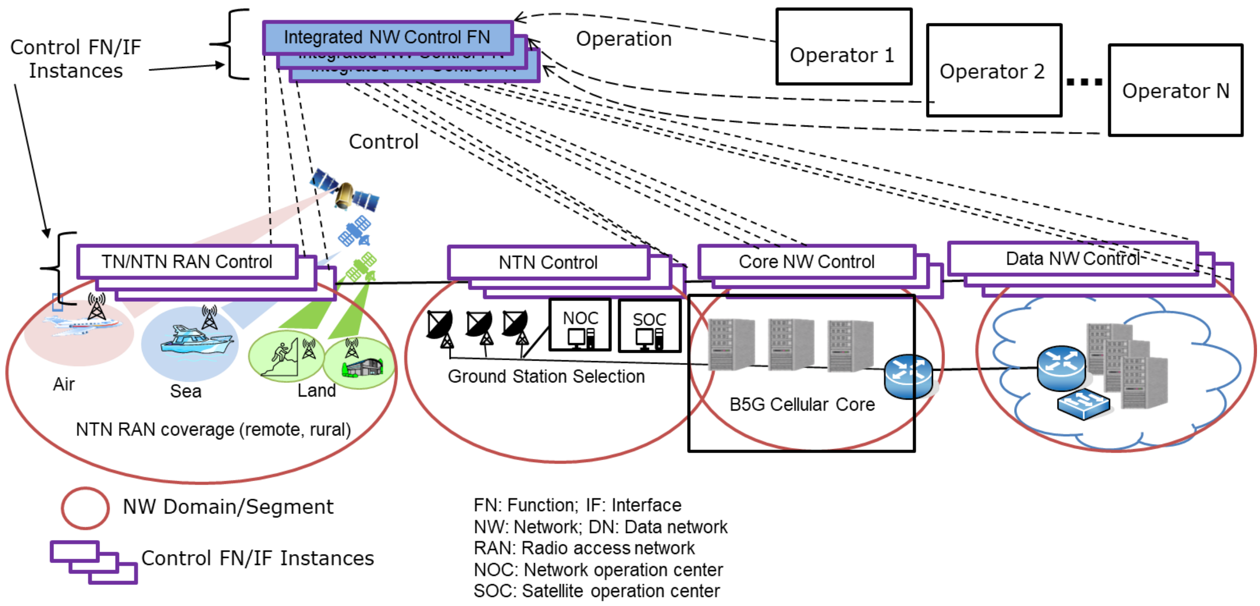


Figure INCA as an enabler of multiple operators deploying network services in different slices of TN and NTN domains/segments

2. INCA for Seamless TN-NTN Handover to Optimize Terrestrial Base Station Power Management

In multi-layered RANs covering overlapping areas, INCA enables efficient power management of terrestrial base stations. It can switch user connections from terrestrial to NTN radios when the user activity as well as data traffic flow is low, allowing base stations to enter sleep mode or power off.

INCA monitors resource utilization across TN and NTN, making intelligent user terminal handover decisions, thus enable effective power management without hampering the quality of services.

3. INCA as an Enabler for Optimal NTN Segment Selection

With the growing use of various NTN segments like satellites and HAPS at different altitudes, INCA can monitor their resource availability and performance, helping select the most suitable NTN segment for each network service.

5.3.4 Interfaces to be standardized

To enable interworking between TN and NTN network segments, both network segments should be equipped with standard interfaces. These interfaces allow the integrated network control system to collect monitoring control data from each network segments. Similarly, standard interfaces are also required to send control commands and parameters from the integrated network control system back to the individual network segments.

In a TN-NTN integration environment, multiple operators can collaborate by sharing monitoring and control parameters through these standard interfaces. Interfaces in the control plane as well as in the data plane are discussed next.

Interfaces are required both in the control plane and the data plane, as discussed below.

- In the control plane, interfaces are used to transmit monitoring data, control parameters, and control commands.
- In the data plane, interfaces enable the transmission of user data traffic between TN and NTN segments, and vice versa.

Based on an experimental system developed at the National Institute of Information and Communications Technology (NICT), example monitoring and control parameters through the interfaces to the DN, CN, and NTN are listed below. The parameters for the RAN interface (Interface_RAN) are assumed to follow specifications set by industry groups such as the O-RAN Alliance; however, they are not discussed in this report.

The parameters can be represented in standard formats such as the JSON, as illustrated in the examples below. Further discussions among TN and NTN operators are required to complete the lists of parameters and their standardization.

5.3.4.1 Control plane monitoring interfaces to collect monitoring data from TN and NTN segments

The control plane monitoring interfaces are used to collect monitoring data from various TN and NTN segments. These interfaces can be categorized into the following four categories:

- Monitoring interface_DN (list of parameters)
- Monitoring interface_CN (list of parameters)
- Monitoring interface_NTN (list of parameters)
- Monitoring interface_RAN (list of parameters)

【Monitoring interface_DN parameters list】

Examples of monitoring parameters collected from each functional instance of the DN are as follows:

{‘timestamp’: 1707187366889805056,
'src': 'osm', #source controller of monitoring data
'nsname': 'haweb', #network service name
'instancename': 'haweb-2',
'cpu_utilization': 0.24,
'memory_utilization’: 0.88,
‘tx_bw_utilization’: 0.4,
‘rx_bw_utilization’: 0.5
}

Examples of monitoring parameters summarizing the monitoring data from all functional instances are as follows:

{‘timestamp’: 1707187366889805056,
'src': 'osm',
'nsname': 'haweb',
'instancename': 'all',
'cpu_utilization': 0.24,
'memory_utilization': 435.88,
‘tx_bw_utilization’: 0.4,
‘rx_bw_utilization’: 0.8,
'num_of_instances': 1
}

【Monitoring interface_CN parameters list】

Examples of the monitoring parameters collected from each functional instance of the core network functions are as follows:

{‘timestamp’: 1707187366889805056,
‘instancename': 'upf1', #name of core network function
'interface': 'eth0',
'cpu_allocation': 1,
'cpu_utilization': 0.3,
'memory_allocation': 8330 MB,

'memory_utilization': 0.41,
'tx_bw_allocation': 1000 Mpbs,
'tx_bw_utilization': 0.1,
'rx_bw_allocation': 1000 Mbps,
'rx_bw_utilization': 0.1
}

【Monitoring interface_NTN parameters list】

The NTN parameter list can be divided into four types: present system parameters, service requirement parameters, system monitoring parameters, and link control parameters. These parameters are listed in Table.

Parameter types	Parameters
Preset system parameters	• Number of satellites in a constellation • Satellite orbit coordinates • Satellite interfaces characteristics (e.g., physically/logically connected, radio or FSO links, transparent or regenerative) • Uplink/downlink beam upper and lower frequencies, bandwidth, modulation methods • Inter-satellite link characteristics (e.g., frequencies bands, FSO wavelength) • Number of available GSTs and their coordinates
Service requirement parameters	• Service type (e.g., voice, video, web browsing, and sensors data) • QoS requirements (e.g., minimum data speed, maximum latency, tolerable call drop or packet loss rate, and security levels)
System monitoring parameters	• Number of active user terminals • Weather conditions • Doppler shift • Performance (e.g., throughput, latency, jitter, packet loss, and call drop rates)
Link control/monitoring parameters	• Number of beams, coverage coordinates, types (fixed or movable), transmission power • Radio frequencies or FSO wavelengths allocated to each beam • Earth station and space station antenna patterns • Feeder and service link performance monitoring (bandwidth, transmission speed, loss rate, interference, coding rate) • Active GSTs (site diversity that changes GSTs depending on the weather)

Table NTN parameters

Some of the NTN monitoring parameters overlap with the control parameters whose values are set based on the values of control parameters/commands issued from the integrated network control system.

5.3.4.2 Control interfaces to send control commands and parameters to TN and NTN segments

Four types of control interfaces can be considered for sending control commands/parameters from the integrated network control system to the four types of network segments: DN, CN, NTN, and RAN.

- Control interface_DN (list of parameters)
- Control interface_CN (list of parameters)
- Control interface_NTN (list of parameters)
- Control interface_RAN (list of parameters)

Control interfaces carry two sets of parameters:

1) one set for network resource allocation to create a network service based on given QoS requirements, and
2) the other set for adjusting network resource to guarantee end-to-end network QoS.

Examples of control interface parameters for DN, CN, and NTN are listed below. Control interfaces for RAN are not discussed in this report, as it is assumed that their parameters will follow the formats specified by global industry organizations such as the O-RAN Alliance.

【Control interface_DN parameters list】

Examples of control parameters used in a request for resource allocation of the DN to a network service are as follows:

{‘timestamp’: 1707187366889805056,
'nsname': 'haweb',
‘number_of_servers’: 1,
‘cpu_allocation’: 2,
'memory_allocation’: 5 GB,
‘tx_bw_allocation’: 1000 Mbps,
‘rx_bw_allocation’: 1000 Mbps
}

Examples of control parameters transmitted through the control interfaces in a request for resource adjustment of a network service are as follows:

{‘timestamp’: 1707187366889805056,
'nsname': 'haweb',
‘instancename’: 'haweb-2',
‘cpu_allocation’: +1,
'memory_allocation’: +2 GB,
‘tx_bw_allocation’: +100 Mbps,
‘rx_bw_allocation’: +100 Mbps
}

【Control interface_CN parameters list】

Examples of control parameters used in a command for resource allocation of CN functional components are shown below:

{‘timestamp’: 1707187366889805056,
'nsname': 'haweb',
‘number_of_network_functions’: 7,
For each network function:
‘cpu_allocation’: 2,
'memory_allocation’: 5 GB,
‘tx_bw_allocation’: 1000 Mbps,
‘rx_bw_allocation’: 1000 Mbps
}

Examples of control parameters used for resource adjustment of CN functional components are shown below:

{‘timestamp’: 1707187366889805056,
'nsname': 'haweb’,
For each network function instance:
‘cpu_allocation’: +1,
'memory_allocation’: +2 GB,
‘tx_bw_allocation’: +100 Mbps,
‘rx_bw_allocation’: +100 Mbps
}

【Control interface_NTN parameters list】

Examples of control parameters used for resource allocation of the NTN are as follows:

{‘timestamp’: 1707187366889805056,
'nsname': 'haweb',
‘number_of_network_functions’: 2,
Network service information:
‘service_type/QoS Identifier’: 1,
‘maximum_number_of_UE’: 100,
‘ul_bw_allocation’: 2000 Mbps,
‘dl_bw_allocation’: 2000 Mbps
‘ntn_segment_latency_limit’: 100 ms
}

Examples of control parameters used for resource adjustment of the NTN are given below:

{‘timestamp’: 1707187366889805056,
'nsname': 'haweb’,
For each network service:
‘ul_bw_allocation’: +100 Mbps,
‘dl_bw_allocation’: +10 Mbps
}

5.3.4.3 Data plane interfaces to transmit data traffic between TN and NTN segments

These interfaces are necessary for transferring user data traffic between different network segments. They can be implemented as simple IP packet forwarding interfaces or as higher-layer tunnels, such as IPsec or IP-in-IP tunnels, to ensure data security and protect user privacy. Established standard interfaces, developed by standards organizations such as the IETF and adopted by 3GPP, can be reused as the data plane interfaces.

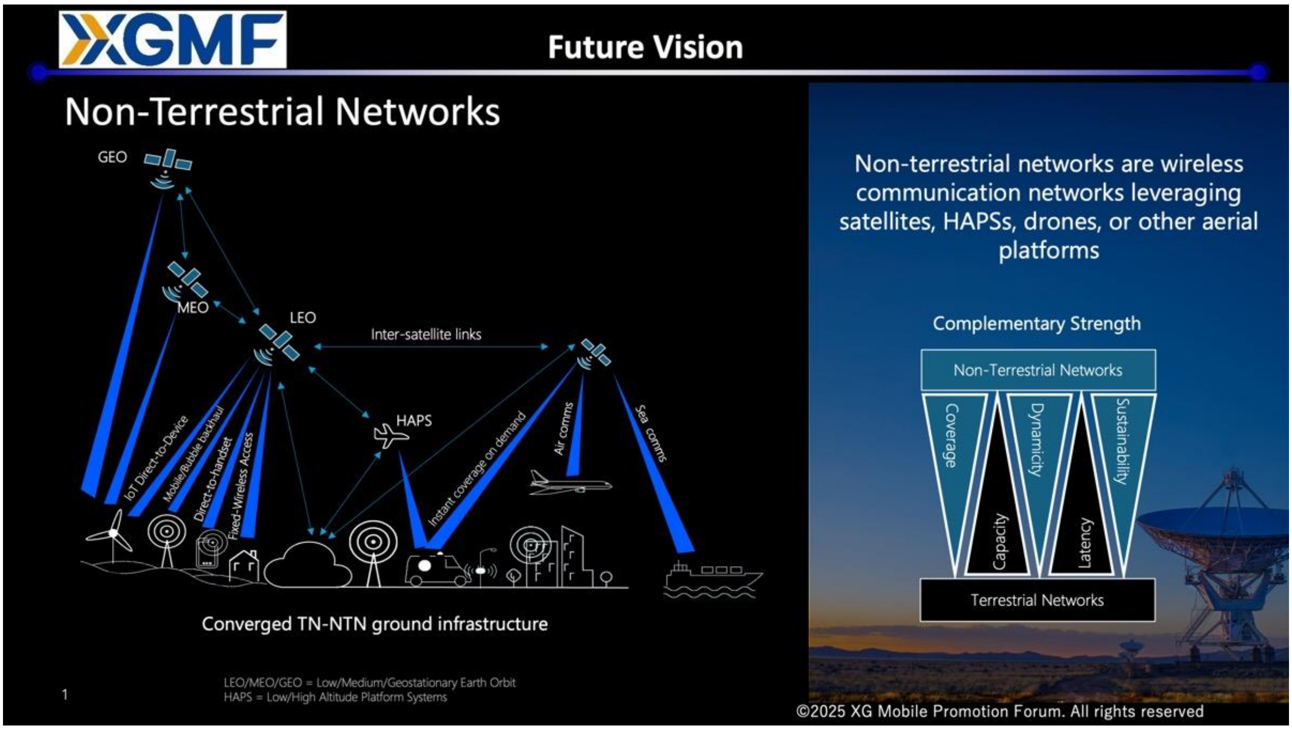
5.4 Summary

As an examination of the issues to realize global connectivity through NTN integration, we examined use cases as an activity to raise interest in TN-NTN integration, which is an important element of Beyond 5G. To disseminate examples that make it easy to imagine that Beyond 5G will be able to do things that could not be done with 5G until now, we have formulated 19 case studies. In particular, this fiscal year, we will take up marine communication use cases such as ships and ocean observations as new use cases of NTN services, and discuss them through opinion exchange meetings with related companies to consider issues and solutions for realizing social implementation. We examined additional cases of use of HAPS from a new industry perspective that takes advantage of the characteristics of HAPS, and added three new examples. In addition, the necessity of an "inter-company collaboration architecture," which is an important issue in the integration of TN and NTN, and specific measures for inter-operator collaboration were examined, and the direction of standardization was discussed. By utilizing NTN, 6G will be able to expand the scope of application to environmental measures that have not been reachable so far, and contribute to the realization of a more human-friendly and environmentally-friendly future, such as optimizing global traffic, monitoring the environment, and reducing energy associated with the movement of people and goods through remote access.

Chapter 6 Summary and Future Issues

6.1 Grand Design

NTN is comprised of multiple different non-terrestrial networks, including satellites such as GEO, MEO, and LEO, and aerial platforms such as HAPS and drones. These networks, along with the terrestrial networks, complement each other with their respective strengths to realize a ubiquitous network that allows anyone, anywhere on the planet, to connect to the network.



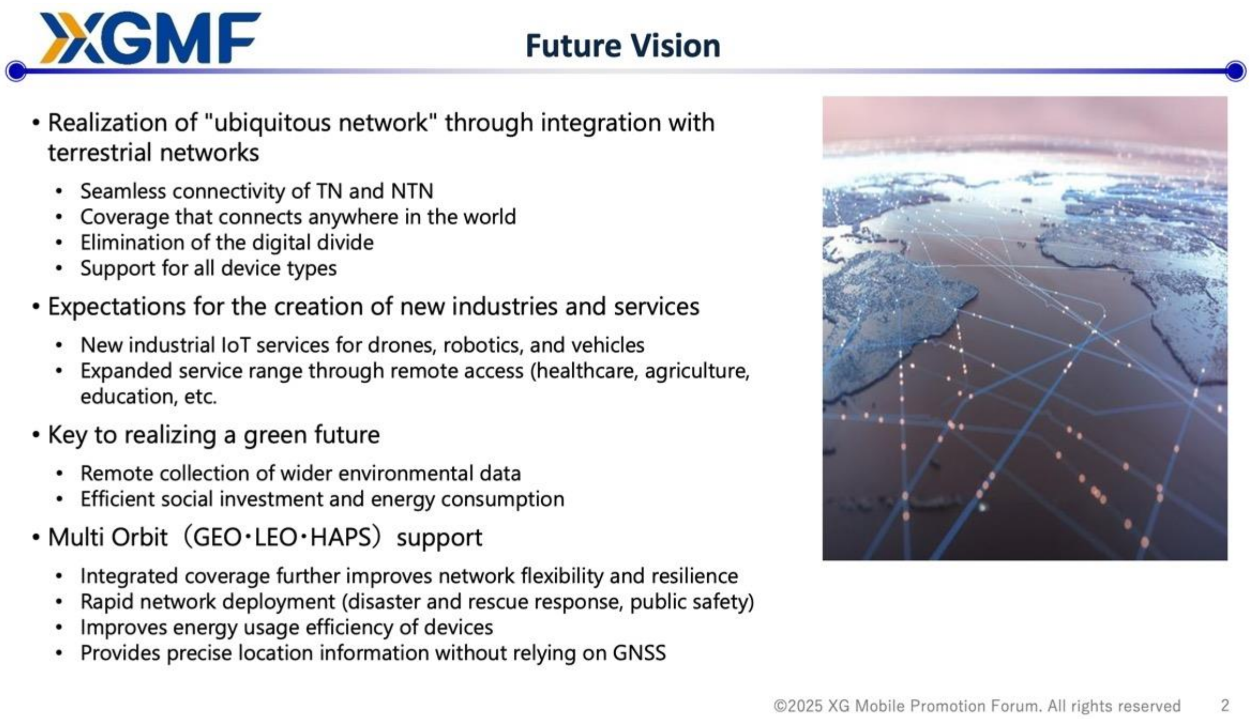
NTN Future Vision

- The deployment of NTN will raise expectations for the provision of functions and services that could not be realized with terrestrial networks alone.
- NTN will achieve global coverage and enable seamless integration with terrestrial networks, allowing people to maintain connectivity with the network anywhere in the world. Enabling all terminals to access NTN will also help to eliminate the digital divide.
- The arrival of NTN will also raise expectations for the creation of new industries. By resolving the coverage issue, it will become possible to use industrial IOT services for vehicles, drones, robotics, and other fields that were not possible until now, as well as new services based on remote access in a variety of fields.
- By making remote access available over a wide area, it will become possible to work without moving personnel even in areas where physical on-site work was previously unavoidable, and by enabling the collection of highly accurate information, including the surrounding

environment, it will become possible to provide appropriate and safe responses quickly.

- Linking multiple non-terrestrial networks can increase the flexibility and resiliency of the network, making it possible to provide connectivity over a wide area, including mountainous regions and oceans, and to respond quickly to emergencies such as disasters and distress.

Using NTN can also expand the scope of application to environmental measures that were previously out of reach. Examples include global environmental monitoring and reducing the energy required for the movement of people and goods through remote access. By being able to obtain more precise positioning information that does not rely on conventional GNSS, it will also be possible to reduce the power consumption of terminals, contributing to the realization of a more environmentally friendly future.



Expectations for NTN

6.2 Summary

The NTN Promotion Project has been conducting activities aiming for examining technologies, companies, and services that NTN should appeal to as Japan, identifying and solving social issues, and creating social value. This year's activities included updating NTN's technology roadmap, understanding related activities in overseas countries, identifying user needs for telecommunications using NTN and clarifying the requirements necessary to realize them, examining issues for the realization of NTN services, clarifying technologies that need to be developed, examining solutions/countermeasures, and formulating a grand design.

This year, we focused on identifying the issues of users in the maritime area and discussing whether NTN technology can be used to solve them, and in particular, the opinion exchange meetings and questionnaires held to understand the needs of users in the maritime area were particularly significant. In response to the requests and issues in the marime area, we examined whether there are solutions with existing technologies, examined the requirements necessary to realize the needs for those for which there is no solution at present, and confronted the operational issues and requests of the user side (demand side) with the business establishment of the service provider side (supply side), and it became clear that it is impossible to solve them by focusing only on technical issues. For this reason, it is necessary to reduce the cost of using NTN in order to achieve widespread dissemination, and for this purpose, the procurement cost of satellites and HAPSs is the issue, and it is essential to form a global ecosystem to reduce the cost of NTN in parallel with the development of technology.

In addition, in order to examine the future vision that NTN should aim for, we discussed what is the grand design of NTN in the NTN Promotion Project. NTN is composed of multiple different non-terrestrial networks, such as satellites including GEO, MEO, and LEO, and aerial platforms such as HAPSs and drones, and is a ubiquitous network that allows anyone anywhere on the planet to connect to the network at any time, while complementing each other with their respective strengths. The deployment of NTN is expected to eliminate the digital divide where all terminals can access NTN, provide IOT services for industries such as vehicles, drones, and robotics, and provide new services based on remote access, as well as provide functions and services that could not be realized by terrestrial networks alone, and will be able to create novel industries. It has a more human-friendly aspect, making extensive use of remote access to work without moving personnel even in areas where physical on-site work was unavoidable, and enabling highly accurate information collection including the surrounding environment, making it possible to quickly provide appropriate and safe responses. By linking multiple terrestrial and non-terrestrial networks, it is possible to increase the flexibility and resiliency of the network, make it possible to utilize connectivity over a wide range of areas, including mountainous and maritime areas, and to respond quickly to future disasters and emergencies such as distress.

In this way, NTN can be used to expand the scope of application to environmental measures that have not been reachable in the past, and contribute to the realization of a greener future, such as optimizing global traffic, monitoring the global environment, and reducing energy associated with the movement of people and goods through remote access. We would like to continue to promote the activities of the NTN Promotion Project so that it will become a place to disseminate Japan's strengths in Beyond 5G/6G, and will lead to the extraction of common issues and proposals, and will be an activity that can contribute to such a large global SDGs.

Lastly, the coordinating member companies, which played a central role in each of the issues to be considered, put a great deal of effort into actively examining the contents in this report. I would like to express the deepest appreciation once again.