FY 2023

Scalability Working Group Activity Report

Beyond 5G Promotion Consortium

International Committee

Scalability Working Group

March 2024

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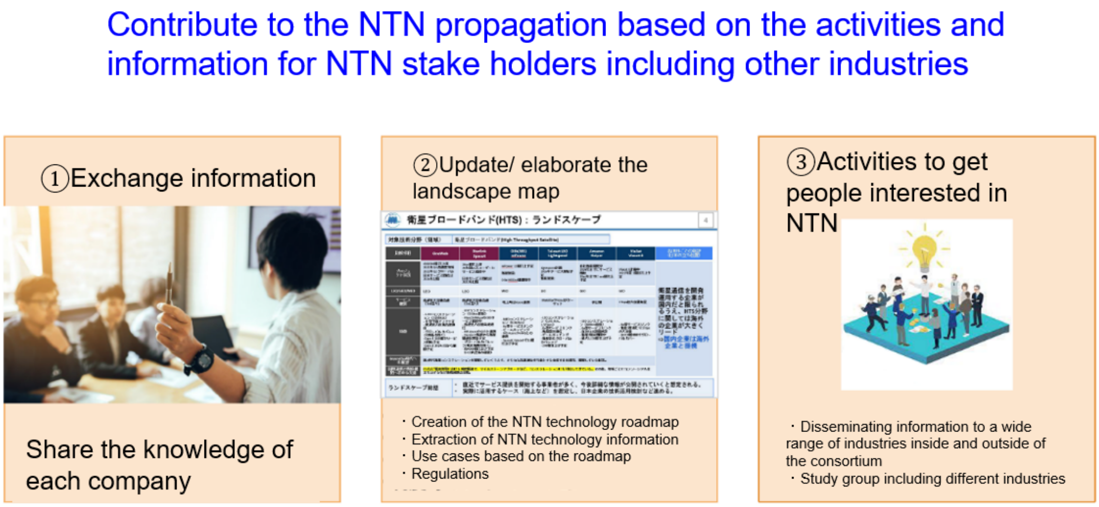
1. Introduction

This document reports the FY 2023 (Japanese fiscal year 2023) activities of Beyond 5G Promotion Consortium Scalability WG.

1.1 The Purpose of WG

Scalability WG contributes to the NTN (Non-Terrestrial Network) propagation based on the activities and information offering for NTN stake holders including other industries.

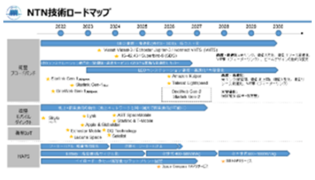
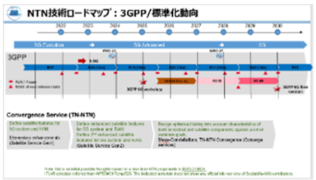


1.2 Activities in FY 2022

The participants for activities in FY 2022 (Japanese fiscal year 2022) were Ericsson Japan, SoftBank, VIAVI Solutions, Huawei Japan, and Rakuten Mobile (titles omitted). Led by Dr. Toyoshima WG group leader (NICT), the WG actively exchanged information among participating companies, updated landscape map, and promoted NTN. The detailed each role are as follows.

Participants (Titles Omitted)	Ericsson Japan, Softbank, VIAVI Solutions, Huawei Japan, Rakuten Mobile

Deliverables (Landscape map)

Technology information	3GPP/Standardization trends	Case study
		

Exchange of opinions

- Introduce case studies collected by the WG to governmental disaster prevention organization and discuss the possibilities of NTN technologies
- We received opinions from the perspective of disaster prevention response such as the networks of each local government

Determine the coordinating company for each sub-WG + all the companies carry out the activities

Activities		Coordinator	Participants	Details
Information exchange		Softbank	Ericsson Japan, Softbank, VIAVI Solutions, Huawei Japan, Rakuten Mobile	• Organize the opinion exchanging meeting at regular meeting (RM)
Update/ elaborate the landscape map	Each NTN technology information	Rakuten Mobile	Same as above	• Research on each NTN technology • FY2022 Interim report to International Committee • FY2022 Results report at GM
	Use cases	Huawei Japan	Same as above	• NTN use cases for other industries • FY2022 Interim report to International Committee • FY2022 Results report at GM
	Regulations	Softbank	Same as above	• Study on related regulations • FY2022 Interim report to International Committee • FY2022 Results report at GM
Activities to get people interested in NTN	Scalability WG	VIAVI Solutions	Same as above	• Provide information to non-members
	Pitch plan to other industries (Opinion exchanges)	Ericsson Japan	Same as above	• Discussion on the future of industries by leveraging NTN • Activity plan/implementation involving other industries

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

1.3 Challenges found in FY 2022

Although NTN standardization is being developed at SDOs such as 3GPP, in FY 2022 we found that there are still many challenges toward realizing NTN. The examples of the challenges include the following points.

Frequency	・System for use of land IMT frequencies of satellites has not yet developed ・Standardization is only for limited frequencies
Terminal	・Required miniaturization/low cost for Satellite UT ・Development is left to vendors
TN-NTN cooperation	・Authentication/billing for 1 SIM - 1 Profile ・Handover (roaming) ・Implementation time of satellite cell – ground station cell hand-in/hand-out
Dependance of oversea	・There is no LEO satellite constellation service in Japan

Specifically, for example, in order to achieve seamless handover between TN and NTN, it is necessary to discuss and search for solutions from the perspective of where the issues are and what kind of solutions are needed. It is difficult for a single company to solve such issues alone. Collaboration among NTN-related companies and organizations is required. As a part of those activities, in FY 2022 we offered wide range of information by posting reports etc. on our website.

We also reported on the following examples of business collaborations.

Business Collaboration Case 1 : HAPS Alliance

Over 50 participants since its establishment in April 2020

（Source）HAPS Alliance https://www.hapsmobile.com/ja/haps-alliance/pdf/haps-alliance-2022.pdf

Promotion of HAPS market & initiatives to revitalize the market

Business Collaboration Case 2 : Joint development of Battery pack for HAPS

Development of HAPS battery pack

Enpower Japan	Joint development of next-gen lithium metal battery of world class boasting gravimetric energy 439Wh/kg and electrolyte suitable for stratosphere
ENAX	Joint development of battery pack materials and succeeded in reducing the weight of each component (restraint mechanisms, heaters and insulation materials etc.)

▲ Enpower Japan lithium metal battery used for battery pack

▲HAPS battery pack jointly developed with ENAX

▲Operation demonstration in the stratosphere

（Source） https://www.softbank.jp/corp/news/press/sbkk/2023/20230316_01/

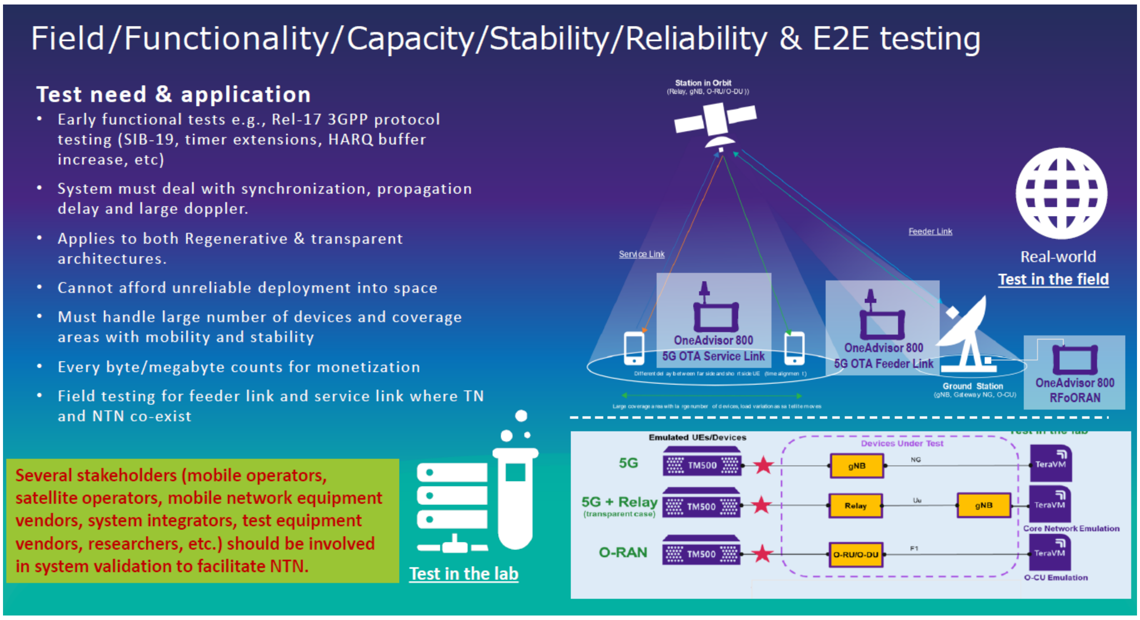
Business Collaboration Case 3 : Joint Study, capital/business alliance

National Hospital Organization DMAT	Joint study for **utilization of next-gen-high-speed satellite communication services at medical care at disaster sites**
HW ELECTRO	Joint study for **supply of mobile infrastructure using NTN solution**
Marindows	Capital/business alliance for **promotion of DX in the maritime industry**

◀"ELEMO" made and distributed by HW ELECTRO

(Source) https://www.softbank.jp/corp/news/press/sbkk/2021/20211029_01/
https://www.softbank.jp/corp/news/press/sbkk/2022/20220214_01/
https://www.softbank.jp/corp/news/press/sbkk/2022/20220726_02/

Business Collaboration Case 4 : Integration testing at lab field

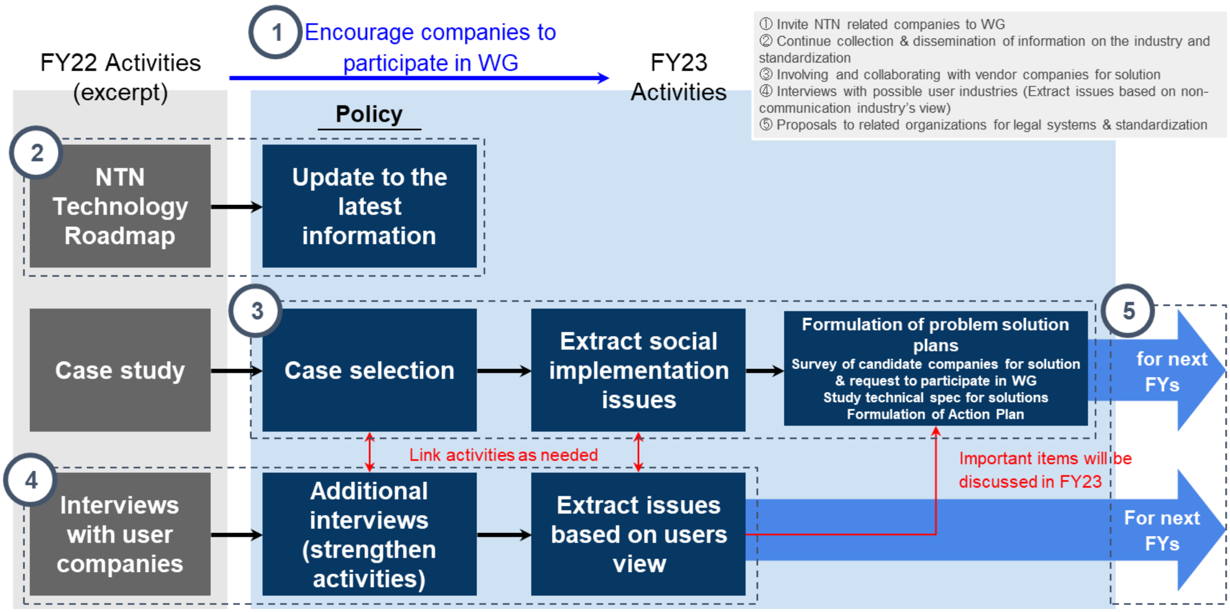


2. FY 2023 Activity Policy

Based on the activities and identified challenges in previous year, we carried out the following activities in FY 2023. KDDI and Space Compass joined us as new WG members. These activity reports are found in the next chapters.

- Invite NTN companies to WG
- Continue collection & dissemination of information on the industry and standardization
- Interviews with possible user industries (to identify issues that cannot be found by telecommunications industry alone)
- Involving and collaborating with vendor companies for solution
- Creating proposals to related organizations for legal systems & standardization

Following shows the relationship of the activities with FY 2022, meeting schedule and each initiative coordinator. As with last year, the discussion was led by Dr. Toyoshima WG group leader (NICT) and the coordinators, and all the WG members actively discussed items.



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								
	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			◎	➡ ★	⇨ ☆			
	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	◎	➡ ★	⇨ ☆					
	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								
	Summary on required standardization								

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

3. Technology Roadmap Update

3.1 News Excerpts from 2023 and beyond

Satellite Broadband

Geostationary Satellites

- The first satellite of Viasat-3 was launched on April 30, 2023. Due to the communication failure, the available bandwidth has decreased significantly to less than 10%. (Viasat, 10/12)
- Konnect VHTS was launched on September 8, 2022 and started its service on October 26, 2023. (Eutelsat, 10/26)
- JUPITER 3 was launched on July 28, 2023 and started its service on December 19, 2023. (Hughes, 12/19)

LEO Constellation

- OneWeb has launched GEN-1 constellation and completed its construction. (Eutelsat OneWeb, 3/27)
- SoftBank started offering Starlink Business service. (Softbank, 7/13)
- Telesat announced the contract with SpaceX to launch LEO satellite. The launch is planned in 2026. (Telesat, 9/11)
- SKY Perfect JSAT, NTT DOCOMO and NTT communications started to offer Starlink Business service. (SKY Perfect JSAT, NTT DOCOMO, 10/31)
- Amason's Project Kuiper, NTT and SKY Perfect JSAT agreed on strategic collaboration. (Amazon, 11/28)
- Project Kuiper launched 2 prototype satellites in October 2023, and succeeded in the test of optical intersatellite communication of 100 Gbps on the orbit. (Amazon, 12/14)
- Starlink subscribers exceeded 2.3 million. (Starlink, 12/22)
- SpaceX announced 100 Starlink satellites in service to voluntarily be destroyed by entering the atmosphere. (2024/2/16)

Satellite Mobile Direct

- SpaceMobile's test satellite BlueWalker 3 achieved voice call (AST, 4/25), video call, and downlink speed over 14 Mbps by existing smartphones (AST, 9/19)
- Bullitt, a British cellular maker, started satellite communication service (text only) compatible to GPP R17 IoT-NTN in May 2023. Slylo provides its networks using geostationary satellites (of Echostar and Immmarsat). (Skylo, 5/3)
- Lynk started satellite communication service (text only) for existing smartphones

in Palau on June 21, 2023. (Lynk, 6/21) The services for the Cook Islands (Lynk, 8/8) and the Solomon Islands (Lynk, 11/7) were also launched.

- KDDI and SpaceX announced a business partnership to provide satellite mobile direct communication by Starlink. (KDDI, 8/30)
- Qualcomm and Iridium terminated the contract of Snapdragon Satellite that provides satellite communication function on Android smartphones. (Iridium, 11/9)
- WRC-23 resolved to study on allocation of 694/698MHz-2.7GHz band frequencies for satellite communication to enable satellite communication from existing cellular phones (direct communication of cellular and satellites). These bands were specified to cellular phone communication. (MIC 12/27)
- Iridium announced Project Stardust that uses existing LEO constellation to provide 3GPP IoT-NTN compatible service planned to start in 2026. (Iridium, 2024/1/10)
- SpaceX launched first 6 satellites compatible with Direct to Cell and succeeded in sending text messages to existing smartphones. (SpaceX, 2024/1/10)
- Rakuten to provide direct-satellite-cellular-communication service with AST Space mobile in 2026. (2024/2/16)

Satellite IoT

- EchoStar announced construction of a S-band LEO constellation consisting of 28 satellites. Provision of satellite communication service compatible with LoRa and 3GPP Rel17 is planned in 2024. (EchoStar, 2/1)
- OQ Technology started satellite commercial communication service based on 3GPP technology. (OQ Technology, 4/17)
- SORACOM announced business partnership with Skylo to provide satellite communication network for IoT compatible with 3GPP Rel17. (SORACOM, 7/6)
- Sateliot confirmed the smooth switching from Telefónica ground network to Sateliot satellite network by installing existing SIM card onto IoT terminals. 3GPP Rel17 compliant commercial satellite communication service is to start in 2024. (Sateliot, 7/28)
- Viasat and Skylo announced the launch of satellite communication service compliant to 3GPP rel17 from early 2024. (Viasat, 11/16)

HAPS

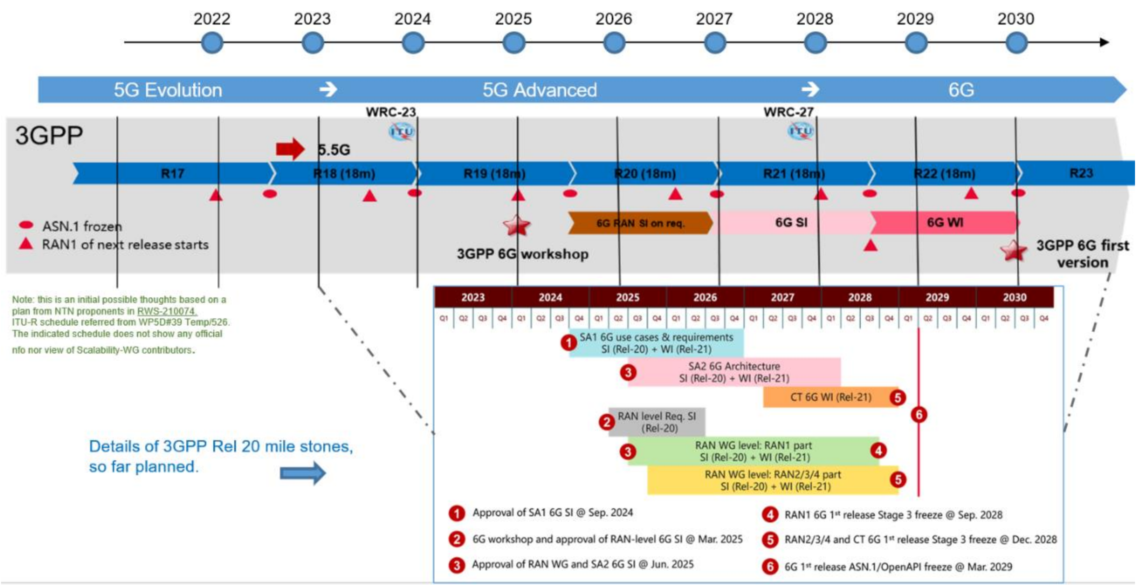
- NTT Docomo and SKY Perfect JSAT succeeded in completing a 38GHz band radio wave propagation test measurement for the first time in the world from the lower stratosphere (approximately 14km above the ground) to a ground receiver.

(NTT DOCOMO, 1/24)

- SoftBank succeeded in 5G communication test from stratosphere. (SoftBank, 10/17)
- Mira Aerospace succeeded in 5G communication test from stratosphere. (Mira Aerospace, 10/27)
- WRC-23 identified frequency bands for using HAPS as mobile base stations: 1.7GHz, 2GHz band and 2.6GHz bands worldwide. With 700MHz, many countries including Japan are to use the band for HAPS as mobile base stations. (MIC, 12/27)

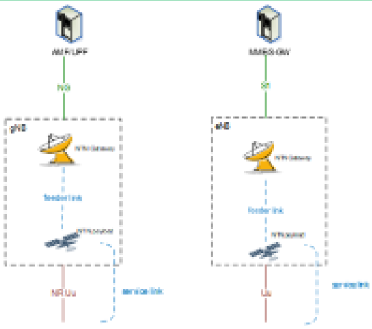
3.2 3GPP Standardization Trend

As with FY 2022, we discussed and partially updated 3GPP standardization trend. 3GPP had nearly completed the discussion on Release 18, and has started discussion on Release 19. The initiation of discussion on use cases based on IMT-2030 framework recommendation (Framework and overall objectives of the future development of IMT for 2030 and beyond) in light of 6G is expected in future.



NTN Technology Roadmap : 3GPP/Standardization trend

- 3GPP started to discuss NTN: Non-Terrestrial NW from Release 15, stipulated the first specification (Phase 1) at Release 17 and functional enhancement (Phase 2) at Release 18. Discussions on expanding NTN are in progress for Release19 and later.
- The transparent relay NTN architecture supports the following use cases at Release 17/18. Expected architecture expansion in future as a regenerative repeater architecture in which some or all of the base station functions are mounted on a satellite is discussed at Release 19 and later.
  - ➢ Handset terminal based on 5G NR
  - ➢ IoT terminals based on NB-IoT/eMTC
- Regarding frequency support targeting NR base, n256/n255 were stipulated at Release17, and n254 was added at Release 18. Expected to further expanding.



NR NTN　　NB-IoT/eMTC NTN

Types of NTN platforms(TR 38.821)

Platforms	Altitude range	Orbit	Typical beam footprint size
Low-Earth Orbit (LEO) satellite	300 – 1500 km	Circular around the earth	100 – 1000 km
Medium-Earth Orbit (MEO) satellite	7000 – 25000 km		100 – 1000 km
Geostationary Earth Orbit (GEO) satellite	35 786 km	notional station keeping position fixed in terms of elevation/azimuth with respect to a given earth point	200 – 3500 km
UAS platform (including HAPS)	8 – 50 km (20 km for HAPS)		5 - 200 km
High Elliptical Orbit (HEO) satellite	400 – 50000 km	Elliptical around the earth	200 – 3500 km

Satellite operating bands in FR1(TS38,108)

Satellite operating band	Uplink (UL) operating band SAN receive / UE transmit $F_{UL,low}$ – $F_{UL,high}$	Downlink (DL) operating band SAN transmit / UE receive $F_{DL,low}$ – $F_{DL,high}$	Duplex mode
n256	1980 MHz – 2010 MHz	2170 MHz – 2200 MHz	FDD
n255	1626.5 MHz – 1660.5 MHz	1525 MHz – 1559 MHz	FDD
n254	1610 MHz – 1626.5 MHz	2483.5 MHz – 2500 MHz	FDD
NOTE: Satellite bands are numbered in descending order from n256.			

NTN Technology Roadmap Comparison : 3GPP

		3GPP NTN(Rel-17) incompatible Rel16 and earlier	3GPP NR NTN (Rel-17/18)	3GPP NB-IoT/eMTC NTN(Rel-17/18)	After Rel-19 Beyond 5G/6G
Satellite		N/A	HAPS/LEO/GEO/MEO	HAPS/LEO/GEO/MEO	To be decided (HAPS/LEO/GEO/MEO)
Service link frequency		3GPP frequency. Use frequencies of partner MNO.			
Terminal		Existing mobile phone (3GPP)	5G NR terminal (3GPP Rel17)	5G IoT terminal (3GPP Rel17)	To be decided
Service		Text, voice, broadband	Text, voice, broadband	Text, voice, broadband	To be decided
Coverage		Global. However, in the range where partner MNO frequencies can be used			
Characteristics					
Related systems	Radio Regulations	・Additional MSS allocation is required for the frequency used ・Article 4.4 applies due to use of unallocated frequencies for mobile satellite service	Can be used with existing MSS allocated frequency (S Band)	Can be used with existing MSS allocated frequency (S Band)	–
	Introduction to Japan	System development is required after solve the institutional issues (type of radio station, license, etc.) due to the direct communication of mobile phone and satellite.	System development is required as regulations are to be set for each system in principle.	System development is required as regulations are to be set for each system in principle.	–
	Standa	3GPP Rel-8 and later (LTE)	3GPP Rel 17 NTN	3GPP Rel 17 NTN	– (3GPP Rel 19 and later)

NTN System 3GPP Rel-15

Approach for 5G		**Introduction of the NTN subject.** Service requirements for 5G via satellite. Satellite propagation model definition & Issues for 5G support NTN.
NTN related standardization activities		• Deployment Scenarios and Related System Parameters (Satellites and HAPS) • 5G service requirements for 5G via satellite • Satellite propagation model definition & Issues for 5G support NTN
Tech.	RAN	• Study item (SI) on NTN scenarios and channel models: TR 38.811
	SA	• KPIs for a 5G system with satellite access: TS 22.261
Use case for satellite access		NR NTN IoT NTN
Possibility of international collaboration		**Yes, at 3GPP**

NTN System 3GPP Rel-16

Approach for 5G		**Assessment of the issues.** Study satellite features for 5G system and RAN.
NTN related standardization activities		• Study satellite features for 5G system and RAN* • Satellite architecture and key issues • Management and orchestration aspects *HAPS could be considered as a special case of non-terrestrial access with lower delay/Doppler value and variation rate
Tech.	RAN	• Study on solutions for NR to support non-terrestrial networks (NTN): TR 38.821
	SA	• Integration of Satellite Access in 5G：WID in SP-180326；TR 22.822 • Study on architecture aspects for using satellite access in 5G：WID in SP-181253；TR 23.737 • Study on management and orchestration aspects with integrated satellite components in a 5G network：WID in SP-190138; TR 28.808
Use case for satellite access		NR NTN IoT NTN
Possibility of international collaboration		**Yes, at 3GPP**

NTN System 3GPP Rel-17

Approach for 5G		**Definition of Market enabling features.** Define satellite features for 5G system and RAN.
NTN related standardization activities		• Specify basic NTNfeatures for 5G system and RAN • Specify basic satellite features for LTE NB IoT/eMTC • Specify NTN components in the 5G architecture • Specify RF requirements based on the result of co-existence study
Tech.	**RAN**	• TS 38 series referred in § 5.1.2 in TR21.917 (NR NTN) • TS 36 and 38 series referred in § 5. 2 in TR21.917 (NB-IoT/eMTC for NTN)
	SA	• TS 23, 24, 29 and 31 series refried in § 5.1.2 and 5.2 in TR21.917
Use case for satellite access		NR NTN IoT NTN
Possibility of international collaboration		**Yes, at 3GPP**

NTN System 3GPP Rel-18

Approach for 5G		**Definition of enhancements optimizing performance and enabling new capabilities.** Define enhanced satellite features for 5G system and RAN.
NTN related standardization activities		• Coverage enhancement for direct smart phone connection • UE location verification for PLMN selection • Support for non-continuous coverage with sparse constellation • Support of Satellite Backhauling
Tech.	**RAN**	• NR NTN (Non-Terrestrial Networks) enhancements：WID in RP-223534 • Introduction of the satellite L/S-band for NR: WID in RP-223485 • IoT (Internet of Things) NTN (non-terrestrial network) enhancements: WID in RP-223519 • NB-IoT/eMTC core & performance requirements for Non-Terrestrial Networks (NTN): WID in RP-223437
	SA	• Enhancement to the 5GC LoCation Services：SID in SP-211637 • Study on Support of Satellite Backhauling in 5GS：SID in SP-211317 • Study on satellite access Phase 2：SID in SP-211651
Use case for satellite access		NR NTN IoT NTN
Possibility of international collaboration		**Yes, at 3GPP**

NTN System 3GPP Rel-19 (preliminary forecast)

Approach for 5G		・**Definition of 2nd set of enhancement optimizing performance and enabling new capabilities**
NTN related standardization activities		• Define 2nd enhanced satellite features for 5G system and RAN • RAN and AS enhancement for global seamless coverage supported by satellite constellation
Tech.	RAN	• Some continuations from Rel-18 (e.g. further performance enhancements, regenerative architecture); • TN-NTN, NTN-NTN with regenerative architecture • Enhanced mobility management • Carrier Aggregation
	SA	• Seamless coverage with satellite constellation; UPF on board; E2E
Use case for satellite access		Enhanced direct to cell services Support Redcap Supporting terminals without GNSS
Possibility of international collaboration		**Yes, at 3GPP**

NTN and MT-2030

https://www.itu.int/en/ITU-R/study-groups/rsg5/rwp5d/imt-2030/Pages/default.aspx

6 Usage scenarios

Extension from IMT-2020 (5G)

eMBB → Immersive Communication
mMTC → Massive Communication
URLLC → HRLLC

New

Ubiquitous Connectivity
Integrated AI and Communication
Integrated Sensing and Communicatio

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

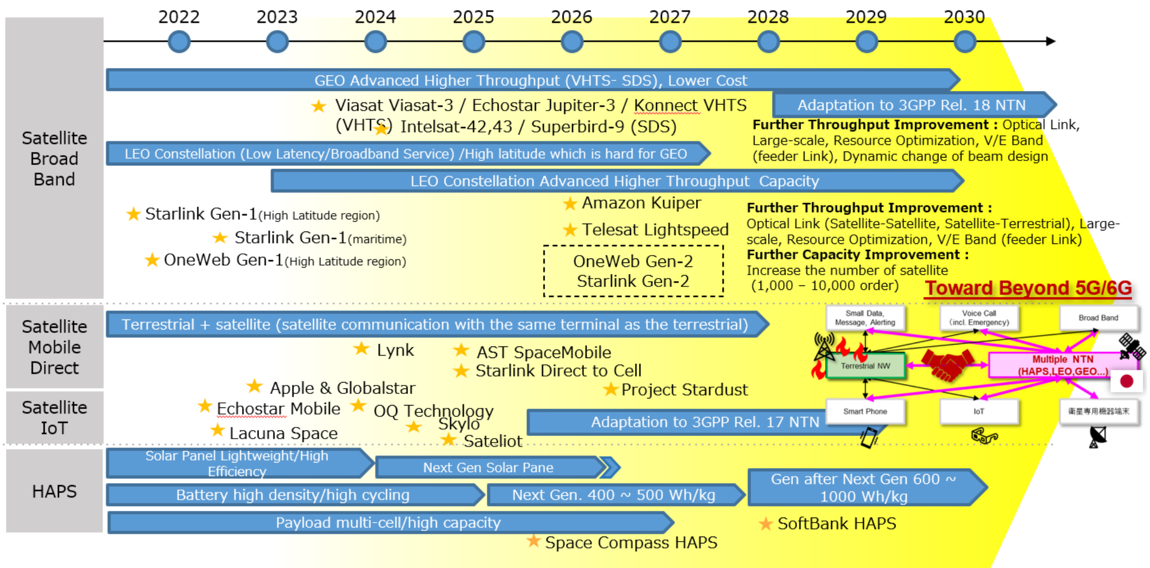
All values in the range have equal priority in research and investigation.

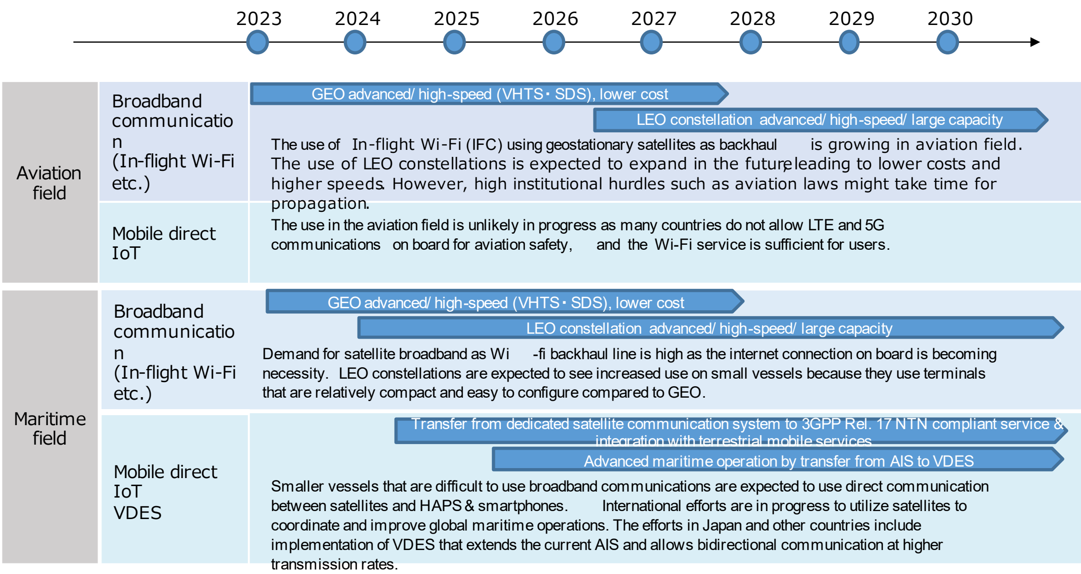
For each usage scenario, a single or multiple values within the range would be developed in future in other ITU-R Recommendations/Reports.

3.3 Technology Roadmap

We carried out detailed studies and updated NTN Technology Roadmap as follows. The Technology Roadmap is divided into the following fields: Satellite Broadband, Satellite Mobile Direct, Satellite IoT, HAPS Framework, and Aviation & Maritime field.

Satellite Broadband	Starlink subscriptions are growing rapidly, with the number exceeding 2.3 million worldwide as of December 2023. The services for vessels have been started, and service expansion to aircraft is also planned in 2024. Competition among LEO constellations is expected to intensify with the launch and expansion of OneWeb and Project Kuiper services. With geostationary satellites, Low-cost, high-speed services have been launched based on VHTS such as Konnect VHTS and JUIPITER 3. Services based on SDS (Software Defined Satellite) are also planned and expected to develop services with low-latency and high-speed. Currently, frequency of service link mainly uses Ku band, usage of Ka band is also increasing. With feeder links, the use of higher frequency bands such as Q/V bands has also begun.
Satellite Mobile Direct Satellite IoT	Direct satellite communication services with smartphone have been started by Lynk and Bullitt, and AST SpaceMobile and Starlink are also planning the launch of services in future. Services can communicate with directly IoT terminals (3GPP Rel 17 NTN compatible terminals and Lora terminals) are about to start, and it enables significantly increased coverage as both terrestrial and satellite networks can be used on the same device. The dissemination of the services is expected with the expansion of the service area and improvement of performance.
HAPS	Research and development is in progress. The usage method of mobile direct communication and CPE is planned. The expected HAPS usage is for a hyper-expanding mobile coverage and backup communications in the event of disasters. Although HAPS has narrower coverage than satellites due to its lower altitude, it can provide high-speed communication services with low latency compared with those of satellites.





We also identified the following technical challenges that need to be resolved to realize NTN utilization.

Technology issues to be solved for utilization of NTN

区分	NTN Technology Issues	Source
Communication	❶Digital coherent optical communication technology, adaptive optics technology, site diversity technology ❷Satellite constellation, Base station backhaul line using HAPS ❸Optical data relay technology transmit sensing information via GEO satellite ❹Development of new frequency sources（Q band/V band)	R&D Theme (※)
Environmental measures	❺HAPS base station that realizes decarbonization	
Area construction/design	❻Radio wave propagation model ❼Technology development ("Cylinder antenna" and "rotating connector" etc.） for stabilized communication area and network construction	
Operation	❽Management for integrated network including satellite, HAPS networks, orchestration technology, autonomous operation technology using AI & machine learning (Zero-touch automation) ❾Space / NTN open architecture technology	
Payload	❿HAPS payload during the disaster ⓫Automatic tracking technology compatible with multiband-NTN antenna and moving NTN nodes (HAPS and LEO) ⓬Regenerative relay payload with gNB and MEC function ⓭Next generation battery ⓮Next generation control technologies for encryption and encryption keys applicable to satellites	
Terminal	⓯Multi access terminal capable of simultaneous connection of NTN and ground networks	
Platform	⓰Cloud platform linking ground and space（Data center)	
Connection protocol	⓱Optimized protocol and multiple access methods for integrated NTN networks	Use cases
Intersatellite link control	⓲Advanced routing and interconnection schemes between satellite constellations	

※Source：Information and communication technology strategy for Beyond 5G ＞Industry, academia and government collaboration on Beyond 5G R&D Theme＞【Theme 6】NTN（HAPS･Space Network）Technology
<https://www.soumu.go.jp/menu_news/s-news/01tsushin03_02000352.html>

Details on each technology roadmap are shown in the following sections.

3.3.1 Satellite Broadband

The main characteristic of Satellite Broadband is installing the dedicated satellite communication terminals on the ground and enable satellite communication directly from that terminal, or through the terminal from communication terminals such as smartphone. In recent years, significant progress has been made in the deployment of low Earth orbit satellites (LEO) in addition to geostationary satellites (GEO), and commercial services have begun in many countries.

		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 device（VSAT etc.） 60cm～1.2m diameter parabolic antenna	Dedicated device ～1.2mdiameter parabolic antenna 50x45cm Flat antenna	Dedicated device 50x30cm Flat antenna 57x51cm Flat antenna	Dedicated device（Flat antenna) 17.8cm x 17.8cm 38cm x 38cm 48cm x 76cm	Parabolic antenna Flat antenna
Throughput		~150Mbps (Downstream)	~195Mbps (Downstream)	~350Mbps (Downstream)	~1Gbps (Downstream)	~7.5Gbps
Latency		~600ms (Altitude 35,000km)	~70ms (Altitude 1,200km)	20~40 ms (Altitude 500km)	~50 ms? (Altitude 600km)	~70ms? (Altitude 1,015km, 1,325km)
Coverage		Depends on the satellite position. Covering polar regions is difficult.	Global	Global	Global	Global
Characteristics		Can use existing ground systems for geostationary satellites. Reduce costs by increasing capacity and optimize coverage with flexible beams.	Intersatellite optical link （Not included in early constellations)	Intersatellite optical link （Not included in early constellations)		Regenerative relay system Intersatellite optical link
Related systems	Radio Regulations	Can be used with existing FSS allocation frequencies (Ku/Ka/Q/V Band etc.)	Can be used with existing FSS allocation frequencies (Ku/Ka Band)	Can be used with existing FSS allocation frequencies (Ku/Ka Band)	Can be used with existing FSS allocation frequencies (Ka Band)	Can be used with existing FSS allocation frequencies (Ka Band)
	Introduction to Japan	Can be used within the allocated FSS frequency system	Gen-1 has been institutionalized	Gen-1 has been institutionalized	System development is required when introducing it to Japan.	System development is required when introducing it to Japan.
	Standards	DVB-S2X(ETSI) etc.	European standards ・ECC Report 271 ・ECC Decision (18)05 ・ETSI EN 303 980	European standards ・ECC Report 271 ・ECC Decision (18)05 ・ETSI EN 303 981	–	–
Use cases		Rural areas, Broadband for ships and aircraft, mobile backhaul, backup lines for disasters	The basic use case is similar to services provided by geostationary satellites (VHTS/SDS). Although it is considered advantageous in terms of latency, throughput, cost, and ease of terminal installation, there will be many cases where it is difficult to use it because of the stricter line-of-sight conditions than those of GEO satellites. With the case for ships & aircraft, they will be actively used in the future as line-of-sight conditions are not an issue.			

VHTS (Very High Throughput Satellite)

Satellite overview		A satellite that places multiple spot beams to reuse frequencies is called an HTS that has a capacity several dozen times more than a conventional geostationary satellite. VHTS is the next generation satellites with even greater capacity than HTS. In 2023, Konnect VHTS (500Gbps) by SES and Jupiter 3 (>500Gbps) by Hughes was launched. These satellites use Ka band for their service links.
Technology		High-power (20kW) supporting thousands beams. Bandwidth can be flexibly reassigned from area with low demand to high demand after launch.
Terminal		VSAT、ESIM (Can use existing terminal used for geostationary satellites.) Throughput: > 100Mbps
Use case		Rural areas, Broadband for ships and aircraft, mobile backhaul, backup lines for disasters. Available more widely and at lower cost than before.
Related systems	Radio Regulations	Can be used with existing FSS allocation frequencies (Ku/Ka/Q/V Band etc.)
	Introduction to Japan	Can be used within the allocated FSS frequency system.
	Standards	DVB-S2X (ETSI) etc.
Others		

SDS (Software Defined Satellite)

Satellite overview		The beam design can be changed after the launch of satellite, unlike conventional satellites. Beam placement, size, bandwidth and power can be changed dynamically. SKY Perfect JSAT's Superbird-9, IS-42, IS-43, IS-41, IS-44 by Intelsat, GX7、8、9 of Inmarsat etc. are planned. Service link uses Ku band and Ka band. GX7, 8, 9 can place thousands of beams simultaneously.
Technology		Thousands of beams can be dynamically repositioned by latest digital processing and phased array antenna.
Terminal		VSAT、ESV、ESIM (Can use existing terminal used for geostationary satellites). Throughput: > 100Mbps
Use case		Rural areas, Broadband for ships and aircraft, mobile backhaul, backup lines for disasters. Available more widely and at lower cost than before.
Related systems	Radio Regulations	Can be used with existing FSS allocation frequencies (Ku/Ka/Q/V Band etc.)
	Introduction to Japan	Can be used within the allocated FSS frequency system.
	Standards	DVB-S2X(ETSI) etc.
Others		

OneWeb

<table>
<tr><td colspan="2">Satellite overview</td><td>・Constellation consists of 588 satellites at the orbit altitude of 1,200km (Gen-1)
・Global coverage (including maritime coverage).</td></tr>
<tr><td rowspan="3">Technology</td><td>Optical communication</td><td>・Not implemented in Gen-1. Planning to implementation of inter-satellite optical link in Gen-2.</td></tr>
<tr><td>Frequency</td><td>・Service link : Ku band
・Feeder link : Ka band
※V/E band (Considering implementation in Gen-2)</td></tr>
<tr><td>Ground station</td><td>・To be installed 40-50 stations worldwide</td></tr>
<tr><td colspan="2">Use case</td><td>・BCP/Remote area/Broadband communications for land mobile
・Broadband communications for ships/aircraft</td></tr>
<tr><td rowspan="3">Related systems</td><td>Radio Regulations</td><td>Can be used with existing FSS allocation frequencies (Ku/Ka band).</td></tr>
<tr><td>Introduction to Japan</td><td>Gen-1 has been institutionalized.</td></tr>
<tr><td>Standards</td><td>European Standards
・ECC Report 271
・ECC Decision (18)05
・ETSI EN 303 980</td></tr>
<tr><td colspan="2">Possibility of international collaboration</td><td>・Solar panel technology
・Debris removal technology</td></tr>
</table>

Starlink

<table>
<tr><td colspan="2">Satellite overview</td><td>Satellite constellation by SpaceX (Altitude approx. 550km)
More than 5,000 units have been launched. The FCC's permission allows the launch of 12,000 units.
Maximum download throughput 220Mbps.
Service link uses Ku band (Gen-2 and later is planning to use of Ka band and V band).
Gen-2 constellation plans to launch 30,000 units (approximately 330km to 610km altitude).</td></tr>
<tr><td colspan="2">Technology</td><td>Adopts the latest digital processing and phased array antenna.
Provides communication services even at locations far from the gateway by Inter Satellite Laser link (ISL).</td></tr>
<tr><td colspan="2">Terminal</td><td>Dedicated Starlink terminal manufactured by SpaceX. Phased array antenna.</td></tr>
<tr><td colspan="2">Use case</td><td>Rural areas, Broadband for ships and aircraft, mobile backhaul, backup lines for disasters.</td></tr>
<tr><td rowspan="3">Related systems</td><td>Radio Regulations</td><td>Can be used with existing FSS allocation frequencies (Ku/Ka band)</td></tr>
<tr><td>Introduction to Japan</td><td>Gen-1 has been institutionalized.</td></tr>
<tr><td>Standards</td><td>European standards
・ECC Report 271
・ECC Decision (18)05
・ETSI EN 303 981</td></tr>
<tr><td colspan="2">Possibility of international collaboration</td><td></td></tr>
</table>

3.3.2 Satellite Mobile Direct

The main characteristic of Satellite Mobile Direct is direct satellite communication using communication terminals such as smartphone without installing dedicated terminals for communication with satellite. It is a major architecture discussed in 3GPP and R&D is underway in many countries due to high usability for users.

		SpaceMobile	Lynk	Starlink Direct to Cell	Apple & Globalstar
Satellite		LEO	LEO	LEO	LEO
Service link frequency		3GPP frequency (Mid-band, Low-band) Use frequencies of partner MNO	3GPP frequency (Low-band) Use frequencies of partner MNO	3GPP frequency (Mid-band) Use frequencies of partner MNO	Use frequency of Globalstar (L-band/S-band)
Terminal		Existing mobile phone (3GPP)	Existing mobile phone (3GPP)	Existing mobile phone (3GPP)	iPhone14, iPhone 15 series
Service		Text, voice, broadband	Text (voice and data in future)	Text (voice and data in future)	Emergency call, roadside service (USA only)
Coverage		Global. However, in the range where partner MNO frequencies can be used.	Global. However, in the range where partner MNO frequencies can be used.	Global. However, in the range where partner MNO frequencies can be used.	16 countries (as of Jan. 2024) (possibly can be used within the range of Globalstar coverage in future).
Characteristics		Large phased array antenna. Bent-pipe method. Doppler and delay correction on the ground.	1m-1.5m phased array antenna. Mount eNodeB & EPC on satellite. Provides text messaging services even at locations far from the gateway by Store & Forward communication.	2.7m x 2.3m phased array antenna. Mount eNodeB on satellite. Doppler correction.	Use satellite communication function of Globalstar.
Related systems	Radio Regulations	・Additional MSS allocation is required for the frequency used ・Article 4.4 applies due to use of unallocated frequencies for mobile satellite service	・Additional MSS allocation is required for the frequency used ・Article 4.4 applies due to use of unallocated frequencies for mobile satellite service	・Additional MSS allocation is required for the frequency used ・Article 4.4 applies due to use of unallocated frequencies for mobile satellite service	【No issues】Can be used with existing MSS allocated frequency (L/S band)
	Introduction to Japan	System development is required after solve the institutional issues (type of radio station, license, etc.) due to the direct communication of mobile phone and satellite.	System development is required after solve the institutional issues (type of radio station, license, etc.) due to the direct communication of mobile phone and satellite.	System development is required after solve the institutional issues (type of radio station, license, etc.) due to the direct communication of mobile phone and satellite.	【Issue unknown】Institutionalized as an MSS system.
	Standards	2G, 4G, 5G	2G, 4G, 5G	3GPP Rel-8 and later (LTE)	Unknown
Use case		Significant expansion of mobile network coverage. Mobile network restoration in the event of a large-scale disaster etc.	Messaging service outside of mobile coverage, emergency call.	Messaging service outside of mobile coverage, emergency call.	Emergency call outside of mobile coverage. Roadside service.

SpaceMobile

Satellite overview		95 satellites constellation by AST SpaceMobile (Altitude approx. 730km). Provides direct communication service to the existing mobile phones (Text, voice, broadband) Uses frequency of MNO partner (3GPP frequency Low-band & Mid-band) Launched test satellite, BlueWalker3 in Sep. 2022. Achieved voice call and downlink throughput of 14Mbps in a demonstration experiment in 2023.
Technology		Large phased array antenna. Bent-pipe method (eNB is placed on the ground). Doppler and delay correction.
Terminal		Existing mobile phone (3GPP terminal)
Use case		Significant expansion of mobile network coverage. Mobile network restoration in the event of a large-scale disaster etc.
Related systems	**Radio Regulations**	・Additional MSS allocation is required for the frequency used ・Article 4.4 applies due to use of unallocated frequencies for mobile satellite service
	Introduction to Japan	System development is required after solve the institutional issues (type of radio station, license, etc.) due to the direct communication of mobile phone and satellite.
	Standards	2G, 4G, 5G
Others		Rakuten Symphony is developing eNodeB for SpaceMobile.

Lynk

Satellite overview		Satellites constellation by Lynk (Altitude approx. 500km). Provides direct communication service to the existing mobile phones (Text). Uses frequency of MNO partner (3GPP frequency Low-band). 3 commercial satellites have been launched. Commercial service started in June 2023.
Technology		1m-1.5m phased array antenna. Mount eNB & EPC on satellite. Provides text messaging services even at locations far from the gateway by Store & Forward communication. Doppler and delay correction.
Terminal		Existing mobile phone (3GPP terminal)
Use case		Communication in the dead zone. Emergency communications during large-scale disasters etc.
Related systems	**Radio Regulations**	・Additional MSS allocation is required for the frequency used ・Article 4.4 applies due to use of unallocated frequencies for mobile satellite service
	Introduction to Japan	System development is required after solve the institutional issues (type of radio station, license, etc.) due to the direct communication of mobile phone and satellite.
	Standards	2G, 4G, 5G
Others		

Starlink Direct to Cell

Satellite overview		Starlink Satellites constellation for communication with mobile phones (Altitude approx. 550km). Provides direct communication service to the existing mobile phones (Text. Voice and data communication will be available in future). Uses frequency of MNO partner (3GPP frequency Mid-band). 6 satellites were launched in January 2024 and succeeded in sending & receiving text. The service is to start within 2024.
Technology		2.7m x 2.3m phased array antenna. Mount eNodeB on satellite. Connects existing Starlink constellation with Laser backhaul (No dedicated gateway is required). Doppler and delay correction.
Terminal		Existing mobile phone (3GPP terminal)
Use case		Communication in the dead zone. Emergency communications during large-scale disasters etc.
Related systems	**Radio Regulations**	・Additional MSS allocation is required for the frequency used ・Article 4.4 applies due to use of unallocated frequencies for mobile satellite service
	Introduction to Japan	System development is required after solve the institutional issues (type of radio station, license, etc.) due to the direct communication of mobile phone and satellite.
	Standards	4G
Others		

3.3.3 Satellite IoT

Satellite IoT has a network configuration that allows direct satellite communication from IoT terminals, similar to Mobile Direct. The characteristics of IoT, such as small data transmission and delay tolerant are highly compatible with satellite communication and allowed relatively earlier start of R&D and commercialization compared to Mobile Direct. For Cellular IoT (NB-IoT/eMTC), 3GPP has specified extensions that enable application to NTN since Release 17.

		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 Licensed frequency	L band & S band?
Terminal		5G IoT terminal (3GPP Rel17)	5G IoT terminal (3GPP Rel17)	Lora terminal for LR-FHSS	Lora terminal for LR-FHSS + dedicated antenna	5G IoT terminal	5G IoT terminal (3GPP Rel17)
Service		Communicate with satellite directly from 5G IoT terminal	Communicate with satellite directly from 5G IoT terminal	Communicate with satellite directly from Lora terminal	Communicate with satellite directly from Lora terminal	Communicate with satellite directly from 5G IoT terminal	Communicate with satellite directly from 5G IoT terminal
Coverage		Global except polar regions	Global. LEO constellation service.	Europe only. Service by EchoStar XXI (geostationary satellite : 10.25°E)	Global. LEO constellation service (Approx. 500km)	Global. LEO constellation service.	Global. LEO constellation service.
Characteristics		Integrate with terrestrial networks to expand 5G IoT coverage	Integrate with terrestrial networks to expand 5G IoT coverage	Integrate with terrestrial networks to expand LoRa coverage	Integrate with terrestrial networks to expand LoRa coverage	Integrate with terrestrial networks to expand 5G IoT coverage	Integrate with terrestrial networks to expand 5G IoT coverage
Related systems	Radio Regulations	Can be used with existing MSS allocated frequency	Can be used with existing MSS allocated frequency (S band)	Can be used with existing MSS allocated frequency (S band)	Can be used with existing MSS allocated frequency (S band)	Can be used with existing MSS allocated frequency (S band)	–
	Introduction to Japan	System development is required as regulations are to be set for each system in principle.	System development is required as regulations are to be set for each system in principle.	System development is required as regulations are to be set for each system in principle.	System development is required as regulations are to be set for each system in principle.	System development is required as regulations are to be set for each system in principle.	System development is required as regulations are to be set for each system in principle.
	Standards	3GPP Rel 17 NTN	3GPP Rel 17 NTN	LR-FHSS	LR-FHSS	–	3GPP Rel 17 NTN
Use case							

OmniSpace

Satellite overview		Satellite constellation by OmniSpace. Provides direct communication service to 5G terminal. Uses frequency 3GPP band n256 (S band) Launched test satellites Spark-1, Spark-2 in April & May 2022. The satellites are for NB-IoT.
Technology		Details are not disclosed.
Terminal		3GPP Rel.17 compatible terminal for band n256.
Use case		IoT use case in general (asset tracking etc.)
Related systems	**Radio Regulations**	【No issues】Can be used with existing MSS allocated frequency (S band)
	Introduction to Japan	【Issues】System development is required as regulations are to be set for each system in principle.
	Standards	3GPP Rel-17 NTN(NB-IoT)
その他		

EchoStar Mobile

Satellite overview		Uses EchoStar XXI (geostationary satellite : 10.25°E). Uses licensed S band frequency. Direct communication service to LoRa terminal has started in Europe since July 2022.
Technology		Can be used by integrating LoRa network on the ground.
Terminal		LR-FHSS compatible Lora terminal
Use case		IoT use case in general (asset tracking etc.) Lora IoT service coverage expansion
Related systems	Radio Regulations	Can be used with existing MSS allocated frequency (S band)
	Introduction to Japan	System development is required as regulations are to be set for each system in principle.
	Standards	LR-FHSS
その他		

Lacuna Space

Satellite overview		Cubesat satellite constellation by Lacuna Space (Approx. 500km). Provides direct communication service to LoRa terminal. S band frequency (2GHz band) Launching commercial satellites (7 satellites have been launched. Plan to launch total 32 satellites).
Technology		Store & forward communication. Can be used by integrating LoRa network on the ground.
Terminal		LoRa module for LR-FHSS + dedicated antenna
Use case		IoT use case in general (asset tracking etc.) LoRa IoT service coverage expansion
Related systems	Radio Regulations	Can be used with existing MSS allocated frequency (S band)
	Introduction to Japan	System development is required as regulations are to be set for each system in principle.
	Standards	LR-FHSS
Others		Announced collaboration with OminiSpace (in March 2021), service uses S band frequencies of OminiSpace.

OQ TECHNOLOGY

Satellite overview		Satellite constellation by OQ TECHNOLOGY (plan to launch 72 satellites). Provides direct communication service to 5GIoT terminal. S band frequency (2GHz band) 8 satellites have been launched. Commercial service started in June 2023.
Technology		Details are not disclosed. Obtained US patent for "wake-up" technology that enables efficient power use only when terminal is communicating with satellites.
Terminal		3GPP R17 IoT-NTN compatible
Use case		IoT use case in general (asset tracking etc.)
Related systems	Radio Regulations	Can be used with existing MSS allocated frequency (S band)
	Introduction to Japan	System development is required as regulations are to be set for each system in principle.
	Standards	3GPP Rel-17 NTN(NB-IoT)
Others		

Sateliot

Satellite overview		Satellite constellation by Sateliot (plan to launch 250 satellites). The 1st satellite for the constellation was launched in April 2023. Provides direct communication service to 5G NB-IoT terminal Commercial service launch is planned in 2024.
Technology		Details are not disclosed.
Terminal		3GPP R17 IoT-NTN compatible.
Use case		IoT use case in general (asset tracking etc.)
Related systems	Radio Regulations	–
	Introduction to Japan	System development is required as regulations are to be set for each system in principle.
	Standards	3GPP Rel-17 NTN(NB-IoT)
Others		

3.3.4 HAPS

HAPS is one of the forms of NTN, and an architectural form that flies unmanned air vehicle (UAV) in stratosphere and enables direct communication with communication terminals such as smartphones. HAPS can provide close to or equivalent to terrestrial networks with low-latency service etc., thanks to the shorter distance from ground compared to those of satellites (GEO, MEO and LEO). In addition, HAPS has significantly shorter launch time compared to those of satellites, is expected to use in time of large-scale disaster.

	HAPS
Satellite	HAPS
Service link frequency	3GPP frequency Use frequencies of partner MNO
Terminal	Existing mobile phone (3GPP) _LTE/5G
Service	Text, voice, Broadband
Coverage	200km diameter area
Characteristics	Footprint fixation technology
Related systems – Radio Regulations	2GHz band has been specified as used frequency worldwide. Also 1.7GHz band & 2.6GHz (worldwide) , 700-900MHz band (worldwide except certain Asian areas) are specified as the result of WRC-23 Agenda 1.4 (Effective from Jan. 1, 2025, when the revised RR comes into effect).
Related systems – Introduction to Japan	System development is required as the different radio station from existing mobile phone base stations
Related systems – Standards	3GPP（HAPS BS Standard）
Use case	・Significant expansion of mobile network coverage. ・Mobile network restoration in the event of a large-scale disaster etc. ・Migration support to next-generation communications ・Realization of low-latency communication

HAPS

Overview		・Uses unmanned aircraft (UAV) that flows in the stratosphere as communication base station to provide communication service over wide area. ・Provides communication network (LTE, 5G) by emitting radio waves towards the ground from the onboard radio equipment.
Technology	Payload	・Develops optical radio of FeederLink (Establishment/improvement of technology for fine/coarse tracking). ・Develops radio management technology assuming ground station interference/prohibited area (fixed footprint, radio wave propagation model/simulation). ・Establishes Inter-HAPS technology（Stratosphere mesh configuration construction/operation rate improvement） ・Multiple cells/increased capacity
	Battery	・High-density/lighter weight (Solid state battery) ・Improved battery life/Improved number of cycles（Next-generation resin foil） ・Improved safety in stratospheric environments
	Solar panel	・Development of module for Stratospheric environmental application ・Lighter weight/higher efficiency
Use case		・Rural areas/remote island areas/3D coverage/disaster communication/IoT/sensing services (camera etc.)
Related systems	Radio Regulations	2GHz band has been specified as used frequency worldwide. Also 1.7GHz band & 2.6GHz (worldwide) , 700-900MHz band (worldwide except certain Asian areas) are specified as the result of WRC-23 Agenda 1.4（Effective from Jan. 1, 2025, when the revised RR comes into effect).
	Introduction to Japan	System development is required as the different radio station from existing mobile phone base stations.
	Standards	3GPP（HAPS BS Standard）
Possibility of international collaboration		・Promotes coordination with other systems（ICAO,FAA,EASA,CASA）、International frequencies（ITU、3GPP）

4. Use Cases

In FY 2022, we draw up use cases to generate interest in NTN which is the crucial component of Beyond 5G. By showing the use cases that illustrate "The things that could not be achieved with 5G will be made possible with NTN in Beyond 5G." We aim to find out users' needs and challenges, as well as create opportunities for collaboration with companies that possess the key technology for them. We have described 17 use cases from two perspectives: a technical perspective that looks at the overview of NTN as a whole, and an industry perspective that expresses specific utilizations.

- 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

In FY 2023 we studied these cases in view of "the most important cases to be realized as beyond 5G" and extracted them for discussion in the chapter below. (the cases marked with * at the end of their names).

Additionally, we studied the following 2 cases identified during this fiscal year's activities.

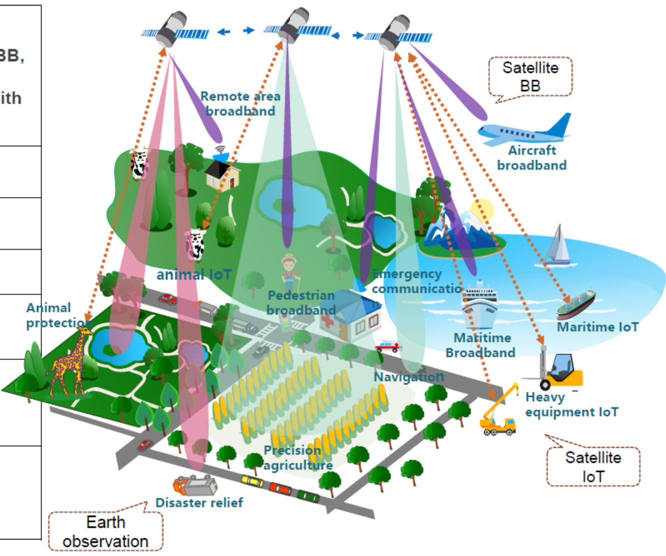
- Additional cases (Industry Perspective)
    - Unmanned delivery (by Satellite) (*)
    - BCP for Cellular Communication

4.1 19 Use Cases

The following sections provide the use cases that we discussed and identified for NTN.

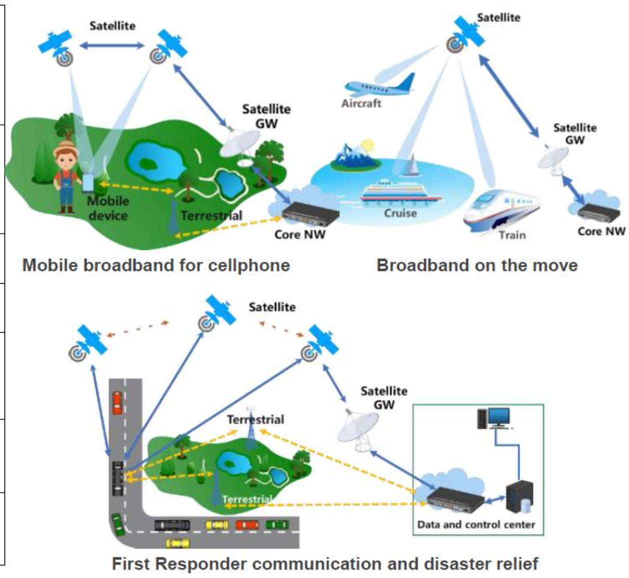
4.1.1 NTN and TN Integration

Use case overview		This shows an overall NTN-TN convergence image. Satellite BB, Satellite IoT, Satellite Observations 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 sub-6G
Expected Service Provided Timing		Year 2025~30



4.1.2 Broadband Communication Outside of TN Coverage

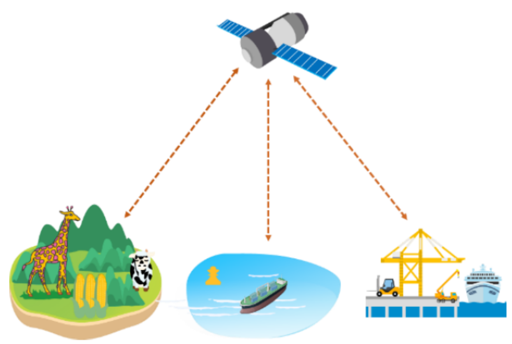
Use case overview		Connectivity to conventionally unconnected objects with Satellite-broadband. (convergence of TN and NTN-BB)
KPI	Throughput	• >100Mbps for moving platforms • >10Mbps for cellphone • >1Mbps for first responder
	Latency	• <20ms
	Coverage	• Rural areas, ocean, etc.
Terminal type		• Dish 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



4.1.3 IoT Communication Outside of TN Coverage

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



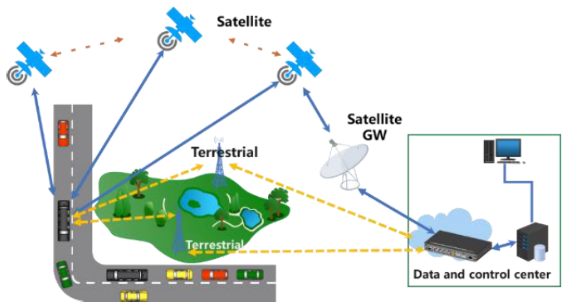
Technical Challenges and issues/difficulties to overcome this scenario includes;
1. Unified Protocol and Multi-Connection Technology for IMT and satellite
2. Intelligent High Dynamic Routing and Inter-satellite Optical Interconnection Tec.
3. Satellite-Ground Network O&M and Resource Management
4. Unified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

Highly expected international cooperation to overcome such challenges/issues.

4.1.4 High-Precision Positioning &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.



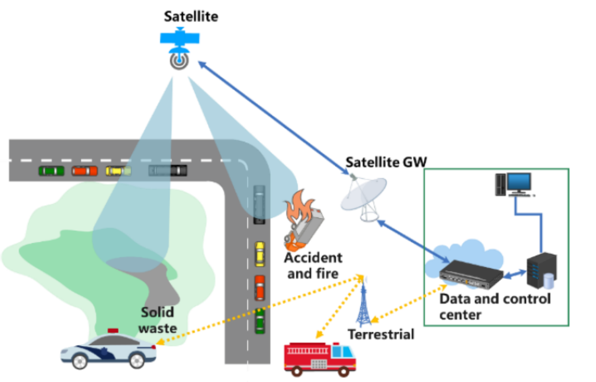
Technical Challenges and issues/difficulties to overcome this scenario includes;
1. Unified Protocol and Multi-Connection Technology for IMT and satellite
2. Intelligent High Dynamic Routing and Inter-satellite Optical Interconnection Tec.
3. Satellite-Ground Network O&M and Resource Management
4. Unified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

Highly expected international cooperation to overcome such challenges/issues.

4.1.5 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.

4.1.6 Observation of River Water Level & 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.

4.1.7 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.

4.1.8 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.

4.1.9 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.

4.1.10 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.

4.1.11 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.

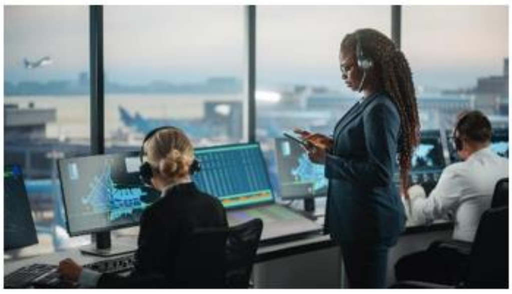
4.1.12 Unmanned Delivery (by HAPS)

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.

4.1.13 Advanced Airport Control

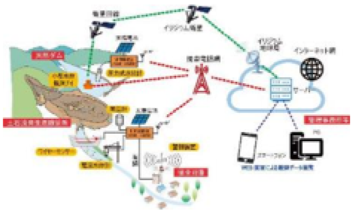
Tech to be used	HAPS + Sensing + Location data		
Use case	High-density operations through advanced control management		
UC Overview	Combining connectivity and sensing to achieve optimization of operation and routes.		
Existing solution	None		
KPI	Throughput	Latency	Coverage
	Tens of Mbps	Several milliseconds 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		



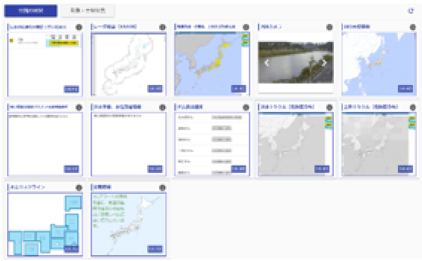
According to the International Air Transport Association (IATA), global aviation demand has shown signs of recovery as of June 2022. The total revenue passenger kilometers (RPK) increased by 76.2% compared to the same month last year, surpassing 70% of pre-pandemic levels. It is also forecasted to reach 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.

4.1.14 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

4.1.15 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

4.1.16 Sensing

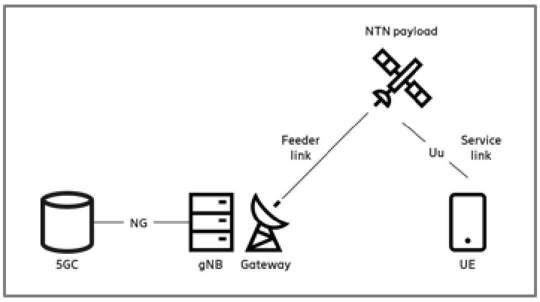
Use case overview		The use of sensing data provided by earth observation satellite is increasing in specialized areas such as weather observation and military. On the other hand, research and development of sensing technology for private-sector applications is also progressing, and in 3GPP Rel-19, a 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

4.1.17 Complementary Service by NTN

Tech to be used	LEO, 5GNR		
Use Case	-5G Service at TN outside coverage -TN Backup to big NW failure/disaster -Reinforcement of government NW		
UC Overview	Global connectivity for transportation, energy and health sector 5G use case		
Existing Solution	None		
KPI	Throughput	Latency	Coverage
	DL:10-15Mbps UL: ~1Mbps	25-42ms (max. RTD)	Outside of TN Coverage
Challenge	1. Doppler effect 2. Latency/Delay 3. Inter-system connection 4. Install functionalities to smart phone		
Expected Benefit	1. Large ecosystem of standard products and components		
Expected Service Provision Timing	Year 2025 or 2026		



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.

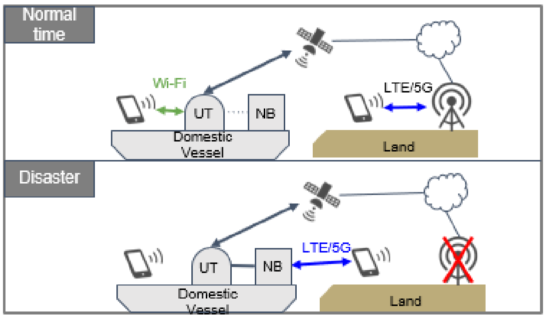
4.1.18 Unmanned Delivery (by Satellite)

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.

4.1.19 BCP 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		

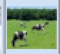
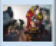
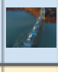
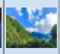
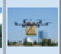
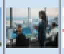


UT : User terminal for satellite communication NB : Cellular base station equipment

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.

4.2 Extraction of Use Cases to identify the challenges

We mapped the use cases mentioned above as shown in the table below. Additionally, we extracted the use cases for identifying challenges towards social implementation from the perspective of “"the most important cases to be realized as beyond 5G”.

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
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
Image																			
Broadband	●	●	-	-	-	-	-	●	●	●	-	-	-	-	-	-	-	-	●
Mobile Direct	-	-	-	-	-	-	-	-	-	-	●	●	-	-	-	-	●	-	-
IoT	●	-	●	-	-	●	●	-	-	●	-	●	-	●	-	-	-	●	-
HAPS	-	-	-	-	-	-	-	-	-	●	●	●	●	-	-	-	-	-	-
Sensing /Location	●	-	-	●	●	-	-	-	-	●	-	●	●	-	-	●	-	●	●
Mobility	-	-	-	●	-	-	-	●	●	●	-	-	-	-	-	-	-	●	●
NTN-TN Integration	●	●	●	●	●	-	-	-	-	-	-	-	-	-	●	●	●	●	-

The extracted use cases with reasons are as follows.

- NTN and TN Integration
  - The importance of TN/NTN integration (Cellular expansion) has been recognized in 3GPP, and continued to be discussed in Release-18.
  - Considered to be essential items for discussing the Beyond 5G world.
  - There are significant technical challenges in TN and NTN integration that use different frequencies, terminals, and communication methods (e.x. Handover between TN and NTN, Design and methods for integrating inter-company systems and network operations, Standardization of terminals).
  - It covers a wide range of use cases including Broadband, IoT and sensing.
- Broadband communication outside of TN coverage (The reasons for extraction are same as description in the “NTN and TN Integration”)
- IoT communication outside of TN coverage (The reasons for extraction are same as the description in the “NTN and TN Integration”)
- High-Precision Positioning &Navigation (The reasons for extraction are same as the description in the “NTN and TN Integration”)
- Collaboration between Disaster Sites and Hospitals
  - It is considered as one of the most demanding cases in terms of requirements in the 17 use cases.
  - The benefit of introducing this use case is thought to be clear and direct.

- Once the challenges in this case can be identified, it is expected to become easier to consider other usage cases.

- Communication Methods for Mountainous Areas
  - By focusing on the main characteristic of NTN, “Expanding network coverage that cannot be covered by terrestrial NW (TN)”, it is believed that further exploration of use cases can be expected.
  - Emergency communication: Mountainous areas are attractive places for outdoor lovers such as climbers and hikers, but there is a high possibility of sudden emergencies occurring. Through Non-Terrestrial Networks, communication with rescue teams and emergency services can be secured. It is possible to send the location information of stranded individuals and support expedited rescue operations.
  - Weather information: Weather may change rapidly in mountainous areas. By utilizing Non-Terrestrial Networks, real-time weather information and emergency alerts can be provided. This is beneficial for the safety of climbers and residents.
  - Tourism information: Tourism is an important source of income for mountain regions. Information on tourist spots, local events and guidance for tourists can be provided via non-terrestrial networks. It is expected to promote tourism and the development of the local economy.
  - Education: Access to high-quality education is crucial for children living in mountainous areas. By utilizing Non-Terrestrial Networks, Educational programs and online education can be provided to remote areas. This is expected to alleviate the educational disparities.
  - Telemedicine: Access to medical facilities can be limited in mountainous areas. By utilizing Non-Terrestrial Networks, remote healthcare services can be provided to residents in remote regions. Telemedicine consultations and remote diagnosis with physicians become possible. As a result, it is expected to improve healthcare.
- Unmanned Delivery (by Satellite)
  - To achieve efficient unmanned delivery, it is effective to utilize aerial routes with drones in addition to land routes.
  - To establish an efficient unmanned delivery system, it is necessary to consider autonomous driving to and from drone take-off and landing sites, as well as design land and aerial routes that are suitable for drone flights. Additionally, it is crucial to establish operational procedures for

flight management.

5. Initiatives to Solve the Issues

5.1 Target Industries Seeking Cooperation to Resolve Issues

Based on the above-mentioned selection, we have mapped target industries and so forth for which we seek cooperation to resolve issues into the following categories. The following shows the list and category of the industries and organizations. Details on each challenge and technology are shown in the following sections.

- Technology Perspective
  - NTN and TN Integration
  - Broadband communication outside of TN coverage
  - IoT communication outside of TN coverage
  - High-Precision Positioning & Navigation
- Industry Perspective
  - Collaboration between Disaster Medical Sites and Hospitals
  - Communication Methods in Mountainous Areas
  - Unmanned Delivery (by Satellite)

#	Category	Remarks
1	User	Auto/Agricultural machinery/Drone manufacturer etc.
2	SDO	3GPP, 5GAA etc.
3	Regulator	ITU-R, MIC etc.
4	NTN operator	LEO/MEO/GEO/HAPS Operator
5	TN operator	Domestic MNO/Global MVNO
6	Wireless communication equipment vendor	Terrestrial GW, antenna, gNB, core NW etc. (except optical communication)
7	Terminal vendor	Smartphone, satellite receiver etc.
8	Optical communication equipment vendor	
9	System integrator	
10	SD-WAN vendor	
11	Satellite manufacturing vendor	Aircraft, control device, storage battery, solar panel etc.
12	HAPS manufacturing vendor	Aircraft, control device, storage battery, solar panel etc.

5.1.1 NTN and TN Integration

With NTN and TN Integration, target industries seeking cooperation to resolve issues are listed below.

No.	Challenges	Details (Subdivision)	Target industries for cooperation to resolve issues											
			User	SDO	Regulator	NTN operator	TN operator	Radio communication equipment vendor	Terminal vendor	Optical communication equipment vendor	System integrator	SD-WAN vendor	Satellite manufacturing vendor	HAPS manufacturing vendor
1	Confirmation of required communication requirements for target use cases	Standardization/industry group trends		●										
		User company trends	●											
2	Mechanism of TN/NTN NW integration	[SD-WAN] Unification of specifications for communication bearer switching and traffic bonding/blending between UT & network side.										●		
		[TN-NTN carrier network connection method] Unification of network interfaces/protocols				●	●	●						
3	Development of terminal compatible with both TN/NTN	・Unification of chipset/SIM/antenna etc.							●					
		・Developing antennas with shapes tailored to use cases							●					
4	Development of customer PF	・Billing system integration for TN/NTN integration				●	●				●			
		・Design/development of visualization system for usage status, etc.				●	●				●			
		・Design/development of line management system				●	●				●			
		・Design/development of communication optimization system				●	●	●						
5	Technical consideration for institutionalization	＊Definition of ideal interwork mechanism for each NW (TN/NTN)				●	●	●						
		＊Examining the optimal means of NW integration (possible idea) －SD-WAN －Inter-operator roaming －Others				●	●	●						
6	Consideration of the application scope of existing systems	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)		●	●									
7	Collaborative Coverage	Coverage enhancement		●		●	●	●	●					
		Dual coverage/multi connections		●		●	●	●	●					
8	Mobility Management	Cell Management		●		●	●	●	●					
		Handover		●		●	●	●	●					
9	Routing management	Dynamic Topology		●		●							●	
		Routing Protocols		●		●			●					
10	Inter satellite communication	High capacity & stable link				●				●			●	
		On Board exchange				●				●			●	
11	Spectrum coordination	Spectrum management		●	●	●								
		Interference detection		●	●	●								
12	O&M	Unified resource management				●	●							
		Unified user management				●	●							
13	Antennas	Satellite antennas											●	
		Terminal antennas							●					

5.1.2 Broadband Communication Outside of TN coverage

With Broadband communication outside of TN coverage, target industries seeking cooperation to resolve issues are listed below.

No.	Challenges	Details (Subdivision)	Target industries for cooperation to resolve issues											
			User	SDO	Regulator	NTN operator	TN operator	Radio communication equipment vendor	Terminal vendor	Optical communication equipment vendor	System integrator	SD-WAN vendor	Satellite manufacturing vendor	HAPS manufacturing vendor
1	Acceleration of Mobile Direct	･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.	※			●								
2	Air interface	Synchronization		●		●	●		●				●	
		Random access		●		●	●	●	●				●	
		MU-MIMO		●		●	●	●	●				●	
3	MAC protocols	Beam hopping		●		●	●	●	●				●	
		Resource allocation		●		●	●	●	●				●	
4	User terminal	Power consumption		●					●					
		Antenna miniaturization		●					●					
		Device miniaturization							●					
5	Satellite payload	Onboard processor		●									●	
		Power supply				●							●	

5.1.3 IoT Communication Outside of TN coverage

With IoT communication outside of TN coverage, target industries seeking cooperation to resolve issues are listed below.

No.	Challenges	Details (Subdivision)	Target industries for cooperation to resolve issues											
			User	SDO	Regulator	NTN operator	TN operator	Radio communication equipment vendor	Terminal vendor	Optical communication equipment vendor	System integrator	SD-WAN vendor	Satellite manufacturing vendor	HAPS manufacturing vendor
1	Definition of TN/NTN integration	・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"	●	●										
2	Air interface	Synchronization		●		●	●	●	●				●	
		Random access		●		●	●	●	●				●	
		Redcap (Extensions to make it easier to connect small, low-power IoT devices with 5G)		●		●	●	●	●				●	
		IoT protocols		●		●	●	●	●				●	
3	MAC protocols	Fixed resource assignment		●		●	●	●	●				●	
		Random resource assignment		●		●	●	●	●				●	
4	User terminal	Power consumption		●				●	●				●	
		Device miniaturization							●					
5	Satellite payload	Onboard processor		●									●	
		Power supply											●	

5.1.4 High-Precision Positioning & Navigation

With High-Precision Positioning & Navigation, target industries seeking cooperation to resolve issues are listed below.

No.	Challenges	Details (Subdivision)	Target industries for cooperation to resolve issues: User	SDO	Regulator	NTN operator	TN operator	Radio communication equipment vendor	Terminal vendor	Optical communication equipment vendor	System integrator	SD-WAN vendor	Satellite manufacturing vendor	HAPS manufacturing vendor
1	High precision positioning	・Clarification of positioning accuracy for enabling self-driving Mobility	●											
		・Development of High precision positioning technology						●						
2	Definition of low latency (Latency : <20ms)	①Consideration of feasibility when placing processing power in satellite side				●								
		②Consideration of feasibility when using HAPS				●								
3	LOS impact	・With satellite communication, there are situations where LOS (line of sight) cannot be obtained. The autonomous driving scenario should take this into account.	●											
4	Air interface	Synchronization		●		●	●		●				●	●
		Random access		●		●	●		●				●	●
		Positioning		●		●	●		●				●	●
		Sensing				●	●		●				●	●
5	MAC protocols	Beam hopping		●		●	●		●				●	●
		Resource allocation		●		●	●		●				●	●
6	User terminal	Power consumption		●					●				●	●
		Antenna miniaturization		●					●					
		Device miniaturization							●					
7	Satellite payload	Onboard processor		●									●	
		Power supply				●							●	

5.1.5 Collaboration between Disaster Medical Sites and Hospitals

With Collaboration between Disaster Medical Sites and Hospitals, target industries seeking cooperation to resolve issues are listed below.

No.	Challenges	Details (Subdivision)	Target industries for cooperation to resolve issues: User	SDO	Regulator	NTN operator	TN operator	Radio communication equipment vendor	Terminal vendor	Optical communication equipment vendor	System integrator	SD-WAN vendor	Satellite manufacturing vendor	HAPS manufacturing vendor
1	Ensuring availability (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.				●								
		②UT (antenna)・Improving satellite communication capabilities (reception/transmission)				●		●	●					
		③Redundancy of ground GW station (area) based on ISL (Inter Satellite Link)				●		●						
2	Ensuring availability (Alternatives for the disaster sites lacking line-of-sight conditions (LoS))	・Consider collaboration with other NWs				●	●							
3	Ensuring availability (connectivity)	Collaboration with other NTN system				●								
		Maritime (use outside Japanese territory)			●	●								
4	Ensuring capacity	①Providing guaranteed bandwidth services				●								
		②Improve satellite capacity －Increase satellites －Use high-frequency（V-band etc.）				●		●						
5	Ensuring reliability	Providing guaranteed bandwidth services				●								
		Retransmission control, high performance FEC, cooperation with other NTNs, increase antennas		●				●	●					
6	Lower latency					●	●							

5.1.6 Communication Methods in Mountainous Areas

With Communication Methods in Mountainous Areas, target industries seeking cooperation to resolve issues are listed below.

No.	Challenges	Details (Subdivision)	Target industries for cooperation to resolve issues											
			User	SDO	Regulator	NTN operator	TN operator	Radio communication equipment vendor	Terminal vendor	Optical communication equipment vendor	System integrator	SD-WAN vendor	Satellite manufacturing vendor	HAPS manufacturing vendor
1	Ensuring availability (Must be available anytime to contact rescue personnel)	①Establishment of flight operations including autonomous driving				●								●
		②Elemental technology development for long flight (charging／storage battery etc.)												●
2	Ensuring availability (difficulty of installing a ground station in mountainous area)	①Realizing InterHAPS communication				●		●		●				
		②Usage of satellite communications as backhaul				●		●		●				
3	Measures against interference with cellular NW radio waves	①Ensuring dedicated frequency			●									
		②Beam forming						●						
		③Canceller technology etc.				●	●	●						

5.1.7 Unmanned Delivery (by Satellite)

With Unmanned Delivery (by Satellite), target industries seeking cooperation to resolve issues are listed below.

No.	Challenges	Details (Subdivision)	Target industries for cooperation to resolve issues											
			User	SDO	Regulator	NTN operator	TN operator	Radio communication equipment vendor	Terminal vendor	Optical communication equipment vendor	System integrator	SD-WAN vendor	Satellite manufacturing vendor	HAPS manufacturing vendor
1	Ensuring availability	①Establishment of flight operations including autonomous driving	●			●					●			
		②Cooperation between cellular and satellite communications				●	●		●		●			
2	User terminal	①Installing the satellite terminal onto drones				●			●					
3	Development of laws	①Laws regarding unmanned drone flights			●									
		②Legal system regarding land, sea and air use of satellite communications			●	●								

5.2 Technical Specification Required for Solving Issues

The required technologies and proposed solution ideas for the challenges are shown below.

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 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
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

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	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 & 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

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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 Satellite)

<table>
<tr><th>No.</th><th>課題
Challenge</th><th>詳細(細分化)
Details (Subdivision)</th><th>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</th><th>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</th><th>備考
Remarks</th></tr>
<tr><td rowspan="2">1</td><td rowspan="2">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）</td><td>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)</td><td>・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</td><td>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</td><td></td></tr>
<tr><td>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.）</td><td>・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</td><td>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.）</td><td>緯度、季節、夜間等の影響も課題
Challenges include effects of latitude, season, nighttime, etc.</td></tr>
<tr><td rowspan="2">2</td><td rowspan="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）</td><td>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)</td><td>・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</td><td>①InterHAPS通信の実現
①Realizing InterHAPS communication</td><td>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)</td></tr>
<tr><td>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)</td><td>・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</td><td>②衛星通信のバックホール利用
②Usage of satellite communications as backhaul</td><td>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.</td></tr>
<tr><td rowspan="3">3</td><td rowspan="3">セルラーNW電波との干渉対策
Measures against interference with cellular NW radio waves</td><td>①専用周波数の確保
①Ensuring dedicated frequency</td><td>・政府
Government</td><td>①専用周波数の確保
①Ensuring dedicated frequency</td><td rowspan="3">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.</td></tr>
<tr><td>②ビームフォーミング
②Beam forming</td><td>・通信機器メーカー
・Communication equipment manufacturer</td><td>②ビームフォーミング
②Beam forming</td></tr>
<tr><td>③キャンセラー技術等
③Canceller technology etc.</td><td>・通信機器メーカー
・MNO
・Communication equipment manufacturer
・MNO</td><td>③キャンセラー技術等
③Canceller technology etc.</td></tr>
</table>

5.3 Target Companies and Organizations Seeking Cooperation to Resolve Issues

Based on the above-mentioned selection of industry for which we seek cooperation, we have identified following target companies and organizations. The following shows the list and category of the target industries and organizations. Although we have not yet carried out concrete activities such as interviews with them, there was a common understanding that it is desirable to actively request participation in this working group.

Use case	No.	課題 Challenge	詳細 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	ポテンシャル企業 Candidates	備考 Remarks
NTNとTN 統合 Integration of NTN & TN	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.)	3GPP、5GAA	
			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.)	HONDA、日産 HONDA, NISSAN	
	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	ヴイエムウェア、ファーティネット、Versa Networks、パロアルトネットワークス、シスコシステムズ VMware, FertiNet, Versa Networks, Palo Alto Networks, Cisco Systems	
			［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 operator ・TN operator ・Global MVNO ・Communication NW equipment manufacturer	スカパーJSAT、SpaceX SKY Perfect JSAT, SpaceX	
	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	クアルコム、Kymeta、Intellian、SHARP Qualcomm, Kymeta, Intellian, SHARP	
			・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		

6. Interviews with Industries

In FY 2023, we interviewed industries of potential NTN users. Following are the identified challenges based on these interviews and discussions.

- There are areas where it is difficult to provide terrestrial network by various network services (autonomous driving, forestry, shipping, DX, etc.) current and in future due to several factors. Covering these areas with NTN is expected to improve the continuity of seamless communication network services.
- At the same time, even in emergency situations on the ground, such as large-scale NW failure, congestion, etc. due to disasters, providing the minimum level of services through NTN as a backup for the terrestrial NW is expected to support on recovery and reconstruction.
- In order to ensure reliability even under disadvantageous conditions compared to ground areas (latency, radio wave quality and reliability), ensuring redundancy and cooperation within the NTN group without depending on a specific network system, constellation, or operator is required.

We explain the detailed examples of using HAPS and satellites and future challenges as well as future initiatives based on the direction of “All Japan” in the following sections.

6.1 HAPS Use Cases and Future Challenges

Through interviews, we have found several use cases for HAPS. This section introduces concrete use cases in forestry and disaster situations.

Forestry often involves dangerous parts: Dozens of fatal accidents occur every year. One reason for this is the difficulties for workers to seek help when they are injured; Calls for help cannot be heard because each worker is in a separate location and the work requires the use of chainsaws. Normally, in such a situation, you can consider calling for help by mobile phone, etc., but in the mountains, existing communications such as LTE do not cover the area, and many cases are unnoticed.

Although development of automatic tree-felling machines aiming for forestry DX is under way, human work within the reach of local communications will remain. Therefore, further forestry DX is expected through high-speed communication and expansion of service areas.

The industry expects significance of the seamless communication between workers and HAPS brought by radio waves to mountainous areas from satellite and HAPS that enable smartphone-direct communications. We received favorable comments that it has great social significance of preventing fatal accidents thanks to communications in case of emergency.

However, forestry industries consist of many SMEs with the exception of some highly profitable companies. This refers high possibility that cost part will be a challenge and require such competitiveness compared to the existing services. Also, it clearly reveals that we need tailored service for end users in light of communication attenuation based on the angle of incidence to the actual forestry site due to frequencies we use. For this challenge, we reaffirm the importance of preliminary verifications in light of various use cases as well as cost reduction by sharing one HAPS communication with other industry fields.

We also interviewed on possibilities of HAPS use cases in the event of disasters such as earthquakes. There were cases where ground stations collapse due to natural disasters, as we experienced in 2024 Noto peninsula earthquake. In that case, even if the ground station had a redundant configuration, the usability such as communication speed would be greatly reduced, and furthermore, there is even a possibility that communication will be completely interrupted.

HAPS has high expectations both in the private and public sectors. Because HAPS is relatively disaster-resistant infrastructure that will use route of satellite backhaul and intact ground stations and it is possible to communicate directly to the customer's smartphone without preparing external devices.

To meet these expectations, the public and private sectors in Japan need to discuss the ground design to clarify the way of communication in initial response to disasters and during the reconstruction period. We recognized the need to address issues from a macro perspective. We will consider TN and NTN communications redundancy methods, and prioritized communications related to life-threatening operations beforehand as well as how Japan as a whole should develop NTN communications, which is lagging behind on a global scale, and how should rules be set for emergencies.

6.2 Satellite Communication Use Case and Future Challenges

In addition to the above-mentioned HAPS use cases, this section presents solutions for maritime and construction industries thorough satellite communications.

In maritime industry, providing large area communication is important as they require meticulous communication with ground staff and there is a need to improve the wellbeing of crew members.

In construction industries, providing large capacity communication from satellite is important as they require secure uplink bandwidth for remote control and autonomous driving.

6.3 Direction toward “All Japan” NTN

Our Working Group have discussed ideal “All Japan” NTN in view of Beyond 5G/6G based on these considerations. We have a common understanding that we need to continue identifying further challenges and initiatives to find potential services in this working group for this purpose.

- Relying on devices dedicated to specific LEO constellations is high risk.
- There are concerns about relying 100% on overseas satellite operators. It would be desirable for Japan to have its own network.
- It is useful to be able to use services from different LEO constellations on the same terminal.
- It is ideal to be able to use services from GEO, LEO, HAPS, and terrestrial networks on the same terminal in future.
- Achieving these requires standardizations of both terminals and network providers (it is unclear whether providers such as Starlink will support this).
- For terminals, standardization might progress in 3 categories: small IoT devices (low power devices), mobile terminals (smartphones) and large terminals (compatible with high-speed communication).
- Japan may need to prepare the network construction in view of above-mentioned points.
- Geographical characteristics of Japan (70% of the country is mountainous/hilly area, a maritime nation with the 6th largest EEZ in the world, and a country prone to natural disasters) may have opportunities for various NTN use cases. It would be desirable to proceed with the development of services tailored to specific use cases.

Toward Ideal All Japan NTN in 10 years

Current Situation

Although there are some exception, conventional NTNs are basically independent systems from terrestrial NWs, and each has evolved and developed independently.

Toward Beyond 5G/6, IMT -2030

1) There are areas where it is difficult to provide TN by various NW services (Autonomous driving, forestry, shipping, DX etc.) current and in future due to several factors. Covering these areas with NTN is expected to improve the continuity of seamless communication network services.

➔ Deepening and developing Japanese -style hospitality services across TN and NTN

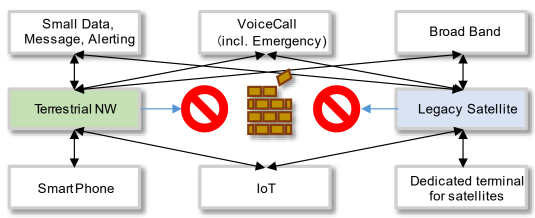
2) Even in emergency situations on the ground, such as large-scale NW failure, congestion, etc. due to disasters, providing the minimum level of services through NTN as a backup for the terrestrial NW is expected to support on recovery and reconstruction.

➔ Establish All Japan NTN that provide cooperation across the ground/satellites during emergencies based on experience and knowledge.

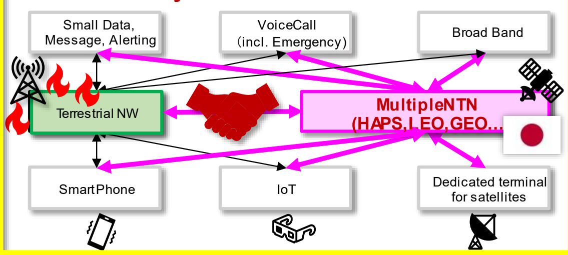
3) In order to ensure reliability even under disadvantageous conditions compared to ground areas (latency, radio wave quality and reliability), ensuring redundancy and cooperation within the NTN group without depending on a specific network system, constellation, or operator is required.

➔Ensure Made in Japan service quality by introducing domestically produced satellites & communication equipment while cooperating with the private sector & overseas satellite services on the premise of cooperation between multiple operators and satellite systems.

Current Situation



NTN Toward Beyond5G/6G



7. Summary and Challenges in Future

The Scalability Working Group has discussed on international cooperation, in other words, how Japanese companies cooperate on Non-Terrestrial Network (NTN) internationally as research and development on Beyond 5G is accelerating around the world. Our mission is to identify scalability. To this end, our members have discussed and succeeded in creating NTN field landscape maps as a foundation to consider where our strengths are and how we should move forward. In addition, the WG carried out unique initiatives in which we showcased new NTN use cases and interviewed potential users to identify challenges to promote NTN use and the development of this area.

Interviews with potential users were fruitful. From maritime industries, we received a proposal from a venture business. They proposed that we need to create a growing 21st-century industry from maritime and create explosively need for NTN in the ocean and increased value to create Japanese-style NTN market. Because in developed countries like Japan, there are very few areas where NTN needs clearly exists and this cannot be a field where economic rationality can be obtained as a market. From forestry industries, we found that there are high radio wave transmission losses in forests, and this causes lack of communication means between workers, and have the highest occupational mortality rate. NTN services realized by such as HAPS and satellites can help to alleviate occupational mortality rate and unexpected accidents. We would like to contribute to the evolution of new technologies for these new services.

We think NTN is an area that will become increasingly important in future and the Scalability WG where companies find collaboration and reach consensus, would like to continue identifying social challenges from companies recognized as NTN user, discussing solutions for that and providing these solutions for the users. If any technical or institutional issues are discovered through these activities, we would like to propose improvement measures for future standardization etc. We are looking forward to the continuous active participation not only current leading members but also new members in the development of NTN from Japan.

Following is the activity record of FY 2023 (Chairperson: Dr. Toyoshima WG leader). In addition, e-mail discussions were held as appropriate for preparation of meetings and summarizing interview results.

August 30, 2023: Kickoff meeting (online)
September 19, 2023: 1st meeting (online)

October 31, 2023: 2nd meeting (online)
November 21, 2023: 3rd meeting (online)
December 19, 2023: 4th meeting (online)
January 23, 2024: Interviews with industries (face-to-face interview)
January 30, 2024: 5th meeting (online)
February 20, 2024: 6th meeting (online)

Last but not least, we would like to express our deepest gratitude to all the participant companies for their enthusiastic discussion and dedication during the monthly discussions in FY 2023.