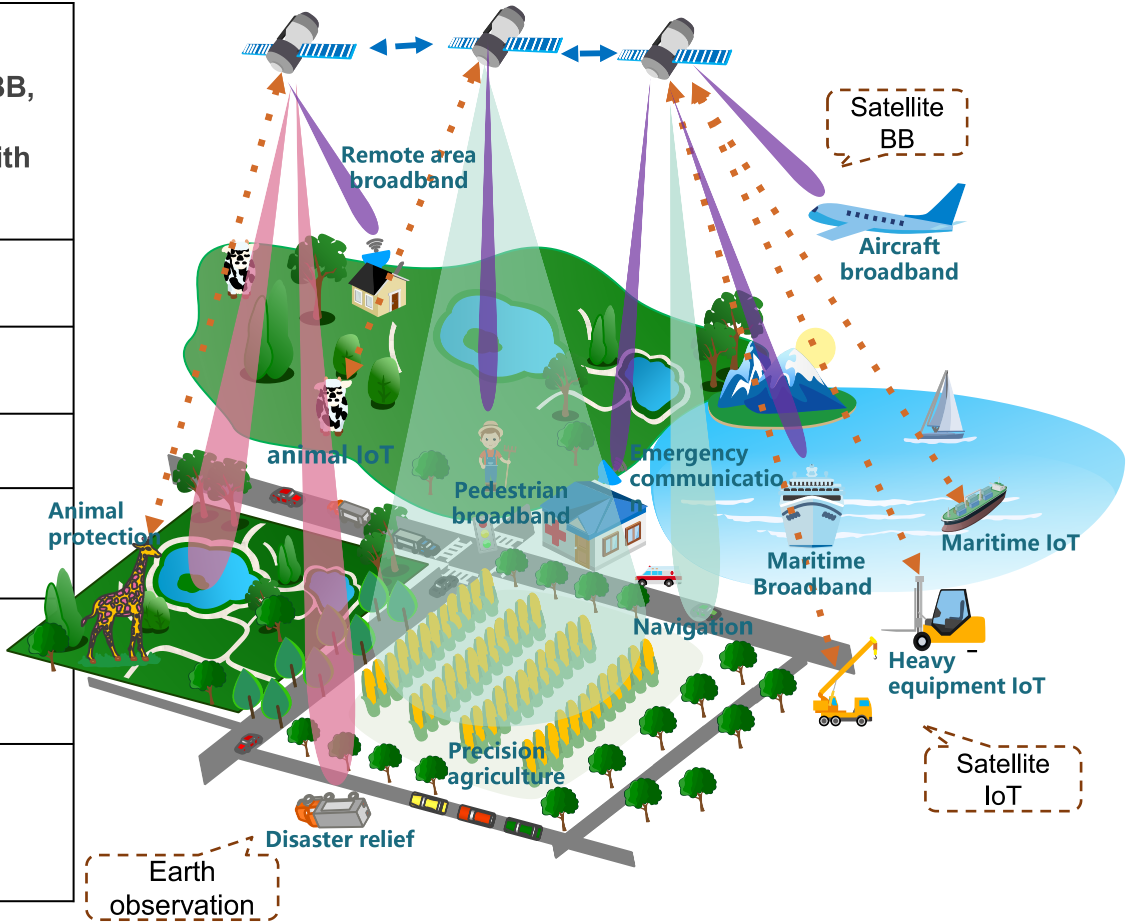
NTN Use Cases (2023 version)

NTN Promotion Project
XG Mobile Promotion Forum
Revised in October, 2024

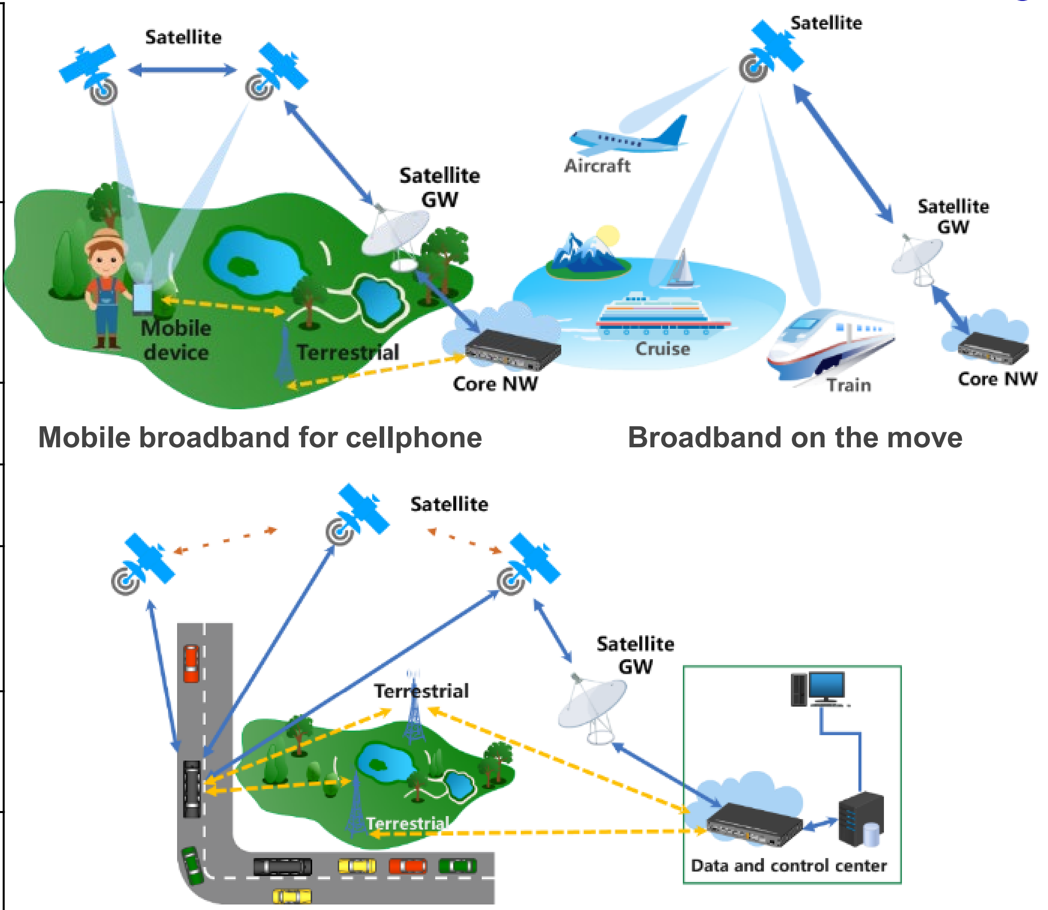
NTN and TN Integration

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



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



Mobile broadband for cellphone

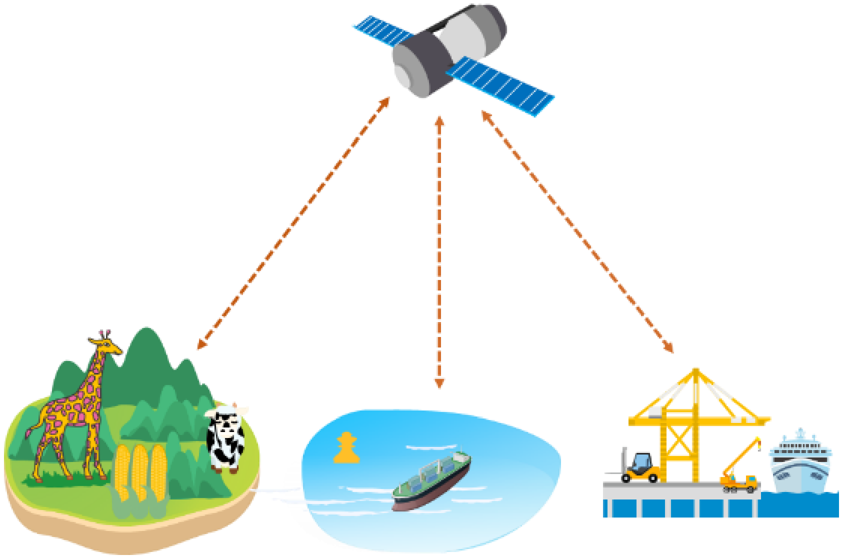
Broadband on the move

First Responder communication and disaster relief

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;

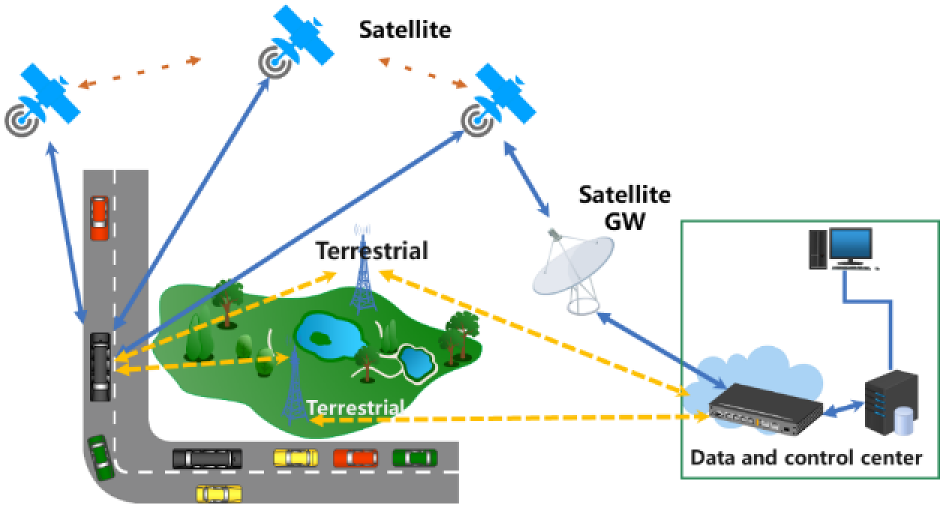
1. Unified Protocol and Multi-Connection Technology for IMT and satellite
2. Intelligent High Dynamic Routing and Inter-satellite Optical Interconnection Tec.
3. Satellite-Ground Network O&M and Resource Management
4. Unified terminal for IMT and satellite communication

Highly expected international cooperation to overcome such challenges/issues.

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	Throughput	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.



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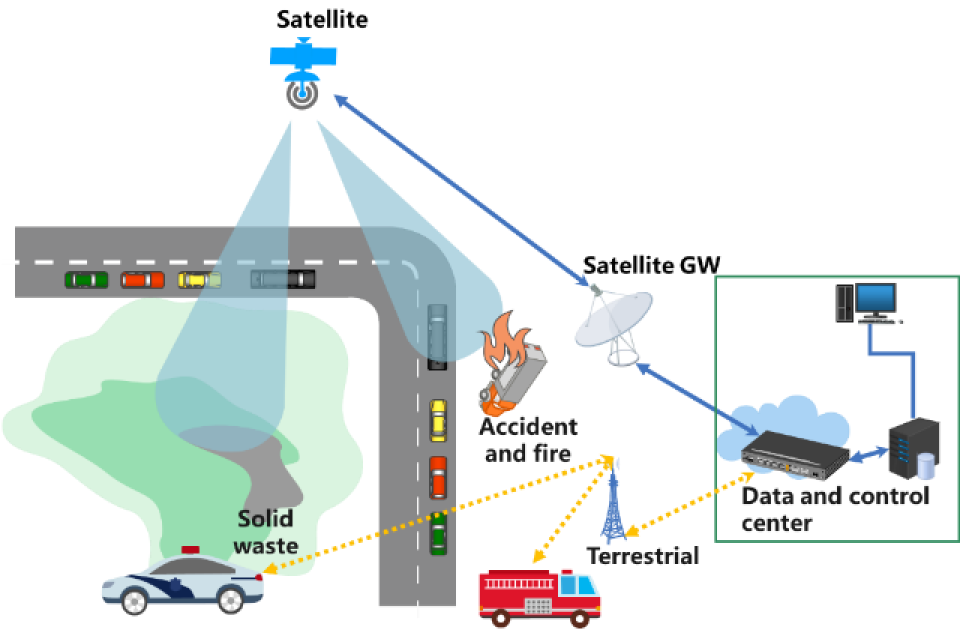
3. Satellite-Ground Network O&M and Resource Management
4. Unified terminal for IMT and satellite communication

Highly expected international cooperation to overcome such challenges/issues.

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



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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.

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**: Several Mbps; **Latency**: -; **Coverage**: 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.

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.

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.

Provision of Power Supply and Communication to Disaster Areas

<table>
<tr><td>Tech to be used</td><td colspan="3">LEO + EV</td></tr>
<tr><td>Use case</td><td colspan="3">Providing power supply and communication through electric vehicles in the event of a disaster.</td></tr>
<tr><td>UC Overview</td><td colspan="3">Provides power supply and communication services in disaster areas by installing antennas on electric vehicles.</td></tr>
<tr><td>Existing solution</td><td colspan="3">None</td></tr>
<tr><td rowspan="2">KPI</td><td>Throughput</td><td>Latency</td><td>Coverage</td></tr>
<tr><td>Tens of Mbps</td><td>-</td><td>Urban/suburban area</td></tr>
<tr><td>Challenge</td><td colspan="3">Ensuring power supply and communications in evacuation shelters</td></tr>
<tr><td>Expected Benefit</td><td colspan="3">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.)</td></tr>
<tr><td>Expected Service Provision Timing</td><td colspan="3">Year 2023～2025</td></tr>
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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.

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.

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**: Tens of Mbps; **Latency**: -; **Coverage**: 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.

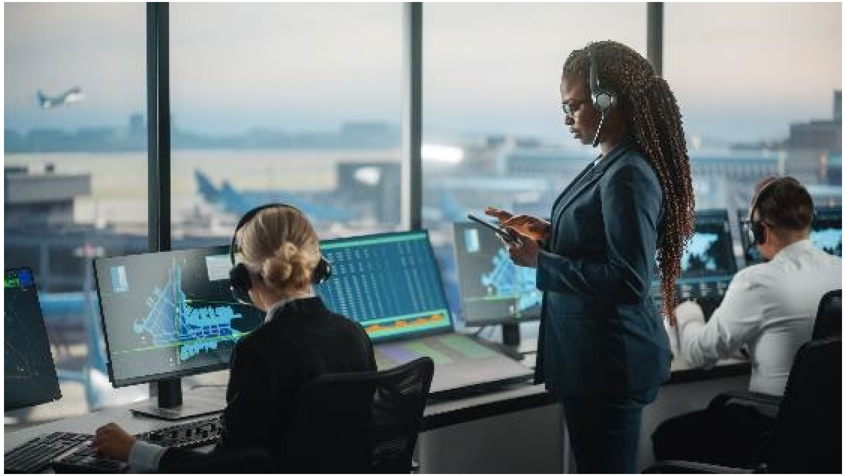
Unmanned Delivery (by HAPS)

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.

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/Subu rban 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		

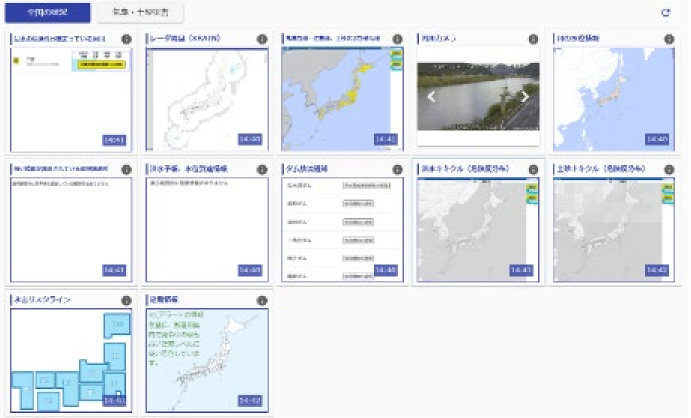


According to the International Air Transport Association (IATA), global aviation demand has shown signs of recovery as of June 2022. The total revenue passenger kilometers (RPK) increased by 76.2% compared to the same month last year, surpassing 70% of pre-pandemic levels. It is also forecasted to reach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

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

Public Safety LTE

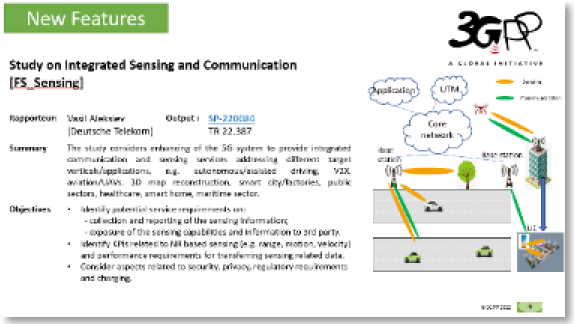
Use case overview		To Provide seamless Public Safety LTE service for areas outside cellular coverage or in the event of base station failure due to disaster by using satellite lines. ------- Public Safety LTE: A shared-use mobile communication network that enables high-speed data communication as well 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

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

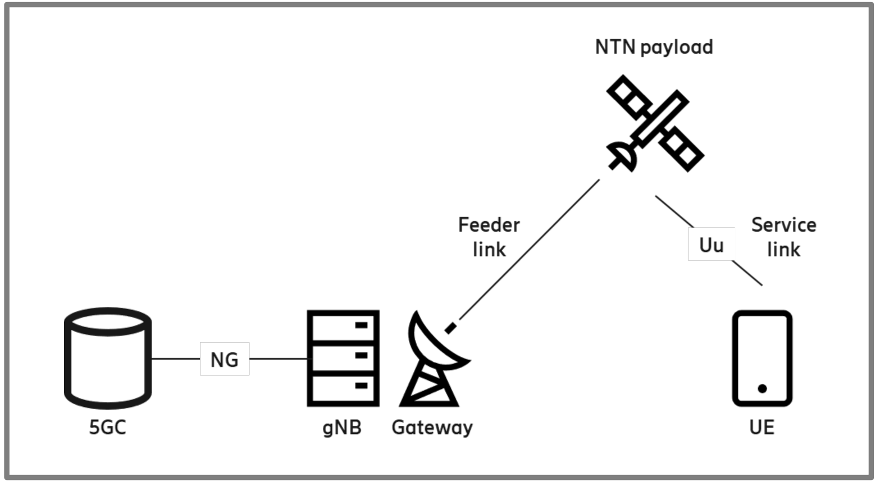
リモートセンシングと放射伝達 – JAXA 第一宇宙技術部門 Earth-graphy



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

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.

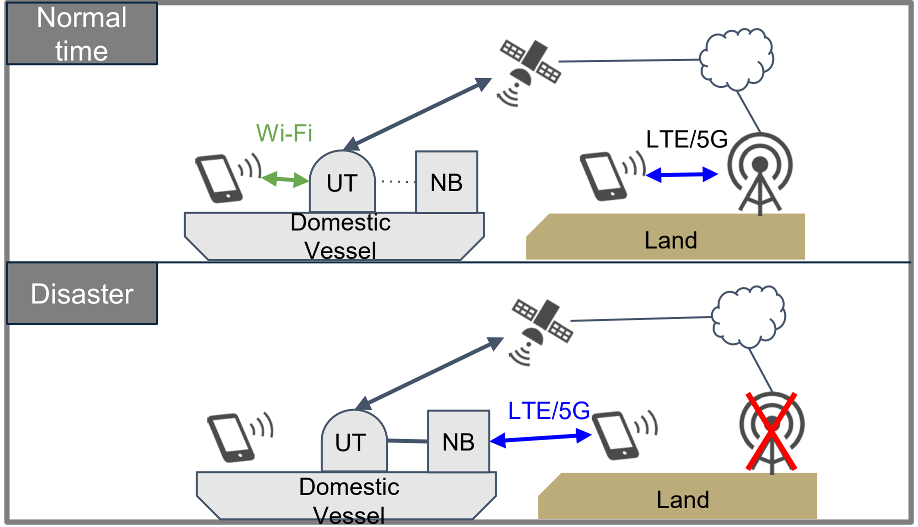
Unmanned Delivery (by Satellite)

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.

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

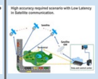
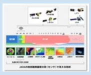
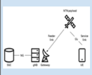
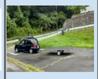
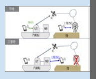


UT：User terminal for satellite communication　NB：Cellular base station equipment

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.

Selection of Use Cases

※Shown in Green are selected cases.

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	●	●	●	●	●	-	-	-	-	-	-	-	-	-	●	●	●	●	-

NTN-TN interworking (Overall Vision of 6G NTN and TN convergence/integration)

No.	Challenges	Details (Subdivision)	Target industries for cooperation to resolve issues											
			User	SDO	Regulator	NTN operator	TN operator	Radiocommunication 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							●					

NTN-Broadband (Broadband Wireless Access for the Unconnected Scenario)

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				●							●	

※Determined as Mobile Direct case based on the requirement［Throughput： >10Mbps for cellphone］.Requirements need to be refined as a first step.

NTN-IoT (Wide-Ranging IoT Services Extended to Unconnected Scenario)

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											●	

NTN-Sensing/Positioning (High-Precision Positioning and Navigation Scenario)

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				●							●	

Collaboration between Disaster Sites and Hospitals

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					●	●							

Communications in Mountain Areas

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.				●	●	●						

Unmanned Delivery (Satellite Communication)

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			●	●								

Initiatives to Solve the Issues

NTN-TN interworking (Overall Vision of 6G NTN and TN convergence/integration) （1/3）

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	

NTN-TN interworking (Overall Vision of 6G NTN and TN convergence/integration) （2/3）

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
		セルの管理	ベンダー＆オペレーター	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	3GPP RAN2 (RP-232669)にて議

NTN-TN interworking (Overall Vision of 6G NTN and TN convergence/integration) （3/3）

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	

NTN-Broadband (Broadband Wireless Access for the Unconnected Scenario) （1/2）

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

NTN-Broadband (Broadband Wireless Access for the Unconnected Scenario) （2/2）

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.

NTN-IoT (Wide-Ranging IoT Services Extended to Unconnected Scenario) （1/2）

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

NTN-IoT（Wide-Ranging IoT Services Extended to Unconnected Scenario） （2/2）

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.

NTN-Sensing/Positioning (High-Precision Positioning and Navigation Scenario) （1/2）

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

NTN-Sensing/Positioning (High-Precision Positioning and Navigation Scenario) (2/2)

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

災害医療現場と病院間の連携（1/1）
Disaster Sites & Hospitals Collaboration （1/1）

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		TN/NTN事業者	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	

山間部での連絡手段（1/1）
Communications in Mountain Areas （1/1）

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.
		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.	

ドローン無人配送 (1/1) Unmanned delivery (Drone) (1/1)

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 Ensuring availability	自律運転を含めた運航オペレーションの確立 Establishment of flight operations including autonomous driving	ドローンオペレータ Drone operator	無人配送を効率的に行うためには陸路だけでなく、ドローンによる空路の活用が有効。ドローン発着地点までの自動運転や、ドローン飛行可能な空域を考慮して、陸上及び上空の経路設計を行うシステムを構築すること、運航管理のオペレーションを確立する必要がある。 For efficient delivery, not only utilizing land route, but also air routes using drones is useful. Establishment of system that designs routes on land and in the air, and flight management operation is required in consideration of airspace where drone flight is permitted.	
2	可用性の確保 Ensuring availability	セルラー通信と衛星通信の連携 (テレメトリデータや動画像のアップロード、制御コマンド実行などの常時利用) Cooperation between cellular and satellite communications (Constant use for uploading telemetry data and video images, executing control commands, etc.)	ドローンオペレータ、MNO Drone operator, MNO	上空において、低遅延で安定した回線速度の確保 ドローン離発着時や地形により衛星見通しが取れない場合など、セルラー回線と衛星回線をシームレスに連携させる仕組みの確立 Ensuring low latency & stable line speed in the sky. Establishment of mechanism for seamless collaboration between cellular and satellite lines when drone lacks satellite LOS, or when taking off and landing.	
3	ユーザ端末 User terminal	衛星端末のドローンへの搭載 Installing the satellite terminal onto drones	LEO事業者、端末メーカー LEO operators, terminal manufacturers	ドローン機体のペイロード、プロペラ配置、ノイズを考慮したアンテナ設置方法の検証、端末の小型化 Antenna installation considering the payload of the drone aircraft, propeller placement and noise and terminal miniaturization	
4	法整備 Development of laws	ドローンの無人飛行に関する法整備 Laws regarding unmanned drone flights	ドローンオペレータ、国土交通省 Drone operator, MLIT	1オペレーターによる複数機体の運航管理、運航管理システムの制度化 Operation management of multiple aircraft by one operator, institutionalization of operation management system.	
5	法整備 Development of laws	衛星通信の陸海上空利用についての法制度整備 Legal system regarding land, sea and air use of satellite communications	MNO、総務省 MNO, MIC		

ポテンシャル企業 (1/1) Potential candidates (1/1)

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		