Non-Terrestrial Network (NTN) Trends and SKY Perfect JSAT Initiatives

—Toward a World That's Never Out of Range—

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1. Introduction

The words Non-Terrestrial Network (NTN) have been appearing with increasing frequency in recent years especially in online media. The feeling that is often conveyed is that NTN is a new technology and new type of network that can satisfy people's expectations for more progress in their everyday lives.

However, it's hard to form an image from those words alone—what exactly is a "non-terrestrial" network?

■ What is NTN?

In the world of mobile networks, NTN lies in contrast to a network configured with base stations installed on the ground, that is, the Terrestrial Network (TN). The NTN does not use base stations on the ground—rather, it is a network that can be deployed just about anywhere including remote areas, in the sky, on the ocean, and even in outer space. It is expected that Geostationary Earth Orbit (GEO) satellites, Low Earth Orbit (LEO) satellites, and High-Altitude Platform Stations (HAPS) will be used as the infrastructure making up the NTN. In this way, the two-dimensional network used mostly on the Earth's surface and configured with base stations on the ground can be significantly extended into a three-dimensional network (Figure 1).

A major part of the background to NTN studies are NTN infrastructure technologies and contributions made to NTN standardization.

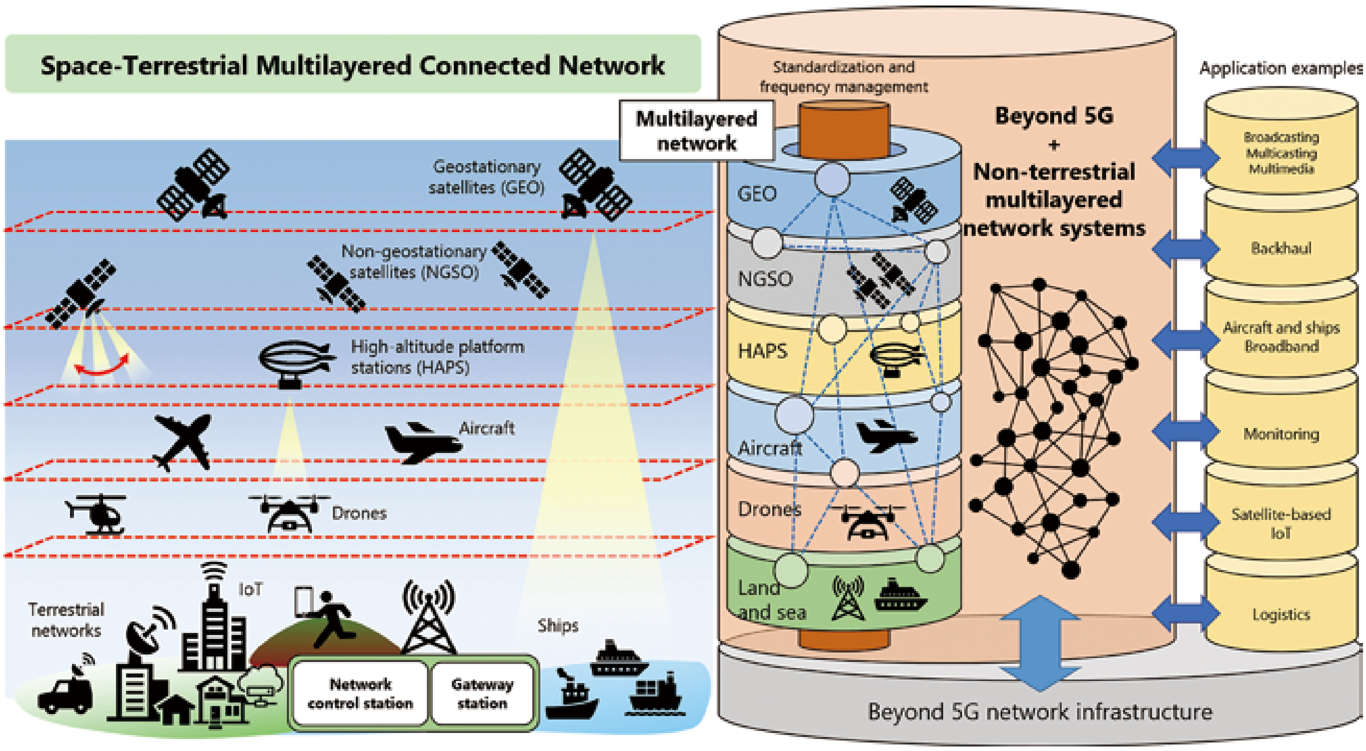
This article introduces recent technological and standardization trends in NTN and NTN initiatives undertaken by various operators.

2. NTN Trends

■ Background to NTN studies

The NTN is a concept proposed at the 3rd Generation Partnership Project (3GPP), a mobile communications standardization organization. Although the norm at one time was to configure networks with mobile phones based on the

■ **Figure 1: Concept of the communication network in Beyond 5G[1]**



proprietary technologies of different companies, this scheme was not necessarily advantageous to end users for many reasons. For example, not only were locally compatible terminals required overseas but compatibility issues arose even within the same country. Against this background, 3GPP was launched to achieve standardization toward third-generation (3G) mobile phones. Through 3GPP, amazing developments have also been achieved in 4G and 5G while striking a balance between cooperation and competition.

Nevertheless, issues are still present. One is coverage. In Japan, although the population coverage of the terrestrial mobile network exceeds 99%, national land (area) coverage is said to be only around 60%. As private companies, mobile operators install base stations with a certain degree of economic rationality, so it is quite difficult to continue to install base stations in 40% of the national land having less than 1% of the population. In this regard, people expect the same access to entertainment in airplanes and on the ocean as on land, and it is assumed that ICT means a continuous connection with the network. As the mobile infrastructure expands and usage grows, coverage issues are conversely becoming more noticeable.

Additionally, as natural disasters become increasingly severe, there is concern that damage to the mobile network caused by destruction of base stations or power outages will have a major impact on people's lives and government/industrial activities. Fortifying the network and formulating methods for speedy recovery have therefore become key issues.

The NTN can be a solution to these issues facing the mobile network, but at the same time, it will never be an infrastructure only for mobile networks. There are high expectations for the creation of totally new use cases such as by linking the mobile network with satellite communications (Figure 2).

■ Smartphone direct satellite communications = NTN?

As described above, NTN was defined by 3GPP, so a network conforming to NTN specifications as prescribed by 3GPP can be called a true "NTN". At present, NTN-supported frequencies are defined as the L-band (1 GHz band), S-band (2 GHz band), Ku-band (12/14 GHz band), and Ka-band (18/28 GHz), and a variety of terminals are envisioned including handsets and Very Small Aperture Terminal (VSAT) ground stations.

At the same time, direct communication between smartphones and satellites has become a hot topic of late, and this capability has also been referred to as NTN. In a broad sense, interpreting this as NTN is not totally incorrect, but there are many cases in which simply connecting smartphones with satellites is mistaken as NTN. This type of direct communication is one form of NTN (strictly speaking, if such a connection does not conform to standards, it may not be compatible with NTN in actual operation), but confusion here should be avoided.

3. NTN Standardization Trends

As described above, NTN-related standardization is proceeding at 3GPP, but coordination with ITUR that's advancing the standardization of wireless interfaces is extremely important. At present, a process is moving forward at ITU-R toward a Recommendation for wireless interfaces that can be applied to 6G, and at 3GPP, studies have begun on standard specifications for radio, core, terminal, and other components to be implemented as 6G.

At 3GPP, studies on enhancing functions and drafting specifications continue as 5G-Advanced also in relation to NTN. SKY Perfect JSAT has been a member of the Association of Radio Industries and Businesses (ARIB) since 2022, and it has been participating in 3GPP particularly in activities seeking to make NTN even more useful from the viewpoint of satellite operators. In Release-19, Ku-band specifications for NTN are progressing, and SKY Perfect JSAT is working together with a variety of overseas and domestic operators and manufacturers on specifications and terminal specifications that can be easily applied to the frequency bandwidths of satellite transponders (repeaters) used by GEO operators, as well as on submitting contributions and proposals on NTN use cases.

Release-19 specifications are expected to be completed by the end of 2025 while supporting products are expected to appear several years later.

4. NTN Initiatives at SKY Perfect JSAT

■ SKY Perfect JSAT's Vision: Universal NTN™

At SKY Perfect JSAT, we are proud to be at the forefront of NTN innovation. Our "Universal NTN™" concept aims to create a seamless, flexible, and intelligent satellite communication network that adapts to diverse user needs—anytime, anywhere [2].

We were among the first in the world to establish a

■ Figure 2: Use case examples of Universal NTN™

dedicated NTN department, driving technology development, standardization, and real-world use cases. By collaborating with global partners and leveraging advanced technologies like Software Defined Satellites (SDS), we are building an ecosystem that supports next-generation connectivity and empowers a super-smart society.

■ Universal NTN strategy

A major goal of Universal NTN™ is to improve the customer experience (CX) and enhance interconnectivity. Providing users with a variety of options is essential to achieving the widespread use of NTN and meeting diverse needs. However, accomplishing that by a single company on its own is difficult, so an ecosystem formed by partnerships and collaborations among companies, research institutions, and other entities having expertise in various fields is expected to ensure diversity. The key to supporting this diversity is interconnectivity through global standards, and the goal is to construct a "horizontally integrated" ecosystem incorporating both business and technical aspects. The NTN, whose standardization is now proceeding at 3GPP, is still under development and the maturation of supporting technologies is expected to take a certain amount of time. Nevertheless, construction of an ecosystem through partnerships is an effective means of supporting the spread of NTN, and it should be a major trend going forward.

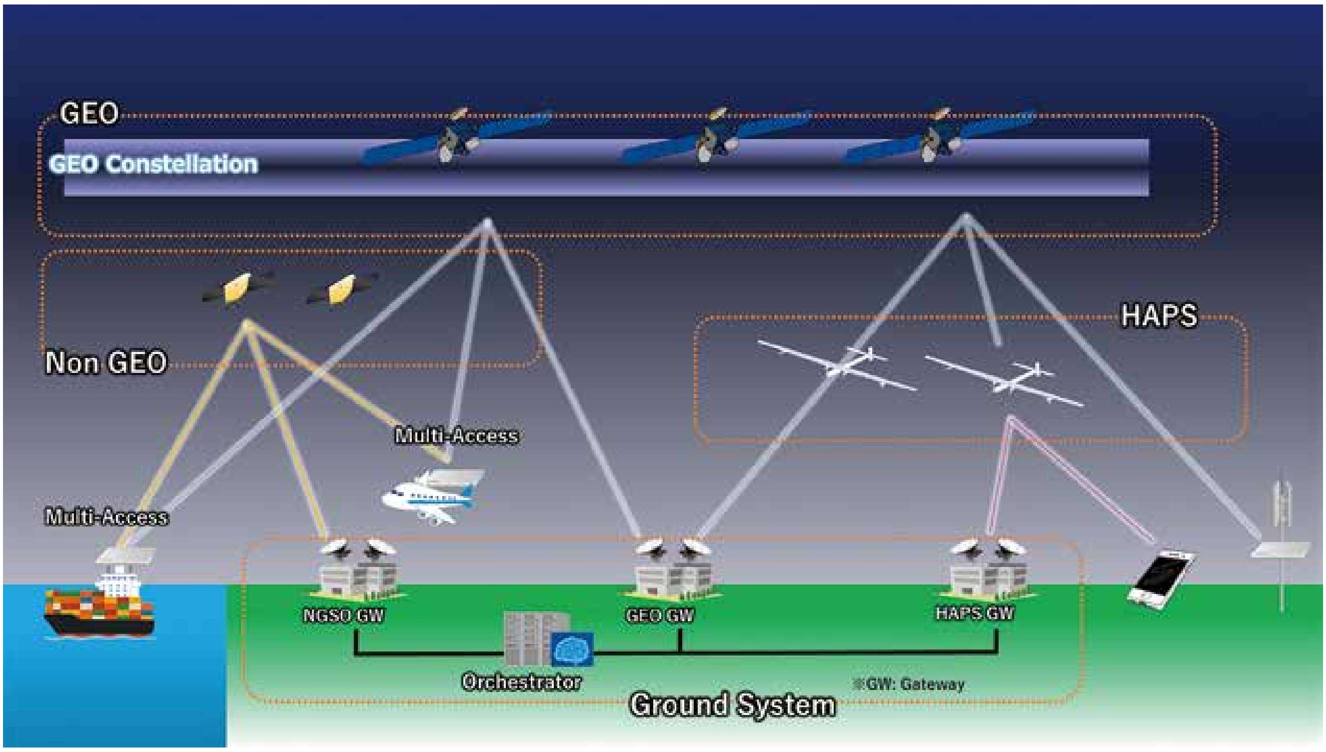
■ Universal NTN™ supporting technologies

An environment that ensures interconnectivity may combine a variety of infrastructures, and Universal NTN™ is a concept that will consist of four layers in the future (Figure 3).

The first is a Geostationary Earth Orbit (GEO) layer. SKY Perfect JSAT has deployed 17 GEO satellites globally (as of June 2025), and by using a certain number of these, a single large-capacity network covering a wide area can be achieved by constructing that network with the same specifications. At SKY Perfect JSAT, such a configuration is called a "GEO constellation." A fully digital Software Defined Satellite (SDS) as described below has an unprecedented level of flexibility and new value for satellite communications. However, at a distance of 36,000 km, a propagation time of approximately 0.25 s is required for a round trip even at the speed of light, so for use cases making use of bidirectional communications, such a delay would really be felt.

The second is a Non-Geostationary Satellite Orbit (NGSO) layer consisting, for example, of Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) satellites. These satellites that orbit the Earth at altitudes lower than that of GEO achieve global coverage, and since delay time is relatively small compared with GEO, throughput is expected to improve. For use cases like remote operation in which small delay time is desirable, NGSO satellites can manifest their power. On the other hand,

■ Figure 3: SKY Perfect JSAT multi-orbit concept



NGSO satellites sink beyond the horizon after being visible from the ground for just a short time, so many satellites must be simultaneously operated to maintain constant communications. As a result, in addition to the massive investment required, complex technical issues must also be addressed such as handovers between satellites and between base stations.

The third is a High-Altitude Platform Station (HAPS) layer. Aircraft on this layer fly in the stratosphere at an altitude of about 20 km, and since they appear to remain within a certain range from the ground similar to GEO satellites, they have also been called High Altitude Pseudo Satellites. Their communication delay is extremely small compared with satellites, and the fact that they can be upgraded and maintained by bringing them down and relaunching is expected to be a major advantage not offered by satellites. On the other hand, achieving both long flights of several weeks and a heavy payload is a technical hurdle, and to cover a wide area, many HAPS aircrafts must be simultaneously operated and kept in the sky, which means that operational issues also exist.

Each of these layers has its advantages and disadvantages as an infrastructure, and to support all kinds of spaces and needs, there are limits to relying on just one. For this reason, a ground system acts as the fourth layer here to interconnect the above three infrastructure layers and appropriately control user-traffic routes, priorities, etc. In this way, the user has no need to be conscious of which infrastructure or frequency is being used. In short, what becomes important for the user is whether one can communicate comfortably with the other party. Here, an intelligent system called an orchestrator establishes the best communications line by selecting an optimal infrastructure according to the Service Level Agreement (SLA) desired by the user and setting parameters to control base stations and terminals to give the best performance possible.

Terminals as well are evolving greatly. In the past, there were few options other than parabolic antennas, but today, many manufacturers around the world are commercializing a type of antenna called a phased array antenna that arranges many antenna elements on a flat substrate and electronically controls those elements to control the direction of radio waves and establish communications. Although phased array antennas are inferior to parabolic antennas in terms of antenna gain and power consumption, they excel in portability and operability thereby giving users a new option to choose from.

New technologies are being actively deployed to meet diverse user needs, and going forward, we can expect the network to evolve in a step-by-step manner.

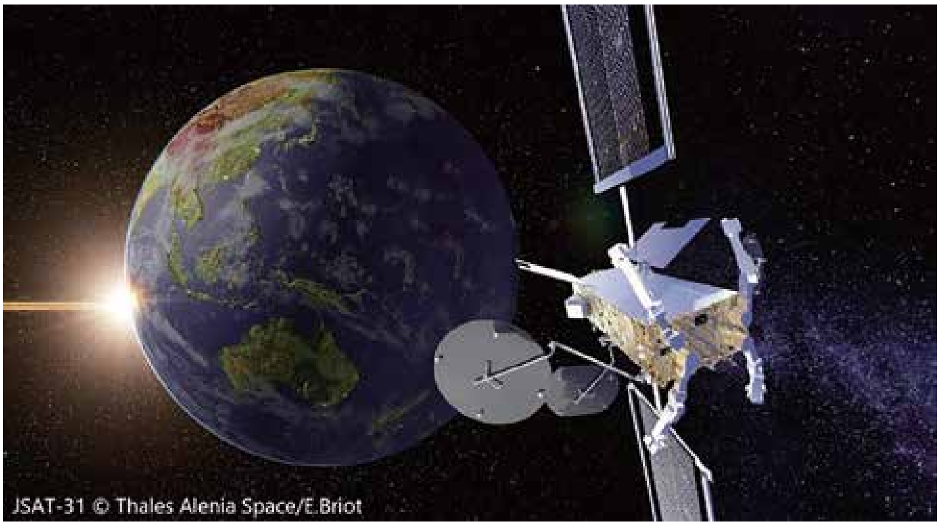
■ Software Defined Satellite (SDS)

Universal NTN™ will also make use of SDS, a powerful tool for next-generation GEO (Figure 4). As the name implies, the functions of a SDS are defined by software in the same manner as a Software Defined Network (SDN) and Software Defined Vehicle (SDV). In the case of conventional satellites, service area is defined at the design stage, so a satellite is configured with hardware such as antennas shaped to irradiate and receive radio waves accordingly plus amplifiers, filters, etc. As a result, the configuration of such a satellite cannot be changed in orbit (although some satellites are equipped with a switch-based function for switching beams).

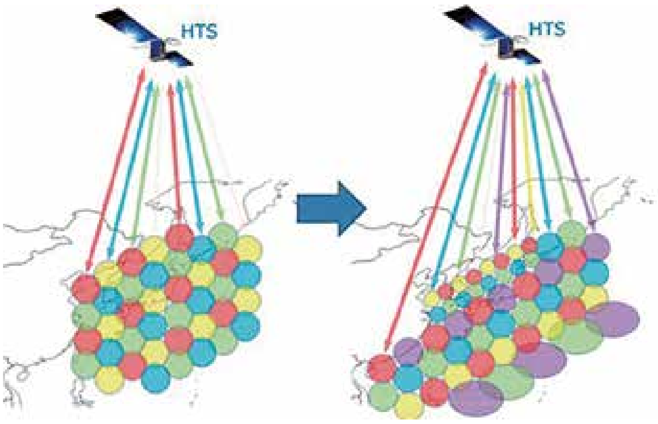
An SDS, however, mounts a powerful processor and performs all basic functions inherent to satellites such as reception, filtering, frequency conversion, amplification, and transmission by digital signal processing.

This makes it possible to change the areas to be irradiated, the frequencies allocated to those areas, and signal intensities

■ **Figure 4: Next-generation satellite JSAT-31 (illustration)**



■ Figure 5: Changing beam configuration in orbit



■ Figure 6: SKY Perfect JSAT Yokohama Satellite Control Center (YSCC)

all while in orbit enabling flexible support of short-term and long-term traffic needs (Figure 5). For example, if traffic should become locally concentrated due to a large-scale earthquake or other disaster, frequencies and power could be intensively allocated to that area so that a large volume of traffic could be processed. Similarly, SDS could be applied to emerging countries where new demand may arise due to changes in the population, economy, etc.

■ Universal NTN™ Innovation Lab

Universal NTN™ will introduce many new technologies, so as a system consisting of wireless and satellite communication facilities, it is essential that thorough technical testing be conducted with technical partners. Additionally, since this is a new system unknown to business partners and users, it will be necessary to check its effectiveness and test use cases through demonstrations.

With the aim of studying Universal NTN™ from both technical and business viewpoints, SKY Perfect JSAT established the "Universal NTN™ Innovation Lab" ("NTN Lab") within its Yokohama Satellite Control Center (YSCC) in 2024 (Figure 6).

Although the word "lab" is part of the name of this facility, it functions not as a research institution but rather as a "site" for technical and business development with various partners. NTN Lab is furnished with emulators of base stations and terminals conforming to 5G NTN (NTN standardized on 5G) that can connect with actual satellite circuits to test characteristics, performance, etc. (Figure 7).

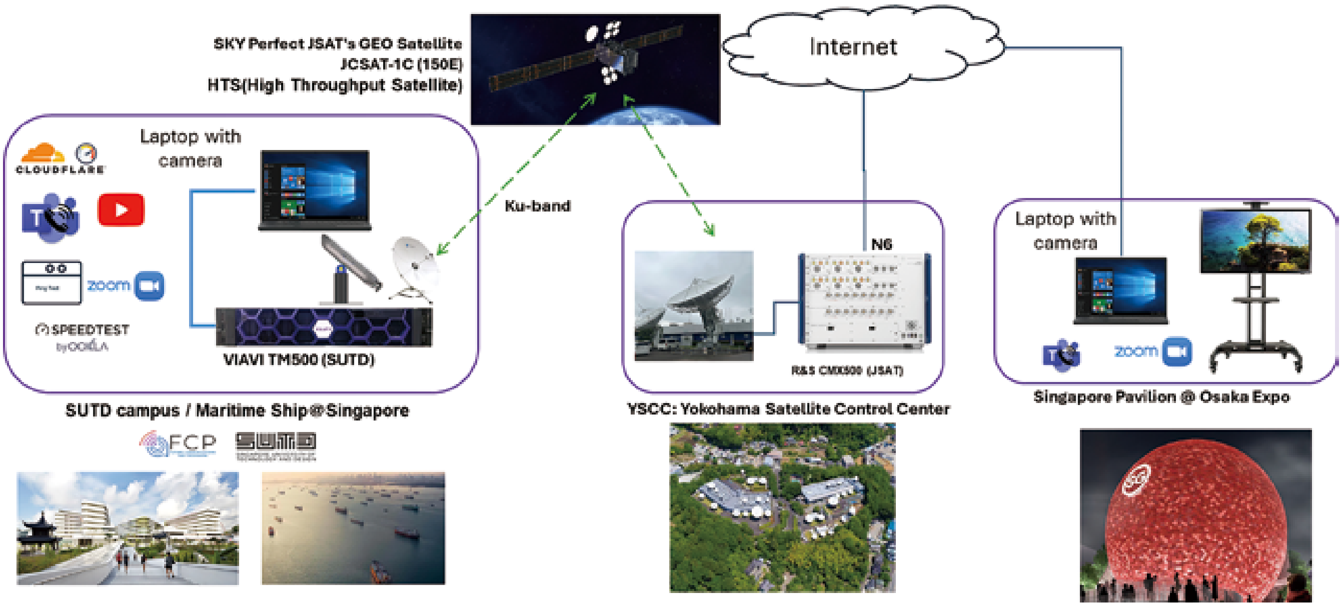
■ Live demonstration at Expo 2025 Osaka, Kansai, Japan

In May 2025, the Republic of Singapore conducted a live video call using a 5G NTN system as a demonstration of future communications at the Singapore Pavilion of Expo 2025 Osaka, Kansai, Japan. SKY Perfect JSAT cooperated in this demonstration via NTN Lab, satellites, technical aspects, etc.

In the demonstration, a circuit was established between

■ Figure 7: NTN Lab facilities

■ Figure 8: Configuration of live demonstration at Expo 2025 Osaka, Kansai, Japan



Singapore University of Technology and Design (SUTD) in Singapore City and NTN LAB using the JSAT-1C satellite marking the world's first transborder communications by 5G NTN (Figure 8). This demonstration not only verified the operability of a global wireless standard with GEO satellites but also system compatibility between countries based on cooperation. It is an achievement that represents a significant and solid step toward realizing a worldview of Universal NTN™ as envisioned by SKY Perfect JSAT.

5. Conclusion

This article introduced the background to NTN and current NTN trends and described related initiatives at SKY Perfect JSAT. NTN is more than just a technological advancement—it's a vision for a safer, more prosperous, and truly connected society. We believe that by embracing innovation and collaboration, we can help make this vision a reality for everyone.

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Cover Art

The Pride of Tokyo's Twelve Months: January, Myogi Visit on the First Rabbit Day of the Year

Tsukioka Yoshitoshi
(1839-1892)

Source: National Diet Library, NDL Image Bank
(https://ndlsearch.ndl.go.jp/imagebank)