NTT DOCOMO's Efforts toward NTN

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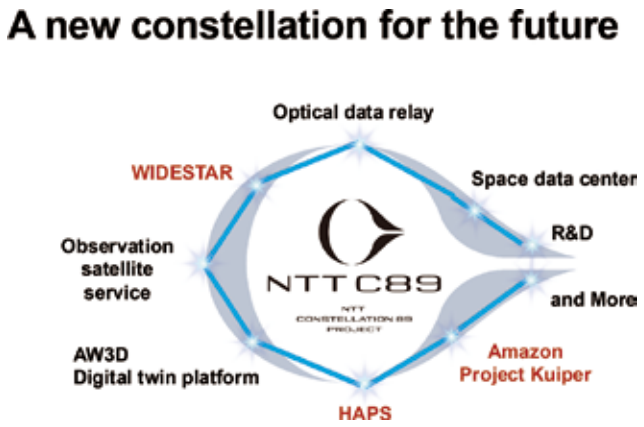
1. Introduction

The market scale of Japan's space business is 4 trillion yen as of 2020 with expectations of reaching 8 trillion yen in the early 2030s*1. This is a high-growth market, and the Japanese government has formulated a "Basic Plan on Space Policy" toward the development of space business with the aim of solving a variety of problems on Earth and achieving more prosperous economic and social activities. Of particular interest here is the space solutions industry, and fields like satellite data usage and communications are expected to be drivers of this growth.

The NTT Group launched "NTT C89" in 2024 as a unified brand in the space business field under the theme of "a new constellation for the future." In this regard, there are 88 constellations in the world that will guide us toward the future as they have guided us in the past. The current space businesses of the NTT Group are like small stars that will come together in an organic manner to become a large business. In other words, we seek to create a new 89th constellation from our current business endeavors and contribute to the future of Japan's space industry (Figure 1).

This article introduces those efforts within NTT C89 centered about the NTT DOCOMO Group such as WIDESTAR, HAPS, and Project Kuiper*2 and the "multi-layer network concept" promoted by the NTT DOCOMO Group.

Figure 1: C89



2. NTN Strategy of NTT DOCOMO Group

At present, the Terrestrial Network (TN) in Japan achieves an extremely high population coverage of more than 99.9%. However, there are still "out of range" areas such as some mountainous areas and remote islands that communication services cannot reach so that area coverage is only at about 60%. With this in mind, a Non-Terrestrial Network (NTN) has been gathering attention as a means of covering a wide area from the sky and providing communication services to locations that TN cannot reach.

NTT DOCOMO has been involved in the NTN area for some time. It launched the WIDESTAR satellite telephone service in 1996 and is currently providing WIDESTAR III as the 3rd generation of this service. In recent years, however, the environment surrounding this area has been undergoing rapid changes, and NTT DOCOMO as well has been particularly active. For example, NTT DOCOMO began in 2023 the provision of "Starlink Business," a satellite broadband Internet service developed by SpaceX, announced a strategic collaboration with Amazon.com, Inc. ("Amazon") in Project Kuiper in the same year, and concluded in 2024 an asset and business partnership with AALTO HAPS Limited ("AALTO"), a subsidiary of Airbus Defence and Space ("Airbus"), toward High-Altitude Platform Station (HAPS) development.

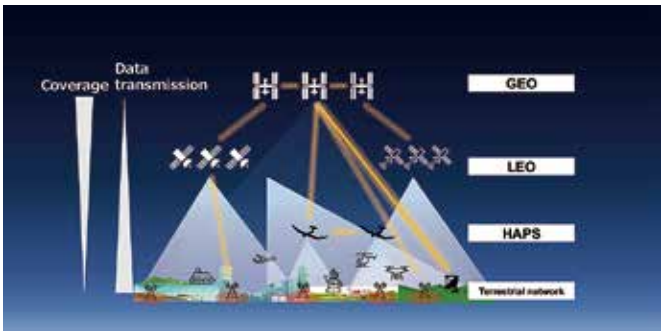
The NTT DOCOMO Group is promoting its original "multi-layer network concept" that aims to integrate Geostationary Earth Orbit (GEO) satellite service, Low Earth Orbit (LEO) satellite service, HAPS, and TN (Figure 2).

The range of coverage, communication characteristics, etc. of GEO/LEO/HAPS differ greatly depending on the altitude, orbit, etc. of each. The idea here is not to make any one of these superior and most powerful but rather to configure an optimal network by combining these systems together with TN. This is a concept that aims to provide high-level seamless and advanced services in the future by linking communications among TN and each of these NTN systems (GEO/LEO/HAPS).

The multi-layer network concept aims for a world in which NTT DOCOMO can "bridge" everyone whenever and wherever, and from that, a world filled with "Wonder" and "Happiness".

*1 From Cabinet Office "Basic Plan on Space Policy" (Approved by the Cabinet on June 13, 2023)
*2 Project Kuiper has changed its name to Amazon Leo.

Figure 2: Multi-layer network concept



3. WIDESTAR (GEO)

NTT DOCOMO launched WIDESTAR III as its 3rd generation mobile satellite communications service in October 2023 (Figure 3). WIDESTAR III covers all of Japan extending to about 200 nautical miles off the coast. This system was the first in the world to provide an LTE over GEO Satellite commercial service through custom development of the Long Term Evolution (LTE) system. It allows for the use of emergency calls (110/119/118) using cell phone numbers.

WIDESTAR III makes effective use of the communication performance of the LTE system, the international standard for cellular systems, and the satellite relay capability of the N-STAR e digital-high-throughput communications satellite equipped with a large deployable antenna. In this way, it has achieved more than six times the number of simultaneous connections (voice call equivalent) of the previous WIDESTAR II system, and as a mobile satellite communications system using frequencies in the 3 GHz band and lower, it has achieved the world's fastest data communication speed in the downlink (maximum 3 Mbps, approximately eight times that of WIDESTAR II). Furthermore, through the development of connection applications with satellite mobile communication terminals ("satellite terminals"), WIDESTAR III has enabled the use of Wi-Fi (Wireless Fidelity)-connected smartphones instead of handsets making communications for users significantly more convenient.

Main features of the WIDESTAR III system are summarized below.

(1) Network reliability

To ensure high reliability as a system, satellite base station equipment and network facilities of the WIDESTAR III system are deployed at two sites with each set of equipment having a redundant configuration of cards, servers, etc. In the event of an emergency such as a natural disaster or base station failure, stable services can still be provided by using the digital processing function of the N-STAR e satellite to change the allocation of frequency resources online.

(2) Load distribution

Load distribution in base station equipment and the core network is essential to stable system operation. To distribute communications load in base station equipment, the system enables a satellite terminal to select the cell of the base station equipment with the lower load at the right time based on information from base station equipment. Additionally, to distribute communications load in core network facilities, the base station equipment directs distributed selection of the core network for satellite terminals accessing the network.

(3) Satellite orbital information

The N-STAR e satellite used by WIDESTAR III is an inclined geostationary orbit satellite having a maximum inclination of ±7 degrees drawing out a "figure 8" in the north-south direction. As a result, fluctuation in satellite propagation delay time normally occurs between base station equipment and satellite terminals. To adjust signal reception timing at the base station equipment from a satellite terminal, satellite control equipment periodically transfers orbital information of the N-STAR e satellite to base station equipment, which notifies satellite terminals of that information through a broadcast signal. Since satellite orbital information includes information covering a certain period of time, service is not affected by a temporary cutoff in the link between base station equipment and satellite control equipment.

Figure 3: WIDESTAR ground station

4. Starlink (LEO)

A LEO satellite orbits the Earth at an altitude around 300 km to 2,000 km, so compared to GEO satellites that orbit at an altitude of about 36,000 km, it is overwhelmingly closer to ground level. Communications services that use LEO satellites therefore feature high speeds, large capacities, and low latency.

In December 2023, NTT DOCOMO began providing "Starlink Business" as a satellite broadband Internet service targeting corporate customers using LEO satellites. In response to the Noto Peninsula Earthquake that occurred in Japan on New Year's Day in 2024, NTT DOCOMO lent out Starlink terminals to stricken local governments and public institutions involved in disaster recovery to support recovery activities. It also provided free Wi-Fi spots using Starlink to give people who had evacuated to shelters a means of communication.

The use of Starlink as cellular backhaul is also progressing, and in the Noto Peninsula Earthquake, the restoration of communications using Starlink achieved results beyond expectations despite the severe damage inflicted on access routes for people and communications. Mobile base station vehicles and ship-mounted base stations used to construct temporary zones in areas losing communications can employ Starlink as backhaul in addition to conventional optical fiber and GEO satellite link. This makes it possible for us to support a variety of environments (Figure 4).

The use of Starlink in normal times is likewise progressing. In this regard, self-driving and autonomous drones are progressing in mountainous areas, the ocean, and other regions in which TN communication is difficult. To give some examples of using Starlink, autonomous weeding and brushing in forestry, real-time video transmission for nighttime search operations, and periodic inspections of the water infrastructure are expected to help reduce workload, improve work accuracy, and reduce costs.

Figure 4: NTT DOCOMO disaster recovery activities using Starlink

5. Project Kuiper (LEO)

In November 2023, NTT DOCOMO together with NTT, NTT DOCOMO Business (NTT Communications at that time), and SKY Perfect JSAT agreed upon a strategic collaboration with Project Kuiper ("Kuiper"), a satellite broadband network provided by Amazon (Figure 5). The reason for this move was to make further and more diversified use of LEO satellite communication services with the aim of providing an advanced satellite broadband network and enhancing the availability and resilience of communications.

The Kuiper system uses a high frequency band called the Ka band that enables high throughput relative to past levels. Additionally, a "private connectivity service" has been announced as part of Kuiper to provide customers with secure satellite communications through direct connections to the user network that bypass the Internet. This will enable users to access their highly confidential servers or proprietary systems in a highly secure manner. Another feature of Kuiper is the ability to access Amazon Web Services (AWS) cloud services and make use of advanced technologies such as AI and machine learning.

As backhaul for base stations, Kuiper has the potential of maintaining communication speed to a certain extent even if traffic should become extremely concentrated such as during a natural disaster.

With Kuiper, NTT DOCOMO aims to make communication services even more robust, provide customers with new options, and contribute to service and value creation.

Figure 5: Project Kuiper

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https://www.aboutamazon.com/what-we-do/devices-services/project-kuiper

6. HAPS

NTT DOCOMO is promoting the commercialization of HAPS communications technology using the stratosphere. HAPS is a system in which unmanned aerial vehicles remain airborne in the stratosphere at an altitude of about 20 km deemed less susceptible to weather effects to provide communications, remote sensing, and other services. Since these vehicles are close to the ground compared to satellites, they can achieve high-speed, high-capacity, and low-latency communications making HAPS applicable to emergency area coverage, early rollout of next-generation communications, etc.

In 2024, NTT DOCOMO and Space Compass formed a capital and business alliance with Airbus and AALTO aiming for commercialization of HAPS in Japan by 2026.

The HAPS "Zephyr" aircraft manufactured and operated by AALTO has a wingspan of 25 m with a weight of only 75 kg.

It features an environment-friendly design driven 100% by solar power. It has been under development for over 20 years, amassed more than 4,000 hours of flight experiments, and set a record in 2025 of 67 consecutive days of flight in the stratosphere (Figure 6).

In terms of communications, a HAPS communications test was conducted in Kenya in January and February of 2025 successfully achieving communications using a special messaging application. Moreover, in a data communications test, a communication speed of 4.46 Mbps was measured.

HAPS and Zephyr provide four main features. The first is "direct and high-speed communications with smartphones." Since the system operates close to the Earth's surface compared to satellites, high-speed and low-latency communications become possible enabling everyday smartphones to be used without modification. The second feature is "service flexibility." Depending on the application, the payload such as communication equipment, cameras, and radar can be easily changed to provide diverse services. The third feature is "high portability." A HAPS system can be rolled out quickly at a location during a natural disaster, a special event, etc. The fourth feature is "environment friendly." The Zephyr aircraft can be operated 100% on solar power enabling sustainable communications with a low environmental load.

Specific application examples include disaster recovery, communications for remote islands, on the sea, and in mountainous areas, and communications with drones flying over a wide area. HAPS can also be used to obtain high-accuracy observation data in real time by mounting an optical camera, and it can be used to manage progress at construction sites, determine conditions during a natural disaster, etc. Going forward, even more applications can be envisioned such as carbon dioxide detection by mounting a hyperspectral camera, mineral exploration, and radio wave monitoring.

7. Conclusion

This article described NTT DOCOMO's efforts in each of the GEO/LEO/HAPS systems and its "multi-layer network concept" that aims for an optimal and advanced network by combining and linking these systems together with TN.

At present, GEO/LEO/HAPS are individual systems each having an original interface and other components. In the future, however, integrating communications and operations among these NTN systems and between NTN and TN will make it possible to provide high-level seamless and advanced services. At that time, we can expect inter-system compatibility and usability to improve and the cost of introduction to be reduced by standardizing interface specifications and enhancing interoperability.

Services that provide direct satellite communications via smartphones have recently been launched. Although there have been many services with dedicated terminals, enabling satellite communications via commonly used smartphones achieves a significant jump in convenience. NTT DOCOMO, as well, is preparing to launch a satellite direct communication service with smartphones in 2026.

Through the evolution of NTN, NTT DOCOMO aims to create a more prosperous society by providing best-mix and robust network services to meet the diverse needs of our customers, such as ensuring communications during natural disasters and making communications in business and everyday life more convenient in remote locations.

Figure 6: HAPS "Zephyr"