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DOCOMO Touchable Network Concept

Non-terrestrial network (NTN) for extreme coverage extension

NTT DOCOMO,INC.

Ultra-Coverage Extension

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Significant extension of area coverage

- Allow users to enjoy Gbps-grade communications anywhere

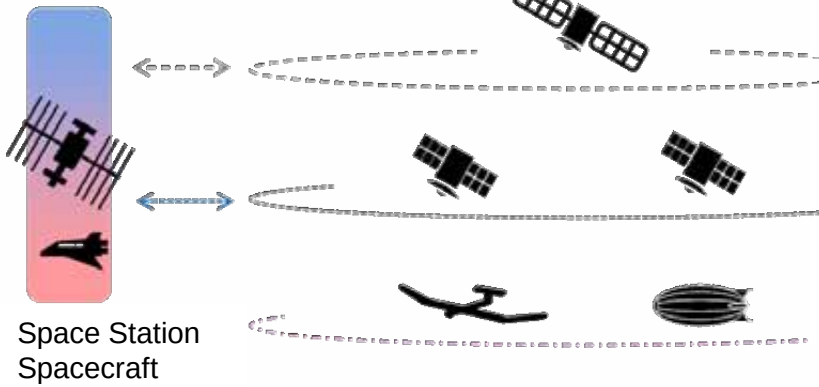
Even in the sky (altitude 10,000m), sea (200 natutical miles) and space

- Aim to achieve ultra-coverage extension to the sky, sea, space and other locations not currently covered by mobile communication systems

Further extension of activity domains for people and things and creation of new industries

- Use cases for logistics such as drone delivery
- Enhance automation in primary industries such as agriculture, forestry and fisheries
- Applications to futuristic scenarios such as flying cars and space travels

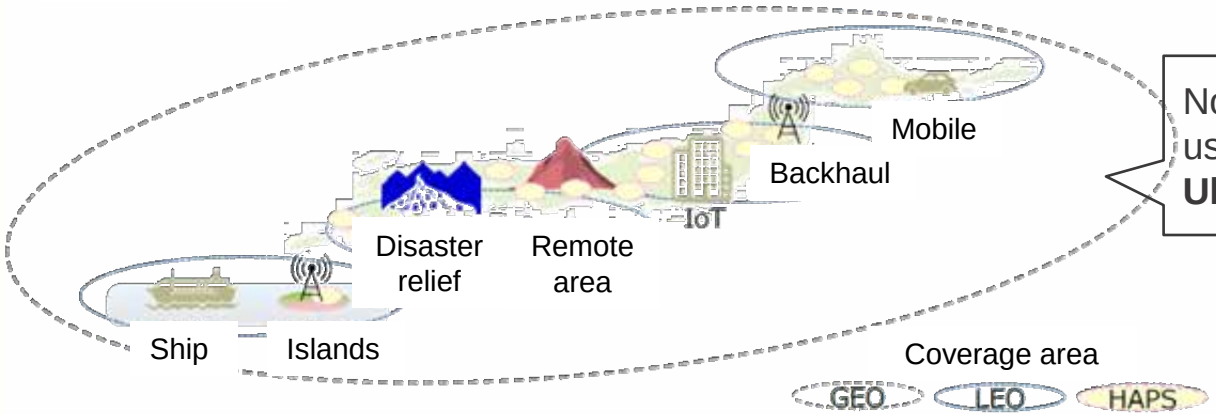
NTN Coverage Extension



Geostationary Earth Orbit (GEO) satellite
Altitude: 36,000 km
Cell Radius: more than 1,000 km

Low Earth Orbit (LEO) satellite
Altitude: up to 2,000 km
Cell Radius: mostly between **200** and **500 km**

High Altitude Platform Station (HAPS)
Altitude: **20 km**
Cell Radius: more than **50 km**



Non-terrestrial network (NTN) uses GEO/LEO/HAPS to achieve **Ultra-Coverage extension**

GEO, LEO, and HAPS

	Altitude	Orbit	Area radius	Round trip delay※1
GEO	36,000km	Stationary	1,000km-	250 msec
LEO	Several100-2,000km	Orbiting the Earth	100-500km	4-40 msec
HAPS	20km	Almost stationary	50-100km	0.1-0.7msec

*Depending on altitude and elevation

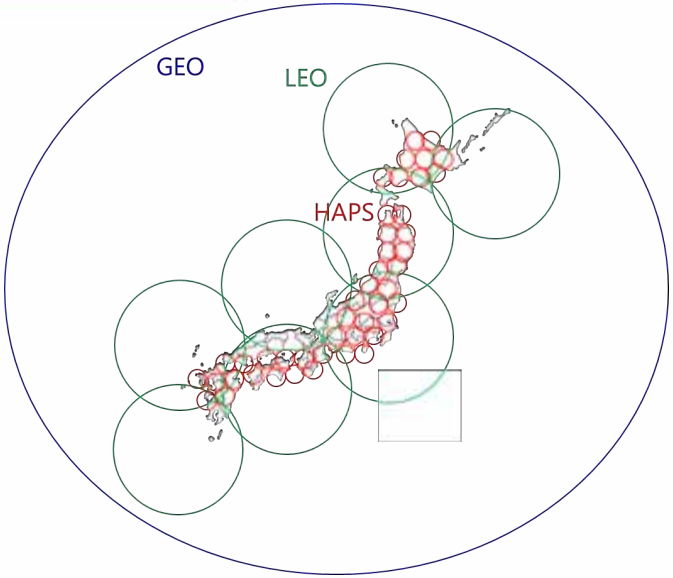


Image of each system footprint

Features of HAPS

- Low latency and high throughput are expected, although area radius is inferior to LEO/GEO
- Direct communication with smartphones
- Fixed-point observation is possible as HAPS can be seen almost stationary from the ground

➡ NTN aims to find the **best combination**, taking into account the characteristics of HAPS, GEO, and LEO.

NTN (HAPS) Use Cases

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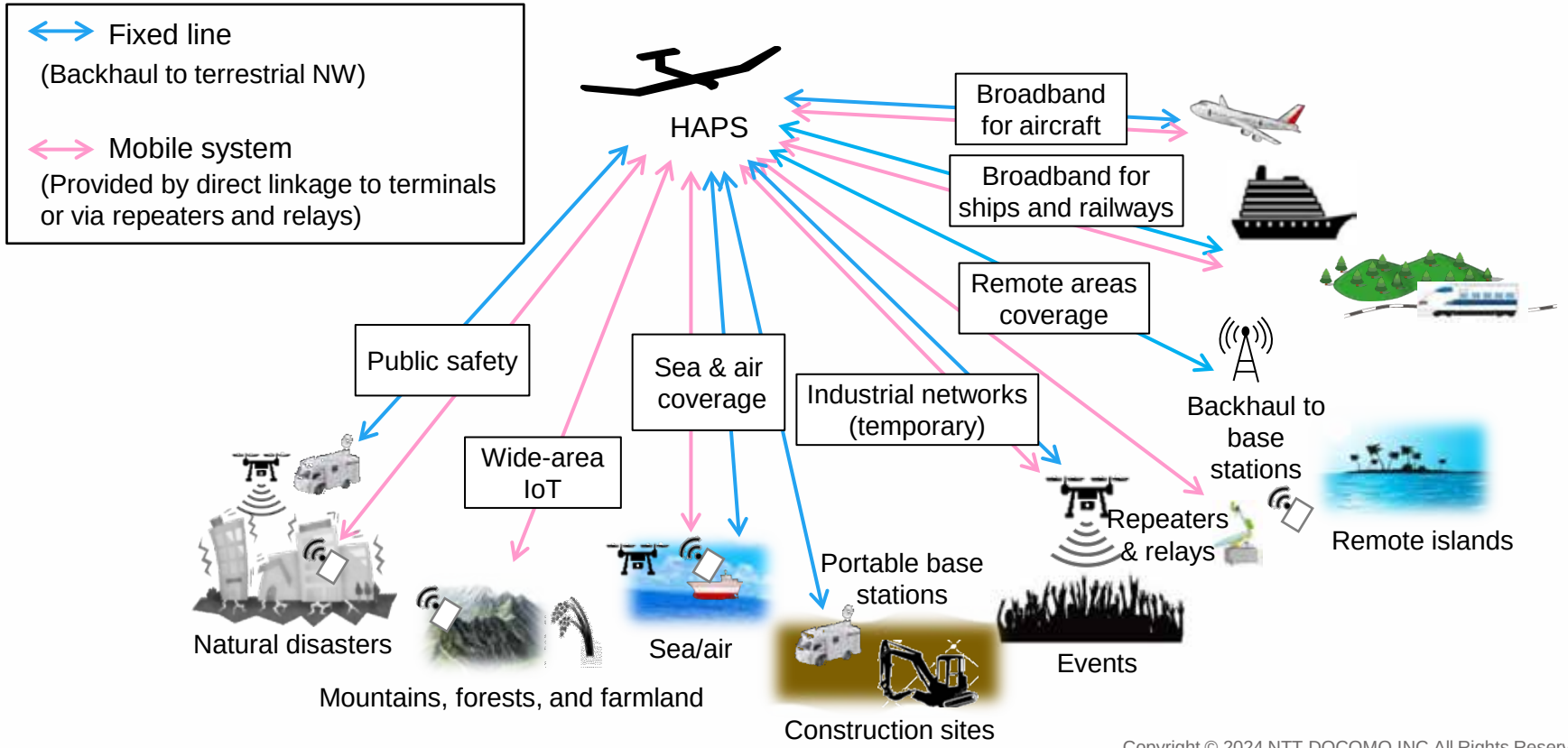
Effective for **diverse industrial use cases** in 5G Evolution & 6G and **public safety**



HAPS Simulator

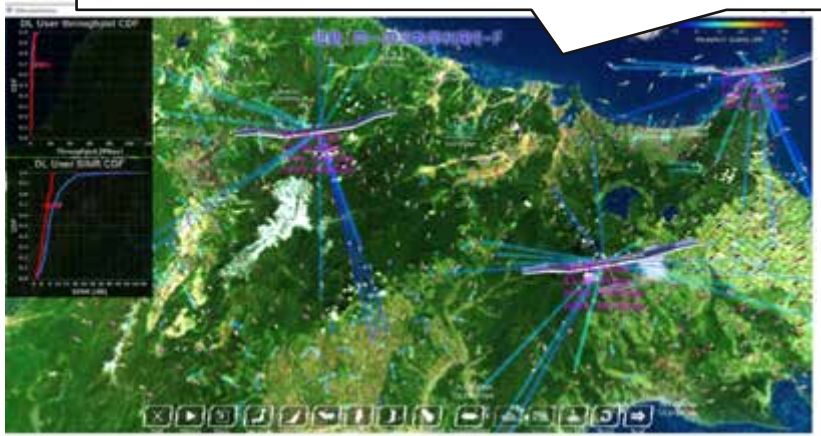
Creating communication coverage using HAPS

- By setting radio parameters, this simulator calculates system capacity according to the communication environment
- Interference avoidance technology and its effectiveness when sharing frequencies with terrestrial 5G networks can be evaluated

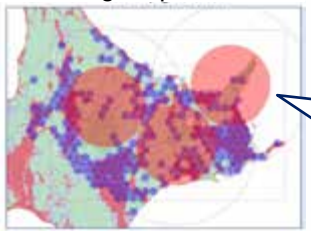
Key features

- Detailed evaluation of intra-system/inter-system interference between HAPS and terrestrial 5G network
- Highly accurate communication performance evaluation that reflects the actual area map

Evaluate communication performance by filling the coverage holes with HAPS



HAPS, gNB placement



Build terrestrial networks reflecting the area map

Part of this exhibition was supported by funding from the Ministry of Internal Affairs and Communications (Research and Development for extension of Radio Resources; JPJ000254), and commissioned research (JPJ012368C07702) by the National Institute of Information and Communications Technology (NICT).

Appendix
Ultra-Coverage Extension using NTN

Network Deployment

- **At initial stage, HAPS will be a promising solution for specific use cases, times and places**
  - Hotspot-like operation with a few aircraft
  - Service is expected to be introduced from south of 30 - 35 degrees north latitude due to constraints of small HAPS aircraft

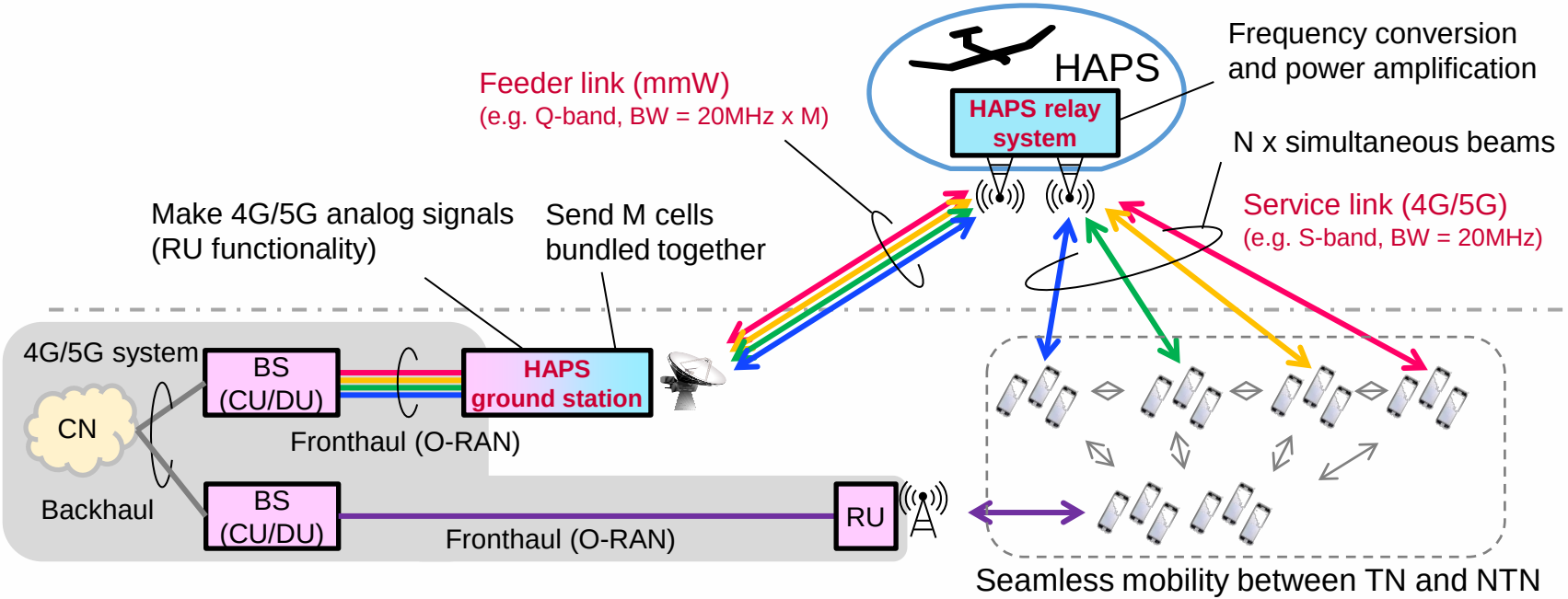
- **Gradual sevice extention in Japan and cost reduction**
  - Develop medium-size HAPS aircraft to expand services nationalwide, alining with market demand
  - Cost-effective deployment/operation compared to current coverage solutions is a must
  - Consider combining HAPS with new satellite solutions as LEO

Using maps from the Geographical Survey Institute website (https://www.gsi.go.jp/KOKUJYOHO/center.htm)

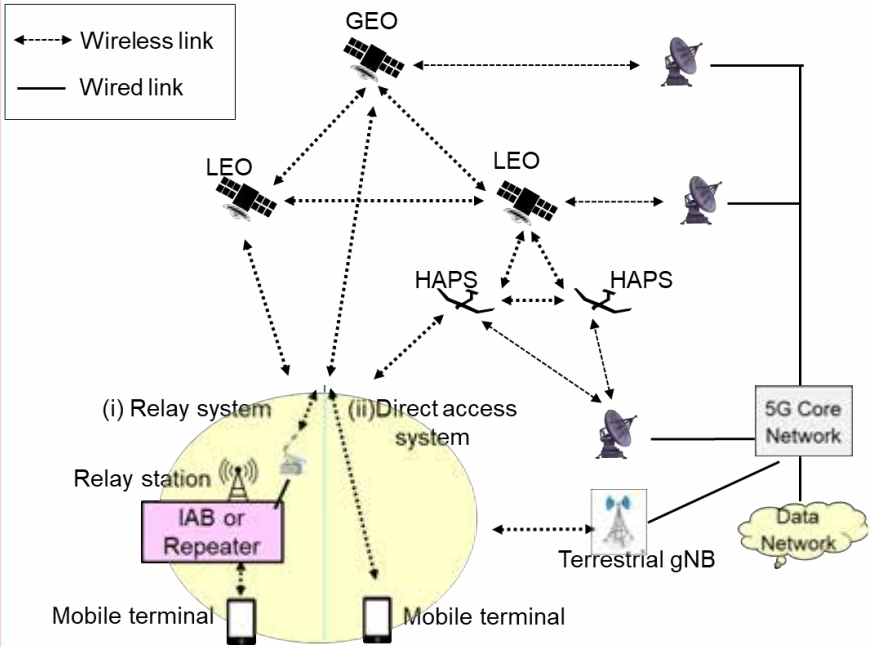
HAPS with 5G Network Access

5G relay system installed in HAPS

- Terrestrial network (TN) is utilized from the core network to the fronthaul
- Ground station equipped with the RU function bundles and communicates signals for multiple beams
- Relay system performs frequency conversion and power control



Examples of Multi-layered NTN System



GEO

- Support for delay-tolerant services

LEO

- Achieves higher communication performance (high speed, large capacity, low latency) than GEO

HAPS

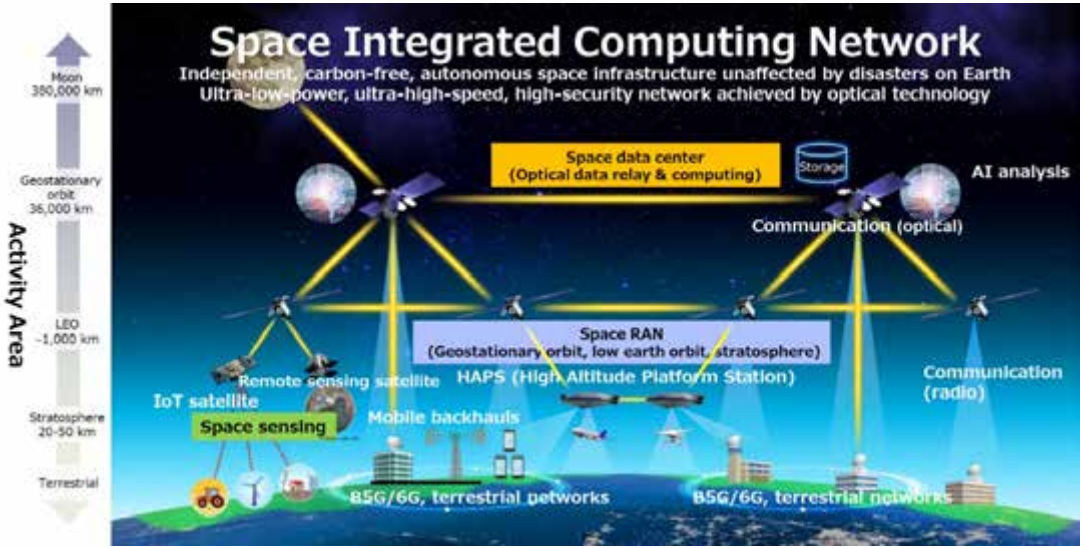
- Enhancing areas with insufficient performance for GEO, LEO and terrestrial NW
- Realization of NTN's hub role by installing base station equipment, core NW, or MEC

Combining GEO, LEO, and HAPS

- Optimal NW connection according to each network feature and UE QoS
  - NW offloading / Site diversity
- Control of NW topology and routing corresponding to movement of LEO and HAPS

R&D Partners

- **Airbus, NTT, NTT DOCOMO and SKY Perfect JSAT** concluded a memorandum of understanding (MoU) to explore collaborative research, development, and testing for the early deployment of HAPS
- NTT and SKY Perfect JSAT will establish **Space Compass Corporation**, aiming to launch communications services using HAPS by the end of fiscal 2025



Appendix
NTN Initiatives of NTT Docomo

Other Major Projects

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R&D project for early commercialization and system evolution for **D2D mobile service via HAPS**
(commissioned by the National Institute of Information and Communications Technology (NICT))

Research and development on **efficient frequency utilization** technology for wireless communication systems using **HAPS** (commissioned by Ministry of Internal Affairs and Communications)

Participation in HAPS Alliance, an organization for HAPS R&D and Commercialization Promotion

HAPS Alliance
HIGH ALTITUDE PLATFORM STATION

GSMA HAPS White Paper
(Joint publication with overseas operators)

GSMA

New Japan National HAPS Project

(Commissioned by NICT)

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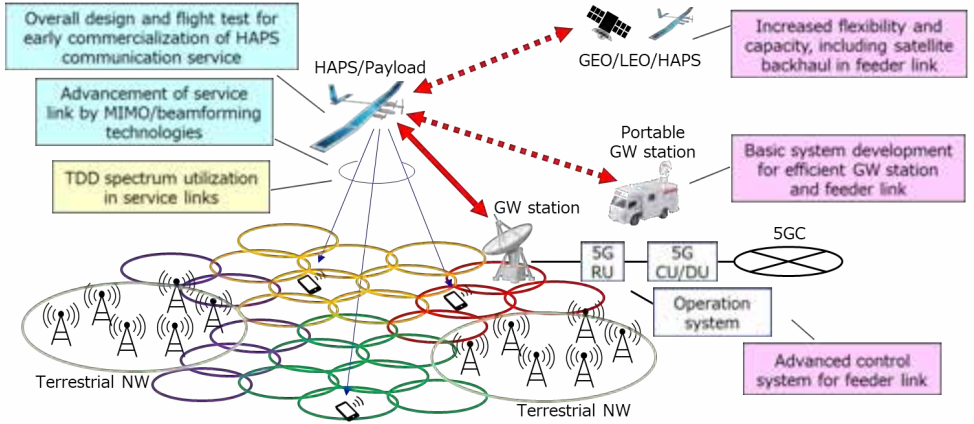
R&D for early commercialization and system evolution of D2D mobile services via HAPS

Phase 1: Towards early commercialization

- Aim to solve various technical issues and demonstrate HAPS communication services in stratosphere over Japan

Phase 2: Enhancement

- R&D to achieve high-speed, high-capacity technology and TDD spectrum utilization in service link



	FY2023	FY2024	FY2025	FY2026	FY2027
R&D for Phase 1	Basic study	Pre-validation	Flight test in Japan		
R&D for Phase 2	Basic study		PoC development	PoC flight test	

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Widestar III (GEO) and Starlink Business (LEO)

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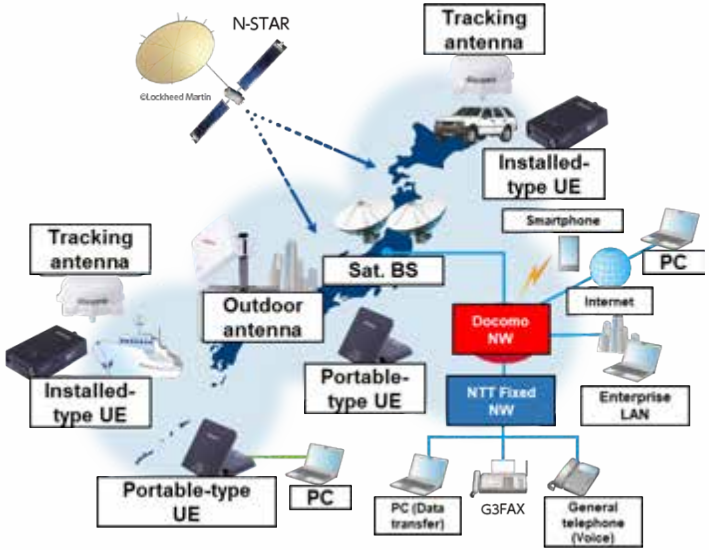
Launch of WideStar III service (GEO) Oct. 2023

- Throughput: 4 times that of the WideStar II
  - DL: Up to 1.5Mbps
  - UL: Up to 250kbps (portable type), 1Mbps (installed type)



https://www.ntt.com/business/services/widestar3.html

Launch of Starlink Business (LEO) Dec. 2023

- High-speed, low-latency satellite broadband Internet as a certified reseller through SKY Perfect JSAT Corporation
- Expected throughput up to hundred times beyond GEO
- Use case examples
  - Emergency backup line
  - Remote monitoring solutions
  - IoT solutions
  - High-speed data communication over the sea

Starlink antenna

https://www.ntt.com/business/services/starlink-business.html

Stratospheric Propagation Test

(Conducted by DOCOMO and Airbus)

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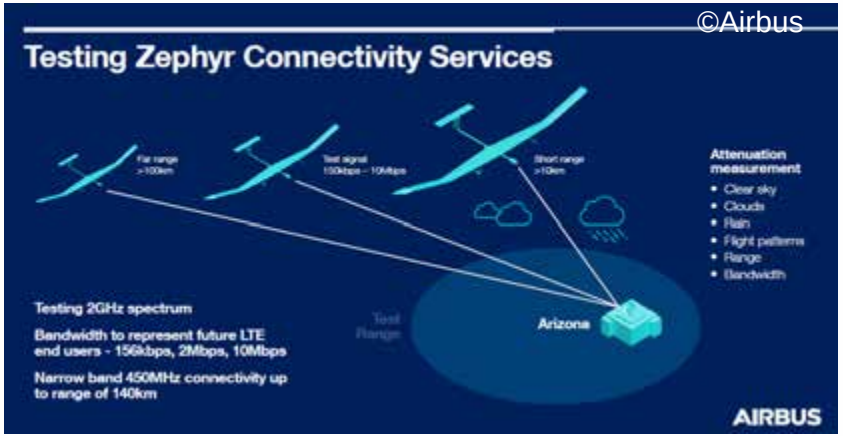
- Propagation mesurement from “HAPS Zephyr S” in the stratosphere over the UHF band (2 GHz, 450 MHz)
- Analyze the impacts of communication distances, meteorological conditions, HAPS flight patterns and other factors during 18-day stratospheric flights
- Confirmed competent communication quality over a distance up to 140 km in the 450 MHz band

“Zephyr S” at takeoff



Overview of demonstration experiment

Measurement of Q-Band Propagation from the Stratosphere to the Ground

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World's first successful radio propagation experiment in the 38 GHz band from the lower stratosphere (October 2022)

- Measured in the 38 GHz band at approximately 14 km latitude, under sunny, cloudy, and rainy weather conditions

Various flight pattern and elevation angles test for actual HAPS operation

Thin cloud

Thick cloud

Line of sight

Ground station antenna,experiment site (Planneralm, Austria)