DOCOMO's Non-Terrestrial Network (NTN) for Extreme Coverage Extension

Ultra-Coverage Extension

Significant extension of area coverage

- Allow users to enjoy Gbps-grade communications anywhere

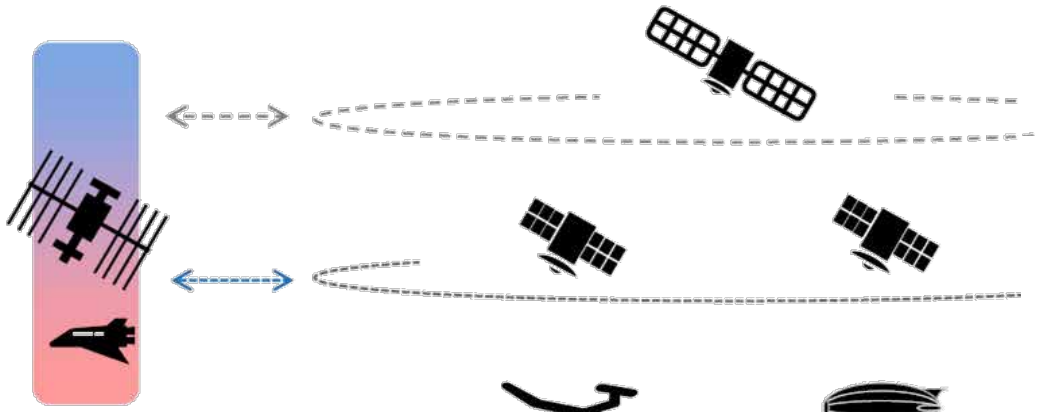
Even in the sky (altitude 10,000m), sea (200 nautical miles) and space

- 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 business

- 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

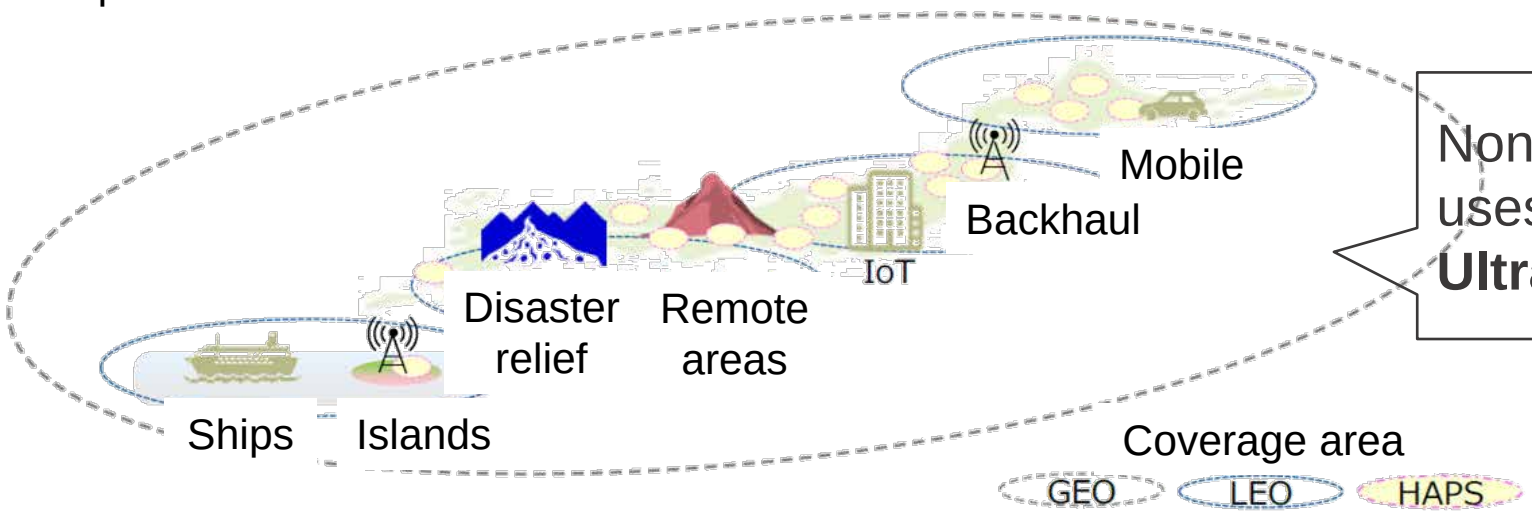
NTN Coverage Extension



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

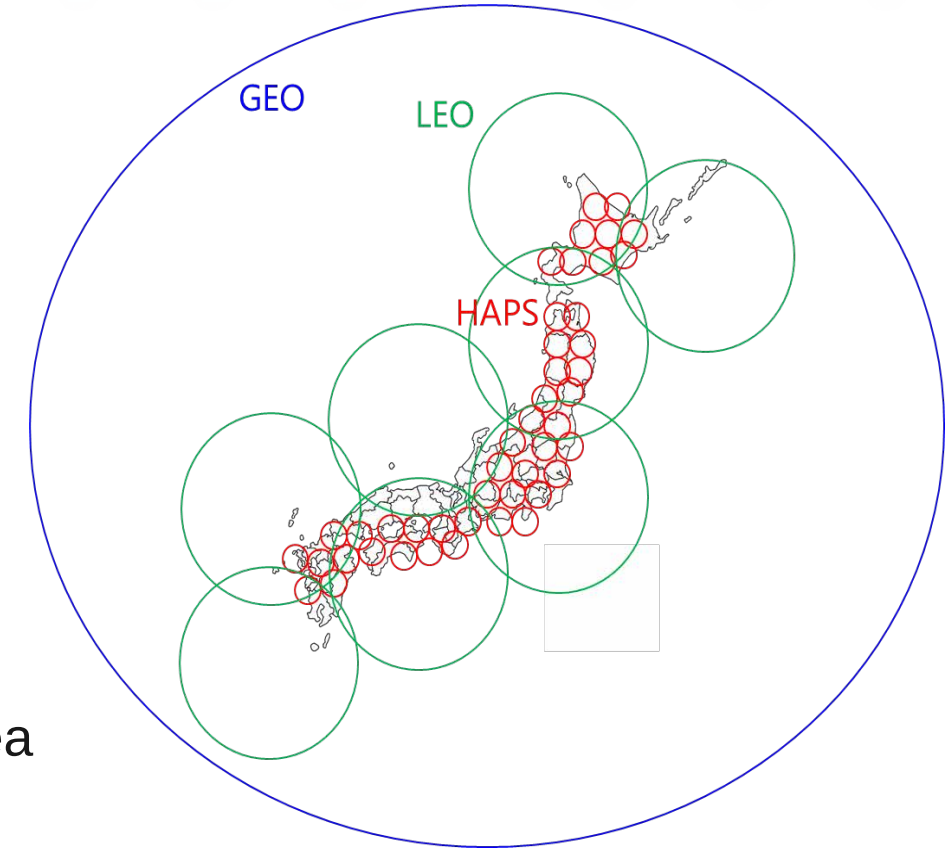


Image of each system footprint

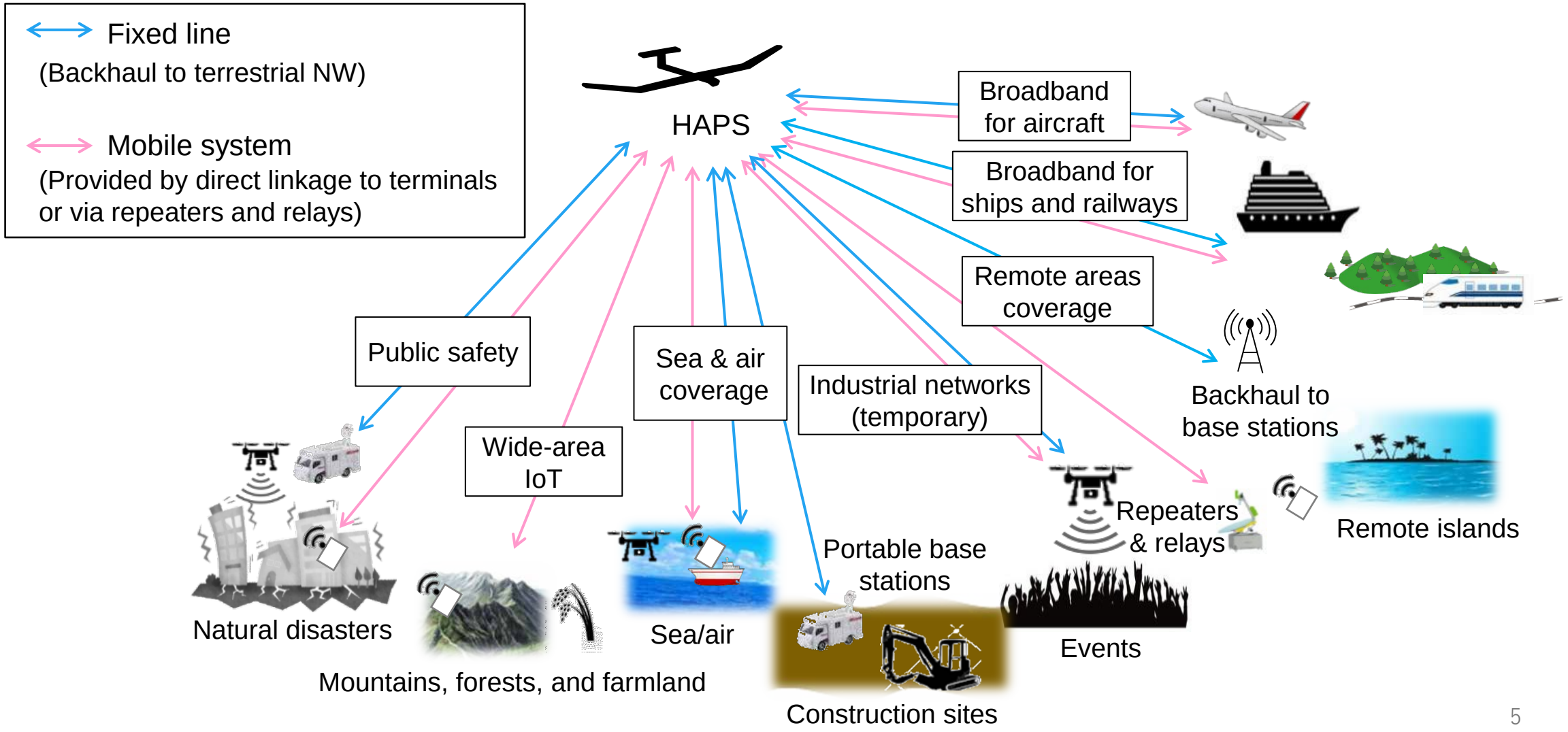
Features of HAPS

- 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

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



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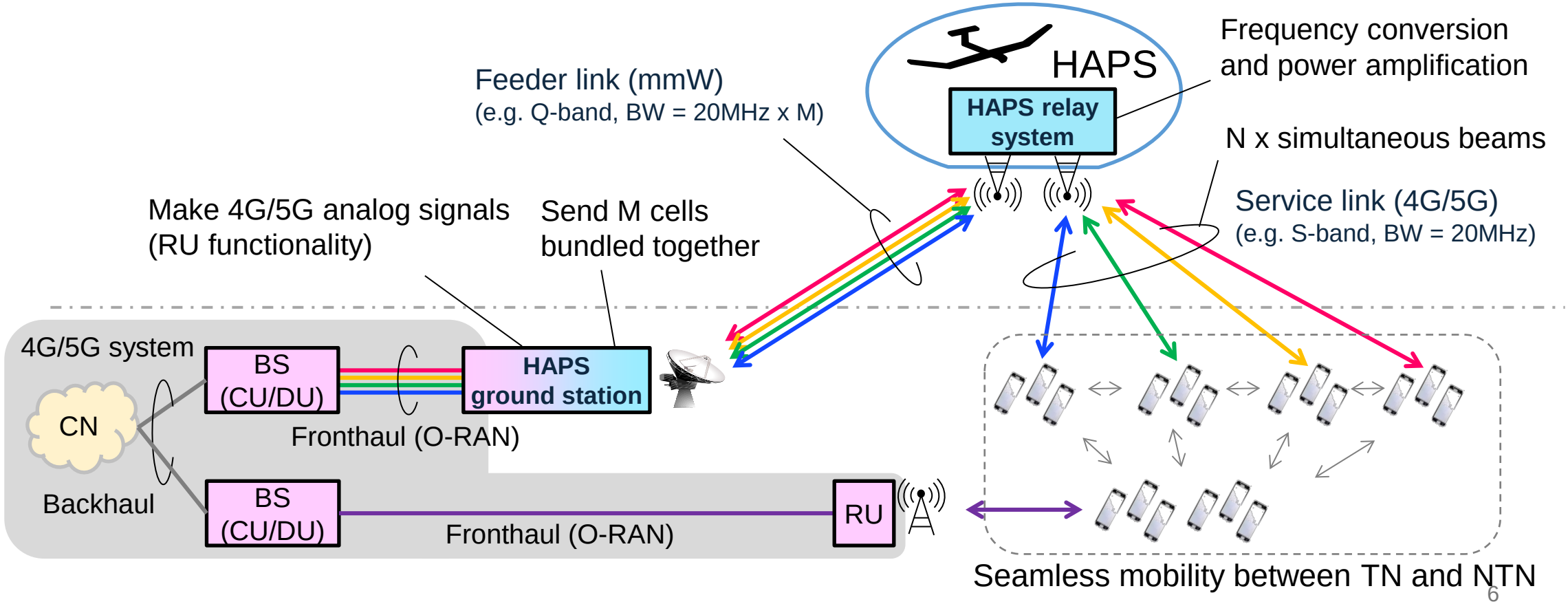
HAPS with 5G Network Access

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

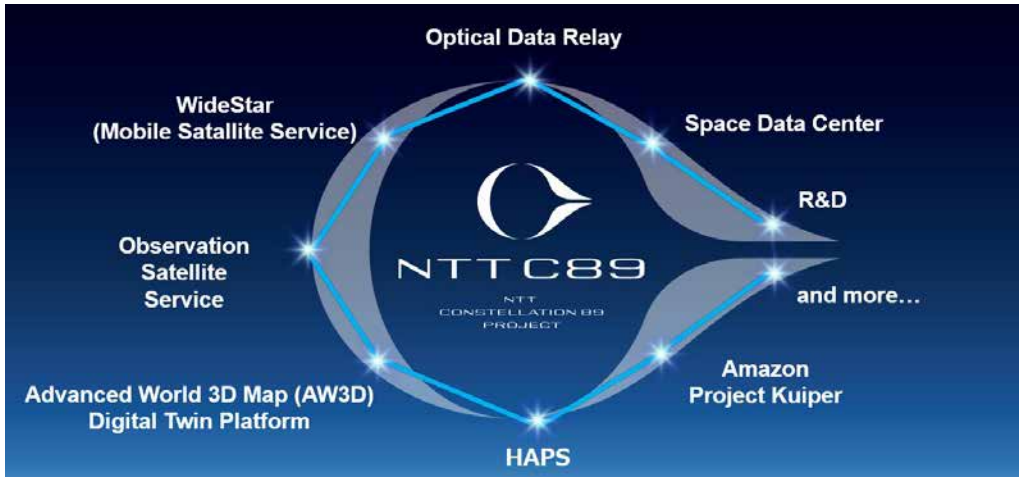


NTT Group's NTN Initiatives: Our Trend Toward HAPS Commercialization

3rd June 2024: Press release & Press conference

- **NTT C89 brand launch (https://group.ntt/en/aerospace/)**
- **NTT DOCOMO and Space Compass partners with Airbus on HAPS, committing to a USD$100 million investment in AALTO to commercialize connectivity and earth observation services in Japan and Asia**
  - Supporting the industrial and commercial roadmap for AALTO's services
  - Targeting service launch in Japan and global entry-into-service by 2026

https://dempa-digital.com/article/567281



https://group.ntt/jp/magazine/blog/ntt_c89/

https://www.watch.impress.co.jp/docs/series/ishino/1597118.html

Japan's New National HAPS Project

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

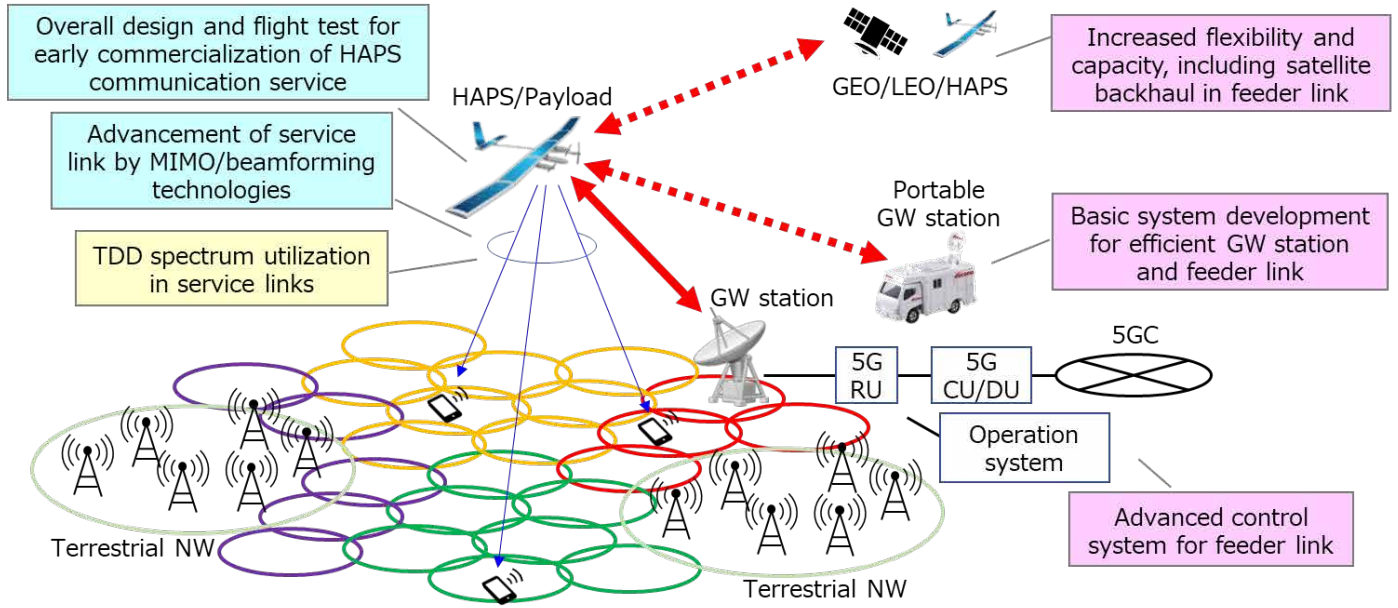
commissioned by the National Institute of Information and Communications Technology (NICT)

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



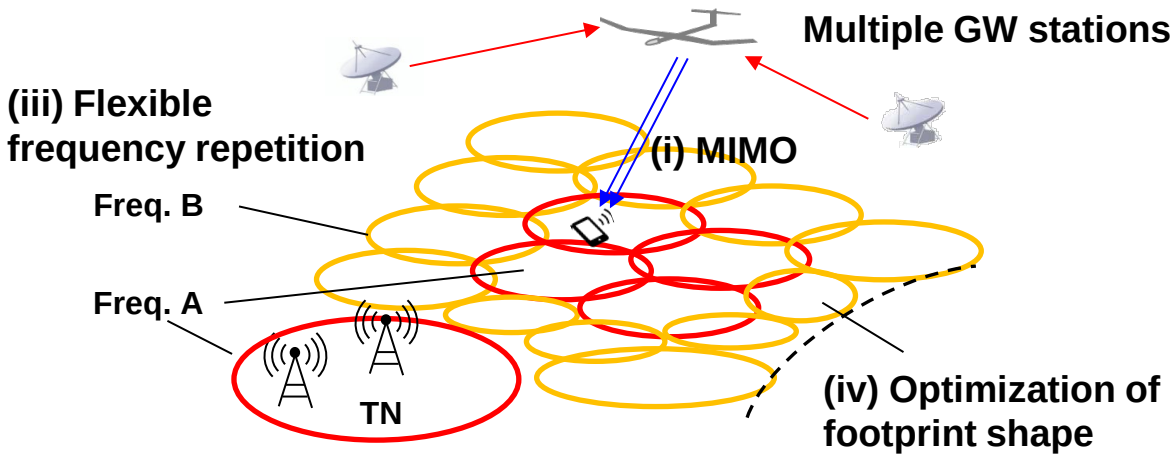
	FY2023	FY2024	FY2025	FY2026	FY2027
R&D for Phase 1	Basic study	Pre-validation	Flight test in Japan		
R&D for Phase 2	Basic study		PoC development		PoC flight test

Overview of Technologies for HAPS Enhancement

High-speed, high-capacity system

FDD & Transparent payload

Equipped with repeater and power amplification functions



(ii) Large number of beams (cells) = 4 to 16 beams

High-mobility system

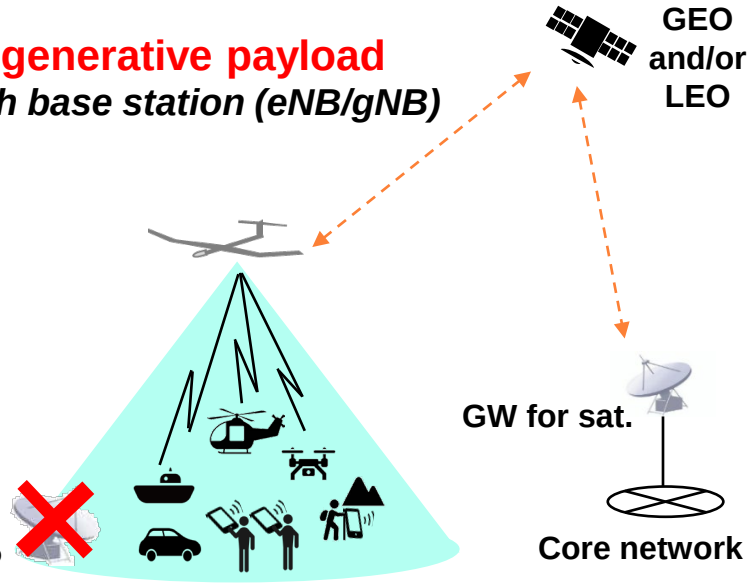
TDD & Regenerative payload

Equipped with base station (eNB/gNB)

(i) Utilization of narrowband Band34 / n34 (15 MHz BW)

(ii) Synchronous/ Asynchronous TDD

(iii) Evaluates long-distance communication under 3GPP TN specifications



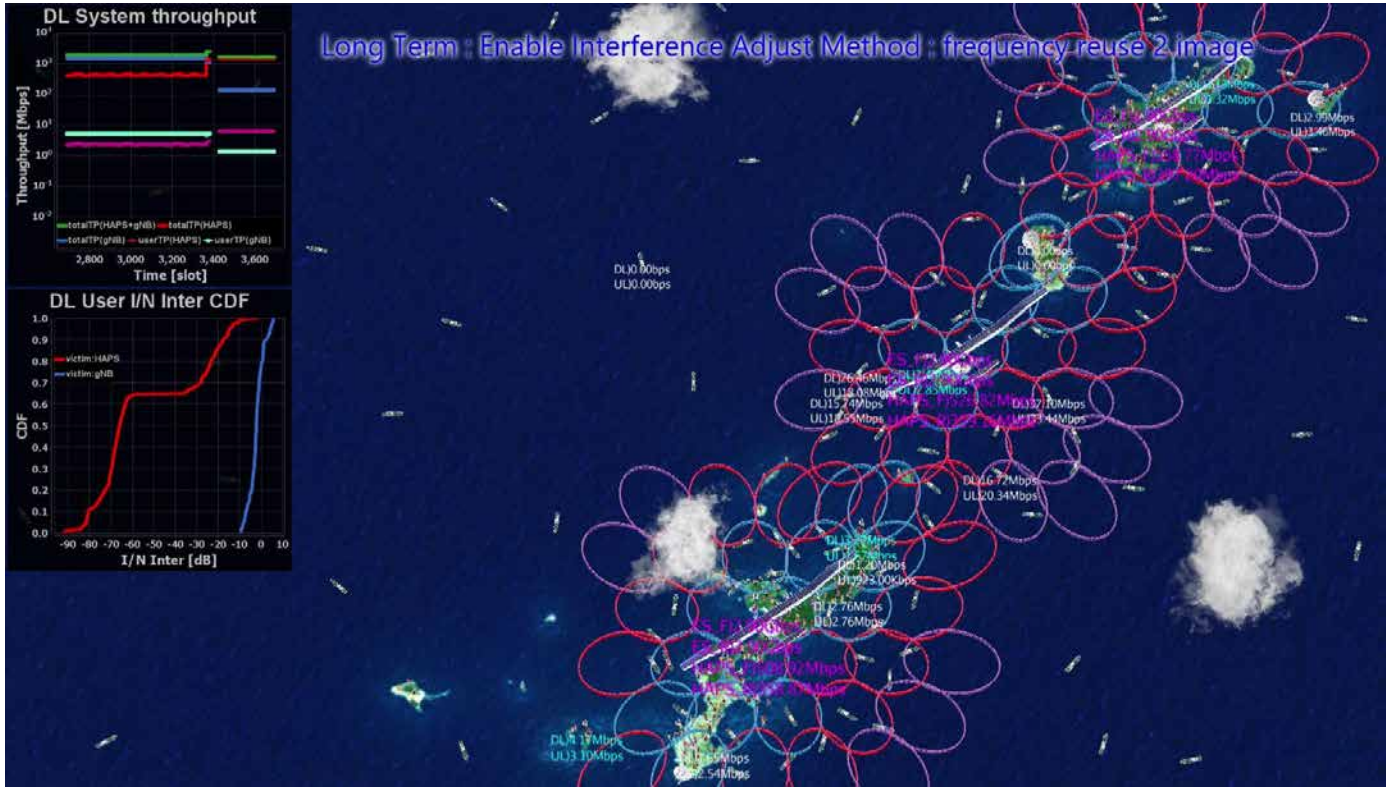
No ground GW stations are required within the HAPS coverage area

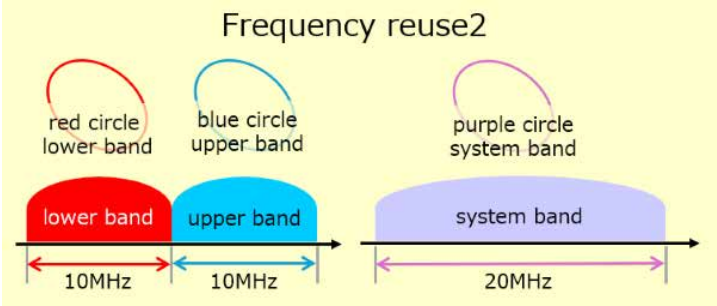
Implement these two systems into the HAPS simulator

HAPS Simulator

The HAPS simulator will demonstrate the feasibility of ultra-coverage extension in two scenarios:

- (i) FDD × Transparent mode
  (ii) TDD × Regenerative mode
- The image on the right illustrates the implementation of interference suppression technology using frequency reuse in overlapping areas between terrestrial gNBs and HAPS beams

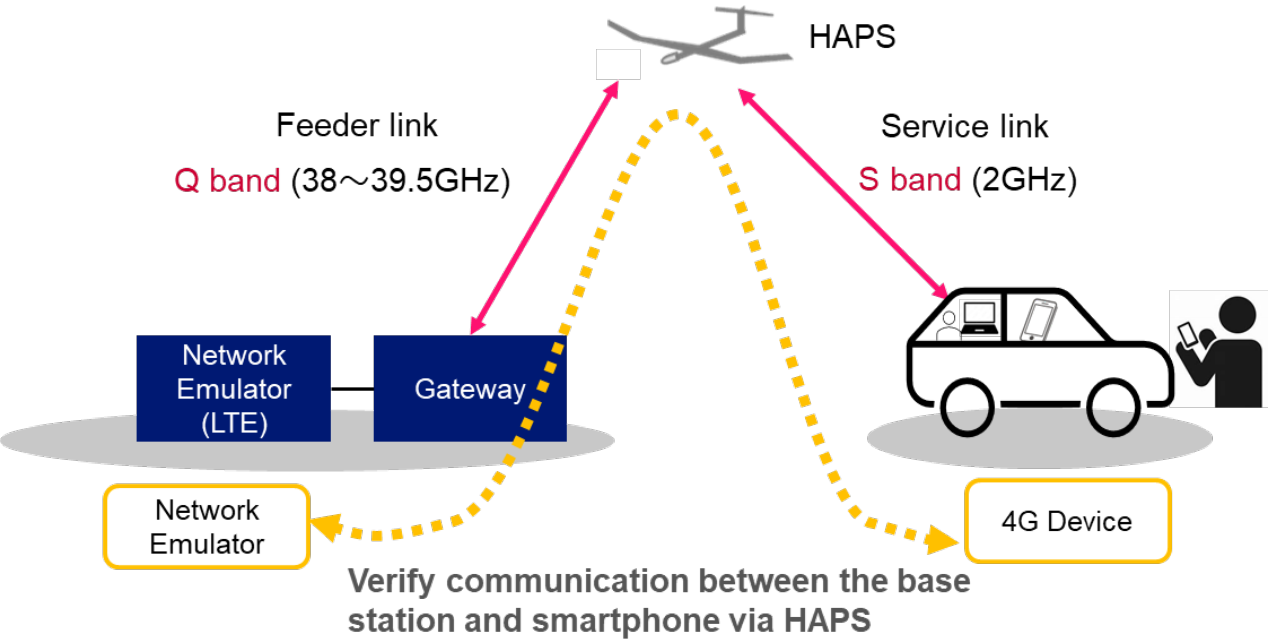


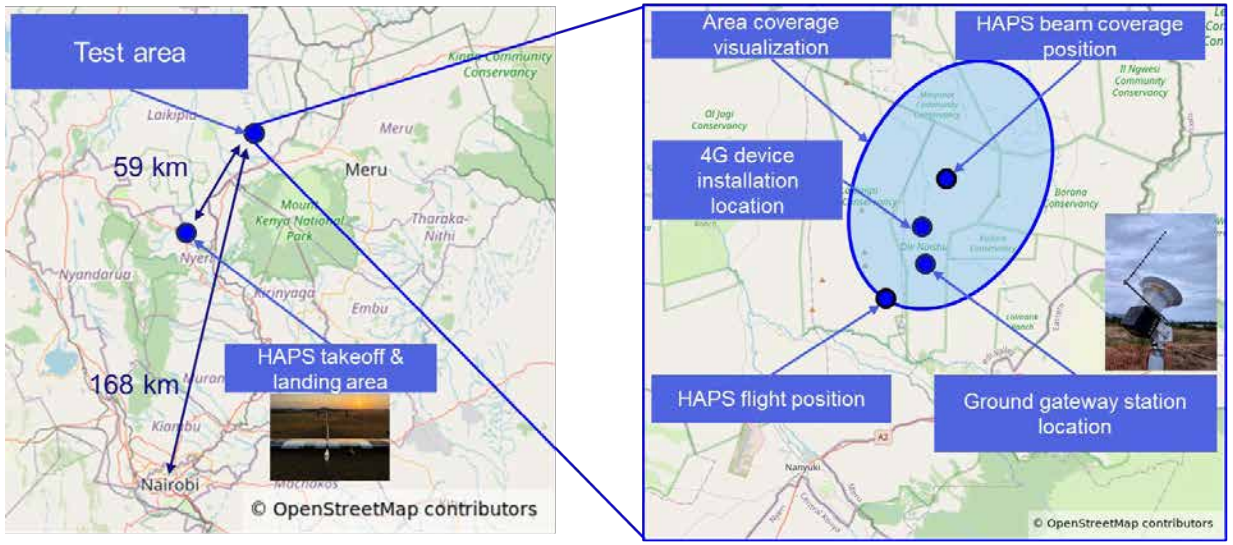


Overview of HAPS Trial in 2025

Space Compass and NTT DOCOMO to conduct connectivity tests from the stratosphere in Kenya (Feb. 2025)

- A communication demonstration using LTE was carried out between the HAPS flying at altitudes around 20km and smartphones on the ground
- A throughput of 4.66 Mbps was observed on the forward link (Gateway→HAPS→4G device)





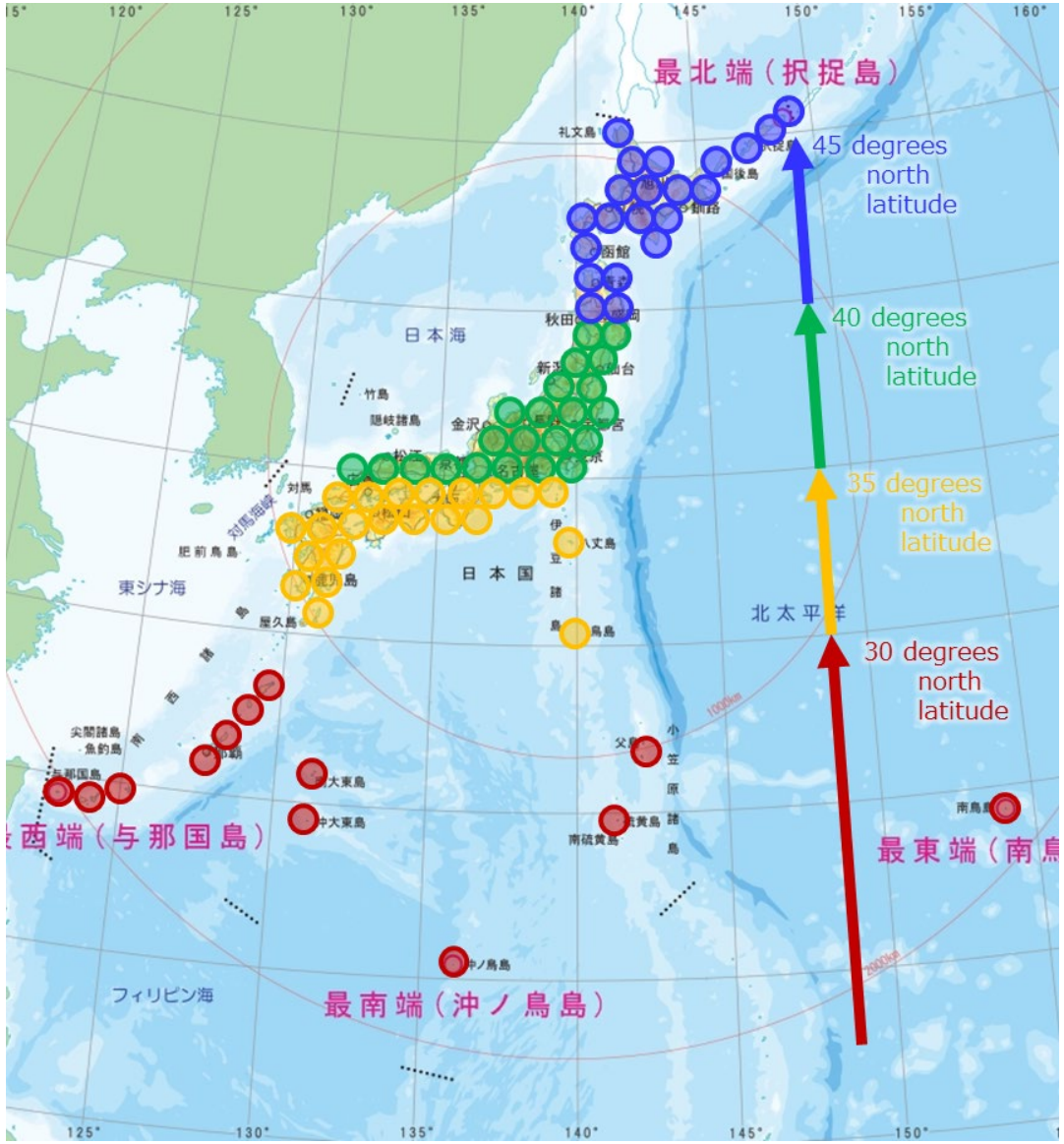
HAPS Flight Location, Ground Gateway Station Position, and Coverage Area of Service Link Beams

Part of this exhibition was supported by funding from commissioned research (JPJ012368C07702)
by the National Institute of Information and Communications Technology (NICT).

Network Deployment

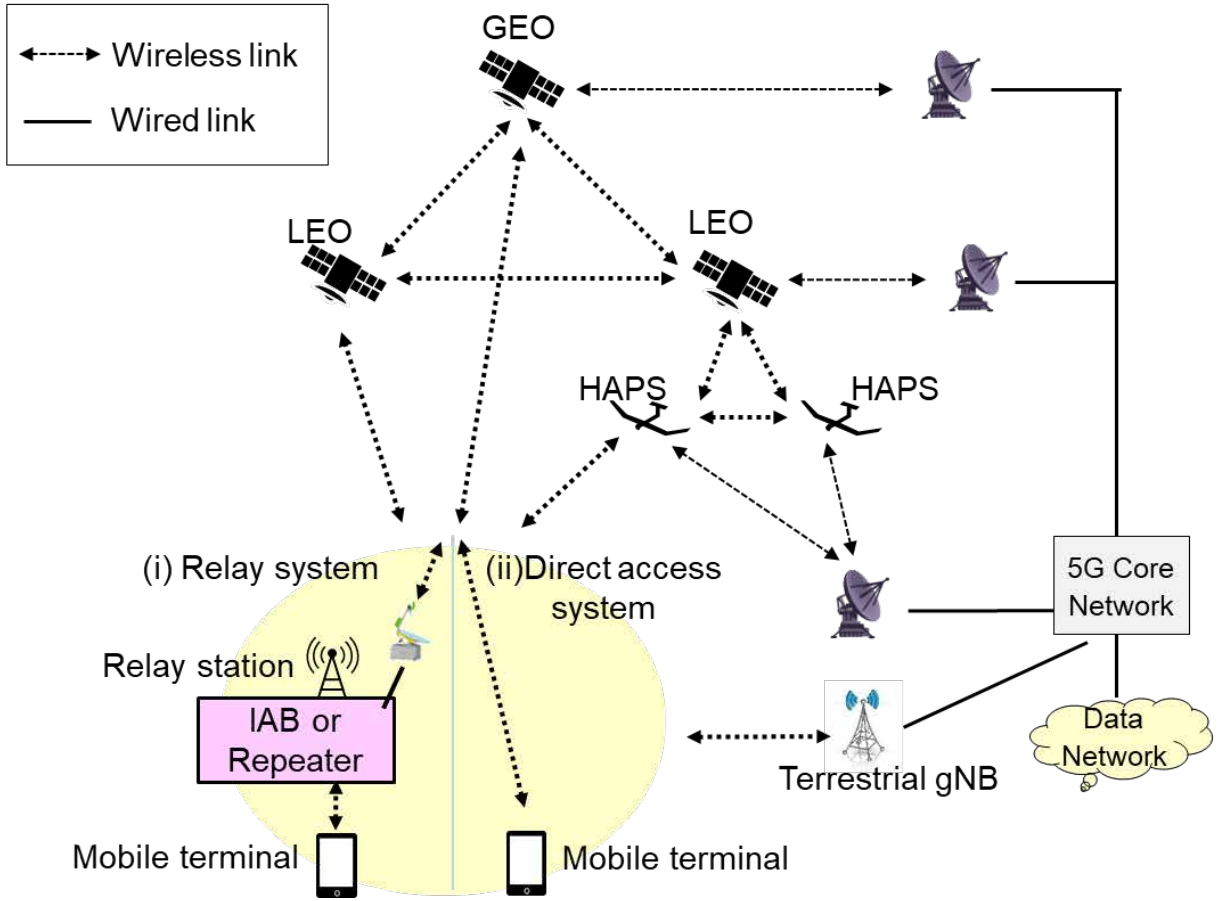
- **At initial stage, HAPS will be a promising solution for specific use cases, times and places**
  - Hotspot-like operation with a few aircraft
  - Service is expected to be introduced from south of 30 - 35 degrees north latitude due to constraints of small HAPS aircraft

- **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)

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

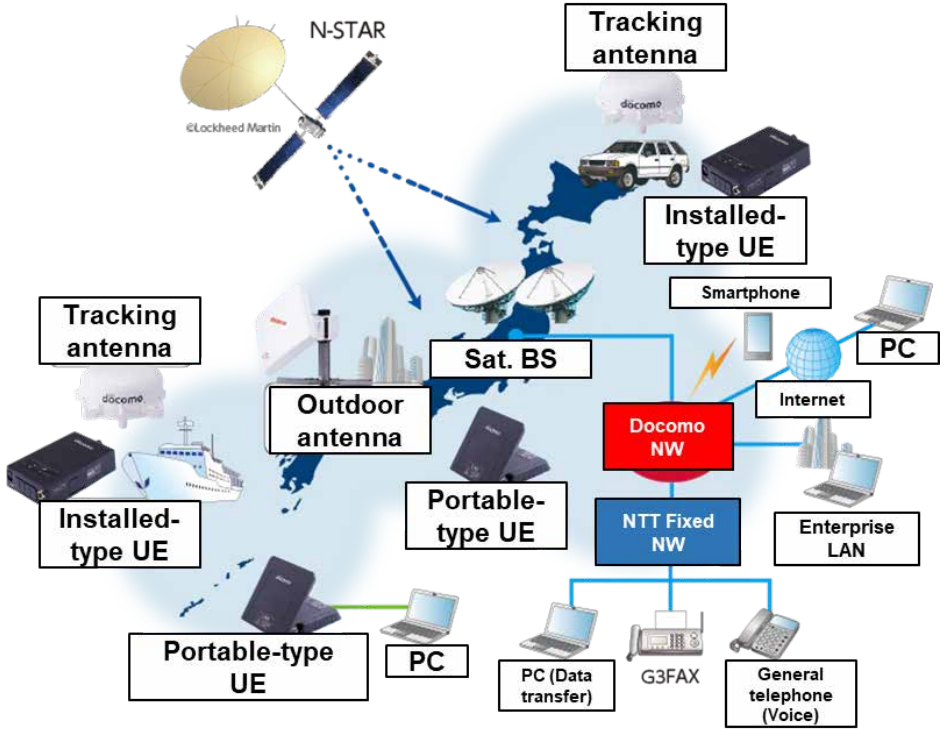
Combining GEO, LEO, and HAPS

- 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

WideStar III (GEO) and Starlink Business (LEO)

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

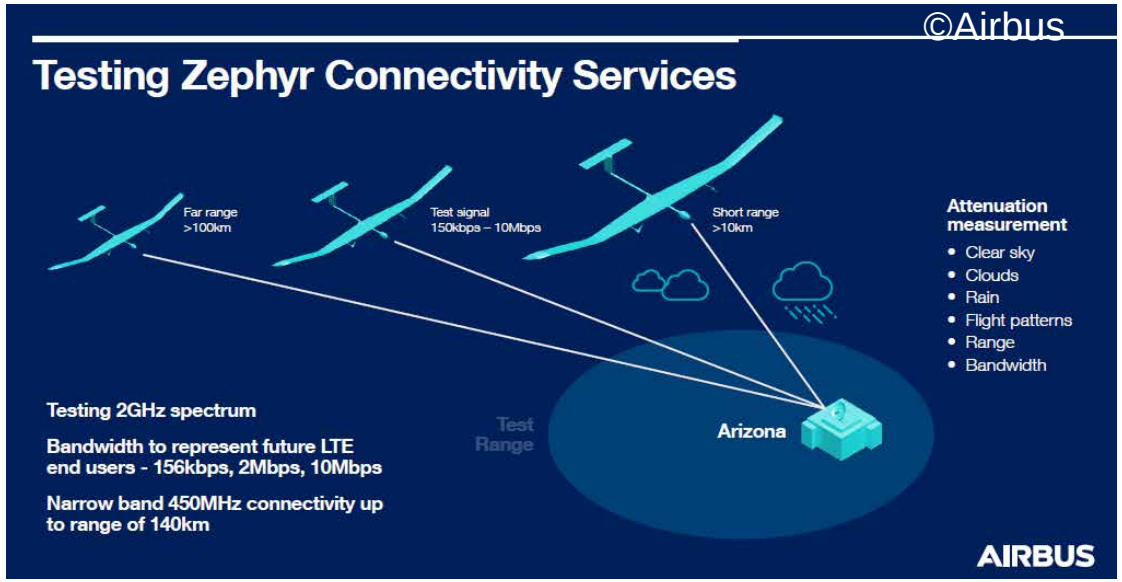
Starlink antenna

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

Stratospheric Propagation Test (Conducted by DOCOMO and Airbus)

- 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

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)