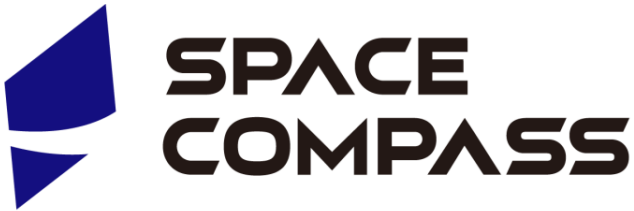
HAPS Strategy of Space Compass

Yoshihisa Kishiyama

Space Compass Corporation / NTT DOCOMO, INC.

Introduction of Space Compass

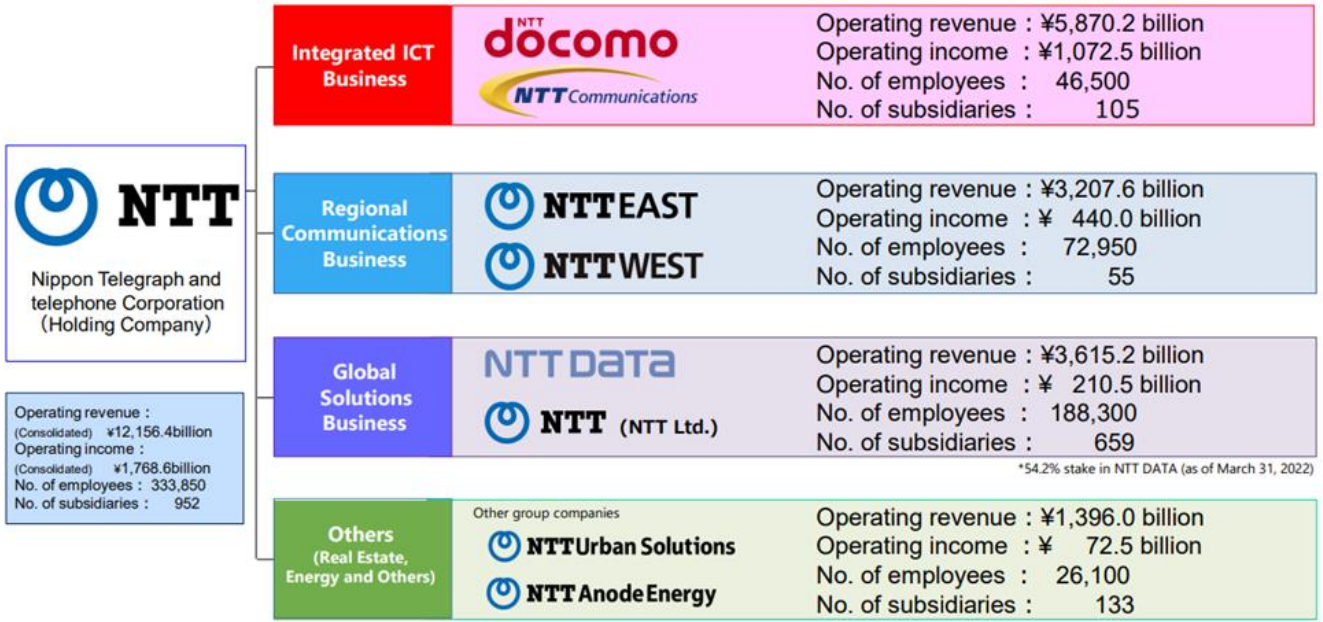


Space Compass - Company Overview

Company name (URL)	**Space Compass Corporation** (https://space-compass.com)
Co-CEO	 Shigehiro Hori  Koichiro Matsufuji
Date of establishment	20th July 2022 by NTT and JSAT
Address	Otemachi Bldg., 1-6-1 Otemachi, Chiyoda-ku, Tokyo, 100-0004, Japan
Capital stock	18B JP-Yen
Business activities	• Space Data Centers - optical data relay / space computing network service • Space RAN (Radio Access Network) - communication infrastructure for beyond-5G/6G

NTT Group

One of the largest network and computing operator in global with R&D capability which especially has some optical technologies.



- Fiscal year ended March 2022. Operating revenue and operating income of each segment include inter-segment transactions.
- No. of employees and subsidiaries are as of the end of March 2022.

NTT's Technical Vision, IOWN

■ In order to utilize all types of information beyond the limits of conventional infrastructures, photonics technologies such as photonics-electronics convergence devices will be utilized everywhere from networks to terminals to realize a network and information processing infrastructure characterized by low power consumption, large capacity, high quality, and low latency (transition from electronics to photonics).

Limitations of transmission and processing capacity | **Increasing energy consumption**

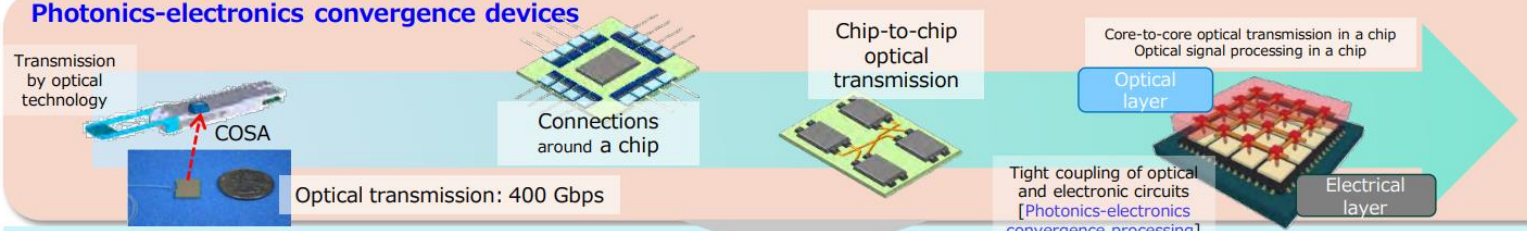
	Low power consumption	Large capacity, high quality	Low latency
Target Perform-ance	100 times greater power efficiency*1	125 times greater transmission capacity*2	End-to-end latency reduced by a factor of 200*3
	Provides various information and communication services at power consumption reduced by a factor of 100.	Capable of downloading 10,000 two-hour movies instantaneously (in 0.3 sec). (Compared with one movie in 3 sec with 5G technology)	Transmits real-time video without the latency experienced with digital TV or satellite broadcasting.

*1 Target power efficiency for portion where photonics technology is applied

*2 Target communication capacity per optical fiber cable

*3 Target latency in video traffic not requiring compression within the same prefecture

Photonics-electronics convergence devices



The world realized by IOWN

1. Total optimization of city and mobility 2. Creation of co-creative space that transcends all constraints 3. Fulfillment of body and soul by integration from the past to the future 4. Regeneration of the global environment and achievement of a sustainable society 5. Safe and secure communication

JSAT Group

Space Business

- First satellite launched in 1989
  - ✓ Know-how over 30 years of satellite operation
- Satellite capacity leasing and managed services
- Solid and diverse customer base
  - ✓ Government sector
  - ✓ Public Service Companies
  - ✓ Telcos, Enterprises
  - ✓ Broadcasters
  - ✓ In Japan and other countries

Largest Satellite Operator in Asia

JSAT

SKY Perfect JSAT Corporation

SKY PerfecTV!

Japan's Largest Multichannel Pay TV Service

- Operation started in 1996
- Pay-TV services through
  - ✓ 3 satellites
  - ✓ Optical Fiber
  - ✓ Over-the-Top VOD
- 3 million subscribers
- 200+ Channels (HD/SD/Audio)

Multichannel Pay TV Business

Joint Vision between NTT and JSAT

NTT's activities

IOWN
(low power consumption, high speed, and high reliability)

SKY Perfect JSAT's activities

Operation of various orbiting assets
Space intelligence business

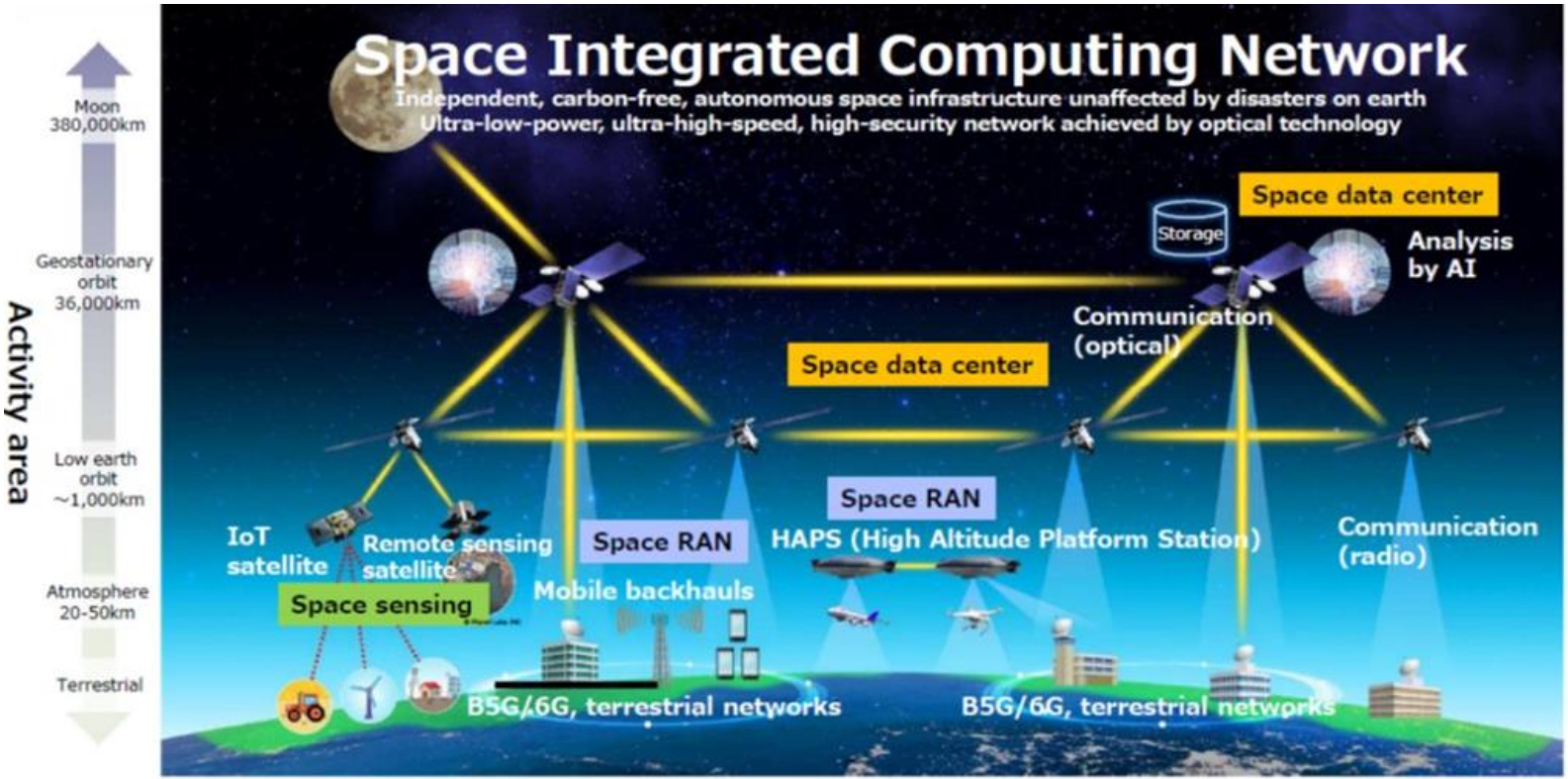
Innovations that break through limits in space

▼

Build the space integrated computing network that contributes to realizing a sustainable society

Company Vision

JSAT and NTT agreed to jointly work to the goal of creating a new space enterprise to aid realization of a sustainable society, combining NTT's IOWN technology and JSAT's space asset operation capability.



New Space Businesses under the Vision

SPACE COMPASS

Realizing the flow from information gathering to value in space

Space Data Center

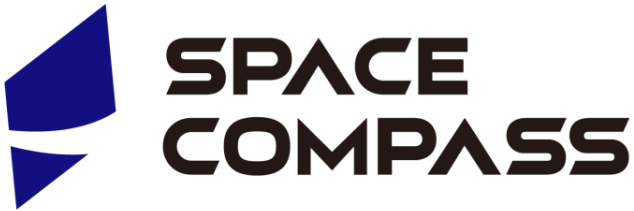
- Optical satellite data relay network for LEO satellites
  + data center with high-performance processors in space

Space RAN (Radio Access Network)

- Space communication infrastructure looking ahead to 5G evolution & 6G and observation

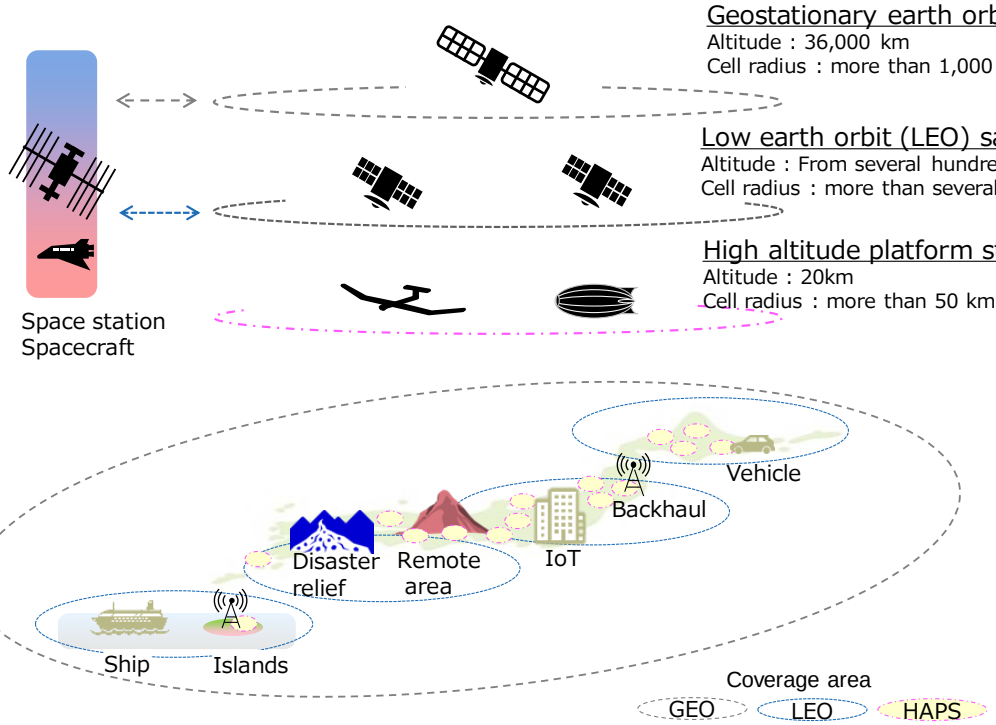
  Target early commercialization of HAPS in FY 2025

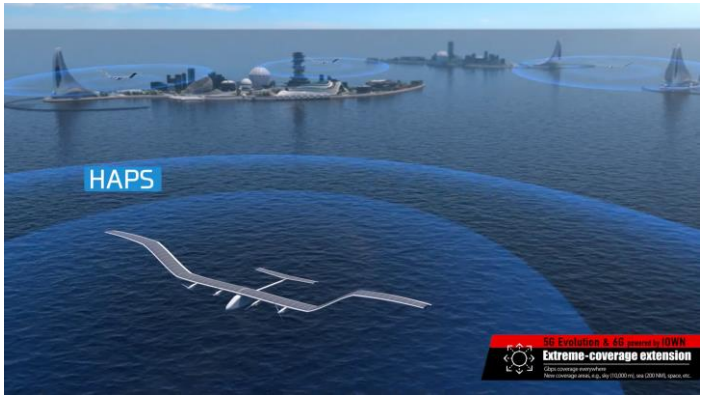
HAPS Strategy toward Early Commercialization



NTN (Non-Terrestrial Network)

- Aiming to provide various services to areas that were not covered by conventional mobile communication networks

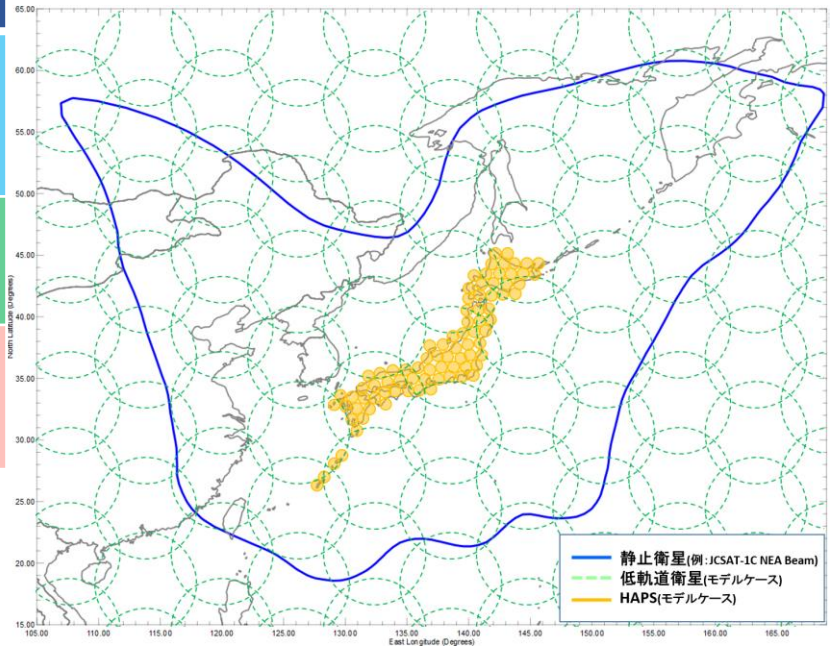




Features of HAPS Compared to GEO/LEO

	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

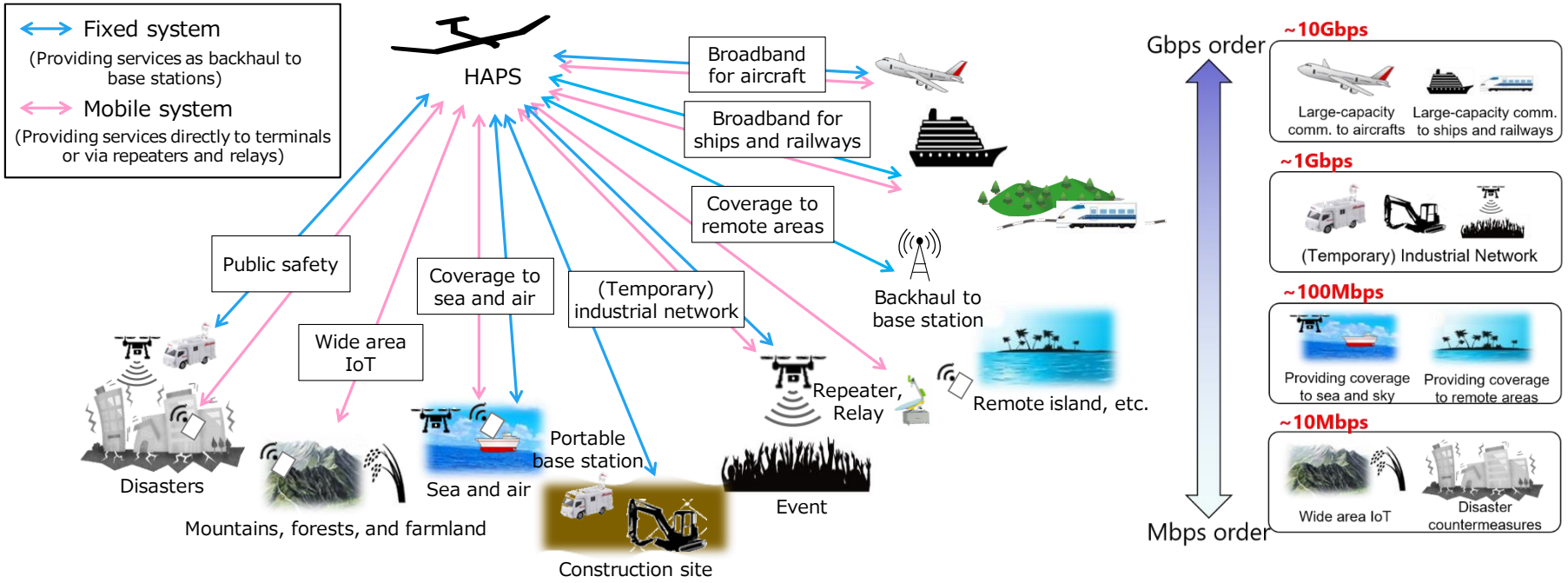
*1 Values depend on altitude and elevation



- Features of HAPS
  - Area radius is inferior to LEO/GEO, but low latency and high throughput are expected
  - Can communicate directly with smartphones
  - Fixed-point observation is possible because HAPS can be seen almost stationary from the ground

NTN/HAPS Use Cases

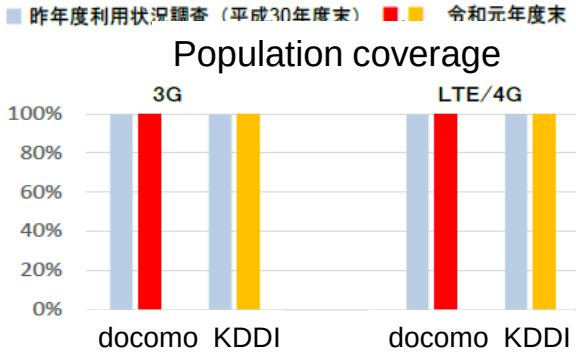
- Combination of NTN and terrestrial networks will allow for cost-effective area expansion
- 100% area coverage for 5G evolution & 6G → Useful for many business use cases
- Various requirements for each use case (throughput, delay, mobility, terminal size, etc.)

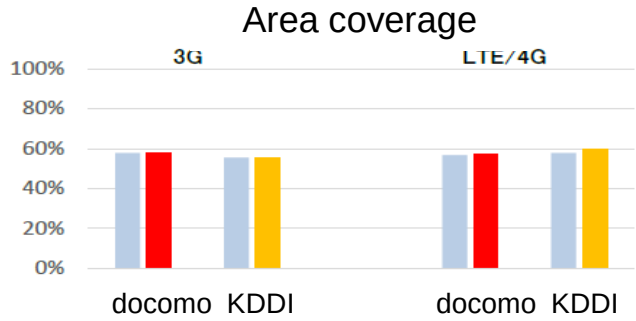


Population Coverage and Area Coverage in Japan

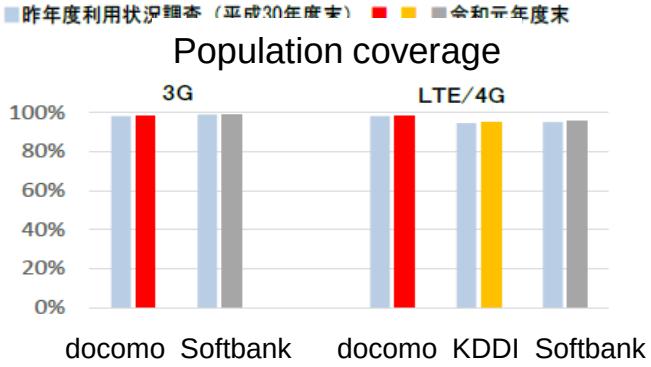
Reference (Japanese): https://www.soumu.go.jp/main_content/000720959.pdf

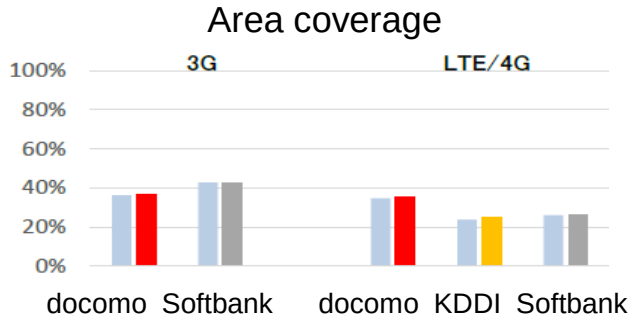
800MHz





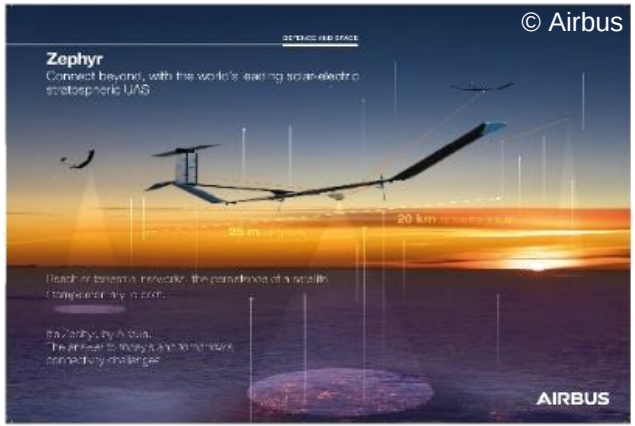
2GHz





Partnership to Realize Space RAN

- Airbus, NTT, DOCOMO and SKY Perfect JSAT jointly studying connectivity services from HAPS (Jan. 2022)
  - The purpose of a memorandum of understanding (MOU)
    - Promotion of R&D for early commercialization of HAPS in Space RAN business
    - Discuss and identify possible future developments necessary to (i) unlock future HAPS-based connectivity services, (ii) lobby for standardization and institutionalization of HAPS operations, and (iii) explore business models for commercializing HAPS



Airbus "Zephyr" HAPS aircraft


Establishment of joint company "Space Compass Inc." between NTT and SKY Perfect JSAT

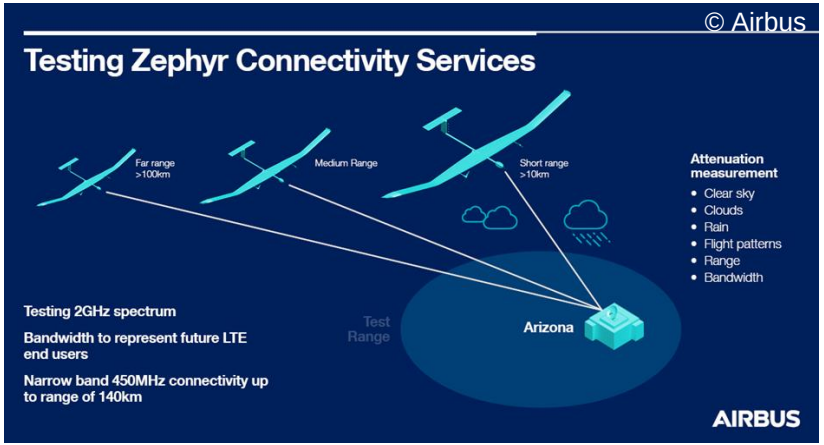
July 2022

Zephyr Achieves Connectivity in Trial Conducted by Airbus and NTT DOCOMO (Nov. 2021)

SPACE COMPASS

- Flight test overview
  - Propagation measurement by transmitting radio waves to the ground in the **UHF-band** (2GHz, 450MHz) from the HAPS “Zephyr S” during a stratospheric flight
  - Confirmed the viability and versatility of the 2GHz spectrum for HAPS-based services and the use of a narrow (450MHz) band to provide connectivity **in a range of up to 140km**
  - **18-day** stratospheric flights
  - Focusing on assessing how connectivity is affected in the stratosphere by factors **including weather conditions, different elevation angles and aircraft flight patterns**
  - **Included various bandwidths** to simulate direct-to-device service from the HAPS to end users using low, nominal and high throughput

“Zephyr S” at takeoff

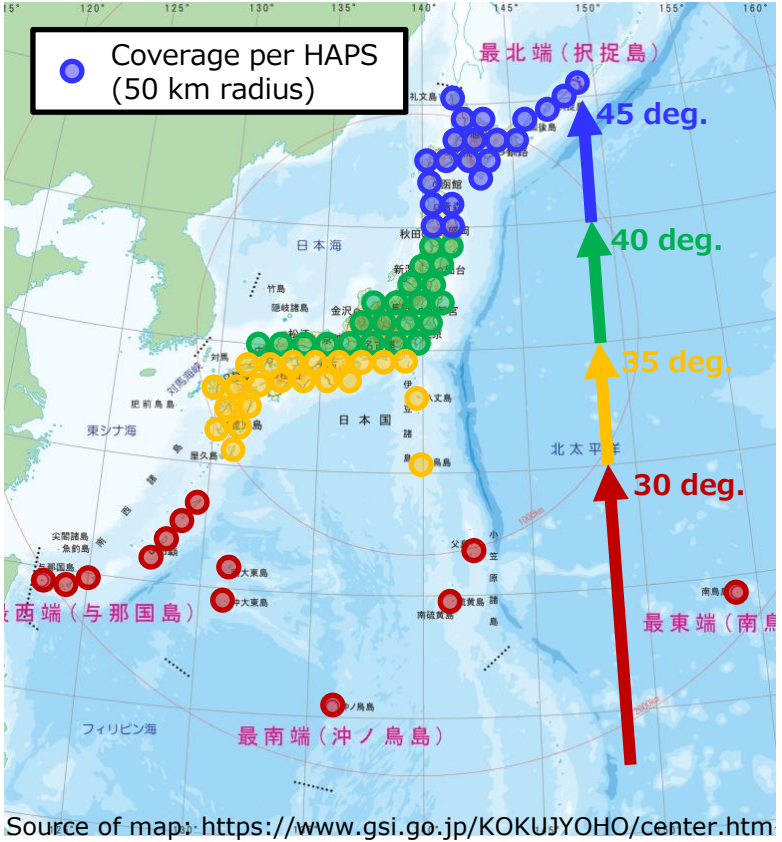


Test overview

Image of HAPS Deployment in Japan

- **Initial deployment will focus on specific locations and use cases**
  - Launch from several spots with market needs
  - Introduced from the south of about 30-35 degrees north latitude
    - Support for higher latitudes is possible for a limited time
  - Advantages over existing satellite solutions are needed ➔ Direct access to user devices

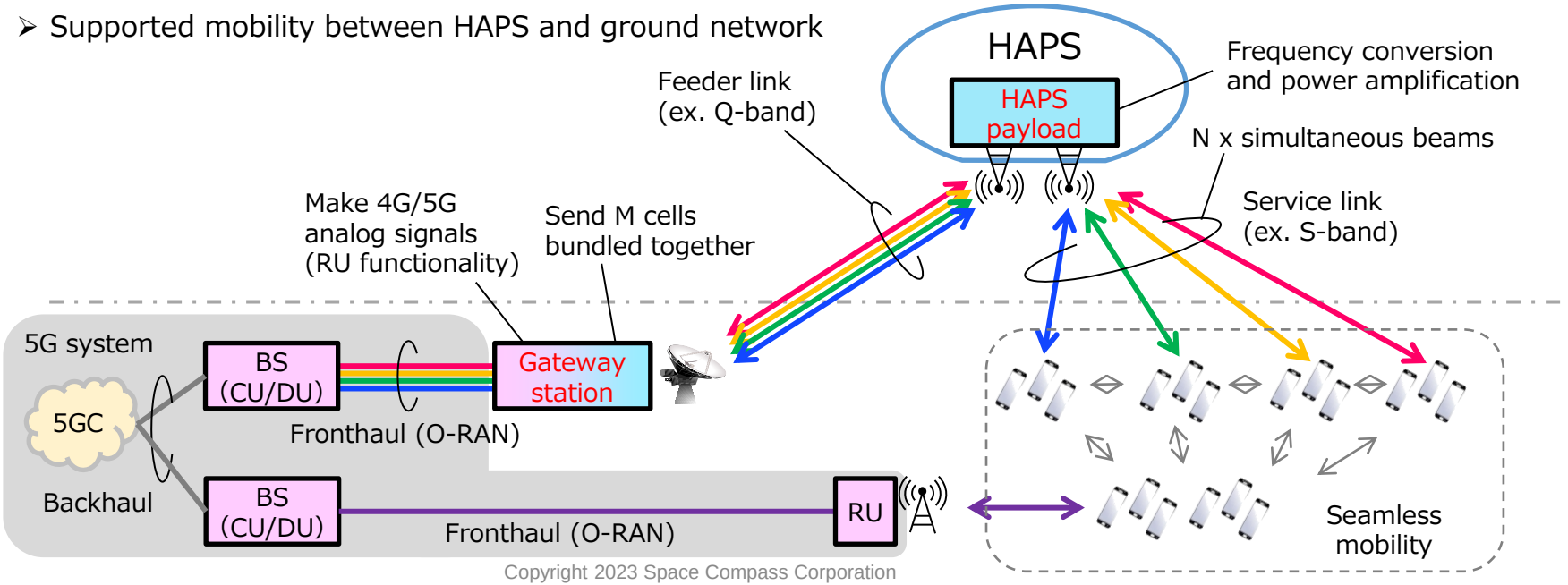
- **Gradually expand coverage nationwide while considering market needs and cost reductions of HAPS**
  - Evolution of HAPS aircraft is necessary
  - Reasonable costs are essential compared with other coverage expansion solutions such as satellites and optical fiber cables
  - Consideration for joint use with new satellite solutions such as LEO



Source of map: https://www.gsi.go.jp/KOKUJYOHO/center.htm

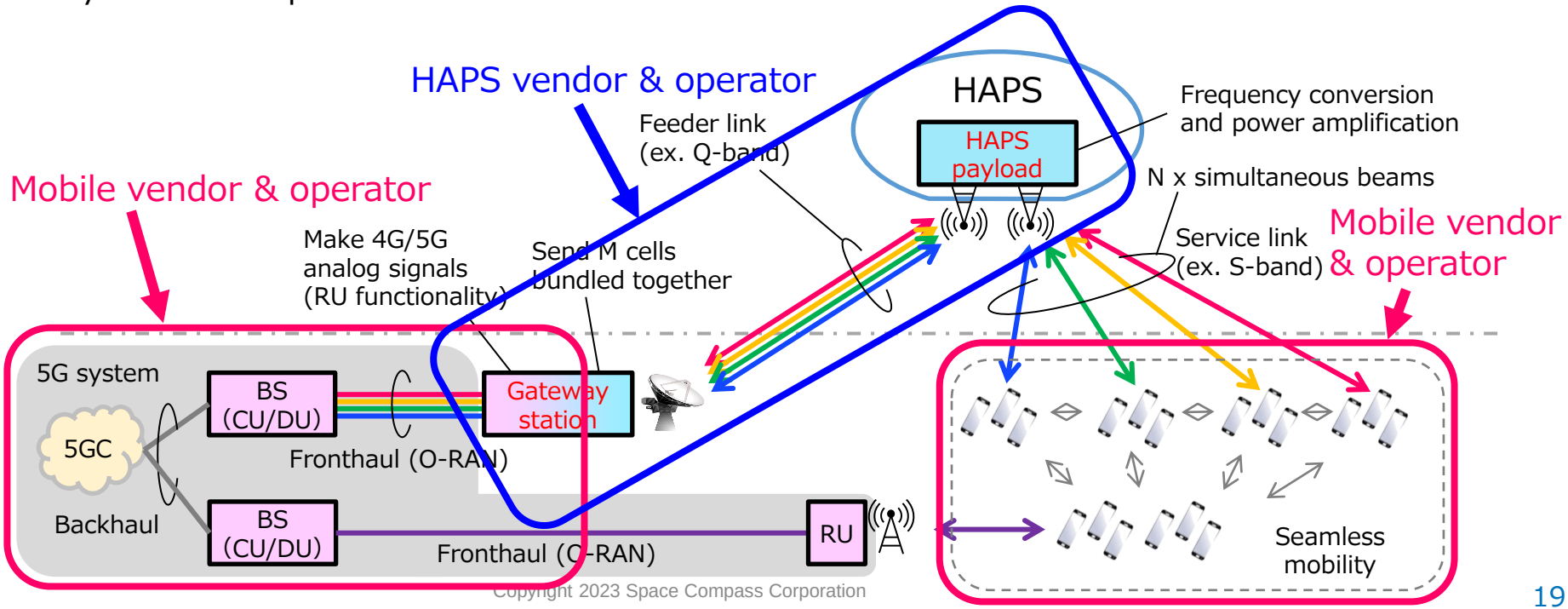
HAPS Direct Access with 5G Network

- Base station on the ground transmits 5G signals directly to user devices via GW station and HAPS-equipped payload systems
  - High-frequency bands used for feeder links (signals of multiple cells/beams are bundled)
  - IMT (5G) frequency bands used for service link (below 2.7 GHz)
  - Supported mobility between HAPS and ground network



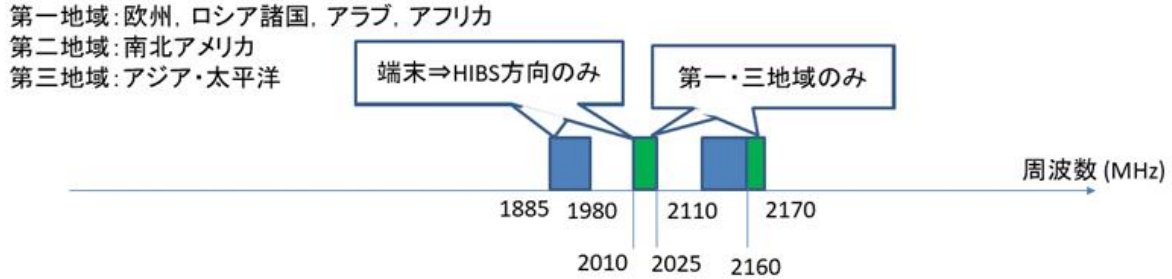
HAPS Direct Access with 5G Network

- Industrial partnership is important to realize the ecosystem
  - HAPS operator needs to work with mobile operator to operate the system
  - System development also needs to be coordinated between HAPS vendor & mobile vendor

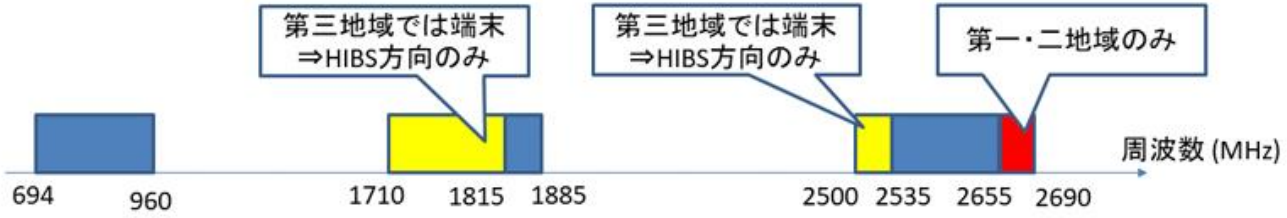


Frequency for HAPS Service Link

- Under current international rule, only 2GHz FDD band is available
  - 1885-1980MHz (UE⇒HAPS only) ・・・ FDD uplink, used by MNOs in Japan
  - 2010-2025MHz (UE⇒HAPS only) ・・・ TDD band, not used in Japan
  - 2110-2170MHz ・・・ FDD downlink, used by MNOs in Japan



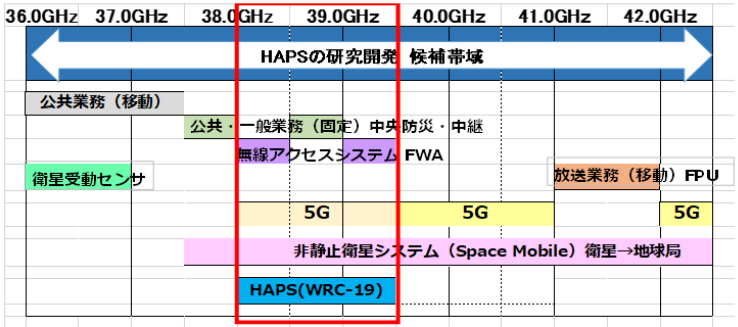
- Expanding available frequencies as international rule to be discussed at WRC-23
  - Frequency bands used by MNOs in Japan included - 700MHz, 800MHz, and 1.7GHz
  - Relaxation of conditions could allow the use of 2GHz TDD band



Frequency for HAPS Feeder Link

- 38-39.5GHz, identified band in WRC-19, is under study as promising candidate
  - Because of its wider bandwidth compared to other candidate frequency bands (31-31.3 GHz, 47.2-47.5GHz, 47.9-48.2GHz, etc.)
  - Need for further bandwidth expansion for WRC-27 is also under consideration

共用検討範囲



共用検討結果

	回線種別	被干渉システム				
		無線アクセス	公共一般	5G基地局	5G移動局	LEO GW局
与干渉	HAPS⇒GW	◎	◎	○	○	○
	GW⇒HAPS	△	○	○	○	○
	HAPS⇒CPE	◎	◎	○	○	○
	CPE⇒HAPS	△	○	○	○	○

注記： ◎：共有可能、○：干渉軽減策や運用制限等にて共有可能 △；干渉軽減策、運用制限に加え、調整交渉が必要

Positive study results for sharing with other systems

Air Interface for HAPS

- 3GPP discusses extension to NTN, but can use the same specifications for HAPS as for normal 4G/5G networks
  - ✓ Coverage extension for 5G TDD band is a potential need for HAPS
  - ✓ Support for long distance transmission (e.g. 100km) is required, so even if specifications are supported, implementations may not

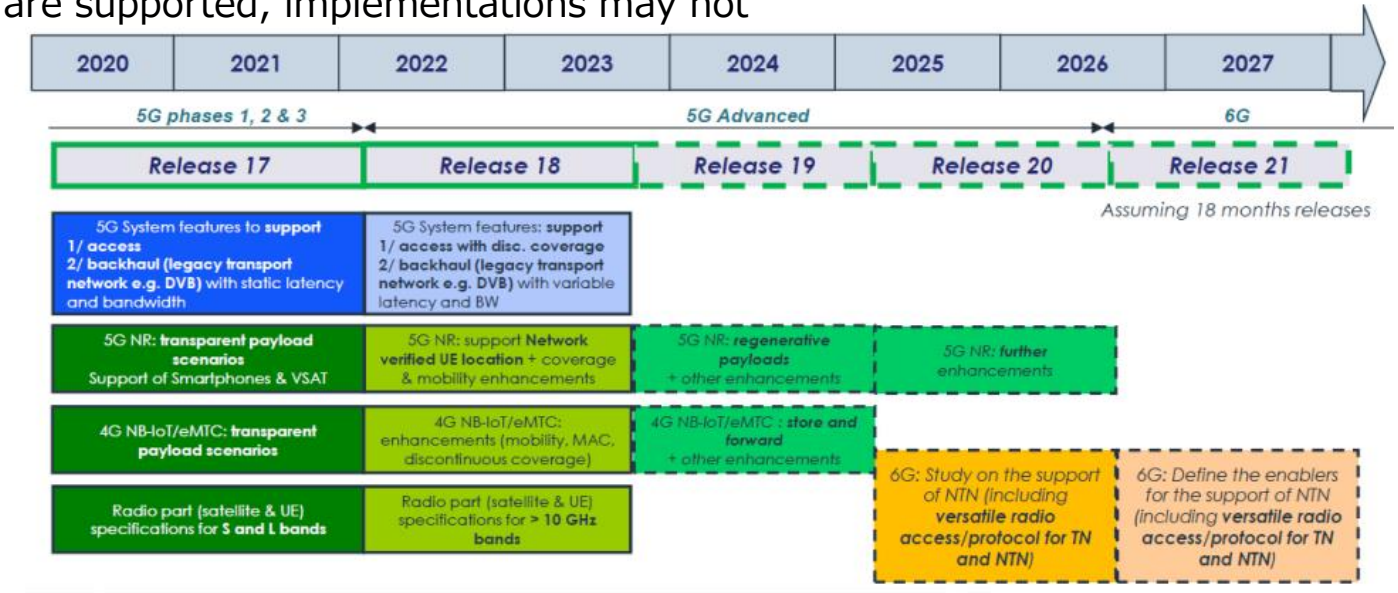


Table 2: 3GPP NTN standardisation roadmap (source Thales Alenia Space)

Steps of NTN in beyond 5G and 6G

It is assumed that the functional equipment of NTN will proceed in stages

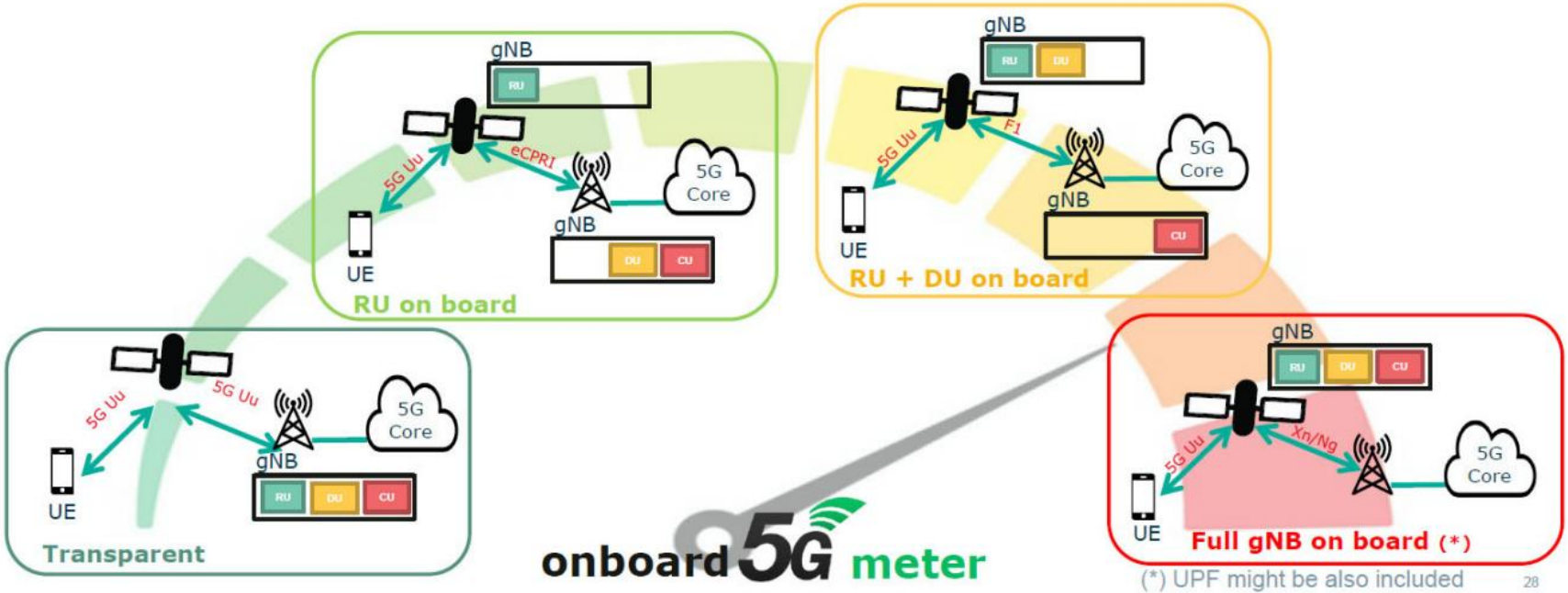
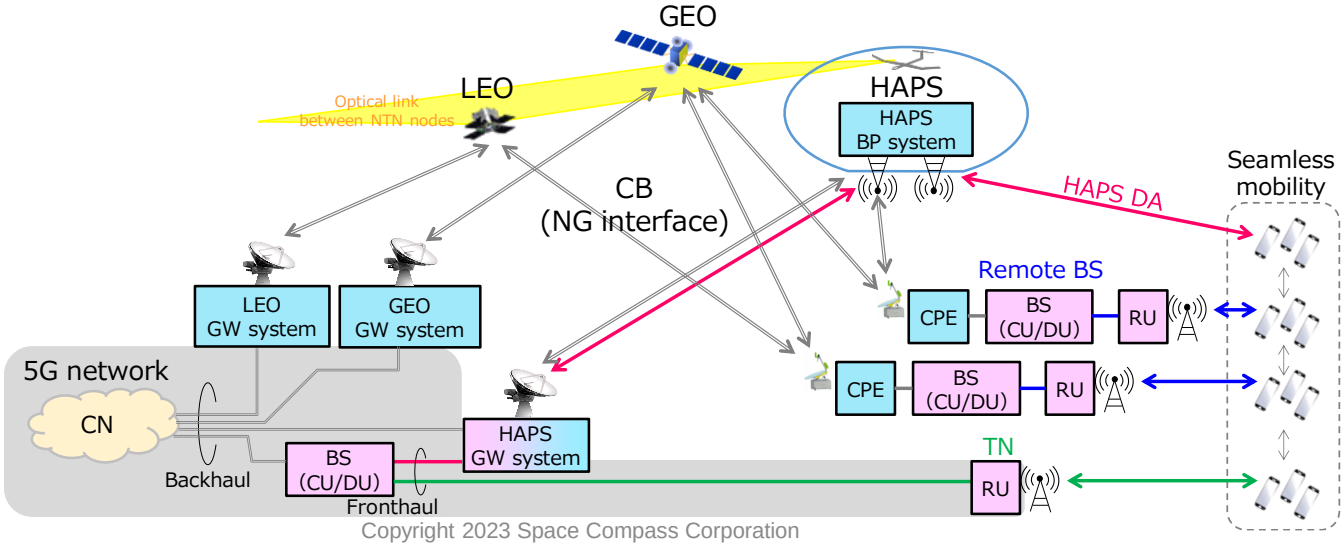


Figure 7 : From transparent to full gNB satellite (source ESA)

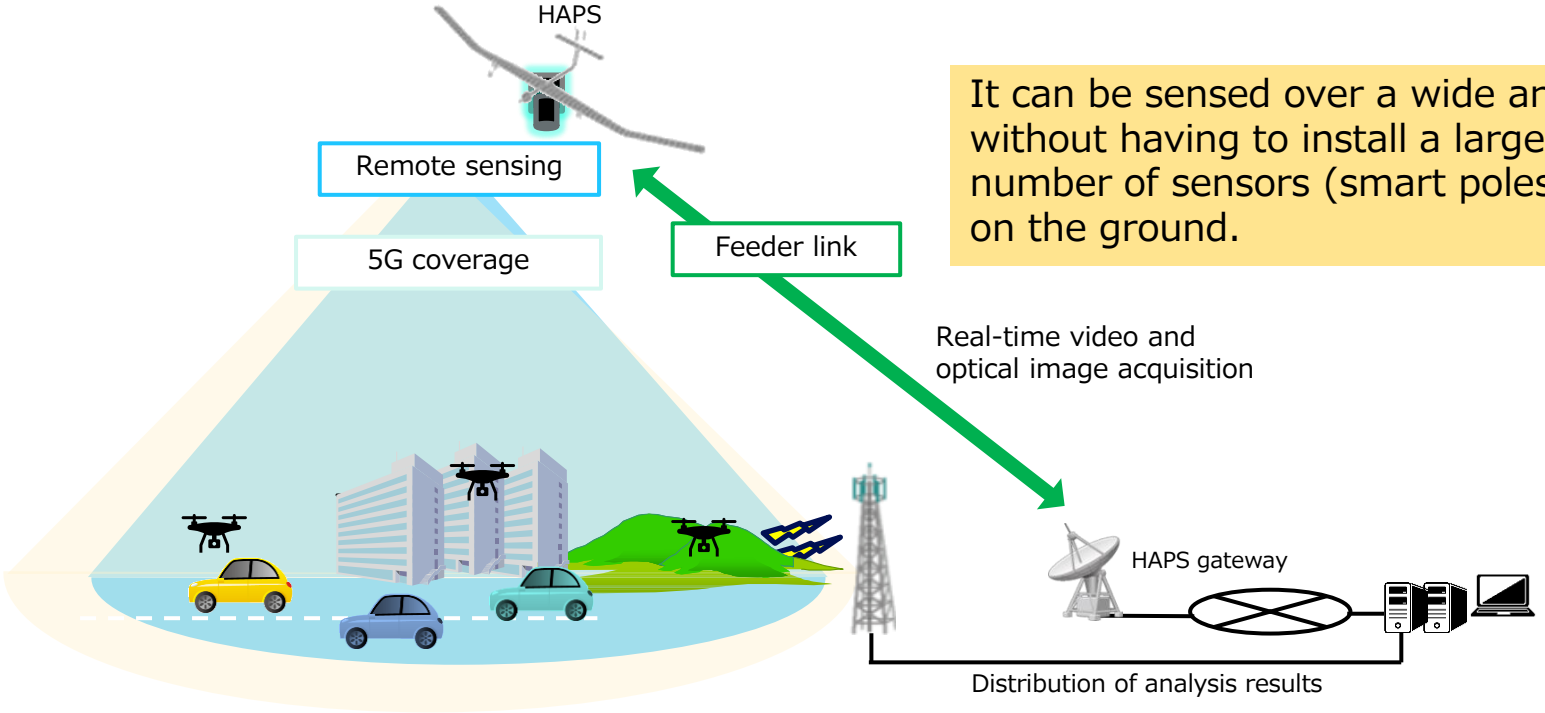
Future NTN Evolution with GEO/LEO/HAPS

- Cost-efficient coverage extension & system migration
  - Balanced use of GEO/LEO/HAPS to reduce network costs while providing the required quality of service
- Providing communications everywhere
  - Combined use of GEO/LEO/HAPS provides both direct access and cellular backhaul everywhere
  - When it is difficult to install GW station within HAPS coverage area, such as at sea or on isolated island without fixed lines, solution that provides backhaul to HAPS through GEO/LEO is effective

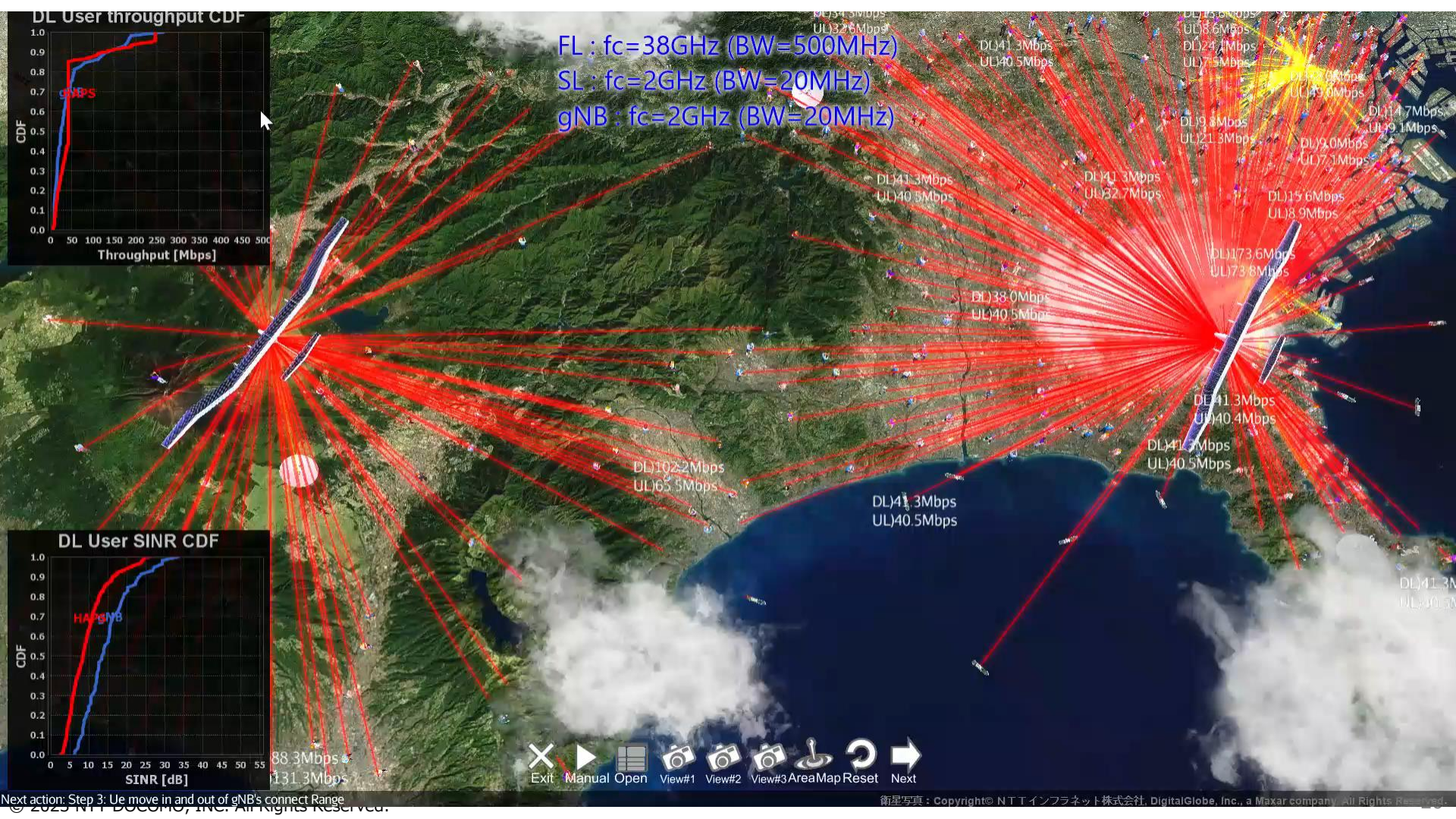


Remote Sensing and Communication Using HAPS

- Using HAPS with optical sensors or radar as a means of acquiring information
- Distribution of analysis results related to acquired information using HAPS or TN



It can be sensed over a wide area without having to install a large number of sensors (smart poles, etc.) on the ground.



Moving forward together!

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