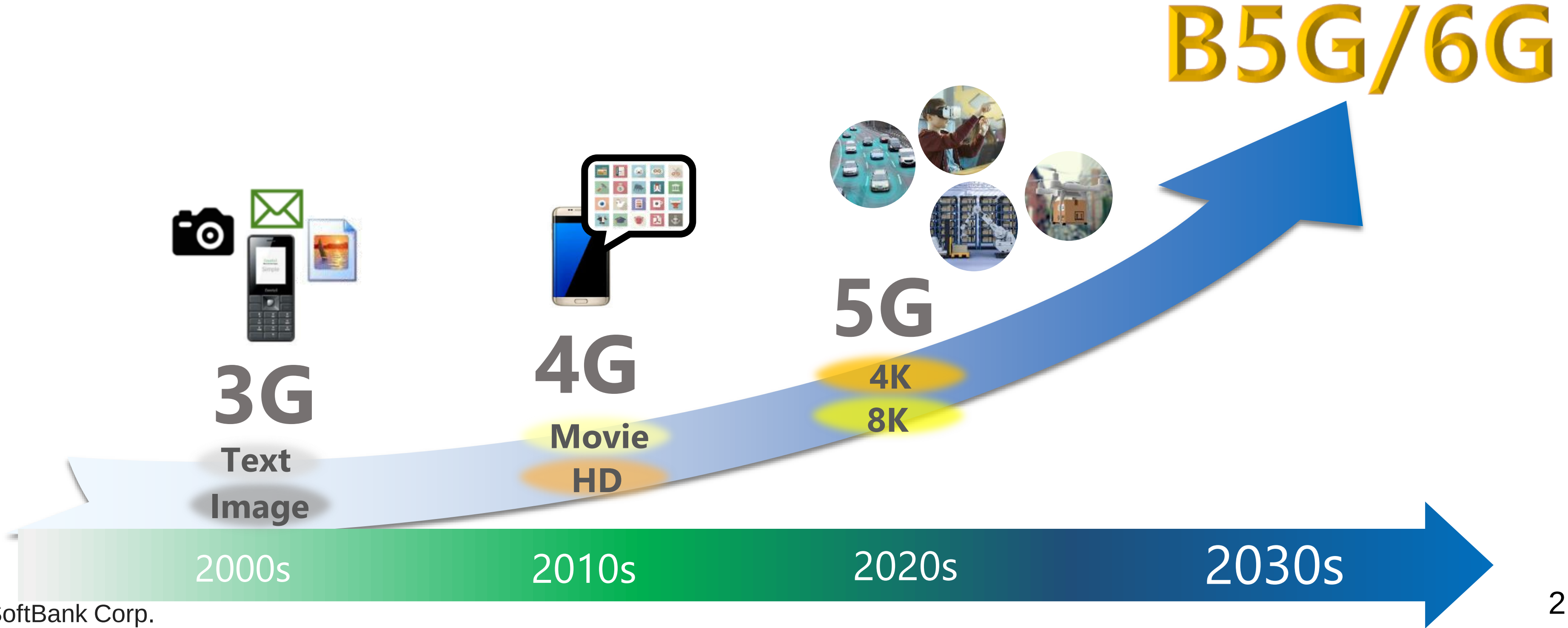
Network infrastructure in the 5G era and beyond

February 7, 2023

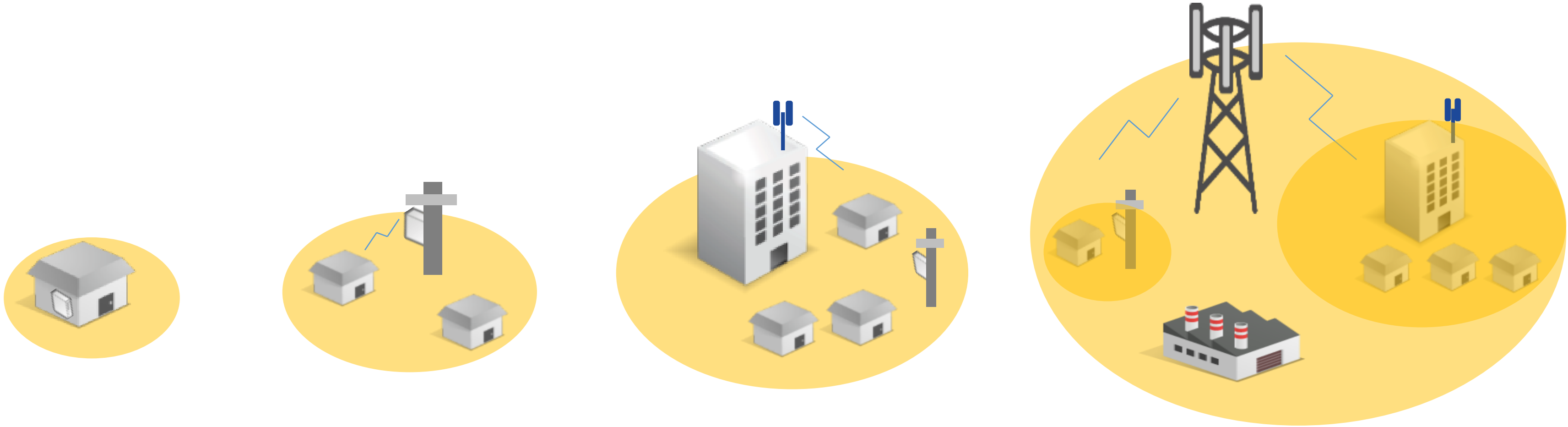
SoftBank Corp.

Communication platform development

Towards the new era beyond 5G, communication platform needs to evolve to provide enriched connectivity for all things, information and humans



Current area coverage method



Picocell (indoor)

Microcell (hotspot)

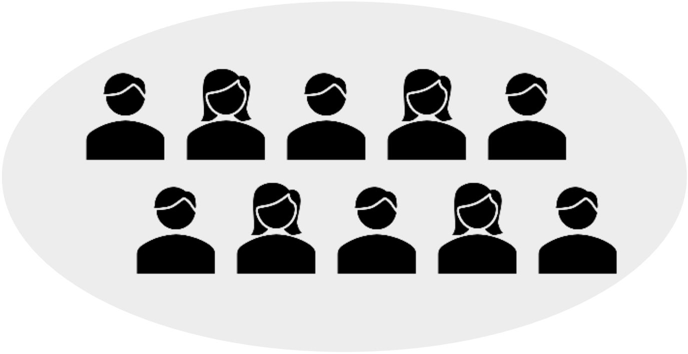
Macrocell (rooftop)

Wider Macrocell (tower)

Terrestrial NW coverage

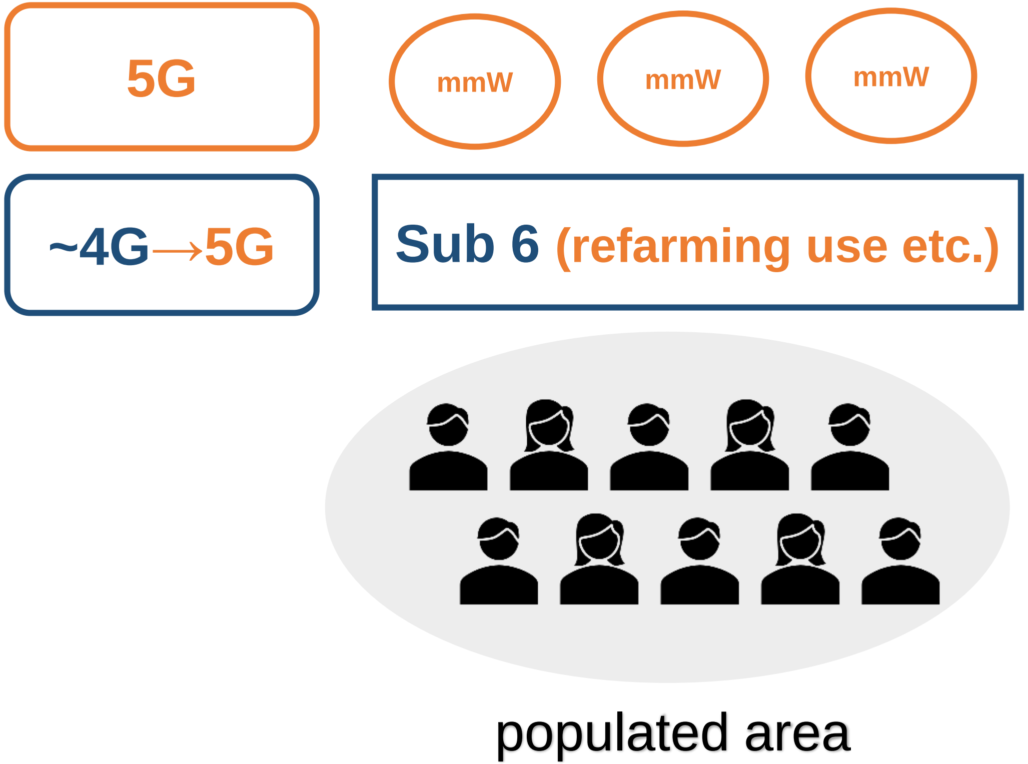
~4G

Sub 6



populated area

Terrestrial NW coverage

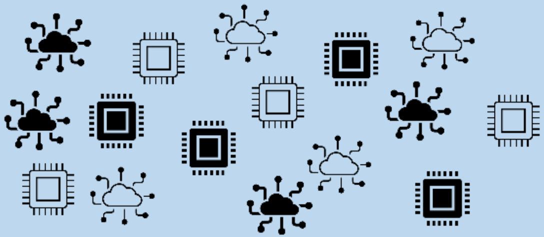


Network deployment trends

populated area coverage

~4G

IoT devices everywhere

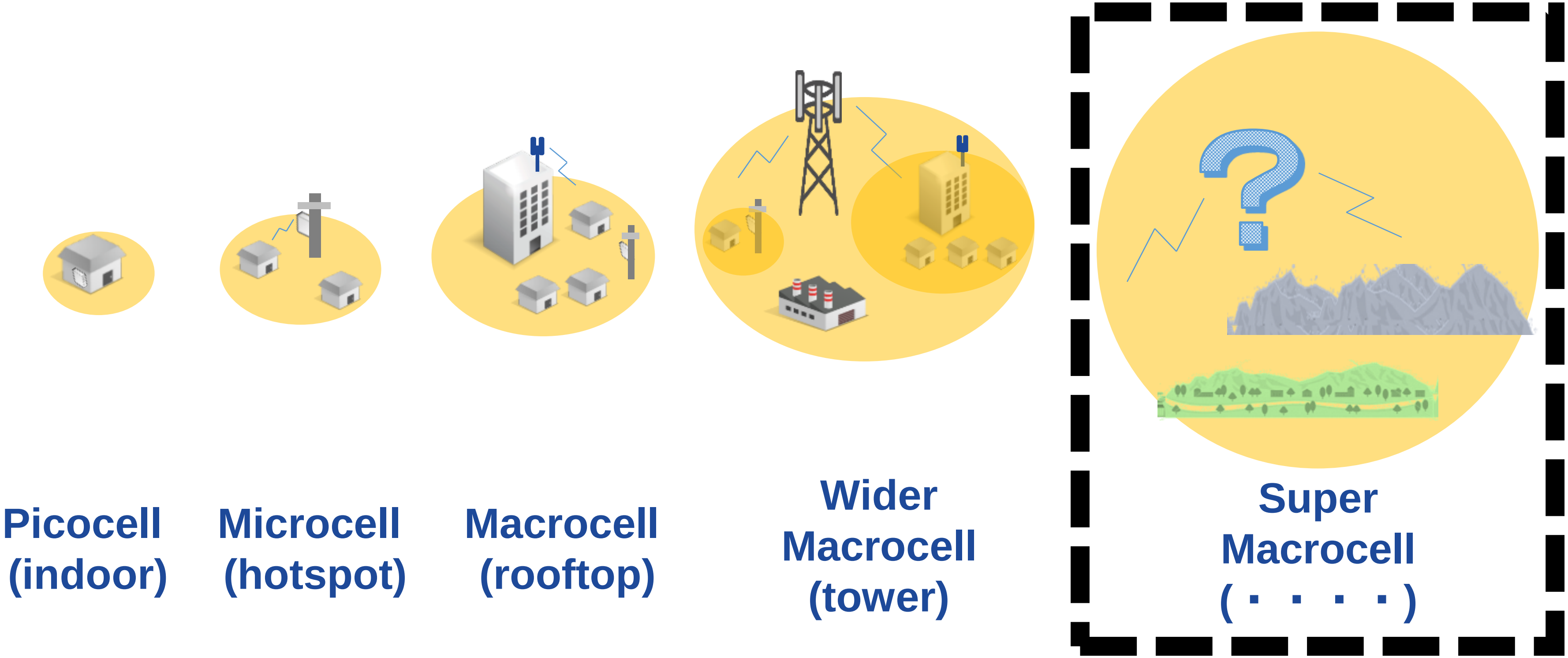


5G and beyond

2.9 billion people around the world still can not or do not access the Internet

SOURCE
・International Telecommunication Union. Measuring digital development: Facts and figures 2021.
https://www.itu.int/en/ITU-D/Statistics/Documents/facts/FactsFigures2021.pdf
・ International Telecommunications Union. World Telecommunication/ICT Indicators Database 2021. 25th edition.
https://www.itu.int/en/ITU-D/Statistics/Pages/publications/wtid.aspx

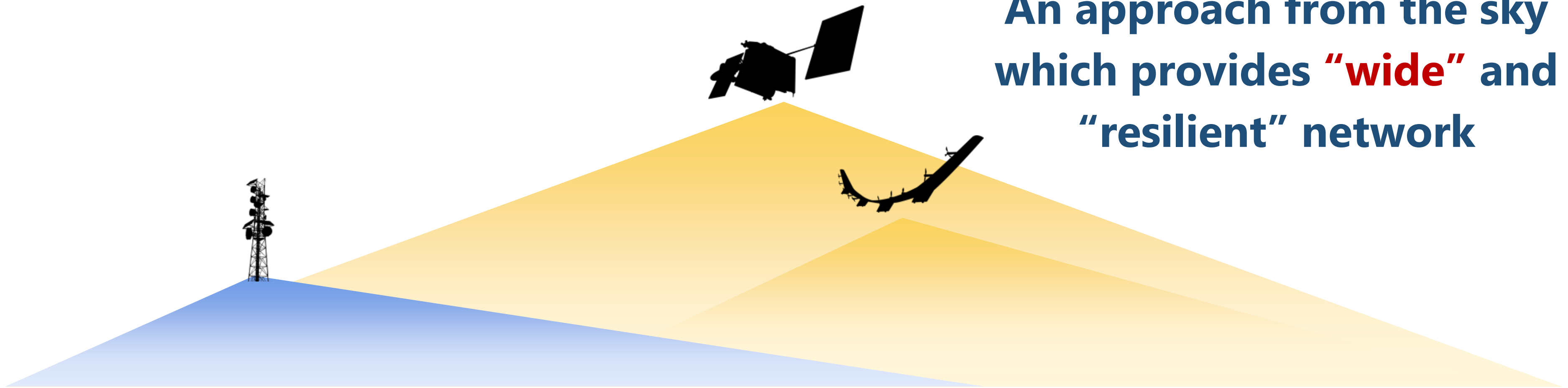
New area coverage method needed



For those areas yet/hard to have ground-based coverage

NTN (Non-Terrestrial Network)

An approach from the sky which provides **“wide”** and **“resilient”** network



Dense Urban | Urban | Rural | Super Rural | Maritime / Sky

NTN (Non-Terrestrial Network)

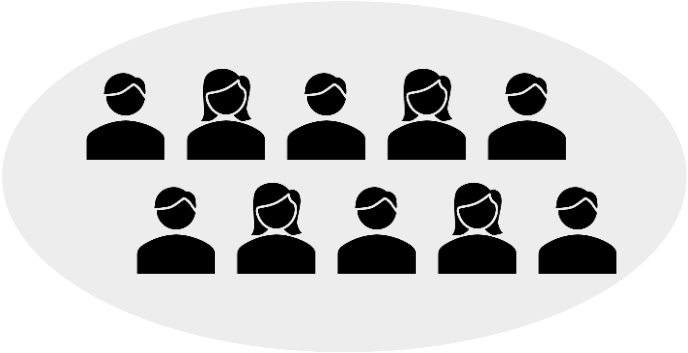
An approach from the sky which provides "wide" and "resilient" network

Also, in case of disasters

Coverage expansion by NTN

~4G

Terrestrial NW



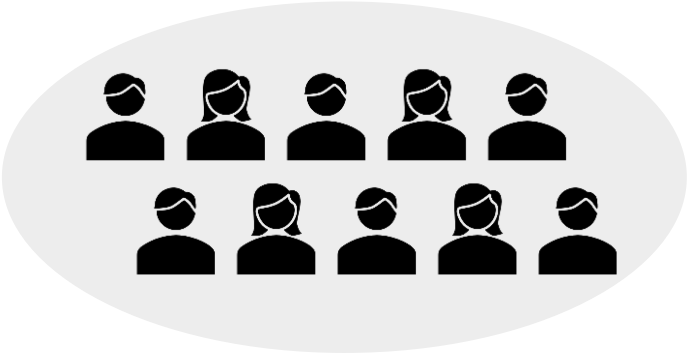
populated area

Coverage expansion by NTN

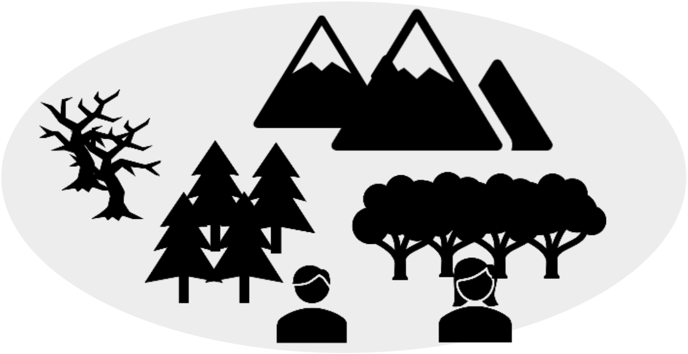
~4G

Terrestrial NW

NTN

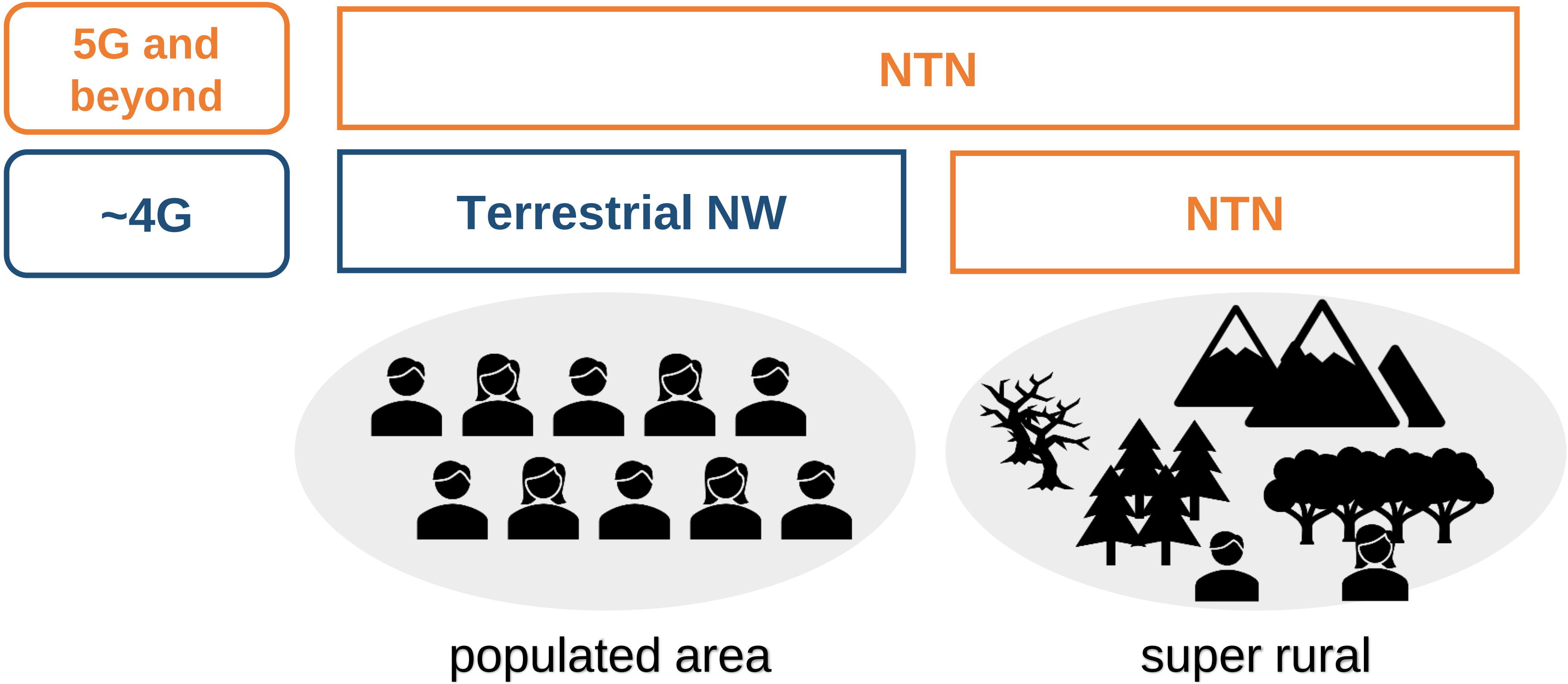


populated area

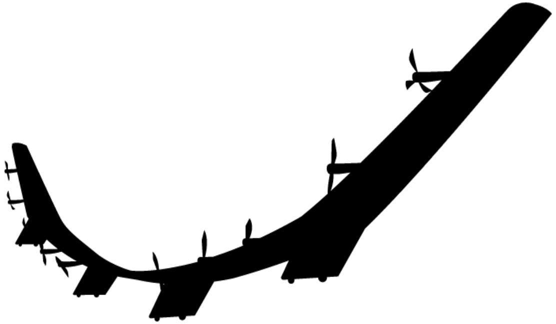


super rural

Coverage expansion by NTN

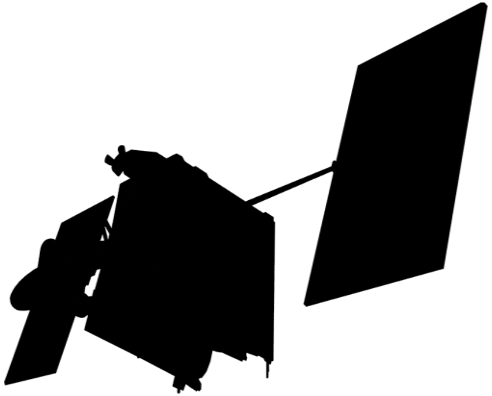


Which NTN is more ・・・?



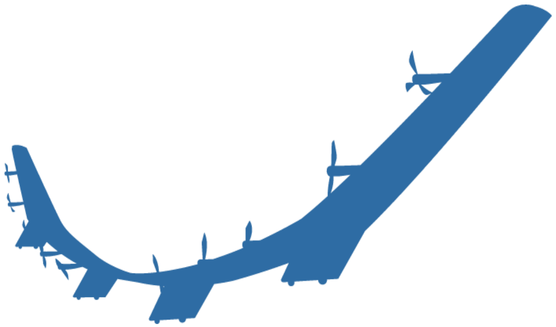
HIBS

in stratosphere



Satellite

in space



HIBS Fundamentals

HIBS

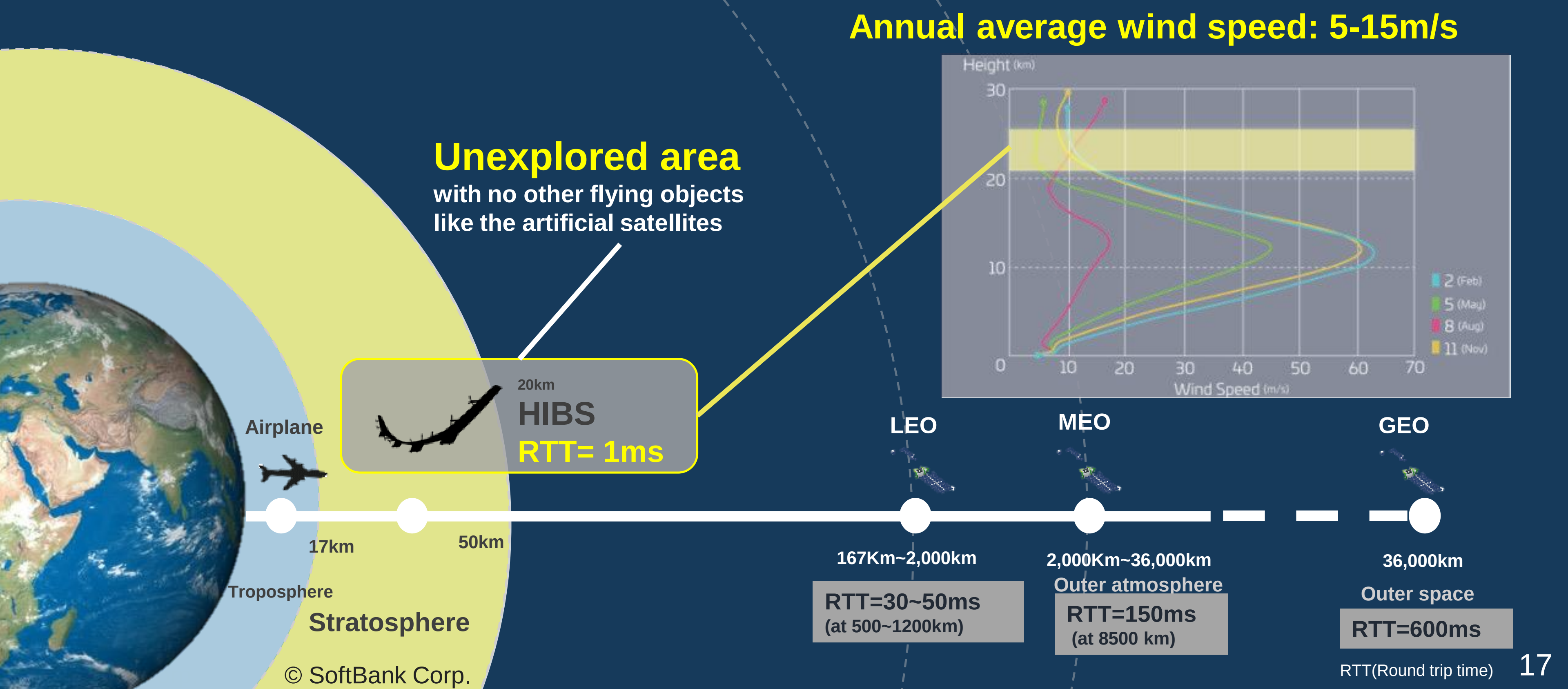
“**H**igh altitude **I**MT **B**ase **S**tations”

or

HAPS as IMT base stations

*HAPS = High altitude platform stations

Advantage of Stratosphere



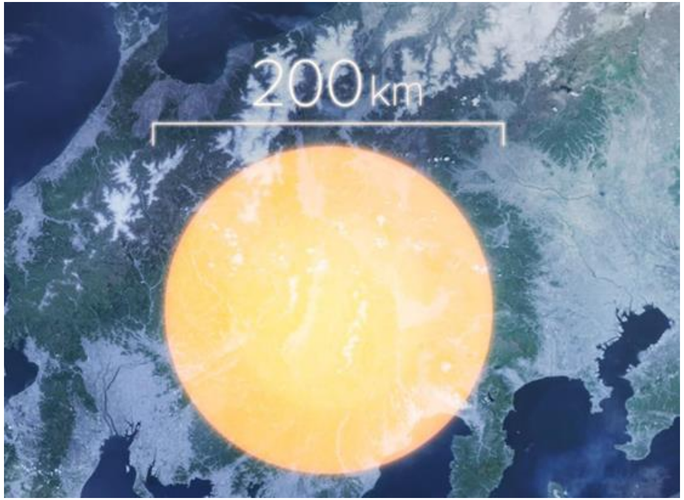
Basic Features of HIBS

Ability to fly
for several months continuously

Stationary rotation possible
at any coordinate

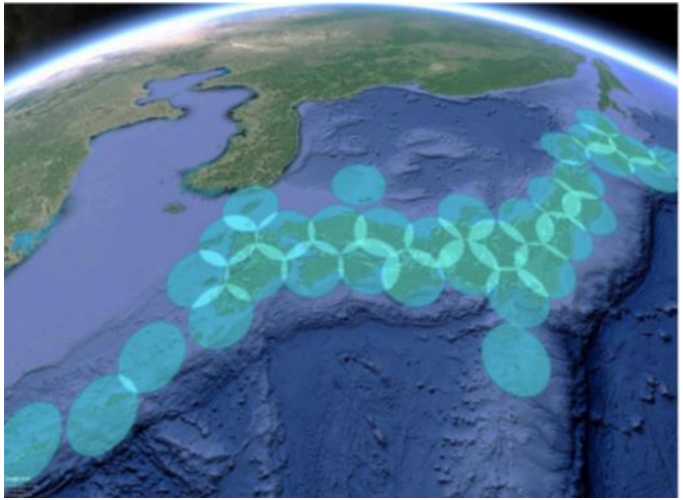
HIBS Coverage

Certain Area



200km diameter
covered by 1 HIBS

Wide Area



Approx. 40 HAPS can cover
Japanese archipelago

Remote area coverage

- Spatial axis in horizontal direction -

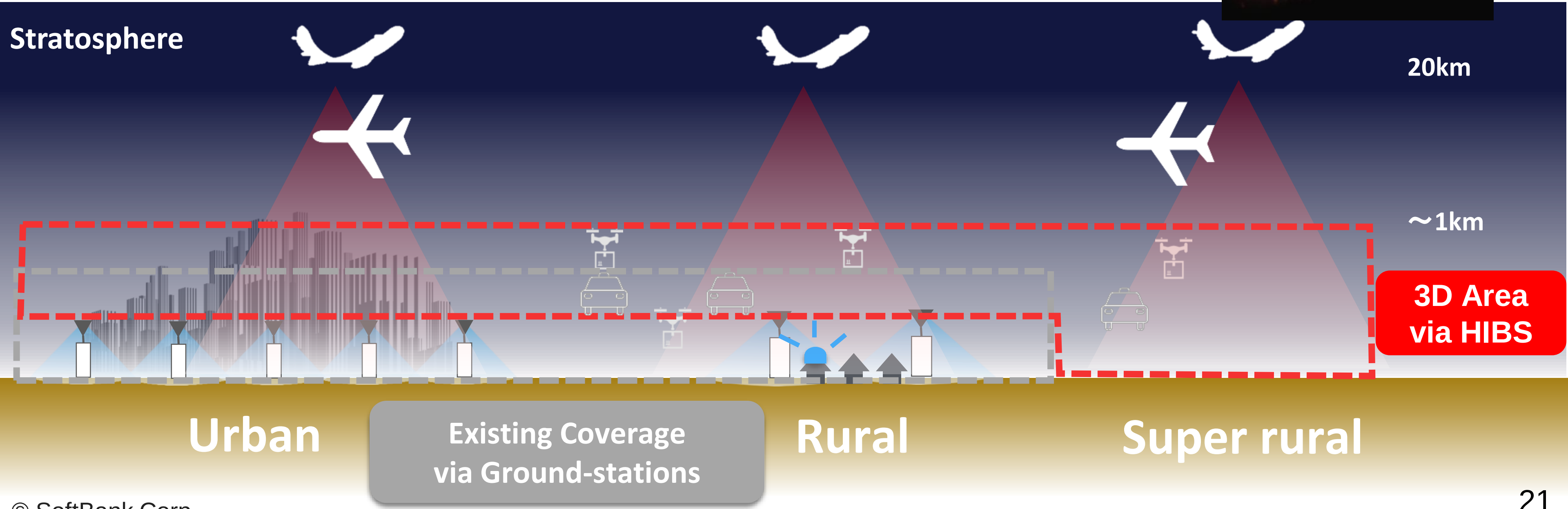
- HIBS can broadly cover **around 200 km in diameter, which will offer cost-effective services to the remote areas** where with no network yet

- Areas where they have challenges to build ground stations such as **isolated islands, mountainous areas and deserts, HIBS can contribute to cover from the sky**

3D Area coverage

- Spatial axis in vertical direction -

- HIBS is capable of providing services not only to the ground but also the sky so that the **network can be leveraged to the flight vehicles like drones and air taxis**.



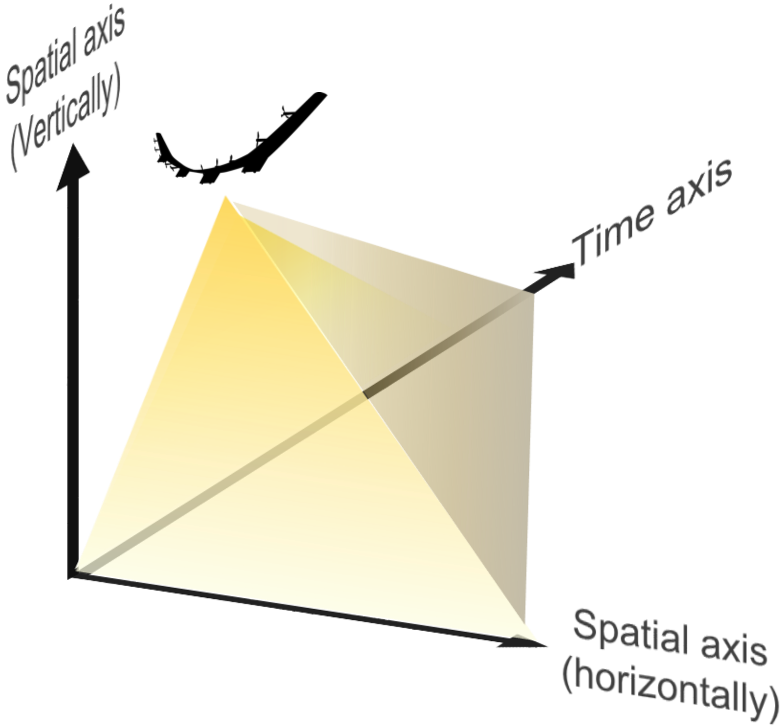
Uninterrupted coverage during disaster

- Time axis -

- HIBS can provide **seamless services to wherever emergency communication is necessary**
- In the case that disconnection caused by significant typhoons, earthquakes and tsunami, **HIBS can restore the communication platform in one day by immediate takeoff from the nearby hanger**

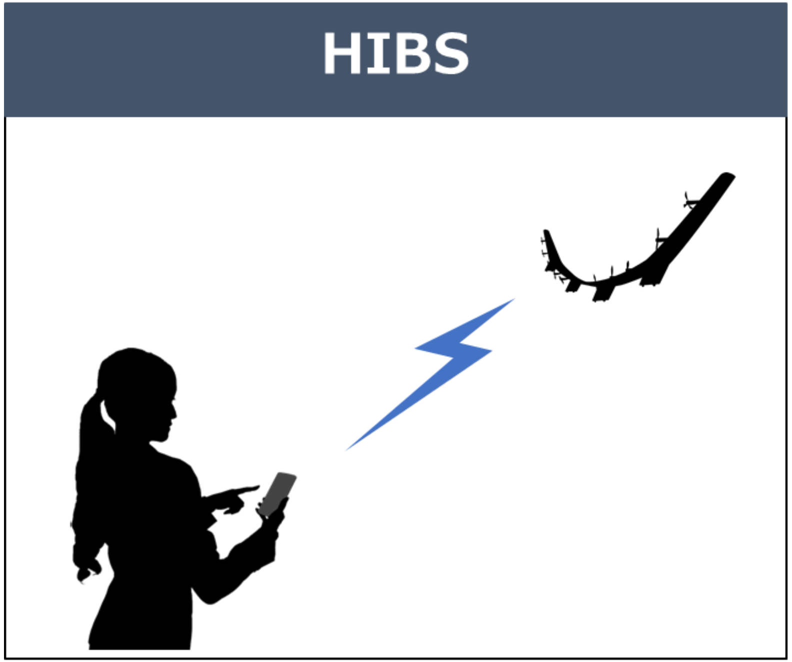
Scalability of HIBS

Contribute effectively in both Time axis and Spatial axis to expand areas connecting the unconnected



Direct connectivity to regular user terminal

No need to replace for specific device



- **3GPP supports IMT transmission up to 100km at least**
  - deployment scenarios in terms of maximum cell range up to 100 km (TR25.913 chapter 7.4)
  - cell range 100 km range to be evaluated through system level simulations (TR38.913 chapter 6.1.6)

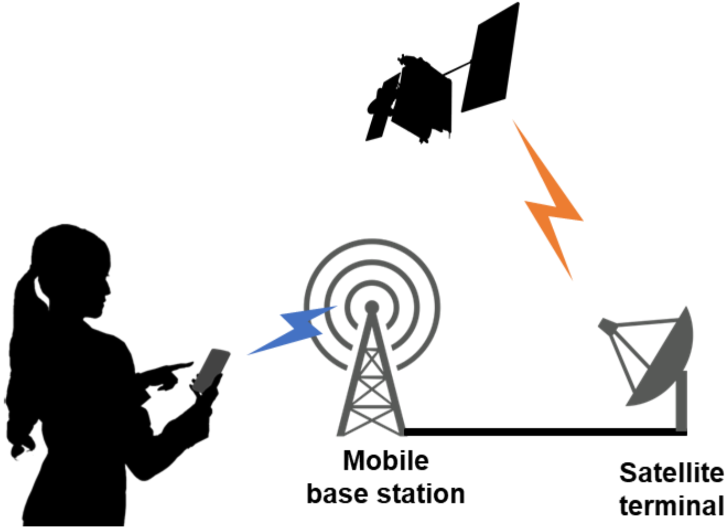
- **LTE/5G communication test from the stratosphere has been conducted by HAPS industries**

Direct connectivity to regular user terminal

No need to replace for specific device

HIBS

Satellite



※In general, direct connectivity to user terminals from satellites is not easy in either technology aspect or regulatory aspect.

International rules

In Radio Regulations,
service shall only use frequency bands which are identified for the use of service

Current rules for "Direct connectivity":

	HAPS/HIBS	Satellite
Ground mobile usage	2GHz	1.6GHz ,2GHz
Common frequency bands with terrestrial IMT usage	2GHz	2GHz ※not major band for IMT

Frequency band expansion in near future

700-900MHz,1.8GHz, 2GHz, 2.6GHz

*to be identified at WRC-23

Not planned so far

NTN satellite & HIBS in “3GPP”

NTN satellite and HIBS operation band are recently clarified

NTN satellite operation band

*Described in 3GPP TS 38.101-5

Operation band	Uplink	Downlink	Duplex mode
n256	1980-2010MHz	2170-2200MHz	FDD
n255	1626.5-1660.5MHz	1525-1559MHz	FDD

1.6GHz(n256), 2GHz(n255) are currently described

which are so far not generally included in popular terrestrial terminals

HIBS operation band

*Described in 3GPP TS 38.104, TR 38.863

Operation band	Uplink	Downlink	Duplex mode
n1	1920-1980MHz	2110-2170MHz	FDD

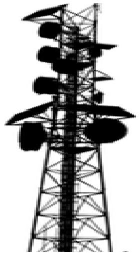
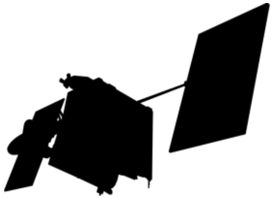
*certain frequency bands below 2.7 GHz is currently been studied in ITU-R to support spectrum allocation decisions in WRC-23

2GHz(n1) is currently described

***additional bands will follow after WRC-23**

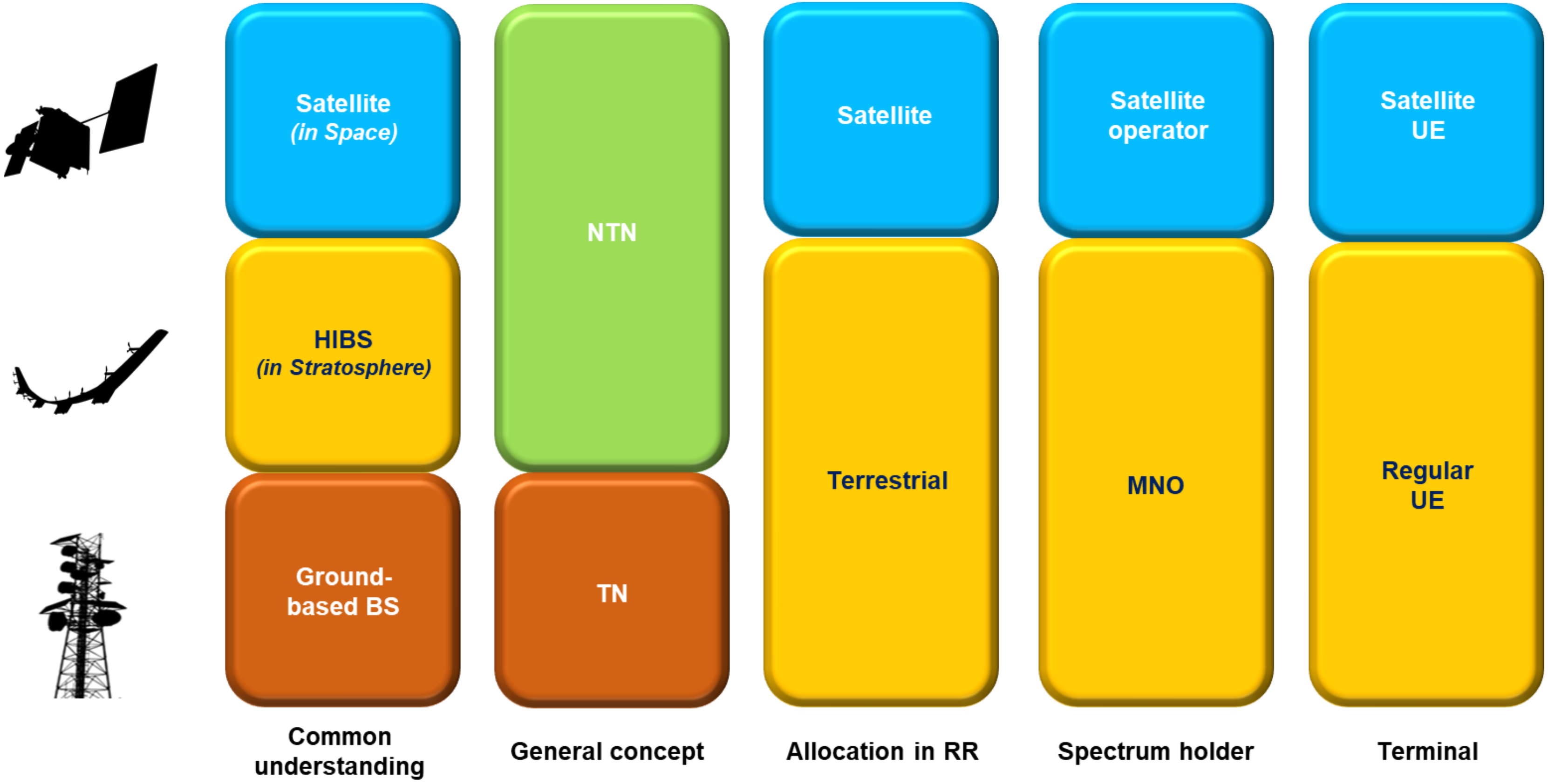
Major features in NW deployment

for "Direct connectivity"

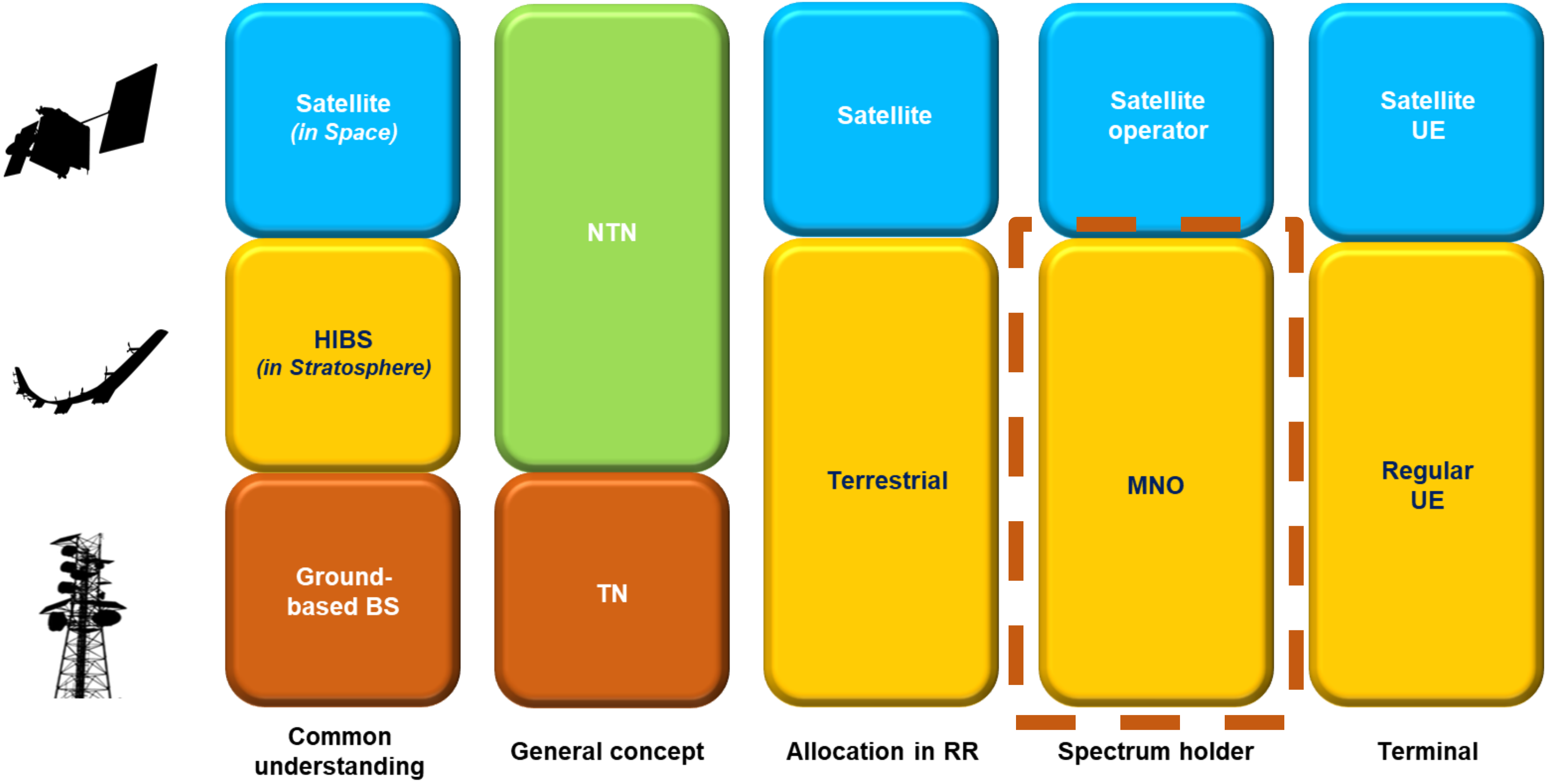
  

Coverage wideness	small	middle	large
Spectrum	IMT identified	IMT identified (partial)	2GHz (not major band)
Latency	1ms	similar as ground-based	30～50ms as LEO (MEO, GEO even higher)
Transmission limitation	no specific limitation	similar as ground-based	some restraints in uplink

Categorization study



Categorization study



Basic concept of spectrum usage

- IMT spectrum assigned to MNOs can be used for HIBS service links

Technology development

Sunglider

Wingspan: 78.9 [meters]

Cruise altitude: around 20,000 [m]

Power Source: Solar Power

IMT communication realized from stratosphere

Successful Test Flight on September 21, 2020

Delivered LTE Connectivity from Sunglider (Fixed-Wing Autonomous Aircraft in the Stratosphere)

Other test flight: UAVOS

UAVOS

HAPS ApusDuo 14

verified data based on the latest trials

The HAPS technology has been tested on the aircraft with a wingspan of up to 28 m, the total flight time is more than 1000 hours, the maximum flight altitude is 19 km, the flight time is 52 hours.

- at an altitude 16 500m
- at an latitude 54°

Test flight – June 5, 2021
Payload weight 3 kg

- at an altitude 16 000m
- at an latitude 54°

Test flight – June 6, 2021
Payload weight 4 kg

- at an altitude 16 000m
- at an latitude 54°

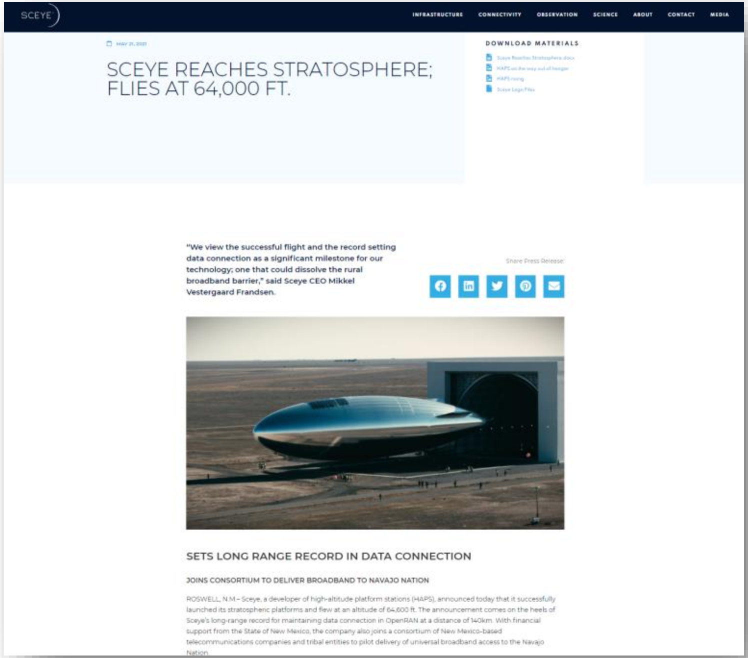
Test flight – June 23-24, 2021
Payload weight 6 kg

https://bit.ly/3jlPbsu

Weight balance tests
Energy balance tests
Static & dynamic tests
Collecting telemetry data
Test flights area – Belarus

Other test flight: Sceye

Announced a significant milestone including a successfully flight at an altitude of 64,600 ft (19.7 km) and the record-setting data connection for a range of 140km



* SOURCE: https://www.sceye.com/sceye-press-releases/sceye-reaches-stratosphere-flies-at-64000-ft/

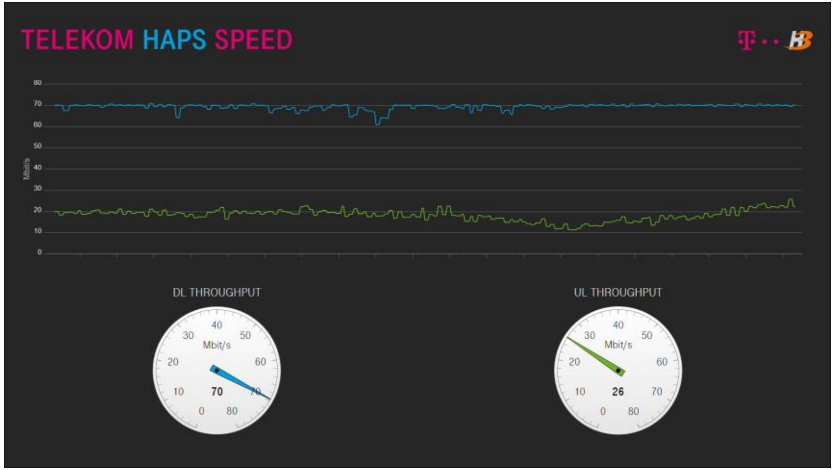
Deutsche Telekom successfully integrated HAPS cell into live network in Germany

LTE flight trials

- A worldwide first demonstration of LTE HAPS system fully integrated into MNO terrestrial network exploiting remotely piloted aircraft technology guaranteeing HAPs cell precisely covering defined target area successfully demonstrated in Q3 2020
- Flight trials organized in Band1 (2.1GHz), 10MHz channel BandWidth

<Key findings>

- Peak throughput performance met theoretical maximum as defined by 3GPP for Rel.8, 2x2MIMO
- Extra latency 1-2ms compared to the live network
- Throughput was very stable across the HAPS cell. Cell Edge performance observed still close to the maximum throughput



LTE HAPS cell performance

H3 HATS G520 aircraft during the test

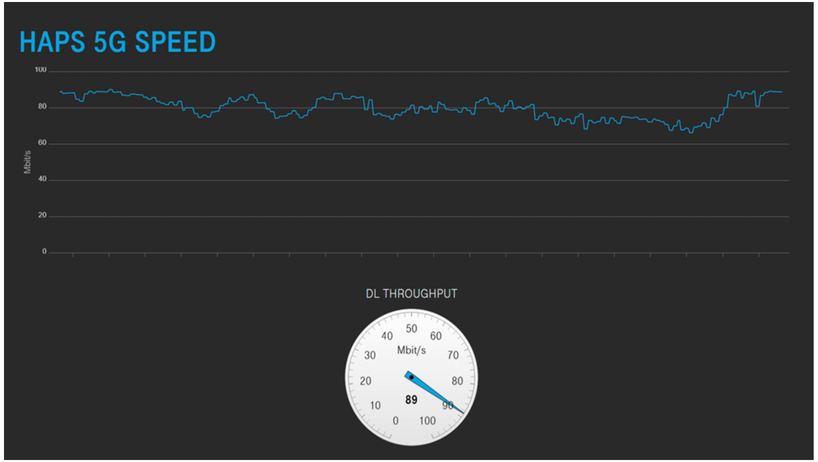
Deutsche Telekom successfully demonstrated 5G Stand Alone HAPS

5G SA flight trials

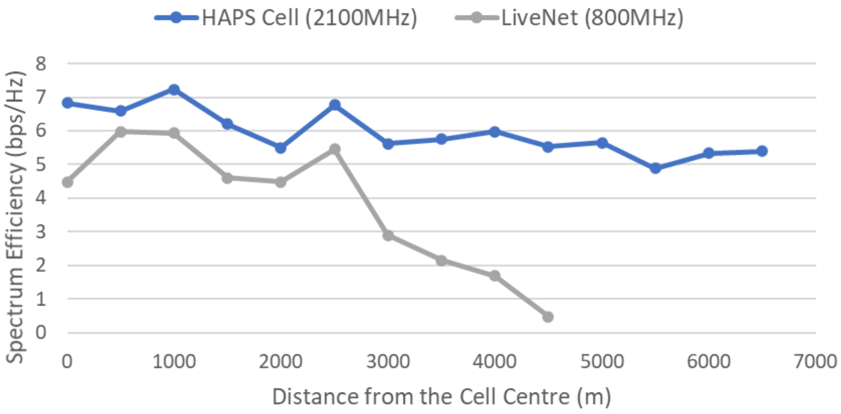
- A worldwide first demonstration of 5G Stand Alone from the low stratosphere in Germany in Q4 2021 including Voice over NR
- Flight trials organized in n1 (2.1GHz), 10MHz channel BandWidth

<Key findings>

- Peak throughput performance was further improved compared to LTE flight trials (90Mbps)
- Spectrum efficiency measured substantially higher compared to terrestrial network in rural - especially in the mid-cell and at the cell edge
- For HAPS cell, operating in the mid-band, coverage area was mainly defined by antenna pattern (3dB roll-off 7km away from the cell center) while for LTE live cell, operating in the low band, it was strictly limited by terrain (<5km in given test scenario)



5G HAPS cell performance



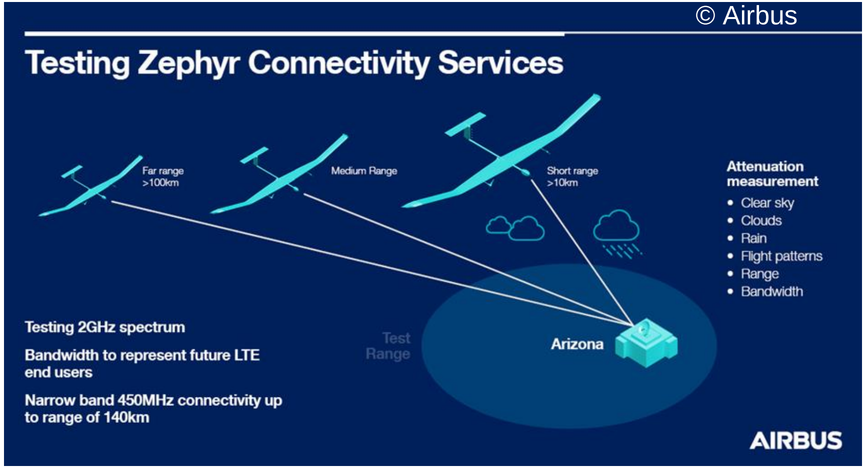
5G HAPS vs. Terrestrial LTE network during the test

Zephyr achieves connectivity in trial conducted by Airbus and NTT DOCOMO (Nov. 2021)

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
- The demonstration 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**
- **Tests 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

Airbus to deliver connectivity services using the Zephyr (Jul. 2022)

Airbus has launched a connectivity services business

- A new company is established which is a subsidiary of Airbus Defence and Space.
- It provide low-latency and direct-to-device connectivity across vast geographies, and economically.
- This connectivity services will provide a viable alternative and complement to terrestrial and satellite-based connectivity solutions.

With the company set to offer telecommunications services via its platform.

- It will play a crucial role in helping to bridge the digital divide through connecting the unconnected on land, air and sea.
- With over 3.7 billion people unserved or severely underserved by current terrestrial and space-based telecommunications networks, Airbus and Zephyr are reimagining connectivity, and working towards bridging the digital divide, offering state of the art connectivity service to commercial.

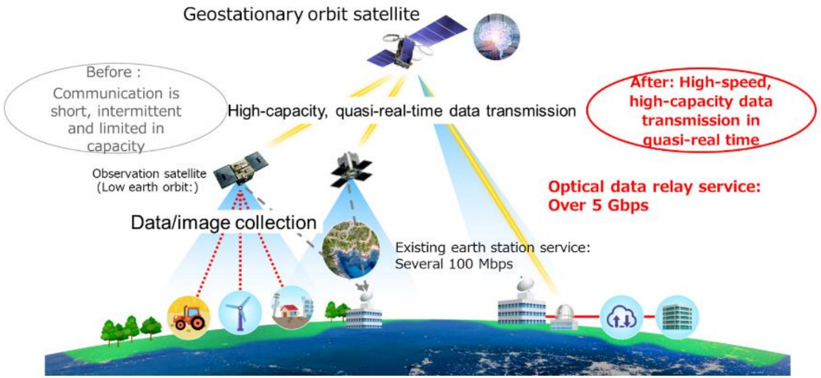
“Zephyr”

NTT and SKY Perfect JSAT have established a connectivity services from HAPS (Jul. 2022)

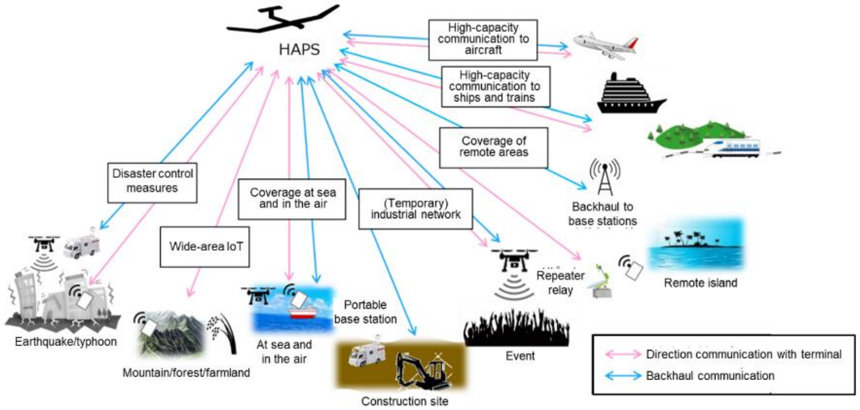
NTT and SKY Perfect JSAT are established new company SPACE COMPASS.

- The following is a summary of the initial business activities to be undertaken by the new company.
- Space data center is high-capacity communication and computing infrastructure in space.
- Space radio access network (RAN) business is communication infrastructure for beyond-5G/6G.

NTT × スカパーJSAT = SPACE COMPASS



"Overview of optical data relay service"



"Overview of HAPS communication services"

Relevant activities worldwide - 1

- Zephyr High Altitude Platform Station (HAPS) achieves connectivity in trial conducted by Airbus and NTT DOCOMO (Nov. 2021)

https://www.airbus.com/en/newsroom/press-releases/2021-11-zephyr-high-altitude-platform-station-haps-achieves-connectivity-in

- Airbus, NTT, DOCOMO and SKY Perfect JSAT Jointly Studying Connectivity Services from High-Altitude Platform Stations (HAPS) (Jan. 2022)

https://www.docomo.ne.jp/English/info/media_center/pr/2022/0117_00.html

- World-First Trial of 5G HAPS Technology Takes Place in Saudi Arabia In the Red Sea Project (Feb. 2022)

https://www.citc.gov.sa/en/mediacenter/pressreleases/Pages/2022030201.aspx

- NTT and SKY Perfect JSAT Agree to Establish Space Compass Corporation (Apr. 2022)

https://group.ntt/en/newsrelease/2022/04/26/220426a.html

- SoftBank Corp.'s HAPSMobile and Lendlease establish joint venture to explore HAPS deployment in Australia(May. 2022)

https://group.ntt/en/newsrelease/2022/04/26/220426a.html

- Airbus to deliver connectivity services using its leading Zephyr High Altitude Platform Station (HAPS)(Jul. 2022)

https://www.airbus.com/en/newsroom/press-releases/2022-07-airbus-to-deliver-connectivity-services-using-its-leading-zephyr

Relevant activities worldwide - 2

- Airbus to deliver connectivity services using the Zephyr (Jul. 2022)
https://www.airbus.com/en/newsroom/press-releases/2022-07-airbus-to-deliver-connectivity-services-using-its-leading-zephyr#

- NTT and SKY Perfect JSAT have established a connectivity services from HAPS (Jul. 2022/Japanese only)
https://www.skyperfectjsat.space/news/detail/post_181.html

- NTT and SKY Perfect JSAT will be established a connectivity services from HAPS (Apr. 2022)
https://group.ntt/en/newsrelease/2022/04/26/220426a.html

- Unexpected end to Zephyr 8's record-smashing 64-day endurance flight (Aug. 2022)
https://newatlas.com/aircraft/zephyr-8-mission-ends-abruptly-record-breaking-endurance-flight/

- Airbus Spinning Off Zephyr HAPS Business (Jan. 2023)
https://aviationweek.com/aerospace/connected-aerospace/airbus-spinning-zephyr-haps-business

- BT Group and SPL look to the stratosphere to deliver 4G and 5G coverage to hard-to-reach areas of the UK (Jan. 2023)
https://newsroom.bt.com/bt-group-and-spl-look-to-the-stratosphere-to-deliver-4g-and-5g-coverage-to-hard-to-reach-areas-of-the-uk/

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https://aviationweek.com/aerospace/connected-aerospace/airbus-spinning-zephyr-haps-business

- BT Group and SPL look to the stratosphere to deliver 4G and 5G coverage to hard-to-reach areas of the UK (Jan. 2023)
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Spectrum regulation

Proper regulation is required

Spectrum	• <u>Use of Mobile Spectrum for HIBS</u> • Flexible Spectrum Use for Non-terrestrial Gateway Links • Harmonized Licensing Frameworks for HAPS Fixed Links

Aviation	• Development of stratospheric flight management rules • Type certification / manufacturing certification / airworthiness certification

In addition,

Coordination	• Conversation with local administration is necessary • Flexible policies and regulatory frameworks for ensuring coexistence of services and avoiding cross-border interference

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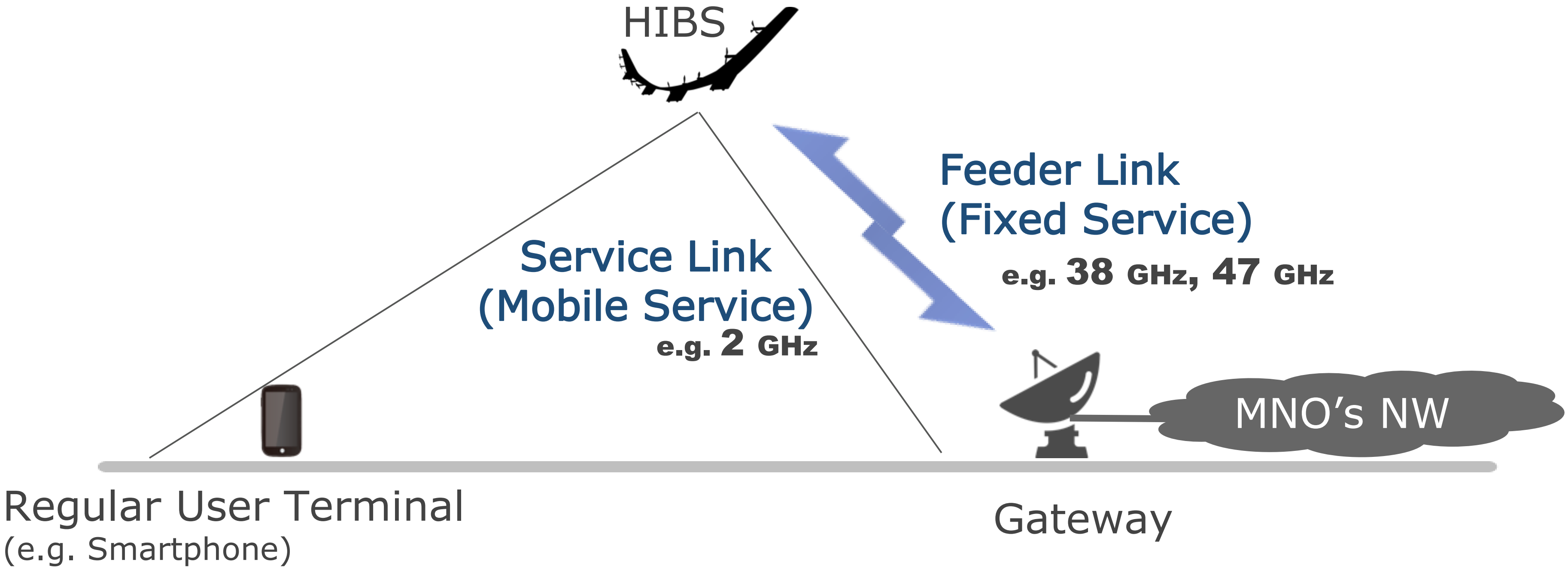
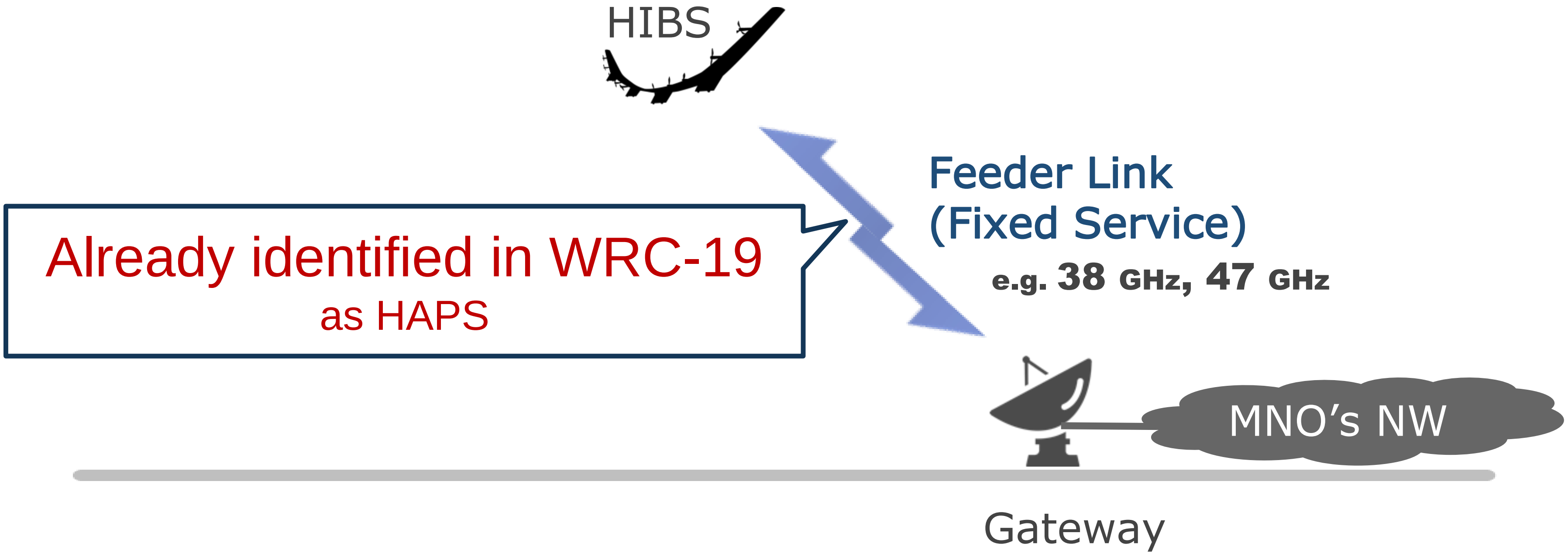
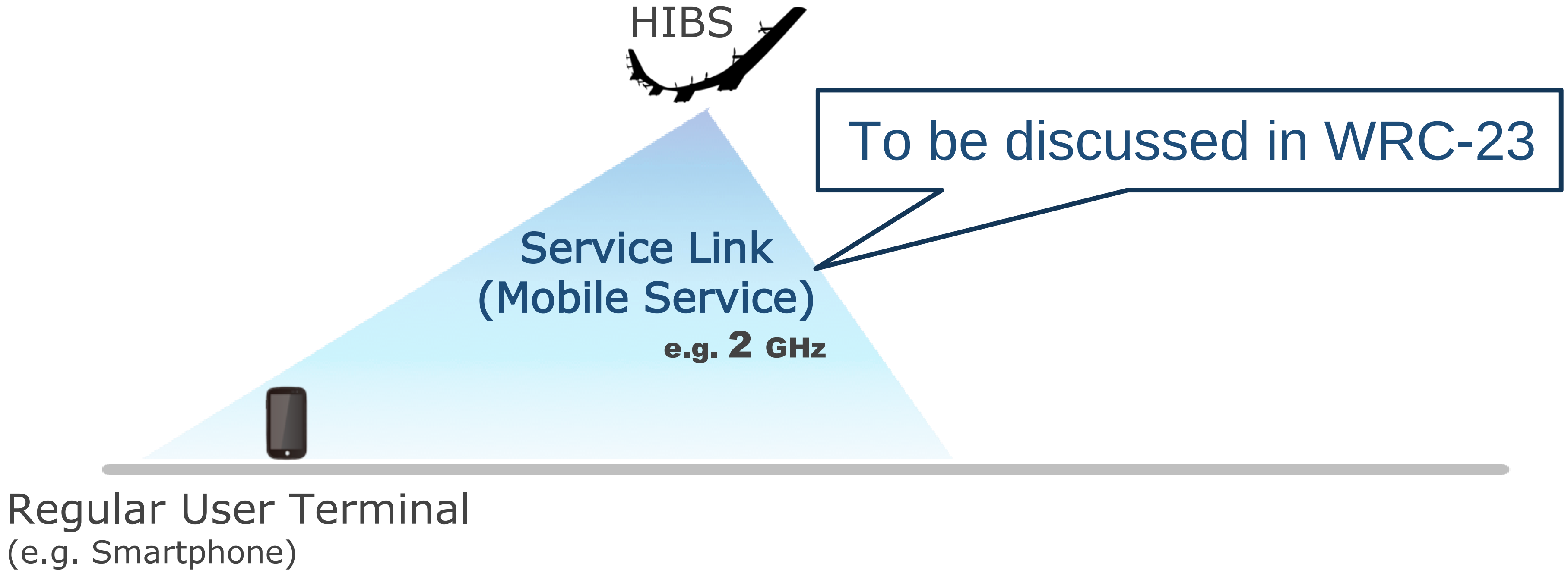
Spectrum usage for HIBS



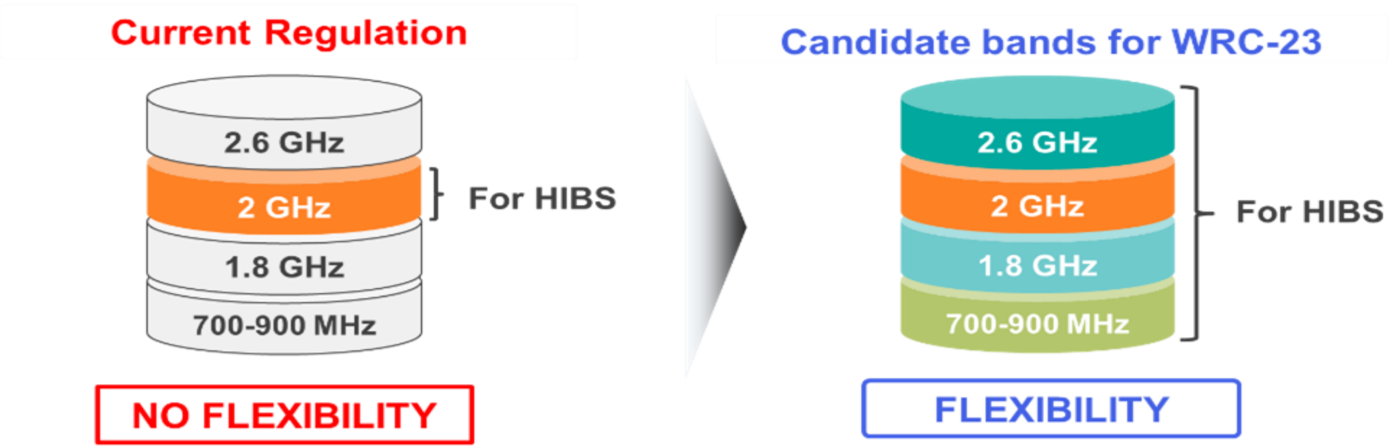
Spectrum usage for HIBS



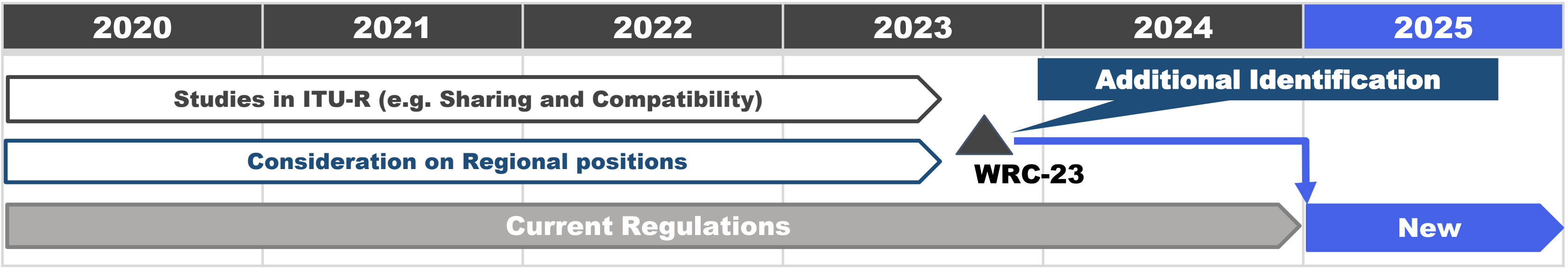
Spectrum usage for HIBS



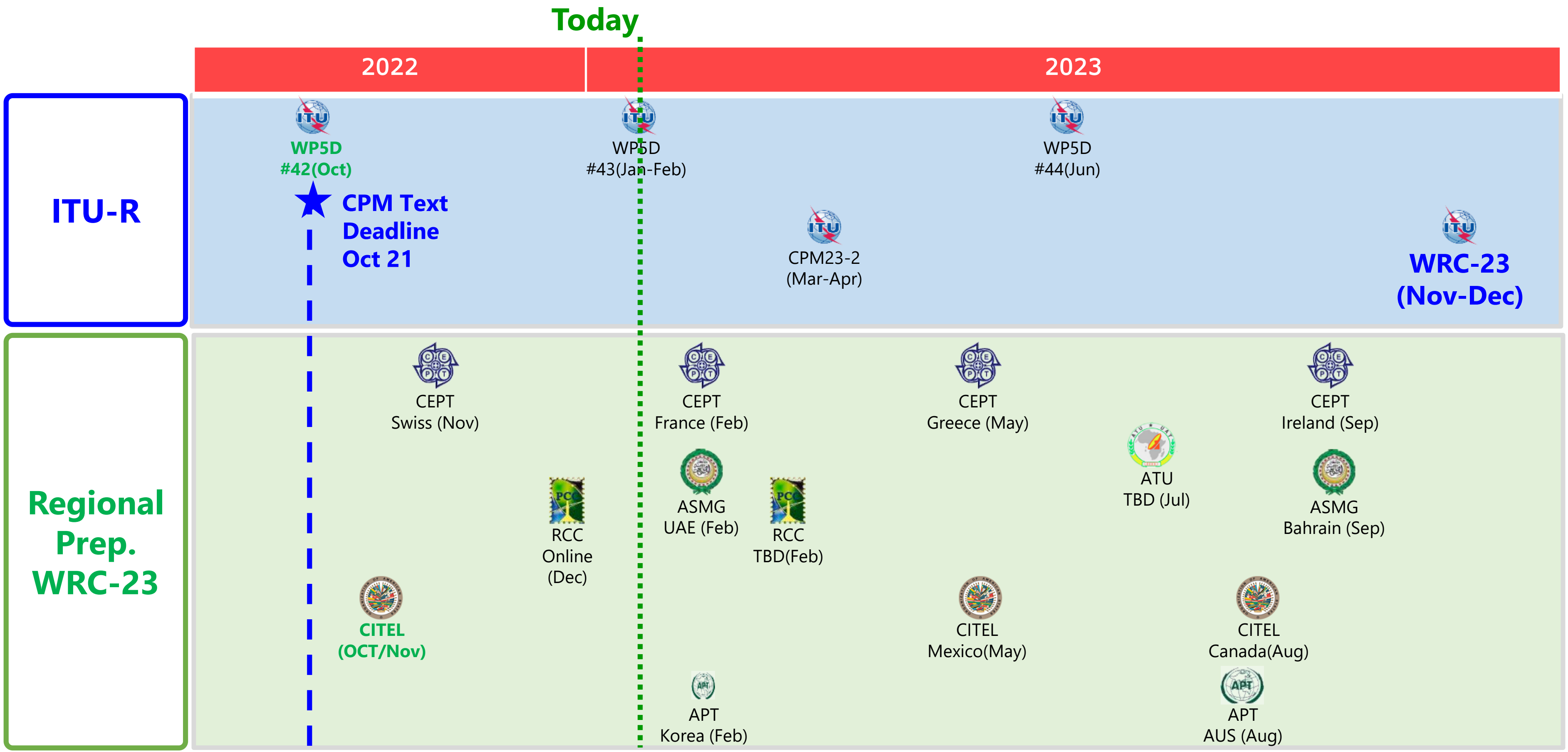
Establishment of WRC-23 Agenda Item



Only 2GHz is allowed in the RR



Overall schedule on WRC-23 AI 1.4



Sharing & compatibility studies

Frequency bands	Co-channel	Adjacent band
700-900 MHz	• Ground based IMT • Aeronautical radionavigation • Broadcasting service	• Aeronautical radionavigation
1.8 GHz, 2.1 GHz	• Ground based IMT • Fixed service • Aeronautical mobile service	• Mobile satellite service • Fixed service • Earth Exploration-Satellite Service, Space Research Service, Space Operation Service
2.6 GHz	• Ground based IMT • Fixed service • Broadcasting satellite service • Mobile satellite service	• Ground based IMT • Mobile satellite service • Radio Determination Satellite Service • Aeronautical radionavigation service • Meteorological radars • Radio astronomy service

Studies has been submitted and discussed for all candidate bands in ITU-R WP 5D

Summary of the CPM Texts

- **The draft CPM texts on WRC-23 agenda item 1.4 were finalized at the ITU-R WP5D#42 meeting in October 2022.**
  - Methods to satisfy this agenda are identified as four for each frequency band.
    - Method X1: NOC (No Change)
    - Method X2: HIBS Global Identification
    - Method X3: HIBS Identification with limitations
    - Method X4: HIBS Regional Identification
  - Regulatory measures for the protection of the existing services have been established, but some issues are not yet completed (etc. actual values for possible HIBS pfd limits).

Preliminary positions in Regional groups

ATU, CITEL, CEPT and RCC are supportive on HIBS identifications.

Regional Group	Preliminary position
CEPT	*(CPG23-6, Nov. 2022)* • CEPT considers the development of regulatory provisions applying to HIBS in order to protect other services and applications in the frequency bands proposed for HIBS as well as in the adjacent bands.
	(PT1 #73, Jan. 2023) • **CEPT supports regulatory provisions applying to HIBS in order to enable the use of the frequency bands 694-960 MHz, 1 710-1 885 MHz and 2 500-2 690 MHz** while protecting other services and applications in the frequency bands proposed for HIBS as well as in the adjacent bands. • CEPT is of the view that the use by HIBS of these bands should be on a non-protection basis, since studies have not addressed the risk that HIBS may require more protection than conventional IMT base stations. • CEPT is of the view to allow for the use of HIBS with an altitude lower than 20 km, down to a minimum of 18 km, since ITU-R studies have confirmed that there is a negligible difference in terms of impact to other services
ATU (APM23-3, Aug-Sep. 2022)	1. Support studies to enable the use of HIBS in bands below 2700 MHz, already identified for IMT; 2. Support the ITU-R sharing and compatibility studies for HIBS usage and protection of existing co-primary and primary services in adjacent bands without adversely affecting these services; **3. Support, based on the result of studies, the global/regional harmonization on the use of the frequency bands for HIBS**, which may include addition of African countries names in the existing footnotes in the RR. **4. Support the identification of the candidate bands for the use of high altitude platform stations as base stations for International Mobile Communications (HIBS)**, taking into account that no additional regulatory or technical restrictions should be imposed on the existing IMT terrestrial systems and applications operating in the same bands or in adjacent bands and also to identify the necessary measures required for coordination with neighbouring countries regarding exceeded coverage.

Preliminary positions in Regional groups

Regional Group	Preliminary position
RCC (6th RCC WG, Dec. 2022)	*(Excerpted from RCC preliminary position developed in December 2022)* **The RCC Administrations believe that the following Methods of the draft CPM Report can be used as the basis for a decision on item 1.4 of the WRC-23 agenda**, taking into account the required conditions set out in the relevant draft Resolutions: • Method A4 - for Question A: HIBS in the frequency band 694-960 MHz; • Method B3 - for Question B: HIBS in the frequency band 1 710-1 885 MHz; • Method C3 - for Question C: HIBS in the bands 1 885-1 980 MHz, 2 010-2 025 MHz and 2 110-2 170 MHz; • Method D3 - on Question D: HIBS in the frequency band 2 500-2 690 MHz.
ASMG (ASMG-29, Jun. 2022)	• Follow-up studies of the possibility of using high-altitude platforms as base stations for International Mobile Telecommunications (HIBS) in the frequency bands referred to in Resolution 247 (WRC-19) with follow-up studies of sharing and compatibility in order to ensure the protection of existing services to which the frequency band is allocated on a primary basis and services operating in adjacent bands as appropriate, in addition to the measures required for coordination with neighboring countries regarding exceeded coverage. • Protection of existing systems and the future development of services to which bands are distributed on a primary basis and services operating in neighboring bands as necessary. • To continue to study the spectrum needs of high-altitude platform stations as base stations for International Mobile Communications (HIBS), taking into account that no additional regulatory or technical restrictions are imposed on IMT terrestrial systems and determining the position on the possibility of using these applications in the bands mentioned in Resolution 247 (WRC-19) or not in the upcoming Arab meetings

Preliminary positions in Regional groups

Regional Group	Preliminary position
APT (APG23-4, Aug. 2022)	• APT Members support the ongoing ITU-R studies for establishing a new globally or regionally harmonized regulatory framework for HIBS with a view to providing flexibility of spectrum usage for HIBS in certain frequency bands below 2.7 GHz already identified for IMT referred to in Resolution 247 (WRC-19), while ensuring the protection of the existing services, to which the frequency band is allocated on a primary basis, and adjacent bands, as appropriate, without adversely affecting in their deployment including other IMT uses, existing systems and the planned development of primary services. • APT Members are considering that there is a need to develop the definition of HIBS with a view to potentially be included in the ITU Radio Regulations.
CITEL (PCCII#40, Oct-Nov. 2022)	• **DIAP supported by Brazil, [Dominican Republic] and Ecuador** – **Support Methods A2, B2, C2 and D2 (HIBS identification)** • PP supported by USA – Support Methods A1, B1, C1 and D1 (No change)

HAPS industry's views on WRC-23 agenda item 1.4

- Supports Methods A2, B2, C2 and D2 in the draft CPM text, which are to enable identification of HIBS in the bands under this agenda item including any modifications to the existing provisions.
  - Additional spectrum identifications are necessary for global harmonization of HIBS and the introduction of national regulations for use of HIBS in many countries.
  - Potential regulations for the protection of existing systems are almost established in the draft WRC Resolutions under these Methods.
  - If appropriate PFD limits are established, sharing between HIBS and existing services would be feasible without large separation distance.

- Those views will be input to the regional meetings from HAPS Alliance, such as Asia Pacific (APG23-5, Feb. 20~25) and Arab (ASMG-30, Feb. 20~23)

Necessity of spectrum identification for use of HIBS

The identification and corresponding regulations are essential to enable globally harmonized use of HIBS.

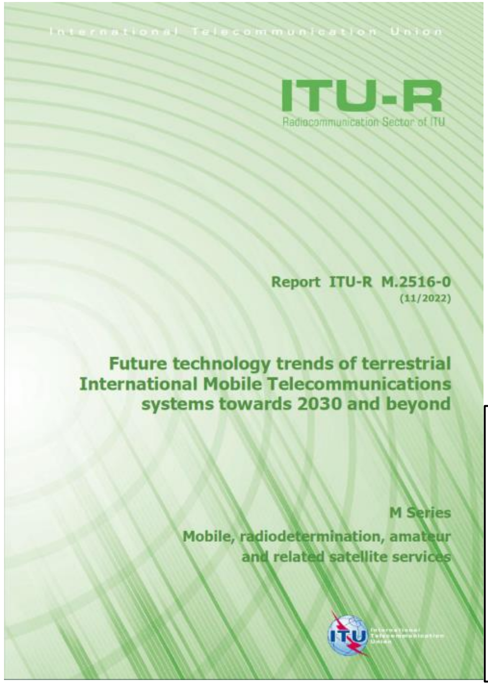
- In principle, RR 4.23 "*Transmissions to or from high altitude platform stations shall be limited to bands specifically identified in Article 5* " shall be applied since HIBS is still addressed as a "*high altitude platform station*".
- Given the large footprint of HIBS, globally/regionally harmonized rules for use of HIBS, especially protection of existing services, would be desired to realize broad area coverage while ensuring protection of existing services.
- Regulatory approach that is similar to existing HIBS use in 2 GHz bands, RR 5.388A (identification) and Resolution 221 (conditions), should be an appropriate outcome of WRC-23 AI 1.4.

It would contribute to the creation of global ecosystem and the introduction of national regulations for use of HIBS in many countries, especially developing countries.

Other activities

HIBS in B5G/6G

(in ITU-R)


International Telecommunication Union

ITU-R

Radiocommunication Sector of ITU

Report ITU-R M.2516-0

(11/2022)

Future technology trends of terrestrial International Mobile Telecommunications systems towards 2030 and beyond

M Series

Mobile, radiodetermination, amateur and related satellite services

7.5 Technologies for interconnection with non-terrestrial networks

The interconnection of terrestrial IMT and non-terrestrial communications aims to expand future terrestrial IMT technology to support seamless interconnectivity with non-terrestrial networks (NTN), including satellite communications, High altitude platform stations as IMT BSs (HIBS) and UASs as IMT BS platform, commonly referred to as drones and a type of aircraft without a human pilot on board. Key technologies for this purpose consist of SDN/NFV, network slicing, network management, edge computing, free space optical communications and other network technologies in the context of future IMT.

HIBS is an IMT BS located on a platform that flies and remains in the stratosphere at an altitude of approximately 20 km and would be used as a part of terrestrial IMT networks. The stratosphere is a layer of the atmosphere far above the clouds, and it is unaffected by rain or snow and less affected by air currents. Consequently, these characteristics enable the flight of a stratospheric platform to be steadier when compared to flight in other layers of the atmosphere. Since HIBS operates at an altitude of approximately 20 km, it can provide services with the same latency as terrestrial mobile networks, among other features. The advantages of HIBS include: 1) a large service area radius of up to 100 km

*approved as ITU-R Report M.2516 in November, 2022

Future technology trends and vision for IMT-2030 are being considered in ITU-R, HIBS is included as one of the fundamental elements for B5G/6G

HIBS in B5G/6G

(in 3GPP)

3GPP TS 38.104 V17.5.0 (2022-03)

Technical Specification

3rd Generation Partnership Project;
Technical Specification Group Radio Access Network;
NR;
Base Station (BS) radio transmission and reception
(Release 17)

A GLOBAL INITIATIVE

Officially defined in 3GPP specification from Rel-17 that HIBS can be used within existing IMT concepts, showing HIBS is part of 5G and later beyond

Towards digital divide (in ITU-D)

World Telecommunication Development Conference (WTDC-22)
Kigali, Rwanda, 6-16 June 2022

PLENARY MEETING
B17

Document WTDC-22/95-E
15 June 2022

SEVENTEENTH SERIES OF TEXTS SUBMITTED BY
EDITORIAL COMMITTEE TO THE PLENARY MEETING

The following texts are submitted to the Plenary Meeting for first reading:

Source	Document	Title
COM3	84	RESOLUTION 37
		RESOLUTION 64
		RESOLUTION 73
		RESOLUTION 76

R. Belhaj
Chairman, Committee 5

Annex: 21 pages

WTDC

considering

a) ITU's role as a catalyst, and in particular that of the ITU Telecommunication Development Sector (ITU-D) as coordinator and promoter of the rational use of resources in the context of the various projects intended to narrow the digital divide;

b) that the programmes of the Telecommunication Development Bureau (BDT) under its action plans, on information and communication infrastructure and technology development, have provided assistance to developing countries in the area of spectrum management and in the efficient and cost-effective development of rural, national and international broadband telecommunication networks, including satellite;

c) that various activities are being executed towards bridging the digital divide by many international and regional organizations, such as, in addition to the ITU, the Organisation for Economic Co-operation and Development (OECD), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Development Programme (UNDP), the United Nations Conference on Trade and Development (UNCTAD), the United Nations Economic and Social Council (ECOSOC), the United Nations economic commissions, the World Bank, the Asia-Pacific Telecommunity (APT), the regional economic communities, the regional development banks and many others, and that such activities have increased following the conclusion of WSIS and the adoption of the Tunis Agenda for the Information Society, particularly in relation to implementation and follow-up;

d) that many stakeholders in the public, private, academic, non-governmental organization and multilateral sectors are seeking to bridge this divide;

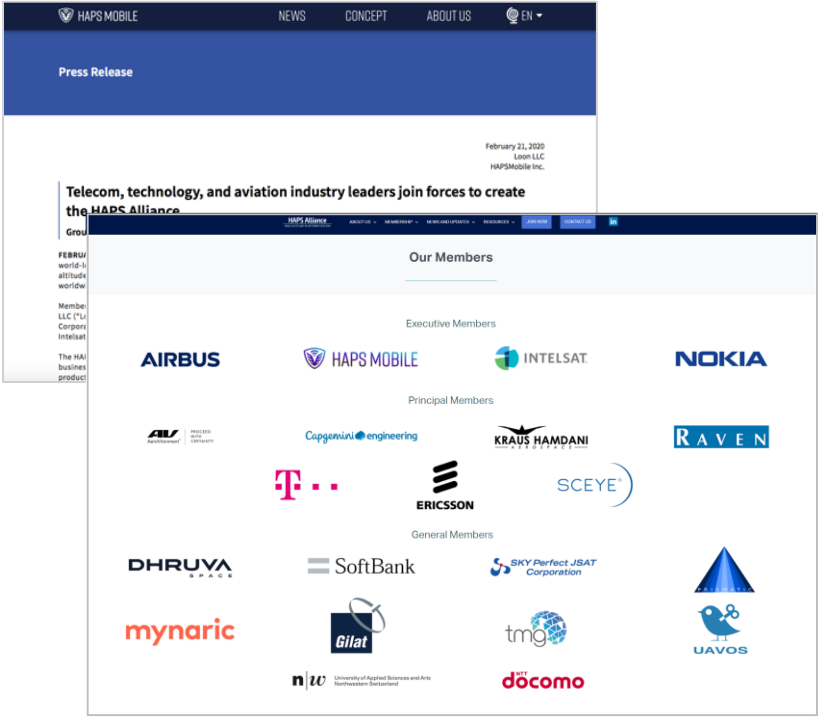
e) that the development of radiocommunication technologies and deployment of terrestrial, stratospheric (e.g. high-altitude platform stations) and space services and applications, enable sustainable and affordable access to information and knowledge, through the provision of communication services with high connectivity (broadband) and wide coverage (regional or global reach), which contribute significantly to bridging the digital divide, efficiently complementing other technologies and enabling countries to be connected directly, quickly and reliably;

*Approved at ITU-D WTDC-22 in Kigali

HAPS in the stratosphere, is considered efficient solution which contributes to bridging the digital divide

HAPS Alliance

By accelerating HAPS technologies and development building a cooperative ecosystem



Aviation

・ Promote and build standards and guidelines for the upper airspace while cooperating with ICAO, FAA and other aviation regulators

Telecom

・Advocate for global harmonization of HAPS/HIBS spectrum at global/national level
・Influence commercial standards including 3GPP NTN

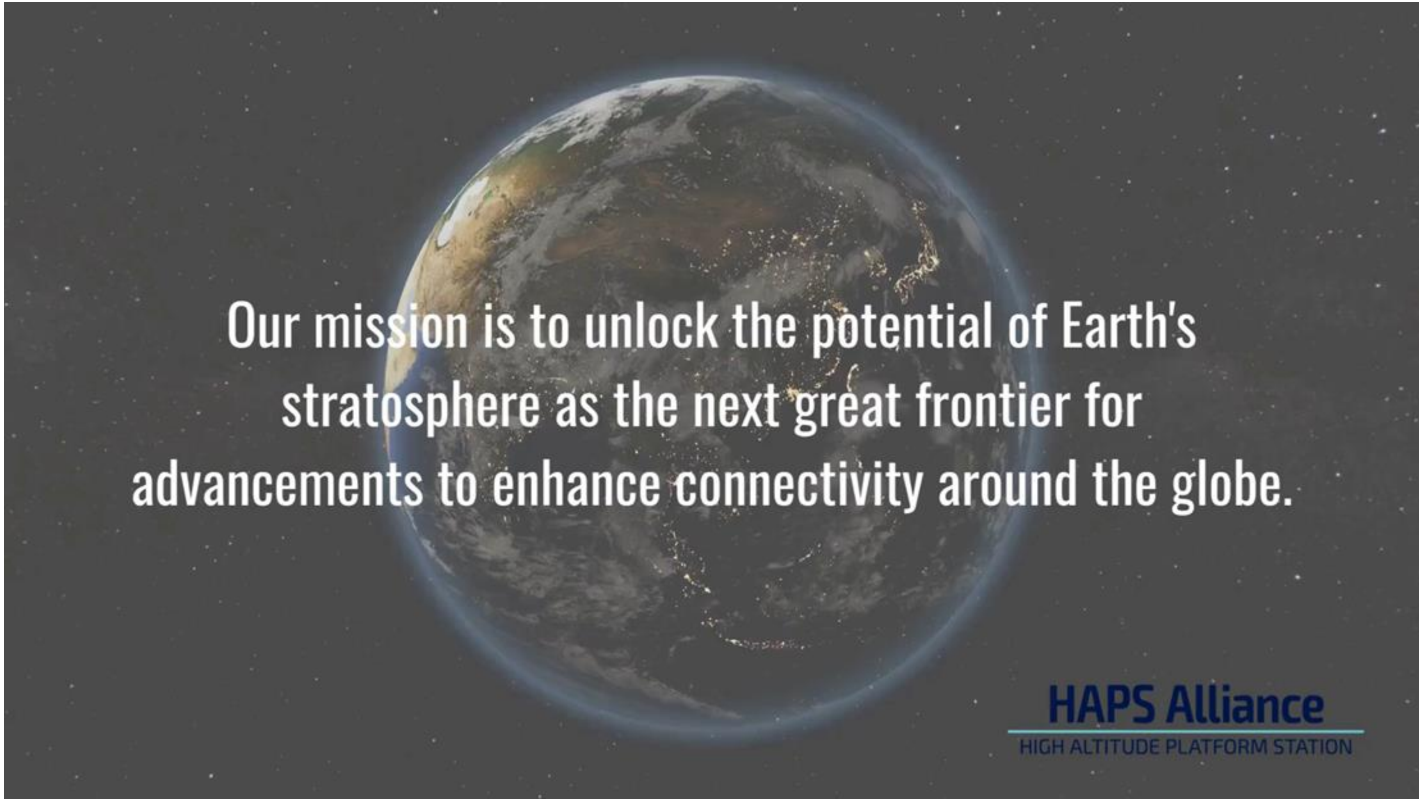
Interoperability

・Develop product specifications
・Standardization of HAPS/HIBS network interoperability

Commercialization

・Publish case studies/whitepapers
・Joint pilot/Proof of Concepts
・Build a cooperative HAPS/HIBS ecosystem

* SOURCE: HAPSMobile website
* SOURCE: HAPSALLIANCE website



https://hapsalliance.org/blog/haps-alliance-members-reach-new-heights%ef%bf%bc/

Our mission is to unlock the potential of Earth's stratosphere as the next great frontier for advancements to enhance connectivity around the globe.

HAPS Alliance

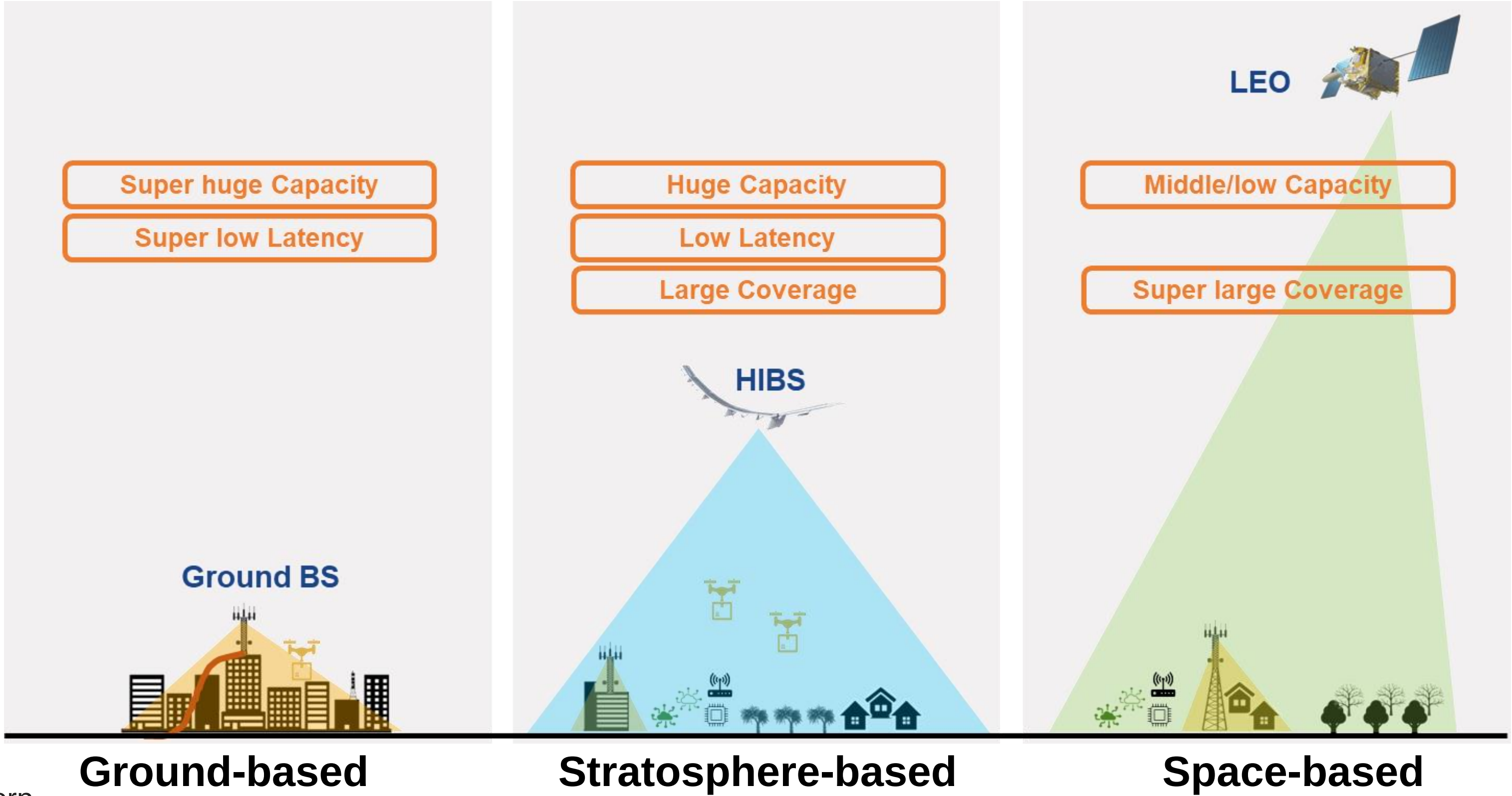
HIGH ALTITUDE PLATFORM STATION

HAPS related Whitepapers

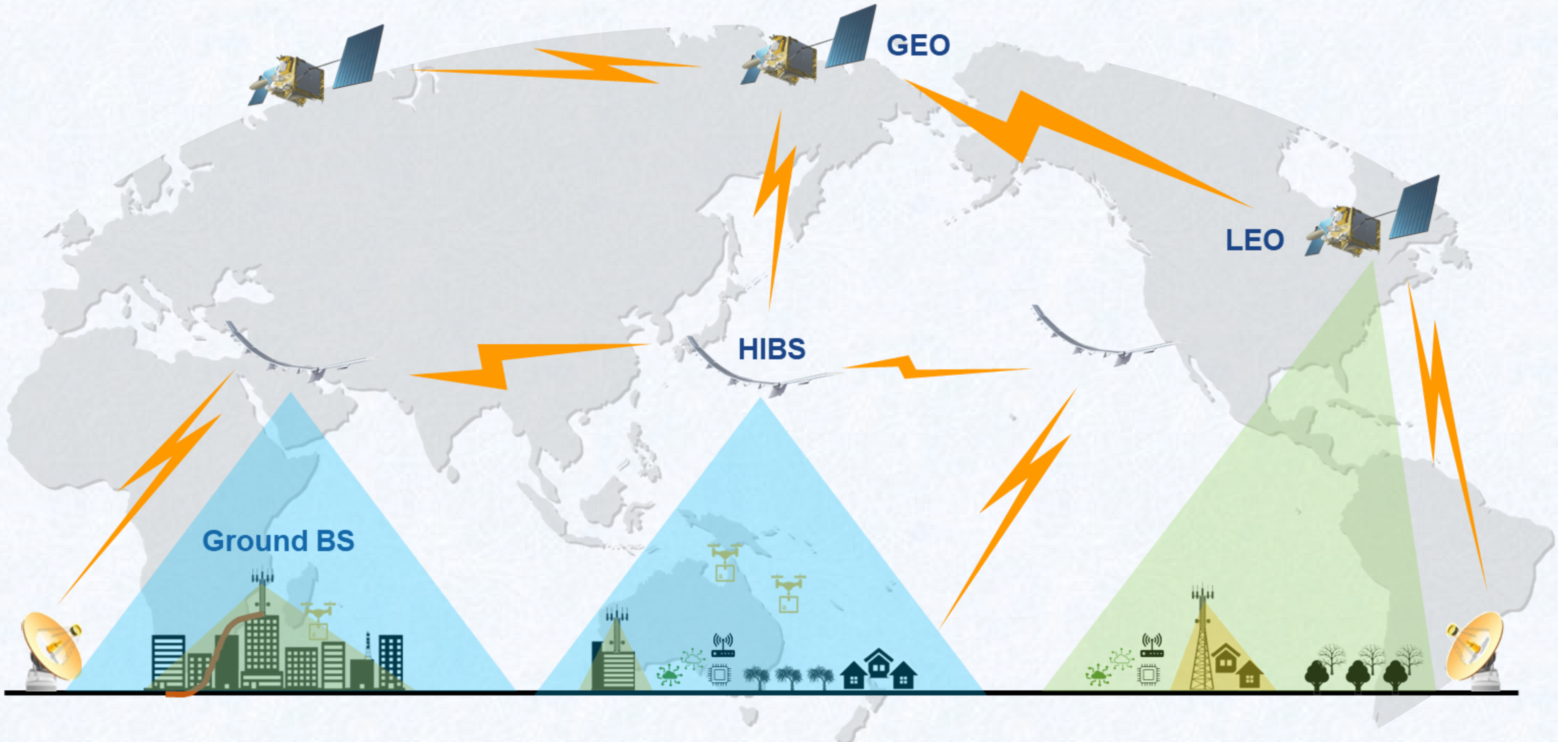
Internet access to the ground from the sky is getting more attention

Three types of networks

We will implement all types in the coming future



Integrated Network in the next era



People would benefit from the orchestrated network connecting TN and NTN

Summary

- ✓ NTN is a solution for MNOs to expand coverage in terms of wide area cover and resilience to disasters, especially the capability that HIBS has can connect regular user terminals directly.
- ✓ Technology and business developments for HIBS are certainly proceeded towards commercialization by many players.
- ✓ Sharing between HIBS and existing services would be feasible without large separation distance, with appropriate regulatory measures (e.g. PFD limits).
- ✓ Therefore, HIBS can contribute to solve crucial social challenges, such as bridging the digital divide and natural disaster recovery.
- ✓ Successful results of WRC-23 AI1.4 will provide the global harmonization for use of HIBS.

Supports from CTU administrations to the DIAP for identification of HIBS in CITEL are highly appreciated !

Mankind's Dream to reach the sky

1903

1957

Now

Airplane

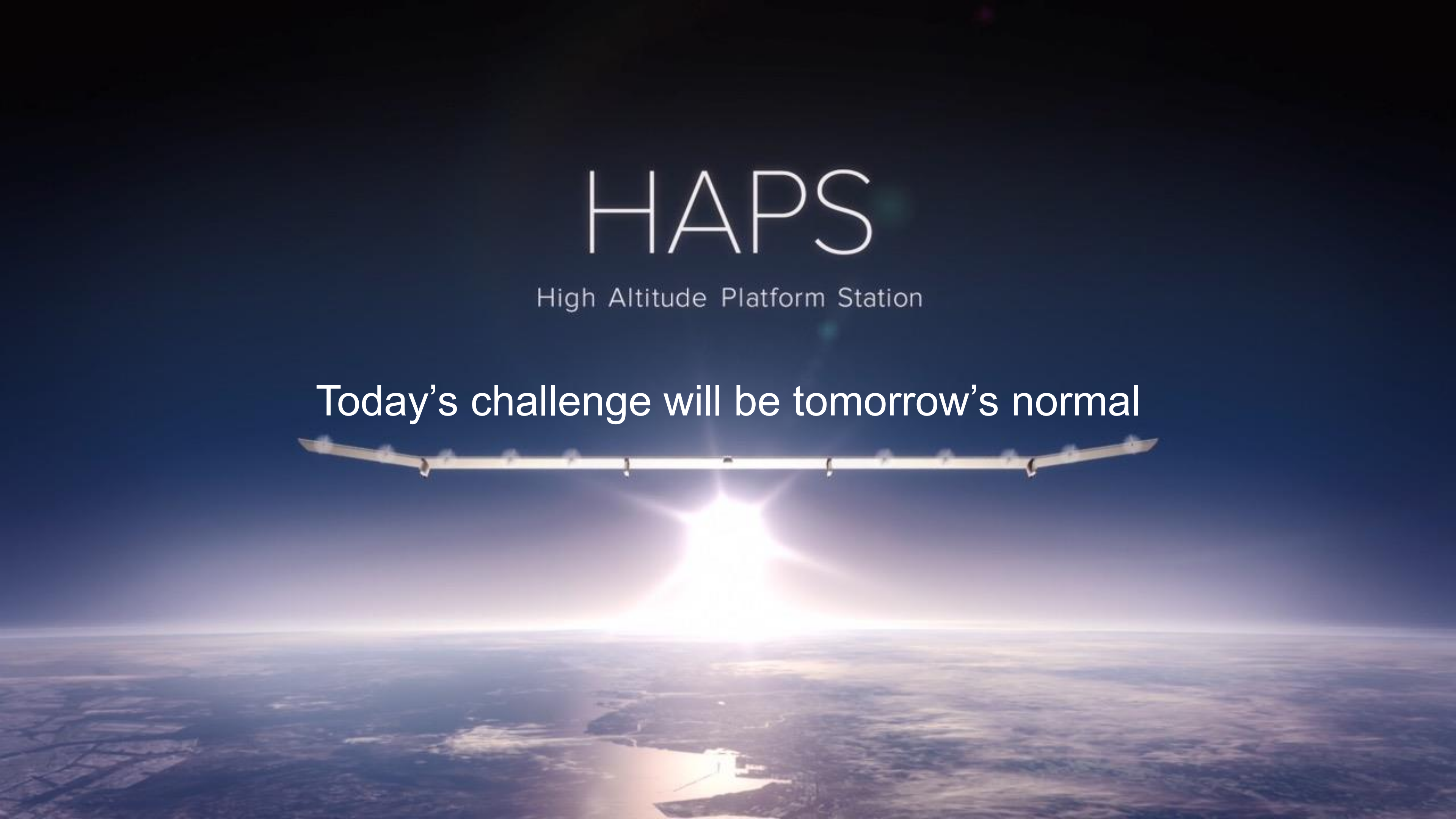
It's not extraordinary anymore!

Satellite

It's not extraordinary anymore!

HAPS
HIBS

What no one imagined it would be possible becomes not extraordinary anymore!


HAPS
High Altitude Platform Station
Today’s challenge will be tomorrow’s normal

Appendix

Frequencies Available for HIBS

Service	Frequency	Area	Note
Mobile service (Service link)	1885-1980/2010-2025/2110-2170 MHz	Region 1, 3	Consideration for appropriate modification in WRC-23 AI1.4
	1885-1980/2110-2160 MHz	Region 2	
	694-960 MHz		Consideration for additional identification in WRC-23 AI1.4
	1710-1885 MHz		
	2500-2690 MHz		
Fixed service (Feeder link)	6440-6520/6560-6640 MHz	5 countries	
	21.4-22 GHz	Region 2	
	24.25-27.5 GHz	Region 2	
	27.9-28.2 GHz	24 countries	
	31-31.3 GHz	Worldwide	
	38-39.5 GHz	Worldwide	
	47.2-47.5/47.9-48.2 GHz	Worldwide	

WRC-23 Agenda Item 1.4

1.4 to consider, in accordance with Resolution **247 (WRC-19),** the use of highaltitude platform stations as IMT base stations (HIBS) in the mobile service in certain frequency bands below 2.7 GHz already identified for IMT, on a global or regional level;

resolves to invite the ITU Radiocommunication Sector **in Resolution 247**

1 to study spectrum needs, as appropriate, for high-altitude platform stations as IMT base stations to provide mobile connectivity in the mobile service taking into account:

– the existing identification in *2GHz frequency band*;

– the usage and deployment scenario envisioned for high-altitude platform stations as IMT base stations as complementary for terrestrial IMT networks;

– the technical and operational characteristics and requirements of high-altitude platform stations as IMT base stations;

2 to conduct and complete in time for WRC-23, taking into account the results of studies already performed and those in progress within ITU-R, sharing and compatibility studies to ensure the protection of services, without imposing any additional technical or regulatory constraints in their deployment, to which the frequency band is allocated on a primary basis, including other IMT uses, existing systems and the planned development of primary allocated services, and adjacent services, as appropriate, for certain frequency bands below 2.7 GHz, or portions thereof, globally or regionally harmonized for IMT, i.e.:

– 694-960 MHz;

– 1 710-1 885 MHz (1 710-1 815 MHz to be used for uplink only in Region 3);

– 2 500-2 690 MHz (2 500-2 535 MHz to be used for uplink only in Region 3, except 2 655-2 690 MHz in Region 3);

3 to study appropriate modifications to the existing footnote and associated resolution in the identification in *recognizing b)* in order to facilitate the use of high-altitude platform stations as IMT base stations with the latest radio interface technologies of IMT;

4 to study the definition of high-altitude platform stations as IMT base stations (HIBS) including possible modifications to the provisions of the Radio Regulations, as appropriate;

5 to develop ITU-R Recommendations and Reports, as appropriate, taking into account *resolves to invite ITU-R* 1, 2, 3, and 4 above,

HIBS definition in the Radio Regulations (RR)

The term of "high altitude platform station" is defined as a station not attributed to the specific services.

Station

HAPS: High Altitude Platform Station

RR 1.66A: A station located on an object at an altitude of 20 to 50 km and at a specified, nominal, fixed point relative to the Earth.

Service

Fixed Service

IMT
(Mobile Service)

HAPS in the fixed service

HIBS
(High Altitude Platform Station as IMT base stations)

HIBS is still addressed as "high altitude platform station" as per RR1.66A in ITU-R studies.

✓ The only issues is operational altitude of HIBS: Although RR 1.66A defines the altitude of HAPS (20-50 km), operational altitude lower than 20 km should also be allowed for flexible operation of HIBS considering the stratospheric environment.

➔ Discussion on HIBS definition under WRC-23 AI1.4 can be focused on the regulation of operational altitude.

Regulatory conditions for protecting existing services (Band 1)

WRC Resolution	Existing services	Examples	Remark
Resolves 1 and 2	ARNS (694-960MHz in the countries mentioned in Nos. 5.312 and 5.323)	**Example 1 (Japan, Brazil)** No.9.21 with the coordination distances (100-597km*) **Example 2 (Russia)** 694-862MHz: No.9.21 with the coordination distance (HIBS TX:563-1327km*, HIBS RX: 150-515km*) 862-960MHz: Separation distance (HIBS TX:960-1327km*, HIBS RX: 515km) *Values depend on the system characteristics of ARNS.	• ARNS in Nos. 5.312 and 5.323 are allocated to RCC counties only. • The coordination distances for Example 1 are based on sharing studies, while Example 2 are based on the Line-of-Sight (LOS) distances between HIBS and ARNS stations regardless of ITU-R study. • Example 2 would stipulate the separation distance (hard limit) since sharing study was not conducted. However, system characteristics of ARNS in this band was not provided by WP 5B. Example 1 proposes to stipulate No.9.21 with the coordination distance in this band to consider the protection of ARNS case by case basis.
Resolves 3 to 5	BROADCASTING (694-862 MHz)	**Example 1 (Japan)** GE06 planning area: GE06 still apply Outside of the GE06 planning area: No.9.21 with the coordination trigger field-strength values in GE06 **Example 2 (Japan, Brazil)** No.9.21 with the coordination threshold PFD value (-135.8 $dBW/m^2/MHz$) **Example 3 (UK, France, Germany)** Both within and outside of the GE06 planning area: PFD limit (-135.8 $dBW/m^2/MHz$)	• Coordination scheme (i.e. RR No. 9.21) in Examples 1 and 2 would be a reasonable solution for the sharing between HIBS and the broadcasting services given the fact that such a bilateral coordination scheme has already been adopted in certain area for frequency sharing between the broadcasting services and other primary services under GE06 agreement. • Example 3 stipulates the PFD limit for the protection of the broadcasting services. However, PFD limit shall apply to all the countries which have registered the frequencies above 694 MHz for the broadcasting services in MIFR despite that some countries have already reallocated the broadcasting services to below 694 MHz. This situation would provide excessive regulatory constraints on HIBS introduction.

Regulatory conditions for protecting existing services (Band 1)

WRC Resolution	Existing services	Examples	Remark
Resolves 6.1 and 6.2	IMT (694-960MHz)	**Example 1 (Japan, Brazil)** For the protection of IMT UE: PFD limit (-114dBW/m2/MHz) **Example 2 (France)** For the protection of IMT UE: PFD limit (-114dBW/m2/MHz) For the protection of IMT BS: PFD limit −136+0.21 (θ)2dB(W/(m2 · MHz)) for 0°≦θ≦8.3° −121.8+0.08 (θ)dB(W/(m2 · MHz)) for 8.3°＜θ≦90° **Example 3 (USA)** For the protection of both IMT UE and BS: PFD limits −150 dB(W/(m2 · MHz)) for 0°≦θ＜11° −150+0.45(θ-11) dB(W/(m2 · MHz)) for 11°≦θ＜38° −145+0.45(θ-38) dB(W/(m2 · MHz)) for 38°≦θ＜81° −125 dB(W/(m2 · MHz)) for 81° ≦θ≦90°	• PFD limits in Examples 1 and 2 are based on ITU-R study, while example 3 are only proposed values without any technical justification. • Examples 3 would stipulate the unified values of PFD limits to protect both IMT UE and BS, however the value for the protection of IMT BS is overprotective for IMT UE as their characteristics are different. • Appropriate conditions should be stipulated according to the IMT frequency arrangement that employed in each country.
Resolves 6.3 and 6.4	RAS (1 610.6-1 613.8 MHz, Second harmonic band of HIBS operating in 805.3-806.9 MHz)	**Example 1 (USA)** No regulatory measure **Example 2 (Germany, Spain, Swizerland, South Africa, SKAO, IUCAF)** PFD limit (-194 dBW/m^2/20kHz)	• There are different views on whether the compatibility studies with second harmonic bands is the scope of WRC-23 AI1.4/Resolution 247.

Regulatory conditions for protecting existing services (Band 2)

WRC Resolution	Existing services	Examples	Remarks
Resolves 1.2 and 1.3	IMT (1 710-1 980 MHz, 2 010-2 025 MHz and 2 110-2 170MHz)	**Example 1 (Japan, Brazil, France)** For the protection of IMT UE: PFD limit (-111dBW/m2/MHz) For the protection of IMT BS: PFD limit −131+0.21 (θ)2dB(W/(m2 · MHz)) for 0°≦θ≦8.3° −116.8+0.08 (θ)dB(W/(m2 · MHz)) for 8.3°＜θ≦90° **Example 2 (USA)** For the protection of both IMT UE and BS: PFD limits −145 dB(W/(m2 · MHz)) for 0°≦θ＜11° −145+0.45(θ-11) dB(W/(m2 · MHz)) for 11°≦θ＜38° −142+0.45(θ-38) dB(W/(m2 · MHz)) for 38°≦θ＜81° −120 dB(W/(m2 · MHz)) for 81° ≦θ≦90°	• PFD limits in Example 1 is based on ITU-R study, while Example 2 are only proposed values without any technical justification. • Examples 2 would stipulate the unified values of PFD limits to protect both IMT UE and BS, however the value for the protection of IMT BS is overprotective for IMT UE as their characteristics are different. • Appropriate conditions should be stipulated according to the IMT frequency arrangement that employed in each country.
Resolves 1.4	MSS (2 160/2 170-2 200 MHz, adjacent band)	Adjacent band PFD limit (−165 dB(W/(m2 · 4kHz))	• Agreed value in WP 5D (retaining the existing adjacent band PFD limit in Resolution 221)

Regulatory conditions for protecting existing services (Band 2)

WRC Resolution	Existing services	Examples	Remarks
Resolves 1.5	FS (2 010-2 100 MHz, adjacent band)	**Example 1 (Japan, Brazil, France)** No regulatory measures **Example 2 (Russia)** Adjacent band PFD limit: −165 dB(W/(m2 · MHz)) for 0°<θ ≦ 5° −165+1.75(θ-5) dB(W/(m2 · MHz)) for 5° < θ<25° −130 dB(W/(m2 · MHz)) for 25° < θ≦90°	• Example 1 is based on ITU-R study which shows that the compatibility between HIBS and FS in the adjacent band is feasible without any mitigation measures, while Example 2 proposes to retain the existing PFD limit in current Resolution 221 without any technical rational for the necessity of this PFD limit in ITU-R study.
Resolves 1.6	FS (1 710-1 980 MHz, 2 010-2 025 MHz and 2 110-2 170MHz)	**Example 1 (Japan, Brazil, France)** −144 dB(W/(m2 · MHz)) for 0°<θ≦10° −144+1.6 (θ-10) dB(W/(m2 · MHz)) for 10°<θ≦25° −120dB (W/(m2 · MHz)) for 25°<θ≦90° **Example 2 (USA, Russia)** −165 dB(W/(m2 · MHz)) for 0°<θ ≦ 5° −165+1.75(θ-5) dB(W/(m2 · MHz)) for 5° < θ<25° −130 dB(W/(m2 · MHz)) for 25° < θ≦90° **Example 3 (USA)** −150 dB(W/(m2 · MHz)) for 0°<θ ≦ 2° −150+1.78(θ-2) dB(W/(m2 · MHz)) for 2° < θ<20° −118+0.215(θ-20) dB(W/(m2 · MHz)) for 20° < θ<48° −112 dB(W/(m2 · MHz)) for 48° < θ≦90°	• The values of Example 2 are come from existing PFD limit for the protection of FS in the adjacent band in Resolution 221 and are not based on ITU-R studies. It is also noted that these values are more stringent than existing PFD limits of satellite services in RR Table 21-4 for the protection of terrestrial services in these frequency ranges. • Example 1 would be appropriate conditions for the protection of FS as the values are based on studies of more realistic scenarios.

Regulatory conditions for protecting existing services (Band 2)

WRC Resolution	Existing services	Examples	Remarks
Resolves 1.7	AMS (1 780-1 850 MHz)	**Example 1 (Japan, Brazil)** No regulatory measures **Example 2 (USA)** Separation distances: 1 135 km (for the protection of airborne stations) 490km (for the protection of ground-based stations)	• Examples 1 and 2 are based on the different sharing studies proposed by each proponent. • The separation distance hard limits in Example 2 shall apply to all the countries despite that there are information on frequency assignments in only one Region 2 administration based on MIFR. This situation would provide excessive regulatory constraints on the introduction of HIBS.

Regulatory conditions for protecting existing services (Band 3)

WRC Resolution	Existing services	Examples	Remarks
Resolves 1.1 and 1.2	IMT (2 500-2 690MHz)	**Example 1 (Japan, Brazil, France)** For the protection of IMT UE: PFD limit (-109dBW/m2/MHz) For the protection of IMT BS: PFD limit −131+0.21 (θ)2dB(W/(m2 · MHz)) for 0°≦θ≦8.3° −116.8+0.08 (θ)dB(W/(m2 · MHz)) for 8.3°＜θ≦90° **Example 2 (USA)** For the protection of both IMT UE and BS: PFD limits −145 dB(W/(m2 · MHz)) for 0°≦θ＜11° −145+0.45(θ-11) dB(W/(m2 · MHz)) for 11°≦θ＜38° −142+0.45(θ-38) dB(W/(m2 · MHz)) for 38°≦θ＜81° −120 dB(W/(m2 · MHz)) for 81° ≦θ≦90°	• PFD limits in Example 1 is based on ITU-R study, while Example 2 are only proposed values without any technical justification. • Examples 2 would stipulate the unified values of PFD limits to protect both IMT UE and BS, however the value for the protection of IMT BS is overprotective for IMT UE as their characteristics are different. • Appropriate conditions should be stipulated according to the IMT frequency arrangement that employed in each country.
Resolves 1.3	FS (2 500-2 690MHz)	**Example 1 (Japan, Brazil, France)** −135 dB(W/(m2 · MHz)) for 0°＜θ≦20° −135+0.7 (θ-20) dB(W/(m2 · MHz)) for 20°＜θ≦47° −116dB (W/(m2 · MHz)) for 47°＜θ≦90° **Example 2 (USA)** −148 dB(W/(m2 · MHz)) for 0°＜θ≦2° −148+0.71 (θ-2) dB(W/(m2 · MHz)) for 2°＜θ≦47° −116dB (W/(m2 · MHz)) for 47°＜θ≦90°	• Example 1 would be appropriate conditions for the protection of FS as the values are based on studies of more realistic scenarios, (conducted Monte-Carlo simulation with multiple (12) HIBS). The values of Example 2 are based on the analysis using the characteristics of FS receiver only.

Regulatory conditions for protecting existing services (Band 3)

WRC Resolution	Existing services	Examples	Remarks
Resolves 1.4	BSS (2 520-2 630MHz)	**Example 1 (Japan, Brazil)** PFD limit −130.5 dB(W/(m2 · MHz)) for 0°＜θ≦20° −139.8 dB(W/(m2 · MHz)) for 20°＜θ＜90° **Example 2 (Iran)** PFD limit: Same values as Example 1 HIBS shall operate Non-interference/Non-claiming protection basis	• The values of PFD limits in Examples 1 and 2 are based on ITU-R study. • There are not any technical basis on why Example 2 proposes to limit HIBS operation to Non-interference/Non-claiming protection basis. In addition, limits to HIBS operation on Non-interference basis is inconsistent with the PFD limit.
Resolves 1.5	ARNS (2 700-2 900 MHz, adjacent band)	Adjacent band PFD limit: −156.2 dB(W/(m² · MHz)) for θ≤7° −163+15 · log_{10} (θ − 4)dB(W/(m² · MHz)) for 7°<θ< 30.5° −141+2.7 · log_{10} (θ − 4)dB(W/(m² · MHz)) for θ=30.5° −157+14 · log_{10} (θ − 4)dB(W/(m² · MHz)) for 30.5°<θ≤40.5° −101.5 dB(W/(m² · MHz)) for θ>40.5°	• Agreed in WP 5D
Resolves 1.6	RADIOLOCATION (2 700-2 900 MHz, adjacent band)	Adjacent band PFD limit: −165.6 dB(W/(m2 · MHz)) for θ≤37° −165.6+5.5 (θ − 37) dB(W/(m2 · MHz)) for 37°<θ<45° −121.6+(θ − 45) / 3 dB(W/(m2 · MHz)) for 45°<θ≤90°	• Agreed in WP 5D

Regulatory conditions for protecting existing services (Band 3)

WRC Resolution	Existing services	Examples	Remarks
Resolves 1.7 and 1.8	RAS (2 690-2 700 MHz, adjacent band)	**Example 1 (IUCAF, Japan, Brazil)** PFD limit (−177 dB(W/(m2 · 10 MHz))) **Example 2 (USA, IUCAF)** Separation distance (LOS distance between HIBS and RAS station)	• PFD limit in example 1 is based of the protection criteria of RAS in Recommendation ITU-R RA.769. • Example 1 is good balance between the protection of RAS and HIBS operation since HIBS operating administration can apply technical and operational measures to comply with this limit. • Separation distance hard limits in Example 2 based on LOS distances provide excessive regulatory constraints on the introduction of HIBS.
Resolves 1.9	RDSS/MSS (s-to-E) (2 483.5-2 500 MHz, adjacent band)	Unwanted emission limit in the frequency band 2 483.5-2 500 MHz: −13 dBm/MHz (Japan, Brazil) −30 dBm/MHz (France, Globalstar)	• ITU-R studies show that the sharing between HIBS and RDSS/MSS would be feasible with the separation distances from HIBS nadir to earth stations are less than 50 km (inside the HIBS area) when the value of spurious emission of HIBS is -13 dBm/MHz. This means that the separation distance from area edge of HIBS to RDSS/MSS earth stations would not be necessary if the unwanted emission limit as -13 dBm/MHz is applied.

ITU-R Documents

- Draft CPM Report (CPM23-2/1)
- Chairman's Report on the 41st meeting of Working Party 5D (5D/1555)
  - Meeting Report of SWG WRC-23 AI1.4 (Annex 4.27)
  - Working document towards a preliminary draft new Report ITU-R M.[HIBS-CHARACTERISTICS] (Annex 4.29)
  - Sharing and compatibility studies of HIBS on WRC-23 AI1.4 (Annex 4.30-4.35)

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