30TH WORLD RADIOCOMMUNICATION SEMINAR

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Trends in broadband radio technologies

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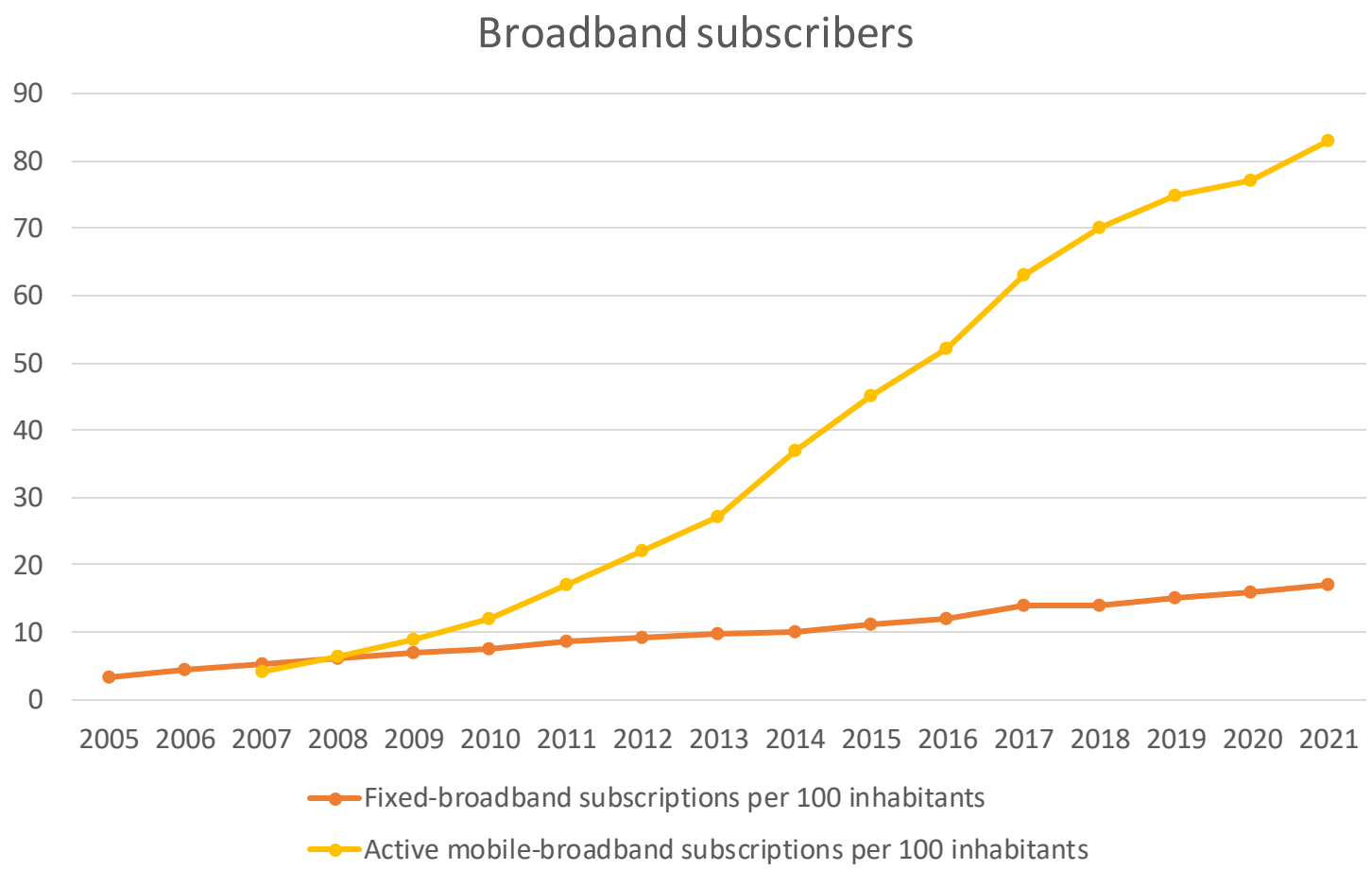
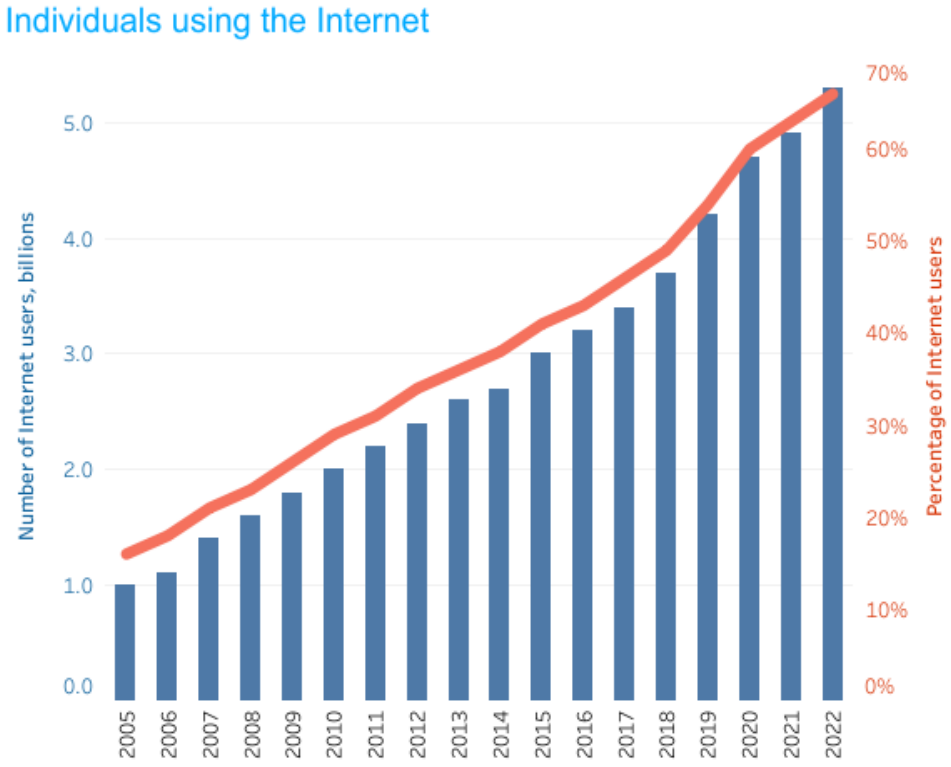
Broadband evolution



Source ITU DataHub



Source: ITU

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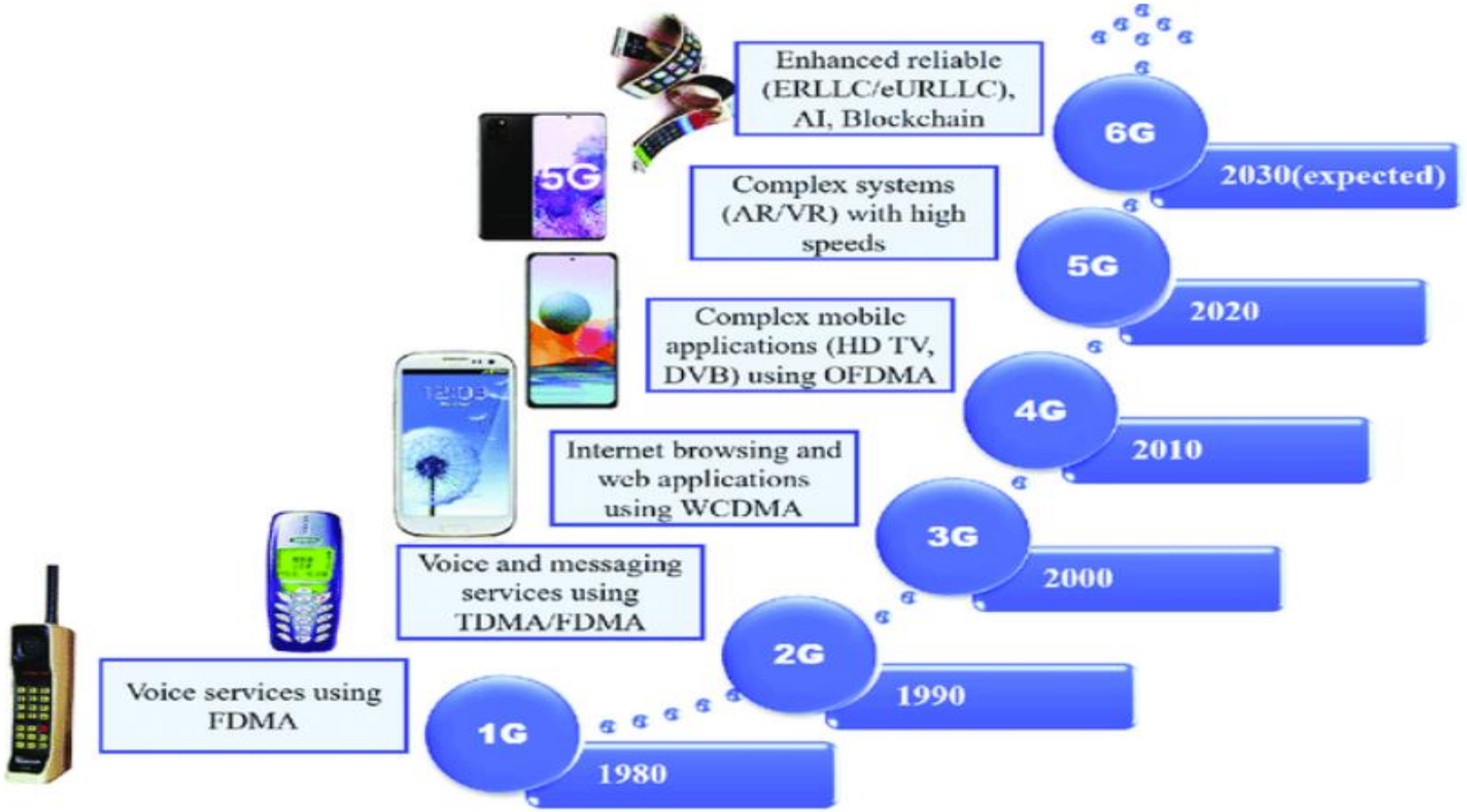
Broadband evolution



The evolution of cellular mobile communications.

IMT-Family and naming conventions

* As of 24. Feb. 2022

International Mobile Telecommunication (IMT)

	IMT-2000	IMT-Advanced	IMT-2020	*[Systems beyond IMT-2020]*
Name				
Rec.	ITU-R M.1457-15	ITU-R M.2012-5	ITU-R M.2150-1	
Radio Interface Techn.	• IMT-2000 CDMA DS • IMT-2000 CDMA MC • IMT-2000 CDMA TDD • IMT-2000 TDMA SC • IMT-2000 FDMA/TDMA • IMT 2000 OFDMA TDD WirelessMAN	• LTE-Advanced • WirelessMAN-Advanced	• 3GPP 5G-SRIT • 3GPP 5G-RIT • 5Gi • DECT 5G-SRIT	
Year 1st / latest publication *(as of 27. June 2022)*	05/2000 – 10/2020	02/2014 – 02/2022	02/2021 – 02/2022	2030 ?
Market name	3G	4G	5G	6G

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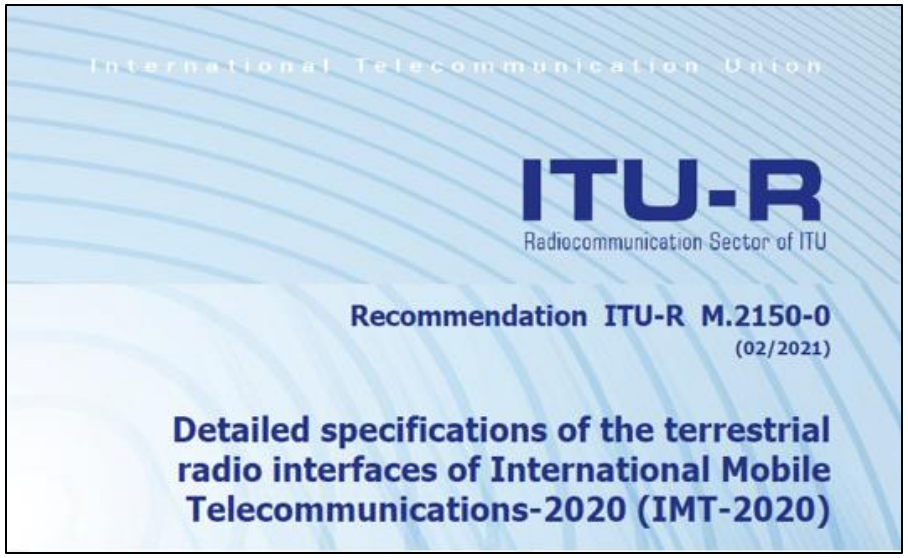
IMT-2020 Radio Interfaces (ITU-R M.2150)



https://www.itu.int/rec/R-REC-M.2150/en

Scope

- identifies and provides the detailed specifications of the radio interfaces for the terr. component of IMT-2020,
- detailed features and parameters of IMT-2020,
- IMT-2020 enables worldwide compatibility, int. roaming, and access to the services under diverse usage scenarios (eMBB, mMTC, URLLC).

Initial release includes 3 standards:

- 3GPP 5G-SRIT [1]
- 3GPP 5G-RIT [2]
- 5Gi [3]

*[1] Developed as "5G, Release 15 and beyond - LTE+NR SRIT" **(5G-NSA)***
*[2] Developed as "5G, Release 15 and beyond - NR RIT" **(5G-SA)***

Two further IMT-2020 candidate technology proposals have undergone additional evaluation (2021) – in the final assessment, one technology has passed all requirements

The first revision (ITU-R M.2150-1) includes:

- DECT 5G-SRIT

Developed by ETSI

The final assessment not passed:

- **EUHT-5G** by Nufront

A further enhanced RIT specification has been submitted for the next revision of Recommendation ITU-R M.2150

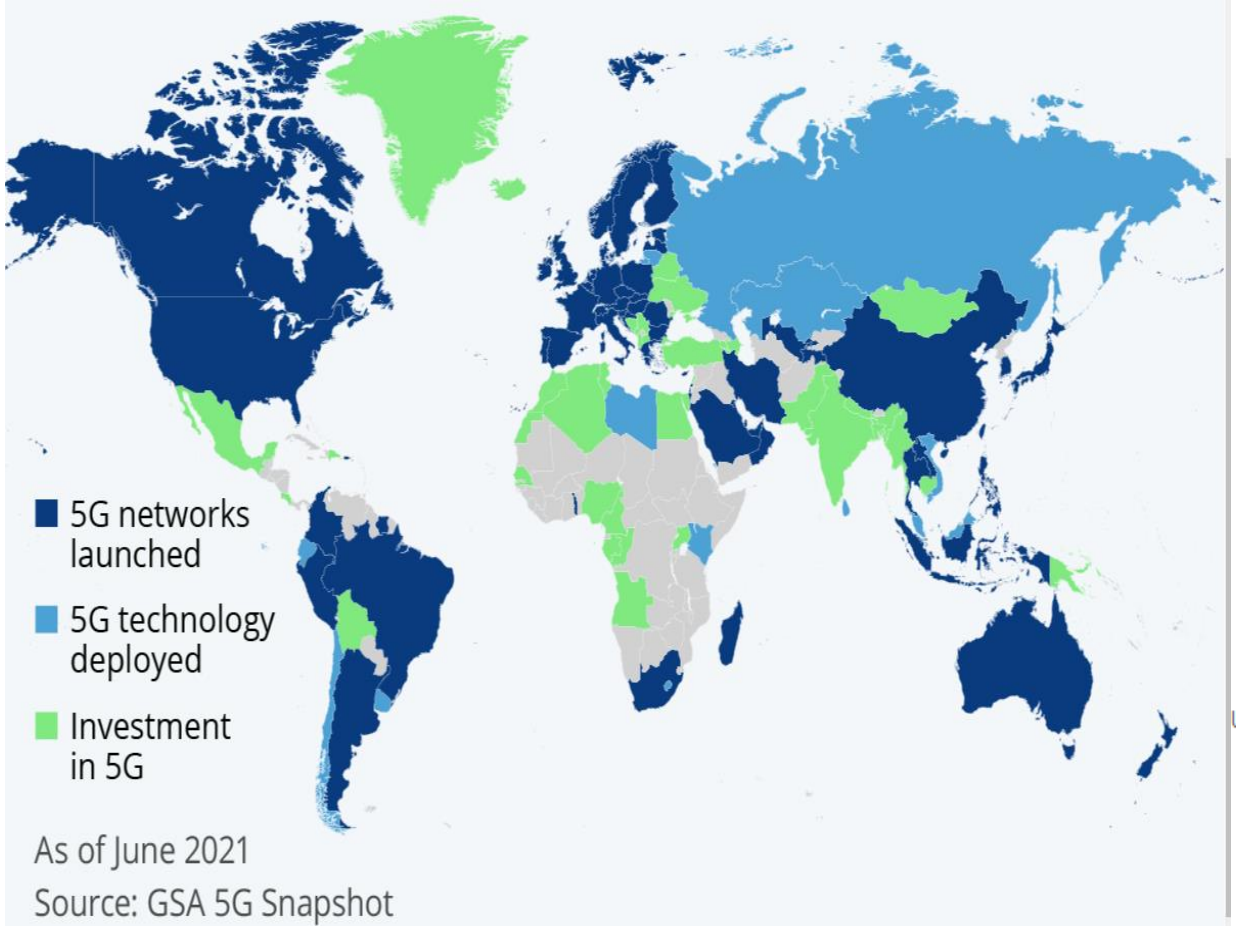
IMT-2020 standardization

Detailed specification of terrestrial IMT-2020 (Rec. ITU-R M.2150)

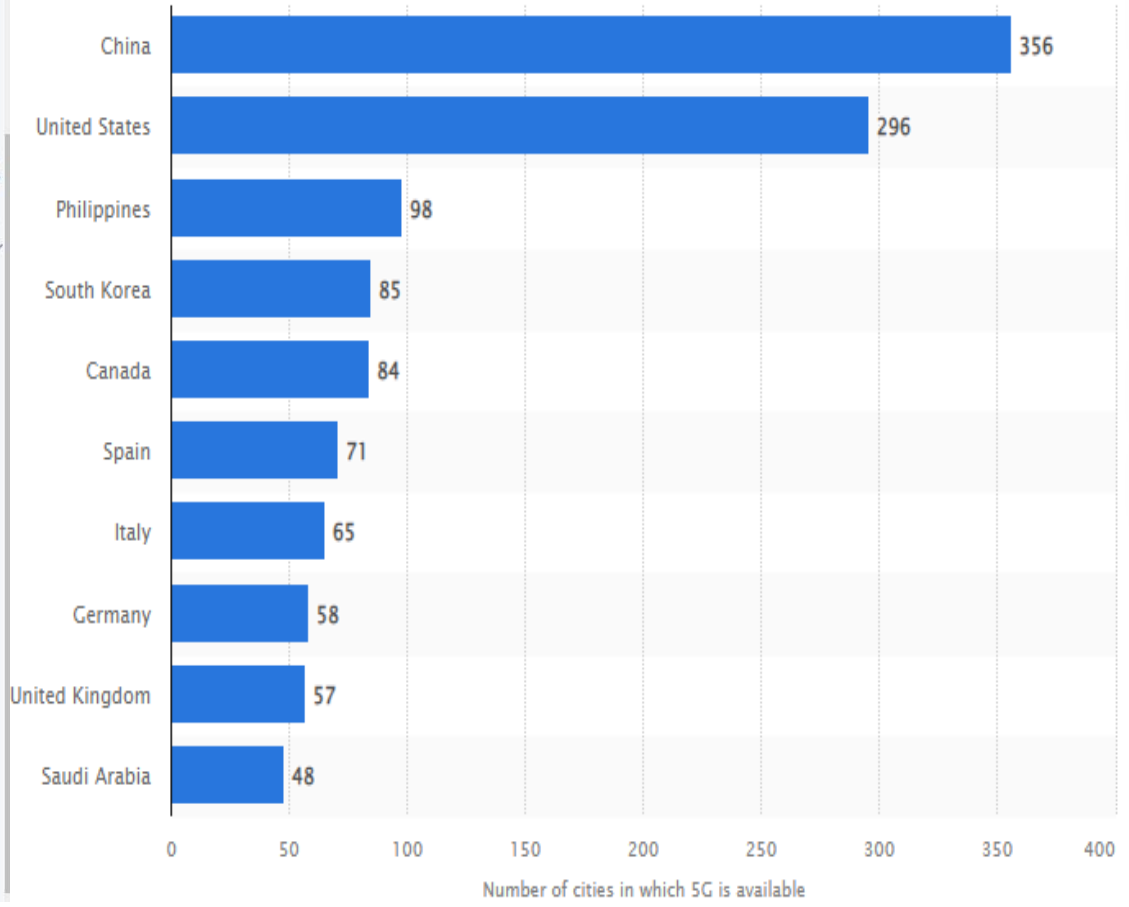
Category	Requirements	3GPP 5G-SRIT (NR + LTE)	3GPP 5G-RIT (NR)	TSDSI 5Gi-RIT	DECT 5G-SRIT (DECT-2020 NR + 3GPP NR)
Service	Wide range of services with different usage scenarios	Yes (eMBB, URLLC, and mMTC)	Yes (eMBB, URLLC, and mMTC)	Yes (eMBB, URLLC, and mMTC)	Yes (eMBB, URLLC, and mMTC)
Spectrum	Supported frequencies below 6 GHz	LTE: 450-5925 MHz NR: 663-5000 MHz	663-5000 MHz	450-6000 MHz	DECT-2020 NR: 450-5925 MHz 3GPP NR: 663-5000 MHz
	Supported frequencies above 24.25 GHz	24.25-40 GHz	24.25-40 GHz	24.25-52.6 GHz	24.25-40 GHz
	Bandwidth flexibility	LTE: Up to 640 MHz NR: Up to 6.4 GHz	Up to 6.4 GHz	5-400 MHz	DECT-2020 NR: Up to 194 MHz 3GPP NR: Up to 6.4 GHz
	Duplex flexibility	FDD/TDD	FDD/TDD	FDD/TDD	DECT-2020 NR: TDD 3GPP NR: FDD/TDD
Technical performance	Report ITU-R M.2410	Yes	Yes	Yes	Yes

5G deployment

Countries where 5G has been deployed



Countries with the highest number of cities in which 5G is available, 2022



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Operators and industries are searching for sustainable and profitable business models

All use cases and services are explored

Enhanced mobile broadband

- eMBB is leading 5G usage
- Broadband in dense areas and everywhere, 50 Mbps
- Last mile wireless access
- 4k/8k and 3D video
- Augmented / virtual reality

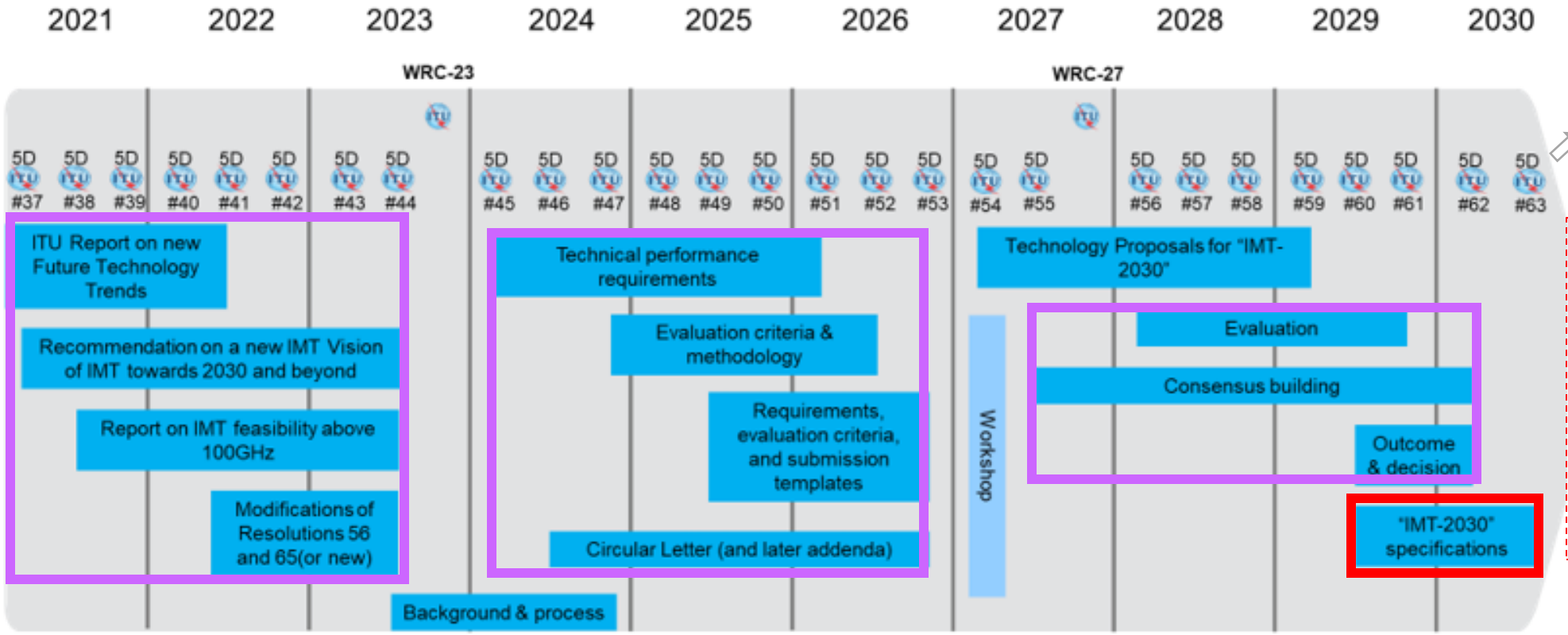
Ultra- reliable and low-latency communications

- Smart factories (robotics, automation)
- High mobility apps (e.g. in trains up to 500 km/h)
- Connected drones
- Autonomous cars

Massive machine-type communications

- 1 million devices per km^2
- Smart cities, ports
- Power, water grids
- Other sensor networks
- Medical and sport wearable

Timeline for “IMT towards 2030 and beyond”



ITU-R – Study Group 5 and subsequent approval by the Member States

Note 1: Meeting 5D#59 will additionally organize a workshop involving the Proponents and registered IEGs to support the evaluation process
Note 2: While not expected to change, details may be adjusted if warranted. Content of deliverables to be defined by responsible WP 5D groups

Vision / Definition ⇨ **Requirements and Evaluation criteria** ⇨ **Evaluation and Consensus building** ⇨ **Specification** ⇨ **Approval**

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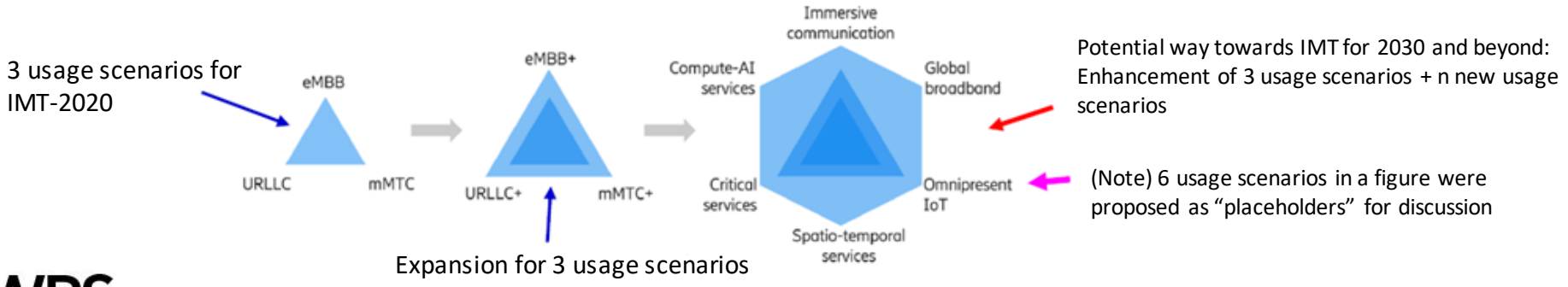
Note: Timeline as agreed at meeting #41 of ITU-R WP 5D (see 5D/1361, Ch. 2, Att 2.12)

Trends of IMT for 2030 and Beyond

Evolution of usage scenarios from IMT-2020 to IMT for 2030 and beyond are under discussion.

Based on inputs, 6 usage scenarios are temporally grouped as candidates.

- Usage scenario A: [Immersive communication, Immersive connectivity, Extending eMBB, uMBB, Further Enhanced MBB, Further enhanced Mobile Broadband with increased data rate, Low Latency Mobile Broadband/Hotspot coverage with ultra-high data rate and ultra-low latency, High Mobility Broadband, High Stability Broadband]
- Usage scenario B: [Super ultra critical communications]
- Usage scenario C: [Ubiquitous massive MTC]
- Usage scenario D: [Broadband for All, All earth coverage]
- Usage scenario E: [Compute-AI services, Quality Guaranteed Network AI services]
- Usage scenario F: [Sensing & Communication]



Technology trends – radio access technologies

Carrier aggregation (CA)

- Within same frequency block and
- Among different bands (e.g. 700 MHz / 1.8 / 2.6 / 3.5 GHz / mm Wave / above 100 GHz)

✓ Enables flexibility of frequency use

Advancements in antennas

- Massive MIMO and Active antenna system (AAS)
- 3D-beamforming, higher order Multi-user MIMO
- Cooperative MIMO (i.e. Network MIMO or Ad-Hoc MIMO)

✓ Enable higher radio link performance

Advancements in modulation

- Filtered OFDM and Filter bank multi-carrier (FBMC) modulation

✓ Ensure a higher level of spectrum efficiency

Non-orthogonal multiple access (NOMA)

✓ Allocating higher power to users with worse channel conditions

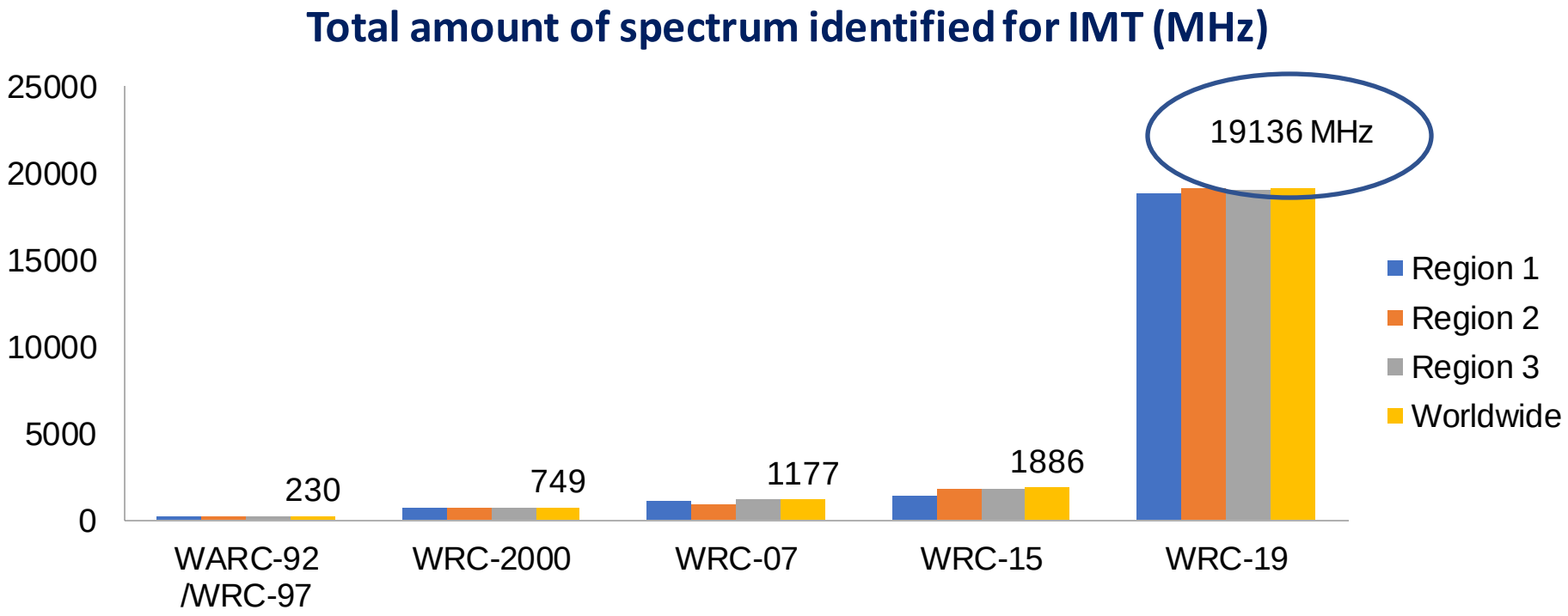
Report ITU-R M.2320

Technology trends - Networks

- **Dual connectivity and heterogeneous networks**
  - **Dual connectivity** between 4G evolution, 5G NR and 6G
  - **Cooperative operation** of FDD and TDD, IMT and RLAN
- **Self-organizing ultra dense networks with small cells support digital TWIN concept**
  - Software defined networking (SDN)
  - Network function virtualization (NFV)
  - Cloud radio access network (C-RAN)
  - Multi-Access Edge Computing (MEC)
- **Artificial Intelligence**: for automatization and orchestration of network management and processing information
- **Network slicing**

International IMT harmonization

- **ITU identifies spectrum for mobile broadband at World Radiocommunication Conferences (WRCs)**



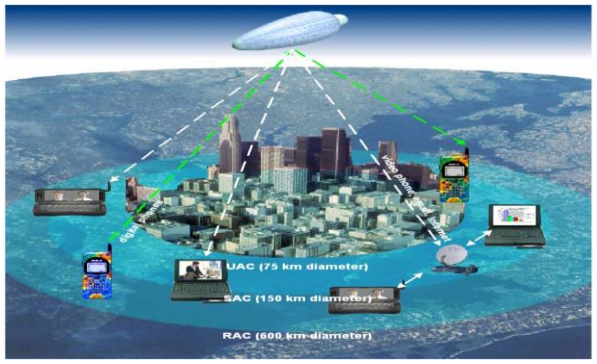
- Spectrum is harmonized globally and regionally. This enables economies of scale and roaming
- 5G needs low, medium and high bands (e.g. in Europe: 700 MHz, 3.6 GHz, 26 GHz)
- WRC-23 will consider possible identification of frequencies for IMT between 3.3 and 10.5 GHz

IMT candidate spectrum at WRC-23

- **Below 1 GHz – coverage bands**
  - **AI 1.5** – consideration of possible introduction of IMT below **700 MHz** in Region 1
- **Between 3.3 and 10.5 GHz - balancing coverage and capacity needs**
  - **AI 1.1**: **4800-4990 MHz** – conditions for IMT use to protect aeronautical and maritime services in international waters and airspace
  - **AI 1.2**: frequency band allocation for mobile service and identification for IMT in:
    - **3 300-3 400 MHz** (Regions 1 and 2)
    - **3 600-3 800 MHz** (Region 2)
    - **6 425 – 7 025 MHz** (Region 1)
    - **7 025-7 125 MHz** (globally)
    - **10.0-10.5 GHz** (Region 2)
  - **AI 1.3**: Upgrade of mobile service to primary in **3.6 – 3.8 GHz** (Region 1)
  - **AI 1.4**: the use of HIBS (high-altitude platform stations as IMT base stations) below 2.7 GHz
    - **694-960 MHz / 1 710-1 980 MHz, 2 010-2 025 MHz and 2 110-2 170 MHz / 2 500-2 690 MHz**

Broadband over other platforms - HAPS

- ITU studies of High Altitude Platform Stations (HAPS) began around 1996
- **WRC-97** officially recognized the HAPS usage (definition of HAPS in RR Art. 1; provisions for operation of HAPS within the fixed service in the 47.2-47.5 GHz, 47.9-48.2 GHz bands)
  - WRC-97 decision was linked to the project of Sky Station International, Inc.



- **140 assignments (8 ADMs) were provisionally recorded in the MIFR in 1997 and kept until 01.01.2012**
- **WRC-2000** enabled the HAPS use as base stations within the IMT-2000 terrestrial component (1885-1980 MHz, 2010-2025 MHz, 2110-2170 MHz bands in Regions 1 and 3; 1885-1980 MHz, 2110-2160 MHz bands in Region 2).

Spectrum for HAPS

- **WRC-03** updated the radio regulatory framework and **WRC-07** modified the use of HAPS in the 27.9-28.2 GHz, 31-31.3 GHz bands in certain Regions 1 and 3 countries;
- **WRC-12** permitted the use of HAPS gateway links in the fixed service in the 6 440-6 520 MHz and 6 560-6 640 MHz bands within the territories of limited number of countries and **WRC-15** updated provision for HAPS in the 31-31.3 GHz band
- **WRC-19** identified additional spectrum for HAPS

Frequency band	Amount	Identification	Dir.	RR Footnotes
1 885-1 980 MHz	95 MHz	Worldwide	↑	5.388A
2 010-2 025 MHz	15 MHz	Regions 1 and 3	↑	5.388A
2 110-2 170 MHz	60 MHz	Regions 1 and 3	↑↓	5.388A
2 110-2 160 MHz	50 MHz	Region 2	↑↓	5.388A
6 440-6 520 / 6 560-6 640 MHz	80 MHz	5 ctry (R1, R3)	↓/↑	5.457
27.9-28.2 GHz	300 MHz	24 ctry (R1, R3)	↓	5.537A
31-31.3 GHz	300 MHz	Worldwide	↑	5.534B
47.2-47.5 & 47.9-48.2 GHz	300+300 MHz	Worldwide	↑↓	5.552
21.4-22 GHz	600 MHz	Region 2	↑	5.530E
25.25-27 GHz / 24.25-25.25 & 27-27.5 GHz	1.75 / 1.5 GHz	Region 2	↑ ↓	5.532AA & 5.534A
38-39.5 GHz	1.5 GHz	Worldwide	↑↓	5.550D

Some current HAPS examples (1)

Project /Product	Type	Company/ Organization	Description / Important features
Sceye *Started at 2014*	Aerostatic (Airship) 	Sceye Inc.	• Telecommunications, maritime safety and surveillance, science missions and different monitoring services are among the primary applications. • A payload is being developed based on OpenRAN technology that supports 2G/3G/4G/5G NR RANs as well as an active array antenna with 3D beamforming technology with 100-200 independently activated beams. BS projected coverage area is up to 150 km radius. • It is currently in precommercial demonstrator phase and expected to be commercially available in the US in 2023.
Stratomast *Started at 2014*	Aerodynamic 	Stratospheric Platforms Limited (SPL)	• Engineered to deliver 4G/5G services directly to standard smartphones and user equipment • It demonstrated the world's first successful HAPS based 5G base station in 2022. • It was envisioned to operate 6-9 days at cruise altitude of above 18 km providing telecommunications within 100% geographic coverage radius ≥70 km. • Commercial service are commencing in 2025.
AVEALTO *Started at 2013*	Aerostatic (Airship) 	AVEALTO Ltd.	• It is designed for connecting unserved- and underserved-regions, mobile operators, and the maritime industry, with telecommunications infrastructure via HAPS. • It is envisioned to operate at an altitude of 18-22 km providing telecommunications with a coverage area for each HAP around 240 km in diameter over most land areas and around 480 km over oceans or plains. • Commercial prototype is expected to have a telecom payload of around 50 kg, operating in the Ku band. The announced commercial services commence by end of 2022.

Sources: 1) GSMA White Paper 'High Altitude Platform Systems: Towers in the Skies Version 2.0' February 2022. 2) https://avealto.com/

Broadband over other platforms - RLANs

- WAS/RLAN has been providing broadband over fixed radio networks since 1997. From 1 Mbps in the beginning, up to multi Gbps today
  - RLAN in 2.4 GHz and 5 GHz bands (Wi-Fi)
    (Rec. ITU-R M.1450, ETSI EN300 328, IEEE 802.11)
  - RLAN in 6 GHz band (outside of ITU studies)
  - Multiple Gigabit Wireless Systems in 60 GHz band (WiGig)
    (Rec. ITU-R M.2003 , ISO/IEC 13156, ETSI EN302 567)
- WRC-19 decided to allow outdoor usage of RLANs in the band 5 150 – 5 925 MHz
- Wi-Fi is extensively used for offloading mobile traffic

Concluding remarks

- Mobile broadband is beneficial for economies, it brings new services, transform societies.
- Mobile Broadband provides necessary connectivity for various sectors, such as smart cities, smart homes, smart works, smart factories, connected vehicles, IoT, etc.
- It ensures higher data rates, higher mobility, higher spectrum efficiency, massive connectivity, higher energy efficiency, ultra low latency
- ITU contributes to broadband developments by:
  - providing harmonized spectrum and stable regulatory environment
  - developing IMT Vision and Standards
  - Disseminating best practices on broadband utilization
- Broadband development should be balanced.

Thank you!

ITU – Radiocommunication Bureau

Questions to brmail@itu.int

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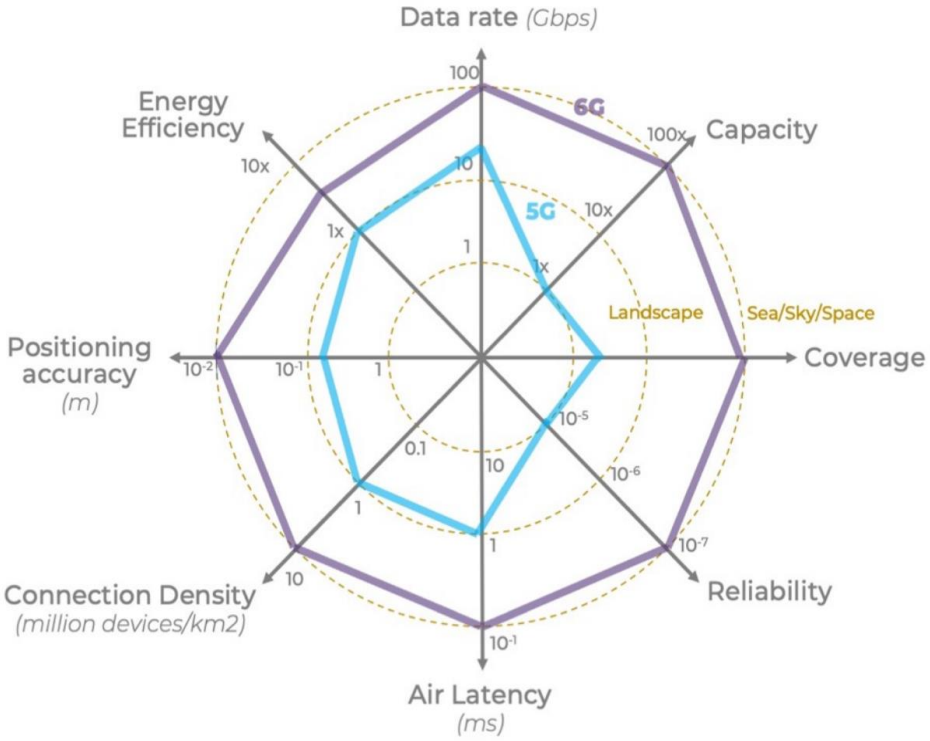
Work for IMT for 2030 and beyond

For the next IMT-generation ("**IMT for 2030 and beyond**")

- Draft new Report ITU-R M. [IMT.FUTURE TECHNOLOGY TRENDS OF TERRESTRIAL IMT SYSTEMS TOWARDS 2030 AND BEYOND] has been developed and it will drive specification work (Document 5/85)
- Preliminary draft new Rec. ITU-R M.[IMT.VISION 2030 and Beyond] – Framework and overall objectives of the future development of IMT for 2030 and beyond including use cases (Annex 3.6 to Document 5D/1361)



Some current HAPS examples (2)

Project /Product	Type	Company/ Organization	Description / Important features
Sunglider (as of 2021) ***Started at 2017***	Aerodynamic 	HAPSMobile	• Primary application is for communication (current smartphones, etc), disaster relieve, IoT, drones. • It is envisioned to offer a BS incorporated into the aircraft to telecom operators as infrastructure. It might be possible to share an aircraft among multiple operators in area. • Its envisioned service area is 200 km in diameter, with flight duration for several months. • It is expected to be commercially available around 2027.
Zephyr 8 ***Started at 2010***	Aerodynamic 	Airbus Defense and space, Zephyr Solar Powered HAPS	• Primary connectivity application is presumed to be the use for Direct to Device Services. • Other secondary connectivity applications include Backhaul, Rural, Disaster Recovery, Maritime, Relay, IoT, Automated, Vehicles/Drones/Machinery. • Next Generation aircraft is envisaged with 15-20 kg payload, radius coverage 25-100km • Currently, it is in pre-commercial and industrialisation phase.
Stratobus ***Started at 2014***	Aerostatic (Airship) 	Thales Alenia Space	• One of its primary target applications is to provide 5G/6G telecommunications. • Telecom commercial applications are 4G/5G mobile broadband access, residential access and backhauling. In each case the feeder link uses HAPS bands (Ka/Q/V). IMT bands are usable for 4G/5G access, and HAPS bands (Ka/Q/V) for residential access and backhauling. • Telecom applications also include connectivity to Drones, UAVs or autonomous cars. Telecom applications can also include optical point-to-point connectivity, either between several airships (max distance ≈500 km), or between satellite and airship, or between ground and airship. The mission duration is about a year. • Demonstrator test flight is expected from 2024 (commercially available from 2030).

Source: GSMA White Paper 'High Altitude Platform Systems: Towers in the Skies Version 2.0' February 2022.