ATU-R RECOMMENDATION

RELATING TO

The Implementation of Emerging Radiocommunication Technologies Namely: 5G/IMT2020; HAPS; FSS ESIM; MSS Applications; FSS VSAT And Other Applications; WiFi in 6GHz; WiGig In 60GHz and 5G NR-U

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Contents

1. Preamble

1.1 The African Telecommunications Union (ATU) is a specialised institution (SI) of the African Union (AU) in the field of telecommunications and ICTs. As an SI, ATU executes tasks assigned to it by the AU from-time-to-time.

1.2 An extra-ordinary meeting of the AU Bureau of the Specialized Technical Committee on Communication and ICT (STC-CICT) was held on 5th May 2020 to "consider strategies and actions to support the continental strategy on COVID-19 pandemic". The meeting took place by videoconference. The STC-CICT Bureau comprises Ministers in charge of Communication and ICTs from Africa.

1.3 As part of the strategies and actions to support the continental strategy on COVID-19 pandemic, the said meeting approved an Action Plan on ICT Sector COVID 19 Response in which one of the long-term action items is "efforts to harness the potential of emerging technologies such […] IoT and 5G/IMT-2020 to improve people lives in Africa."

1.4 Pursuant to the above stated Action Plan, the ATU has developed recommendations on the implementation of emerging radiocommunication technologies in Africa relating to 5G/IMT-2020; HAPS; Satellite applications; and Wi-Fi in 6GHz, WiGig in 60GHz and 5G NR-U.

1.5 The respective recommendations on the implantation of the afore-mentioned emerging technologies are presented in Sections (1) to (4) of this document.

2. Purpose and Scope

This Recommendation provides guidance on the implementation of 5G/IMT-2020; HAPS; FSS ESIM, MSS applications, FSS VSAT and Other applications; Wi-Fi in 6GHz, WiGig in 60GHz and 5G NR-U, with a view to assisting administrations on spectrum-related technical issues relevant to the harmonised implementation and use of the technologies.

The Recommendation was developed from the perspective of enabling the most effective and efficient use of the spectrum to deliver broadband and related services in Africa – while minimizing the impact on incumbent services – and facilitating the growth of the emerging technologies.

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This Recommendation is complemented by other ATU Recommendations as well as ITU-R Recommendations and Reports relevant to these emerging technologies that provide additional details on a number of aspects including technical, operating and regulatory conditions.

3. Presentation of the Recommendation

The Recommendation is presented as follows:

- Section 1: 5G/IMT-2020
- Section 2: HAPS
- Section 3: Satellite applications: FSS ESIM, MSS and FSS VSAT and other applications
- Section 4: WiFi in 6GHz, WiGig in 60GHz and 5G NR-U

Each section is laid out in four (4) parts, namely: (1) Brief Introduction; (2) Main elements for consideration; (3) Recommends; and (4) Annexes where applicable.

Section 1

5TH GENERATION MOBILE SYSTEMS/IMT-2020 (5G/IMT-2020)

Contents for this Section

S1(1): Introduction

5G/IMT-2020 represent more than just another step in the evolution of wireless technologies. It is the convergence of wireless with computing and the cloud. 5G/IMT-2020 is a new paradigm, enabling everything to be “smart”, because everything is connected. 5G/IMT-2020 will enable use cases and applications that are especially relevant for African countries such as communications, agriculture, healthcare, education, mining, manufacturing, public safety, and disaster response.

It is already common understanding that connectivity is a key factor for success in the new, increasingly digital economy. The COVID-19 pandemic has further demonstrated the importance of robust connectivity in the 21st century. To enable 5G/IMT-2020 in Africa, it is critical to provide enough spectrum per operator for 5G/IMT-2020 in low-bands, mid-bands and high-bands at a reasonable price. Supportive policies, such as those that make it easier and cheaper to get wayleaves and that reduce the taxation in order to make broadband affordable, will also be necessary to foster the deployment of 5G/IMT-2020.

1. 5G/IMT-2020 as a new enabler of broadband in Africa

The need for greater broadband coverage in Africa is well-known, as is the need for it to be more affordable. Mobile networks will keep on playing a critical role in delivering broadband connectivity. Broadband usage is growing rapidly and will continue to do so, as evidenced by the experience during the COVID-19 pandemic.

The lack of affordable broadband is detrimental to individuals (education, healthcare), businesses and the public sector (security).

With the relatively high cost and long rollout time for fibre-to-the- building (FTTB), Fixed Wireless Access (FWA) using 5G/IMT-2020 can play an important role in Africa as in other parts of the world. With a form of fixed wireless access service delivered to Consumer Premise Equipment (CPE) devices which in turn provide local connectivity to other devices (typically over Wi-Fi), and dongles, 5G/IMT-2020 FWA can be rolled out rapidly and affordably to help address the broadband affordability challenge. Today more than half of operators with commercial LTE or 5G networks worldwide[1] have service offers for FWA using LTE or 5G. While current FWA using 4G networks continue to play an important role, they are limited by spectrum and capacity. With the right policies and regulations 5G/IMT-2020 has the potential to increase efficiencies and affordability.

1 423 operators in 166 countries offer FWA services based on LTE, 44 operators have announced 5G FWA services. Source: FIXED WIRELESS ACCESS Global status update November 2020, GSA. https://gsacom.com/paper/fwa-update-november-2020-global-status/

5G/IMT-2020 also has the potential to help mitigate the risk of a widening digital divide between the cities with inhabitants increasingly able to access fibre, and the rural and remote areas where connectivity is limited (and often cannot access any mobile broadband at all). African countries can take advantage of 5G/IMT-2020 to reduce the digital divide and provide services to all citizens regardless of geographical location, including the currently underserved and unserved areas.

Finally, 5G/IMT-2020, can be leveraged as a tool for global economic competitiveness, industrialization and integration into the global digital economy.

S1(2): Main Elements For Consideration

1. What is 5G/IMT-2020?

5G/IMT-2020 will power substantial improvements to wireless broadband networks, going beyond a faster version of 4G to enable a new kind of network, supporting a vast diversity of devices with unprecedented scale, speed, and complexity. The introduction of 5G/IMT-2020 will not only help to meet current market demands, but also will bring the potential to connect new industries and devices, empower new services, open up new business models, and bring new levels of cost savings and energy efficiency.

The full deployment of 5G/IMT-2020 can power applications across the economy and society — in our homes, communities, and businesses, and across industries, like in transportation, manufacturing, agriculture, and healthcare. Increased data speeds and reduced latency and data costs are expected to enable the incorporation of intelligent wireless technology into new industries and sectors.

IMT for 2020 and beyond (IMT-2020) is envisaged to expand and support diverse usage scenarios and applications that will continue beyond the current IMT. These intended different usage scenarios and applications for IMT for 2020 and beyond have been defined in ITU[2] (see Figure 1 below) as follows:

- Enhanced Mobile Broadband (eMBB): 5G/IMT-2020 will offer advanced mobile broadband, bringing ultra-high-speed internet to the home, the office and on the move. It will enable data-intensive applications such as those bringing immersive experiences (e.g. virtual reality, augmented reality).
- Massive machine type communications (mMTC): 5G/IMT-2020 networks will enable the rapid exchange of information on a massive scale, connecting sensors, infrastructure, wearables,

2 Recommendation ITU-R M.2083 - IMT Vision – Framework and overall objectives of the future development of IMT for 2020 and beyond

and other devices in the Internet of Things (IoT), as well as connecting with other evolving technologies, such as cloud storage and processing, and artificial intelligence. Applications include smart home, smart cities, and sensors.

- Ultra-Reliable Low Latency Communications (URLLC): Applications include mission critical type communication (e.g. autonomous driving, industrial automation).

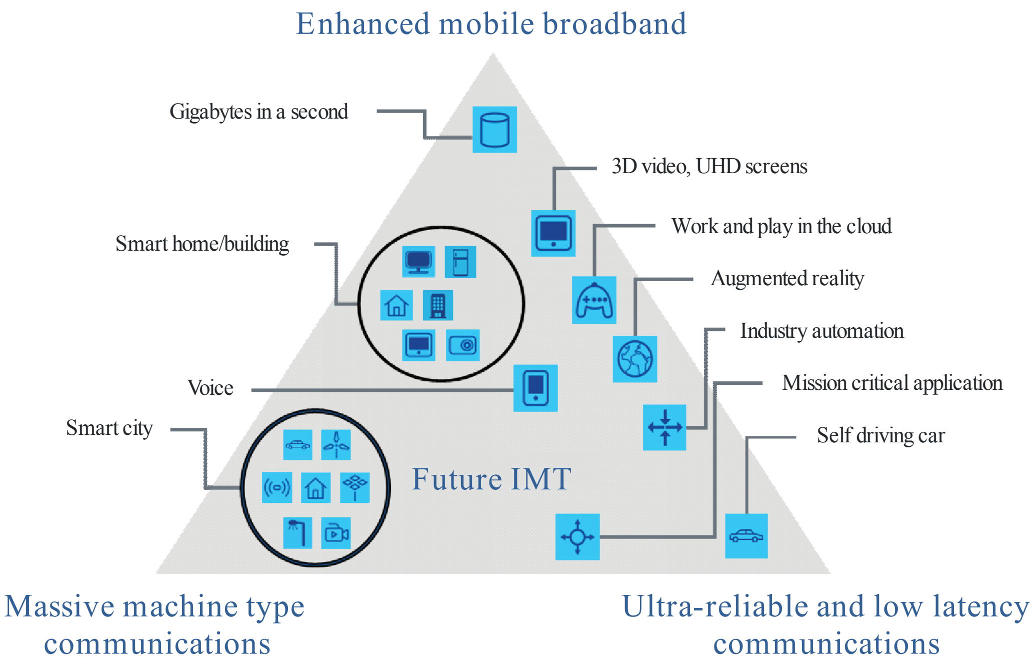

Figure 1: Usage scenarios of IMT for 2020 and beyond

The capabilities of IMT-2020 technologies are enhanced and backward compatible with those of IMT-Advanced as indicated in Figure 2 below. These IMT-2020 capabilities include, notably:

1. The peak data rate for enhanced Mobile Broadband features up to 20 Gbps which is 20 times higher than the data rates of IMT-Advanced.
2. The area traffic capacity is 100 times higher than that of IMT-Advanced.
3. A spectral efficiency 3x more efficient than IMT-Advanced for enhanced Mobile Broadband.
4. A sub- 1 millisecond end-to-end delay for low latency applications.

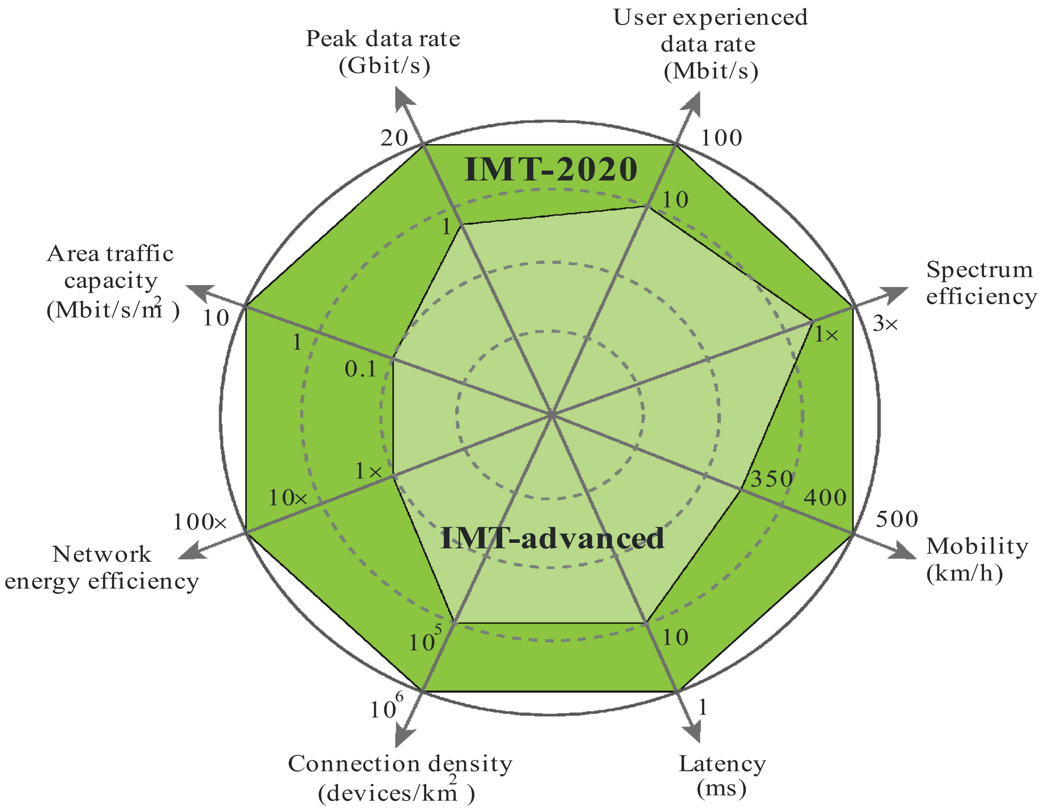

Figure 2: Enhancement of key capabilities from IMT-Advanced to IMT-2020

2. 5G/IMT-2020 use case relevant to Africa

The majority of internet access in Africa is through mobile[3] unlike other regions. One reason is because penetration and speeds of fixed broadband in the continent are low[4]. 5G networks will be

3 "Connecting Africa Through Broadband", a report from the Broadband Commission for Sustainable Development, https://broadbandcommission.org/Documents/working-groups/DigitalMoonshotforAfrica_Report.pdf

4 According to Ovum´s Consumer Broadband Subscription and Revenue Forecast: 2017–22, less than 8% of African households have fixed broadband access, and the average speed is less than 10 Mbps.

used to support future growth of mobile broadband and fixed wireless access. There are two trends that point to an increase in mobile broadband traffic:

- The cost per bit of mobile broadband provisioning is going down[5,6,7]
- Unlimited (or >100GB) data packages and high-speed networks are becoming widespread[8]

These trends suggest that WiFi offload may decrease: with the cost per bit in mobile networks going down, the business case of operator offloading become less appealing[9]. Secondly, from a consumer perspective, the hassle of connecting to WiFi hotspots is not justified with an unlimited data package and 4G/5G networks. Instead of WiFi offload, there may be an increase in "WiFi onload" where a mobile connection is used to backhaul a WiFi access point[10]. This mode of connectivity to the internet is frequent in African countries.

Beyond better and faster mobile broadband, the possible applications that can be supported with 5G/IMT-2020's increases in connection speed, mobility, and capacity are vast, with the potential to impact across industries. In Africa, there are several 5G/IMT-2020 enabled use cases and applications that hold particular potential for the region (Table 1).

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5 "The 5G consumer business case", Ericsson, https://www.ericsson.com/491c9e/assets/local/networks/documents/the-5g-consumer-business-case.pdf

6 "A playbook for accelerating 5G in Europe", Boston Consulting Group, https://image-src.bcg.com/Images/BCG-A-Playbook-for-Accelerating-5G-in-Europe-Sep-2018_tcm9-202394.pdf

7 "Building the 5G Business Case", Cisco, https://blogs.cisco.com/sp/building-the-5g-business-case

8 Many operators from all regions have introduced unlimited/high data commercial offers. Examples include Pelephone in Israel, Vodafone in the UK, Vodacom in SA (see links below), O2 in the UK, SK Telecom in South Korea, Sprint and TMobile in the US, NTT DoCoMo in Japan, Swisscom in Switzerland and many more https://www.datacenterdynamics.com/en/news/israel-awards-5g-contracts-pelephone-hot-mobile-and-partner-comms/https://www.vodafone.co.uk/unlimited-data-plans/https://www.vodacom.co.za/

9 Data made available by the Ministry of Science and Technology of South Korea shows that the traffic carried by Korean MNOs has grown from 130,000 TB/month to 640,000 TB/month since 2015. However, the proportion of this traffic that operators offload to their WiFi networks has decreased steadily in the same period (from 6% to 2%). On absolute terms, offloaded traffic reached a maximum in 2019 and has started to decrease slowly while the cellular traffic has skyrocketed. Source data: https://www.msit.go.kr/bbs/list.do?sCode=user&mPid=74&mId=99

10 "The 6 GHz opportunity for IMT", Coleago Consulting, http://www.coleago.com/keynote-presentations-and-resources/

Table 1: Selected 5G/IMT-2020 impacts across verticals in Africa

Application	Use Cases	Examples
Communications	• High-speed broadband in the home • High-speed broadband in the office	• Improved broadband connectivity due to higher-speed, lower-latency connections • Expanded Internet access due to new or expanded network deployments
Agriculture	• Stationary/near-stationary monitoring networks • Collaborative robots	• Connected sensors can be quickly deployed in agricultural settings, allowing for better monitoring of crops, animals, and equipment • Monitoring could also benefit wildlife management and protection • Integration into agricultural processes can increase efficiencies and lower costs for labour-intensive industries
Healthcare	• Virtual meeting • High-speed broadband in the home • High-speed broadband in the office • Remote object manipulation • Smart wearables	• Remote access to medical professionals and specialized care through enhanced videoconferencing, remote diagnosis, and remote surgery • Collection and analysis of patient data from connected wearable sensors/monitors • Personalized medicine leveraging data collected from wearables and improved access to providers
Education	• High-speed broadband in the home • Virtual meeting • Virtual or augmented reality • Remote object manipulation	• Improved and more immersive distance learning via videoconferencing and improved access to rich media resources • Industrial/workplace education due to videoconferencing, augmented reality/virtual reality, and haptic feedback
Manufacturing, Mining, and Construction	• Collaborative robots • Remote object manipulation • Virtual meeting • Virtual or augmented reality • Ultra-low-cost networks	• Smart factories, including replacement of wired connections, cell automation, machine vision, improved efficiency • Real-time assistance via videoconferencing and augmented reality • Remote control of industrial equipment
Public Safety and Disaster Response	• Broadband to special events • Remote object manipulation	• Enhanced, secure, mission-critical communications • Coverage extension in out-of-network areas through new device-to-device connectivity models • Unmanned vehicles for rescue and reconnaissance

3. Economic contributions of 5G/IMT-2020

There is potential for 5G/IMT-2020 to bring changes across a range of sectors and settings. Depending on their implementation, these 5G/IMT-2020 enabled changes can lead to both qualitative and quantitative impacts. For example, at a qualitative level, improved access to medical professionals and health data could lead to overall health improvements. Expanded availability of educational resources and job training could affect the characteristics of the labour pool. Improvements in industrial settings could increase efficiency and productivity, resulting in changes to the cost structures of underlying products used throughout the economy.

On a quantitative level, 5G/IMT-2020 studies and forecasts indicate that 5G/IMT-2020 use cases will be reflected across multiple sectors or verticals, demonstrating the wide range of potential impacts of 5G/IMT-2020 technology and services across economies in Africa and globally.[11]

According to a study by IHS Economics and IHS Technology, by 2035 a broad range of industries—from retail to education, transportation to entertainment, and everything in between—could produce up to USD 12 trillion worth of goods and services enabled by 5G/IMT-2020.[12]

A 2018 study published by GSMA and Telecommunications Management Group (TMG) considered the economic impact of deploying mmWave spectrum for 5G/IMT-2020, and found that 5G/IMT-2020 is expected to generate USD 2.2 trillion in GDP by 2034, with mmWave spectrum responsible for USD 565 billion, or approximately a quarter of that total.[13] Further, it considered the impact of mmWave spectrum on various regions, including the Middle East and North Africa as well as Sub-Saharan Africa. The study's findings indicated that mmWave spectrum used for 5G/IMT-2020 services would enable USD 15.4 billion of GDP growth in the Middle East and North Africa region, and USD 5.2 billion in Sub-Saharan Africa, or 1.1% GDP growth in the former and 0.7% GDP growth in the latter, as indicated in Figure 3.

11 See, for example, SNS Research (2017), "The 5G Wireless Ecosystem: 2017 – 2030: Technologies, Applications, Verticals, Strategies & Forecasts," http://www.snstelecom.com/5g and 5G Americas (2017), "5G Services & Use Cases," http://www.5gamericas.org/files/9615/1217/2471/5G_Service_and_Use_Cases__FINAL.pdf

12 IHS Economics and IHS Technology, "The 5G economy: How 5G technology will contribute to the global economy" (January 2017), https://www.qualcomm.com/documents/ihs-5g-economic-impact-study.

13 GSMA/TMG, "Study on Socio-Economic Benefits of 5G Services Provided in mmWave Bands," (December 2018), https://www.gsma.com/spectrum/wp-content/uploads/2019/06/mmWave-5G-benefits.pdf.

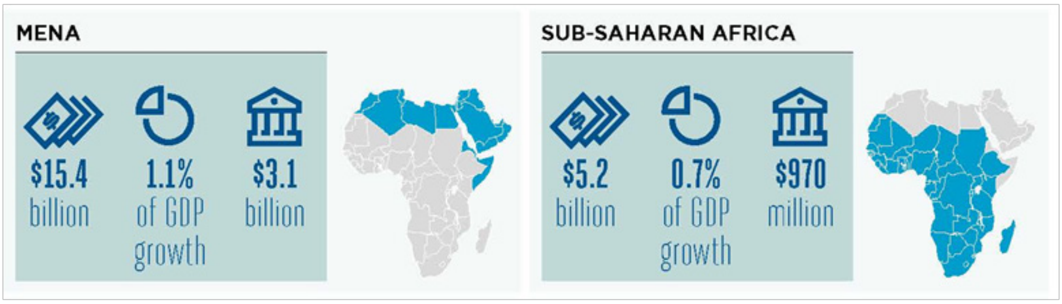

Figure 3: Economic impact of mmWave-enabled 5G/IMT-2020 in Africa[14]

A 2021 study from the GSMA looks at the benefits of using the 3.3-4.2 MHz range for 5G. For Sub-Saharan Africa, it concludes that an allocation of 500 MHz would bring economic benefits of $3Billion over 15 years, above a baseline of using only 200 MHz for 5G.[15]

These estimates considered 5G/IMT-2020's potential impact before the global pandemic that has hit the global economy this year, and therefore the projections may need to be revised slightly to account for the downturns in the economy due to COVID-19. At the same time, the crisis increased the demand for quality broadband connectivity at home, underlining the great the opportunities that 5G FWA would offer. Thankfully, Africa as a region has seen less marked drops in GDP growth compared to other regions[16] and the potential economic impact of 5G/IMT-2020 remains significant and will accrue as countries deploy networks.

4. Policy/Regulations actions to support 5G/-IMT-2020 Implementation

For 5G/IMT--2020 and its use cases to flourish in Africa, it is important that governments take steps to review and revise laws and regulations that could inhibit the deployment and development of 5G/IMT-2020, whilst at the same time ensuring compatibility with existing services. This should include the review and update of existing broadband and digital economy strategies, as well as modernization of existing regulations to incorporate the needs of 5G/IMT-2020. While the circumstances within each Member State may differ, it is beneficial to develop a framework of regulations and guidelines to be reviewed at the appropriate level in order to identify potential obstacles for successful 5G/IMT-2020 deployment.

14 Source: GSMA/TMG, "Study on Socio-Economic Benefits of 5G/IMT-2020 Services Provided in mmWave Bands," (December 2018), https://www.gsma.com/spectrum/wp-content/uploads/2019/06/mmWave-5G/IMT2020-benefits.pdf

15 https://www.gsma.com/spectrum/wp-content/uploads/2021/03/3.5-GHz-for-5G-Economic-Benefits.pdf

16 IMF, Real GDP growth: annual percent change (2020), https://www.imf.org/external/datamapper/NGDP_RPCH@WEO/OEMDC/ADVEC/WEOWORLD

This section contains recommendations in three broad areas:

- Policies to support of 5G/IMT-2020 adoption.
- Specific spectrum policies.
- Actions at a regional and African level.

4.1 Policies in support of 5G / IMT-2020 adoption

1) Regulatory review

It is recommended to review and modernize existing regulations to adapt to new technological developments (i.e. 5G/IMT-2020), including the elimination of regulations **that have outlived their original purpose, or that create unnecessary burdens which negatively impact deployment and adoption.**

2) Infrastructure support

Administrations should support the deployment of infrastructure that will facilitate 5G/IMT-2020 such as fibre, satellite, data centres and edge computing. In particular, 5G deployment can be significantly accelerated and made cheaper through deployment of a significant fiber infrastructure. Many countries have identified that public work costs are directly leading to deployment delay and that mutualisation of the physical infrastructure (ducts, trenches and dark fiber, poles, public buildings) can significantly accelerate 5G deployment.

For example, connecting public building with fiber – including dark fiber made available to MNOs – and allowing MNOs to install 5G BSs on public building would significantly accelerate 5G deployment.

3) Authorisation of new sites

5G/-IMT-2020 networks and the use of mmWave spectrum will require more dense network deployments, potentially increasing the number of base stations and towers. It is critical for regulators to develop streamlined approval processes to support the rollout of 5G/IMT-2020 and avoid cumbersome delays due to regulatory procedures. This could entail improving coordination across national, regional, and local governments, streamlining processes between the different levels of government, developing a public database of available station sites, or publishing detailed information regarding approval processes and instructions to obtain authorization.

4) Network traffic management

5G/IMT-2020 networks will enable the prioritization of different types of traffic depending on user needs and use cases. It will therefore be important for regulators to review "net neutrality" obligations to ensure that mobile network operators are able to leverage 5G/IMT-2020's technological benefits.

5) Privacy

In order to take advantage of improved connectivity due to 5G/IMT-2020 networks and devices, including distance learning, intelligent transportation systems, and smart healthcare devices, it is appropriate to review economy-wide and sector-specific privacy requirements to ensure that the legal and regulatory frameworks strike a balance between enabling information sharing from new categories of devices or newly connected devices and protecting sensitive personal and corporate data.

6) Role of public institutions

It is recommended to use 5G/IMT-2020 to connect public institutions. This will create synergies and kick-start 5G/IMT-2020 by providing key initial customers for operators. For example, connecting schools, police stations and clinics can catalyse 5G/IMT-2020 roll-out and help accelerate uptake.

7) Fixed Broadband

Administrations should encourage and facilitate the deployment of 5G/IMT-2020 for fixed wireless access, which can significantly increase broadband penetration, including in rural areas. 5G FWA relies on a device using a 5G link and a high gain antenna to connect the house to a 5G base station and distributes this connectivity within the house through WiFi. This setup results in greater broadband reach into rural areas and higher spectral efficiency for urban and suburban areas.

8) Consumer policy

Considerations should be made to support consumers access to broadband services- by providing subsidies, rebates or tax reductions for CPEs to lower income families and to businesses SMME's to help them take full advantage of 5G/IMT-2020 capabilities.

9) Misinformation

Administrations should provide clear and authoritative communications about the safety aspects of 5G/IMT-2020 to consumers to address misinformation.

10) Licence Obligations

Africa is a large continent, with significant variation in regional usage of communications services across countries. When licensing services, Administrations should consider imposing coverage obligations on licensees in line with universal access objectives to ensure that 5G/IMT-2020 services are provided in rural areas and not just in profitable urban areas.

Administration should also consider providing incentives in appropriate resources to licenses in order to facilitate the roll out in rural areas.

4.2 Spectrum Policy

1) Spectrum licences

Licences should be technology neutral, making it easy and without cost for licensees to refarm spectrum when appropriate:

- When licensing spectrum, regulators should issue technology-neutral licenses that can adapt to changing market circumstances over the course of the license's duration. Technology-neutral licenses allow operators to upgrade networks and deploy the latest technologies on existing licenses, and thus benefit from increased spectral efficiency. In the 5G/IMT-2020 network, technology-neutral licensing allows operators to leverage existing IMT mobile spectrum holdings and augment them with appropriate additional frequency bands.
- Regulators should aim to issue licences for 5G/IMT-2020 on a national basis to support the deployment of nationwide networks. Making spectrum available solely on a regional basis would complicate the process for a nationwide operator to obtain spectrum, potentially making investment in a nationwide network less attractive. In higher bands consideration could be made for the licensing of spectrum for verticals on a local licensing basis.
- Allowing spectrum trading and/or Licensed Shared Access (LSA) in the licence terms introduces flexibility into the licence, and can help balance spectrum demand with supply by allowing operators to sell unused spectrum to another party that will use it more effectively, especially important for long license durations.

2) Priority bands for early deployment of IMT-2020

The successful launch of 5G NR MFCN systems within a country or region will require the timely availability of sufficient spectrum, in suitable frequency bands for the support of targeted network coverage, capacity and speed.

Many Administrations around the world are currently focusing on licensing/assigning the 3.5 GHz (3.3/3.4 - 3.6 GHz) band and the 26 GHz (24.25 - 27.5 GHz) band for the early deployment of 5G/IMT-2020 as per examples provided in Annex 1.

Accordingly, Administrations are encouraged to make these two bands, **3.3/3.4 - 3.6** GHz band and **24.25 - 27.5 GHz** available for the timely deployment of 5G/IMT-2020.

3) Channel Sizes

a) 3300 – 3600 MHz

The band 3300 – 3600 MHz (part of the so-called C-band) is emerging as the primary frequency band for early deployments of 5G across the world, providing an optimal balance between coverage and capacity for cost efficient network implementation.

There is a broad agreement among the mobile industry, regulators and policy makers[17] on the importance of assigning large contiguous blocks of spectrum, preferably 80 - 100 MHz per 5G network, in order to facilitate the delivery of affordable, high throughput, 5G NR-based services.

While the assignment of non-contiguous spectrum can be a consideration for administrations[18], in light of the possibility of operators employing carrier aggregation (CA), **Annex 2** provides the compelling reasons and evidence, including lower network deployment cost, in support of the assignment of contiguous spectrum.

Accordingly, it is recommended that Administration wishing to implement IMT-2020 in the 3.3/3.4 - 3.6 GHz band, be and are hereby encouraged to assign large contiguous blocks of spectrum, preferably 80 - 100 MHz of bandwidth, to their respective 5G Operators. This recommendation does not, however, preclude Administrations from assigning smaller bandwidths to their respective Operators, as may be deemed appropriate.

b) 24.25 – 27.5 GHz

Spectrum in mmWave bands is crucial for in 5G networks for the support of ultra-high capacity and delivery of extremely high data rates required by some 5G eMBB applications.

There is a recognition that a contiguous bandwidth of approximately 1GHz per MNO network will be needed to support the achievement of certain IMT-2020 key performance indicators such as peak throughput and area density.

Accordingly, it is recommended that Administration wishing to implement IMT-2020 in the 24.25 – 27.5 GHz band be and are hereby encouraged to assign large contiguous blocks of spectrum, preferably 800 - 1000 MHz of bandwidth, to their respective 5G Operators. This recommendation does not, however, preclude Administrations from allowing operators to obtain smaller bandwidths for lower throughput 5G applications on a national basis as may be necessary.

4) Spectrum caps

Spectrum acquisition thresholds should be reviewed in order to ensure that they do not prevent potential licensees from gaining access to quantities of spectrum that will enable deployment of robust 5G/IMT-2020 networks. For example, overall spectrum holding limits that were designed for 3G or 4G networks may prevent operators from obtaining the large blocks of mmWave spectrum that enable the high speeds and low latencies of enhanced mobile broadband.

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17 See European Commission Decision 2019/235, ECC Report 287, GSMA whitepaper “3 GHz in the 5G era” , GSA whitepaper “3300-4200 MHz: a key band for 5G” and final IMT Roadmap 2019 (Republic of South Africa)

18 Report ITU-R M.2410

5) Spectrum pricing

Administrations should consider spectrum pricing for 5G/IMT-2020 at a level that does not hinder network investment or lead to high prices for consumers. Specific measures could include:

1. Allowing an initial period of time without spectrum fees to enable licensee to concentrate on investment in roll out.
2. Spreading out payment of applicable fees over the lifetime of the spectrum licence

Below are some examples of innovative licensing and pricing mechanisms from countries around the world.

Table 2: Examples of licencing incentives for 5G/IMT-2020 deployment around the world

Thailand	• Utilised revenue from spectrum to provide subsidies to telecom companies to provide free broadband data to citizens. • The cost of 5G/IMT-2020 spectrum per MHz was 10% of the cost of 4G spectrum, ensuring affordability for operators. • The 2.6 GHz spectrum is paid in instalments for 10 years with no payments necessary in the second to fourth year (10% in year 1 and then 15% per year from 5th-10th years). • Thailand also set obligations with 50% geographic coverage of EEC (Eastern Economic Corridor) area in 1 Year and 50% geographic coverage of 6 large cities within 4 Years.
China	• spectrum has no fee for first 3 years, then discount: 25%, 50% 75% for 4-6th year. • China Mobile received 160 MHz in 2.6 GHz and 100 MHz in 4.9 GHz; China Telecom and China Unicom each received 100 MHz in 3.5 GHz. China Broadcasting Network received the about 100 MHz in the 700 MHz range.
Austria	• provided subsidies for 5G/IMT-2020 sites for operators of €27,000 per site.
Japan	• 15% of 5G/IMT-2020 investment are exempt from corporate tax within 2 years; operators have targets for population coverage of 5G/IMT-2020 ranging from 56% to 90%.
UAE and Saudi Arabia	• both countries delay the payment for spectrum for 1 year to allow for initial investment. • UAE provided 2 operators with 1 block of 100 MHz each of spectrum in 3.6 GHz and will extend that to more than 200 MHz each.
Germany	• set 5G/IMT-2020 obligations for numbers and population coverage and speeds. • Licence obligation that by 2022 at least 98% of households per state with 100 Mbps+, and • 18,000 km motorway coverage with 100Mbps+ & 10ms- by 2022.

France	• in 2018 launched funding scheme ("Cohésion Numérique des Territoires") to help identified underserved < 8Mbps • FBB areas to get wireless broadband services by 2020: 100M€ budget devoted to provide CPE subsidies of 150€/household.
Malaysia	• smart device subsidy initiative was first introduced in 2014 by offering selected model of smartphones to users under the B40 group in rural areas. Through this initiative, eligible users will receive a RM250 subsidy including a one-year free internet subscription for the selected smartphones purchase. This subsidy is offered through major service providers namely Celcom, Maxis, DiGi and U Mobile.
United Kingdom (UK)	• provides vouchers of 1,500 GBP for homes and 3,000 GBP for businesses in rural areas to help them get high speed broadband.

6) Licence obligations

Spectrum obligations could be considered to mitigate the digital divide and to connect strategic whilst creating a balance by ensuring that obligations are not onerous to the extent that they jeopardise network investment and contribute to increased consumer prices. Administrations should provide supportive policies related to infrastructure sharing between public and private sectors, especially utility companies.

The government could consider licence obligations in lieu of spectrum fees; or funding support to connect public institutions, thus helping to create a strong incentive/business model for the operators to build the 5G/IMT-2020 network, which can then be used to also service local households and businesses.

The need to reduce policy and regulatory barriers, create pro-investment environments, and examine new sources of financing and shared deployment models are just some of the options that can have lasting impact.

Overall, Regulators should take full advantage of dialogue with relevant spectrum users to arrive at the most practical obligations.

7) Spectrum sharing, trading, pooling and Licensed Shared Access (LSA)

Licensed spectrum should remain the core 5G spectrum management approach. Spectrum sharing, trading and pooling can play a complementary role. Therefore, while spectrum for IMT is often assigned through individual licensing, regulators should also consider creating necessary regulatory framework to facilitate spectrum sharing, and secondary spectrum markets. Shared access arrangements usually allow a limited number of licensed users to access the spectrum, under certain conditions.

Spectrum sharing enables more local deployment for differentiated 5G services (e.g. support for ultra-low latency can be enabled for a local network that does not have to synchronise with a national frame). Spectrum sharing is often used when spectrum cannot be released everywhere or is underutilised within a certain timeframe, or if spectrum use must be coordinated to mitigate interference, and/or to facilitate for the bridging of coverage gap(s).

Also. Some regulators have issued shared licenses to support local/private 5G/IMT-2020 networks, managing interference through geographic separation or other mitigation techniques. The limited coverage needed for private networks makes it well-suited for a shared-use format in mmWave bands, for instance, where interference can largely be avoided and managed by the licensee(s).

8) License-exempt spectrum

License-exempt spectrum does not require a licence and allows use according to defined technical operating parameters. This approach is ideal for local access, or low-power or short-range devices, where there is a low risk of interference. Shared-access approaches in unlicensed spectrum bands may encourage effective spectrum use, and aims to promote innovation and the development of new technologies Monitoring the use of the spectrum to identify frequency bands that are underused at regional or national level for the relocation process.

4.3 Africa-wide actions

1) 5G/IMT-2020 Regional coordination

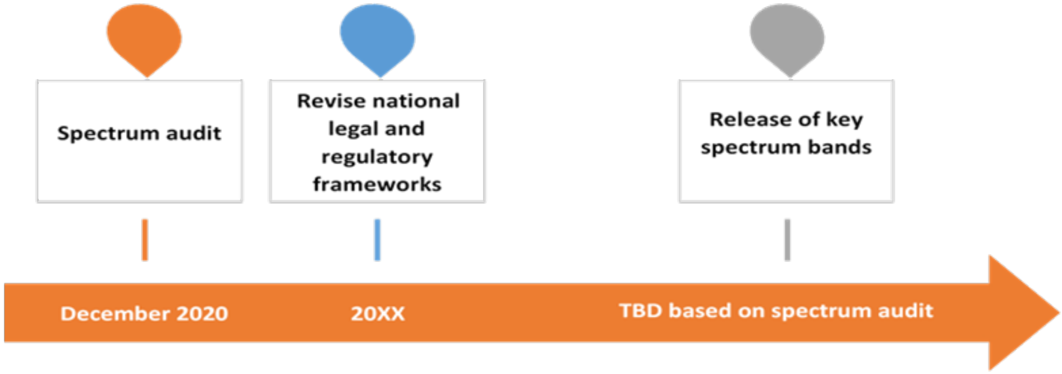
Regional coordination and harmonization of 5G/IMT-2020 use cases and applications in the African region will help to create an enabling environment for the deployment and uptake of 5G/IMT-2020 technology. Discussion and agreement on key issues, best practices, and interim milestones should take place within an established organizational framework that lends itself to multi-stakeholder cooperation. The African Telecommunication Union (ATU) in close consultation with the Africa Union Commission (AUC) is a suitable vehicle for such discussions.

It is recommended that AU Member States agree upon an overall 5G plan and goals, with the necessary discussion, compilation, and development of best practices to be carried out under the auspices of the ATU/AUC. Elements of this plan could be:

a. consultations in order to identify potential obstacles to successful 5G deployment.

b. a coordinated timeline to indicate the broad strokes of a common 5G plan, as well as a timeline for its implementation.

While countries will ultimately see 5G deployments on different schedules, adopting a coordinated plan for the release of spectrum for 5G will signal a commitment to 5G development and advance the spectrum harmonization process.



2) Cross-border interference

To realize the potential benefits of 5G/IMT-2020 at scale, and to reduce cross-border interference, countries need to coordinate with their neighbours regarding 5G/IMT-2020 frequency allocations and, where relevant, TDD synchronization frame structures.

3) Support for common technical standards

Widespread adoption of common technical standards for network infrastructure and devices is one of the key drivers of economies of scale and interoperability. In order for Africa to obtain the greatest possible benefit from 5G/IMT-2020, it will be critical to ensure that network deployments are in line with globally accepted standards. In contrast, adoption of unique technical requirements for mobile networks run the risk of limiting the availability network infrastructure and user devices, as well as making the resulting smaller pool of available equipment more expensive.

3.1) 5G/IMT-2020 Standardization approaches

3.1.1) 5G/IMT-2020 Standardization - 3GPP

In June 2018, 3GPP RAN completed the 1st version of all 3GPP 5G New Radio (NR) specifications for key deployment scenarios, Non-Standalone (NSA) and Standalone (SA), for use cases of Mobile Broadband (MBB) and Ultra Reliable Low Latency Communication (URLLC). The 3GPP RAN-adjusted schedule for the 2nd wave of 5G NR specifications is shown in Figure 3 below. The primary focus of the 3GPP Release-15 5G NR standard completed in June 2018 is enhanced mobile broadband (eMBB) services. Commercial deployments are already available starting from 2019. The 3GPP Release-16 5G NR standard, completed at the beginning of July 2020, incorporates features supporting the Internet of Things (IoT).

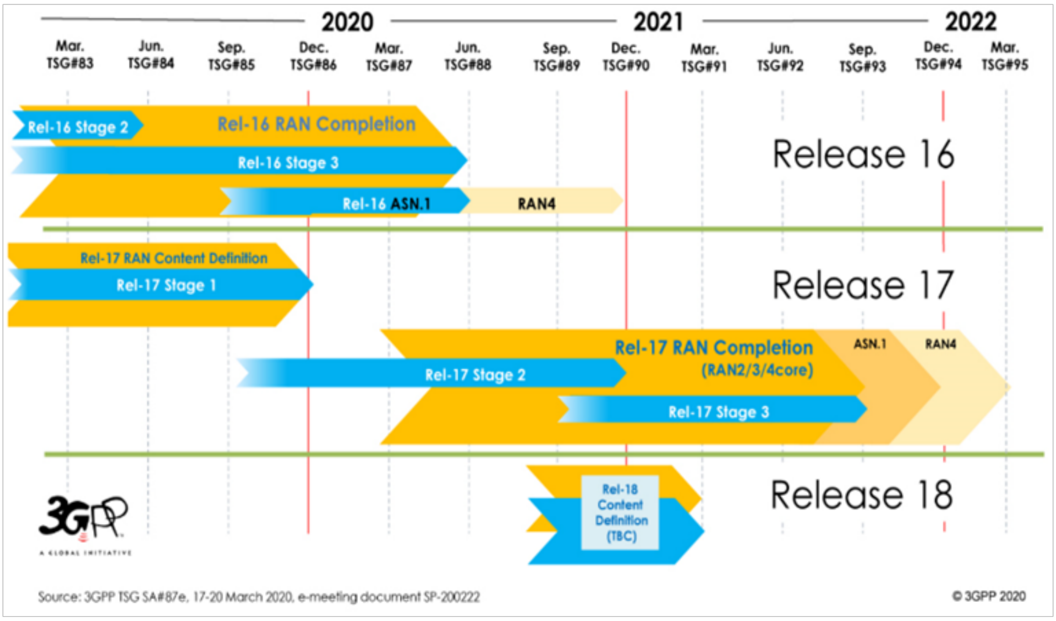


Figure 4: Adjusted overall schedule for 2nd wave of 5G NR specifications

- 3GPP Release 15 (NSA & SA) completed (2017 – 2019): Focused on eMBB & URLLC.
- 3GPP Release 16 (2018 – 2020): Enhancements, URLLC+ & IoT+, V2X, etc…

3.1.2) IMT-2020 Standardization – ITU-R

The process and activities identified for the development of the IMT-2020 terrestrial components radio interface Recommendations are described in Doc. IMT 2020/2(Rev2) - Submission, evaluation process and consensus building for IMT-2020[19]. The detailed timeline and process for the development of IMT-2020 in ITU-R[20] is shown in Figure 4 below.

19 https://www.itu.int/en/ITU-R/study-groups/rsg5/rwp5d/imt-2020/Pages/submission-eval.aspx

20 https://www.itu.int/en/ITU-R/study-groups/rsg5/rwp5d/imt-2020/Pages/default.aspx;

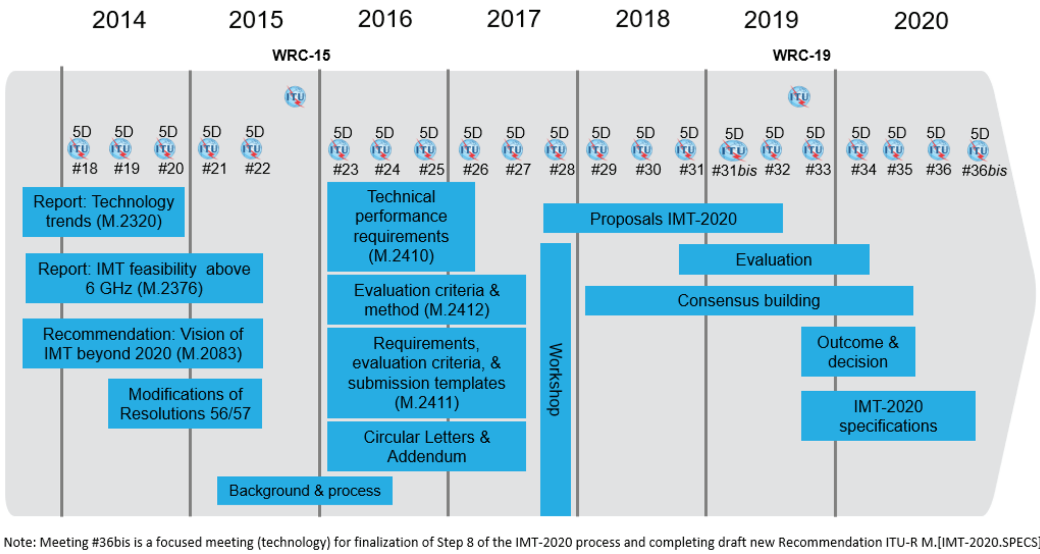


Figure 5: Detailed Timeline & Process for IMT-2020 in ITU-R

4) Target bands for 5G/IMT-2020

Low-band spectrum below 1 GHz, mid-band spectrum from 1 to 6 GHz, and high-band spectrum above 24 GHz (see Table 3) are needed for the successful deployment of 5G/IMT-2020.

The characteristics of low-, mid-, and high-band spectrum differ, with lower bands offering greater propagation distances and better in-building penetration with fewer sites required, while mid-band and high-band spectrum offer wider bandwidths and greater capacity over shorter distances through the use of a denser cell network. As such, the different spectrum bands expected to be employed for early 5G/IMT-2020 services notably the 3.4-3.6 GHz and 26 GHz bands are each well-suited to delivering particular services.

Table 3: Examples of Spectrum Bands

Frequency range	Examples of frequency bands	Expected use
Low-band	700 MHz	Longer-range applications, including mobile broadband and massive IoT
Mid-band	1.5 GHz, 2.3 GHz, 3.3-3.4 GHz, 3.4-3.6 GHz, 4.8-4.99 GHz	Wider bandwidths enabling enhanced mobile broadband and mission-critical communications
High-band	24.25-27.5 GHz, 37-43.5 GHz, 45.5-47 GHz, 47.2-48.2 GHz, 66-71 GHz	Extreme bandwidths for ultra-high broadband speeds

It is noted that all existing bands identified for IMT, including 800, 900, 1800 MHz, 2.1 GHz, 2.3 GHz and 2.6 GHz, could be refarmed for 5G/IMT-2020 deployment.

5) Safety of 5G/IMT 2020 Network

The international Commission on Non-Ionizing Radiation Protection (ICNIRP) issued the latest RF EMF Guidelines[21] in March 2020. The Guidelines on Limiting Exposure to Electromagnetic Fields are for the protection of humans exposed to radiofrequency electromagnetic fields (RF) in the range 100 kHz to 300 GHz. The guidelines cover many applications such as 5G technologies, WiFi, Bluetooth, mobile phones, and base stations.

5G exposures will not cause any harm providing that they adhere to the ICNIRP (2020) guidelines. Radio signals used by mobile technologies have been extensively studied for decades. This scientific evidence is the basis for the international safety guidelines for radio signals. These guidelines extend to 300 GHz and cover all the frequencies under consideration for 5G, include mmWave bands. The consensus of expert reviews[22] is that compliance with the international limits provides protection against all established health hazards.

6) TDD Synchronization

To increase flexibility as well as make spectrum usage more efficient, Time Division Duplex (TDD) is important. TDD uses the same frequency for each duplex direction, with a frame that includes different time periods and slots for uplink or downlink communications. By changing the duration of these, network performance can be tailored to meet different needs and help provide the best possible experience.

However, for this to work all TDD networks, either LTE or 5G, operating in the same frequency range and within the same area have to be synchronised. Base stations need to transmit at the same fixed time periods and all devices should only transmit in dedicated time periods. Failure to do so creates interference, which has a major impact on performance as well as coverage.

Current recommendations focus on the way in which the network is configured with respect to the timing of Download (D), Special slot (S) and Upload (U) elements in each period of time (the frame). One approach that provides a good compromise between download and upload speeds with a low latency, for synchronisation requirements in 5G. is to use a DDDSU frame structure. However, regulators, in consultation with relevant spectrum users, should decide on the most appropriate frame structure, taking into consideration their local requirements. As an example, local networks, should be allowed to diverge from this in order to support use cases such as URLLC (Ultra Reliable/ Low Latency Communication), recognising that a separation distance may be required.

21 https://www.icnirp.org/en/activities/news/news-article/rf-guidelines-2020-published.html

22 https://www.gsma.com/publicpolicy/emf-and-health/expert-reports
https://www.gsma.com/publicpolicy/resources/5g-internet-things-iot-wearable-devices

S1(3): Recommendations

In order to foster harmonised implementation of 5G/IMT-2020 in Africa, ATU recommends Member States to:

1. **Define** and **agree**, under the auspices of the African Union, on a 5G/IMT-2020 roadmap, including any plans and an implementation timeline aimed at achieving coordinated and harmonized regional 5G/MT-2020 deployment.
2. **Review** national policy/regulatory frameworks by 2022 and **develop** a five-year national plan/roadmap for the release and licensing of spectrum for IMT. The 5-year spectrum roadmap should aim at maximizing the socio-economic benefits and the number of users the spectrum can serve, with a focus on all IMT identified bands (e.g. 700 MHz, 800 MHz, 900 MHz, 1 400 MHz, 1 800 MHz, 2 100 MHz, 2 300 MHz, 2 600 MHz, 3 300 - 3 600 MHz, 4800-4990 MHz, 26 GHz and other mmWave bands identified at WRC-19).
3. **Adopt** regionally harmonized frequency allocations, especially for core 5G/IMT-2020 frequency bands such as 3.3/3.4-3.6 GHz, as wider as possible, and 26 GHz, as a start for other mmWave bands, in order to reduce cross-border interference and support common technical standards.
4. **Assign** spectrum for 5G/IMT 2020 in low, mid, and high bands in sufficient quantities to support 5G/IMT 2020 rollout and licensing terms that best meet policy goals, including technology neutrality and national assignments. In this regard, the targets of 80 to 100 MHz per operator in the 3.5 GHz band and 800 to 1000 MHz per operator in the 26 GHz band may be considered.
5. **Allow** shared and license-exempt spectrum to increase access and efficient use of spectrum for 5G/IMT-2020, while prioritising the use of licensed spectrum.
6. **Encourage** full synchronization for TDD networks, where appropriate.
7. **Consider** some local licensing to enable flexibility for local users wanting to use URLLC services.
8. **Review** the real need for spectrum caps in order to balance policy aims of promoting network deployment while also upholding competition.
9. **Take** advantage of the opportunities that 5G/IMT-2020 offers to create an investment-led market-oriented scenario through targeted policies in the overall licensing process.
10. **Uphold** comprehensive, secure, and transparent data privacy regimes to protect the substantial data handled by 5G/IMT-2020 and consider developing a regional framework.
11. **Allow** operators to use network slicing to efficiently use spectrum resources to meet the needs of a variety of customers and industries.

12. **Implement** global standards related to 5G/IMT-2020 issued by ITU and 3GPP.
13. **Communicate** clearly on the safety aspects of 5G/IMT-2020 with the evidence of various international bodies from a medical and scientific perspective as well as field tests from around the world.
14. **Consider** reducing taxation on broadband devices and broadband internet.
15. **Establish** standard, simple, one-stop shop, process for wayleave applications nationwide with application fees at a reasonable level to cover processing costs; and simplify and speed-up application and approval processes for other relevant approvals such as from aviation authorities or environmental authorities.
16. **Establish** policy and regulatory frameworks that encourage infrastructure sharing between private and public sector including utilities, as well as rental or use of public land/infrastructure.
17. **Establish** licence obligations for 5G/IMT-2020 that are reasonable, targeted, measurable, and enforceable, taking into account spectrum fee discounts (if any).
18. **Consider** spectrum pricing schemes that allow licensees to delay initial payments, spreading out of fees over time, as well as less onerous spectrum fees for backhaul. Especially for 5G, that will require a higher amount of investment, Governments and regulators should avoid inflating (setting high) 5G spectrum prices (e.g. setting of high reserve prices and annual fees thereby creating a barrier to spectrum access) as this may limit network investment and drive the cost of services up.
19. **Support** the deployment of infrastructure that facilitates 5G/IMT-2020 implementation/roll-out such as fibre, data centres, edge compute and transformed networks.
20. **License** spectrum on technology and service neutrality basis.
21. **Consider** making available 5G spectrum, for local or shared licences in order to address the spectrum needs for verticals. Accordingly, administrations are encouraged to develop a regulatory framework that facilitates access to local and shared spectrum.
22. **Consult** 5G stakeholders to ensure spectrum awards and licensing approaches consider technical and commercial deployment plans.
23. **Monitor** the use of the spectrum to identify frequency bands that are underused at regional or national level for the relocation process – including generic ‘Use-it-or-share-it’ approach in spectrum licences.

S1(4): Annexes

Annex 1

Review of the 5G/IMT 2020 deployment around the world as at 02-SEPT-2020

The state of 5G/IMT 2020 deployment is different in nearly every country around the world and varies based on several factors. In many regions, 5G/IMT 2020 spectrum auctions have taken place, been planned, or seen consultations opened; however, most countries have yet to make the spectrum available and begin rolling out services. The primary frequency bands for 5G/IMT 2020 services are the 3.5 GHz and the 26 GHz bands. As such, many countries have begun preparing to make spectrum available in said ranges in advance of the rollout of 5G/IMT 2020 services, as is indicated by the tables below. In some cases, services have been rolled out and are already being offered.

Table 4: mmWave Spectrum

Country	Date of Auction	Range	Total Spectrum	Licensees
Australia	December 2020	24.7-25.1 GHz and 27.5-29.5 GHz		Local licences
Australia	April 2021	25.1–27.5 GHz	2400 MHz	Dense Air, Mobile jv, Optus Mobile, Pentanet, Telstra
Chile	Feb-21	25.9-27.5 GHz	1600 MHz	Claro, Entel, Wom
Denmark	Apr-21	24.65 - 27.5 GHz	2850 MHz	Hi3G, TDC Net, TT Network
Finland	June 8, 2020	25.1 – 27.5 GHz	2400 MHz	Elisa, Telia Finland, DNA
Hong Kong S.A.R.	Applications opened July 2019	27.95–28.35 GHz		Local licences
Hong Kong S.A.R.	Mar-19	26.55–27.75 GHz	1200 MHz	China Mobile Hong Kong, SmarTone Mobile, Hong Kong Telecom
Greece	Nov-20	26.5-27.5 GHz	1000 MHz	Cosmote, Vodafone, Wind
Italy[23]	October 2, 2018	26.5 – 27.5 GHz	1000 MHz	Telecom Italia, Vodafone, WindTre, FastWeb, Iliad
Japan	Applications opened December 2019	28.2–28.3 GHz		Local licences

23 Ministry of Economic Development (MISE), Resolution N. 231/18/CONS (2018), https://www.mise.gov.it/images/stories/normativa/delibera-AGCOM%20231-18-CONS.pdf.

Japan	April 2019	27.0–28.2 GHz, 29.1–29.5 GHz	1600 MHz	KDDI, NTT Docomo, Softbank, Rakuten
Republic of Korea[24]	June 19, 2018	26.5 – 28.9 GHz	2400 MHz	Korea Telecom, SK Telecom, LG Uplus
Russia	Jul-20	24.25–24.65 GHz	400 MHz	MTS
Singapore	Jun-20	26.3-29.5 GHz	3200 MHz	M1, Singtel, Starhub, TPG
Slovenia	01/04/2021	26.5-27.5 GHz	1000 MHz	A1, Telemach, Telekom Slovenia
Taiwan[25]	February 21, 2020	27.9 – 29.3 GHz	1600 MHz	Chungwa Telecom, Far EasTone, Taiwan Mobile, Asia Pacific Telecom
Thailand[26]	February 16, 2020	26 GHz	2600 MHz	TUC, TOT, DTAC – TriNet, AWN
UAE	Sep-20	26.5-27.5 GHz	1000 MHz	Du, Etisalat (assignments to be confirmed)
UK	Jul-19	24.25–26.6 GHz (indoor usage only)		Local licences
Uruguay	May-19	27.5–28.35	850 MHz	Antel
USA	Jan-19	27.500 – 28.350 GHz	850 MHz	Multiple
USA	May-19	24.25-24.45 and 24.75-25.25 GHz	700 MHz	Multiple
USA	Mar-20	37.6-40 GHz	2400 MHz	Multiple
USA	Mar-20	47.2-48.2 GHz	1000 MHz	Multiple

24 Cho Mu-Hyun, ZDNet, South Korea completes 5G spectrum auction (June 19, 2018), https://www.zdnet.com/article/south-korea-completes-5g-spectrum-auction/.

25 National Communications Commission, Frequency Band Auction Results (2018), https://www.ncc.gov.tw/chinese/files/20022/8_42757_200221_1.pdf.

26 National Broadcasting and Telecommuniactions Commission (NBTC), The 5G auction has ended (February 16, 2020), http://www.nbtc.go.th/getattachment/News/Information/40146/NBTC-Press-Release-160263-%E0%B8%9C%E0%B8%A5%E0%B8%81%E0%B8%B2%E0%B8%A3%E0%B8%9B%E0%B8%A3%E0%B8%B0%E0%B8%A1%E0%B8%B9%E0%B8%A5-5%E0%B8%88%E0%B8%B5.pdf.aspx.

Table 5: C-Band Spectrum

Country	Date of Auction	Range	Total Spectrum	Licensees
Australia[27]	November 20, 2018	3575 – 3700 MHz	125 MHz	Dense Air Australia, Mobile JV, Optus Mobile, Telstra
Austria[28]	March 8, 2019	3.5 GHz	330 MHz	A1 Telekom Austria AG, Hutchinson Three, T-Mobile
Belgium	July 2020	3600-3800 MHz	200 MHz	Temporary assignments to Cegeka, Orange Belgium, Proxiums and Telenet
Bulgaria	April 2021	3500-3800 MHz	300 MHz	A1, BTC, Telenor
Chile	Feb 2021	3300-3400 MHz plus 3600-3650 MHz	150 MHz	Entel, Movistar, Wom
China	Feb 2020	3300-3400 MHz	100 MHz	China Broadcasting Network China Telecom China Unicom
China	Test licences Dec 2018, commercial operating licences Jun 2019	3.5 GHz	200 MHz	China Telecom, China Unicom
Cyprus	January 2021	3400-3800 MHz	400 MHz	CYTA, and others to be confirmed
Czechia	Nov 2020	3400-3600 MHz	200 MHz	CentroNet, O2, Nordic telecom, T-Mobile, Vodafone
Czechia[29]	July 11, 2017	3600 – 3800 MHz	200 MHz	O2 Telefonica, Vodafone, PODA, Nordic Telecom
Denmark	April 2021	3410-3800 MHz	390 MHz	Hi3G, TDC Net, TT Network

27 Australian Communications and Media Authority, Auction summary – 3.6 GHz band (2018), https://www.acma.gov.au/auction-summary-36-ghz-band-2018.

28 Telecom Control Commission (TKK), Tender Document in the proceeding concerning frequency assignments in the 3410 to 3800 MHz range (September 19, 2018), https://www.rtr.at/de/tk/5G-Auction-Tender-Documents/Ausschreibungsunterlage_3_4_-_3_8_GHz_ohne_Anhaenge_DE.pdf.

29 Czech Telecommunications Office, Tender for Granting of the Rights to Use Radio Frequencies to Provide

Electronic Communications Networks in the 3600–3800 MHz Frequency Band (2017), https://www.ctu.eu/sites/default/files/obsah/ctu/information-termination-and-results-auction-phase-tender-granting-rights-use-radio-frequencies/obrazky/noticeofterminationandresultsofauctionphase.pdf.

Finland[30]	October 1, 2018	3410 – 3800 MHz	390 MHz	Telia, Elisa, DNA
France	Nov 2020	3490-3800 MHz	310 MHz	Bouygues Telecom, Free Mobile, Orange, SFR
Germany[31]	June 12, 2019	3400 – 3700 MHz	300 MHz	Vodafone, 1&1 Drillisch, TelefonicaO2, Deutsche Telekom
Greece	Nov 2020	3410-3800 MHz	390 MHz	Cosmote, Vodafone, Wind
Hong Kong SAR[32]	November 6, 2019; October 14, 2019[33]	3300 – 3400 MHz; 3400 – 3600 MHz	100 MHz; 200 MHz	Hutchinson, HKT, SmarTone, China Mobile HK; Hutchinson, HKT, SmarTone China Mobile HK
Hungary	Mar 2020	3600 MHz	To be confirmed	Magyar Telecom
Hungary[34]	June 7, 2016	3410 – 3440 MHz and 3510 – 3540 MHz; 3780 – 3800 MHz	80 MHz	Vodafone, Digi
Iceland	Mar 2020	3500-3800 MHz	300 MHz	Nova, Siminn, Vodafone
Ireland[35]	May 22, 2017	3.5 GHz	280 MHz	Vodafone, Three, Meteor
Israel[36]	August 4, 2020	3500 - 3800 MHz	300 MHz	Partner Hot Mobile, Cellcom Golan Maraton, “Cell Phone”

30 Finnish Transport and Communications Agency (Traficom), 5G spectrum auction has ended (June 10, 2018), https://www.traficom.fi/en/news/5g-spectrum-auction-has-ended.

31 BNetzA, Frequency Auction 2019 Round 496 Result (2019), https://www.bundesnetzagentur.de/_tools/FrequenzXml/Auktion2019_XML/496.html.

32 Office of the Communications Authority (OFCA) Successful Conclusion of Auction of 5G Spectrum in 3.5 GHz Band (October 14, 2019), https://www.ofca.gov.hk/en/media_focus/press_releases/index_id_2005.html.

33 OFCA, Successful Conclusion of Auction of 5G Spectrum in the 3.3 GHz Band (November 6, 2019), https://www.ofca.gov.hk/en/media_focus/press_releases/index_id_2023.html.

34 NMHH, NMHH: Two bidders won 80 MHz in the 3400 – 3800 MHz band (June 7, 2016), http://english.nmhh.hu/article/170832/NMHH_Two_bidders_won_80_MHz_in_the_34003800_MHz_band.

35 Commission for Communications Regulation (ComReg), Results of the 3.6 GHz Band Spectrum Award (May 22, 2017), https://www.comreg.ie/media/dlm_uploads/2017/05/ComReg-1738.pdf.

36 Ministry of Communication, Completion of 5G Frequency Tender (August 12, 2020), https://www.gov.il/he/departments/news/12082020_2.

Italy[37]	October 2, 2018	3.5 GHz	200 MHz	Telecom Italia, Vodafone, WindTre, Iliad
Japan	April 2019	3600-4100 MHz	500 MHz	KDDI, NTT Docomo, Rakuten, Softbank
Kuwait	May 2019	3500-3800 MHz	300 MHz	STC, Ooredoo, Zain
Latvia[38]	December 11, 2017	3400 – 3450 and 3650 – 3700 MHz	100 MHz	LMT
Latvia	Sep 2018	3550-3600 MHz	50 MHz	Tele2
Latvia	May 2019	3500-3550 MHz (licence extension)	50 MHz	Tele2
Luxembourg[39]	July 13, 2020	3420– 3750 MHz	330 MHz	Luxembourg Online SA, Orange Communications Luxembourg, Post Luxembourg, Proximus Luxembourg
Mauritius	Jun-21	3400-3600 MHz		To be confirmed
Mexico	Jan-20	3450-3600 MHz	150 MHz	FWA spectrum renewal
New Zealand[40]	June 2020	3590 – 3750 MHz	160 MHz	Dense Air, Spark, 2degrees
Norway	2016	3610-3800 MHz	190 MHz	Telenor, TeliaSonera
Oman	Dec-18	3400–3600 MHz allocated, 3600–3800 MHz set aside for new entrant	200 MHz	Omantel, Ooredoo
Philippines	2019	3.3–3.4 GHz	100 MHz	Dito Telecommunity
Qatar	Jan-19	3400–3800 MHz	200 MHz assigned	Ooredoo, Vodafone
Republic of Korea[41]	June 19, 2018	3420 – 3700 MHz	280 MHz	Korea Telecom, SK Telecom, LG Uplus

37 Ministry of Economic Development (MISE), Resolution N. 231/18/CONS (2018), https://www.mise.gov.it/images/stories/normativa/delibera-AGCOM%20231-18-CONS.pdf.

38 CommsUpdate, LMT secures 5G-compatible spectrum (December 11, 2017), https://www.commsupdate.com/articles/2017/12/11/lmt-secures-5g-compatible-spectrum/.

39 Government of Luxembourg, Results of auctions for the allocation of frequencies intended for 5G (July 22, 2020), https://gouvernement.lu/fr/actualites/toutes_actualites/communiques/2020/07-juillet/22-resultats-5g.html.

40 Radio Spectrum Management Department (RSM), Preparing for 5G in New Zealand (July 2020), https://www.rsm.govt.nz/projects-and-auctions/current-projects/preparing-for-5g-in-new-zealand/

41 Cho Mu-Hyun, ZDNet, South Korea completes 5G spectrum auction (June 19, 2018), https://www.zdnet.com/article/south-korea-completes-5g-spectrum-auction/.

Saudi Arabia	March 2019	3400-3800 MHz	400 MHz	ITC, Go Telecom, Zain, STC, Mobily
Singapore[42]	April 29, 2020	3.5 GHz	200 MHz	Join Venture Consortium (StarHub and M1), Singtel
Slovakia	2017	3600–3800 MHz	200 MHz	AMTEL, O2 Slovakia, Slovak telecom
Slovenia	Apr-21	3420–3800 MHz	380 MHz	A1, Telekom Slovenije, Telemach
Spain	2016	3.5 GHz		TBC
Spain[43]	July 25, 2018	3600 – 3800 MHz	200 MHz	Orange, Telefonica, Vodafone
Spain	Feb 2021	3580-3600 MHz	20 MHz	Orange, Telefonica
Sweden	Jan-21	3400-3720 MHz	320 MHz	Hi3G Access, Net4Mobility, Telia
Switzerland	Feb-19	3500–3800 MHz	300 MHz	Salt, Swisscom, Sunrise
Taiwan[44]	February 21, 2020	3300 – 3570 MHz	270 MHz	Chungwa Telecom, Far EasTone Telecom, Taiwan Mobile, Taiwan Star
UAE	2018	3400-3800 MHz	400 MHz	Etisalat, Du
United Kingdom[45]	April 5, 2018	3410 – 3580 MHz	150 MHz	O2, Vodafone, EE, Three
United Kingdom	Apr-21	3680-3800 MHz	120 MHz	EE, O2, Vodafone
United Kingdom	Jul-19	3800–4200 MHz	400 MHz	Local licences
United States[46]	July 23, 2020	3550 – 3650 MHz	100 MHz	Multiple
United States	Feb 2021	3700-3980 MHz	280 MHz	Multiple

42 Infocomm Media Development Authority (IMDA), Singapore Forges Ahead with Nationwide 5G Rollout (April 29, 2020), https://www.imda.gov.sg/news-and-events/Media-Room/Media-Releases/2020/Singapore-Forges-Ahead-with-Nationwide-5G-Rollout#1.

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45 Ofcom, Award of 2.3 and 3.4 GHz spectrum bands (April 13, 2018), https://www.ofcom.org.uk/__data/assets/pdf_file/0018/112932/Regulation-111-Final-outcome-of-award.pdf.

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Annex 2

Bandwidth considerations for IMT-2020

5G-NR is designed from the outset to be deployed with large channels. 5G-NR will support wideband operation by design, allowing operators to take full advantage of larger allocations of contiguous spectrum to increase peak rates and user experiences, with manageable terminal complexity and minimal power consumption.

5G-NR on large bandwidths will reduce terminal front-end complexity and power consumption, compared to LTE using multiple 5 to 20 MHz Carrier Aggregation to exploit a similar large bandwidth. Wideband carriers and flexibility in sub-carrier spacing result in efficient RF front-end and baseband processing, resulting in better power consumption per Mbps and per MHz.

5G-NR will also bring the ability to 'multiplex' new forward compatible services with limited impact on eMBB capacity needs, and the ability to deliver simultaneous wireless backhauling and front-hauling capabilities to 5G-NR base stations. A wide bandwidth channel will significantly facilitate the use of these capabilities.

The key element for successful deployment of Massive MIMO and active antennas is the availability of large contiguous bandwidths, as this will enable absolute gains from Massive MIMO to support new usages related to eMBB.

The following sections introduce in more detail the benefits assigning large blocks to operators for 5G deployment, and the importance that the blocks are contiguous.

1) The benefits of large bandwidth for 5G

The new 5G-NR air interface will bring improvements in the spectral efficiency and the link budget, but this has to be supported by sufficiently large BWs to provide the expected data rates. The table below shows the theoretical cell data rates based on ITU's spectral efficiency targets for IMT-2020[47].

Table 6: Cell data rates based on IMT-2020 spectral efficiency targets

RF channel bandwidth	Peak data rates (single user in cell)	Average data rates	5th percentile data rates
40 MHz	1.2 Gbps	0.312 Gbps	9 Mbps
100 MHz	3 Gbps	0.78 Gbps	22.5 Mbps

47 Report ITU-R M.2410, Minimum requirements related to technical performance for IMT-2020 radio interface(s): Peak spectral efficiency (SE) requirement for IMT-2020: 30 bit/s/Hz in DL, Average SE requirement: 7.8 bit/s/Hz in DL for Dense Urban scenario, 5th percentile SE requirement: 0.225 bit/s/Hz in DL for Dense Urban scenario (cell edge users).

Due to the technical constraints and the need to avoid interference between adjacent networks, the resource blocks do not fully occupy the channel bandwidth and the spectrum utilisation is less than 100% for all 5G-NR channel bandwidth options. However, the utilisation decreases with the channel bandwidth as shown in the table below for 30 kHz subcarrier spacing.

Table 7: 5G-NR utilisation of channel bandwidth (source: 3GPP, GSA)

Channel BW	Number of resource blocks	Transmission BW (MHz)	Lost BW (MHz)	Utilisation
100 MHz	273	98.280	1.720	98.3%
80 MHz	217	78.120	1.880	97.7%
60 MHz	162	58.320	1.680	97.2%
50 MHz	133	47.880	2.120	95.8%
40 MHz	106	38.160	1.840	95.4%
20 MHz	51	18.360	1.640	91.8%

The following figure from 3GPP TS 38.104 section 5.3.3, illustrates this.

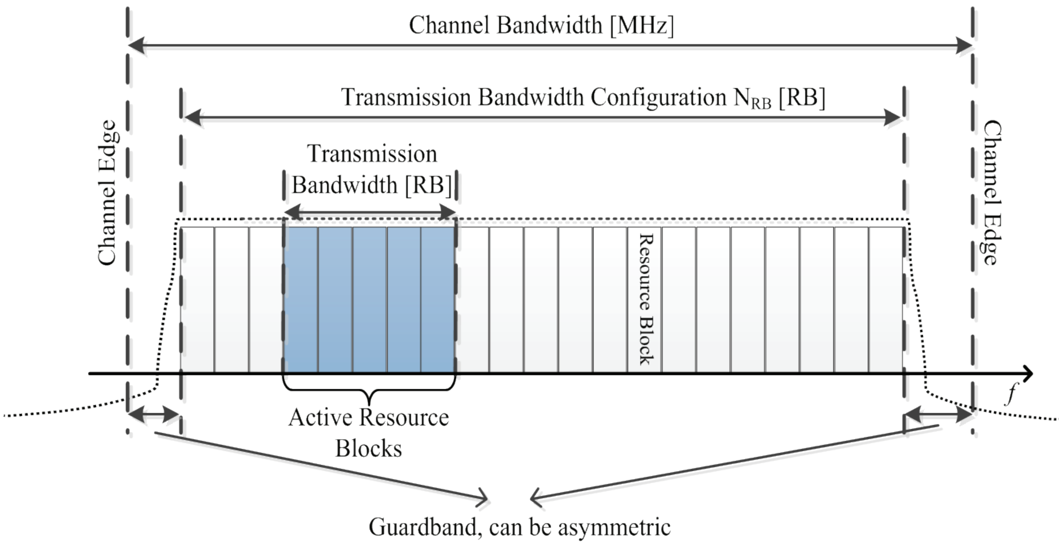

Figure 6: 5G NR channel bandwidth utilisation (source: 3GPP)

In practice, capacity gains vs. channel size exceed the simple proportional rule: doubling the bandwidth provides considerably more than twice the system capacity. The figure below shows the results of a simulation of cell edge user throughput (5th percentile) for different channel bandwidths: 100 MHz spectrum gives a 2.7x increase in capacity in the cell while maintaining a 100 Mbps cell edge throughput.

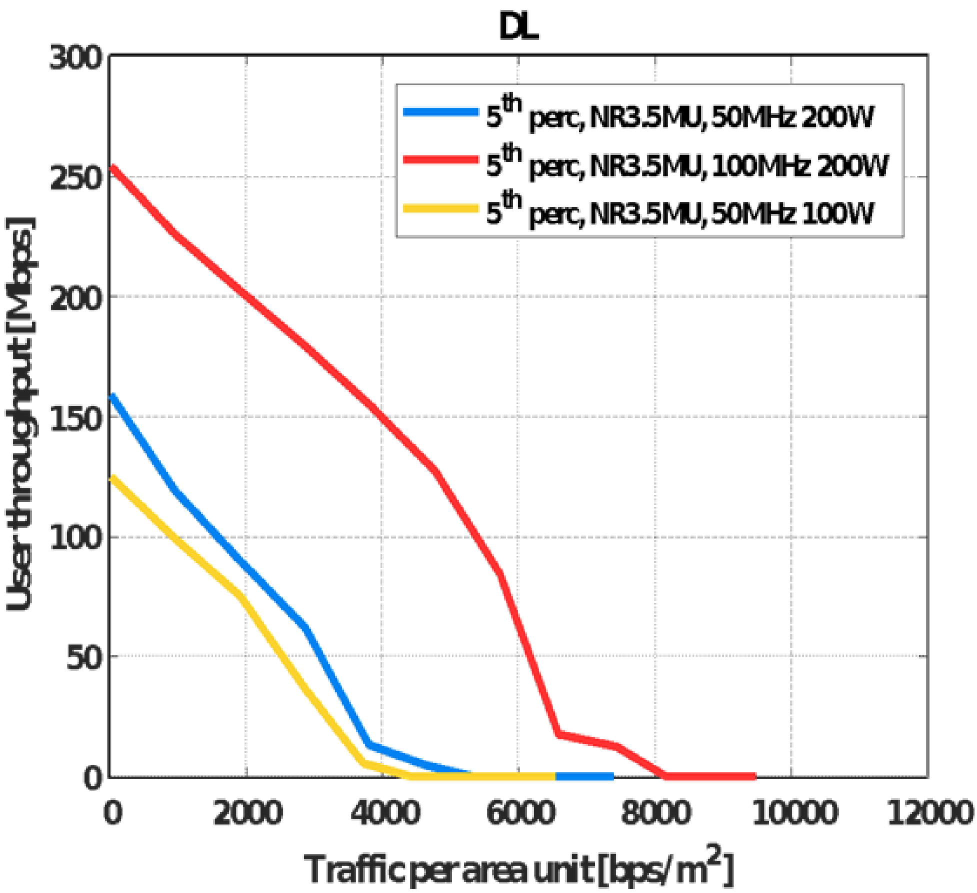

Figure 7: Cell edge throughput increase associated with larger channel bandwidths (source: Ericsson)

2) Deployment aspects

Another useful quantitative assessment of the importance of large BW is to look at the impact of different operator block sizes on network roll-out (and hence on cost of deployment), for a given assumption on area traffic capacity. In a dense urban scenario[48], an operator with a 60 MHz block would have to deploy 64% more BW than an operator with a 100 MHz block.

48 Dense Urban Scenario: data rate requirement of 750 Gbps/km2 (from 3GPP 22.261), deployment of three-sector macro base stations, indoor CPEs, penetration loss 26 dB, and downlink user edge rate 100 Mbit/s.

Table 8: Impact of different operator block sizes on network roll-out (source: GSA)

	DL coverage distance/site (km)	Coverage area/ site (km2)	Number of sites/ km2	Site increase rate (%)
100 MHz	0.19	0.070395	14	Reference
60 MHz	0.15	0.043875	23	+64%

3) Support of URLLC applications

5G-NR on large bandwidths allows improved access to ultra-reliable services by offsetting mission-critical capacity needs and access to a new generation of services by providing native forward compatibility for straightforward launches, with limited impact on legacy services. The new 5G design allows for optimal trade-offs between capacity, latency and reliability (e.g. leveraging wider bandwidths to offset mission-critical capacity reductions).

Efforts in achieving lower latency (e.g. using a shorter transmission time interval (TTI)) might have an impact on overall system capacity (more ACK/NACK[49], thus more overhead) as optimisation is now occurring on the method of communication to cut down latency. Also, using shorter packets means that optimisation is not for capacity. To optimise for higher reliability, there is also a trade-off with capacity. For example, capacity might need to be sacrificed as well to achieve lower BLER[50] (e.g., more retransmissions). But to offset this, it would be possible to utilise wider bandwidth, which will give the system more capacity.

An example of the application of this is Virtual Reality / Augmented Reality (VR/AR). A key requirement for VR/AR is that the delay between movement of the head and the changes on the screen cannot exceed a 20 ms threshold. This puts stringent requirements on the network when the image is rendered remotely. However, the latency requirement can be relaxed if a broader video stream (for instance one that contains a 360-degree video) is transmitted to the head mounted display, which can now adjust on its own for sudden head movements. In this case, the required throughput would be significantly higher, but the latency requirement is relaxed.

4) Impact of non-contiguous allocation

4.1 Technology aspects

As explained above, not all of the channel bandwidth of a 5G NR carrier is occupied by usable resource blocks. This characteristic of the 5G NR specification also means that non-contiguous aggregation of two (or more) channels will always result in a loss of usable spectrum, and hence a

49 ACK/NACK: Acknowledgement / Negative acknowledgement

50 BLER: Block Error Rate

degradation in performance when compared to a contiguous block of the same amount of spectrum as shown below.

Table 9: Performance loss for non-contiguous aggregation (source: GSA)

Configuration	Performance loss compared to contiguous block
100 MHz contiguous, 273 PRB[51]s	Baseline
CA 50+50 MHz, 133+133 PRBs	2.52 MHz less spectrum available vs. 100 MHz contiguous
CA 80+20 MHz, 217+51 PRBs	1.8 MHz less spectrum available vs. 100 MHz contiguous
CA 60+40 MHz, 162+106 PRBs	1.8 MHz less spectrum available vs. 100 MHz contiguous
80 MHz contiguous, 217 PRBs	Baseline
CA 40+40 MHz, 106+106 PRBs	1.8 MHz more spectrum available vs. 80 MHz contiguous

At the physical layer, multiple sub-bands can coexist in one carrier; each sub-band could be configured with a specific numerology intended for a specific application/deployment scenario. Having a continuous carrier provides more flexibility than two non-contiguous carriers. To put it differently, 100 MHz provides more flexibility to the MNO in how the MNO decides to partition/allocate resources for different services, compared to the cases where the MNO would have multiple carriers.

In terms of signalling, the PDCCH[52] overhead of a single 100 MHz carrier is 6.3%, and this would be roughly doubled to 12% for two carriers[53]. In addition, a single wide carrier can save more than 20% in cell configuration/addition/deletion overheads compared to a two-carrier configuration. Two carriers also require more resources in the base band, as each cell requires certain processing to build the information for common channels and schedule/process user plane data.

With regards to latency, a carrier aggregation configuration increases the delay to adapt the bandwidth. The carrier activation/deactivation delay is of the order of 10 ms for a CA configuration, whereas a single wide carrier allows for switching a carrier Bandwidth Part (BWP) for control and data with a less than 2 ms delay. Furthermore, there is no cell set-up delay for secondary cell in wideband operation.

4.2 Implementation aspects

Commercially available NR base stations operating in the 3400–3800 MHz range typically have a bandwidth smaller than 400 MHz (sometimes referred to as 'instantaneous bandwidth'). If an operator holds spectrum blocks that are separated further than the IBW, then two different radio units would be needed.

51 RB: Physical Resource Block

52 PDDCCH: Physical Downlink Control channel

53 This is approximate, since more users need to be scheduled in the wideband carrier.

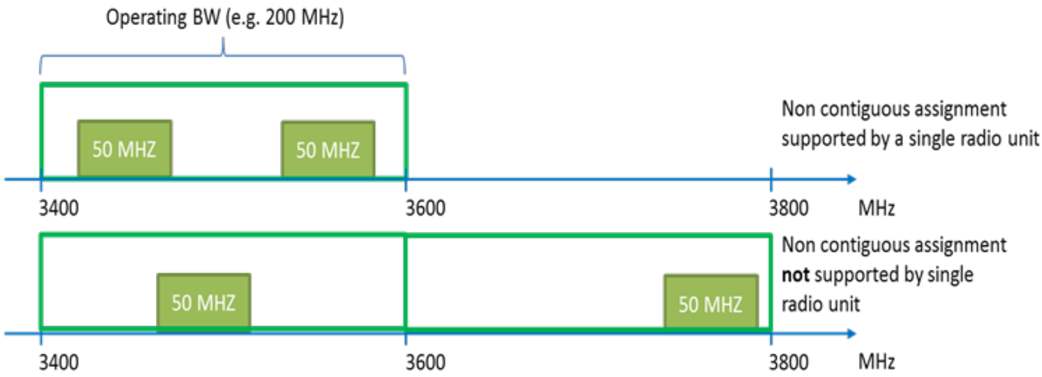

Figure 8: BS implementation aspects

4.3 Spectrum management aspects

The assignment of non-contiguous blocks results in additional boundaries between operators. This would lead to wasted spectrum in the case of unsynchronised networks' operations (which would require much stricter OOB power limits as well as inter-operator guard bands of at least 20–25 MHz with currently available filtering technology. Furthermore, as the number of boundaries between MNOs increases, the negotiations for achieving a synchronised operation will become more complex.

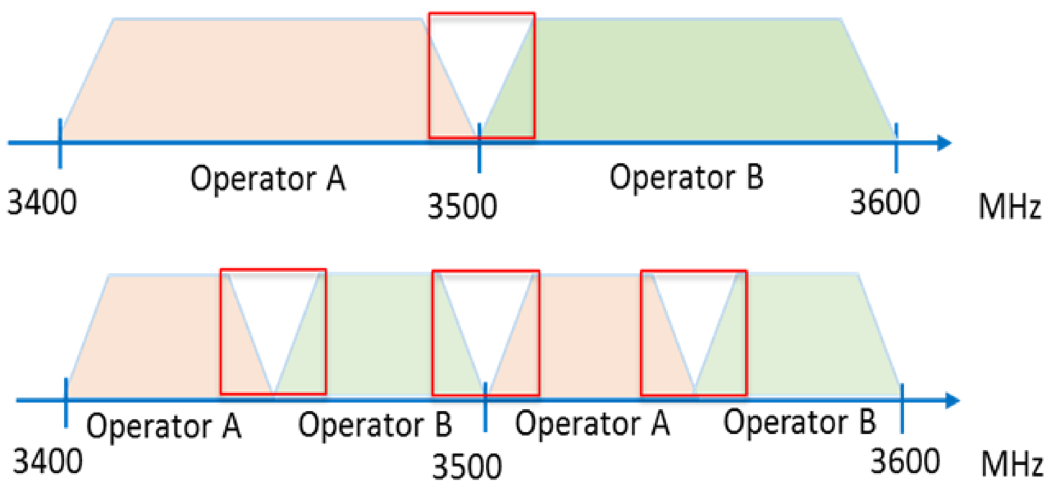

Figure 9: the impact of small blocks on guard-bands

4.4 Terminal aspects

Uplink CA (especially non-contiguous UL CA) is more complex, thus is usually not supported by all UEs. In this context, a larger channel BW has benefits over non-contiguous blocks.

- A larger channel does not require UL CA to be supported by the UE in order to use the entire available UL channel bandwidth.
- Higher trunking efficiency is achievable within continuous spectrum than non-continuous spectrum (since not all UEs will support or be configured with CA, and CA adaptation is slow).

In addition, UE power consumption increases significantly for CA. NR allows for applying a reduced BWP for control monitoring in periods of low traffic activity and also allows for less signalling and faster adaptation to bursty traffic within a single carrier. For intra-band CA, there could be an increase in power consumption of up to 30 mA for an additional component carrier. This means an increase of anything from 50% to approximately 90% in the power consumption of the RF block. For inter-band CA, an additional 50–60 mA or thereabouts could be consumed for an additional carrier. Even if the second carrier is not activated, the CA configuration results in an additional 5–10 mA consumed.

Summary of the impact of non-contiguous blocks

Table 12: Comparison of 100 MHz vs. 50+50 MHz (source: GSA)

	100 MHz	50 + 50 MHz
Complexity	Single carrier	Needs intra-band CA
Channel utilisation	98.3%	95.8%
Physical layer signalling	6.3% overhead	Approx. 12% overhead
Physical layer configuration	A single 100 MHz carrier offers more flexibility than 2x50 MHz carriers to configure sub-bands within the carrier	
Carrier activation/deactivation delay	2 ms	10 ms
BS implementation	Requires one radio unit only	May need two radio units
Spectrum management	Guard bands may be required if networks are unsynchronised	Two additional guard bands if networks are unsynchronised
UL support	No CA required in the UL	Uplink CA may not be supported by all UEs
UE power consumption		30 mA additional power consumption for the second CC (50–90% RF power increase over the non-CA case)

Section 2

High-Altitude Platform Stations (HAPS)

Contents for this Section

S2(1): Introduction

High-altitude platform stations (HAPS) are easily deployable stations operating in the stratosphere that can provide a variety of connectivity services to end users on the ground. HAPS are high enough to provide services to a large area or to augment the capacity of other broadband service providers. With the advantage of height, one HAPS can transmit service over an area 20-30 times greater than a traditional ground-based mobile system and at higher throughput and lower latency than satellites. Development of HAPS is expected to pave the way to connect more of the world's people to the benefits of today's digital economy, particularly in underserved communities and in rural and remote areas.[54]

HAPS can take different forms, such as lightweight, solar-powered balloons, fixed-wing aircraft, or airships operating in the stratosphere. These platforms draw upon the advances in solar panel efficiency, battery energy density, lightweight composite materials, autonomous avionics, and antennas, which together have made HAPS a viable technology that has already started to deploy commercially in Africa. Today, HAPS can stay aloft for several months at a time, have operated for over a million hours and 40 million kilometers in the stratosphere, and have connected hundreds of thousands of users in commercial and disaster preparedness situations.[55]

HAPS leverage a combination of interference avoidance techniques to coexist with fixed, mobile, and satellite users. Techniques may include physical separation of ground equipment, angular separation of antennas, and traditional frequency planning techniques such as cross-polar discrimination. Moreover, HAPS that employ network orchestration systems such as Temporospatial Software-Defined Networking (SDN) can programmatically avoid in-line events with incumbent networks.[56]

HAPS have a number of important use cases. First, because they rely on minimal ground network infrastructure, HAPS technology can help extend mobile broadband networks into areas that do not have connectivity, including remote and hard-to-serve areas (e.g., mountains, deserts, jungles, and islands) where there is no ground-based access to the service area. IMT services delivered directly to end users' devices via base stations operating in the stratosphere are known as high altitude IMT base stations or HIBS. HAPS are also being tested for 5G connectivity to end users.

- HAPS can potentially enable lower cost of connectivity and faster deployment to areas long left on the wrong side of the digital divide.

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54 See White Paper, "The Stratosphere: High Altitude, Higher Ambitions" (2020), available at https://www.loon.co/resources/content-library/.

55 See Salvatore Candido, "312 Days in the Stratosphere," Loon Blog (Oct. 28, 2020), available at https://medium.com/loon-for-all/312-days-in-the-stratosphere-5c50bd233ec5.

56 See Dynamic Spectrum Alliance, "Dynamic Spectrum for Aerospace Networks" (Nov. 24, 2020), available at http://dynamicspectrumalliance.org/dynamic-spectrum-aerospace-networks/; Brian Barritt and Vint Cerf, "Loon SDN: Applicability to NASA's Next-Generation Space Communications Architecture," 2018 IEEE Aerospace Conference, available at https://research.google/pubs/pub47138/..

- Second, HAPS may be used to provide disaster preparedness when ground-based networks have been impacted or additional capacity is needed. HAPS have already been used to connect hundreds of thousands of affected individuals after floods, hurricanes, earthquakes, and during the COVID-19 pandemic.
- Third, HAPS may also be used to provide fixed wireless backhaul for industrial use cases, such as for high-speed backhaul or Internet-of-Things connectivity in the energy and agriculture sectors.

It is anticipated that HAPS technology will help to fast-track the bridging of digital divide between rural and urban Africa and support emergency situations in the African region.

S2(2): Main Elements For Consideration

1. Spectrum Requirement

In accordance with RR No. 4.23, transmissions to or from high altitude platform stations shall be limited to the bands specifically identified in Article 5. (WRC-12)

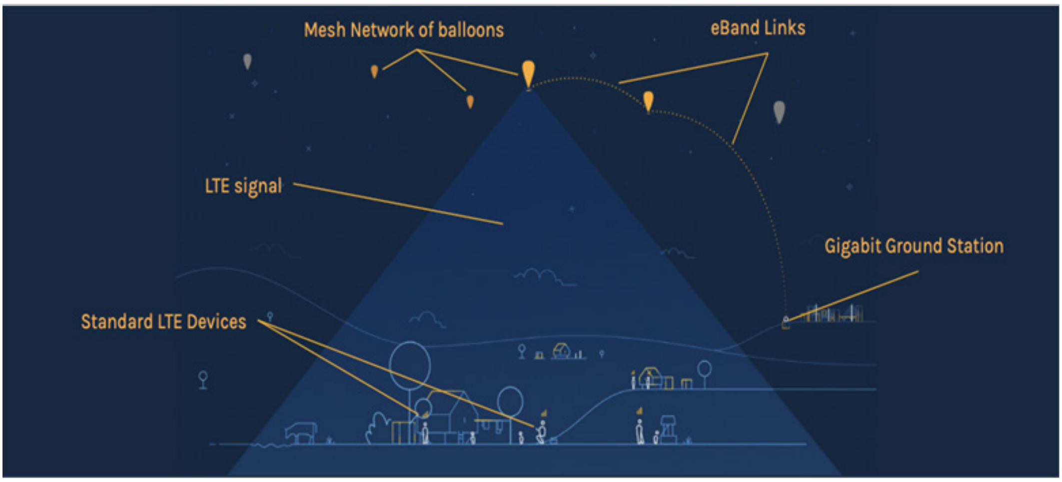
The frequency bands identified for HAPS in Region 1 or African countries are listed in Table below.

Table 13: The frequency bands identified for HAPS in Region 1 or African countries

Frequency range (MHz)	Service	Geographical area	Direction	Reference
1 885 - 1 980	Mobile	Worldwide	Uplink	RR No. **5.388A,** Resolution 221 (Rev.WRC-07)
2 010 - 2 025	Mobile	Regions 1 & 3	Uplink	RR No. No. **5.388A,** Resolution 221 (Rev.WRC-07)
2 110- 2 170	Mobile	Regions 1 & 3	Bidirectional links	RR No. **5.388A,** Resolution 221 (Rev.WRC-07)
6 440 - 6 520	Fixed	Countries in RR No. **5.457**	Down link	RR No. **5.457,** Resolution 150 (WRC-12)
6 560 - 6 640	Fixed	Countries in RR No. **5.457**	Uplink	RR No. **5.457,** Resolution 150 (WRC-12)
27 900 - 28 200	Fixed	Countries in RR No. **5.537A**	Down link	RR No. **5.537A,** Resolution 145 (Rev.WRC-19)
31 000 - 31 300	Fixed	Worldwide	Bidirectional links	RR No. **5.543B,** Resolution 167 (WRC-19)
38 000 - 39 500	Fixed	Worldwide	Bidirectional links	RR No. **5.550D,** Resolution 168 (WRC-19)
47 200 - 47 500 and 47 900 - 48 200	Fixed	Worldwide	Bidirectional links	RR No. **5.552A,** Resolution 122 (Rev. WRC-19)

In addition, WRC-23 will consider, under Agenda Item 1.4, the use of HAPS as IMT (HIBS) in the mobile service in certain frequency bands below 2.7 GHz already identified for IMT on global or regional level.

In order to provide adequate capacity to end users, HAPS must have access to backhaul and access spectrum. This figure describes a currently deployed HAPS network in Africa that uses E-band for backhaul and LTE for access spectrum:



Source: Loon

Before 2021 there were tests of HAPS conducted in some parts of Africa using E-band (71-76 GHz/81-86 GHz) for point-to-point backhaul connections -- both between airborne HAPS stations and between an airborne HAPS station and a ground station. These systems used the 81-86 GHz uplink, paired with 71-76 GHz downlink, with a channel bandwidth of 2 x 750 MHz to ensure sufficient capacity. The use of “pencil beam” links in E-band ensures that these stratospheric backhaul links can coexist with incumbent and future users of the band with a low risk of interference. It should be, however, noted that the bands 71-76 GHz/81-86 GHz are not identified for HAPS use in the ITU Radio Regulations. In the future, HAPS may be deployed using different spectrum bands for fixed service backhaul, such as 31-31.3 GHz, 42.2-47.5 GHz/47.9-48.2 GHz.

With respect to access spectrum, future HAPS systems might potentially use LTE spectrum below 2.7 GHz (e.g., spectrum bands between 700 and 900 MHz if identified by WRC-23) licensed to local operator partners to provide connectivity between the airborne platforms and the user equipment (i.e., traditional 4G/LTE smartphones). Using already licensed spectrum enables mobile network operators to use HAPS to extend their networks quickly and cost-effectively into areas where ground-based infrastructure is either too expensive or too difficult to deploy. Current tests and research proposals are also exploring the use of 5G IMT spectrum to provide access to end users, to ensure that rural and remote populations are not left on the wrong side of the digital divide.

2. Licensing Requirement

This section provides a high-level overview of the recommended licensing framework to enable rapid deployment of HAPS throughout Africa. To obtain the necessary spectrum, a HAPS provider or its network operator partner (e.g., an MNO or fiber network operator) will either use its existing license or apply with a national regulator for the necessary mobile spectrum authorization, depending on the circumstances.

2.1 Backhaul Spectrum Licensing

a. Incorporate HAPS Backhaul into Existing Fixed Point-to-Point Licensing Framework

The ITU has recognized that HAPS backhaul links fall within the fixed service. Since point-to-point HAPS links have the same general technical characteristics as point-to-point links on the ground and are generally used to extend terrestrial networks, HAPS are best seen as a part of the terrestrial service. To accommodate HAPS within fixed service frameworks, traditional point-to-point link licensing models can be modified to include technical parameters that allow registration of links between a ground station and a stratospheric platform. These additional technical parameters would include the elevation range and azimuth range of the ground-to-air link to create a three-dimensional inverted cone around ground station that may be used for interference coordination. Using these additional parameters will enable regulators to efficiently incorporate HAPS into existing licensing frameworks without requiring a separate HAPS framework.

b. Adopt Self-Coordinated Light Licensing for Backhaul Spectrum

In order to promote rapid deployment of HAPS, we recommend adopting a self-coordinated light-licensing framework for fixed service links in spectrum bands where HAPS backhaul networks operate today or will operate in the future. For example, self-coordination of millimeter wave spectrum such as E-band is a proven model that promotes innovation and efficient use of spectrum, and has been adopted by a number of administrations, most notably in the United States, to coordinate narrow-beam fixed point-to-point links.[57]

Self-coordinated management approaches are supported by online link registration databases and automated coordination mechanisms for interference management that licensees use to upload license applications and obtain information on available link locations, as well as details of existing spectrum uses that must be protected from interference.[58] Importantly, these databases may be

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57 David Abecassis, Janette Stewart, and Alex Reichl, “Review of Spectrum Management Approaches for E-Band (70/80GHz) in Selected Markets,” Analysys Mason (Jan. 5, 2016) (noting that the FCC was “the first regulator to implement a self-coordinated, light licensed regime in E-Band,” which has “led the way for other regulators worldwide to adopt similar approaches,” including India, New Zealand, Nigeria, Sweden, and the United Kingdom).

58 Dynamic Spectrum Alliance, “Automated Frequency Coordination: An Established Tool for Modern Spectrum Management,” 18-20 (March 2019), available at http://dynamicspectrumalliance.org/wp-content/uploads/2019/03/DSA_DB-Report_Final_03122019.pdf.

expanded to incorporate other new and emerging services, such as mobile and satellite, with minimal changes to maximize efficiency and promote coexistence. These databases may be managed by an administration or a third-party database manager, and made available online.

A typical process for self-coordinated light licensing (using E-band as a model) is as follows:

1. The applicant applies for a non-exclusive, multi-year, nationwide license, which authorizes the licensee to register point-to-point wireless links on a national basis.
2. When the nationwide license is granted, the licensee may register individual E-band links, along with technical characteristics, in a third-party automated link database for approval to proceed. When submitting a link, the applicant must complete automated coordination, which will either approve the proposed link or require the applicant to move the link so that it does not interfere with existing links.
3. When the request is approved, the link is registered in the database on a first-come, first-served basis.

This approach has a number of benefits for administrations and providers alike, including more efficient network planning and spectrum use and the possibility of dynamic spectrum sharing in millimeter wave bands.

c. Adopt Flat, Per-link Spectrum Fee Schedule for HAPS Backhaul Spectrum

In order to promote HAPS deployment, spectrum fees must be predictable and reasonable. Various jurisdictions have adopted licensing frameworks for millimeter wave spectrum with reasonable per-link flat fees, such as in E-band. A flat fee enables providers to predict costs and effectively deploy stratospheric Internet platform backhaul, and this spectrum fee framework aligns with the framework other national regulators have used for ground-to-platform links.

2.2 Mobile Spectrum for HAPS-based Connectivity

HAPS also require timely access to mobile spectrum to deliver service to end users, whether for rural connectivity, in response to emergencies, or to demonstrate the capabilities of the technology. Based on the Radio Regulations, in Region 1 the frequency bands of 1 885 - 1 980 MHz, 2 010 - 2 025 MHz, 2 110 - 2 170 MHz are currently identified as mobile spectrum for HAPS.

To facilitate the rapid deployment of IMT services into rural areas that currently lack connectivity, administrations can permit mobile network operators to use their existing access spectrum licenses to provide services to end users via high-altitude platforms.

Another example of mobile spectrum licensing to promote HAPS deployment is special (i.e., temporary) licenses, which can facilitate timely access to LTE spectrum for emergency response and recovery. While many ATU member states already have a process in place for obtaining special (temporary) licenses, those typically only permit temporary authority for a limited non-extendable number of days, which is often insufficient for emergency connectivity.

To accommodate the unique case of disaster preparedness, we recommend a harmonized special (i.e., temporary) license model that provides:

1. A temporary license for up to 12 months, extendable for the same period of time, to limit administrative burden and ensure licenses are in place well before a disaster;
2. Regulatory authority to grant expeditiously the license for disaster communications purposes;
3. To the extent possible, a license in line with the national frequency allocation table;
4. Priority to disaster-related radiocommunications over other services being provided by users of the needed frequencies.

3. Equipment Type Approval

Acceptance of Suppliers' Declaration of Conformity (SDOC) has worked in many regions for equipment authorization for the sake of rapid equipment type approval. This will facilitate network deployment and emergency preparedness by enabling providers to deploy necessary ground infrastructure more rapidly.

S2(3): Recommendations

Harmonization of regulatory frameworks across the ATU Member States would permit innovative service providers to rapidly deploy equipment and services to facilitate emergency and non-emergency connectivity across Africa. Above all, spectrum policies should be flexible so that HAPS are not precluded from accessing spectrum or sharing spectrum with other platforms.

In order to foster harmonised implementation of HAPS in Africa, ATU recommends Member States to:

1. **Adopt**, under the auspices of the ATU, a harmonized, flexible and streamlined approach to spectrum licensing that accommodates stratospheric Internet platforms in existing fixed service frameworks for bands identified in Article 5 of the Radio Regulations where HAPS operate or may operate in the future;
2. **Adopt** a self-coordinated spectrum licensing framework for the spectrum used for stratospheric Internet platform backhaul taking into account the technical and operational requirements given in the Radio Regulations;
3. **Consider** applying a flat fee per-link;
4. **Accept** Suppliers' Declaration of Conformity (SDOC) for a rapid equipment type approval;

5. **Consider** developing/adopting import pre-approvals and streamlined customs clearance;
6. **Consider** manufacturing and assembly of HAPS and its related devices in the continent;
7. **Consider** permitting mobile network operators to use their existing access spectrum licenses to provide services to end users via HAPS in support of technology neutrality principle for Spectrum Licences and subject to compliance with technical conditions;
8. **Adopt** a special (temporary) license to enable timely access to mobile and fixed spectrum to be able to deliver service to end users in response to emergencies, and for trials of commercial networks;
9. **Perform** regular technology reviews, approximately every five years that scan the environment for usage trends of existing technologies to determine whether they have sufficient or too much spectrum while making spectrum available for innovation and new technologies.

Section 3

SATELLITE APPLICATIONS:

Earth Stations in Motion under the Fixed Satellite Service
(FSS ESIM)

and

Mobile Satellite Service applications
(MSS)

and

Very Small Aperture Terminals and Other Applications under
the Fixed Satellite Service
(FSS VSAT and Other Applications)

Introduction

1. In the context of allowing a timely introduction of new satellite technologies, a regional harmonisation and streamlining of regulatory arrangements for certain types of satellite user terminals, for fixed or mobile applications and with similar technical and operational characteristics (e.g. ESIM/ VSATs), is useful. One way to encourage expansion of existing satellite technologies and the deployment of new ones is to encourage `blanket or class licensing', along with free circulation of foreign visiting ESIM. This is also to permit faster availability of high-bandwidth/broadband applications to meet demand, including satellite-powered high capacity services supporting end users (e.g. backhaul for terrestrial communications)

2. Examples of licensing practices that help streamlining the authorization process and, therefore, the provision of new services, are as follows:

   - Licensing process to be harmonised, as much as possible, among the member countries.
   - Domestic user terminals to be licenced without the need for individual terminal-by-terminal authorization (e.g. on a blanket licensing basis)
   - Free circulation of foreign visiting ESIM, based on mutual recognition of authorizations issued by other countries
   - Administrations to take appropriate actions to publish in a timely manner procedures for authorizing user terminals operations in their countries
   - Designation of the relevant frequencies for use by satellite user terminals on a domestic, regional or international basis
   - Reasonable spectrum fees, taking also into account the large amount of bandwidth used by systems operating in higher frequency bands

3. On the other hand satellite operators shall ensure that the operation of satellite services and transmitting earth stations within the territory of an administration shall be carried out only if authorized by that administration and when an administration identifies the presence of unauthorized operation in its territories satellite operators and/or service providers shall take all appropriate actions to ceases such unauthorized transmissions in accordance with Article 18 of RR and Resolution 22 (WRC-19).

4. Also the licensee (e.g. service provider) and satellite operator need to ensure that they have the capability to limit operations of such earth stations to the territory or territories of administrations having authorised those earth stations and to comply with Article 18 of the ITU Radio Regulations.

Sub-Section 3-1

Earth Stations in Motion under the Fixed Satellite Service (FSS ESIM)

Contents for this Sub-Section

SS3-1(1): Introduction

1. There is global demand today and anticipated growth for broadband communications including connectivity requirements for users on aircraft, vessels and vehicles in motion. The satellite user terminals provide the connectivity to the Internet to meet that demand at both fixed locations and while in motion, in urban, suburban and rural and remote areas around the globe.

2. Earth Stations in Motion (ESIM) are satellite user terminals operating with Fixed Satellite Service (FSS) networks using some of the frequency bands allocated to FSS, with small directional antennas, that provide broadband communication services. The terminals may be mounted on aircraft, ships or land vehicles in motion.

3. Therefore, Earth Station in Motion (ESIM) refers to the collective designation of earth stations operating in different environments that administrations are already authorizing to transmit while in motion. These earth stations provide broadband connectivity ubiquitously on Land (Land ESIM), pier-to-pier for maritime (Maritime ESIM) and gate-to-gate for aviation (Aeronautical ESIM) while communicating with space stations based on national administration authorisations/local licensing conditions. Noting that Earth station in motion which use Ku band are also called Vehicle-Mounted Earth Stations (VMESs), Earth Stations on Vessels (ESVs) and Aeronautical Earth Stations (AES).

4. Today, all earth stations used in motion are using Ku and Ka bands, however, the rules and spectrum use regimes for Ka band and Ku band are different. This paper will maintain the separation of the two bands in order to explain the differences and avoid any confusion. It further addresses only use of the frequencies allocated to those parts of the fixed satellite service under which operation of ESIMs is permitted by the Radio Regulations.

5. In addition, the usage of ESIM in Q/V bands will be studied in the study cycle for WRC-27.

6. ESIM were originally called Earth Stations on Mobile Platforms (ESOMPs). WRC-15 renamed ESOMP as ESIM as that term more closely describes how these type of earth stations operate.

7. Various types of satellite terminals have been used on board ships and aircraft since the 1980s. Initially operating over mobile satellite service (MSS) systems in the L-band, these terminals provided modest narrowband services (voice and low data rates). New technology capabilities, adopted by satellite designers and terminal equipment manufacturers, have allowed the development of more spectrally efficient, small terminals that can provide broadband communications to support voice, video, high-speed data, and access to the Internet.

8. ESIM enable the provision of high data rate broadband communications, to mobile platforms that often cannot be served using other satellite communications technologies. ESIM are used to deliver broadband connectivity to aircraft, ships, trains, and vehicles in motion using the same frequency bands, satellites, beams, and control stations used to provide broadband services via earth stations at fixed locations. In particular, the connectivity via ESIM provides broadband internet services for vessel and aircraft operators, service providers, crew, passengers and first responders.

9. ESIM will enable government, media, enterprise, and other end users, to rely on global mobile communications, with increased flexibility and reliability, including in remote parts of the globe. This is of particular interest to the maritime industry (merchant, cruise, fishing) as well as the aeronautical users (business, transport, and passengers), that have traditionally had only limited connectivity options. Transportation operations will benefit from the improved services they can offer to their customers, for example video streaming, Internet connectivity to personal electronic devices, fleet digitization, software and firmware updates and also by lowering the airplane, ship or vehicle's carbon footprint. ESIM will also facilitate applications related to critical infrastructure, disaster communications, corporate communications, telemedicine, satellite news gathering and other remote communications that will positively affect users' efficiency and quality of life.

10. ESIM, as with any technology, require technical operating guidelines to ensure that operations can meet the requirements of the environment in which they are providing broadband service Depending on the frequency band and type of satellite network, the nature of providing satellite connectivity to moving platforms necessitates careful regulation to ensure that incumbent services (Terrestrial-Satellite) in neighbouring or fly-over countries are protected in addition to other space services which share the same frequency band. Therefore, ESIM operations need to comply with the technical and operational requirements of the countries in which they operate.

11. Fixed-Satellite Service (FSS) networks in Ka-band that employ advanced technology are available and capable of meeting the connectivity requirements of ESIM, including very high-throughput (VHT) and ultra-high throughput (UHT) applications. These FSS systems operate within geostationary (GSO) and non-geostationary (NGSO) satellites networks. Ku-band also offer similar advantages and has been offering similar connectivity services around the world for decades as well.

12. The African Administrations needs to streamline the regulatory framework for such operations, particularly for the domestic deployment and for ESIM that roam by use of mutual recognition of other regions' certifications of ESIM equipment, including type approval. Streamlining these processes facilitates introduction of ESIM domestically and provides for seamless movement of ESIM within the region taking into consideration the national sovereignty of administrations.

13. This recommendation does not address the spectrum related aspects for the implementation and use of ESIM in the frequency bands under consideration for future WRC (WRC-23 and WRC-27). Wherever elements on the concerned frequency bands are provided in some parts of the document, it is for information purposes only.

SS3-1(2): Main Elements For Consideration

a. Services & technology aspects

1. The figure below illustrates some of the use cases for ESIM.

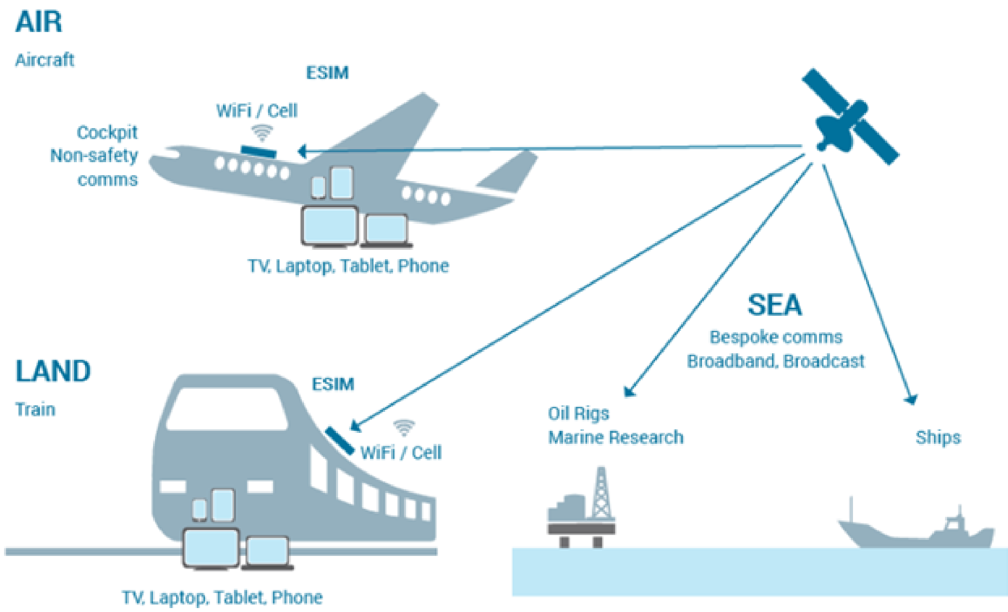

Figure 10: Some use cases of ESIM

2. Increasingly, ESIM on aircraft are being used to connect certain airline functions, e.g., electronic flight bag, aircraft fleet sensors and others. This trend is also taking place with maritime and land mobile applications.

3. Advances in satellite antenna technology, including the development of stabilized antennas capable of maintaining a high degree of pointing accuracy even when moving rapidly, have allowed the development of user terminals with very stable pointing characteristics, even when in motion. In addition, highly directional antennas allow ESIMs moving up to 1,000 km/h to accurately send information to geostationary and non-geostationary satellites without interfering with other duly authorized services, while delivering broadband connectivity.

4. ESIM are designed to operate in the same interference environment and comply with technical operating requirements and regulatory constraints similar to those for typical uncoordinated FSS earth stations. ESIM may operate in some bands where there are also terrestrial services. These operations are subject to requirements defined in the Radio Regulations and methodology currently being developed by the responsible ITU-R Working Party (e.g. pfd limits on the ground for ESIM on aircraft at different altitudes above the earth for aeronautical ESIMs; pfd at the shore or minimum off-shore distance for ESIM on ships and maximum transmitting EIRP for Maritime ESIM).

b. Technical and operational aspects

5. Technical and operational requirements for operating ESIM with GSO FSS networks are based on characteristics that are defined in the International Telecommunication Union's (ITU) Radio Regulations. In addition, there are certain regional frameworks such as CEPT, EACO, CRASA also further define ESIM regulations. These technical and operational characteristics cover aspects such as techniques to track the intended FSS satellites, avoiding interference to adjacent satellites and meeting off-axis EIRP limit. By complying with such provisions, ESIM can efficiently reuse spectrum that is simultaneously being used by other FSS networks.

c. Ka-Band ESIM in GSO FSS

6. The ITU World Radio Conferences (WRC) have considered international regulations for ESIM in Ka band for the provision of satellite broadband services:

   - WRC-15 validated the technical framework for GSO ESIM operations, in the 19.7-20.2 and 29.5-30 GHz bands in the Ka Band[59].
   - WRC-19 further expanded on WRC-15's framework and validated the use of ESIM with GSO FSS networks in the 27.5-29.5 and 17.7-19.7 GHz bands.[60] Footnote 5.517A and Resolution 169 (WRC-19) establishes the technical and regulatory conditions under which ESIM must operate.

7. The main ESIM technical and operational characteristics that have been developed address inter alia:

   - The small antenna sizes that are in use and the necessity of keeping the antenna beam within the off-axis EIRP density mask and to inhibit transmissions if the antenna pointing exceeds the required operational threshold;
   - The tracking system that is required to maintain the pointing accuracy within ±0.2 degrees to the intended satellite at all times;
   - Coordination between satellites and satellite constellations, and;
   - Operation under control of a network management system.

59 See ITU Radio Regulation Footnote 5.527A and Resolution 156 (WRC-15, Geneva) "Use of the frequency bands 19.7-20.2 GHz and 29.5-30 GHz by earth stations in motion communicating with geostationary space stations in the fixed-satellite service" considering e), resolves 1.1.

60 See ITU Radio Regulation Footnote 5.517A and Resolution 169 (WRC-19, Sharm el-Sheikh) "Use of the frequency bands 17.7-19.7 GHz and 27.5-29.5 GHz by earth stations in motion communicating with geostationary space stations in the fixed-satellite service" resolves 6; and footnote 5.517A of the Radio Regulations as adopted by WRC-19.

d. Ka-band ESIM operating with NGSO FSS networks

8. In terms of technical and operational aspects, NGSO ESIM in Ka-band are also characterised by small antennas, tracking systems, operation under control of a network management system and satellite network coordination.

9. The WRC-23 agenda includes an Agenda Item pursuant to ITU Resolution 173 (WRC-19) (WRC-23 AI 1.16) to study the regulatory and technical conditions for operation of NGSO ESIM in the frequency bands 17.7-18.6 GHz, 18.8-19.3 GHz and 19.7-20.2 GHz (space-to-Earth) and 27.5-29.1 GHz and 29.5-30 GHz (Earth-to-space) bands.

10. The regulatory framework covering NGSO ESIM in Ka-band already exists in other jurisdictions. Further details in point 17 below.

e. Ku band ESIM operating with GSO FSS networks

11. The main technical and operational aspects for the use of earth station on vessels (ESV)/ESIM in the 14-14.5 GHz (Earth-to-space) band (Ku Band) are:

    - The minimum distance from the low-water mark as officially recognized by the coastal State beyond which ESV can operate without the prior agreement of any administration is 125 Km in 14-14.5 GHz.
    - The minimum antenna diameter of ESV is 0.6 m.
    - The pointing accuracy is maintained to be ±0.2 degrees to the target satellite at all times.
    - The maximum EIRP of ESIM toward the horizon is 16.3 dBW.

12. The technical and operational requirements for aircraft earth stations (AES) using fixed-satellite service network in the band 14-14.5 GHz (Earth-to-space) are specified in Recommendation ITU-R M.1643.

13. In addition, the WRC-23 includes an Agenda Item (WRC-23 AI 1.15) to provide the regulatory and technical conditions under which GSO ESIM can be used in the 12.75-13.25 GHz (Earth-to-space) band pursuant to ITU Resolution **172 (WRC-19).**

f. Ku-Band ESIM in NGSO FSS

14. Currently there is no global/ITU regulation governing the operation of ESIM in Ku band NGSO FSS. Within CEPT, reports have been developed on the technical and operational conditions for the operation of ESIM to FSS NGSO systems in the frequency bands 10.7 – 12.75 GHz (space-to-Earth) and 14 – 14.5 GHz (Earth-to-Space). Further details are provided in point 17 below.

g. Existing regulatory frameworks

15. Overall, the existing ITU-R technical operating framework, as well as those of regional and national regulatory authorities, present examples for how ESIM can operate within the environments where they can travel and protect other operators and services as appropriate.

16. The existing body of ITU ESIM regulatory documents includes:

Document Reference	Title	Frequency Range
Resolution 22 (WRC-19)	Measures to limit unauthorized uplink transmissions from earth stations	-
Ku Band		
Resolution 902 (WRC-03)	Provisions relating to earth stations located on board vessels which operate in fixed-satellite service networks in the uplink bands 5 925-6 425 MHz and 14-14.5 GHz	5 925-6 425 MHz 14-14.5 GHz (Earth-to-space)
Recommendation ITU-R M.1643	Technical and operational requirements for aircraft earth stations of aeronautical mobile-satellite service including those using fixed-satellite service network transponders in the band 14-14.5 GHz (Earth-to-space)	14-14.5 GHz (Earth-to-space)
Recommendation ITU-R S.1587	Technical characteristics of earth stations on board vessels operating in the frequency bands 5925-6425 MHz and 14-14.5 GHz which are allocated to the fixed-satellite service	5925 – 6425 MHz 14.0 – 14.5 GHz (Earth-to-space)
Recommendation ITU-R S.1857	Methodologies to estimate the off-axis e.i.r.p. density levels and to assess the interference towards adjacent satellites resulting from pointing errors of vehicle-mounted earth stations in the 14 GHz frequency band	
Ka Band		
Radio Regulations Footnote 5.527A Resolution 156 (WRC-15)	Use of the frequency bands 19.7-20.2 GHz and 29.5-30.0 GHz by earth stations in motion communicating with geostationary space stations in the fixed-satellite service	19.7 – 20.2 GHz (space-to-Earth) 29.5 – 30.0 GHz (Earth-to-space)
Radio Regulations Footnote 5.517A Resolution 169 (WRC-19)	Use of the frequency bands 17.7-19.7 GHz and 27.5-29.5 GHz by earth stations in motion communicating with geostationary space stations in the fixed-satellite service	17.7 - 19.7 GHz (space-to-Earth) 27.5 - 29.5 GHz (Earth-to-space)
Report ITU-R S.2223	Technical and operational requirements for GSO FSS earth stations on mobile platforms in bands from 17.3 to 30.0 GHz	17.3-20.2 (space-to-Earth) and 27.5-30.0 GHz (Earth-to-space)

Report ITU-R S.2261	Technical and operational requirements for earth stations on mobile platforms operating in non-GSO FSS systems in the frequency bands from 17.3 to 19.3, 19.7 to 20.2, 27 to 29.1 and from 29.5 to 30.0 GHz	17.3 - 19.3, 19.7-20.2 GHz (space-to-Earth) 27-29.1, 29.5 -30.0 GHz (Earth-to-space)
Regulation under Development		
Ku Band		
WRC-23 Agenda Item 1.15/ Resolution 172 (WRC-19)	Operation of earth stations on aircraft and vessels communicating with geostationary space stations in the fixed-satellite service in the frequency band 12.75-13.25 GHz (Earth-to-space)	12.75-13.25 GHz (Earth-to-space)
Ka band		
WRC-23 Agenda Item 1.16/ Resolution 173 (WRC-19)	Use of the frequency bands 17.7-18.6 GHz, 18.8-19.3 GHz and 19.7-20.2 GHz (space-to-Earth) and 27.5-29.1 GHz and 29.5-30 GHz (Earth-to-space) by earth stations in motion communicating with non-geostationary space stations in the fixed-satellite service	17.7-18.8GHz 18.8-19.3GHz 19.7-20.2GHz (Space-Earth) 27.5-29.1GHz 29.5-30GHz (Earth-space)

17. CEPT has developed the following ECC Decisions to provide a harmonised framework for ESIM.

Document Reference	Title	Frequency Range
Ku Band		
ECC Decision (05)10	The free circulation and use of Earth Stations on board Vessels operating in fixed satellite service networks in the frequency bands 14-14.5 GHz	10.7 - 11.7 GHz (space-to-Earth) 12.5 - 12.75 GHz (space-to-Earth) 14.0 - 14.5 GHz (Earth-to-space)
ECC Decision (05)11	The free circulation and use of Aircraft Earth Stations (AES) in the frequency bands 14.0-14.5 GHz (Earth-to-space), 10.7-11.7 GHz (space-to-Earth) and 12.5-12.75 GHz (space-to-Earth)	10.7 - 11.7 GHz (space-to-Earth) 12.5 - 12.75 GHz (space-to-Earth) 14.0 - 14.5 GHz (Earth-to-space)

ECC Decision (18)04	The harmonised use, exemption from individual licensing and free circulation and use of land-based Earth Stations In-Motion (ESIM) operating with GSO FSS satellite systems in the frequency bands 10.7-12.75 GHz and 14.0- 14.5 GHz	10.7 - 12.75 GHz (space-to-Earth) 14.0 - 14.5 GHz (Earth-to-space)
ECC Decision (19)04	The harmonised use of spectrum, free circulation and use of earth stations on-board aircraft operating with GSO FSS networks and NGSO FSS systems in the frequency bands 12.75-13.25 GHz (Earth-to-space) and 10.7-12.75 GHz (space-to-Earth)	10.7 - 12.75 GHz (space-to-Earth) 12.75 - 13.25 GHz (Earth-to-space)
ECC Report 279	The Use of Earth Stations In-Motion (ESIM) operating to NGSO Satellite Systems	10.7 – 12.75 GHz (space-to-Earth) 14 – 14.5 GHz (Earth-to-Space)
ECC Report 271	Compatibility and sharing studies related to NGSO satellite systems operating in the FSS bands	10.7-12.75 GHz (space-to-Earth) 14-14.5 GHz (Earth-to-space)
Ka Band		
ECC Decision (13)01	The harmonised use, free circulation and exemption from individual licensing of Earth Stations On Mobile Platforms (ESOMPs) within the frequency bands 17.3-20.2 GHz and 27.5-30.0 GHz	17.3 - 20.2 GHz (space-to-Earth) 27.5 - 30.0 GHz (Earth-to-space)
ECC/Decision (15)04	The harmonised use, free circulation and exemption from individual licensing of Land, Maritime and Aeronautical Earth Stations On Mobile Platforms (ESOMPs) operating with NGSO FSS satellite systems in the frequency ranges 17.3-20.2 GHz, 27.5-29.1 GHz and 29.5-30.0 GHz	17.3 - 20.2 GHz (space-to-Earth) 27.5 – 29.1 and 29.5-30.0 GHz (Earth-to-space)

18. ETSI has developed a number of applicable technical standards for ESIM. These include:

Document Reference	Title	Frequency Range
ETSI EN 303 978	Satellite Earth Stations and Systems (SES); Harmonized EN for Earth Stations on Mobile Platforms (ESOMP) transmitting towards satellites in geostationary orbit in the 27,5 GHz to 30,0 GHz frequency bands covering the essential requirements of article 3.2 of the R&TTE Directive	17.3 - 20.2 GHz (space-to-Earth) 27.5 - 30.0 GHz (Earth-to-space)

ETSI EN 303 979	Satellite Earth Stations and Systems (SES); Harmonised Standard for Earth Stations on Mobile Platforms (ESOMP) transmitting towards satellites in non-geostationary orbit, operating in the 27,5 GHz to 29,1 GHz and 29,5 GHz to 30,0 GHz frequency bands covering the essential requirements of article 3.2 of the Directive 2014/53/EU	17.3 - 20.2 GHz 27.5 – 29.1 and 29.5-30.0 GHz (Earth-to-space)
EN 302 186 V2.1.0 (2016-02)	Satellite Earth Stations and Systems (SES); Harmonised Standard for satellite mobile Aircraft Earth Stations (AESs) operating in the 11/12/14 GHz frequency bands covering the essential requirements of article 3.2 of the Directive 2014/53/EU	10,70 - 11,70 GHz & 12,50 - 12,75 GHz (space-to-Earth) 14,00 - 14,50 GHz (Earth-to-space)

SS3-1(3): Recommendations

In order to foster harmonised implementation of Earth Stations in Motion (ESIM) under the Fixed Satellite Service (FSS) in Africa, ATU recommends Member States to:

a. General Aspects

1. **Support**, under the auspices of the ATU, the development of an African streamlined and harmonized policy, regulatory, technical and operational approach to bring the ESIM connectivity benefits to its citizens as well as facilitate timely deployment of satellite services across Africa and ensure no unacceptable interference environment. This approach should, among other things:
   a. Address the existing and growing wide-spread use of GSO ESIM services in the Ku band (14-14.5 GHz) and the Ka bands (17.7-20.2/27.5-30 GHz).
   b. Regulatory, technical and operational frameworks to enable NGSO ESIM operations.
   c. Take into account the streamlined approach on ESIM operating in GSO FSS networks in Ka-band 19.7-20.2 GHz (space-to-Earth) and 29.5-30.0 GHz (Earth-to-space) bands already being considered in the sub-regions.
   d. Help extend satellite broadband connectivity across the continent for the ultimate benefit of users.
2. **Support**, under the auspices of the ITU, the development of a global framework governing the operation of ESIM communicating with FSS NGSO systems.
3. **Ensure** that regulation and licensing conditions promote the use of all emerging technologies that contribute to eliminating the digital divide and in furtherance of the technology neutrality principle. This includes satellite-based technologies that allows multiple connectivity solutions across Africa and contribute to reducing the digital gap between the ATU Member States and other parts of the world.

b. Authorization Aspects

4. **Establish** licensing requirements that focus on facilitating the use of ESIM communicating with geostationary space stations in the FSS Ka band (17.7-20.2/27.5-30 GHz) and FSS Ku band (14-14.5 GHz) to speed up their deployment within the region, taking into consideration the national sovereignty of administrations.

5. **Take** all appropriate actions to make publicly and readily available the procedures for authorizing the operation of satellite services to provide broadband services in their territories to eliminating the digital divide and reducing the gap between African countries and other parts.

6. **Consider** including, in their national regulations, the following elements:

   a. Satellite operators shall ensure that the operation of satellite services and transmitting earth stations within the territory of an administration shall be carried out only if authorized by that administration and when an administration identifies the presence of unauthorized operation in its territories satellite operators and/or service providers shall take all appropriate actions to cease such unauthorized transmissions[61] in accordance with Article 18 of RR and Resolution 22 (WRC-19).

   b. The licensee and satellite operator shall ensure that they have the capability to limit operations of such earth stations to the territory or territories of administrations having authorised those earth stations and to comply with Article 18 of the ITU Radio Regulations.

   c. Any airplane, ship, or vehicle equipped with and operating ESIM (aeronautical, maritime or land) shall be authorized for radio communication using ESIM, by the administration of the country in which the vehicle is registered.

   d. The operation of the ESIM (land, maritime and aeronautical) within the territory(-ies), territorial waters and airspace under the jurisdiction of an administration, shall be carried out only if authorized by the administration.

   e. To operate in the territory of a country, the ESIM service provider and network operator must be authorized by the administration of that country.

   f. ESIM shall operate within the technical, operational and coordinated envelope of typical Earth stations of the satellite network with which they are operating.

   g. Authorisation requirements of foreign visiting aeronautical and maritime ESIM as it is a fundamental aspect to allow global operations based on the authorisations issued by administrations around the world in line with international treaties.

   h. Simplified licensing by way of having authorization requirements that focus on facilitating the use of streamlined requirements to facilitate innovative services provided by ESIM to benefit of citizens and Africans in general while protecting existing and operational services within the region.

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61 See also Resolution 22 (WRC-19).

7. **Consider** for domestic ESIM and when an authorization is required, a class or blanket license as best practice for multiple units with similar technical characteristics which greatly simplifies the task of administrations and operator/service providers.

8. **Take** into account that many countries around the world, including within Africa, take a General Authorisation approach to licensing which allows for a class, "umbrella" or "blanket" license approach on their territory, without the need for cumbersome individual terminal-by-terminal licenses. A more streamlined approach to domestic blanket licensing of ESIM and mutual license recognition (including type approval) of maritime and aeronautical ESIM may help. Streamlining these authorization processes ensure that broadband satellite services are being adopted as a competitive option for connectivity solutions and on a technology-neutral basis.

9. **Ensure** that national technical and operational framework address:

   a. Designation of the relevant frequencies for use by ESIM.

   b. Establishment of a technical framework governing ESIM operation in the associated frequency bands, while ensuring the protection of line-of-sight co-frequency or adjacent band services of equal status domestically and in neighbouring countries as appropriate.

   c. Allow seamless circulation across borders of ESIM terminals between Member States. For ESIM terminals installed on land, authorisation shall be managed by each administration while the services are provided in its territory, in the case of ESIM on maritime or aeronautical platforms, a process based on mutual recognition of licences and free circulation may be considered.

   d. Consideration of internationally recognised technical standards.

   e. Consideration of principles of simplified licensing by Administrations for ESIM operating with NGSO systems, where feasible and according to the national table of frequency allocation (e.g. in frequency bands where there is no risk of interference to other incumbent terrestrial services operating in the same frequency band) taking into consideration the sharing and compatibility work is an ongoing process under WRC-23 A.I. 1.16.

c. Spectrum aspects

10. **Ensure** that adequate spectrum is made available within Ku-band (14GHz) and Ka-band (28 GHz) for ESIM given that adequate spectrum is required. Commercial satellite broadband networks currently use the existing Ku and Ka band spectrum ranges to provide broadband internet access. Satellite broadband spectrum requirements expand as user demand continues to grow.

11. **Implement** the outcomes of WRC-15 and WRC-19 in their national regulations, including implementation of RR footnotes **5.517A** and **5.527A**. Accordingly, Member States are encouraged to allocate the frequency bands 27.5-30 GHz and 17.7-20.2 GHz to FSS and

authorize ESIM FSS operations in the same bands. In particular, ESIM are in receive mode in the 17.7-19.7 GHz band, with no risk of interference to any other incumbent services. Such a decision would facilitate ESIM service provision throughout Africa. It is therefore recommended that exclusive satellite allocations be made in the 28 GHz band at national/regional level (see also **RR 5.516B**).

12. **Take** into account that advanced next generation High Throughput Satellites systems (GSO and NGSO) can use spectrum flexibly and efficiently, spanning over several GHz, and therefore, take into consideration spectrum fees when authorizing these systems, so that the fees do not become a barrier to entry - potentially rendering the project financially non-viable at national level.

d. Technical and operational requirements

13. **Implement** the internationally recognised technical and operational requirements of ESIMs are contained in **paragraph 16 of SS3-1(2)** above, while fully recognising the sovereign right of each Member State to add additional/different technical requirements for domestic operations.
14. **Implement** the existing ITU-R technical and operations requirements, to ensure that aeronautical, maritime, and land mobile ESIM can operate while ensuring the protection of incumbent co-frequency and adjacent band services, when authorized and operating within the borders of Administrations as well as those in neighbouring countries or flyover countries.

e. Socio-economic impact

15. **Take** into account the following when developing national policy for ESIM:
    a. ESIM and satellite internet connectivity, in general, are vital to development plans of the African continent and the growth of various countries in Africa.
    b. Digital divide is a complex socio-economic problem that extends beyond financial constraints to lack of capacity building at the very first level; and African administrations face huge challenges in linking both in order to bridge the digital divide.
    c. Access to broadband is instrumental in accelerating the growth and maturity of any country; this is a technology ecosystem and satellite industry helps integrating ICT innovation in this ecosystem and it creates new businesses and jobs which results in transforming the economy in all verticals: education, healthcare, finance, government; which in turn leads to more employment opportunities, which in turn will increase country's GDP.
    d. The rapid advancements in both ground and space technology will allow meeting the communication needs for socio-economic development and improving access to both urban and remote regions as well as meeting the needs of national security, strategic communications, surveillance and critical economic transactions.

Sub-Section 3-2

Mobile Satellite Service Applications (MSS)

Contents for this Sub-Section

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SS3-2(2): Main Elements For Consideration

a. Definition of Internet of Things (IoT)

b. IoT/M2M using MSS

c. Satellite IoT Service Typology

d. Mobile satellite service and emergencies

e. Mobile satellite service with a complementary ground component

f. Benefits of MSS/CGC

g. Existing regulatory frameworks in the S-band

SS3-2(3): Recommendations

a. Licensing aspects

b. Spectrum aspects

SS3-2(1): Introduction

1. The global mobile satellite services market is set to record phenomenal growth in the upcoming years, primarily due to the rising demand for mobility and developments in digital technologies. In addition, advancements in satellite technologies have resulted in game-changing new mobile satellite services such as the explosion of the Internet of things (IoT) and the complementary ground component (CGC) of the mobile satellite service[62] that will help spur demand.

2. Mobile satellite services provide two-way data as well as voice communication to users located in remote locations across the globe through geostationary or non-geostationary satellites. Traditionally, they have provided critical services to the maritime, aviation, energy, transportation, and public safety sectors, with an extraordinary ability to deliver vital services during natural and man-made disasters irrespective of the location

3. The African continent reported 2 810 disaster events of natural and technological origin from 1968 to 2017. In these disasters, 587 403 people lost their lives and almost 435 million were affected. The economic losses produced by these emergencies reached a total of USD 27.3 billion (in 2017 dollars). Based on the data reviewed, climatological, hydrological and technological disasters such as droughts, floods and transport accidents represent the greatest vulnerability for countries in Africa in terms of frequency, fatalities and total number of people affected.

4. The integration of mobile satellite services with IoT has created a new global market opportunity to connect the unconnected. IoT is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

5. Satellites can be used to support global IoT connectivity, which will help to improve environmental monitoring, agriculture, supply chain management, autonomous vehicles, natural resource and public infrastructure management and other activities benefiting from wide area remote sensing. As the availability of low cost, low power global connectivity l increases, the total number of connected sensors collecting data-for a variety of global environmental, societal, industrial, agricultural and logistical applications will also increase, enhancing the accuracy of forecasts and trends.

6. Traditional Mobile Satellite Systems like Inmarsat, Thuraya, Iridium, Globalstar have been dominant in the M2M/IoT market, using their L-band spectrum with a focus on mobile and maritime applications. In the last 10 years, they have deployed 3.5 - 4 million-satellite IoT terminals in the field.

62 The complementary ground component (CGC) is also referred to as the ancillary terrestrial component (ATC) or the complementary terrestrial component (CTC) by some administrations.

7. The global market for IoT-focused satellite services, based on end-device connectivity hardware and the annual connectivity fees, is forecasted to grow to US$ 5.9 Billion in 2025. During the 2021-2022 period, new NGSO satellite constellations will be launched to provide MSS and to add opportunities for IoT technology, thus facilitating communications with all things that move.

8. This implies a massive tripling or quadrupling of satellite IoT/M2M devices and applications in the next 5 years. By 2025, some 30.3 million satellite IoT devices are expected to be deployed globally. Therefore, it is clear that satellite IoT will bring massive change in the coming years to the world in general, the IoT industry and to the satellite industry in particular.

9. MSS/CGC is a well-established and spectrally efficient platform for the provision of instant and reliable global communications anywhere on the planet delivering social, economic, public safety and humanitarian benefits to governments, enterprises and consumers. The availability of interoperable devices, alongside the expanding suite of cloud-based applications, as well as voice and data, continues to enlarge the diversity of use cases and hence creating a growing demand for MSS spectrum. Various administrations have granted mobile satellite service licenses with a complementary ground component in the L- and S- bands.

SS3-2(2): Main Elements For Consideration

a. Definition of Internet of Things (IoT)

The Internet of Things (IoT) is defined in Recommendation ITU-T Y.2060 as a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies. Value is not in the network (collection and connectivity) but it is in the data itself. IoT is an opportunity for countries and people to make better use of data and especially to provide valuable local information and data in real time or near real time.

b. IoT/M2M using MSS

The 1.5 – 4 GHz range provides optimum spectrum for facilitating the deployment of IoT and M2M MSS systems. Operators have recently become more interested in using the MSS bands for the deployment of IoT/M2M networks via satellite. Some of these satellite filings relate to systems that use a satellite architecture known as cube satellites. Such networks can be built and deployed rapidly, at a lower cost relative to larger traditional satellites.

c. Satellite IoT Service Typology

The satellite industry is responding to the IoT market demand with two types of satellite IoT connectivity service in the MSS IoT backhaul service. Comparable to the GSM or Wifi backhaul service, the IoT gateway backhaul over satellite emerges as a new SATCOM application segment. The IoT market is currently experiencing the advent of ultra-low-cost terrestrial radio transmission standards for IoT such as LoRa™, Sigfox™, LTE-M or NB-IoT targeting less than US$ 5 per radio transmitter. These networks come with low cost localized gateways to concentrate larger numbers and even thousands of IoT devices in their vicinity. For the satellite industry, providing connectivity to these gateways is leading to a new satellite application segment.

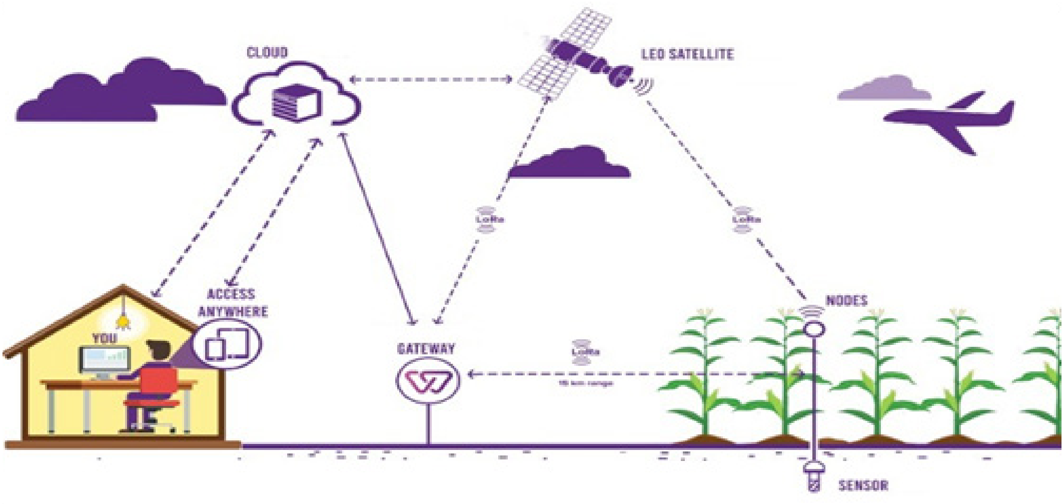


Figure 11: Example of IoT Gateway Backhaul Over Satellite

The other kind of IoT service that is growing is the direct to satellite service, especially the low cost and low power variety as provided by some of the satellite IoT players, is ideal for wide area sensor network with sensors dispersed over wide geographical territory.

The low power feature is important as they are mostly deploying in remote areas, and the low cost will enable massive networks with new data-points around the world to feed the data-analytics servers in a wide range of industries.

d. Mobile satellite service and emergencies

Mobile-satellite service (MSS) systems can provide disaster relief Radiocommunication. In addition, it provides descriptions of the operating and planned MSS systems, which can provide such operations. The wide coverage area of an MSS system is particularly helpful as the location and time of occurrence of a disaster event is unpredictable and as an MSS system operation is typically independent of local telecommunications infrastructure which may be lost by the disaster event, and given that MSS systems have wide-area earth coverage, they can provide for disaster relief telecommunications. Furthermore, most mobile earth stations (MESs) are battery powered and so can operate for some period even if the local electricity supply is non-functioning and more over some MESs come with solar and/or wind chargers.

Since MSS systems provide very large coverage areas, spectrum coordination is accomplished on a regional or global basis. Each system is constrained to operate on frequencies authorized by Administrations as identified in Recommendation ITU-R M.1854.

Figure 12: Example of MSS Usage during a Disaster or National Emergency

e. Mobile satellite service with a complementary ground component

MSS/CGC is recognized by many administrations and standards bodies as a critical component of the 5G network infrastructure supporting ubiquitous coverage throughout the satellite footprint while simultaneously facilitating local broadband connectivity where it is required. Harmonized technical standards and national regulatory frameworks are being developed to effectively manage the use of spectrum for different technologies and maximize spectrum efficiency. MSS/CGC is an extremely efficient use of spectrum while also bringing the advantages of ubiquitous MSS coverage combined with the higher quality of terrestrial services achieved by CGC operations. Recognizing expanding pressures on spectrum resources, national regulatory authorities can adopt national regulatory frameworks facilitating the deployment of MSS/CGC in their countries. MSS/CGC networks are being employed as the connectivity solution for a variety of services including Internet-of-Things (IoT), Machine-to-Machine (M2M), MVNOs, UAVs and autonomous vehicles.

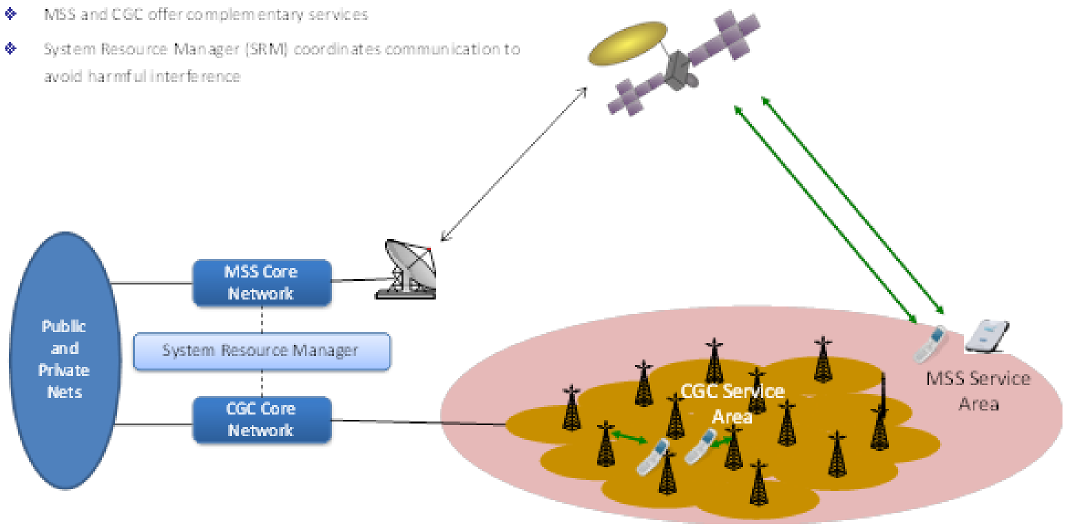


Figure 13: Integrated MSS / CGC

3GPP has developed standards harmonizing the technical characteristics of LTE and 5G base station and user equipment, driving economies of scale in network and radio equipment and user terminals that was previously unavailable. Deployment is on-going using these standards in several countries.

f. Benefits of MSS/CGC

MSS/CGC networks retain all the benefits of MSS derived from their expansive geographic coverage and resilience but also deliver additional value for governments, enterprises and consumers, including:

- Improved coverage, eliminating line-of-sight blockages between users and the satellite.
- The ability to develop device capabilities for each component as well as a single device with capability for both components to meet users' needs;
- Increased spectrum efficiency by utilizing the CGC component to provide broadband connectivity without sacrificing the ubiquitous benefits provided by the satellite component; and
- An interoperable terrestrial and satellite communication network, enhancing network resilience and enabling application of the most appropriate technology for a given application;
- Immediate accessibility and ability to deploy critical satellite and terrestrial infrastructure during natural and man-made disasters;
- Infrastructure investments and innovation by operators interested in the deployment of world-class wireless networks using the latest technologies; and

Availability of these benefits to support communications in rural and/or remote areas to improve efficiency in a multitude of sectors such as oil and gas, mining, health, agriculture, education, logistics and vertical markets.

g. Existing regulatory frameworks in the S-band

Overall, the existing ITU-R technical operating framework, as well as those of regional and national regulatory authorities, present examples for how MSS/CGC can operate within various environments while protecting other operators and services as appropriate.

The existing body of ITU regulatory documents includes:

Document Reference	Title	Frequency Range
Resolution 212 (Rev. WRC-19)	Implementation of International Mobile Telecommunications in the frequency bands 1885-2025 MHz and 2110-2200 MHz	1885-2025 MHz 2110-2200 MHz
Recommendation ITU-R M.2047 (12/2013)	Detailed specifications of the satellite radio interfaces of International Mobile Telecommunications-Advanced (IMT Advanced)	N/A
Report ITU-R M.2398 (10/2016)	Scenarios and performance of an integrated MSS system operating in frequency bands below 3 GHz	Bands below 3 GHz

The European Commission (EC) and CEPT have developed the following EC and ECC Decisions and Reports to provide a harmonised framework for MSS/CGC.

Document Reference	Title	Frequency Range
Decision 2007/98/EC	On the harmonised use of radio spectrum in the 2 GHz frequency bands for the implementation of systems providing mobile satellite services	1980-2010 MHz and 2170-2200 MHz
Decision 626/2008/EC	On the selection and authorisation of systems providing mobile satellite services (MSS)	1980-2010 MHz and 2170-2200 MHz
Decision 2009/449/EC	On the selection of operators of European systems providing mobile satellite services (MSS) in each Member State	1980-2010 MHz and 2170-2200 MHz
Decision 2011/667/EU	On modalities for coordinated application of the rules on enforcement with regard to mobile satellite services (MSS)	1980-2010 MHz and 2170-2200 MHz
ECC/DEC/(06)09	On the designation of the bands 1980-2010 MHz and 2170-2200 MHz for use by systems in the Mobile Satellite Service including those supplemented by a Complementary Ground Component (CGC)	1980-2010 MHz and 2170-2200 MHz

ECC/DEC/(06)10	On transitional arrangements for the Fixed Service and Tactical Radio Relay Systems in the Bands 1980 2010 MHz and 2170 2200 MHz in order to facilitate the Harmonised Introduction and Development of Systems in the Mobile Satellite Service including those supplemented by a Complementary Ground Component, amended on 3 March 201	1980-2010 MHz and 2170-2200 MHz
ECC/DEC/(12)/01	Exemption from individual licensing and free circulation and use of terrestrial and satellite mobile terminals operating under the control of networks	L-band and S-band
CEPT Report 13	Report from CEPT to the European Commission in response to the Mandate on: Harmonised technical conditions for the use of the 2 GHz bands for Mobile Satellite Services in the European Union	1980-2010 MHz and 2170-2200 MHz
ECC Report 233	Adjacent band compatibility studies for aeronautical CGC systems operating in the bands 1980-2010 MHz and 2170-2200 MHz	1980-2010 MHz and 2170-2200 MHz
ECC Report 065	Adjacent band compatibility between UMTS and other services in the 2 GHz band	1900-1980 MHz, 2010-2025 MHz, 2110-2170 MHz
ECC Report 197	Compatibility studies – MSS terminals transmitting to a satellite in the band 1980-2010 MHz and adjacent channel UMTS services	1920-1980 MHz (IMT), 1980-2010 MHz (MSS Earth stations), 2010-2025 MHz (IMT), 2170-2200 MHz (MSS Earth stations)

ETSI has developed a number of applicable technical standards. These include:

Document Reference	Title	Frequency Range
ETSI EN 302 574	Satellite earth station for MSS operating in 1980-2010 MHz (E/s) and 2170-2200 MHz (s/E) frequency bands	1980-2010 MHz and 2170-2200 MHz
ETSI EN 301 442	Handheld earth stations, for Satellite Personal Communications Networks (S-PCN) in the 2.0 GHz bands under the Mobile Satellite Service (MSS)	1980-2010 MHz and 2170-2200 MHz

SS3-2(3): Recommendations

In order to facilitate the utilization of the mobile satellite service technology, including the implementation of IoT and the complementary ground component using GSO/ NGSO mobile satellites, ATU recommends Member States to:

Licensing aspects

1. **Encourage** service providers to provide their services within the African continent by introducing a relevant regulatory environment factors so that African countries can keep pace with the coming technological revolution without any delay.
2. **Establish** an easy and simple regulatory framework for mobile satellite service providers that support IoT and CGC applications while setting controls for each administration to ensure the preservation of national sovereignty without complication.
3. **Apply** the principle of equality and free competition by granting licenses to more than one service provider within the state to guarantee service quality.
4. **Consider** including in their national regulatory frameworks:
    a. defining CGC as an integrated component of the MSS;
    b. blanket licensing for MSS user terminals;
    c. providing flexibility to the licensee on network design if MSS requirements are met and there is service integration in the licensee's network;
    d. a requirement that CGC can be deployed only in the same geographical areas where the mobile earth stations of the associated MSS network are authorised to operate.
    e. a common licensee(s) for the MSS and CGC in the same paired band segment; authorization of preferably 2 x 15 MHz for each licensee; and, ensuring the same direction of transmission for both MSS and CGC.

Spectrum aspects:

5. **Take** into account the diversity of IoT application requirements (varying bandwidth requirements[63], long-range vs short-range, long battery life, various QoS requirements) when determining the amount of spectrum to be made available in a range of frequency bands.
6. **Implement** the outcomes of agenda item 1.2 in WRC-19 for the power limits in the frequency bands 401-403 MHz and 399.9-400.05 MHz with the objective to protect the operations of Data Collection Systems (DCS) from geostationary (GSO) and non-geostationary (NGSO) Earth exploration satellite service (EESS) and MetSat satellite systems.
7. **Participate** actively in the ongoing studies under WRC-23 Agenda Item 1.18 as it discusses spectrum needs and potential new allocations to the mobile satellite service in the frequency bands 1 695-1 710 MHz, 2 010-2 025 MHz, 3 300-3 315 MHz and 3 385-3 400 MHz for future development of narrowband mobile-satellite systems.

63 how much information is sent.

Sub-Section 3-3

Very Small Aperture Terminals and Other Applications under the Fixed Satellite Service (FSS VSAT and Other Applications)

Contents for this Sub-Section

SS3-3(1): Introduction

1. According to article 1 of RR FSS is *"A radiocommunication service between earth stations at given positions, when one or more satellites are used; the given position may be a specified fixed point or any fixed point within specified areas; in some cases this service includes satellite-to-satellite links, which may also be operated in the inter-satellite service; the fixed-satellite service may also include feeder links for other space radiocommunication services".*

2. Satellites have been successfully serving the traditional markets i.e. telephony and broadcasting, covering large geographical areas using single beam/transmission. There is a demand for two-way broadband access over large geographical areas not served by terrestrial telecommunications infrastructure.

3. Satellite telecommunications technology has the potential to accelerate the availability of high-speed Internet services in developing countries, including the least-developed countries, the land-locked and island nations, and economies in transition. There is a close link between the availability of a large-scale broadband infrastructure and the provision of public education, health, and trade services and on-line access to e-government and e-trade information. The use of ICT has helped in boosting economic growth in Africa.

4. Effectiveness of satellite broadband is more pronounced when it serves wide areas with global, regional or national coverage; satellites are inherently highly reliable and provide a very high availability (up-time) compared with terrestrial solutions like fibre/copper cable or terrestrial wireless – particularly in developing countries where long, uninhabited distances need to be covered.

5. While traditional FSS VSATs systems are not new, innovative GSO and NGSO FSS satellite systems, thanks to the new technologies available, additional capacity to users, and allow new applications. The new systems are expected to be less expensive than previous generations.

6. Innovative FSS systems will be complementary to terrestrial systems, and can help to provide broadband connectivity in the more remote areas. The NGSO systems will also have, in addition to other characteristics, the benefit of lower latency than GSO.

7. The demand for broadband services including cloud services has increased in all markets where adoption is still low, and in parallel, there has been an urgent need for remote working due to the COVID-19 pandemic. The 5G ecosystem (as a network of networks), which includes satellite services, and other next generation applications is also driving network performance demands in industries such as mining, energy, and financial services where connectivity to operations in underserved areas was previously impossible.

SS3-3(2): Main Elements For Consideration

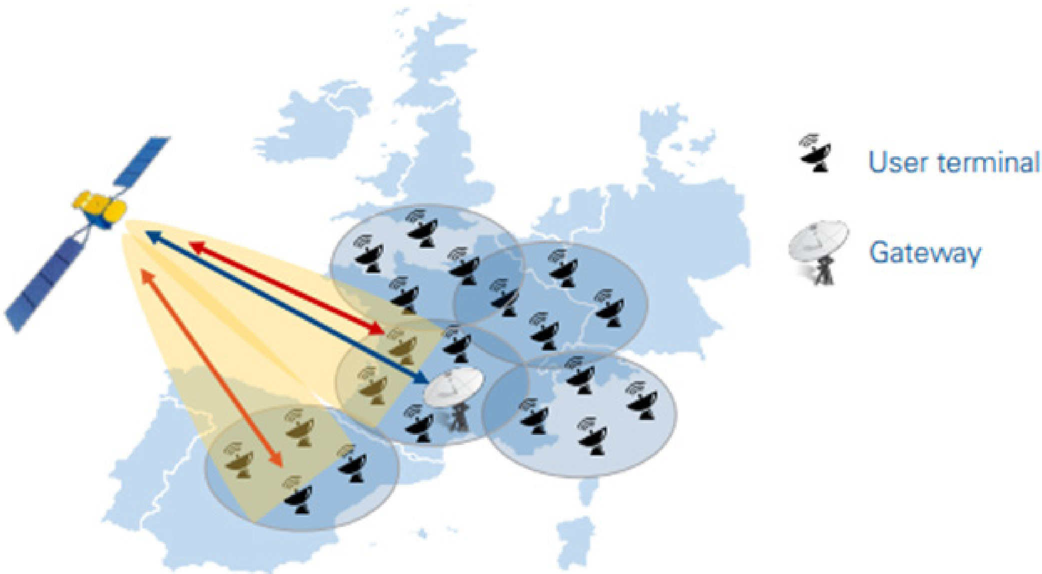
a. Services and applications aspects

1. Satellite networks are part of the connectivity solution and can provide the same services as terrestrial and submarine cable networks, and enhance the broadband delivery ecosystem. Africa's service providers use a mixture of terrestrial and satellite transmission and access networks in order to optimally and most cost-effectively deliver broadband services.
2. Satellite broadband is a means of achieving rural access and therefore can thus support socio-economic development. Unlike submarine cables or terrestrial fibre optic networks, satellite bandwidth can be delivered to any location in Africa. The socioeconomic benefits of providing broadband through satellites in rural areas include helping to redress the urban/rural divide in broadband access, and the implications for economic growth associated with broadband.
3. Satellites already deliver direct broadband connectivity at 100 Mbit/s to citizens beyond the geographical reach of other technologies; also enabling services for businesses and governments. New generation high throughput satellites are capable of Gbps connectivity to end users.
4. Innovative technologies like on-board processing and inter-satellite links, amongst others, will augment the flexibility and efficiency of satellite networks, also for the benefit of the users. Satellites can provide ubiquitous coverage and connect remote locations to broadband enabling high throughput speed of 100 Mbps and beyond.
5. Satellite-broadband connectivity can help:
   - provide coverage in rural/remote areas which are not within the terrestrial footprint
   - to connect mobile data centre solutions,
   - to connect remote locations where terrestrial networks are unavailable,
   - as a backup to ensure business continuity when terrestrial connections fail,
   - to quickly connect locations that have a long lead time for fibre.
6. Broadband connectivity can support the creation and functioning of small enterprises, stimulating growth and employment, and ultimately benefit populations at work or at home. Where satellite broadband is economically feasible for such businesses it may help support greater connectivity outside terrestrial networks.
7. The virtualisation of satellite communications network functions radio spectrum have improved satellite broadband services.
8. In addition to GEO and MEO satellite systems, there is also significant investment in LEO constellations and small satellites. Existing GEO+MEO+LEO solutions are able to:
   - Provide broadband services in urban, suburban, and rural locations;
   - send and receive large volumes of real-time data across geographical areas;

- Provide connectivity off-shore or on board moving platforms (cars, trains, ships, flights);
- Deliver video content to broadcast and VOD platforms worldwide;
- Provide a private, dedicated connection of up to 2 Gbps, or remote access by VPN through the public cloud of up to 500 Mbps.

b. Spectrum and technology aspects

1. Fixed satellite broadband services are offered in five broad spectrum ranges:
   - C band (4/6 GHz)
   - Ku band (11/14 GHz)
   - Ka band (20/30 GHz)
   - And recently in Q/V bands (40/50 GHz).
2. The satellite communications industry has dramatically evolved thanks to numerous technological innovations, such as:
   - Increasingly powerful satellites
   - Improved payload technology: multibeam antennas with large number of beams (up to a few 100 on a single satellite)
   - Radio frequency link development: better characterisation of propagation channels via improved channel models
   - Enhanced digital communication techniques
   - Improvement in ground terminals
3. The demand for more bandwidth will increase with Multiple Radio Access Technology (Multi-RAT) planning for 5G that will rely on various heterogeneous networks for over 99% availability such as WiGig, 4G, 100G Ethernet, and satellite networks.
4. One of the main trends of FSS is High Throughput Satellites which offer much higher speeds than legacy satellites. However, growing demand for these services also requires additional spectrum to meet that demand, similar to terrestrial services.
5. Instead of using a singular beam to cover as many users as possible, multiple small beams (spot beams) are implemented such that there is large amounts of frequency reuse – this can be accomplished by altering signal frequencies and polarization.
6. High Throughput Satellites (HTS) with nearly 20 times the throughput of fixed service satellites (FSS), can offer for connecting end users with multiple technologies with a significant drop in cost-per-bit compared to legacy FSS. This further precipitates the need for highly efficient transmitters with solid-state power amplifiers (SSPA), highly sensitive receivers, and reconfigurable phased array antennas for flexibility.



7. One innovative application can be provided through satellite are Cloud Services. As cloud and edge service demands grow, satellite can newly help small and medium organisations with geographically dispersed operations or isolated workforces to benefit from reliable and secure connectivity as needed well into the future. This can benefit local governmental entities, hospitals, schools but also SMEs or any other private communities equipped with satellite antennas (VSAT) of a new generation.

8. Satellite intelligent networks can provide broadband access within their footprints which will allow, inter alia, connection to cloud services.

9. Satellite broadband services are becoming more affordable. This is partly because of increased supply: the recent introduction of Ka-band GSO satellites in addition to MEO and LEO constellations have brought much more satellite capacity to the region, and the lower costs of units enables significantly lower retail pricing for satellite broadband services.

10. The satellite industry has seen a major shift from the manufacturing of massive traditional, multi hundred-million-dollar satellites (>5000 kg) to the generation of several-million dollar small-sats (<500 kg).

11. In recent years there has been a significant downtrend in the number of GEO satellite orders.

12. The ability to activate additional capacity dynamically, as and when needed grants customers the flexibility to offer extra services for limited periods of time, rather than having to order a more expensive, fixed bandwidth package based solely on peak demand.

13. Satellite networks are being newly designed to allow users to dynamically allocate low-latency, high-bandwidth service anywhere. This is made possible thanks to:

- Launch of high throughput, highly flexible and scalable satellite communications platforms with full coverage of the African continent.
- Development of a new generation of VSAT-type customer terminal antennas that are multi-orbit and multi-frequency.
- Adoption and implementation of Adaptive Resource Control software systems to manage resources to follow customer demand, synchronise satellite spacecraft and ground system resources, dynamically controlling power levels, throughput, and frequency allocation to reliably meet robust service level agreements. These systems enable the dynamic control and optimisation of power, throughput, beams and also frequency allocation across the entire satellite system's space and ground assets. Dynamic frequency allocation capability can also be leveraged to mitigate interference and comply with regulatory requirement.

c. Satellite Connectivity in the 5G Ecosystem[64]

1. Satellite communications are being integrated into the 5G ecosystem, making it possible for standalone satellite-powered services to extend and accelerate 5G connectivity everywhere and also may be complementary to terrestrial networks.

   Several use cases have been identified and are recognised[65] where satellite can contribute in the 5G ecosystem. These include:

   - Communications on the move;
   - Direct-to-premises connectivity;
   - Direct connectivity to end-user devices;
   - Backhaul and tower feed (cell-site backhaul and content distribution); and
   - Trunking and head-end feed (aggregated mobile backhaul and content distribution).

2. Satellite networks specifications and developments to integrate non-terrestrial networks (NTN) into the 5G ecosystem are taking place to help accelerate the deployment of IMT 2020 generic use cases (refer to Report ITU-R M.2460[66] and 3GPP Releases 17 and 18[67]):

   - massive machine-type communications (mMTC),

64 This sub section text on 5G NR and 5G NTN, as well as hybrid solutions, apply to other systems such as MSS as well as FSS systems.

65 See 3GPP "Study on using Satellite Access in 5G," TR22.822 V16.0.0

66 https://www.itu.int/en/ITU-R/space/workshops/2019-SatSymp/PublishingImages/Pages/Programme/R-REP-M.2460-2019-PDF-E.pdf

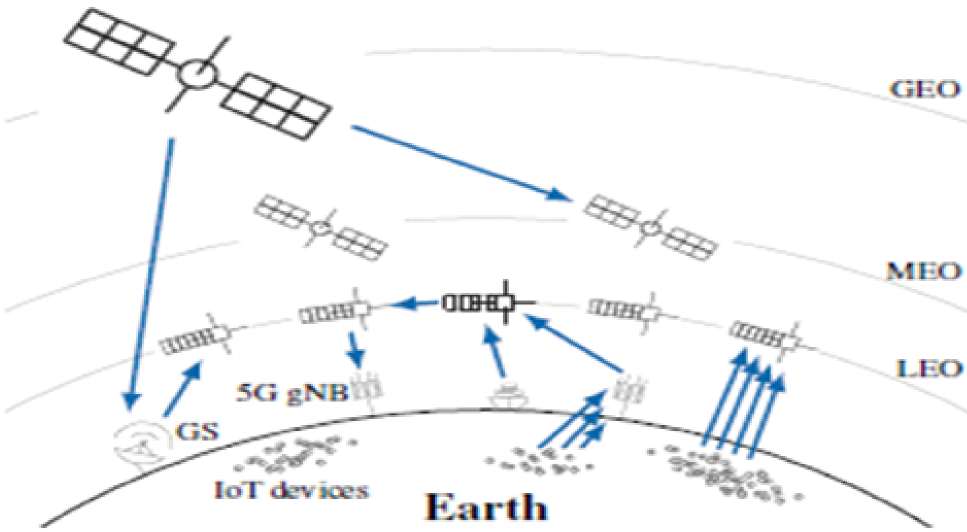
67 https://www.3gpp.org/release-17 and https://www.3gpp.org/release18

- enhanced mobile broadband (eMBB),
- and ultra-reliable low latency communications (URLLC).

3. Truly ubiquitous coverage is one of the 5G drivers, and this can be supported by use of satellite networks as part of the 5G ecosystem and beyond.

4. The use cases for satellite networks as part of the 5G ecosystem is divided into three categories:

   - Service continuity: Continuous coverage for mobile ground terminals that have been previously granted access to 5G services, such as terrestrial vehicles, ships, and airborne platforms.
   - Service ubiquity: 5G access in areas without high-quality terrestrial coverage, including areas where the terrestrial coverage is interrupted by a natural disaster, such as earthquake or flood.
   - Service scalability: Support to the 5G ecosystem with massive multicasting (downlink) or IoT (uplink) applications, as in ultra-high definition TV and ultra-densely IoT deployments.



5. For many years, non-terrestrial devices have been considered to support services like package delivery, meteorology, video surveillance, television broadcasting, remote sensing, and navigation. However, recent technological developments in the aerial/space industry have opened up the way towards integration between terrestrial and non-terrestrial technologies to enable more advanced use cases.

6. Satellite can play a role to increase network resiliency to cellular sites, which involves deployment to terrestrial network operators to deliver high-capacity backhaul connections.

7. The development of non-terrestrial networks (NTNs) to promote ubiquitous and high-capacity global connectivity in which terrestrial infrastructures are complemented by non-terrestrial stations including satellites.

8. Non-terrestrial systems feature:

    - Terrestrial terminal.
    - Aerial/space station, which may operate similarly to a terrestrial base station.
    - Service link between the terrestrial terminal and space station.
    - Gateway that connects the non-terrestrial access network to the core network through a feeder link.

9. Hybrid solutions can lower the total cost of ownership for customers, reducing cost-per-bit as their capacity requirements increase. Customer terminals in a range of sizes are also cheaper than before. By reducing the size of the antennas, operators have made them easier to install.

10. Connectivity solutions based on hybrid networking combining satellite and terrestrial services can support wider additional network 5G ecosystem may rely on a mix of technologies.

d. Regulatory issues

1. Satellite operator must ensure that their services are provided according to the rules set from each administration (licence, Permission, etc).

2. Authorization and licensing procedures enabling service providers to operate should be streamlined and not be unduly complicated.

3. These measures would allow for effective international competition, lower prices, significant end-user benefits and a strong innovation drive.

4. CEPT has developed several ECC Decisions to provide a harmonised framework for VSATs.

These include:

Table 14: ECC Decisions for harmonised use within CEPT for satellite services

Document Reference	Title	Frequency Range
ECC/DEC/03)04	Exemption from Individual Licensing of Very Small Aperture Terminals (VSAT) operating in the frequency bands 14.25 - 14.50 GHz Earth-to-space and 10.70-11.70 GHz space-to-Earth	14.25 - 14.50 GHz Earth-to-space 10.70-11.70 GHz space-to-Earth

ECC/DEC/06)02	Exemption from Individual Licensing of Low e.i.r.p. Satellite Terminals (LEST) operating within the frequency bands 10.70–12.75 GHz or 19.70–20.20 GHz space-to-Earth and 14.00–14.25 GHz or 29.50–30.00 GHz Earth-to-Space	10.70–12.75 GHz space-to-Earth 19.70–20.20 GHz space-to-Earth 14.00–14.25 GHz Earth-to-Space 29.50–30.00 GHz Earth-to-Space
ECC/DEC/06)03	Exemption from Individual Licensing of High e.i.r.p. Satellite Terminals (HEST) with e.i.r.p. above 34 dBW operating within the frequency bands 10.70 - 12.75 GHz or 19.70 - 20.20 GHz space-to-Earth and 14.00 - 14.25 GHz or 29.50 - 30.00 GHz Earth-to-space,	10.70 - 12.75 GHz space-to-Earth 19.70 - 20.20 GHz space-to-Earth 14.00 - 14.25 GHz Earth-to-space 29.50 - 30.00 GHz Earth-to-space

SS3-3(3): Recommendations

In order to foster harmonised implementation of Very Small Aperture Terminals (VSATs) and Other Applications under the Fixed Satellite Service (FSS), ATU recommends Member States to:

a. Licensing aspects

1. **Consider** including in their national regulatory frameworks:
    a. a requirement for Satellite operators to commit themselves to ensure that the operation of satellite services within the territory of an administration shall be carried out only if authorized by that administration and when an administration identifies the presence of unauthorized operation in its territories satellite operators and/or Service providers shall take all appropriate actions to stop such unauthorized transmissions.
    b. provisions of the Radio Regulations relating to GSO and NGSO VSAT operation in FSS bands.
    c. general principles for licensing and spectrum aspects applicable to ubiquitous FSS VSAT. In particular, the licensing of ubiquitous VSAT will greatly benefit from a simplified class-licensing spectrum aspects regime. Such licensing regime are already implemented in several countries around the world, including within Africa (e.g. Nigeria).
2. **Take** all appropriate actions to make publicly and readily available the procedures for licensing/authorizing the operation of satellite services in their territories.
3. **Ensure** that regulation and licensing conditions promote the use of all emerging technologies that contribute to eliminating the digital divide in furtherance of the technology neutrality principle. This includes GSO and NGSO satellites that allows multiple connectivity solutions

across Africa and contribute to reducing the gap between the ATU Member States and other parts of the world.

4. **Establish** simplified licensing by way of having authorization requirements that focus on facilitating the use of streamlined requirements to facilitate services provided by ubiquitous FSS VSAT networks. Specifically, consider implementing the general authorisation approach to licensing which allows for a class, “umbrella” or “blanket” license approach on their territory, without the need for cumbersome individual terminal-by-terminal licenses.

b. Spectrum aspects

5. **Take** a balanced approach to spectrum allocation, making optimal use of all bands considering that enough spectrum to meet user needs is a requirement for all wireless systems, whether terrestrial or space.

6. **Ensure** that operation of space services in the national territory are done in an efficient way without interference to or from other services.

7. **Consider** how best to implement RR No. **5.516B** which indicates identification for HD-FSS (High Density Fixed Satellite Services).

Section 4

Wi-Fi in 6 GHz Band (5 925 – 6 425 MHz)

and

RLANs (WiGig and 5G NR-U) in 60GHz (57 - 66 GHz)

Section 4-1

Wi-Fi in 6 GHz Band (5 925 – 6 425 MHz)

Contents for this Sub-Section

SS4-1(1): Introduction

1. Access to connectivity is a major driver of economic growth and societal development. Today, nearly half of the world's population is still not connected to the Internet. Among those that have connectivity, many are under-connected. Bringing connectivity to all will require a mix of technical solutions that are affordable.
2. Emerging technologies all require access to spectrum, making spectrum policy critically important to bringing innovative connectivity solutions to ATU member nations.
3. The COVID-19 pandemic has resulted in people commuting less and working from home more, meaning telecoms operators are seeing greater demand for home broadband internet access.
4. Both licensed and license-exempt wireless technologies are likely to be required to support broadband connectivity.
5. Radio LANs (RLANs)[68] are widely used to connect a variety of devices, from tablets and televisions to cameras and speakers, without the inconvenience of connecting devices through wires. RLANs have largely replaced the LAN cable for employees in organisations and people at home. However, wired LANs are still preferred in some cases for network security reasons.
6. RLANs provides the access network to connect to the consumer devices. Both licensed and license-exempt solutions require backhaul. A broadband connection to the premises (through fibre, copper, FWA, 5G or satellite) is required in order to provide service. Sufficient license-exempt spectrum is then required to make use of the data speed of the broadband connection. RLAN devices operate in a number of bands including 2.4 GHz, 5 GHz, 6 GHz and 60 GHz.
7. The lower 6 GHz band (5 925 – 6 425 MHz) is being considered by a number of administrations in all three regions of ITU for license-exempt use.
8. Under agenda item 1.2, WRC-23 will consider 6 425 – 7 025 MHz in Region 1 and 7 025 – 7 125 MHz for identification of IMT globally. Therefore, this document considers the lower part of the 6 GHz band (5 925 – 6 425 MHz) only.

SS4-1(2): Main Elements For Consideration

1. Highlights of the Issue

1. IEEE-based technologies (Wi-Fi 6 based on 802.11ax and beyond, and WiGig based on IEEE 802.11ad/ay) complement 5G/IMT-2020 (3GPP standards i.e. Release 15 and beyond).
2. 3GPP 5G NR-Unlicensed is able to coexist with Wi-Fi and WiGig technologies in license-exempt spectrum as is already the case for 4G IMT-Advanced with LAA (Licensed-Assisted Access).

68 RLANs include license exempt technologies such as Wi-Fi and Wi-Fi 6, 3GPP 5G NR-U

3. Today Wi-Fi supports high-resolution video streaming, Wi-Fi calling, smart home monitoring, hotspot access, automation of city-wide services, residential connectivity, augmented reality (AR) / virtual reality (VR) applications, and seamless roaming.

4. RLAN technologies are expected to play an important role in supporting 5G networks, with ultra-dense, high-speed connections to wireless and wired networks. For example, 5G FWA is expected to deliver home connectivity to CPE devices distributing the connection throughout the house and to all users within the house through Wi-Fi.

5. Wi-Fi 6, based on the IEEE 802.11ax standard, brings about lower latency due to increased capabilities such as higher throughput and better traffic offloading. Wi-Fi and WiGig are harmonized through Recommendations ITU-R M.1450, M.1801 and M.2003.

6. Multi-band Wi-Fi Certified products are able to smartly and seamlessly switch between 2.4, 5, and 60 GHz frequencies, according to the connectivity environment.

7. Tri-band solutions are available that use both the 802.11ac and 802.11 ad standards and operate in the 2.4 GHz, 5 GHz and 60 GHz bands.

8. 5G NR-U has been developed by 3GPP (Release 16 specifications refers) which allows for both non-standalone and standalone operation of 5G NR transmissions in the license-exempt 5 GHz and 6 GHz bands.

9. The lower part of the 6 GHz band (5 925 - 6 425 MHz) is being considered to support demands for license-exempt wireless access systems (WAS)/radio local access network (RLAN) technologies, including Wi-Fi 6E and 5G NR-U.

10. Wi-Fi 6 is designed to provide wireless capacity for high-bandwidth applications and can support 160 MHz channels and uses advanced modulation techniques.

11. Opening the lower part of the 6 GHz band (5 925 - 6 425 MHz) will enable license-exempt technologies to deliver bandwidth-intensive applications to consumers and businesses across the African continent. RLANs using existing frequency bands is restricted to lower channel bandwidth but nevertheless delivers speeds of hundreds of Mbps.

12. Expanding the spectrum available for RLANs will enable increased capacity for local-area networks which, on a global basis, deliver a significant percentage of traffic delivered to users' mobile devices. Cisco estimates that, globally, 59% of mobile data traffic will be off-loaded to Wi-Fi by 2022, as compared to 54% of such traffic in 2017.[69]

13. This increase offsets a projected increase in mobile data usage that would result in increased traffic on wide-area mobile networks.

69 https://s3.amazonaws.com/media.mediapost.com/uploads/CiscoForecast.pd

14. The Cisco Annual Internet Report[70] states that in the Middle East and Africa, by 2023, 75% of devices will connect to the internet by mobile and 25% by Wi-Fi as shown in Table below.

Table 15: Regional predictions of Wi-Fi vs Mobile Connectivity by the year 2023

	Region	% 2023 connectivity from Wi-Fi-connected devices
1	APAC	51%
2	C.E. Europe	52%
3	LatAm	51%
4	MEA	25%
5	N America	75%
6	W. Europe	69%

15. The 2.4 GHz and 5 GHz bands used globally for Wi-Fi have become increasingly used in areas with sufficient fibre infrastructure.

16. The 6 GHz spectrum can be used by Wi-Fi 6E to increase responsiveness for latency-sensitive applications.

2. The case for enabling licence-exempt access to the 6 GHz band

a) Economic value of Wi-Fi

1. The value of Wi-Fi to the economy and society is expected to rise as next generation products and deployments are introduced.

2. Wi-Fi delivered global value of €1.73 trillion in 2018, a figure that is set to rise to €3.06 trillion in 2023, according to Telecom Advisory Services[71].

b) Wi-Fi complements 4G and 5G

3. Wi-Fi complements 4G and 5G connectivity. Globally, Wi-Fi offload will remain important.

   Cisco estimates show that Wi-Fi supports the offload of 54% of mobile data traffic globally and this is set to grow to 71% with 5G by 2022 at a global level (see Figure 1). Cisco VNI forecasts for Africa shows that the share of mobile traffic offloaded to Wi-Fi in Africa would be 33% in 2022, compared to 31% in 2017.

70 https://www.cisco.com/c/en/us/solutions/collateral/executive-perspectives/annual-internet-report/white-paper-c11-741490.html

71 https://morningconsult.com/wp-content/uploads/2018/10/Economic_Value_of_Wi-Fi_2018.pdf

4. 5G is expected to deliver FWA to rural areas in Africa. In areas where fixed lines are scarce, IMT technologies (4G/5G) can provide high-speed broadband access to the home, FWA typically connects a CPE and a BS through 5G, and the CPE distributes the connectivity throughout the house and to all users therein, with Wi-Fi.

5. Where fixed or fibre networks exist, Wi-Fi offload can lower data load on mobile networks.

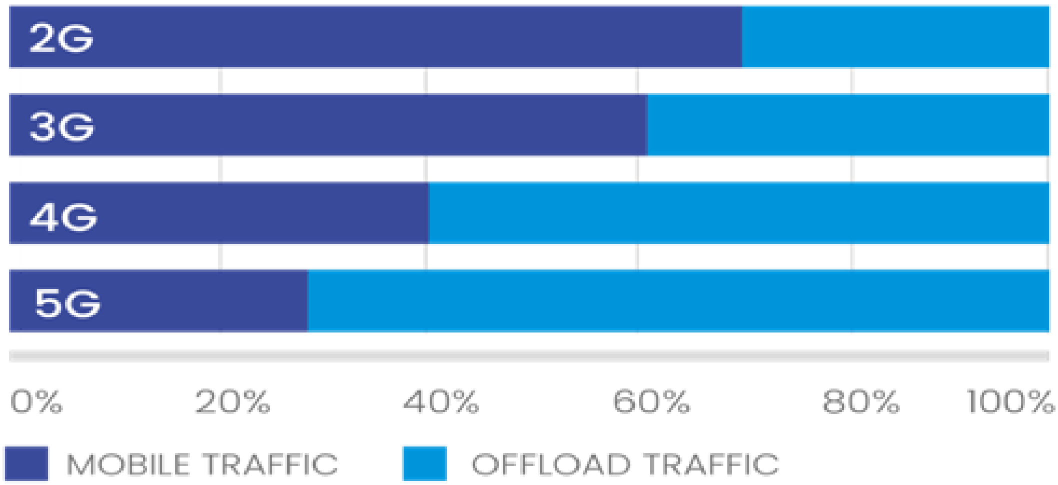


Figure 14: Wi-Fi offload at global level (Source: Cisco VNI)

6. Wi-Fi offloading can be triggered by the end user (for instance, when the user manually connects to a Wi-Fi hotspot in a shop or the Wi-Fi access point at home) or by the network operator (who may have deployed own Wi-Fi network or reached agreements with other operators).

c) Support for innovation

7. Technologies using Licence-exempt spectrum offer very low barriers to entry. Wi-Fi serves as a platform for the creation of innovative business models that underpin unique services, while enabling more people to access the communication services provided by mobile, fixed and satellite networks through Wi-Fi hotspots.

d) COVID-19 pandemic resilience and recovery

8. In the wake of the COVID-19 pandemic, broadband wireless services have empowered remote workforce. In addition, citizens, businesses and governments are relying heavily on broadband wireless services to remain connected with colleagues, teachers, healthcare professionals and other vital services.

9. Wi-Fi can support the attainment of the Africa Union's Agenda 2063, where the Africa Union is aiming to double ICT penetration and its contribution to GDP between 2015 and 2023, supported by a 70% increase in broadband accessibility by 2020.

e) Evolution of Wi-Fi

10. A new Wi-Fi standard, IEEE 802.11ax, also known as Wi-Fi 6, is enabling compatible devices to benefit from higher data rates, greater responsiveness, increased capacity, better performance in environments with many connected devices and improved power efficiency.

11. New devices, including Wi-Fi 6 routers, are now available. Wi-Fi 6E will extend the features of Wi-Fi 6 into the 6 GHz band and enable the use of 160 MHz wide channels for bandwidth-intensive applications, such as high-definition video streaming and virtual reality services.

f) Licence-exempt spectrum

12. There is currently 538.5 MHz of mid-band spectrum available for licence-exempt use in Africa, Europe and Middle East (ITU Region 1). The bands used are:

    - 2 400 - 2 483.5 MHz
    - 5 150 - 5 350 MHz
    - 5 470 - 5 725 MHz

13. The 5 GHz bands were agreed at WRC-03 and the conditions of use are laid out in Resolution 229 (Rev. WRC-19). Subsequent to this, additional licensed-exempt bands were discussed at WRC-15 and again at WRC-19.

14. There have been two studies undertaken one by Quotient Associates Limited and the other by Qualcomm[72] to provide a basis for consideration of additional mid-band spectrum for Wi-Fi. The Quotient Associates Limited study concluded that between 500 MHz and 1 000 MHz of additional spectrum may be needed in various world regions to support expected growth in Wi-Fi by 2020.The Qualcomm study concluded that in dense environments that primarily rely on Wireless Local Area Networking (WLAN), a total amount of approximately 1 280 MHz of spectrum is required centred around the 5 GHz band.

g) The lower 6 GHz band

15. The lower part of the 6 GHz band (5 925 – 6425 MHz) which has a bandwidth of 500 MHz is adjacent to the licence-exempt 5 GHz band and is being considered by some countries across the globe for licence-exempt use.

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72 https://www.qualcomm.com/media/documents/files/a-quantification-of-5-ghz-unlicensed-band-spectrum-needs.pdf

16. Allowing licence-exempt technology in this band enhances the impact of next generation RLANs, provide more indoor connectivity and enable new Wi-Fi use cases based on the Wi Fi 6 standard and 3GPP 5G NR-U. These include personal area network applications, such as transferring data between a smartphone and an AR or VR headset, and a new generation of AR/VR solutions, for entertainment (gaming, content), industrial applications, eHealth and other services.

17. The first Wi-Fi 6E products, which can employ the 6 GHz band, have been launched at the end of 2020.

18. Research firm IDC has forecast that more than 316 million Wi-Fi 6E devices will enter the market in 2021.

19. If equipment providers can distribute the same Wi-Fi 6E products around the world, they will be able to achieve economies of scale and end-users will benefit from lower prices and greater choice.

3. Collation of Practices

1. There is growing momentum for license-exempt in the 6 GHz band, with draft or final regulations being published in various countries from all three ITU Regions.

2. Some examples of the different regulations which have been adopted by different countries are summarised in table below.

Table 16: Examples of power limits for license-exempt technologies

Country/Region	Range	Use	Power Limits
Europe (CEPT)	5945 - 6425 MHz	Low Power Indoor	23 dBm - 200mW
	5945 - 6425 MHz	Very Low Power portable	14 dBm - 25mW
USA	5925 - 6425 MHz	Database connected	36dBm - 4W
	6525 - 6875 MHz		
	5925 - 7125 MHz	Low Power Indoor	30dBm - 1W
Korea	5925 - 7125 MHz	Low Power Indoor	24dBm - 250mW
Chile	5925 - 7125 MHz	Indoor, no external antennas	30dBm - 1W
UK	5925 - 6425 MHz	Indoor low power	24dBm - 250mW
		Outdoor very low power	14 dBm - 25mW
UAE	5925 - 6425 MHz	Indoor	24dBm - 250mW
Brazil	5925 - 7125 MHz	Low Power Indoor	AP:30 dBm – 1W
User terminal:24 dBm – 250 mW			
		Very Low Power	17dBm-50 mW

3. The detailed practices adopted by various Administrations for license-exempt Wi-Fi in the 6 GHz band is provided in Annex 3.

SS4-1(3): Recommendations

In order to foster harmonised use of the band 5925 - 6425 GHz by WAS/RLANS on a licence-exempt basis in Africa, ATU recommends Member States to adopt the following policy, regulatory, technical and operating frameworks:

1. **Designate** the frequency band 5925 - 6425 MHz for use by WAS/RLAN equipment restricted to very low power (VLP) (both outdoor and indoor use) and low power indoor (LPI) use only on a non-exclusive, non-interference and non-protected basis;
2. **Adopt** the technical and operating conditions as provided in **Annex 3** and allow all compliant technologies when implementing **WAS/RLAN in** the frequency band 5925 - 6425 MHz.
3. **Exempt** WAS/RLAN equipment that comply with the technical details in **Annex 3** from individual licensing.
4. **Consider** authorizing any WAS/RLAN systems that operate in the frequency band 5925 - 6425 MHz and comply with operating conditions that are provided in **Annex 3**.
5. **Ensure** that WAS/RLAN equipment and devices comply with the technical and operating conditions provided in **Annex 3**;
6. **Allow** free (seamless) cross border circulation and use of WAS/RLAN equipment/devices that comply with technical and operational conditions specified in **Annex 3**.

Sub-Section 4-2

RLANs (WiGig and 5G NR-U) in 60GHz (57 - 66 GHz)

Contents for this Sub-Section

SS4-2(1): Introduction

1. Today, nearly half of the world's population is still not connected to the Internet. Among those that have connectivity, many are under-connected. Bringing connectivity to all will require a mix of technical solutions.
2. All emerging technologies require access to spectrum, making spectrum policy critically important to bringing innovative connectivity solutions to ATU member nations.
3. WiGig was first announced in 2009 by the Wireless Gigabit Alliance, which is a trade association promoting this technology.
4. The original version of WiGig, published in 2012, uses the 802.11ad standard. It offers speeds of about 5 Gbps over a maximum distance of 10 meters.
5. In 2013, the Wireless Gigabit Alliance closed and the Wi-Fi Alliance the same body that oversees Wi-Fi standards like Wi-Fi 6 took over.
6. "Wi-Fi CERTIFIED WiGig" is a Wi-Fi Alliance IEEE standard named 802.11ay.
7. Multi-band Wi-Fi Certified products are able to switch between 2.4, 5, and 60 GHz frequencies, according to the connectivity environment.
8. WiGig can be used commercially in the enterprise environment or at home. At home, WiGig can be used to replace cables between devices, enabling an always-on device connection
9. WiGig technology can also be used on board trains, to provide low latency, multi-gigabit data services.

Ss4-2(2): Main Elements For Consideration

1. Brief Description/Highlights of the Issue

1. To deliver wireless broadband to consumers in Africa, IEEE-based technologies (Wi-Fi 6 based on 802.11ax and beyond, and WiGig based on IEEE 802.11ad/ay) may be able to complement 5G/IMT-2020 (3GPP standards i.e. Release 15 and beyond).
2. 5G/IMT-2020 will also interoperate with Wi-Fi and WiGig technologies in license-exempt spectrum as already the case for 4G IMT-Advanced with LAA (Licensed-Assisted Access).
3. IEEE 802.11ay is an amendment to 802.11ad which aims to increase the capacity from 7 Gbit/s to 30 Gbit/s as shown in Figure 1.

WiGig Standard	Year released	Frequency	Data rate	Range
802.11ad	2009	60GHz	7Gbps	30 feet
802.11ay	2018	60GHz	20-30Gbps	33-100 feet

Figure 15: Comparison of IEEE 802.11ay and 802.11ad standards

4. License-exempt technologies in high-frequency bands 57-71 GHz can support broadband connectivity and new applications.

   WiGig[73] technologies based on IEEE 802.11ad/ay and operating within the 57 – 71 GHz band, can support multi-gigabit throughput, low latency access.

5. WiGig technologies can also support sensing and radar use cases in short range devices.

6. The frequency band 66 - 71 GHz is identified for use by IMT. The identification of the band for IMT does not preclude the use of the frequency band by any application of the services to which this frequency band is allocated. Resolution **241** (WRC-19) on the use of the frequency band 66-71 GHz for IMT and coexistence with other applications of the mobile service states that Administrations who also wish to implement other applications of the mobile service, including other WAS in the same frequency band, consider coexistence between IMT and these applications.

7. CEPT further clarifies that 5G applications are expected to operate in 66-71 GHz band under Recommendation 70-03.

8. That Recommendation ITU-R M.2003 lays out general characteristics and radio interface standards for Multiple Gigabit Wireless Systems in frequencies around 60 GHz.

9. At 60 GHz band, the antenna is a small dish that matches the small form factor of the small cell and can be installed unobtrusively.

10. The 60 GHz band is currently used for backhaul applications, as well as WLAN applications.

11. WiGig provides the access network, providing connectivity to the end user devices such as smartphones and laptops when linked to appropriate backhaul connectivity.

73 Wi-Fi CERTIFIED WiGig | Wi-Fi Alliance (wi-fi.org)

12. Equipment vendors are working through the 3GPP to develop Rel. 16 specifications related to both non standalone and standalone operation of 5G New Radio (NR) transmissions in the license-exempt 5 GHz and 6 GHz bands that's referred to as 5G NR-U. 5G NR-U for 60 GHz band is anticipated in future releases.
13. WiGig acts as a complement to existing Wi-Fi rather than a replacement for it, and provides extremely fast, low-latency wireless internet connectivity under certain circumstances.
14. Wi-Fi products operating in the 2.4 GHz and 5 GHz bands can communicate over longer distances and through walls. WiGig products will normally be confined to applications within a room or large open area.
15. WiGig uses beamforming technology to send a finely directed signal between devices at a distance of up to 10 metres. This focused broadcast serves to eliminate any interference from nearby devices, as well as to maintain high performance even in areas where the 60 GHz spectrum might be in heavy use.
16. Radio signals at 60 GHz cannot penetrate walls or other solid objects.
17. Tiny antennas are required to point the signals in the right direction. The WiGig antenna is a little smaller than a postage stamp
18. WiGig provides low latency and is extremely responsive offering similar responsiveness to a physical wired connection.
19. Vendors have started making WiGig docking stations. However, beyond the cable free and file sharing use cases, the wireless industry has been exploring opportunities to using WiGig as a complement for Wi-Fi connections.
20. WiGig provides connectivity for devices that require very high throughput over short distances (e.g., AR/VR, 360-degree video, a home video projector). IEEE 802.11ay enhances initial WiGig standard based on IEEE 802.11 ad by supporting peak data rates in excess of 100 Gbps through use of channel bonding and 8x8 MIMO.

SS4-2(3): Recommendations

In order to foster harmonised use of the band 57 – 66 GHz by WAS/RLANS on a licence-exempt basis in Africa, ATU recommends Member States to adopt the following policy, regulatory, technical and operating frameworks:

1. **Designate** the frequency band 57 - 66 GHz for use by WAS/RLAN such as WiGig and 5G NR-U on a non-exclusive, non-interference and non-protected basis.
2. **Adopt** the ATU harmonised operating conditions as provided in **Annex 4** and allow all compliant technologies, when implementing WAS/RLAN in the frequency band 57 - 66 GHz,

3. **Exempt** WAS/RLAN equipment that comply with the technical details in **Annex 4** from individual licensing;
4. **Consider** authorizing any WAS/RLAN systems that operate in the frequency band 57 – 66 GHz and comply with operating conditions that are provided in **Annex 4**.
5. **Ensure** that WAS/RLAN equipment and devices comply with the technical and operating conditions provided in **Annex 4**.
6. **Allow** free (seamless) cross border circulation and use of WAS/RLAN equipment/devices that comply with technical and operational conditions specified in **Annex 4**.

SS4-2(4): Annexes

Annex 1

Wi-Fi In 6 GHz Band Practices Adopted By Different Countries

The collation of practices adopted by different countries are as follows: -

1. United States (FCC)

1. In April 2020 the **US** adopted a decision to open up 1 200 MHz of spectrum in the 6 GHz band (5 925 - 7 125 MHz) to enable use of wider channels (160 MHz and 320 MHz channel bandwidth) and meet growing demand for licence-exempt spectrum[74] with appropriate protections for incumbent services.
2. In doing so, the FCC, the U.S. regulator, noted:
   - "Making the entire band available for these license-exempt operations enables use of wide swaths of spectrum, including several 160 MHz channels as well as 320 MHz channels in the future, which promotes more efficient and productive use of the spectrum."
   - "To obtain unlicensed 5G-like capabilities, 160 MHz channels, or eventually 320 MHz under Wi-Fi 6, are absolutely necessary. Ultimately, this allocation will provide seven new and needed channels going forward, which can also be combined with the 5 GHz frequencies already in use. And this allocation for license-exempt services will accelerate, rather than compete with, the American effort to deploy nationwide 5G advanced wireless services. In sum, 5G will happen faster and more widely with our action here."
3. Recent economic research[75] in the U.S. shows how allowing low power indoor (LPI) and very low power (VLP) Wi Fi devices in the full 6 GHz band (5 925 – 7 125 MHz) will generate significant

74 https://docs.fcc.gov/public/attachments/DOC-363490A1.pdf

75 By Telecom Advisory Services: http://wififorward.org/wp-content/uploads/2020/04/5.9-6.0-FINAL-for-distribution.pdf

economic value by improving connectivity indoors and outdoors, extending the Internet of Things, boosting productivity and the development of richer applications and services.

4. Key elements of the FCC regulations are the power level allowed, and the mechanisms to avoid interference with incumbent users, notably fixed links. The authorised power levels are shown in the table below:

Device Class	Operating Bands	Maximum EIRP	Maximum EIRP Power Spectral Density
Standard-Power Access Point (AFC Controlled)	U-NII-5 (5.925-6.425 GHz) U-NII-7 (6.525-6.875 GHz)	36 dBm	23 dBm/MHz
Client Connected to Standard-Power Access Point		30 dBm	17 dBm/MHz
Low-Power Access Point (indoor only)	U-NII-5 (5.925-6.425 GHz) U-NII-6 (6.425-6.525 GHz) U-NII-7 (6.525-6.875 GHz) U-NII-8 (6.875-7.125 GHz)	30 dBm	5 dBm/MHz
Client Connected to Low-Power Access Point		24 dBm	-1 dBm/MHz

5. Standard-Power APs must connect to an Automatic Frequency Coordination function before they transmit. This AFC is a database that contains information from incumbent fixed links, and establishes exclusion zones for protection.

6. A Standard Power AP will communicate its locations to the AFC which will determine the channels available for the AP so that fixed links in the proximity are not interfered.

7. Low Power APs have usage restrictions: they can only be operated indoor, must have an integrated antenna, cannot be battery powered, and cannot have a weatherized enclosure.

2. United Kingdom (UK), Ofcom

1. In July 2020, in the **United Kingdom (UK), Ofcom** decided to make the lower 6 GHz band (5 925 – 6 425 MHz) available for Wi-Fi and other RLAN technologies on a license-exempt basis, enabling indoor and very low power (VLP) indoor/outdoor use[76]

2. Ofcom's decision will make more channels available, increase capacity, and reduce congestion in existing bands due to the large number of devices and overwhelming popularity of Wi-Fi connectivity. Ofcom anticipates that the opening of the lower 6 GHz band for Wi-Fi, coupled with the development of new standards, could provide user benefits by enabling new technologies and improvements in equipment performance.

76 https://www.ofcom.org.uk/__data/assets/pdf_file/0036/198927/6ghz-statement.pdf

3. Ofcom also notes the importance of global harmonization in order to maximize economies of scale. The UK decision was informed by Ofcom's own analysis, as well as European Conference of Postal and Telecommunications Authorities (CEPT) analysis of RLAN coexistence with fixed-satellite services.

3. Europe (CEPT)

1. CEPT has concluded the technical work to allow RLAN use in the 5945-6425 MHz. The equipment characteristics are as follows[77]:

   - Low Power Device: 23 dBm maximum EIRP, restricted to indoor use only. An Access Point must be powered from a wired connection and have an integrated antenna. A client can be battery powered.
   - Very Low Power Device: 14 dBm maximum EIRP, allowed outdoor and indoor, portable

2. CEPT Report 75[78] and ECC DEC (20)01[79] was approved at ECC Meeting in 2020. The European Commission Decision is likely to mandate that by December 2021 Member States shall designate and make available 5945-6425 MHz for the implementation of WAS/RLANs.

3. CEPT has imposed significantly stricter power limits than the FCC, as well as precluding outdoor use for the higher power class.

4. South Korea (MSIT)

1. In October 2020, **South Korea's** Ministry of Science and ICT (MSIT) made the decision to open up the entire 5 925 - 7 125 M Hz range for license-exempt RLAN use.[80]

2. The decision makes the 5 925-7 125 MHz band at under 25 mW available for use at indoor settings.

3. For device-to-device connections like tethering, spectrum sitting in the 5 925 – 6 455 MHz range will also be available for use indoors or outdoors.

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77 ECC Decision (20)01 on the harmonised use of the frequency band 5945-6425 MHz for Wireless Access Systems including Radio Local Area Networks (WAS/RLAN),

ECC Report 316 Sharing studies assessing short-term interference from Wireless Access Systems including Radio Local Area Networks (WAS/RLAN) into Fixed Service in the frequency band 5925-6425 MHz

78 https://docdb.cept.org/download/aefb853d-8780/CEPT%20Report%2075.pdf

79 https://docdb.cept.org/download/50365191-a99d/ECC%20Decision%20(20)01.pdf

80 MSIT. MSIT to supply next-generation unlicensed frequency in the 6 GHz band. June 25, 2020. https://www.msit.go.kr/web/msipContents/contentsView.do?cateId=_policycom2&artId=2941487; MSIT. Administrative notice of partial amendment to the technical standards of radio equipment for unlicensed radio stations. June 26, 2020. https://msit.go.kr/web/msipContents/contentsView.do?cateId=_law4&artId=2942268.

5. Other Administrations

1. United Arab Emirates (UAE) approved final regulations in December 2020 for 5925 – 6425 MHz[81]
2. Consultations published in Saudi Arabia[82] and Jordan.
3. Germany announced that they will open the band in 2021.
4. Chile approved 1200 MHz (5925 – 7125 MHz) in October 2020[83]

Annex 2

WiGig in 60GHz BAND - Practices Adopted By Some Administrations

Possible Practices and Associated Implications

The following are some country practices that may be of reference:

1. South Africa - V-band (57 - 66 GHz) Rules

In 2015 ICASA published guidelines https://www.icasa.org.za/legislation-and-regulations/amendment-to-the-radio-frequency-spectrum-regulations for the use of V-band in South Africa. The following are the notables:

1. The V Band refers to a continuous block of 9 GHz of spectrum between 57 and 66 GHz.
2. The use of the V-band is license exempt provided that technical parameters are complied with
3. The detailed frequency coordination is not required and there are no prescribed channel arrangements
4. Single frequency (TDD) systems and two frequency (FDD) systems may use any channel
5. The radio frequency spectrum fee is not applicable
6. Technical parameters comply with ECC/REC/ (09)01 and includes the following:-

   7.1. Maximum transmitter output power: 10 dBm.

   7.3. Maximum e.i.r.p.: 55 dBm.

   7.4. Minimum antenna gain: 30 dBi.

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81 https://www.tra.gov.ae/en/media-hub/press-releases/2020/12/28/the-telecommunications-regulatory-authority-tra-adds-additional-500-mhz-of-6-ghz-band-for-the-wi-fi-radio-frequency-spectrum.aspx

82 https://www.citc.gov.sa/en/new/publicConsultation/Documents/Spectrum_Innovation_E.PDF

83 https://www.bcn.cl/leychile/navegar?idNorma=1109333&idParte=9841504&idVersion=&r_c=6

2. European rules to use WiGig in the 60 GHz

7. In late 2013, the European Commission (EC) issued a decision, the 2013/752/EU, that made a number of amendments to a prior policy document (2006/771/ EC).

8. The main objective of the revised policy document is to set out regulation for transmission power levels to ensure co-existence with other wireless equipment.

9. In the case of the short-range devices operating in the 57 GHz to 66 GHz band, they are restricted to 40 dBm Equivalent Isotropically Radiated Power (EIRP) and 13 dBm/MHz EIRP densities.

10. Fixed outdoor installations are excluded from complying with these restrictions. Furthermore, it will ensure that these short-range devices do not become a serious source of interference for backhaul links in the 57 GHz to 64 GHz band.

    o ETSI standard: EN 302 567

    o Frequency band: 57 – 66 GHz.

    o EIRP: 40 dBm (Indoor only)

    o EIRP: 25 dBm (Indoor & outdoor)

11. License-exempt mmWave spectrum in the 57-71 GHz range is also an important element of the European Short-Range Device (SRD) regulation and CEPT has already made available the entire band in 2019 under harmonized European conditions for license-exempt use[84].

3. USA (FCC) rules to use WiGig in the 60 GHz:

12. In late 2013, the FCC updated its rules governing the 60 GHz license-exempt band and noted that the new raised power levels would improve the use of license-exempt spectrum for high-capacity, short range outdoor backhaul.

13. There are several reasons why this rule change was important for small cell backhaul. In the 60 GHz band, wireless transmissions are attenuated by oxygen absorption and moisture or "rain fade," which limits their range; also, the signal will not penetrate foliage or buildings, requiring a clear LoS.

14. The FCC raised the power limit for outdoor links operating in the 57 GHz to 64 GHz band on an license-exempt basis.

15. The EIRP limit was raised from 40 dBm (equivalent to 10 Watts) to a maximum of 82 dBm (158,489 Watts), depending on how high the antenna gain is.

84 https://www.ecodocdb.dk/download/25c41779-cd6e/Rec7003e.pdf

16. The new power limit is comparable to others the FCC has in the fixed microwave services.

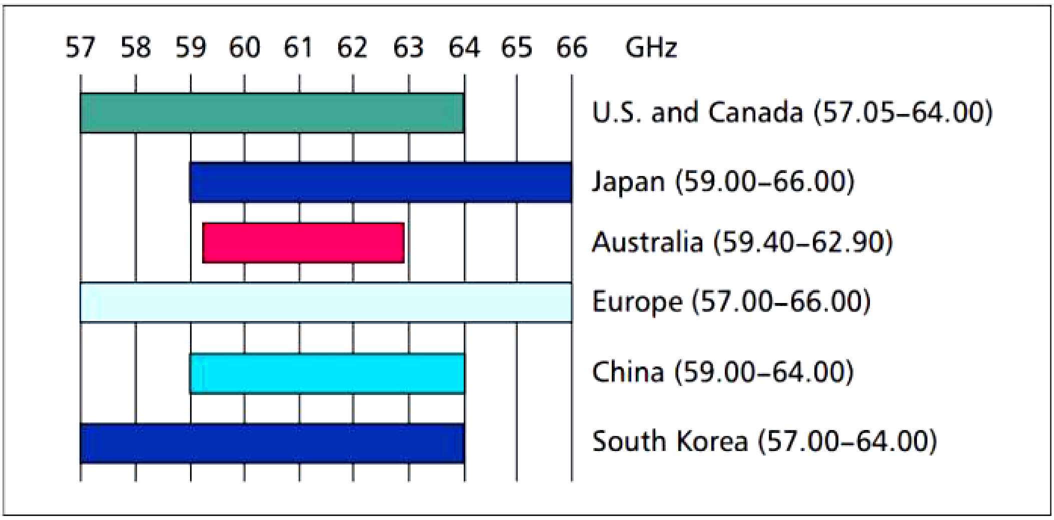
    a. The FCC decided to maintain the license-exempt use of the 64 - 71 GHz band and even to expand these operations on to aircraft in flight.[85]

    b. The FCC believes this will support higher-capacity outdoor links, such as small cells, extending to about 1 mile (1.6 km).

    c. The FCC also eliminated the need for outdoor 60 GHz devices to transmit an identifier. Indoor 60 GHz devices (for example, those based on WiGig's 802.11ad standard) are still constrained to the much lower power limitations, which prevents interference with outdoor fixed link devices.

17. Similarly, UK Ofcom adopted regulations[85] for license-exempt operations in the 57-71 GHz band.

18. The table below shows the 60 GHz spectrum availability in various countries



85 Use of Spectrum Bands Above 24 GHz for Mobile Radio Services Second Report and Order, Second Further Notice of Proposed Rulemaking, Order on Reconsideration, and Memorandum Opinion and Order, GN Docket No. 14-177

86 https://www.ofcom.org.uk/__data/assets/pdf_file/0013/126121/Statement_Implementing-Ofcoms-decision-on-the-57-71GHz-band.pdf

Annex 3

Technical And Operating Conditions For Wireless Access Systems Including Radio Local Area Networks (WAS/RLAIN) In The Band 5925 – 6425 MHz

Frequency band	Application	Maximum radiated power or field strength limits	Technical conditions	Additional Information
5925-6425 MHz	WAS RLAN	23 dBm (200 mW) mean e.i.r.p.	• Restricted to indoor use only • Low Power Indoor (LPI) use only (including trains where metal coated windows (Note 1) are fitted and aircraft • Outdoor use (including in road vehicles) is not permitted. • An adequate spectrum sharing mechanism shall be implemented for channel access and occupation • Mean e.i.r.p. density for in-band emissions – 10 dBm/MHz	• Low Power Indoor (LPI) devices • An LPI access point or bridge is a device that is supplied power from a wired connection, has an integrated antenna and is not battery powered. • An LPI client device is a device that is connected to an LPI access point or another LPI client device and may or may not be battery powered.
5925-6425 MHz	WAS RLAN	14 dBm (25 mW) e.i.r.p.	• Very Low Power (VLP) Indoor and outdoor use • Use on drones is prohibited • An adequate spectrum sharing mechanism shall be implemented for channel access and occupation • Maximum mean e.i.r.p. for in-band emissions (Note 2) • Mean e.i.r.p. density for in-band emissions – 1 dBm/MHz (note 2)	• Very Low Power (VLP) device is a portable device
Note 1: Or similar structures made of material with comparable attenuation characteristics.				
Note 2: The “mean e.i.r.p.” refers to the e.i.r.p. during the transmission burst, which corresponds to the highest power, if power control is implemented				

Annex 4

Technical And Operating Conditions For License Exempt Use In The 57 – 66 GHz Band

Frequency band	Application	Maximum radiated power or field strength limits	Technical conditions	Additional Information	Relevant standard/ Additional requirements
57 GHz - 66 GHz band	SRD WAS RLAN	• 40 dBm (10 W) mean e.i.r.p. (Indoor only) • 23 dBm/MHz e.i.r.p. density	• Adequate spectrum sharing mechanism shall be implemented	• Fixed outdoor installations are excluded	• WiGig 802.11ad standard • ETSI standard: EN 302 567 • ERC Recommendation 70-03
57 GHz - 66 GHz band	SRD WAS	• 40 dBm (10 W) mean e.i.r.p. (Indoor only) • 23 dBm/MHz e.i.r.p. density • maximum transmit power of 27 dBm at the antenna port or ports	• Adequate spectrum sharing mechanism shall be implemented		• ETSI standard: draft EN 303 722 • ETSI standard: draft EN 303 753 • ERC Recommendation 70-03
57 GHz - 66 GHz band	SRD WAS	• 55 dBm (316 W) mean e.i.r.p. • 38 dBm/MHz e.i.r.p. density • transmit antenna gain ≥30 dBi	• Mean e.i.r.p. density for in-band emissions – 38 dBm/MHz and transmit antenna gain ≥ 30 dBi • Adequate spectrum sharing mechanism shall be implemented	• Applies only to fixed outdoor installations	• ETSI standard: draft EN 303 722 • ERC Recommendation 70-03

About this Recommendation

Development: This recommendation was developed by an ATU Task Group on Spectrum Recommendations from July 2020 to February 2021. This group was led by the following:

Role	Name (Country)
Chair – Task Group	Baxton SIREWU (Zimbabwe representing SADC)
Rapporteur – Section 1	Mohamed OMER (Sudan representing North Africa)
Rapporteur – Section 2	Abraham OSHADAMI (Nigeria and representing ECOWAS)
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Validation: This recommendation was validated by a validation forum that was held from 1 to 2 July 2021. The forum was led by the following bureau:

- Chair: Valéry Hilaire OTTOU (Cameroun representing ECCAS)
- Vice-Chair: Ahmed BORAUD (Niger representing ECOWAS)
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