Preparing for WRC-19

ITUWRC
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Understanding the issues at stake and the impact of decisions to be made

Background Paper

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The purpose of this paper is to provide ICT stakeholders with an understanding of some of the main topics related to spectrum management and underline relevant issues that will be considered at the upcoming World Radiocommunications Conference 2019 (WRC-19).

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1. Introduction

The increasing use of wireless technologies, and the opportunities for social development that these technologies provide, highlight the importance of radio-frequency spectrum and national spectrum management processes.

Increased demand requires that spectrum be used efficiently and that effective spectrum management processes and (computerized) systems be implemented to facilitate the deployment of radio systems and ensure minimum interference.

Spectrum's use must be coordinated and regulated through both national regulations and the Radio Regulations of the International Telecommunication Union (ITU).

National spectrum management consists of the structures, procedures, and regulations whereby an administration controls the use of the radio spectrum within its geographical boundaries.

What are the goals and objectives of a spectrum management system?

- Making the radio spectrum available for government and non-government uses to stimulate social and economic progress; and
- Making efficient and effective use of the spectrum.

National spectrum management is closely associated with national law, policy statements, radio regulations and a long-term spectrum plan.

The spectrum management system must provide an orderly method for allocating and assigning frequency bands, authorizing and recording frequency assignments and establishing regulations and standards.

Regulations can specify technical factors, establish licensing criteria, and set priorities that will be used to determine who will be authorized to access a frequency band, and for what purpose it will be used.

While policy statements also can be a link between the government agenda and spectrum managers, stability of radiocommunication policies is essential for investments.

ITU activities and decisions have a significant impact on the national spectrum management environment. It is therefore essential that administrations understand and are fully aware of these activities so that they may participate to ensure that all of their national interests are taken into account.

Frequency coordination, notification and registration are essential tasks for administrations so that their radiocommunication services obtain international protection. This activity may be performed by correspondence with the ITU and other administrations, or in bilateral or multilateral negotiations.

The main elements of spectrum management, including its basic documents, organizational structure and processes, functional requirements and responsibilities are described in detail in the ITU-R Handbook on National Spectrum Management.

World Radiocommunication Conference process

World Radiocommunication Conferences (WRCs) establish and revise the texts of the Radio Regulations (RR), the international treaty covering the use of the radio frequency spectrum by radiocommunication services. WRCs are normally convened on a three/four-year cycle. The agenda is set by the Council on the basis of the draft agenda as agreed by the previous WRC. WRC-19 will take place in Sharm el Sheikh, Egypt from 28 October to 22 November 2019.

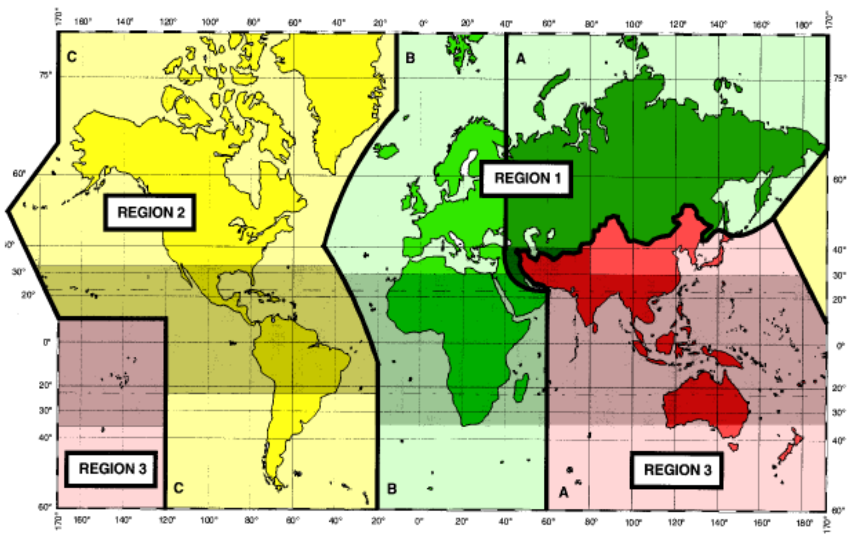
The purpose of the ITU-R Study Groups is to undertake studies of a technical, operational, and regulatory nature and develop Recommendations, Reports and other material that provide the technical bases for spectrum management and decision making at WRCs. The work is conducted by specialists from administrations and other telecommunication organizations throughout the world. Recommendations include criteria for sharing between radiocommunication services, as defined in the Radio Regulations. The Conference Preparatory Meeting (CPM) consolidates in a single comprehensive report the technical, operational and regulatory and procedural bases for the forthcoming WRC.

In parallel with ITU activities, administrations have the opportunity to prepare for WRCs through participation in the preparatory groups of regional organizations (CITEL, CEPT, APT, ASMG, RCC and ATU). These regional groups prepare common proposals for each agenda item together with technical and regulatory information on the background. Regional preparations can ease the burden on administrations with limited resources by sharing the results of any necessary technical and regulatory studies. Most importantly, the regional groups facilitate information sharing and consensus-building within and across regions, making it possible for WRCs to address challenging issues and reach successful outcomes within their limited time and resource constraints.

After each WRC, follow-up action is required nationally to implement WRC Decisions. As part of the ongoing consultation process, the first step is usually to publish a report of the outcome, with suitable explanations of the expected impact on existing users and opportunities for new services. The second step will be to revise the national allocation table and other related documents and databases to comport with the agreed global changes, including any timescales for the changes to come into force.

International Table of Frequency Allocation

The International Table of Frequency Allocations (Article 5 of the Radio Regulations (RR)) is agreed and updated by the world radio conferences for all three ITU Regions. This table should be the basis for a national allocation table. The ITU table (covering all three Regions), however, usually provide for a number of different services in a frequency band. Today, nearly all countries worldwide have adopted their own national table to facilitate spectrum use within their borders and in 83 per cent of these countries, the table is part of regionally harmonised frequency allocation[i].



2. Spectrum decisions at WRC -19

The agenda for WRC-19 covers a series of issues related to the use of radio-frequency spectrum and satellite orbits. Below we bring to your attention the discussions related to agenda items that will have an impact on the future broadband and on the digital society. They include 5G (IMT-2020 in ITU terminology), High Altitude Platforms (HAPS), terrestrial wireless applications such as aeronautical and maritime communications, radio local area networks (RLANs), intelligent transport systems (ITS) and Railway wireless technologies and Satellite systems such as non-geostationary satellite orbits (non-GSO) FSS, and Earth stations in motion (ESIM).

2.1 Fifth Generation of Mobile Technologies 5G (IMT 2020)

Consumer demands are shaping the development of mobile broadband services. Anticipated increases in traffic, estimated between 10 and 100 times in the period 2020 - 2030, and growth of number of devices and services, as well as demand for enhanced affordability and user experience will require innovative solutions. The number of connected devices on the Internet is projected to reach 50 billion any time from 2025 onwards.

5G is expected to connect people, things, data, applications, transport systems and cities in smart networked communication environments. It should transport a huge amount of data much faster, reliably connect an extremely large number of devices and process very high volumes of data with minimal delay.

5G technologies are expected to support applications such as smart homes and buildings, smart cities, 3D video, work and play in the cloud, remote medical services, virtual and augmented reality, and massive machine-to-machine communications for industry automation. 3G and 4G networks currently face challenges in supporting these services.

Figure 1: IMT-2020/5G usage scenarios

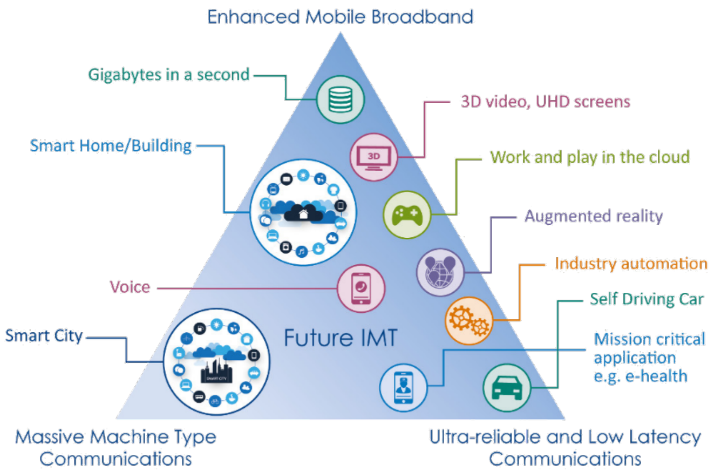


Figure 1: 5G usage scenarios. Source: IMT Vision for 2020 and beyond from Recommendation ITU-R M.2083, 2015

IMT-2020, the name used in ITU for the standards of 5G, is expected to continue to be developed from 2020 onwards, with 5G trials and pre-commercial activities already underway to assist in evaluating the candidate technologies and frequency bands that may be used for this purpose.

5G intends to accelerate the achievement of all 17 Sustainable Development Goals (SDGs), from affordable and clean energy to zero hunger.

The implications of 5G for spectrum allocation, management and sharing are immense. ITU is working towards providing stable international regulations, sufficient spectrum and suitable standards for IMT-2020 and the core network to enable successful 5G deployments at the regional and international levels.

Challenges and solutions: building 5G networks for the future

When deployed, 5G networks should deliver more speed and capacity to support massive machine-to-machine communications and to provide low-latency (delay), high-reliability service for time-critical applications. Based on trials to date, 5G networks are starting to demonstrate high performance in different scenarios such as dense urban areas and indoor hotspots.

With these ambitious goals, 5G networks face considerable challenges. The increased capacity and data rates promised by 5G require more spectrum and vastly more spectrally efficient technologies, beyond what is currently used in 3G and 4G systems.

Some of this additional spectrum will likely come from frequency bands above 24 GHz, which pose considerable challenges. The first challenge refers to the intrinsic propagation characteristics of millimeter waves. These radio waves propagate over much shorter distances than those of medium- (between 1-6 GHz) and low- (below 1 GHz) frequency bands.

Furthermore, coverage of a given area will require a significantly increased number of base stations that will increase the complexity of the infrastructure, including the need to deploy radio equipment on street facilities, such as traffic lights, lampposts, utility poles and power supplies.

Another challenge relates to 5G connection links between base stations and the core network (backhaul), which rely both on fiber and wireless technologies. Considerable work is required for implementing fiber services and ensuring availability of wireless backhaul solutions with sufficient capacity, such as microwave and satellite links, and potentially with High-Altitude Platform Stations (HAPS) systems where they are deployed.

Furthermore, spectrum is a scarce and very valuable resource, and there is intense – and intensifying – competition for spectrum, at the national, regional and international levels. As the radio spectrum is divided into frequency bands allocated to different radiocommunication services, each band may be used only by services that can coexist with each other without creating harmful interference to adjacent services. ITU-R studies examine the sharing and compatibility of IMT systems with a number of other existing radiocommunication services, notably satellite communications, science services used for weather forecasting, monitoring of Earth resources and climate change, radio astronomy and other systems.

National and international regulations need to be adopted and applied in a global context to avoid interference between 5G and these services and to create a viable mobile ecosystem for the future — while reducing prices through the global market’s economies of scale and enabling interoperability and roaming. The additional spectrum to be used by 5G therefore needs to be identified and, to the extent practicable, harmonized at global or regional levels. For similar reasons, the radio technologies used in 5G devices need to be supported by globally harmonized standards.

WRC and ITU's contribution

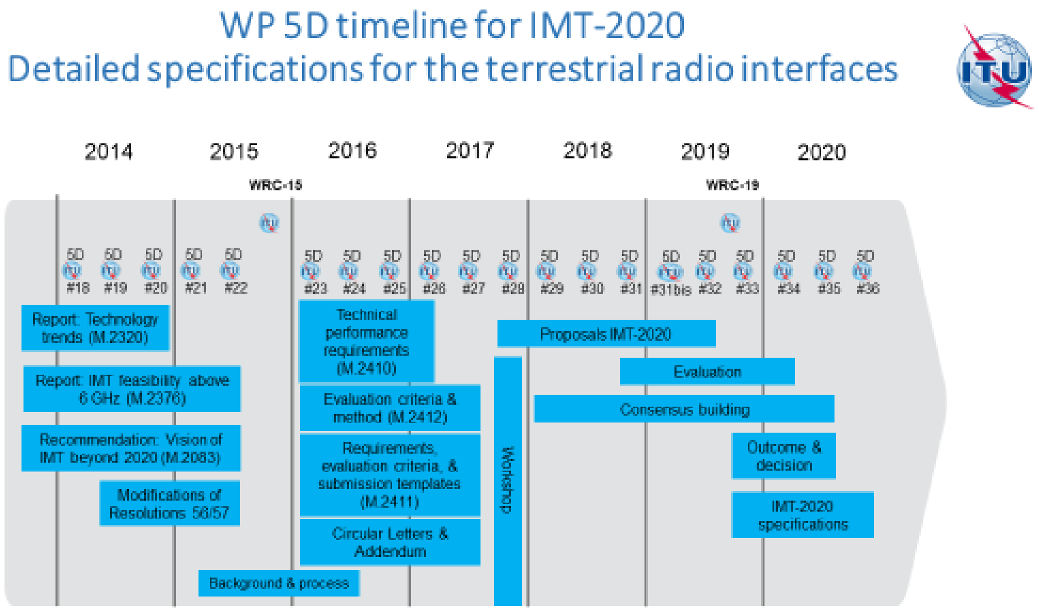
ITU plays a leading role in managing the radio spectrum and developing globally applicable standards for IMT-2020. Its activities support the development and implementation of international regulations and standards to ensure that 5G networks are secure, interoperable, and that they operate without causing or receiving harmful interference to or from adjacent services.

Under ITU's IMT-2020 programme, ITU membership is developing the international standards to achieve well-performing 5G networks.

At the WRC-19, global stakeholders are working towards building consensus on additional spectrum for IMT. New allocations will be considered for the mobile service and identification for IMT of frequencies within the following frequency ranges:

Bands already allocated to mobile services	**Bands that would require an additional allocation to mobile services**
24.25 – 27.5 GHz	31.8 – 33.4 GHz
37 – 40.5 GHz	40.5 – 42.5 GHz
42.5 – 43.5 GHz	
45.5 – 47 GHz	47 – 47.2 GHz
47.2 – 50.2 GHz	
50.4 – 52.6 GHz	
66 – 76 GHz	
81 – 86 GHz	

Figure 2: Detailed Timeline & Process for IMT-2020 in ITU-R



The results of ITU compatibility studies between IMT and other applications operating in these bands, along with examples of regulatory solutions, have been consolidated in the CPM Report to WRC-19.

As for the current situation, a number of countries have started 5G trials and the results are under assessment. In many parts of the world strategies for 5G deployment have been established. Already, a few regulators have been auctioning licenses to operate 5G networks in the frequency bands allocated in the RR to the land mobile service. The first full-scale commercial deployments for 5G are expected sometime after IMT-2020 specifications are finalized in 2020. Some countries already commenced commercial deployment of 5G networks in 2019.

At some point in the future the challenges to develop a sustainable 5G system will be overcome and today's 3G and 4G mobile networks will be gradually upgraded to 5G. In the meantime, national governments should and are continuing to make every effort to close the digital divide, significantly increase access to information and communications technology and provide universal and affordable access to the Internet (as per the Sustainable Development Goal #9) by using all the regulatory tools and technologies at their disposal.

Policy makers and regulators may consider the following issues when formulating strategies to stimulate investment in 5G networks:

No.	Summary	For consideration…
1)	Investment case	Policymakers may consider undertaking their own independent economic assessment of the commercial viability of deploying 5G networks
2)	4G network strategy	Until the case for 5G networks can be clearly made, policy makers may consider enhancing the availability of and boosting the quality of 4G networks
3)	Harmonize spectrum	NRAs may consider allocating/assigning globally harmonized 5G spectrum bands
4)	Spectrum roadmap	NRAs may consider adopting a spectrum roadmap and a predictable renewal process
5)	Spectrum sharing	NRAs may consider allowing sharing to maximize efficient use of available spectrum, particularly to benefit rural areas
6)	Spectrum pricing	NRAs may consider selecting spectrum award procedures that favour investment
7)	700MHz spectrum	Policymakers may consider supporting the use of affordable wireless coverage (e.g. through the 700 MHz band) to reduce the risk of digital divide
8)	Fibre investment incentives	Policymakers, where the market has failed, may consider stimulating fibre investment and passive assets through PPPs, investment funds and the offering of grant funding, etc.
9)	Fibre tax	Policymakers may consider removing any tax burdens associated with deploying fibre networks to reduce the associated costs
10)	Copper migration to fibre	Policymakers may consider adopting policies/financial incentives to encourage migration from copper to fibre and stimulate deployment of fibre
11)	Wireless backhaul	Operators may consider a portfolio of wireless technologies for 5G backhaul in addition to fibre, including point-to-multipoint (PMP), microwave and millimeter wave (mmWave) radio relays, high altitude platform systems (HAPS) and satellites
12)	Access/sharing of passive infrastructure	Policy makers may consider allowing access to government-owned infrastructure such as utility poles, traffic lights and lampposts to give wireless operators the appropriate rights to deploy electronic small cell apparatus to street furniture NRAs may consider continuing to elaborate existing duct access regimes to encompass 5G networks allowing affordable fibre deployments
13)	Access costs	Policymakers/NRAs may consider ensuring reasonable fees are charged to operators to deploy small-cell radio equipment onto street furniture
14)	Asset database	Policymakers may consider holding a central database identifying key contacts, showing assets such as utility ducts, fibre networks, CCTV posts, lampposts, etc. This will help operators cost and plan their infrastructure deployment more accurately
15)	Wayleave (rights of way) agreements	Policymakers may agree upon standardized wayleave agreements to reduce cost and time to deploy fibre and wireless networks
16)	5G test beds	Policymakers may consider encouraging 5G pilots and test beds to test 5G technologies, and use cases, and to stimulate market engagement

2.2 HAPS – High Altitude Platform Systems

High-altitude platform systems (HAPS) can potentially be used to provide broadband connectivity and telecommunication services in communities, rural and remote areas that are undeserved.

It would do so by providing fixed broadband connectivity for end users and transmission links between the core and mobile networks (backhaul). Both of these types of HAPS applications would enable wireless broadband deployment in remote areas, including in mountainous, coastal and desert areas.

In some situations, HAPS may be rapidly deployed for disaster recovery communications, particularly because the use of inter-HAPS links allows the provision of services with minimal ground network infrastructure.

ITU Radio Regulations (RR) define HAPS as radio stations located on an object at an altitude of 20-50 km and at a specified, nominal, fixed point relative to the Earth.

Some industries are currently testing the delivery of broadband over lightweight, solar-powered aircraft and airships at an altitude of 20-25 kilometres, which can operate for several months at a nominal fixed-point relative to the ground below. Another example of HAPS includes drones operating at high altitudes in quasi-fixed positions.

Challenges and solutions

The technological innovations and the growing urgency to expand the availability of broadband led to the development of platforms such as HAPS. These easily deployable stations operating in the stratosphere are high enough to provide service to a large area or to augment the capacity of other broadband service providers.

HAPS is not a new concept and ITU studies of HAPS began around 1996. Nevertheless, HAPS have become more viable due to the evolution of technology through advances in solar panel efficiency, battery energy density, lightweight composite materials, autonomous avionics and antennas.

Recent test deployments of such stations delivering broadband from approximately 20 km above ground have demonstrated their ability to provide connectivity to remote or underserved communities.

Nevertheless, HAPS faces challenges to becoming a commercially available option to drive global broadband delivery, especially for countries with limited infrastructure.

The current ITU-R studies estimate that the total spectrum needs for HAPS systems is in the range from 396 MHz to 2 969 MHz for the ground-to-HAPS platform links and in the range from 324 MHz to 1 505 MHz for the HAPS platform to ground links. These ranges include the spectrum needs to cover specific applications (e.g. disaster relief missions) plus that for connectivity applications (e.g. commercial broadband).

Three world radiocommunication conferences (WRC-97, WRC-2000, and WRC-12) designated spectrum for HAPS in the frequency bands 47/48 GHz, 2 GHz, 27/31 GHz and 6 GHz respectively.

The ITU-R studies on spectrum needs for HAPS demonstrate that spectrum requirements for broadband HAPS applications may not be fully accommodated within current HAPS identifications. In addition, some of the current HAPS frequency bands have geographical limitations, while common worldwide identifications for HAPS are desirable to improve and harmonize their utilization.

Therefore, additional spectrum is being considered to be identified for HAPS systems, taking into account that HAPS will need to ensure the protection of existing and future services, such as mobile and satellite services.

The revision of the regulatory provisions for HAPS may include global or regional designations for HAPS, limitations regarding link directions, and inclusion of technical conditions of operation of HAPS systems for the protection of other services. Further conditions could be imposed on the operation of HAPS, such as mandatory coordination with potentially affected countries and notification of the stations to ITU.

WRC and ITU's contribution

In 1997, the first frequency bands were globally designated for HAPS in the Radio Regulations (RR) where use for HAPS is permissible. Since then, ITU has allowed additional frequency bands regionally and in specific countries. At that time, the concerns with rain fade, i.e. loss of signal power due to the rain, in the upper frequency bands were considered, and the HAPS identifications were established without reference to today's broadband capabilities.

Thus, the frequency resource for HAPS was made by ITU a long time ago. However, it was not used due to the above constraints and immaturity of technical solutions in general.

More recently, the technological advances that improved HAPS viability and the pressing need to facilitate access to global broadband applications have led to the review of the current regulatory provisions.

HAPS is an item on the agenda of the World Radiocommunication Conference 2019. As a result of the sharing and compatibility studies conducted by ITU-R, the following existing and new frequency bands allocated to the fixed service are proposed for identification for use by HAPS under various regulatory and technical conditions:

- 6 440-6 520 MHz and 6 560-6 640 MHz;
- 21.4-22 GHz (Region 2 only);
- 24.25-27.5 GHz (Region 2 only)*;
- 27.9-28.2 GHz and 31-31.3 GHz;
- 38-39.5 GHz*;
- 47.2-47.5 GHz and 47.9-48.2 GHz.

The results of ITU-R compatibility studies between HAPS and other applications operating in these bands, and examples of regulatory solutions have been consolidated in the Report of the Conference Preparatory Meeting to WRC-19.

HAPS trials have been taking place in some countries to demonstrate their ability for providing broadband connectivity, backhaul links and for disaster recovery communications. Possible global and regionally harmonized designations for HAPS at WRC-19 may facilitate the development of these applications and allow trials to move towards commercial deployments.

*The band 24.25-27.5 GHz (in Region 2) is also being considered for IMT identification (5G) and the band 38-39.5 GHz is being considered for both IMT identification and for non-geostationary satellite orbit systems operating in the fixed-satellite service (NGSO FSS). Studies have been carried out to address mutual compatibility and sharing feasibility among the services/applications for which allocation of spectrum and identification of this spectrum for applications is envisaged.

2.3 Other terrestrial wireless applications at WRC-19

2.3.1 Aeronautical communications

As the case of many previous world radiocommunication conferences, WRC-19 will address spectrum needs of emerging maritime and aeronautical technologies. Concerning aviation communications, the Conference will work on the introduction in the Radio Regulations of the new concept of Global Aeronautical Distress and Safety System developed by ICAO, though no additional frequency allocations are necessary to support this system.

Figure 3: GADSS Concept of Operations from Draft Report ITU-R M.[GADSS]

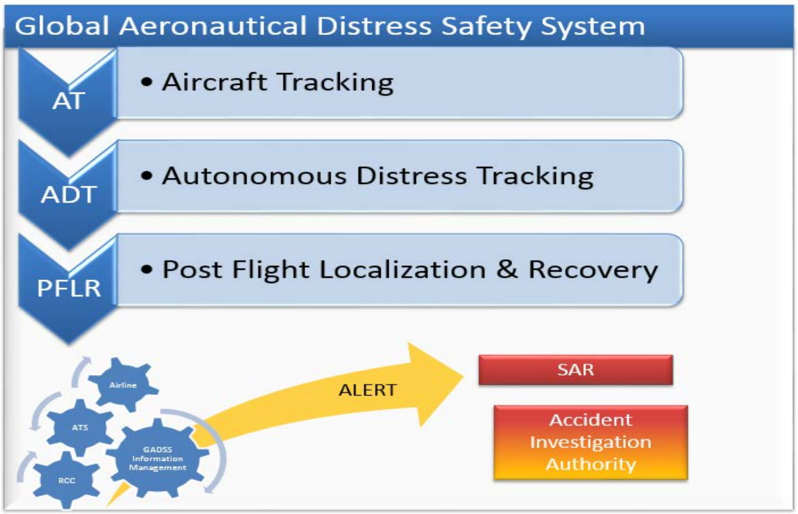


Figure 3: GADSS Concept of Operations from Draft Report ITU-R M.[GADSS]

Another aeronautical agenda item deals with frequency requirements, technical and operational measures to ensure interference-free communications with sub-orbital vehicles, their navigation, surveillance, telemetry and command. Such vehicles might take-off as aircraft, fly at altitudes of over 100 km using non-orbital or sub-orbital trajectories and land on Earth. As a result, they could use frequencies allocated to both space and terrestrial services, which represents a considerable challenge to the spectrum regulators.

Other challenges are linked to a possible communication blackout due to the radio frequency shielding caused by ionization of the atmosphere and a concern about frequency planning issues. Consequently, the aviation community may seek an agenda item on this issue for a future WRC, and studies would continue to resolve the above regulatory and technical questions and concerns.

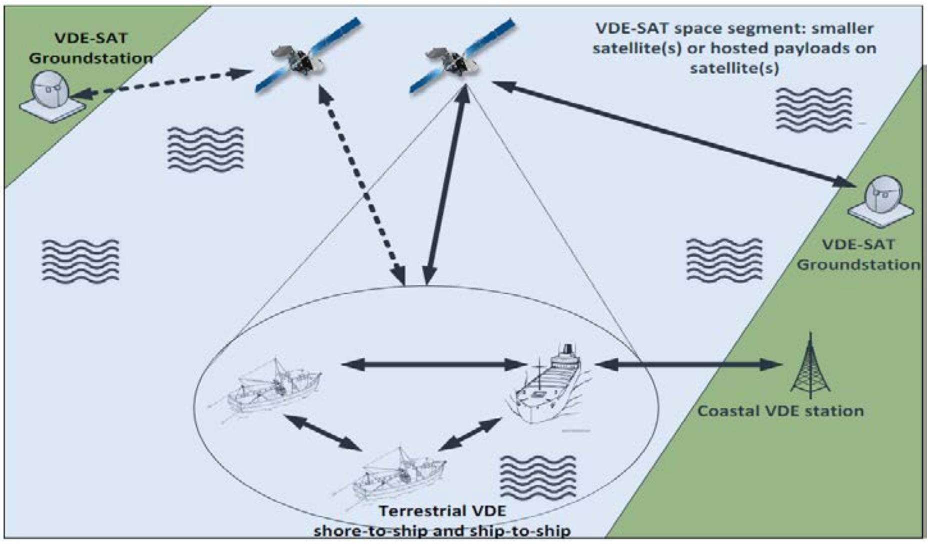
2.3.2 Maritime communications

The maritime community seeks to introduce an additional mobile-satellite service system (MSS) into the Global Maritime Distress and Safety System (GMDSS) and make necessary updates in the Radio Regulations. Such a non-GSO MSS system operating in the frequency band 1 616-1 626.5 MHz was recognized by the International Maritime Organization in 2018. The system is expected to come into operation in early 2020 and provide worldwide operation of GMDSS, including in the Arctic and Antarctic areas.

One of the issues to be resolved by WRC-19 is associated to the fact that the allocation used by this MSS system in the downlink is on a secondary basis. Some administrations, therefore, consider that such a "non-interference, non-protection" operation may not ensure reliable safety-of-life services as required by the GMDSS. Another challenge is to avoid additional impact on the incumbent services, including radio astronomy in the adjacent band.

The maritime issues on the WRC-19 agenda also include identification of frequencies and establishing regulations for autonomous maritime radio devices (AMRDs) in the VHF bands of Appendix 18 to the RR. In addition, the Conference will consider new allocations to the maritime mobile-satellite service in the bands between 156 -162MHz, to support the satellite component of the VHF Data Exchange System (VDES) and the digital evolution of maritime radio communications.

Figure 4: VHF Data Exchange System from Report ITU-R M.2092



2.3.3 Radio Local Area Networks (RLANs)

The Conference will address additional frequency requirements of RLANs in the 5GHz band. These systems have been widely used for internet connectivity, data delivery and offloading mobile traffic to reduce the amount of data carried on cellular networks. The traditional RLAN bands in 2.4 GHz and 5 GHz are heavily used and growing consumer demand requires additional capacity. Identification of additional frequencies for RLANs represents a challenging task for WRC-19 due to the need for protection of several existing services.

2.3.4 Intelligent Transport Systems (ITS)

A variety of technologies can contribute to ITS, including wireless access systems, sensors, cellular networks and radars. They enter in various areas of transportation networks, such as vehicle navigation, traffic control, road signs and automatic license plate recognition, *etc.* These technologies are gradually changing the shape of road transport, making cars smarter, driving more convenient and roads safer.

WRC-19 will seek globally or regionally harmonized spectrum for ITS applications, with some focus on the 5.8 GHz band. It is expected that Conference decisions will assist in the development of automated and connected vehicles, sharply reducing traffic fatalities, which currently account for 1.3 million individuals per year.

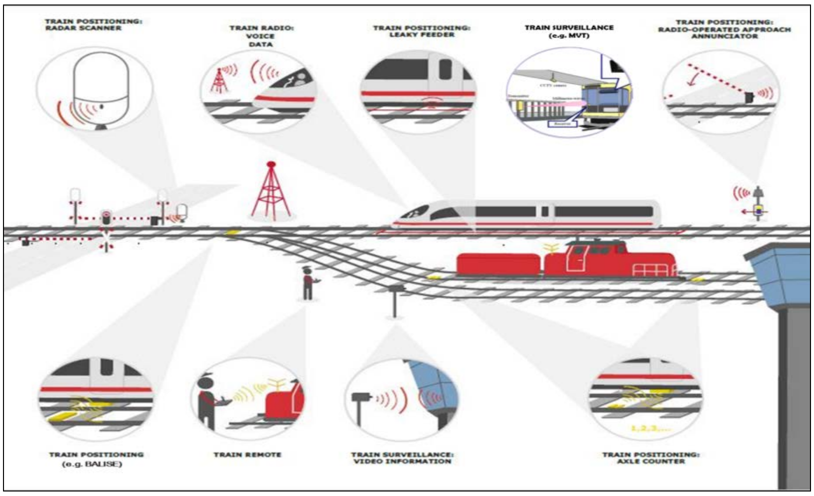
Figure 5: Intelligent Transport Systems from Report ITU-R M.2445

2.3.5 Railway wireless technologies

Railway transportation is also an important user of radio technologies. Such technologies increase accuracy of train positioning, enable automatic train operation, remote driving. Evolved communication systems will also support virtual coupling of trains, automatic train assembly of cargo trains, real-time monitoring of trains. In addition, radio applications should meet the demand for passenger services, such as web browsing, streaming services, mobile office or video conferences during their travel.

WRC-19 will consider a part of the family of railway applications that is Railway Radiocommunication Systems between Train and Trackside (RSTT). These include wireless technologies used on board trains, positioning information, train remote control and surveillance. The Conference will determine the ways of harmonizing frequency bands for these applications to improve their interoperability and reduce investments.

Figure 6: Railway radiocommunication systems between train and trackside from Report ITU-R M.2418



2.4 Satellites issues

2.4.1 Non-GSO FSS satellite systems

An innovation in satellite technology is brought through the increased use of non-geostationary satellite orbits (non-GSO), such as medium earth orbits (MEO) and low earth orbits (LEO). While GSO satellites are at 36 000 km above the Earth, MEO altitudes are below that between 20 000 and 8 000 km, while LEO altitudes are even lower between 2 000 to 400 km above the Earth. To enable continuous service from these altitudes, non-GSO operators must deploy a fleet of satellites, generally called "constellations". Massive constellations of non-GSO LEO satellites intend to cover the globe providing low-latency, high-bandwidth connectivity.

Advances in satellite design, manufacturing and launch service capabilities have enabled the development and future deployment of non-GSO fixed-satellite service (FSS) constellations. Additionally, the advances in antenna and terminal technology have enabled the usage of the 50/40 GHz frequency bands for both GSO FSS/broadcasting-satellite service (BSS) networks and non-GSO FSS systems.

The technological advances described above improve the quality, increase the capacity and reduce the costs of satellite services, enabling satellite operators to bring to market innovative solutions to bridging the digital divide and providing broadband for all.

These developments have the potential to increase access to broadband infrastructure, especially for the populations living in rural areas. Access to terrestrial networks is limited or non-existent in many parts of the world, particularly in sparsely populated rural or remote areas. Satellite technologies are well-placed for the delivery of broadband services in those areas either on their own, or in combination with other technologies. Although satellites are key to delivering broadband Internet access to unserved areas, their impacts go far beyond that, including applications in urban and already-connected areas, which are important to the aviation, maritime, energy, and other sectors, enabling new capabilities and applications in areas already connected to the global network, and helping drive down costs for many people.

Space-based connectivity is helping make smart societies a reality (including intelligent transport systems, e-government, tele-education, e-health, e-logistics, smart energy, smart agriculture), in both developed and developing countries. These technologies are also facilitating advances in sustainability, banking, and diverse government services.

Satellite systems offer significant advantages for expanding broadband coverage: they provide instant-on coverage across wide geographies without regard to challenging topography; they are reliable and largely immune to many risks that face other networks (including accidental damage, theft, conflict areas and natural disasters). Moreover, these systems are environmentally efficient and can leverage development in solar technology and electric propulsion. Finally, as global satellite coverage exists, network deployment can be as simple as providing ground terminals.

Challenges and solutions

There is a need to encourage the development and implementation of new technologies in the FSS at frequencies above 30 GHz. The FSS systems based on the use of new technologies operated above 30 GHz and associated with both GSO and non-GSO satellite constellations are capable of providing high-capacity and low-cost means of communication even to the most isolated regions of the world.

The Radio Regulations (RR) should enable the introduction of new applications of radiocommunication technology to ensure the operation of as many systems as possible in order to ensure efficient use of the spectrum. In accordance with RR No. 22.2, non-GSO systems are prohibited from causing unacceptable interference to GSO FSS and BSS networks and, unless otherwise specified in the RR, they are prohibited from claiming protection from GSO FSS and BSS satellite networks. However, this provision does not define or quantify what constitutes “unacceptable interference”, which may create legal uncertainty for satellite operators. Consequently, non-GSO FSS systems would benefit from the certainty that would result from the specification of measures required to protect GSO FSS and BSS satellite networks under RR No. 22.2.

In the FSS, there are GSO satellite networks and non-GSO satellite systems operating and/or planned for near-term operation in the frequency bands allocated to the FSS in the range 37.5-51.4 GHz. However, there are currently no regulatory provisions other than RR No. 22.2 addressing sharing between non-GSO systems and GSO networks in the 50/40 GHz frequency bands. Moreover, there are no existing mechanisms in the RR establishing coordination procedures applicable to non-GSO systems operating within the FSS allocations in bands in the 37.5 to 51.4 GHz frequency range. This also contributes to uncertainty among potential operators of non-GSO satellite systems in these bands.

Therefore, technical studies were needed in order to ascertain the feasibility of, and conditions for, non-GSO FSS satellite systems sharing the frequency bands 37.5-42.5 GHz (space-to-Earth) and 47.2-50.2 GHz (Earth-to-space) and 50.4-51.4 GHz (Earth-to-space): 1) with GSO satellite networks (FSS, MSS and BSS, as appropriate to the frequency band), and 2) with other non-GSO FSS satellite systems.

Another challenge relates to the determination of requirements for the bringing into use of frequency assignments to non-GSO systems in order to avoid spectrum warehousing and virtual (also known as “paper”) satellites. WRC-12 and WRC-15 adopted into the RR a series of specific provisions, including RR No. 11.44B, that clarified the requirements for the bringing into use (BIU) and the bringing back into use (BBIU) of frequency assignments to a space station in a GSO satellite network. However, there are no provisions in the RR that specifically address the BIU of frequency assignments to space stations in non-GSO systems.

WRC and ITU’s contribution

WRC-19 agenda item 1.6 addresses the development of technical, operational and regulatory provisions in the 50/40 GHz frequency bands to facilitate sharing between non-GSO and GSO satellite systems operating in the fixed-satellite service (FSS), broadcasting-satellite service (BSS), and mobile-satellite service (MSS).

The ITU-R developed Recommendations ITU-R S.1323, ITU-R S.1325, ITU-R S.1328, ITU-R S.1529 and ITU-R S.1557 that provide information on system characteristics, operational requirements and protection criteria of such systems that may be used in sharing studies.

ITU-R studies in the 50/40 GHz frequency bands have been conducted on sharing between non-GSO systems and GSO FSS and BSS networks. These studies concluded that, in this frequency range, developing epfd limits based on the operational parameters for a single, specific, non-GSO system results in spectrum inefficiencies for other non-GSO systems.

On the other hand, these studies have identified an alternative methodology that provides more flexibility on the design and operation of non-GSO systems operating in the 50/40 GHz frequency bands and concluded that the protection of GSO networks is possible based on an assessment of aggregate interference from multiple non-GSO systems that have different configurations and orbits.

Furthermore, the ITU-R studied both the BIU of frequency assignments to non-GSO systems, and the possibility of adopting a milestone-based approach for the deployment of non-GSO systems composed of multiple, multi-satellite constellations in particular frequency bands. The ITU-R studies have led to two general conclusions, one related to the BIU concept for non-GSO systems and the other related to the milestone-based approach for the deployment of non-GSO systems, each with multiple options for implementation.

WRC-19 will decide on the regulatory framework for non-GSO FSS satellite systems that may operate in the 37.5-39.5 GHz (space-to-Earth), 39.5-42.5 GHz (space to Earth), 47.2-50.2 GHz (Earth-to-space) and 50.4-51.4 GHz (Earth-to-space) frequency bands, as well as the requirements for the BIU of frequency assignments to non-GSO systems and possible adoption of a milestone-based approach for the deployment of these systems in specific frequency bands and services.

2.4.2 Non-GSO satellite systems with short-duration missions

In recent years, an increasing number of academic institutions, amateur satellite organizations and government agencies have been developing non-GSO satellite systems with short duration missions using nano- and pico-satellites. The use of these types of satellites has presented various regulatory challenges, including difficulties for the notifying administrations to provide accurate orbital characteristics at the beginning of the development cycle and, in some instances, even prior to the launch of the satellites.

At WRC-15, a proposal for a new agenda item for WRC-19 “to consider modifications to the regulatory procedures for notifying satellite networks to accommodate nanosatellite and picosatellite missions” was submitted. WRC-15 decided not to include this as a specific item on the WRC-19 agenda, because it concluded that this matter could best be dealt with by the ITU-R under the standing WRC agenda item 7.

Considering that the size of a satellite is independent of the nature of the service that it is intended to provide, a simplified regulatory regime needs to be developed for non-GSO satellites with short-duration missions, independent of the size of the satellite.

These short-duration missions provide an affordable means to get access to orbital resources (spectrum and orbit) for new entrants into the use of space-based applications. The mass and dimensions of these satellites have significantly contributed to their successful adoption among newly spacefaring nations. Thus, the demand for suitable allocations (particularly for telemetry, tracking and telecommand in the space operation service (SOS)) will likely increase.

Challenges and solutions

Non-GSO satellites with short-duration missions are currently treated the same as all other satellites under Articles 9 and 11 of the Radio Regulations (RR). Furthermore, there is no dedicated radiocommunication service associated with short-duration satellite system frequency usage. However, non-GSO satellites with short-duration missions are required operate in spectrum allocated to satellite services in accordance with the relevant conditions of the allocation. It is noted that these short-duration satellite systems are beginning to operate in bands that are not allocated to the amateur-satellite service. Given their short development cycle, short lifetimes, and typical missions, a modified regulatory procedure for the advance publication, notification and recording in the Master International Frequency Register (MIFR) may be beneficial for facilitating the introduction of these systems.

Furthermore, it is important to ensure that any satellite radio-frequency operation avoids harmful interference to incumbent and authorized systems and services. The two frequency bands below 1 GHz under consideration for new or upgraded allocation to the SOS (150.05-174 MHz and 400.15-420 MHz) are used for a wide variety of terrestrial and space applications, including for safety of life purposes, and some of these bands are heavily used on a consistent basis. Nevertheless, if new allocations to the SOS in these frequency bands are considered, they should not put undue constraints on any incumbent services.

WRC and ITU's contribution

Based on input contributions from the membership, ITU-R discussed the possibility of accelerating the timing of the processing of frequency assignments to non-GSO satellite networks and systems with a short-duration mission not subject to coordination under Section II of RR Article 9. This could be achieved, in part, by taking advantage of the recent development and implementation of an online tool for the submission of all the notices. Other possibilities presented involved reducing the time provided to affected administrations to submit their comments. In both cases, the impacts of these modifications on the Radiocommunication Bureau or administrations may need to be further considered. These modifications to the existing regulatory procedures to facilitate the recording of non-GSO satellite systems with short-duration missions in the MIFR, including a draft new WRC Resolution, have been developed to address this issue.

Furthermore, ITU-R has performed studies on spectrum needs for telemetry, tracking and telecommand in the SOS for non-GSO satellites with short duration missions, to assess the suitability of existing allocations to the SOS and, if necessary, to consider possible new allocations. Typical technical parameters for space operations of non-GSO satellites with short duration missions were developed for use in the studies. In addition, technical and regulatory studies, including sharing studies, were carried out and resulted in different possible options to address the abovementioned spectrum requirements, such as new SOS (Earth-to-space) allocations in the 403-404 MHz or 404-405 MHz frequency bands, or using the existing SOS allocations in the 137-138 MHz (space-to-Earth) and 148-149.9 MHz (Earth-to-space) frequency bands with associated regulatory provisions appropriately modified for non-GSO satellites with short duration missions.

WRC-19 will decide on the simplified regulatory regime, as well as frequency allocations for telemetry, tracking and telecommand in the space operation service, for non-GSO satellite systems with short-duration missions.

2.4.3 Earth stations in motion (ESIM)

Earth stations in motion (ESIM) are earth stations that communicate with GSO FSS space stations but operate on platforms in motion in the frequency ranges 17.7-20.2 GHz and 27.5-30 GHz. Currently there are three types of ESIM: ESIM on aircraft (aeronautical ESIM), ESIM on ships (maritime ESIM) and ESIM on land vehicles (land ESIM). Any of the three types of ESIM can be used to provide broadband communications, including Internet connectivity.

The user requirements addressed by ESIM are principally the provision of broadband communications on mobile platforms (e.g. ships, aircraft, land vehicles). The provision of communication service to mobile platforms has traditionally been accomplished by satellite systems in the mobile-satellite service (MSS) using relatively low frequency bands (such as the 1.5 GHz, 1.6 GHz, 2.1 GHz, and 2.4 GHz bands). The frequency bandwidths available to an individual user in these frequency ranges are relatively low - typically a few kHz to a few hundred kHz. The narrow frequency bandwidths available consequently limit the data rates that can be provided - current capabilities in these frequency bands range from a few kbit/s to around 700 kbit/s in a single channel.

Over the last ten years or so, there has been very high growth in broadband connectivity provided to homes and businesses. The growth has been in both the number of connections and in the data rate or throughput per connection. For some users, none of the terrestrial connectivity solutions are available, particularly for those on ships and aircraft. For example, when ships are at sea and aircraft cross the oceans, they are beyond the reach of any terrestrial network. For aircraft on long-distance routes, an ESIM system can provide continuous broadband connectivity for passengers and crew.

A similar requirement exists for cruise ships, the largest of which can accommodate several thousands of passengers. For ships there is additionally a broadband communication requirement separate from passenger requirements for managing the ship's operation (for example for transmission of engine diagnostics and for access to the corporate network) and for crew communications. A similar growth rate as with aircraft connectivity can also be witnessed in new and better options for vessels. The number of maritime vessels in service grew by almost 25% between 2012 and 2013. In 2014 over 20 000 vessels were connected via satellite and this number is expected to increase to around 50 000 vessels over the next few years only.

Land vehicles with broadband connectivity requirements that can be met by ESIM include trains, coaches, vans, trucks and motorhomes. Land ESIM can provide connectivity throughout countries and are particularly useful in areas without coverage by terrestrial networks.

In addition to the above, there are ESIM applications for government users and aid organizations that have broadband communication needs for land vehicles, ships and aircraft.

Challenges and solutions

For some ESIM users, especially those on-board ships and aircraft, the required geographic coverage may virtually be the entire Earth, since the ships operate on almost any sea and aircraft operate over almost any location over land and sea. This leads to a requirement for ESIM systems to provide continuous and consistent service with very wide or global geographic coverage.

The typical data rates currently provided by terminals operating in networks serving ESIM are around 100 Mbit/s. Data rates may increase to support higher broadband demand or be lower for some applications that use smaller antennas (while still being higher than what has been available from existing MSS systems).

For the operation of ESIM, the technical, operational and regulatory responsibilities of administrations and entities responsible for the operation, authorization and the interference management system of the various types of ESIM (on board aircraft, on board vessels and on-board land vehicles) need to be defined.

The frequency bands 19.7-20.2 GHz and 29.5-30 GHz are already available to ESIM operating in accordance with Resolution 156 (WRC-15). These bands are shared with terrestrial services in a limited number of countries (see RR No. **5.524** and RR No. **5.542**) and therefore may accommodate ESIM operations with relatively limited technical and operational constraints.

The frequency bands within the scope of WRC-19 agenda item 1.5 (17.7-19.7 GHz and 27.5-29.5 GHz) are allocated to several different services and parts of these bands are used by non-GSO FSS satellite systems, including feeder links for non-GSO MSS systems. The necessary sharing constraints are more complex than in the 19.7-20.2 GHz and 29.5-30.0 GHz frequency bands and consequently, the use of ESIM in some parts of the 17.7-19.7 GHz and 27.5-29.5 GHz frequency bands may not be feasible in some geographic locations due to use by other services, the current use and future availability of which needs to be protected.

For example, the 27.8285-28.4445 GHz and 28.8365-29.4525 GHz frequency bands are used by the fixed service in various countries in Europe on the basis of a harmonized channel plan, and ESIM are not able to transmit on those same frequencies when operated in the national territory of some countries. When ESIM operate in international waters and airspace, the responsible operators need to take the necessary steps, such as complying with appropriate technical limits to protect the abovementioned fixed services from harmful interference.

It should be noted that, in order to protect other services sharing the 27.5-29.5 GHz frequency band, different constraints could apply to different types of ESIM, as the interference scenarios with respect to some other services will be different for maritime, aeronautical and land based ESIM.

Considering the above described restrictions, as ESIM move from one location to another or from one country to another, the operating frequencies used might therefore need to change. To ensure continuity of service and meet user requirements, ESIM operators deem it critical to have the ability to operate within different parts of the frequency bands 17.7-19.7 GHz and 27.5-29.5 GHz, so that they can access the spectrum they need to provide the intended service.

WRC and ITU's contribution

WRC-19 agenda item 1.5 considers the use of the 17.7-19.7 GHz (space-to-Earth) and 27.5-29.5 GHz (Earth-to-space) frequency bands by earth stations in motion (ESIM) communicating with geostationary (GSO) space stations in the fixed-satellite service (FSS). This agenda item has studied three types of ESIM: aeronautical, maritime and land, depending on the type of vehicle on which they are installed.

Studies have been carried out on sharing and compatibility between ESIM and space as well as terrestrial services allocated in the frequency bands above. The studies carried out so far have identified example provisions to protect such services or example guidelines to assist an administration wishing to deploy ESIM on the territory under its jurisdiction.

WRC-15 adopted RR No. **5.527A** and Resolution 156 (WRC-15) specifying the conditions for the use of the 19.7-20.2 GHz and 29.5-30.0 GHz frequency bands by ESIM with some GSO FSS space stations. These conditions include: operation of ESIM within the envelope of the coordination agreements of the satellite network with which the ESIM is associated or, in the absence of such agreements, meeting the off-axis e.i.r.p. density levels specified in Annex 1 of Resolution 156 (WRC-15); permanent monitoring and control of ESIM and at least having the capability of receiving and acting upon "enable transmission" and "disable transmission" commands; use of techniques to track the associated GSO FSS satellite; and capability of the satellite network communicating with the ESIM to limit operation of such earth stations depending on geographical location.

The ESIM addressed under WRC-19 agenda item 1.5, which would potentially operate in the 27.5-29.5 GHz and 17.7-19.7 GHz bands, are similar in function and concept to the ESIM addressed in RR No. **5.527A** and Resolution 156 (WRC-15) for the 29.5-30.0 GHz and 19.7-20.2 GHz bands and, for the maritime ESIM case, the earth stations on board vessels (ESV) that were addressed in Resolution 902 (Rev.WRC-15) by WRC-03 and WRC-15. However, the allocation, sharing and interference environments of the C-band, the Ku-band, and the 19.7-20.2 GHz/29.5-30 GHz bands are different from those in the 17.7-19.7 GHz/27.5-29.5 GHz bands, and must be addressed accordingly.

As background, for ESVs in the 6 GHz and 14 GHz frequency bands, WRC-03 recognized difficulties in the use of the coordination procedure in Appendix 7 to the Radio Regulations and decided to use instead the concept of fixed distance and specific antenna diameters for the protection of terrestrial systems.

In addressing ESIM in the 27.5-29.5 GHz and 17.7-19.7 GHz bands, due account is taken of available ITU-R materials, such as those included in the CPM Reports to previous WRC's on ESIM and ESV in other FSS bands.

WRC-19 will decide on the regulatory and technical conditions under which the 17.7-19.7 GHz (space-to-Earth) and 27.5-29.5 GHz (Earth-to-space) frequency bands can be used by ESIM communicating with GSO space stations in the FSS.

3. Overlapping Frequency Bands under consideration

Studies have been done to address mutual compatibility & sharing feasibility among the services/applications for which allocation/identification is envisaged.

AI1.6 – NGSO FSS Res. 159 (WRC-15)	AI1.13 – IMT Res. 238 (WRC-15)	AI1.14 – HAPS Res. 160 (WRC-15)	AI9.1 (9.1.9) – FSS Res. 162 (WRC-15)
	24.25-27.5	24.25-27.5 (Reg. 2)	
37.5-39.5 (s-E*)	37-40.5	38-39.5 (globally)	
39.5-42.5 (s-E*)	40.5-42.5		
47.2-50.2 (E-s*)	47.2-50.2		
50.4-51.4 (E-s*)	50.4-52.6		51.4-52.4 (E-s*)

* E-s: Earth-to-space; s-E: space-to-Earth ** Frequency in GHz

Annex 1: Relevant links

5G

- ITU's approach to 5G
- IMT Vision for 2020 and beyond
- 5G — Fifth generation of mobile technologies
- IMT Traffic estimates for the years 2020 to 2030
- ITU agrees on key 5G performance requirements for IMT-2020
- ITU Forum "Towards 5G Enabled Gigabit Society"
- ITU-T specifications related to IMT-2020
- Minimum requirements related to technical performance for IMT-2020 radio interface
- Emerging Trends in 5G/IMT2020
- WRC-19 Agenda Item 1.13
- Resolution 238 (WRC-15)
- Report of the CPM to WRC-19

HAPS

- Connecting the World from 20,000 meters
- WRC-19 Agenda Item 1.14
- Resolution 160 (WRC-15)
- Report of the CPM to WRC-19

NON GEO FSS Satellite

- ITU-R Working Party 4A
- Report of the CPM to WRC-19
- WRC-19 Agenda Item 1.6 and Resolution 159 (WRC-15).
- WRC-19 Agenda Item 7 and Resolution 86 (Rev.WRC-07).

non-GSO satellite systems with short-duration missions

- ITU-R Working Party 4A
- ITU-R Working Party 7B
- Report of the CPM to WRC-19
- WRC-19 Agenda Item 7 and Resolution 86 (Rev.WRC-07)
- WRC-19 Agenda Item 1.7 and to Resolution 659 (WRC-15)

Earth stations in motion (ESIM)

- ITU-R Working Party 4A
- Report of the CPM to WRC-19
- WRC-19 Agenda Item 1.5
- Resolution 158 (WRC-15)

[i] See ITU ICT Regulatory database.