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Satellite connectivity

Visions for space services at the World Radiocommunication Conference

ITUWRC DUBAI2023

ITU

Securing sustainable development in and from space

Doreen Bogdan-Martin, ITU Secretary-General

> *Satellites are a critical part of our toolkit to connect the unconnected.*
>
> Doreen Bogdan-Martin

Satellite networks are essential for improving access to information, education, health, and other vital services. At the midpoint of the United Nations 2030 Agenda, they can help put the Sustainable Development Goals (SDGs) back on track.

With 2.6 billion people still offline worldwide, satellites are a critical part of our toolkit to connect the unconnected.

Innovative space-based technologies offer increasingly economical connectivity for remote and underserved people and communities, including in the least-developed countries (LDCs) where about two-thirds of the population remains offline.

Space services rely on efficient use of the radio spectrum and associated orbits. These will be major topics at our upcoming World Radiocommunication Conference, WRC-23, whose outcomes will shape digital development for the rest of the decade and further into the future.

When over 3000 delegates from the Member States of the International Telecommunication Union (ITU) gather in Dubai towards the end of this year, they will negotiate intensively over updates to the Radio Regulations.

The regulatory procedures outlined in that unique, extensive, ITU-maintained treaty include the coordination of radio-frequency assignments and avoidance of harmful radio interference to and from space services.

This latest *ITU News Magazine* highlights such key topics for space services at WRC-23.

Alongside the nuts and bolts of spectrum regulation and harmonization, we will tackle pressing questions about sustainability of the radio-frequency spectrum and associated satellite-orbit resources used by space services. In parallel, the conference gives us a prime opportunity to advance ITU's central mission: connecting the whole world and leaving no one behind.


WORLD RADIOCOMMUNICATION CONFERENCE
ITUWRC
DUBAI2023
20 November – 15 December 2023
Dubai, United Arab Emirates
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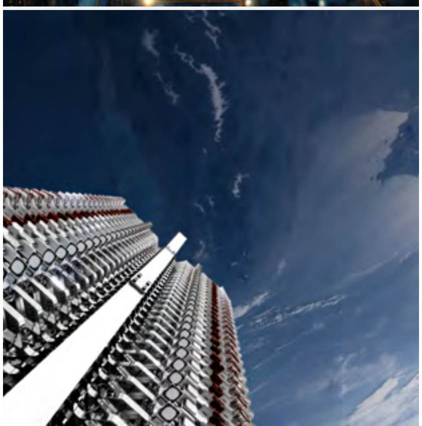
Editor-in-Chief: Neil MacDonald
Editorial Assistant: Angela Smith
Digital Communication Editor: Christine Vanoli

Editorial office:
Tel.: +41 22 730 5723/5683
E-mail: itunews@itu.int

Mailing address:
International Telecommunication Union
Place des Nations
CH–1211 Geneva 20 (Switzerland)



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> *“Satellites are essential for enhancing lives in the modern digital economy.”*
>
> Mario Maniewicz

Space services: Connectivity and Earth observation via satellite

Mario Maniewicz, Director,
ITU Radiocommunication Bureau

Satellites are essential for enhancing lives in the modern digital economy. They provide much needed communication connectivity solutions and support vital services across diverse sectors, including agriculture, banking, and transportation. They also save lives during emergencies and offer crucial environmental insights.

Despite their diverse applications, all satellite technologies depend on one key factor: the availability of radio frequencies that are protected from receiving harmful interference. This makes the International Telecommunication Union (ITU) essential to ensuring sustainable and equitable access to space.

During the ITU Plenipotentiary Conference (PP-22) held in Bucharest, Romania, last year, governments from around the world recognized and bolstered the organization’s indispensable role in satellite communication regulation.

PP-22 Resolution 219, "Sustainability of the radio-frequency spectrum and associate satellite orbit resources used by space services," calls for urgent studies in the ITU Radiocommunication Sector (ITU–R) on the increasing use of spectrum and associated non-geostationary satellite orbits and the long-term sustainability of those resources.

It also calls for ITU–R studies on equitable access to, and rational and compatible use of, geostationary and non-geostationary orbit and spectrum resources, consistent with the objectives of Article 44 of ITU's Constitution.

Clearly, spectrum for the space services will be a key focus at the World Radiocommunication Conference (WRC-23), set to take place in Dubai, United Arab Emirates, between 20 November and 15 December 2023.

Key issues to be discussed at WRC-23 include:

- Improvements to the international regulatory framework for geostationary and non-geostationary satellites while promoting equitable access for all countries.
- The regulatory framework for the use of earth stations in motion, notably onboard aircraft and ships, for communication with geostationary and non-geostationary satellites.
- Use of satellite technologies for broadband services to improve connectivity, particularly in remote areas.
- Increasing the use of inter-satellite links for downloading Earth-observation data in quasi-real time.
- New spectrum to enhance radiocommunications for the safety of aircraft and regularity of flights.
- Facilitating the use of space research and Earth exploration-satellite services for climate monitoring, weather prediction and other scientific missions.

> *"Clearly, spectrum for the space services will be a key focus at the World Radiocommunication Conference."*

Ensuring adequate spectrum availability

Scientific observation is crucial on Earth and in space. Satellite data, especially from Earth observation and meteorological satellites, is vital for weather forecasts, climate monitoring, and timely alerts that aid decision-making for societal well-being.

WRC-23 participants will therefore work on better addressing the need for spectrum for Earth observation and space weather monitoring. Delegates will be considering the spectrum requirements for space weather sensors in unprecedented detail.

Access to protection and proper frequency band management for Earth observation is vital for accurate weather predictions. Successive World Radiocommunication Conference cycles have safeguarded radio-frequency bands for atmospheric observation systems like radar, sounders, and radiosondes.

The conference will also review the use of the 1240–1300 megahertz (MHz) frequency band by radio amateurs to determine whether additional measures are required to protect radionavigation satellite ground receivers in this band.

Shaping future radiocommunication frameworks

ITU's Member States in April approved the Report of the Conference Preparatory Meeting to WRC-23, which summarizes and analyses the results of extensive ITU–R technical studies and possible solutions to satisfy WRC-23 agenda items. The report is available in ITU's six official languages.

The third and final Inter-regional Workshop on WRC-23 Preparations, taking place 27–29 September, gives participants another opportunity to consider proposed solutions to the issues that have been identified.

This latest *ITU News Magazine* captures industry perspectives, as well as the views of specialized international and regional organizations, on key issues related to space services ahead of WRC-23.

These include views from satellite operators; insights on maximizing spectrum usage; questions about equitable access; concerns about space sustainability; and calls for regulation to keep pace with fast-evolving investments and technologies.

The outcomes of WRC-23 will be pivotal in shaping the future frameworks for radiocommunication services in all countries. I thank all the experts who have contributed to this edition for bringing their perspectives to the table.

I am confident these articles offer a well-informed overview and look forward to welcoming our delegates from around the world to WRC-23.

"Satellite data, especially from Earth observation and meteorological satellites, is vital for weather forecasts, climate monitoring, and timely alerts that aid decision-making for societal well-being."

"The outcomes of WRC-23 will be pivotal in shaping the future frameworks for radiocommunication services in all countries."

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Key issues for discussion at WRC-23

Victor Strelets, Chairman,
ITU Radiocommunication Sector Study Group 4

Some items on the agenda of the upcoming World Radiocommunication Conference, WRC-23, relate to fixed, mobile, broadcasting, and radio-determination satellite services.

Study Group 4 of the ITU Radiocommunication Sector (ITU-R – *one of three sectors of the International Telecommunication Union*) is responsible for preparing these agenda items, aiming to ensure efficient use of the radio spectrum and satellite orbit systems and networks.

> *Non-GSO satellite systems are one of the top priorities on the WRC-23 agenda.*
>
> Victor Strelets

GSO and non-GSO satellite systems

Non-geostationary satellite orbit (non-GSO) systems are one of the top priorities on the WRC-23 agenda.

First, coexistence must be ensured between non-GSO and geostationary satellite orbit (GSO) systems, with protection being ensured for both kinds of satellites. This requires accurate calculations of potential interference to and from non-GSOs, allowing possible modifications to non-GSO systems to be considered where needed.

Improved rules for non-GSOs should also cover those on orbital tolerances. These will be treated under the conference's agenda items for satellite services (7A), milestone reporting (7B), and aggregate interference to GSOs (7J), along with a functional description for software tools to determine non-GSO fixed-satellite service (FSS) system or network conformity (ITU–R Recommendation S.1503).

More efficient use of spectrum

Satellite operators expect decisions at WRC-23 to provide maximum flexibility in the use of spectrum allocations for certain purposes.

These include: earth stations in motion (ESIM) in the FSS, under agenda items 1.15 and 1.16; inter-satellite communications in the FSS, item 1.17; and FSS in the existing broadcasting-satellite service (BSS), item 1.19.

WRC-23 discussions on these topics will aim to allow for more efficient spectrum use than is currently the case.

“Satellite operators expect decisions at WRC-23 to provide maximum flexibility in the use of spectrum allocations for certain purposes.”

Fast-moving satellite industry

Amid rapid satellite development in recent years, non-GSO systems have been deployed on a large scale. At the same time, new high-capacity satellites have gone into geostationary orbit.

On the regulatory side, the addition of a satellite component to the International Mobile Telecommunications (IMT-2020) ecosystem has enabled satellite usage in cellular networks, along with new satellite services and other innovations.

Member States of the International Telecommunication Union (ITU) are increasingly raising the issue of sustainability, equitable access, and the rational use of GSO and non-GSO spectrum resources. Resolution 219 of the ITU Plenipotentiary Conference (Bucharest, 2022) reflects these concerns.

WRC-23 needs to continue giving high priority to establishing equitable access to satellite orbits. This means recognizing the special needs of developing countries, often including geographical challenges.

“WRC-23 needs to continue giving high priority to establishing equitable access to satellite orbits.”

Keeping regulation timely and efficient

The development of innovative satellite technologies has now moved significantly ahead of regulations in the use of radio-frequency spectrum and satellite orbits. As this gap continues widening, ITU must find new approaches to keep international satellite regulation timely and relevant for the industry.

Technology is advancing so rapidly that some operators have begun to introduce new satellite technologies using GSO and non-GSO satellites without waiting for conference decisions to regulate such use. Moreover, national administrations sometimes grant authorization for such uses in the absence of internationally agreed rules.

Exceptions and exemptions

Concerns are growing about derogations from the ITU Radio Regulations, particularly under 4.4 of Article 4 – which allows national administrations to assign frequencies exceptionally, outside the Table of Frequency Allocations and other treaty requirements, as long as such assignments do not cause harmful interference to any existing radio services.

The conference will consider how to deal with the widespread use of 4.4, for non-coordinated satellite networks. It should also clarify whether the derogation option under 4.4 should be available for all radio systems, or only non-commercial systems.

Overall, WRC-23 must clarify how administrations use the provision, when they have the right to invoke it, and which specific circumstances justify exceptional use of 4.4 on a temporary basis.

“WRC-23 should instruct the ITU Radiocommunication Sector to conduct urgent studies on the potential for reusing frequency bands allocated to mobile services for non-GSO satellite systems.”

Simplifying the WRC preparatory cycle

The Radio Regulations, containing the rules and regulations for the use of the radio-frequency spectrum and satellite orbits, are updated approximately every four years, in line with ITU's associated conference cycle.

Perhaps the time has come to think about reducing the number of years between World Radiocommunication Conferences and simplifying the preparatory cycle and associated documentation. One way forward could be to reassess the current Conference Preparatory Meeting (CPM) format and to consider merging the two CPM sessions into one.

Given the rapid growth, transformation and innovation phase the satellite industry is now going through, WRC-23 should instruct the ITU Radiocommunication Sector to conduct urgent studies on the potential for reusing frequency bands allocated to mobile services for non-GSO satellite systems.

National administrations, as well as companies and organizations taking part as ITU Sector Members, need to jointly address these new issues, strengthen the ITU–R framework, and pursue global solutions for the benefit of all.

About the World Radiocommunication Conference (WRC-23)

Convened by the International Telecommunication Union (ITU) every 3–4 years, World Radiocommunication Conferences enable administrations worldwide to review, and, if necessary, revise the Radio Regulations, the international treaty governing the use of the radio-frequency spectrum and geostationary and non-geostationary satellite orbits.

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Explore WRC-23 topics:

Countdown to WRC-23

The future of Coordinated Universal Time

Land, sea and airwaves

Conference website: WRC-23.

WRC-23: What's at stake for the space industry?

Isabelle Mauro, Director General,
Global Satellite Operators Association

The World Radiocommunication Conference (WRC-23) is taking place at a time of rapid growth and innovation in the satellite sector.

This key part of the space industry is booming, with global investments exceeding USD 10 billion last year – up from USD 300 million in 2012. Today, multiple networks in several orbits are set to work together to provide resilient, secure and continuous Internet coverage in every part of the world.

At the same time, the satellite sector is becoming fully integrated into the telecoms ecosystem. This entails supporting 5G and cloud connectivity – as is reflected with the inclusion of non-terrestrial networks (NTN) in the technical specifications for 3GPP (3rd Generation Partnership Project) mobile broadband standards.

For satellite operators and their hundreds of millions of users worldwide, WRC-23 can unlock further opportunities.

> *For satellite operators and their hundreds of millions of users worldwide, WRC-23 can unlock further opportunities.*
>
> Isabelle Mauro

Several agenda items for the conference seek more efficient use of existing radio spectrum for satellites, subject to appropriate safeguards to protect incumbent services. In effect, updating spectrum allocations would extend connectivity to where it is most needed, from landlocked countries and small island developing states to earth stations in motion (ESIM) – mobile telecommunication platforms to connect ships, aircraft and land vehicles.

"Amid extreme weather and a rising incidence of disasters, space-based systems increasingly provide backup for vital emergency services."

The merits of satellite connectivity

With access to sufficient spectrum, satellites can provide crucial wide-area connectivity, either through direct links or by providing backhaul for cellular or community Wi-Fi solutions.

Satellites are continually improving people's access to information, education and health, as well as contributing to sustainable development. By 2030, the number of people connecting to broadband via satellite is set to reach 500 million globally – double the current number – with the related social and economic benefits expected to soar from USD 39 billion last year to USD 250 billion in 2030.

Amid extreme weather and a rising incidence of disasters, space-based systems increasingly provide backup for vital emergency services. The response to the earthquake in Türkiye and Syria earlier this year is just one example.

Satellite connectivity is fast improving, with high throughout satellite platforms concentrating power in smaller areas and increasing link performance, allowing repeated reuse of spectrum in existing fixed-satellite service (FSS) allocations.

This technology supports the use of smaller devices, which lowers equipment costs while giving users more bandwidth. In parallel, next-generation software-defined networking is helping to reduce operating costs, enabling greater scale and agility.

How WRC-23 can help satellite services

While some of the proposed regulatory updates look advantageous for the satellite industry, others appear potentially harmful.

New satellite systems increasingly rely on existing allocations in the L, S, C, Ku- and Ka-band for fixed and mobile users, while new allocations in Q/V bands are becoming essential for the expansion of gateways to interconnect with terrestrial systems, among other reasons. WRC-23 agenda items 1.15, 1.16 and 1.18 support these trends.

Satellite frequency allocations at 3600–3800 megahertz (MHz) and 6425–7025 MHz are similarly crucial to safeguard from harmful interference. However, the global expansion of mobile telecom services is putting pressure on these vital spectrum resources.

For this reason, the satellite industry supports no change in response to agenda items 1.2 and 1.3, which propose to identify additional spectrum for terrestrial International Mobile Telecommunications (IMT). Further, our industry is asking to suppress a four-year-old decision on harmonized IMT frequency bands (Resolution 175, WRC-19) and would support clarifications on Article No. 21.5 of the Radio Regulations to protect space services from aggregated interference from new generations of terrestrial stations.

“With a positive outcome from WRC-23, the satellite sector can continue making great strides to connect the globe.”

The industry's concerns about IMT

Given that demand for satellite services also continues rising, the satellite industry is very concerned about the proposal to harness spectrum for IMT in the already-congested 7–24 GHz frequency range. Proceeding with studies for a possible IMT identification in this range would cause major uncertainty for existing satellite services and could hinder their future development.

In our experience, commercial IMT deployments are not possible without relocating incumbent services from the relevant spectrum band. Furthermore, IMT already has access to around 1.9 gigahertz (GHz) of low and mid-band spectrum globally.

Additionally, much of the 17.25 GHz of mmWave spectrum that was made available at the last World Radiocommunication Conference (WRC-19) has neither been assigned nationally nor brought into use.

Cooperation on spectrum to connect the unconnected

By working together, we can pool the strengths of terrestrial and non-terrestrial technologies to connect the 2.6 billion people worldwide who are still offline. To do this, we must ensure adequate spectrum, free from harmful interference, for both existing and new satellite-based services.

We are facing these challenges in a period of unprecedented innovation. With a positive outcome from WRC-23, the satellite sector can continue making great strides to connect the globe.


Intelsat

Expanding the use of geostationary FSS space stations with mobility

Hazem Moakkit, Vice President, Spectrum Strategy, Intelsat

In our increasingly connected world, the expectation of being "always on" is no longer bound by geography or location. But while terrestrial mobile coverage continues expanding, there will always be situations and locations where satellite connectivity is the only solution to keep people and machines connected everywhere and on the go.

Terrestrial coverage may remain unavailable due to geographic or economic limitations, or it may be disrupted by temporary events or disasters. Satellites, geostationary and non-geostationary, provide the crucial backstop in such situations.

> *"In our increasingly connected world, the expectation of being "always on" is no longer bound by geography or location."*
>
> Hazem Moakkit

Relying on satellite connectivity

Industries such as mining, construction, and agriculture require satellite services to keep their heavy equipment and crews connected in hard-to-reach locations. Vessels at sea, such as cruise ships, merchant ships, commercial fishing fleets and even offshore platforms, also rely on satellites to stay connected.

Whether on land, at sea or in the air, companies continue to rely on satellite connectivity services and solutions to keep their operations in motion, continuously connected everywhere. And when disaster strikes, emergency responders rely on satellite access for critical communications whenever and wherever cellular connectivity fails.

“Whether on land, at sea or in the air, companies continue to rely on satellite connectivity services and solutions to keep their operations in motion, continuously connected everywhere.”

The need for cost-efficient, high-performing mobile earth stations

As the demand for mobile connectivity surges, so does the need for cost-efficient, high-performing mobile earth stations.

Historically, ground stations for two-way satellite communications were large and heavy. Even the relatively low-cost VSAT (very small aperture terminal) systems in use since the 1980s had to be operated by specialist technicians.

Today's terminals, in contrast, meet the size and performance efficiencies for a host of mobile connectivity applications.*

Flat-panel antennas – with their simple design and make-before-break capability that enables them to link to satellites ahead – have proven ideal for land and air mobile use.

Electronically steered, phased-array antennas (ESAs) use multi-beam scanning to seamlessly track and switch between multi-orbit satellites. For operators, these auto-point antennas are simpler and easy to use.

Satellite connectivity leaders KVH, Satcube, Starwin, and ST Engineering iDirect all provided information for this article on the latest advances in ground terminals.

Enhanced performance

New advances in satellite systems make mobility readily accessible and economical. Beamforming technology enables software-defined satellites – commonly called SDSs – to deliver satellite capacity precisely where and when needed.

Each SDS can form thousands of beams within its service area, only bound by the amount of spectrum available and the power of the spacecraft needed to launch these systems. This significantly changes the economics of satellite services.

The proliferation of non-geostationary satellites in the last few years has also brought a new paradigm to satellite communications, driven by a big push from advances in technology and a significant pull from consumers with an insatiable appetite for connectivity.

“Convergence is a recurring theme within the telecommunications industry at large.”

Regulatory challenges

Providing mobility in the fixed-satellite service (FSS), however, presents new regulatory challenges. The "classic" definition of FSS implies that earth stations are fixed, not mobile.

Over the years, successive World Radiocommunication Conferences have explored technical and regulatory frameworks to allow more flexibility within FSS systems. The upcoming World Radiocommunication Conference, WRC-23, is no different.

Agenda item 1.15 for the conference considers the possibility of providing aero and maritime flexibility within the planned FSS bands for geostationary satellites. Agenda item 1.16 focuses on earth stations in motion operating with non-geostationary satellites in the Ka-band.

The Radio Regulations – the international treaty governing the radio spectrum and geostationary and non-geostationary satellite orbits – are constantly evolving to stay up to date with the needs of countries worldwide.

Converging spectrum allocations

Convergence is a recurring theme within the telecommunications industry at large. Video, voice and data have all converged under the Internet Protocol (IP) as a unifying platform to transport all data.

Similarly, the regulatory lines between the various satellite spectrum allocations are becoming blurry. A Ku-band SDS, for instance, while fully respecting the Radio Regulations, may rely on unfettered access to large swaths of spectrum across the 10.7–12.75 gigahertz (GHz) frequency range.

Those frequencies also encompass multiple satellite spectrum allocations: FSS, Planned FSS, and broadcasting-satellite service (BSS). With proper coordination, such flexibility increases spectrum efficiency.

Keeping up with technology

The broader challenge that satellite operators and service providers all face is to keep up with the pace of technology, as well as rapidly evolving Radio Regulations. Unfortunately, decisions taken at World Radiocommunication Conferences every four years are often not quickly adopted in regulations at the national level.

The International Telecommunication Union (ITU) – the custodian of the Radio Regulations – holds workshops around the world to disseminate updates and explain the latest changes to governments, regulators and the industry. In the same vein, all ITU Member States are encouraged to integrate ITU decisions promptly into local regulations and make good use of the resulting flexibility.

"ITU Member States are encouraged to integrate ITU decisions promptly into local regulations and make good use of the resulting flexibility."

Telesat

Mobility through non-geostationary satellites: Enabling connections in motion

Mario Neri, Director, Spectrum Strategy and Innovation, Telesat

> *Many users could benefit from access to broadband connectivity through earth stations in motion.*
>
> Mario Neri

Connecting to a virtual private network, attending a video-conference call, or just streaming content from the Internet– are all doable with a portable, personal, connected device. These are online activities, like many others, that connected-device users can easily begin to take for granted.

Yet, they are only possible for those who are lucky enough to be served by high-speed, low-latency broadband.

The luxury may not always be available though, when on a ship, an aircraft or any other platform in motion.

You might view this as a fortunate coincidence. After all, who wants to travel next to someone taking a long video call, maybe engaging with their counterpart a bit too loudly?

At the same time, many users could benefit from access to broadband connectivity through earth stations in motion (ESIM) – particularly those connected via non-geostationary orbit (non-GSO) fixed-satellite service (FSS) systems, or non-GSO ESIM.

Shipboard and inflight links

Think of oceangoing ship crews, who may sail for months at a time, gaining high-quality video links to connect with family, with friends or with a medical practitioner. The stranding of some seafarers on maritime platforms amid the COVID-19 pandemic further underlined the value of crew connectivity.

Making connectivity mobile can also support aeronautical applications. With growing demand for inflight connectivity and a focus on the gate-to-gate, fully connected passenger experience, non-GSO ESIM offer the potential for fibre-like link performance across the entire flight path.

This will apply globally, even over the polar regions.

Overall, innovative non-GSO FSS systems supporting ESIM applications could soon provide the same level of connectivity as that enjoyed by fixed, land-based users. This includes the same low-latency experience – something that cannot be achieved when using geostationary-satellite technologies. The upcoming World Radiocommunication Conference (WRC-23) – under agenda item 1.16 – will address the use of non-GSO ESIM in Ka-band frequencies to enable high-quality shipboard and in-flight connectivity.

This is not the first time the International Telecommunication Union (ITU) has developed a regulatory framework that could bridge the digital divide for users of satellite services on the move.

Let us remind ourselves of the successful deliberations at the last two WRCs, in 2015 and 2019, that enabled the use of ESIM communicating with GSO networks (GSO ESIM) in some parts of the Ka-band.

“Just think of oceangoing ship crews, who may sail for months at a time, gaining high-quality video links to connect with family, with friends or with a medical practitioner.”

Ensuring protection alongside development

Clearly, a sound regulatory framework should foster the development of new technologies, while also ensuring the protection of existing and planned services and related applications.

As was the case for GSO ESIM in the Ka-band before, the draft text for the new resolution under agenda item 1.16 contains technical, regulatory and operational provisions to protect incumbent space and terrestrial services operating under a co-frequency allocation. These provisions will make harmful interference unlikely. Even so, during the WRC-23 preparatory study cycle, ITU's membership has considered the responsibilities of administrations in case a non-GSO ESIM causes interference.

The general agreement seems to be that the sole formal responsibility for removing such interference would be with the notifying administration for the non-GSO satellite system under which the interfering ESIM operates.

While the role of other administrations in such cases, if any, is still under discussion, the conference is expected to provide the necessary guidance. Among the topics that may help in this discussion at WRC-23 are the functionalities of a network control and monitoring centre (NCMC) with operational authority over non-GSO ESIM.

Enabling new technology deployments

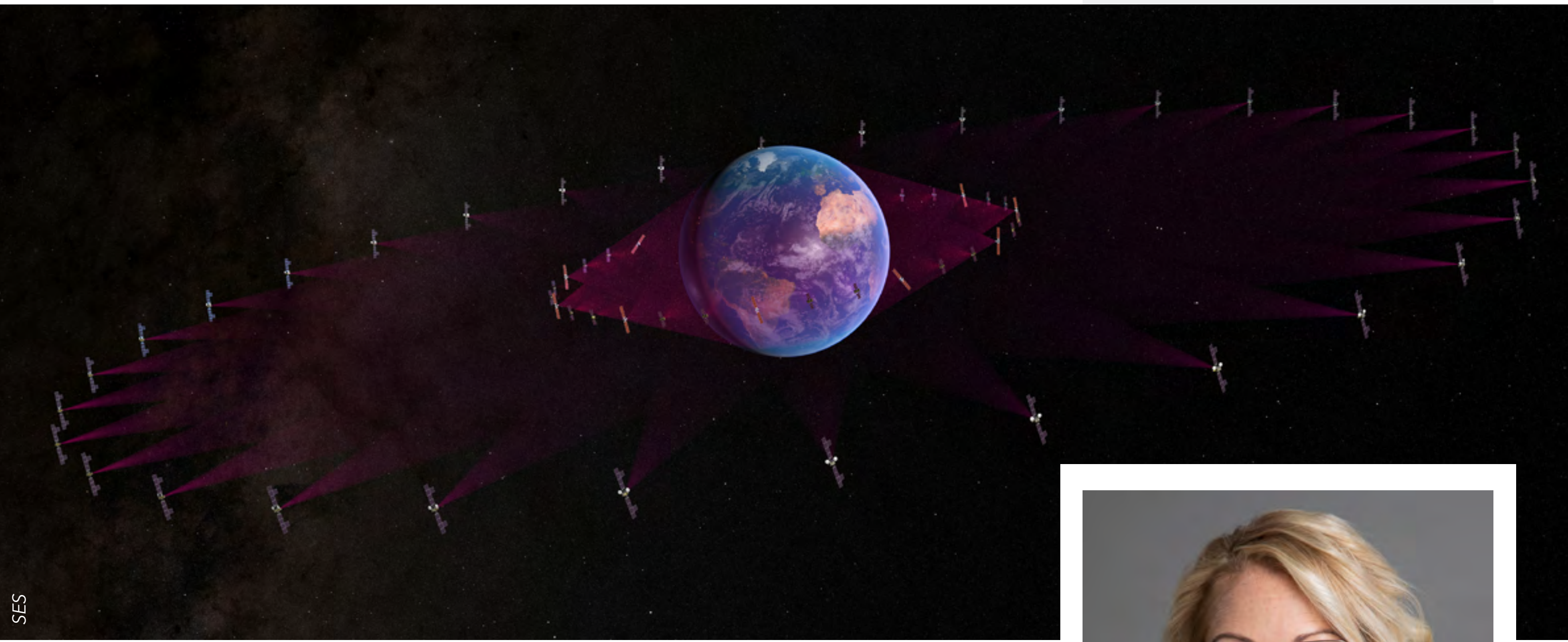
WRC-23 is expected, like the previous WRCs, to achieve broad consensus on key issues for satellite operation and communications. By defining a fair, balanced and effective regulatory environment, the quadrennial ITU conference series enables the development and deployment of innovative satellite technologies.

Any new communication technology can be useful for consumers, businesses and governments, bringing potential improvements in the lives of citizens worldwide.

The benefits that non-GSO ESIM operating in the Ka-band can provide – including, for instance, high throughput links, terrestrial-like low-latency, and full global service – are undoubtedly worth the effort involved in WRC-23 discussions.

And in your future travels, if you feel your fellow passengers are talking too loudly, you may just have to ask them to kindly lower the volume on their devices!

"The benefits that non-GSO ESIM operating in the Ka-band can provide... are undoubtedly worth the effort involved in WRC-23 discussions."



SES

> *Earth-observation satellites in low Earth orbit will be able to transmit high-quality images or other data back to the ground in real time.*
>
> Anna Marklund

Inter-satellite links: Why it's important to expand usage in available spectrum

Anna Marklund, Director, WRC Lead,
Spectrum Management and Development, SES

Historically, the Tracking and Data Relay Satellite (TDRS) constellation and the European Data Relay Satellite (EDRS) system have provided some degree of satellite-to-satellite relay capability.

However, more spectrum is needed to support the growing number of Earth observation, Internet-of-Things, scientific, and other satellite missions in low Earth orbit, as well as their growing bandwidth requirements.

This is because low-Earth-orbit satellites can only communicate with ground stations within a restricted view of the Earth. Inter-satellite links are one way to overcome this limitation, as data can be relayed to and from the ground via other satellites, including those located in a different orbit.

A concerted solution

The upcoming World Radiocommunication Conference (WRC-23) will consider ways to facilitate connecting the globe by extending available options when operating satellite spectrum. Under agenda item 1.17, the conference will define the regulatory framework for the use of certain fixed-satellite service (FSS) frequencies – namely 11.7–12.7 gigahertz (GHz), 18.1–18.6 GHz, 18.8–20.2 GHz, and 27.5–30 GHz – for inter-satellite links.

Establishing such a framework would enable FSS satellites in higher orbits to serve as relays for satellites operating in low Earth orbit, resulting in more efficient and intensive use of existing FSS spectrum. Thus, Earth-observation satellites in low Earth orbit will be able to transmit high-quality images or other data back to the ground in real time. Internet-of-Things traffic will be deliverable in real time everywhere. Similarly, future crewed space stations should be able to communicate with the Earth at any time, even when over water and out of sight of land.

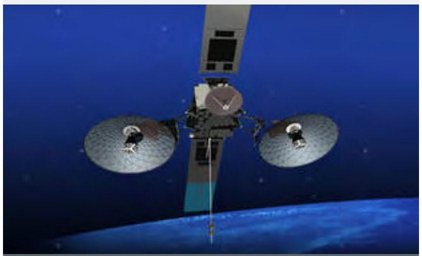
About agenda item 1.17

WRC-23's agenda item 1.17 aims to find a regulatory mechanism and define the steps for implementation, including the introduction of new FSS space-to-space allocations or new inter-satellite service allocations, subject to appropriate technical and operational limitations to avoid harmful interference.

The most promising approach to arise from WRC-23 preparatory work involves adding an inter-satellite service allocation in the subject bands while limiting inter-satellite operations to the cone of coverage of the FSS satellite. The use of an inter-satellite service allocation helps overcome different interpretations of the FSS definition.

In addition, limiting the cone of coverage ensures overall similarity to current FSS operations that may have already been coordinated. Inter-satellite service operations that are similar to current FSS operations will ease the work of assessing interference impacts for national administrations and the International Telecommunication Union (ITU).

"WRC-23's agenda item 1.17 aims to find a regulatory mechanism and define the steps for implementation."



NASA's Tracking and Data Relay Satellite constellation

The TDRS constellation, deployed by the National Aeronautics and Space Administration (NASA), consists of a number of geosynchronous (GEO) satellites (first generation, second generation and third generation satellites) distributed over the Atlantic Ocean, Pacific Ocean and Indian Ocean.

Learn more

Over the course of the WRC-23 study cycle, the ITU Radiocommunication Sector (ITU-R) has drafted various innovative and tailored solutions to protect other radio services, including during the second session of the Conference Preparatory Meeting (CPM) in March and April this year. Administrations, industry members and stakeholders at the meeting were able to converge on this single approach for agenda item 1.17 in the CPM Report, highlighting the collaborative spirit on this agenda item.

From antenna characteristics to power-flux densities on the ground, and via the reuse of existing coordination agreements, the CPM Report includes regulatory answers on how best to enable satellite-based data relay without changing the overall interference environment.

Building up satellite relay services

The benefits of using existing FSS spectrum for inter-satellite links are clear. Such a solution will help telecom operators swiftly meet an immediate and growing need.

The entire industry and governments globally, therefore, have an interest in reaching a conclusion at WRC-23 to enable the use of FSS spectrum for inter-satellite links without undue constraints. Just as important, of course, is to protect all potentially impacted radio services, including geostationary and non-geostationary satellite, terrestrial and Earth-observation services.

Building on the excellent work on agenda item 1.17, a future topic is also proposed for study for the 2027 World Radiocommunication Conference. This future agenda item would aim to enable other existing satellite bands – such as the mobile satellite service bands and potentially the C-band and other FSS bands – to also be used for satellite relay services.

"The entire industry and governments globally have an interest in reaching a conclusion at WRC-23 to enable the use of FSS spectrum for inter-satellite links without undue constraints."

European Data Relay Satellite System

The EDRS reduces time delays in the transmission of large quantities of data, supporting a fast, reliable, seamless telecom network. By making on-demand data available at the right place at the right time, this independent satellite system enhances Europe's self-reliance.

Learn more

The future of narrowband mobile satellite services

Jennifer A. Manner, Senior Vice President, EchoStar

Innovative technology and standards are finally coming together to enable a global ecosystem of satellite-enabled 5G narrowband mobile-satellite services (MSS).

Today, mobile satellite service systems can transmit to and receive from consumer electronic devices, while offering transparency to the user. These devices include Apple and Android, as well as small Internet-of-Things (IoT) devices that also support terrestrial-wireless services.

The existing mobile satellite service spectrum can support all those services. As standards are implemented, as devices go to market, and as users recognize the benefits of mobile-satellite service capability, however, demand for it will grow.

This warrants the allocation of additional spectrum for mobile-satellite services.

> *Innovative technology and standards are finally coming together to enable a global ecosystem of satellite-enabled 5G narrowband mobile-satellite services.*
>
> Jennifer A. Manner

ITU studies and potential new allocations

Studies by the International Telecommunication Union (ITU) ahead of the upcoming World Radiocommunication Conference (WRC-23) have considered possible new spectrum allocations for mobile-satellite services in several frequency bands between 1695 megahertz (MHz) and 3400 MHz.

At the previous conference four years ago, Resolution 248 (WRC-19) invited the ITU Radiocommunication Sector (ITU–R) to conduct "studies relating to spectrum needs and potential new allocations to the mobile-satellite service in the frequency bands 1695–1710 MHz, 2010–2025 MHz, 3300–3315 MHz and 3385–3400 MHz for future development of narrowband mobile-satellite systems" while ensuring the protection of existing primary services in those bands and adjacent frequency bands.

Such studies were limited to non-geostationary satellites for mobile-satellite services operating low data rate systems.

Ambiguity leading to inconclusive studies

As the Conference Preparatory Meeting (CPM) text for WRC-23 notes, Resolution 248 (WRC-19) is ambiguous regarding the appropriate technical and operational characteristics of narrowband mobile-satellite services.

With this ambiguity still unresolved, studies were not concluded either on the spectrum needs for those services or on potential sharing and compatibility with existing primary services. Consequently, suitable new allocations were not determined for low data-rate or narrowband applications.

Nor can the key discussion at WRC-23, under agenda item 1.18, produce new allocations for future development of narrowband mobile-satellite systems.

> *"As standards are implemented, as devices go to market, and as users recognize the benefits of mobile-satellite service capability ... demand for it will grow."*

Resolution 248 (WRC-19) – excerpt

*[T]*he studies… are to be limited to those systems with space stations that have a maximum equivalent isotropically radiated power (e.i.r.p.) of 27 dBW *[decibel watts]* or less, with a beamwidth of no more than 120 degrees, and earth stations that individually communicate no more than once every 15 minutes, for no more than 4 seconds at a time, with a maximum e.i.r.p. of 7 dBW.

The preparatory meeting identified three ways to satisfy agenda item 1.18:

1. ***Suppressing*** Resolution 248
2. ***Revising*** Resolution 248
3. ***Allocating*** the 2010–2025 MHz frequency band to mobile-satellite services in ITU–R Region 1 (consisting of Africa, Europe and parts of Asia) despite the lack of studies, either for narrowband mobile-satellite services in Region 1 or for conventional mobile-satellite services – with the latter option also requiring the suppression of Resolution 248.

A future agenda item to meet high demand

Whichever way agenda item 1.18 is addressed, WRC-23 will likely have to consider an agenda item for the next conference to allocate spectrum for mobile-satellite services.

Demand continues growing, not only for established services like Internet of Things, but also new and innovative ones, such as direct-to-device, that are already proliferating in discussions among standards bodies. The 3rd Generation Partnership Project (3GPP), for example, now allows satellite services to be included in its non-terrestrial network (NTN) standards.

"Whichever way agenda item 1.18 is addressed, WRC-23 will likely have to consider an agenda item for the next conference to allocate spectrum for mobile-satellite services."

CPM Report

The CPM Report, prepared and approved at the second CPM session (CPM23-2) in Geneva, Switzerland, between 27 March and 6 April, provides a good basis for the discussions at the WRC-23 conference later this year.

Download your copy (available in six languages)


Adobe Stock

Orbital characteristics and operational flexibility in non-GSO space stations

Julie Zoller, Head, Global Regulatory Affairs, Amazon Project Kuiper

There are two types of Earth orbits: geostationary-satellite orbits (GSO), where satellites are at an altitude of almost 36,000 km above the equator and appear motionless to antennas on Earth, and non-geostationary satellite orbits (non-GSO), the category for all other satellites.

Non-GSO systems generally fall into two types based on altitude: low Earth orbit (LEO), between 400 km and 2000 km; and medium Earth orbit (MEO), between LEO and GSO levels.

Every satellite filing with the International Telecommunication Union (ITU) should include essential orbital characteristics, such as planned altitude and inclination. In addition, GSO operators must provide certain orbital tolerance details, including limits – meaning the extent of possible deviations from the orbital information provided to ITU.

For non-GSO systems, however, orbital tolerance is neither required in the filing nor limited in practice.

> *"ITU filings for non-GSO systems continue to grow in volume and size, with plans now calling for constellations of tens, hundreds, or thousands of satellites in low Earth orbit."*
>
> Julie Zoller

Expanding non-GSO systems

ITU filings for non-GSO systems continue to grow in volume and size, with plans now calling for constellations of tens, hundreds, or thousands of satellites in low Earth orbit. This has heightened the need to consider orbital tolerance in the non-GSO environment.

The issue is on the table for the upcoming World Radiocommunication Conference (WRC-23).

Under agenda item 7, topic A considers setting tolerance limits on certain orbital characteristics of non-GSO space stations. Agenda item 7, topic B, considers a post-milestone procedure to address the scenario of a sustained reduction in the number of satellites in orbit after milestones have been met.

Besides numbers of satellites, the most important orbital parameters for a non-GSO system are the altitudes and inclinations of the orbital planes making up the constellation. Orbital tolerance information would establish the permissible variation in altitude and inclination from the filed parameters.

A simple example illustrates the point: If WRC-23 decides to limit orbital tolerance to 10 per cent for altitude and 10 per cent for inclination, then a non-GSO system in a circular orbit, if filed with an altitude of 500 kilometres (km) and an inclination of 30 degrees, would have an orbital tolerance of +/– 50 km altitude and +/– 3 degrees inclination.

> *While ITU does not manage physical aspects of objects in space, there is a relationship between space safety and orbital tolerance.*

Why does orbital tolerance matter?

Orbital tolerance affects how the Radio Regulations are applied.

Orbital tolerance has a bearing on whether a particular space station is considered to be in the right place at the right time to meet the first major milestone in the life of a non-GSO system, "bringing into use."

Using the above example, a satellite at 450 km and 27 degrees inclination, or 550 km and 33 degrees inclination, or anything in between, would be regarded as maintained on a notified orbital plane. Thus, after a continuous period of 90 days, it would satisfy the criteria of bringing into use.

Orbital tolerance also affects the accuracy of the ITU Master International Frequency Register (MIFR). By extension, it may alter how we understand the ITU Radiocommunication Bureau's findings on matters such as Article 21 of the Radio Regulations regarding power flux-density limits, or the approach to coordination between non-GSO systems.

To calculate power-flux densities on the ground, or to avoid harmful radio interference, we need to know exactly where satellites are.

Space safety and orbital tolerance

While ITU does not manage physical aspects of objects in space, there is a relationship between space safety and orbital tolerance. Temporary operational variances in orbital parameters – such as during the re-phasing of satellites in a constellation or due to the solar cycle – are expected occurrences that should be excluded from orbital tolerance requirements.

Satellite operators require this flexibility. Among the operator community, the generally accepted best practice is to have adequate radial separation between large non-GSO constellations for space safety purposes.

The preparatory report (CPM Report) for WRC-23 reflects the general agreement "*that any tolerances should provide the necessary flexibility to accommodate normal operations of non-GSO systems and allow operational coexistence between systems filed at the same or close orbital positions.*"

Decisions needed at WRC-23

The decisions ITU Member States make at WRC-23 on non-GSO orbital tolerance will affect the rational, efficient, economic, and equitable use of the radio-frequency spectrum and satellite orbits, as well as influence the space safety ecosystem.

Ideally, the decision on orbital tolerance will meet the needs of countries and operators worldwide. This means enabling the operational flexibility needed for satellite operators to provide good service to their customers, while complementing space safety objectives.

These overarching objectives suggest that WRC-23 should limit non-GSO orbital tolerance.

"The decisions ITU Member States make at WRC-23 on non-GSO orbital tolerance will affect the rational, efficient, economic, and equitable use of the radio frequency spectrum and satellite orbits, as well as influence the space safety ecosystem."

Rwanda Space Agency

Space plans: Protecting long-term access to orbit and spectrum

Georges Kwizera, Chief Technology Officer, Rwanda Space Agency and Chairman, African Telecommunications Union (ATU) Working Group on Satellite Regulatory Matters

Satellites are revolutionizing telecommunications and transforming domains such as Earth observation, navigation, and space exploration. In an era such as this, we must urgently address the challenges of securing the two fundamental resources for satellite operations: space orbital positions and their associated frequency spectrum.

The International Telecommunication Union (ITU) has been entrusted with the task of allocating and safeguarding satellite resources. In line with its mandate, ITU has employed two primary approaches:

- allocating a portion of the radio-frequency spectrum on a first come, first served basis to promote efficient utilization.
- reserving the remaining resources, with a special focus on providing equitable access for developing countries.

"Satellites are revolutionizing telecoms and transforming domains such as Earth observation, navigation, and space exploration."

Georges Kwizera

The commitment to fairness is enshrined in the Radio Regulations, especially Appendices 30, 30A and 30B.

A critical opportunity for resource recovery

Unfortunately, over the years, reserved resources have suffered from a lack of adequate protection measures within the treaty. The upcoming World Radiocommunication Conference (WRC-23) in Dubai, United Arab Emirates, presents a critical opportunity to address this pressing issue and ensure the long-term accessibility and sustainability of satellite orbit resources.

One significant focus of WRC-23 will be the recovery of orbital resources for satellite-based broadcasting services in 55 affected countries, with 31 of those being African nations.

The discussions aim to incorporate the recovered resources into planned resource allocations, offering the necessary protection and ensuring future utilization in line with the treaty. This commendable effort, supported by ITU and its Radiocommunication Bureau (BR) since 2015, demonstrates a commitment to rectifying past oversights and fostering equitable access for all nations.

The concept of implicit agreement

Another key topic to be addressed at WRC-23 is the concept of "implicit agreement" within the treaty governing planned satellite resources. While intended to facilitate coordination between existing satellite resource holders and new satellite network introducers, this concept has inadvertently caused significant challenges, especially for developing countries.

A lack of qualified staff and low capacity to respond to coordination requests has often resulted in the degradation of planned satellite resources, rendering them unusable. In effect, a country's silence on such interference or infringement has amounted to consent in international legal terms.

As developing countries seek to unlock their satellite potential, this concept of implicit agreement must be removed or mitigated. Such measures are imperative for WRC-23 to address.

Such steps will ensure that all nations can pursue their development aspirations, irrespective of current resources, without undue hindrance.

"As developing countries seek to unlock their satellite potential, the concept of implicit agreement must be removed or mitigated."

Radio Regulations

The Radio Regulations consist of four volumes of text, produced and maintained by ITU. These correspond to the international treaty governing the global use of radio-frequency spectrum and satellite orbits.

The 2020 version, currently in force, will be updated in 2024, after the next quadrennial global conference organized by ITU to harmonize radio frequency and satellite orbit requirements worldwide.

Equitable access to satellite resources

WRC-23 will also delve into the issue of satellite networks that are registered with ITU for global coverage while serving only a small area of the globe in reality. This limitation undermines the aspirations of countries, particularly developing ones, seeking to establish satellite services.

By addressing this concern and considering mechanisms to enable wider access, the conference can promote equitable access to satellite resources, which will fuel innovation, economic growth, and knowledge exchange for all nations.

Furthermore, ITU needs mechanisms to enable new or increasingly engaged members to acquire satellite resources and establish long-term access without unnecessary bureaucratic hurdles. This inclusive approach will foster global collaboration and ensure that every nation can participate fully in the benefits of ITU membership.

"As we embark on this crucial event, let us seize the opportunity to foster global cooperation and unleash the full potential of satellite resources for the benefit of all nations."

What WRC-23 can resolve

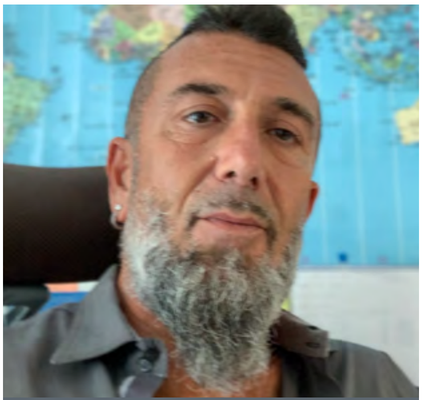
The upcoming WRC-23 promises to be a significant milestone in safeguarding long-term access to satellite resources. The protection of orbital positions and associated frequency spectrum is paramount for the efficient operation of satellites, which is vital to facilitate communication, Earth observation, navigation, and space exploration.

This conference – by addressing resource recovery, revisiting the concept of implicit agreement, re-examining unnecessary global coverage for certain networks, and ensuring smooth access for all ITU members – holds the potential to shape a more equitable and sustainable future for satellite technology.

As we embark on this crucial event, let us seize the opportunity to foster global cooperation and unleash the full potential of satellite resources for the benefit of all nations.

Nairobi, Kenya, 2020: An ITU workshop brought together 31 African countries and European counterparts to discuss the recovery of affected satellite resources.

Eutelsat



Pier Francesco Foggia

Zeljko Mendas

Effective space plans for satellite connectivity and broadcasting

Pier Francesco Foggia, Senior Engineer, Access to Spectrum and Orbit Resources, and Zeljko Mendas, Senior Engineer, Planned Spectrum, Eutelsat

In 1977, the World Administrative Radiocommunication Conference adopted a new global plan to secure equitable orbital access for satellite broadcasting for each Member State of the International Telecommunication Union (ITU).

Appendices 30 and 30A – Direct-to-home services

This led to the addition of Appendices 30 and 30A in the Radio Regulations, the international treaty that governs the use of the frequency spectrum and associated satellite orbits.

Each ITU Member State was assigned 10 channels with a bandwidth of 27 megahertz (MHz) to be used for direct-to-home broadcasting services with domestic coverage.

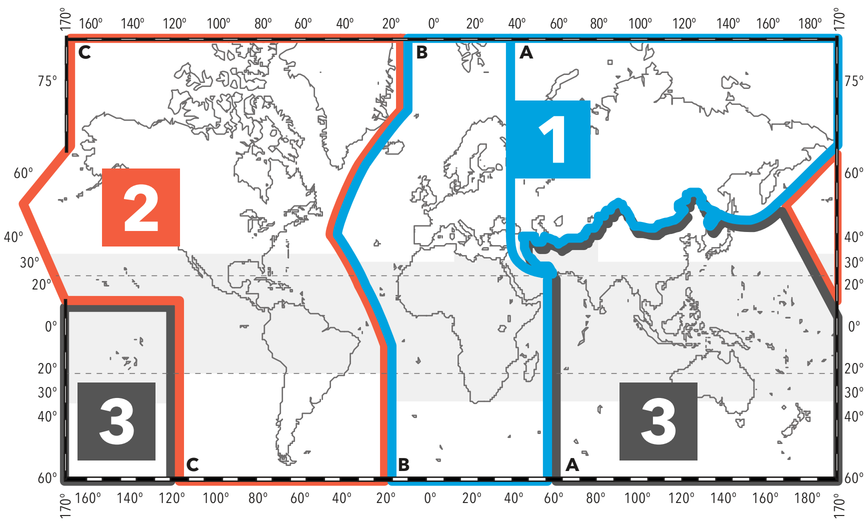
However, the original Broadcasting Satellite Service (BSS) Plan established at the 1977 conference covered only countries in ITU Regions 1 and 3 (see map), leaving out the Americas and parts of the Pacific.

The Regional Administrative Radiocommunication Conference in 1983, however, added national frequency assignments for Region 2 countries, thus completing the global plan.

> *In 1977, the World Administrative Radio-communication Conference adopted a new global plan to secure equitable orbital access for satellite broadcasting for each ITU Member State.*
>
> Pier Francesco Foggia and Zeljko Mendas

Global regions for spectrum allocation

For the allocation of radio spectrum frequencies the world is divided into three regions



Region 1	Region 2	Region 3
Arab States	Americas	Asia-Pacific
Africa		
Europe		
Commonwealth of Independent States		

Digital in the 1990s

The situation changed dramatically in the 1990s with the emergence of digital modulation and digital broadcasting. Improved technical characteristics provided more capacity for each country, while the use of smaller receiving antennas and lower operating EIRP (effective isotropic radiated power) levels paved the way for the effective deployment of nationwide satellite-broadcasting services in many countries.

As a result, the World Radiocommunication Conference in 2000 revised the global BSS Plan, adopting new technical parameters. These included more resilient digital modulation and coding, associated with smaller receiving antennas and lower operating EIRP for national coverage.

With these changes, new satellite projects proved technically and economically viable with the creation of sub-regional systems. These new satellite networks covered large territories and provided services to a very large number of countries.

Several of these enjoyed great success, with wide acceptance by the populations they served. This was particularly true in Europe, with the Eutelsat 13E project providing a good example.

Several other projects followed, some national and some supra-national and sub-regional, demonstrating the benefits of the digital broadcasting service for those countries covered by satellite beams, both within and outside Europe.

Renewed national frequency assignments

The last World Radiocommunication Conference, WRC-19, adopted Resolution 559, providing more than 50 countries with the possibility of applying for a renewed national assignment in the global BSS Plan at an alternative orbital position.

This would enhance signal quality in their territories, enabling those countries to finalize and pursue their own satellite broadcasting plans.

Appendix 30B – planned FSS bands

WARC Orb-88 – The World Administrative Radio Conference on the use of the geostationary-satellite orbit and planning of space services utilizing (2nd session), held in Geneva, Switzerland in 1988 – added Appendix 30B, defining planned fixed-satellite service (FSS) bands, to the Radio Regulations. The new appendix introduced national allotments, guaranteeing equitable access to orbits for every ITU Member State.

> *The World Radiocommunication Conference in 2000 revised the global BSS Plan, adopting new technical parameters.*

What are planned and unplanned services?

Planned services >> based on *a priori* planning procedures guaranteeing equitable access to orbit/spectrum resources for future use.

Non-planned services >> based on *ad hoc* coordination procedures aiming for efficiency of orbit/spectrum use and interference-free operation, satisfying actual requirements.

Learn more

Appendix 30B gives each country the right to operate portions of a frequency band, according to specified characteristics, in both C and Ku frequency bands.

The main difference between the traditional, unplanned FSS frequency bands and the Appendix 30B bands is the coexistence of national allocations and additional systems. Since 1988, many changes have been made to fully protect national allotments and allow additional systems to operate in an interference-free environment.

Appendix 30B – increased capacity for satellite communications

The total amount of spectrum allocated to Appendix 30B in the Radio Regulations is 800 megahertz (MHz), including 300 MHz for the C band and 500 MHz for the Ku band. This represents a considerable increase in capacity for satellite communications.

The need for additional resources

The number of satellites capable of operating in the planned bands has increased significantly over the last 30 years, reflecting interest among satellite operators and in turn increasing the need for spectrum resources.

In addition, many countries have been able to convert their national allocations into actual frequency assignments, allowing them to operate geostationary-satellite orbit (GSO) satellites in compliance with the Radio Regulations.

The upcoming World Radiocommunication Conference (WRC-23) will address several proposed amendments to Appendices 30, 30A and 30B.

The proposed modifications under WRC-23 agenda item 7 follow on from the latest study cycle – aiming to ensure equitable access to space for each country and make resources available for satellite space stations.

These bands, as the only ones available for national satellite projects, are especially crucial for emerging economies.

> *"The last World Radiocommunication Conference, WRC-19, adopted Resolution 559, providing more than 50 countries with the possibility of applying for a renewed national assignment in the global BSS Plan at an alternative orbital position."*

> *"The number of satellites capable of operating in the planned bands has increased significantly over the last 30 years, reflecting interest among satellite operators and in turn increasing the need for spectrum resources."*

Viasat

Sharing between satellite orbit systems

Mark Dankberg, Chairman of the Board,
Chief Executive Officer, and Co-Founder, Viasat

GSOs provide a large and constant field of view and are more economical for regional operators.

Mark Dankberg

Countries invest in satellites for many reasons, including national security, sovereign control, and to connect their people. For most of them, satellite communications will be their most significant participation in the space economy.

In the coming months, however, a few large operators for non-geostationary-satellite orbit (non-GSO) systems seek to change long-standing spectrum sharing rules in a way that would impact tens of billions of dollars of satellite investments, with consequences for all countries. The largest non-GSO operators seek to reduce interference protection for geostationary-satellite orbit (GSO) system operators, claiming non-GSOs are superior and merit regulatory precedence. But GSOs and non-GSOs are both just orbits, both using the same payload technology.

To draw a parallel, terrestrial wireless coverage depends on tower locations. For satellites, orbits are like tower locations.

GSOs provide a large and constant field of view and are more economical for regional operators. A constant field of view makes GSO much more financially attractive for virtually all applications, including high-speed data, and much better for broadcasting.

Because non-GSOs are closer to the Earth and their field of view is smaller, the coverage provided by each satellite is less. It may require dozens, hundreds, or thousands of satellites to provide the same service to a region that a single GSO provides. Non-GSO operators must therefore be global because the limitations of their orbits demand it.

The technologies currently used

An orbit only defines the location of satellite towers. Payload technology defines capability.

While the same technology can be used in both GSOs and non-GSOs, GSOs have demonstrated more advancements in technologies such as ground-based beam forming, large deployable antennas, efficient high-power buses, and thermal management.

GSO and non-GSO systems have both used fixed-feed spot beams, electronically steered spot beams, software defined on-board processing and routing, adaptive modulation and coding, multi-band user and feeder link architectures, and satellite-to-satellite links. Satellites in both orbits can use ground terminals with the latest phased arrays. But only GSOs can use simple, very inexpensive, fixed terminals.

Hundreds of millions of homes worldwide depend on free-to-air TV provided by GSOs. This happens through receive-only terminals on sides of buildings in densely-populated neighbourhoods, without the 360-degree view of the sky required by most non-GSOs.

New GSO systems will offer similarly inexpensive "OTT streaming terminals" that can bring the latest Internet entertainment and information services to those homes on similar terms.

"New GSO systems will offer similarly inexpensive "OTT streaming terminals" that can bring the latest Internet entertainment and information services to those homes on similar terms."

Service speeds

The shorter signal propagation paths used by non-GSOs – because they are closer to the Earth – does not mean higher transmission speeds.

Service speeds depend on power-flux density (PFD) on the ground, terminal size and gain (G/T), and the interference received from other users of the same spectrum at different look angles. Thermal link budgets yield the same downlink data rates for GSOs and non-GSOs with equivalent terminal size and PFD.

Spatial separation

The first large non-GSO operators are unfortunately seeking to exploit the lack of competition and deploy numerous small terminals. These increase interference potential, require very large spatial separation, and thus pre-empt future non-GSO competition.

GSO orbital slots define the spatial separation among operators and enable the type of spectrum sharing that allows access to space by any nation on Earth.

Both non-GSO and GSO operators need spatial separation, along with the associated spectrum re-use and interference protection. Spread spectrum technology and innovative coordination agreements can enable GSO systems to use terminals just as small – while preserving equitable access.

Rules for sharing spectrum

Rules for sharing spectrum in non-geostationary orbits are nascent, and the largest non-GSO systems could exploit that void by deploying many very small terminals. This would pre-empt prospective new non-GSO operators using the same spectrum, as well as taking spectrum and look-angles away from GSO operators.

Nations need to understand the implications of these dynamics and act now, at the national level, to ensure access to space.

“Nations need to understand the implications of these dynamics and act now, at the national level, to ensure access to space.”

Spectrum sharing rules, including spatial interference protection and PFD, amount to "rules of the road" that allow all nations to participate in space. When it comes to sharing spectrum with GSOs, the principles of interference protection are expressed in terms such as equivalent power-flux density (EPFD) and inline events.

These rules have enabled decades of non-GSO and GSO innovations. Reducing GSO interference protection would not only undermine innovation for GSOs, it would also limit, or even completely deny, spatial protection and look angles to future non-GSOs.

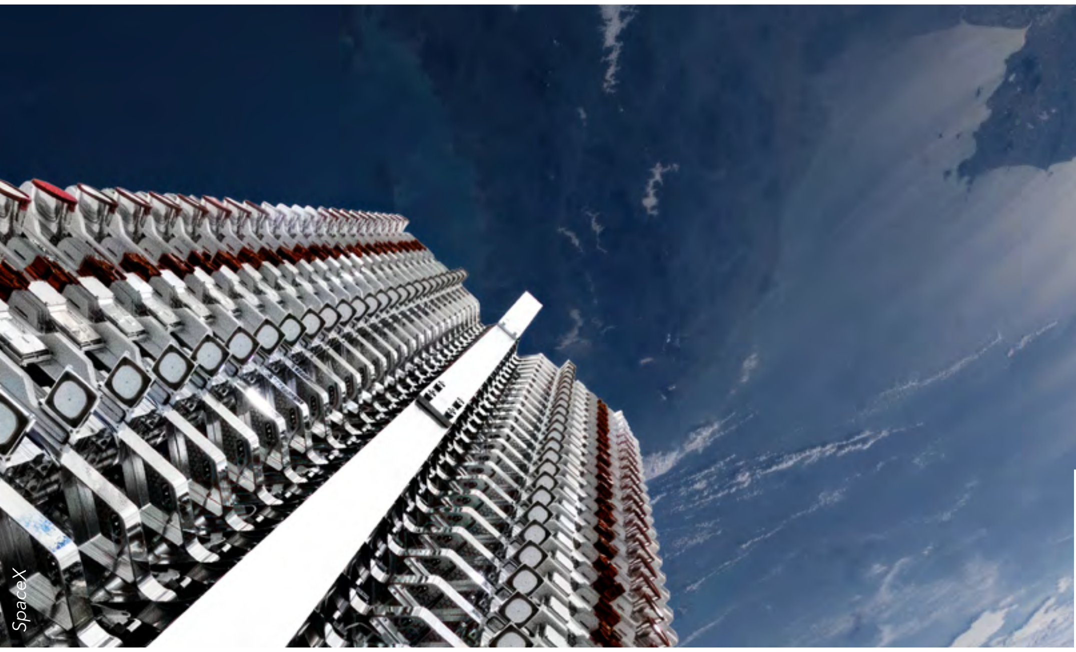
Safeguarding the New Space Age for all

Viasat, a global communications company with a long-term vision for global satellite development, urges all ITU Member States to get the facts on how the changes advocated by the largest non-GSO systems would change the rules of the road.

Changes that purport to improve non-GSO services would adversely affect GSO satellites and constrain the ability of all nations to participate in the high-speed, bandwidth-rich, multi-orbit New Space Age.

The proposed changes would benefit only the largest and richest few – while constraining the rest of us not only in non-GSO, but in what should be an exciting GSO future as well.

"Changes that purport to improve non-GSO services would adversely affect GSO satellites and constrain the ability of all nations to participate in the high-speed, bandwidth-rich, multi-orbit New Space Age."



Enabling global connectivity with non-GSO satellite constellations

David Goldman, Vice President, Satellite Policy, SpaceX

With the upcoming World Radiocommunication Conference (WRC-23), we have a generational opportunity to ensure low-latency connectivity and equitable access to the world's airwaves for people that need it most by reconsidering decades-old regulations designed for a previous era. This opportunity arises because those living in unserved areas around the globe are on the precipice of a transformation in connectivity, built on the services provided by next-generation satellite networks. Advanced technologies using non-geostationary-satellite orbit (non-GSO) constellations are bringing high-quality broadband everywhere, and with key enabling technologies, like SpaceX's interconnected laser mesh, do so essentially immediately.

Recognizing this potential, several ITU Member State administrations have proposed considering whether updated rules can increase the capability of next-generation satellite systems to serve people without harming users of legacy technologies.

> *With the upcoming WRC-23, we have a generational opportunity to ensure low-latency connectivity and equitable access to the world's airwaves for people that need it most...*
>
> David Goldman

This entails updating the applicable rules encapsulated in the Radio Regulations maintained by the International Telecommunication Union (ITU). One potential option is to simply apply methods already adopted in other spectrum bands to the workhorse Ku and Ka frequencies, which have physical qualities best suited for connecting the unconnected. This can be done, of course, acknowledging that specific cases like geostationary-satellite orbit (GSO) broadcasting services in Ku-band may require protection criteria that are different from those of typical fixed satellite service ones.

The choice is straightforward. If the world's top radio-frequency engineers cannot find a way to improve the rules after studying the issue, then nothing changes. But if they can come up with a solution, millions of previously unserved people will finally receive the low-latency broadband they need, with no effect on GSO systems.

The only wrong choice is delay, which could prove debilitating for people who remain unserved and need connectivity now. Missing this narrow window for action will deny them next-generation broadband access for a generation, all because of an outdated regulatory regime.

After all, one of ITU's key pillars is the efficient use of shared spectrum resources. The ITU established this principle for a good reason: efficiency means more and better systems to connect people.

“Unlike mobile systems, which enjoy access to exclusive spectrum, next-generation low-Earth-orbit systems must share spectrum bands both with each other and with other technologies such as traditional GSO satellites.”

Issues with ITU Radio Regulation Article 22 “EPFD” limits and why they should be revised urgently

Unlike mobile systems, which enjoy access to exclusive spectrum, next-generation low-Earth-orbit systems must share spectrum bands both with each other and with other technologies such as traditional GSO satellites. To help manage the assortment of technologies that share the same frequencies, ITU has developed a complex array of sharing rules.

For their part, GSO-satellite operators devised a set of rules while non-GSOs were still hypothetical back in 1997 and 2000. These rules required future non-GSOs to meet an equivalent power flux density (EPFD). The GSOs essentially said that non-GSO satellites are required to whisper while distant GSOs can shout. EPFD rules that were adopted are increasingly recognized as over-protective, thus resulting in severe operational constraints, significant capacity reduction and unused spectrum for non-GSO systems. Today's next-generation systems include advanced capabilities that can connect countless more people worldwide without causing unacceptable interference to GSOs using the same spectrum.

The EPFD limits set out in ITU Radio Regulation Article 22, therefore, should be revised urgently to bring the promise of high-speed broadband to everyone, no matter their location.

Inefficient EPFD provisions

ITU explored similar rules in the 40/50 gigahertz frequency bands (also known as the "Q/V" bands) during the last World Radiocommunication Conference study cycle from 2015 to 2019.

Just as the organization's study groups and membership concluded then, the existing EPFD provisions in Ku- and Ka-bands are spectrally inefficient. This inefficiency unnecessarily constrains the ability of non-GSO systems to meet growing demand from consumers for high-speed, low-latency broadband, without providing any additional protections for legacy GSO satellites.

Fortunately, this study of the Q/V bands can help point the way for the prime Ku/Ka bands. The last conference, WRC-19, approved a new sharing framework to protect GSO networks in Q/V while allowing non-GSO systems some needed operational flexibility to meet demand.

We should now study whether we can leverage the same findings for Ku/Ka while ensuring protection criteria for specific legacy services, like satellite broadcasting, which may require *ad hoc* solutions.

"Today's next-generation systems include advanced capabilities that can connect countless more people worldwide without causing unacceptable interference to GSOs using the same spectrum."

The urgency of EPFD in Ku/Ka bands

Revisiting EPFD in Ku/Ka is even more urgent today given Resolution 219 from the last ITU Plenipotentiary Conference (PP-22), which instructed study groups in the Radiocommunication Sector (ITU–R) to study equitable access to, and rational and compatible use of, GSO and non-GSO spectrum resources.

In other words, re-evaluating EPFD would ensure that users that depend on next-generation satellite systems have equitable access to the spectrum.

"Re-evaluating EPFD would ensure that users that depend on next-generation satellite systems have equitable access to the spectrum."

The WRC-23 proposal would also require that any studies of how to improve the rules ensure GSO systems will not receive unacceptable interference, driving the best outcome for all users — particularly those in emerging markets that have been denied equitable access to connectivity by outdated rules for too long.

Adobe Stock

With the onset of IMT services, the accompanying satellite component of IMT became inevitable.

David Weinreich

Direct satellite connectivity to mobile

David Weinreich, Chair, Working Party 4B,
ITU Radiocommunication Sector Study Group 4

Right now, direct-to-handset satellite communication is attracting consumers. It is also being considered by regulators. And as a very likely agenda item for the World Radiocommunication Conference in another four years, direct-to-handset is also being examined at the International Telecommunication Union (ITU) by study groups of the ITU Radiocommunication Sector (ITU-R).

The earliest promise of a mobile phone service

In the mid-to-late 1990s, the mobile-satellite service (MSS) segment was the first to show the promise of a true portable telephone service – where you could dial a number from almost anywhere, to connect with whoever you liked, anytime you wanted. This was the idea behind the so-called "Big LEO" (low Earth-orbit) systems of the time.

What the MSS proponents did not anticipate, of course, was the exponential growth and implementation of competing systems, initially called the Future Public Land Mobile Telecommunication Service (FPLMTS) and nowadays known as International Mobile Telecommunications (IMT).

A lack of customers soon led to financial difficulties and the eventual reorganization of MSS non-geostationary orbit (non-GSO) systems.

Today, however, we seem to have come full circle, with non-GSO MSS systems ready to soon provide direct-to-handset connectivity. This is due mainly to two new factors: the ability to construct smaller, more efficient spacecraft; and reduced launch costs.

The satellite component of IMT

With the onset of IMT services, the accompanying satellite component of IMT became inevitable. Consequently, the ITU working party for MSS and other satellite systems – Working Party 4B in ITU–R Study Group 4 (Satellite Services) – developed ITU–R Recommendations for both the satellite components of the initial version of IMT and the follow-on IMT Advanced – commonly known as 4G.

At its recent June meeting, WP 4B approved steps to begin developing satellite radio interfaces for IMT 2030 – broadly equated with 6G mobile services. This work draws heavily on similar characteristics and documentation developed for the terrestrial element of IMT under ITU–R Study Group 5 (Terrestrial Services), Working Party 5D.

Technological developments

Direct-to-handset services will require new applications of current technologies. Due to the compactness of today's cell phones, the antenna contained within is necessarily small. This means they offer relatively little antenna gain – just the ability to get enough satellite signal to make communication possible.

Coupled with this is the distance to and from the satellite over which the signal must travel. Given small antenna size, the satellite needs to be relatively near and is almost sure to be part of a low Earth-orbit constellation.

Advanced antenna techniques, possibly involving multi-beam, electronically configured adaptive arrays for both user terminals and spacecraft, are also likely be required.

"Due to the compactness of today's cell phones, the antenna contained within is necessarily small."

ITU-R Study Group 4

Systems and networks for the fixed-satellite service, mobile-satellite service, broadcasting-satellite service, and radiodetermination-satellite service.

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Radio frequency issues

Which type of radio-frequency spectrum will be used to support direct-to-handset communication is important to know. Will it be terrestrial or satellite?

Both hold existing, worldwide allocations in the ITU Radio Regulations, and each offers advantages and disadvantages. The tricky part will be determining how to utilize the same spectrum for both satellite and terrestrial terminals simultaneously.

Major differences between terrestrial and satellite signal levels could create significant interference problems that need solving before direct-to-handset services can begin.

> *Regulatory bodies have begun to tackle issues that might arise with the implementation of direct-to-handset services.*

Tackling technical challenges

Regulatory bodies have already begun to tackle the anticipated problems and regulatory issues that might arise with the implementation of direct-to-handset services.

In North America, the US Federal Communications Commission has released a rulemaking inquiry requesting comments on how to provide "supplemental coverage from space" that would give users a single network solution. This would mean seamless connectivity, even when the user is beyond cellular coverage range.

In Europe, Project Team FM 44 of the European Conference of Postal and Telecommunications Administrations (CEPT) Electronic Communications Committee is considering the frequency management aspects of direct-to-handset. A forthcoming report may provide guidance on technical challenges, including how to address potential interference problems.

The scenario is also being considered in Asia and Australasia as various satellite operators initiate services with limited functionality, such as emergency-only connectivity to first responders.

All in one handset

Direct-to-handset IMT operation is coming soon. If, as hoped, it achieves a safe and productive landing, it will give users a full complement of expected mobile services with far greater range and versatility, all with a single handset.

The views expressed in this article are those of the Chairman of Working Party 4B of ITU–R Study Group 4, and do not reflect the views or actions of any commercial entity.


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