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# Synergy for outer space sustainability: ITU's role today and tomorrow

**Véronique Glaude[a], Cessy Karina[b]**

*Senior Radiocommunication Engineers, Space Services Department, International Telecommunication Union, Place des Nations 1211 Genève, Switzerland [a] veronique.glaude@itu.int and [b] cessy.karina@itu.int*

**Abstract**

This paper analyses the growing concerns about the long-term sustainability of space activities from the perspective of the International Telecommunication Union (ITU), the UN's specialized agency for ICTs, and how the ITU Radiocommunication Sector can strengthen its impact in global governance of outer space. The paper will also address the importance of balancing the interests of new companies on the one hand, particularly those providing connectivity everywhere on land, while preserving existing space activities on the other hand, notably astronomy. This is relevant given that radio spectrum and associated orbits in outer space are limited natural resources to be accessed equitably by all states.

This paper will specifically assess the existing mechanisms supporting sustainability of space as laid in the Radio Regulations, as well as the ongoing development of mechanisms in the space sector by international actors. This study will draw a map of the roles and interactions of the main actors in sustainability of space to identify gaps and missing links.

The results show that the ITU has a specific, established and continuing role to play in maintaining and ensuring sustainability of space for all through its elaborate international mechanisms, such as the Radio Regulations and the World Radiocommunication Conferences.

The ITU can further increase and strengthen its contribution and impact on the sustainability of the outer space activities by, among others, including rules on satellite constellation deployment, end-of-life conditions, and more generally by establishing the exchange of best practices and lessons learned with other sectors for the management and monitoring of limited natural resources. These recommendations can reinforce other initiatives by fostering multistakeholder and multidisciplinary synergies and cooperation for a comprehensive global approach to the governance of sustainable activities in outer space tomorrow.

**Keywords:** ITU, space sustainability, Radio Regulations, spectrum, constellations, space law

**Acronyms/Abbreviations**

ADR : Active Debris Removal
ASAT : Anti-satellite weapons
The Bureau : The ITU Radiocommunication Bureau
BSS : Broadcasting Satellite Service
COPUOS: Committee on the Peaceful Uses of Outer Space
EOL : End-Of-Life
EPFL : École Polytechnique Fédérale de Lausanne
FSS : Fixed Satellite Service
GSO : Geostationary Orbit
GNSS : Global Navigation Satellite System
Non-GSO: Non-Geostationary Orbit
ITU : International Telecommunication Union
ITU-D : ITU Telecommunication Development Sector
ITU-R : ITU Radiocommunication Sector
ITU-T : ITU Telecommunication Standardization Sector
ITU Master Register: ITU Master International Frequency Register
IADC : Inter-Agency Orbital Debris Coordination Committee
IAU : International Astronomical Union
ICTs : Information and Communication Technologies
ISO : International Organization for Standardization
IOS : In Orbit Servicing
IoT : Internet of Things
ITSO : International Telecommunications Satellite Organization
LEX : Life extension
LTS : Long-term Sustainability of Outer Space Activities
RR : Radio Regulations
SIRRS : Satellite Interference Reporting and Resolution System
TFA : RR Table of Frequency Allocation
UN : United Nations
UNIDIR: UN Institute for Disarmament Research
UNODA: UN Office for Disarmament Affairs
UNOOSA: UN Office for Outer Space Affairs
WRC : World Radiocommunication Conference
WRC-15: WRC in 2015
WRC-19: WRC in 2019
WRC-23: WRC in 2023

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## 1. Introduction

As the use of space resources and the number of satellite launches increase, the global economy is becoming increasingly dependent on the reliability of these satellites for telecommunications, Earth observation, geo-localisation, and other services. The concept of "space sustainability" has become a key issue for all stakeholders in the space sector, whether they are new (e.g. small satellite operators or constellation entrepreneurs) or more established private sector companies, or from the public sector (e.g. the strong dependency of critical national infrastructure on space-based assets). Consequently, it is critical that governance structures strike the right balance between the interests of private companies and governments in space activities (e.g. global connectivity), and the protection of existing space activities on one hand (e.g. astronomical observations), while managing the increase of objects in space on the other hand.

The existing United Nations (UN) treaties [1] and principles on outer space, together with the more recent Long-term Sustainability of Outer Space Activities Guidelines (LTS Guidelines) adopted in 2019 [9] provide the fundamental regulatory framework for long-term sustainability of outer space activities. However, the implementation of the LTS Guidelines is voluntary and not legally binding under international law. States may choose to incorporate elements of the guidelines in their national legislation. However, this is highly dependent on political will and does not guarantee the implementation of the Guidelines in their entirety.

The International Telecommunication Union (ITU) is the UN Specialised Agency for information and communication technologies (ICTs). When investigating options for a new international binding regulatory framework, the ITU mechanism and principles are regularly cited and referenced in studies and analyses related to space sustainability.

In this paper we explore the role of ITU and how it contributes to space sustainability. After mapping the key space stakeholders, we examine the legal and regulatory frameworks in place and practical tools in the framework of the ITU environment. Before concluding, we explore the possible use of the ITU model and the possibilities for consolidating synergies at the international level to foster space sustainability.

## 2. International, national and organisational space stakeholders' cooperation

### *2.1 Intergovernmental level: ITU and other UN bodies*

The UN plays a key role in promoting the governance of space activities on a global scale and in the spirit of cooperation. It provides an overall framework to facilitate the negotiation and adoption of international treaties and other kinds of agreements on space, which are necessary to ensure its sustainable use.

The Committee on the Peaceful Uses of Outer Space (COPUOS) is the UN body responsible for promoting international cooperation in the peaceful uses of outer space and for the development of the international legal regime governing outer space. The UN Office for Outer Space Affairs (UNOOSA) is the secretariat for COPUOS. To date, COPUOS has developed five key treaties on activities in outer space, reflecting its essential role in enabling and sustaining space activities.

As the UN specialised agency for ICTs, ITU has three main areas of activity organised in 'sectors', sharing the responsibility of: the development of telecommunications networks to ensure connectivity for all (ITU-D), standardization in the telecommunication sector (ITU-T), and finally the sector dedicated to radiocommunications (ITU-R). The latter oversees the allocation and procedural management of radio spectrum and the use of associated orbits (GSO and non-GSO).

The UN Office for Disarmament Affairs (UNODA) and the UN Institute for Disarmament Research (UNIDIR) [2] are working on the safety and security of outer space. Their respective spheres of responsibility, however, remain exclusively in the security domain. For example, in May 2022, the first Open-ended Working Group on Reducing Space Threats [3] intended to create momentum at the international level to promote "norms, rules and principles of responsible behaviours" among current and future space actors. This is excluding the spectrum and orbit resources which remain under the responsibility of the ITU-R (see Fig. 1).

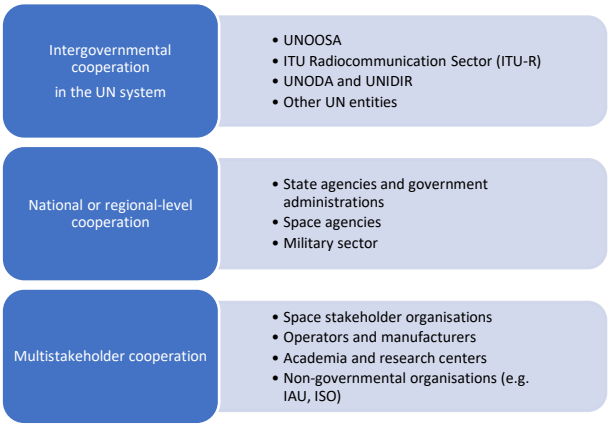


Fig. 1. International, national and organisational space stakeholders

### *2.2 Disparities between the space activities of national administrations and military activities*

More than 60 years after the beginning of human activities in space, there are still great disparities in resources between countries; not all have a programme dedicated to space activities, and/or legal and regulatory

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frameworks surrounding space activities. At the same time, the handful of countries that have been historically active in the space sector have benefited from well-organised activities with responsibilities clearly distributed among several national entities and administrations.

Military activity in space has also evolved to become more complex, as countries have integrated space into their national military capabilities and rely on space-based information for national security. The use of space for military purposes raises international, regional, and national security issues. For example, any interference with satellites (such as signal jamming) could trigger tensions or escalate conflicts. It also raises sustainability issues. The testing or use of anti-satellite (ASAT) weapons, for instance, involves physical collisions with satellites at high speeds (also known as "kinetic energy ASATs"), and are major sources of orbital debris [4].

*2.3 The role of space agencies*

Space agencies, such as ESA or NASA, are actively including sustainability-related considerations in their activities. To this end, they develop policies, standards, engineering tools, and programs; and they actively collaborate with key stakeholders in space to enable, and foster sustainability in their activities [5,6].

In addition, more than a dozen national space agencies participate in the Inter-Agency Orbital Debris Coordination Committee (IADC) to develop technical standards for orbital debris mitigation. While the IADC standards themselves are voluntary by nature (i.e. not legally binding), a growing number of countries have implemented national policies and regulatory frameworks in line with mitigation standards.

*2.4 The commercialisation of space*

Over the past decades, space activities have shifted from fully government-led to private sector involvement. The complex and lengthy considerations of appropriate norms and laws for a controlled and coordinated approach to space activities have given priority to an economic perspective such as the need to increase revenues rapidly within a few years.

Commercial satellite operators providing broadcasting or mobile communications are now developing offers to ensure space-based connectivity to cruise ships, planes and trains. Other constellations aim to bring broadband internet to every remote area on Earth.

Small satellites allow academics to explore the Earth, monitor climate change and connect the Internet of Things (IoT). More recently, crewed space missions are evolving and plans for space tourism, including hotels [7], are emerging.

These developments have prompted the private sector to request more and more access to space considering that it is large enough to operate any project. As newcomers to the space sector, private sector entities must learn and understand the rules and norms and be aware of the need for coordination, rights, and obligations to ensure the appropriate and sustainable use of outer space. From that perspective, the UN system must ensure that these new actors have a voice in UN fora and that the pace and capacity for adaptation is responsive to new needs, which are diverse and have yet to be proven by experience. In other words, new needs are evolving as space projects mature.

The practical case for constellations of thousands of satellites is at the heart of discussions on space sustainability because they are usually assumed to change the regulatory landscape of known space systems. Gaps in some rules established in the 1960s, when the first satellites were launched, are starting to appear, such as orbital debris management.

*2.5 Protecting astronomy: the role of the International Astronomical Union (IAU)*

The IAU is concerned about the growing number of satellite constellations that threaten astronomical observatories with pollution from light and radio emissions. In the spirit of cooperation, the organisation issued recommendations to all stakeholders and created the IAU Centre for the Protection of the Dark and Quiet Skies from satellite constellation interference [8].

## 3. Legal and regulatory frameworks among space stakeholders

Before analysing practical rules within the ITU framework, this paper will go through texts and regulatory frameworks related to space activities (as shown in Fig. 2).

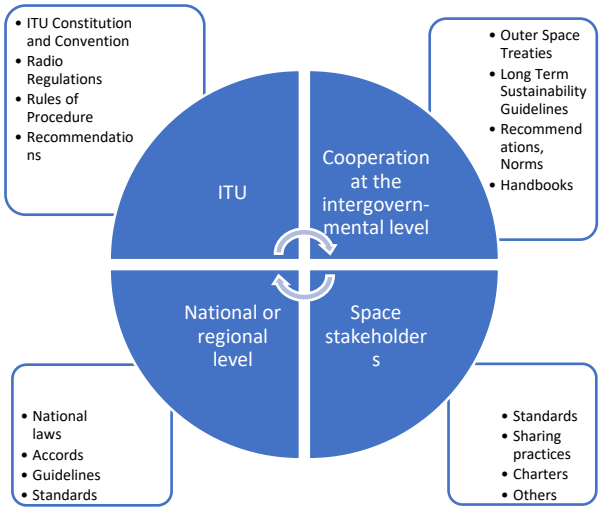


Fig. 2. Texts and regulatory frameworks

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*3.1 Outer Space Treaties and Guidelines for the Long-term Sustainability of Outer Space Activities*

The 1967 Outer Space Treaty and the other four treaties set the foundations of outer space law, including the following principles:

- Outer space is free for exploitation and use by all states in conformity with international regulations;
- States retain jurisdiction and control over objects launched into outer space; and
- States shall be liable for damage caused by their space objects.

Additionally, COPUOS developed non-binding agreements and recommendations to address orbital debris mitigation, cooperative arrangements for sharing remote sensing data, and other related matters. These agreements have been subsequently adopted or endorsed by the UN General Assembly. The adoption of the Guidelines for the Long-term Sustainability of Outer Space Activities (LTS) in June 2019 [9] was a key advancement.

States and intergovernmental organisations have an obligation to ensure the proper registration of space objects for the safety and long-term sustainability of space activities. Inadequate registration practices may have negative implications for the safety of space operations.

LTS guideline A.4 [10] relates to ITU in describing the importance of the equitable, rational and efficient use of radio frequency spectrum and orbital regions used by satellites. It states: "In fulfilling their obligations under the Constitution and the Radio Regulations of the ITU, states should pay particular attention to the long-term sustainability of space activities and sustainable development on Earth and to facilitating the prompt resolution of identified harmful radio frequency interference."

*3.2 ITU's governance framework*

As a binding international treaty (see No. 31 of the ITU Constitution) [11], the ITU Radio Regulations [12] (RR) form the main governing framework for the use of radio spectrum in outer space. Founded on principles related to the ITU Constitution and Convention, the RR state:

- ITU Members shall endeavour to limit the number of frequencies and the spectrum used to the minimum essential to provide in a satisfactory manner the necessary services. To that end, they shall endeavour to apply the latest technical advances as soon as possible. (Preamble 0.2)
- In using frequency bands for radio services, Members shall bear in mind that radio frequencies and any associated orbits, including the geostationary satellite orbit are limited natural resources and that they must be used rationally, efficiently and economically, in conformity with the provisions of these Regulations, so that countries or groups of countries may have equitable access to those orbits and frequencies, taking into account the special needs of the developing countries and the geographical situation of particular countries. (Preamble 0.3)

These principles are part of the broader framework defined in Article 1 of the ITU Constitution which is to "maintain and extend international cooperation among all the Member States of the Union for the improvement and rational use of telecommunications of all kinds."

The specific role of ITU-R within this framework is:

- to undertake allocation of radio frequency spectrum, allotment of radio frequencies and registration of radio frequency assignments as well as any associated orbital position in the geostationary satellite orbit or any associated characteristics of satellites in other orbits; and
- to avoid harmful interference between radio stations of different countries.

Detailed regulations and procedures governing orbits and spectrum resources are contained in the RR, which are reviewed and revised, if necessary, by World Radiocommunication Conferences [13] (WRC) every three to four years. Revisions are made based on an agenda agreed by the ITU Council, which is based in turn on a draft made by the preceding WRC.

The general scope of each WRC agenda is established four years in advance, with the final agenda approved by the ITU Council two years before the conference, with the concurrence of the majority of Member States.

*3.3 Non-binding rules, standards and guidelines*

Alternatives to binding instruments are being sought by policymakers, in particular non-legally binding tools and frameworks which support the existing UN treaties on outer space, that could contribute to establishing standards for responsible spacefaring nations in the near term.

Although these non-legally binding tools and frameworks may not be completely effective, owing to their lack of enforcement mechanisms, they are often considered useful since they provide a level of flexibility, can be amended relatively easily amid economic or technological changes, and capture the interests of almost all spacefaring countries while shaping and promoting sustainable conduct in outer space.

An example of a non-binding instrument is the development of behavioural norms for outer space activities, such as the European Union's proposal for an International Code of Conduct for Outer Space Activities.

*3.4 National space law*

The term "global space governance" refers not only to a set of international and regional laws, but also to their implementation by governments, who are ultimately responsible for their national space activities, whether carried out by governmental or non-governmental entities [14, 15]. Countries retain ownership and jurisdiction over

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any object they launch into outer space and are accordingly liable for damage caused by their space objects.

In addition to the implementation of international space law instruments, states need to develop national regulatory frameworks to govern the conduct of space activities.

States that have adopted national space legislation have taken several different approaches to dealing with national space activities. National space legislation can be contained in unified acts or in a combination of national legal instruments. Furthermore, some countries have adapted their national legal frameworks to the specific needs and practical considerations of different space activities, which vary in terms of non-governmental entity involvement.

The fact that the ITU Constitution, Convention and RR are intergovernmental treaties ratified by countries means that Member States are legally bound to:

- apply the provisions in their countries; and
- adopt adequate national legislation that includes, as a minimum, the essential provisions of each international treaty.

ITU Member States issue licences for satellite systems, to ensure that satellite operators comply with the rules and conditions contained in the RR and with the outcome of bilateral discussions. They may also impose additional domestic rules that do not contradict the RR, to which each Member State is bound.

## 4. Practical tools in ITU-R for sustainable spectrum and orbit use

Currently, ITU's practical approaches to maintaining space sustainability include:

- the mechanisms in the RR; and
- ITU-R Recommendations.

Within the ITU Radiocommunication Sector (ITU-R), the Radiocommunication Bureau (the Bureau) at the ITU Headquarters acts as the secretariat, implementing RR provisions and supporting WRC processes. The Bureau also processes satellite frequency registration submissions from ITU Member States in conformity with the RR [16].

### *4.1 The registration of satellite radio frequencies allows for transparent and sustainable use*

Registering satellite radio frequencies enables more transparency into the global coordination of radio spectrum use before a new satellite becomes operational and throughout its lifetime, which can range from a few weeks for a small satellite to twenty or thirty years for one on the GSO.

The first step in the registration process is the creation of an ITU filing by investigating the Table of Frequency Allocations in RR Article 5. This internationally agreed matrix combines spectrum allocation information for radio services worldwide and by ITU Region (as shown in Fig. 3). This grouping into three Regions provides some flexibility if global harmonisation of spectrum use cannot be obtained.

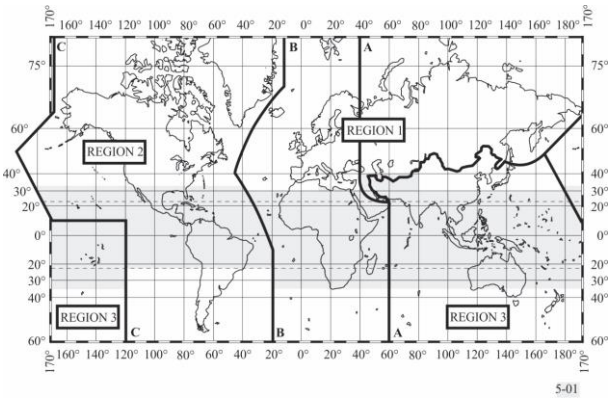


Fig. 3. The three ITU Regions

Each national frequency spectrum management authority then selects frequencies that meet operator requirements and assigns them to stations of a given radiocommunication service in each country.

Two important mechanisms for the stable sharing of orbits and spectrum resources have been developed and implemented in the RR to establish a fair balance between equitable access and efficient use:

- A priori planning procedures ensure equitable and guaranteed access to the GSO and spectrum resources for all ITU Member States. These Plans are established and agreed by Member States during WRCs, with similar a priori radio parameters for all. The last planning exercises date back to 2007. These Plans are protected from interference by other transmissions and are assured transmission quality for future use. However, these Plans only apply to the GSO in part of the radio spectrum allocated to the most popular space services, namely the broadcast satellite service (BSS) and fixed satellite service (FSS).
- Coordination procedures have the primary aim to ensure the efficient use of orbits and spectrum for interference-free operation that meets operators' real requirements in the GSO and non-GSO. The balance of rights and obligations between incumbents and newcomers is established through a series of RR provisions, which guarantees effectiveness while preventing spectrum warehousing, monopolisation or exclusion.

Both mechanisms are composed of regulatory and technical provisions contained in the RR. Deadlines for advancing the registration process are also defined, as well as fixed limits and requirements for coordinating with other networks according to the types of antennas and services.

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Once regulatory compliance and system coordination have been achieved, the last step is recording the satellite frequency assignment in the ITU Master International Frequency Register (ITU Master Register) [17] with a favourable finding. The satellite network acquires the right to international recognition for the transmission of its assignment from an orbit defined by the recorded orbital parameters. Other administrations and operators must take this right into account when designing or operating their own frequency assignments, to avoid harmful signal interference (see RR No. 8.3).

For a satellite network, in addition to the formal ITU registration, each station in the network is required to obtain licenses from the national administrations to operate the service within the countries concerned, in accordance with RR Article 18. The licensing conditions may vary from country to country depending on the national legislation in force.

Since the ITU Master Register is public and published regularly by the Bureau, the occupancy and use of spectrum and orbits are visible to all stakeholders in the space sector. This transparency allows space stakeholders to predict and coordinate their activities while ensuring sustainable and interference-free transmissions. Figure 4 summarises the registration process implemented in ITU.

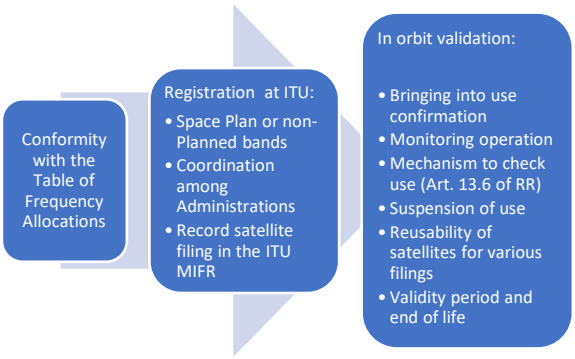


Fig. 4. ITU mechanism for satellite frequency registration

Altogether, the Table of Frequency Allocations, the planning and coordination mechanisms, the technical and regulatory provisions and the ITU Master Register form a secure environment in which risks of signal interference are prevented before a satellite launches, as well as during its entire operational life.

*4.2 Obligation to file satellite networks with the ITU*

Every ITU Member State must submit satellite network or system projects to the ITU at the design stage, well before launch, even if the satellite is for experimental purposes. Notifying the ITU enables the satellite system to obtain international recognition, protect frequency assignments, and resolve potential difficulties in advance, in order to mitigate harmful interference during and after deployment.

The centralisation of space activity data could increase the transparency of such activities and potentially indicate levels of space sustainability. Data currently collected by the ITU includes orbit information (nominal geographical longitude, inclination and East-West tolerances for GSO systems, and number of orbital planes, number of satellites per plane, inclination of orbital planes, altitude of apogee and perigee of the space stations, and argument of the perigee of the orbital plane for non-GSO systems), launch information, space station characteristics, and frequency bands. The analysis of this information, which is shared with other organisations and space stakeholders, could help make space congestion quantifiable.

*4.3 Capacity of cessation of emissions*

Administrations shall have the ability to identify and track their own space stations to avoid threats to other space assets. As stipulated by RR No. 22.1, Administrations shall also ensure that sufficient telecommand earth stations are established before launch when authorising space stations to ensure that any harmful interference caused by emissions from the space station can be terminated immediately.

*4.4 RR provisions to ensure sustainable use once frequency assignments are registered in the ITU Master Register*

*4.4.1 A realistic ITU Master Register*

The Bureau's control of the consistency of orbital parameters reduces the risk of unrealistic non-GSO system designs that would operate not as registered and coordinated.

The orbital period for a satellite can be computed from the values of the apogee and perigee altitudes provided in a satellite network filing (see RR Appendix 4 Table A). When the orbital reference body is Earth, these values should be consistent.

When the Bureau carries out consistency checks on such parameters, the coordinated networks are closer to the actual systems will operate in orbit. A realistic ITU Master Register therefore ensures a more sustainable and predictable use of physical satellites.

*4.4.2 An up-to-date ITU Master Register*

ITU keeps the Master Register as up to date as possible when it comes to transmissions in use through the provisions for bringing into use and suspension of operation.

The bringing into use of frequency assignments for a satellite network space station involves several steps (RR No. 11.44**)**.

For a non-GSO satellite network, a frequency assignment is considered "brought into use" when a single satellite with the capability to transmit or receive that frequency assignment has been deployed in one of the

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notified orbital planes. This is irrespective of the number of satellites and orbital planes in the satellite network constellation. To confirm the "brought into use" status, the satellite must operate for a continuous period of at least three months.

The ITU also requires administrations to submit administrative due diligence for some radiocommunication services (see RR Resolutions 49 and 552).

For all networks in the fixed, mobile or broadcasting satellite services, the notifying shall send due diligence information, including the satellite manufacturer and launch service provider, to the Bureau as early as possible before the bringing into use date ( see RR Annex 2 to Resolution 49).

For some services, the rules have even been reinforced during recent WRCs to ensure real operations and to adapt to the evolution of space radiocommunication technologies. For all networks in the broadcasting satellite service in the 21.4-22 GHz frequency band, the notifying Administration shall provide the information within 30 days of the actual commencement, or resumption, of use of the frequency assignments (see RR Resolution 552 revised at WRC-15).

*4.4.3 New milestone-based approach for deploying non-GSO systems*

According to the Radiocommunication Bureau's latest annual report [18], ITU received a total of 4182 valid satellite network filings from 80 Member States. During the last decade, ITU saw a significant increase in submissions of filings for frequency assignments for non-GSO satellite systems composed of hundreds or thousands of satellites, especially in frequency bands allocated to the fixed and mobile satellite services (see Fig. 5).

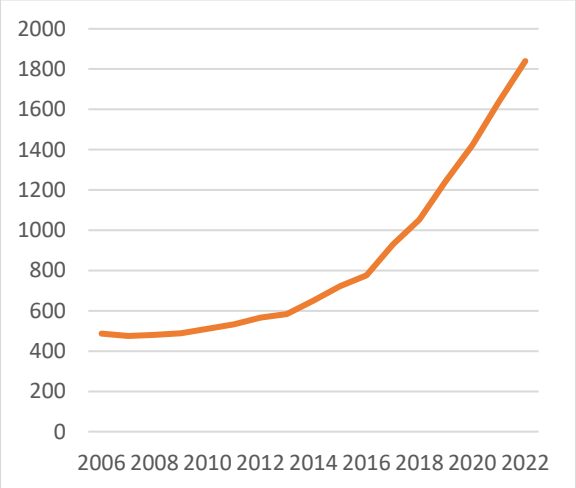


Fig. 5. Non-GSO system filing registration submitted to the ITU (total number per year)

WRC-19 has adopted a new innovative milestone-based regulatory approach for the deployment of non-GSO satellites in specific bands and services. In accordance with RR Resolution 35 (see Fig. 6), these systems will be required to deploy ten per cent of their constellations within two years from the end of their current period for bringing into use, fifty per cent within five years, and must complete the deployment within seven years.

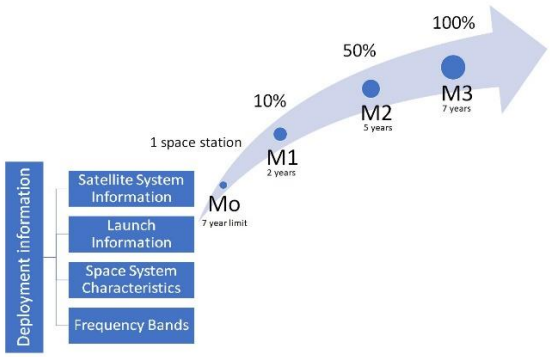


Fig. 6. Resolution 35 and constellation deployment milestones (WRC-19)

The milestone-based approach provides a regulatory mechanism to help ensure that ITU Master register reflects the actual deployment of non-GSO satellite systems in certain frequency bands and services.

In defining more flexible timelines and objective criteria, this approach also seeks to strike a balance between the prevention of spectrum warehousing, the proper functioning of coordination mechanisms, and the operational requirements related to the deployment of non-GSO systems. Resolution 35 also stipulates that a report on implementation should be presented to the next WRC in 2023 to evaluate and possibly adjust the rules.

This flexible adjustment of RR rules allows them to be balanced with technological needs and guarantees their sustainable relevance.

*4.4.4 Review of the ITU Master Register*

Upon receipt of bringing into use information or whenever it appears from reliable information available that a notified assignment has not been brought into use, the Bureau will apply a regulated consultation procedure (RR No. 13.6). The Bureau will request clarifications as to whether the assignment was brought into use or continues to be in use in accordance with the notified characteristics in the ITU Master Register and includes the reason for the query. Depending on the response of the notifying Administration, the Bureau will cancel, modify or retain the basic characteristics of the entry.

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The aim is to review the information provided by the notifying administrations so that the ITU Master Register corresponds to real operations.

*4.4.5 Possible suspension and resumption of use of the satellite network in the ITU Master Register*

An Administration may inform the Bureau of the suspension of the use of a frequency assignment to a space station as long as the period does not exceed three years (RR No. 11.49). During this period, the frequency assignment shall continue to benefit the protection acquired under the coordination agreements already obtained.

Other provisions regulate the actual resumption of operation by a GSO satellite network in order to mitigate the risk of a "hopping satellite". This phenomenon occurs when an Administration moves a GSO satellite from one orbital position to another within a short period of time only to obtain the protection of the registered ITU filing without any lasting use of the transmissions.

When informing the Bureau of bringing a frequency assignment back into use after suspension, the notifying Administration shall also indicate whether the newly operational space station had previously been used at a different orbital location (see RR Resolution 40).

The RR include rules to mitigate risks of abuse of their application. This ensures the RR are used as consensually agreed by Member States during WRCs.

*4.4.6 Releasing unchanged spectrum and orbit resources after the end of use of a recorded satellite filing*

A frequency assignment to a space station shall be deemed definitively discontinued after the period of operation expires. This period is counted from the date of bringing into use plus the submitted and recorded period of validity. The notifying Administration should request the cancellation of these recorded frequency assignments if there is no plan to continue their use (see RR Resolution 4).

The concept of limiting the period of validity promotes the objectives of rational and efficient use of spectrum and orbit resources (see RR Resolution 2). This increases the possibility for all countries to use, with equal rights and equitable access, frequency bands and associated satellite orbits for space radiocommunication services.

*4.4.7 Harmful interference reporting and monitoring*

The rapid expansion of satellite connectivity also means increased risks of interference disrupting a continuous signal transmission.

ITU has developed an online tool called the Satellite Interference Reporting and Resolution System (SIRRS) [19]. This platform facilitates the work of Administrations and space stakeholders in reporting cases of harmful interference affecting space services. They can request the Bureau's assistance and exchange all necessary information among the concerned parties involved in an interference case.

The Bureau is also working together with the satellite industry through ITU-R Study Groups and regularly disseminates information about innovative solutions to overcome the ongoing challenge of harmful interference affecting space services.

Continuous space monitoring [20] is essential to identify and mitigate harmful radio frequency interference. The ITU therefore seeks cooperation agreements with Administrations who have monitoring facilities. Such agreements have already been signed with Germany, Pakistan, the Republic of Korea, China, Viet Nam, Belarus, Brazil and Oman. Space transmission monitoring can help mitigate intentional and unintentional misuse of spectrum, thereby securing its sustainable use.

The attention of the Bureau and the Radio Regulations Board was recently drawn by the increasing number of interference incidents affecting the Global Navigation Satellite System (GNSS) used for safety of life services, positioning and navigation on Earth, and by satellite systems in low-Earth orbits.

In response, ITU issued a warning to its Member States and provided recommendations to prevent and mitigate this interference [21].

*4.5 Environmental protection of the geostationary satellite orbit*

The ITU-R developed a dedicated recommendation (ITU-R S.1003.2) [22] to provide guidance on disposal orbits for satellites in the GSO. An increased number of debris in this orbit is due to fragments from satellites, which are increasing in turn. The text stipulates "that as little debris as possible should be released into the geostationary orbit during the placement of a satellite in orbit" and that "a geostationary satellite at the end of its life should be transferred, before complete exhaustion of its propellant, to a super synchronous graveyard orbit" at a minimum altitude of 200 kilometres above the GSO altitude.

*4.6 Enforcement and shortcomings in the ITU framework about space sustainability*

*4.6.1 Implication of non-conformity with the RR*

The RR are effective to the degree to which they are respected. Like any law, they require an enforcement system.

RR Article 15 regulates the infringement of the Constitution, Convention or the RR themselves. It stipulates that "if an administration has information of an infringement of the Constitution, the Convention or the Radio Regulations (in particular Article 45 of the Constitution and RR No. 15.1) committed by a station

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under its jurisdiction, the administration shall ascertain the facts and take the necessary actions."

Yet, although such infringements can cause significant damage to space activities, there is no international court to enact jurisprudence nor mechanism for automatic formal sanctions.

The RR encourage the usage of diplomatic procedures and appeal to the goodwill of ITU Member States.

*4.6.2 Abuse of Amateur Satellite Service*

The frequency bands allocated to the amateur satellite service have been heavily used by small satellites over the past twenty years. However, several applications and operations in these frequency bands do not comply with all the requirements for amateur usage and have been authorised for experimental operation only.

Experimental use is only appropriate when the definitions of the amateur service (see RR No. 1.56) and amateur satellite service (see RR No. 1.57) are strictly met: "A radiocommunication service for the purpose of self-training, intercommunication and technical investigations carried out by amateurs, that is, duly authorised persons interested in radio technique solely with a personal aim and without pecuniary interest." Therefore, the amateur satellite service shall be used in a non-commercial and non-profit way which is incompatible with business operations.

*4.6.3 Absence of explicit "sustainable space" language*

Another shortcoming is that the language used in the RR does not explicitly refer to the sustainable aspect of its mechanisms. The words "sustainable" and "sustainability" are not present as such in the RR, its Rules of Procedure, the ITU Convention or the Constitution.

*4.6.4 Space sustainability on the WRC-23 agenda*

Space technologies will again be central to the agenda of the next WRC set to take place in the United Arab Emirates at the end of 2023. It will address additional radio spectrum for Earth stations in motion, progress on spectrum use by numerous non-GSO satellite constellations, and narrow-band transmissions for the satellite component of the Internet of Things (IoT). Decisions made by delegates at the end of WRC-23 will update the Radio Regulations.

In July 2022, a proposal directly related to space sustainability was added to the WRC agenda through the consideration of regulatory provisions for telemetry, telecommand and control frequencies for non-GSO satellites for in-orbit servicing (IOS) satellite systems (see WRC-23 agenda item 7 Topic L) [23]. IOS is performed by a spacecraft to maintain, repair, upgrade, refuel or de-orbit a space asset while it is in orbit or to de-orbit or re-orbit a space debris object. These activities require the IOS spacecraft to approach, rendezvous and dock with the space asset or debris object. Types of IOS include active debris removal (ADR), end-of-life (EOL), and life extension (LEX) services.

## 5. The WRC mechanism as a model for other space governance initiatives

When we consider a broader vision of a sustainable space environment, the ITU offers an instructive example of global synergy in view of protecting and sharing resources at the intergovernmental level through the United Nations.

The strength of the WRC (see Fig. 7) and RR mechanisms lies in its governance through a binding intergovernmental treaty, decided by consensus at the conferences, and evolving through a four-year study cycle involving all space stakeholders. The mechanisms of spectrum allocation, limits, coordination, frequency registration, and monitoring at every moment of a satellite's life cycle allows for risk prevention. As a supervisory authority and a UN specialised agency, ITU is uniquely placed to balance the rights and obligations of governments and operators, while benefitting from the international recognition and stability that brings security to investors.

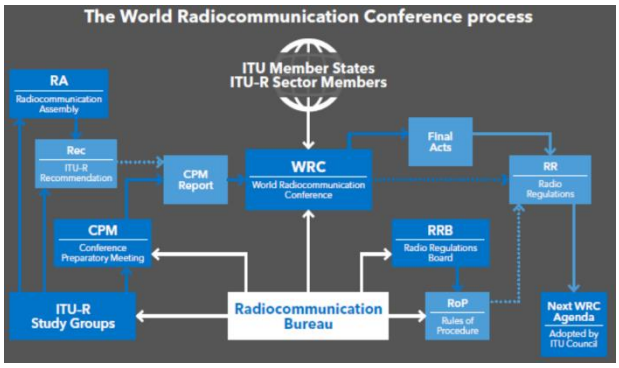


Fig. 7: The WRC process

*5.1 Governing orbits occupation by objects*

The number of space objects in orbit around the Earth is increasing exponentially, creating constant collision risks and jeopardizing satellite operations.

Just as spectrum is governed to ensure non-interference of radio signals, an international governance mechanism could be created to ensure Earth's orbits, a global natural resource, can be occupied without physical interference from objects.

This would initially involve mapping the orbits as if they were "parking lots" in a three-dimensional schema, and then defining regulatory and technical limits for their occupancy to ensure economic, rational and efficient use as well as equitable access. Such limits could include calculated values from the space sustainability rating system [24], or from the size of objects and acceptable brightness values [25].

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Some of those limits could be considered as sustainable by the RR when apropriate, for example in the mechanism whereby Administrations must confirm the bringing into use of GSO and non-GSO satellites as mentioned in Section 4. This mechanism could also be improved by adding new criteria to the UNOOSA Register of Objects Launched into Outer Space, and collecting additional data such as each object's location, trajectory, and operational status (active in orbit, inactive debris, limited time activity for launchers, short duration missions, probes, etc.).

A new mechanism related to space objects will also need to identify when to coordinate traffic between newcomers and stakeholders already using the orbits.

This mechanism should also consider equitable access to outer space, with special rules facilitating access for new spacefarers.

After coordination, an international registry of the objects with their trajectory parameters would enable them to operate free from physical interference, claim rights in case of damage, predict collisions thanks to access to trajectories of other objects, and to fulfil obligations regarding debris creation. In sum, it would help to foster the use of orbits as registered while respecting other space objects.

Object monitoring by space situational awareness systems would also be required to anticipate and prevent potential collisions, with appropriate mechanisms for communication between satellite operators in case of emergency.

Specific rules on end of operation could be developed to include limits, change of trajectory or location and debris mitigation to complete a sustainable life cycle of space objects.

### *5.2 Governance of space resources extraction*

Work on the global governance of space resource extraction is already being studied by the Hague International Space Resources Governance Working Group [26] as well as by COPUOS and its subcommittees with dedicated agenda items. The idea of building a model inspired by the mechanisms of coordination, limits, equal priorities, and planning approaches of the RR and WRCs is also under study.

### *5.3 Evolution of ITU Recommendations and handbooks*

As mentioned in Section 4.5, the ITU-R Recommendation S.1003 provides guidance on disposal orbits for satellites in the GSO. However, there is no ITU-R Recommendation on disposal orbits for satellites in the non-GSO. The space ecosystem has identified this new need for rules at the international level.

The ITU-R is currently developing a Small Satellite Handbook [27] in response to the provisions of Resolution 68 on "Improving the dissemination of knowledge concerning the applicable regulatory procedures for small satellites, including nanosatellites and picosatellites."

By assisting national governments and new space stakeholders with information on relevant space radio services, including the issue of space debris mitigation, ITU aims to ensure the interference-free operation of small satellite systems and while ensuring the sustainable use of space resources.

## 6. The need to reinforce synergy among space stakeholders and ITU role

As space is the province of all humankind [1], states and stakeholders, whether established, emerging, or future space actors, face the challenge of engaging in multilateral dialogues and finding a cooperative international solution to mitigate hazards related to joint space activities.

Having analysed and mapped relevant roles and interactions to assess space sustainability (see Fig. 8 at the end of this document), we can make the following recommendations:

**On texts**: Strengthen the responsibility of each space actor through more internationally harmonised and binding rules (e.g. on debris management) and through better knowledge of impacts on other actors. The ITU acts through the decisions of WRC delegates, who, through agenda items and study group cycles, can add new elements to the RR concerning the sustainable use of spectrum/orbit resources, thereby addressing the impact of new non-GSO uses as shown in this paper.

**On tools**: Work towards an "international orbit situation register" of active and non-active space objects, globally agreed by all stakeholders. The RR Table of Frequency Allocations (TFA) allows for the harmonisation and coordinated management of a limited natural resource. Since orbits are also limited natural resources that can be quantified, and trajectories of objects can be modelled, ongoing research should investigate mechanisms to regulate orbits with new rules, including sustainability ratings, balancing priorities for incumbent users and newcomers, and enabling the obtention of rights to use an orbit before operation.

**On fora for negotiation**: Increase liaisons between existing stakeholders and between their various levels. In this perspective, the ITU conferences and study groups are recognised models of fora that balance technical inputs from the private sector with regulatory certainty offered by consensus and ratified by national authorities. Increased liaisons between fora also imply greater participation in these various fora. Allocating resources to represent each stakeholder group and establishing effective liaisons between working groups are efforts that can be costly and complex but would improve synergies leading to better knowledge flow and more consensual decisions.

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## 7. ITU's continued role in space sustainability

When it comes to making space safer, more secure and sustainable, the ecosystem is evolving towards greater complexity. This increased complexity was not as critical when activities were mainly focused in the GSO.

ITU Secretary-General Houlin Zhao recently noted how "as space technologies evolve, concerns are being raised about space sustainability, with issues like the impact of large constellations of non-geostationary satellites on radioastronomy, or the risks of space debris on the safe and effective operation of low-Earth orbits. ITU remains committed to supporting efforts towards a more sustainable space environment and the implementation of the COPUOS Guidelines for the Long-Term Sustainability of Outer Space Activities." [28]

The ITU RR has proven effective over time, as an evolving intergovernmental binding treaty, providing a recognised mechanism considering the sustainable use of the radio spectrum as a natural resource on a global scale, through its founding texts and WRC mechanism. As shown in this paper, the ITU remains committed to contribute to and strengthen its impact on space sustainability, balancing the interests of the space economy with reliable and sustainable services for telecommunications and other services in an ever-changing environment.

This includes improving the rules on the use of radio spectrum for the development of new technologies and the deployment of satellite constellations (e.g. concerns about increasing non-GSO satellites and their end-of-life conditions). It also involves sharing practices such as the successful WRC mechanism as a model for the management and monitoring of use of natural resources other than spectrum, such as orbits and space mineral resources. Finally, it is about reinforcing other space stakeholder initiatives at UN, national, regional or industry levels through cooperation, leading to a comprehensive and lasting global approach to space governance.

We believe that the solution to improve synergy in the field of space sustainability lies in the texts governing these activities, in the tools providing data and information about space objects, and in the collaboration between stakeholders, thereby reinforcing their accountability.

## 8. Disclaimer

The views expressed in this paper are those of the authors and do not necessarily reflect the views of the International Telecommunication Union.

## 9. Acknowledgements

The authors would like to thank the management team of the Bureau, our colleague Jorge Ciccorossi, for their encouragements in the drafting of this paper, and Nicole Harper and Yasmin Afina for their editorial reviews.

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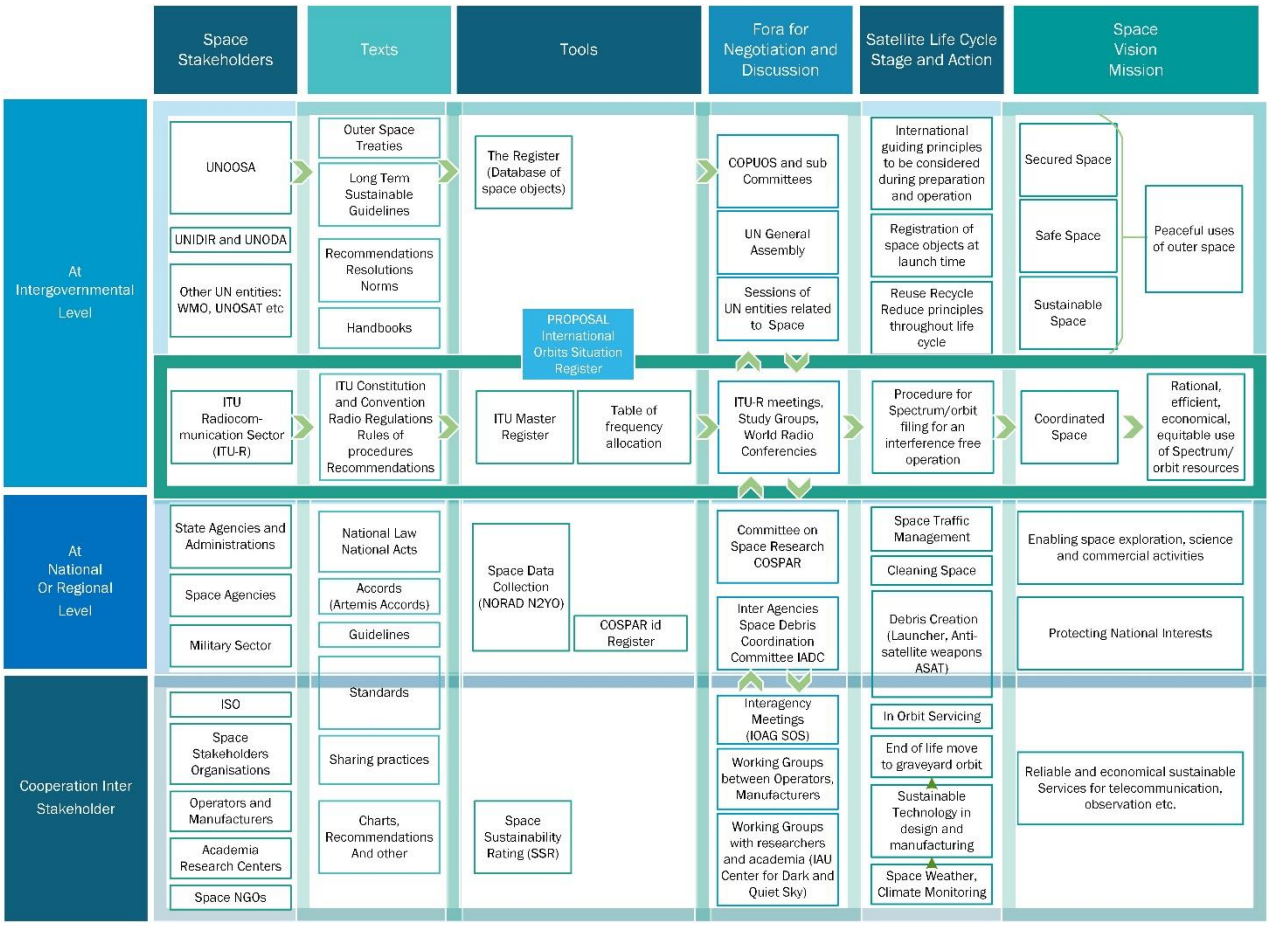


Fig. 8. Map of roles and interaction to assess space sustainability