Small Satellite Spectrum Access: Navigating the Path to WRC-27

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***Abstract*— The World Radiocommunication Conference in 2027 (WRC-27) presents a significant opportunity for the small satellite community to secure and defend critical spectrum access, vital to their operations and growth. Although the event is still three years away, proactive engagement is essential to ensure that the unique needs and challenges of small satellites are addressed appropriately within the broader regulatory framework. Historically, there has been a misconception within parts of the small satellite sector that their operations might be subject to a simplified regulatory process or that the International Telecommunication Union (ITU) might offer separate pathways tailored for small satellites. Apart from a small segment of spectrum dedicated to telemetry and tracking, small satellites face the same complex rules and constraints, but also opportunities as larger satellites.**

Keywords—smallsat, radiofrequency, interference, ITU, WRC-27, regulations

I. Introduction

Over the past few decades, satellite development was largely defined by the construction of increasingly larger, more sophisticated systems capable of delivering reliable space-based services with enhanced performance, complexity, and operational lifetimes. However, recent years have seen a notable paradigm shift. The proliferation of small satellites—driven by increased demand for radio-frequency spectrum and orbital resources, rapid technological advances, and lower manufacturing costs—has redefined the dynamics of the space industry.

This transformation has been especially pronounced over the past decade. Small satellites now represent the forefront of innovation due to their reduced technical and financial barriers to entry. These systems, which include minisatellites, microsatellites, CubeSats, nanosatellites, picosatellites, and femtosatellites, have seen widespread adoption across commercial, academic, and government sectors.

Despite their increasing ubiquity, small satellites remain undefined under current international law. No legal or regulatory framework currently distinguishes small satellites from their larger counterparts..

II. Regulatory Framework and General Misconception

A prevailing misconception within segments of the small satellite sector is that their size or scope might entitle them to a simplified regulatory process—particularly in the context of frequency coordination—and that the International Telecommunication Union (ITU) might offer separate pathways tailored for small satellites.

However, in accordance with No. **4.2** of the ITU Radio Regulations (RR), Member States must ensure that frequency assignments for stations capable of causing harmful interference must comply fully with international requirements, including the Table of Frequency Allocations and relevant provisions under Article **5**.

While the term ‘small satellite’ refers to physical characteristics, such as mass and form, these attributes carry no weight within the international regulatory framework for frequency management. Small satellites are subject to the same regulatory constraints as larger satellites, but they also benefit from the same opportunities, particularly as discussions intensify ahead of WRC-27.

As we approach WRC-27, there is a strategic opportunity for small satellite operators to actively engage in shaping the international regulatory environment. Several agenda items at the upcoming World Radiocommunication Conference carry direct implications for small satellite missions and Earth observation services.

III. Key WRC-27 Agenda Items Relevant to Small Satellites

The ITU oversees the international coordination and allocation of radiofrequency spectrum through the RR, which is revised every three to four years at the World Radiocommunication Conference (WRC). The next such event, WRC-27, scheduled for 2027, includes over 80% of agenda items directly related to satellite services, many of which might affect the small satellite ecosystem.

A. Agenda Item 1.11 – Use of Space-to-Space Links in MSS Bands

The increasing deployment of non-geostationary orbit (NGSO) small satellites, particularly for short-duration missions, has accelerated demand for space-to-space communication links. These inter-satellite links (ISLs) allow satellites to communicate directly, reducing latency and dependence on ground infrastructure.

Agenda Item 1.11 explores the potential use of Mobile-Satellite Service (MSS) services for ISLs in the following bands:

- 1518–1544 MHz
- 1545–1559 MHz
- 1610–1645.5 MHz
- 1646.5–1660 MHz
- 1670–1675 MHz
- 2483.5–2500 MHz

ISLs enable real-time communication between satellites, significantly reducing data transmission latency across orbital paths. This functionality is especially valuable for Earth Exploration-Satellite Service (EESS) missions, which rely on the timely collection and dissemination of data for crucial applications such as weather forecasting, disaster response, and environmental monitoring. By facilitating direct satellite-to-satellite communication, ISLs streamline the flow of information, ensuring that essential data reaches end users with minimal delay.

The implementation of space-to-space-satellite links enhances the spatial coverage capabilities of EESS constellations. Satellites equipped with ISLs can maintain continuous observation of targeted regions, including remote or underserved areas where terrestrial ground stations are scarce. This persistent coverage is vital for monitoring dynamic environmental phenomena – such as natural disasters, climate patterns, and ecological shifts – in real time.

Moreover, the use of ISLs reduces dependency on ground infrastructure, a significant advantage for missions operating in geographically inaccessible or politically sensitive regions. Minimizing the need for ground stations not only lowers operational costs but also enhances system resilience by mitigating the risk of service interruptions due to terrestrial distributions, including natural disasters, geopolitical instability, or equipment failure.

While the relevant bands are already allocated to MSS, their use for space-to-space communication introduces new sharing scenarios, including possible interference between satellite uplinks and downlinks. WRC-27 will need to address these concerns through compatibility studies and potential revisions to the regulatory framework.

B. *Agenda Item 1.17 – Protection of Space Weather Sensors*

Space weather (encompassing phenomena such as solar wind, geomagnetic storms, ionospheric disturbances, and solar energetic particles) can adversely affect both terrestrial and space-based systems. Sensors that monitor these conditions often rely on reception of naturally occurring low-level emissions, making them highly susceptible to harmful interference.

Agenda Item 1.17 proposes the creation of new primary allocations for receive-only space weather sensors in selected frequency bands. These allocations would provide a regulatory basis for interference protection without imposing constraints on incumbent services.

Space weather sensors help protect satellite assets by providing real-time monitoring of conditions like solar flares, coronal mass ejections (CMEs), and high-energy particle storms. These phenomena can damage satellite electronics, degrade solar panels, and cause malfunctions. Timely space weather data allows operators to place satellites in safe modes or adjust operations to mitigate potential harm.

Ionospheric disturbances caused by space weather events can degrade the accuracy and reliability of GNSS signals (e.g., GPS, Galileo). Sensors that monitor ionospheric conditions help detect and forecast such disturbances, enabling users to apply corrections or switch to alternative positioning techniques when necessary. This is crucial for applications like autonomous navigation, agriculture, surveying, and timing.

Space weather sensors are critical components of a resilient and technologically advanced society. They provide vital data that helps protect infrastructure, ensure the safety of people in space and aviation, and maintain the reliability of services we depend on every day.

Under Agenda Item 1.17, it is important to clarify that the proposed new primary allocations are designated exclusively for receive-only space weather sensors. These systems, by their nature, do not transmit any signals and therefore do not pose any risk of causing interference to other radiocommunication services operating in the same or adjacent frequency bands. This fundamental characteristic eliminates the need for traditional sharing and compatibility studies that typically assess outbound interference potential.

Instead, the focus of technical studies should shift to assessing the vulnerability of these passive systems to interference from existing active services currently authorized in the bands under consideration. Given their reliance on detecting extremely weak natural signals, space weather sensors are particularly susceptible to interference from out-of-band emissions or adjacent channel transmissions.

The objective of these studies is to ensure that the performance of receive-only space weather sensors is not compromised by existing spectrum usage. Rather than evaluating the potential impact of these sensors on incumbent services, the aim is to determine whether the scientific functions they support, such as monitoring solar activity, ionospheric conditions, and geomagnetic disturbances, can be sustained without harmful degradation due to emissions from co-frequency or nearby active systems.)

C. *Agenda Item 1.18 – Protection of EESS Passive Services Above 86 GHz and RAS*

Agenda Item 1.18 addresses two closely related issues. First, it examines the need to harmonize compatibility measures between active services and Earth exploration-satellite services (passive) operating in the frequency band subject to No. **5.340** above 86 GHz. The growing interest in frequency bands above 71 GHz necessitates these measures to secure passive EESS operations, which are critical for climate monitoring and scientific research.

Additionally, the agenda item highlights the importance of protecting the Radio Astronomy Service (RAS). Radio astronomical observations rely on extensive instruments that operate within protected frequency bands. Facilities such as NOEMA and IRAM in Europe, ALMA in Chile, and the proposed next-generation Very Large Array (ngVLA) in North America depend on these bands for high-fidelity observations.

It is important to recognize that passive sensors under the EESS are particularly vulnerable to unwanted emissions from a wide range of active services operating in adjacent or even non-adjacent frequency bands. When assessing potential interference into passive services, it is essential to consider the aggregate effect of emissions from all relevant sources. In the case of EESS (passive), this cumulative impact can be significant, as illustrated below.

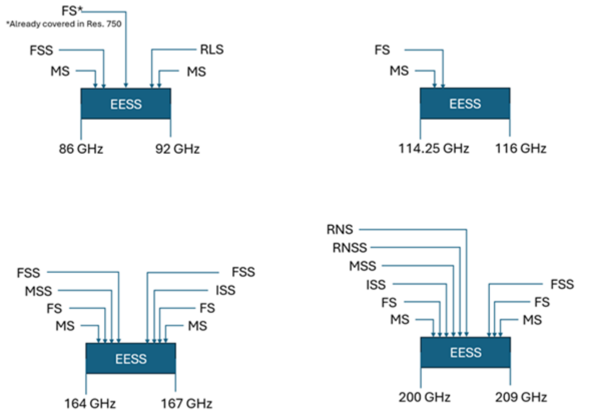

Fig. 1. Overlapping servcies in EESS bands. (*Source CEPT Brief on AI 1.18)*)

To manage this risk, it may be necessary to apportion the allowable interference margin, i.e. the total permissible level of emissions received by passive sensors, among the various active services contributing to the interference environment. This process, commonly referred to as 'apportionment,' enables spectrum regulators to ensure that the combined emissions from all active systems remain within acceptable thresholds, thereby protecting the sensitivity and accuracy of passive EESS operations.

By contrast, apportionment is less critical for the protection of the Radio Astronomy Service (RAS). RAS frequency allocations are typically shared with a limited number of services, primarily Fixed-Satellite Service (FSS), with some restricted use by the Mobile-Satellite Service (MSS) and the Broadcasting-Satellite Service (BSS); all of which are space-based. This narrower sharing environment simplifies compatibility assessments and interference mitigation.

In contrast, the frequency bands allocated to EESS (passive) are shared across a broader array of both space-based and terrestrial services, resulting in a more complex and challenging interference landscape. Accordingly, Agenda Item 1.18 will focus on defining appropriate threshold levels for unwanted emissions from geostationary (GSO) and non-geostationary (NGSO) space stations. These thresholds are critical to ensuring adequate protection of passive EESS sensors and maintaining the reliability of environmental and climate monitoring applications.

D. Agenda Item 1.19 – Protection of SST Observations

Sea Surface Temperature (SST) measurements, vital for weather forecasting and climate modeling, have traditionally been conducted within the 6425–7250 MHz range under RR No. **5.458**.

The measurements by satellite in microwave (6 or 11 GHz) or infrared domains have different and complementary characteristics. The advantages of using microwave frequencies include the ability to conduct observations in diverse weather conditions, even under cloud cover, unlike infrared systems, which are limited to clear sky conditions.

Proposals under Agenda Item 1.19 suggest new allocations in the 4 200-4 400 MHz and 8 400-8 500 MHz bands as complimentary to existing SST measurements currently performed in the 6/7 GHz range. Accurate SST data is crucial for predicting the formation and intensification of tropical cyclones Warm sea surfaces fuel these storms, so accurate SST measurements help meteorologists predict storm formation, track their development, and assess potential intensity.

These measurements form the cornerstone of Earth observation, underpinning our ability to understand and predict complex oceanic and atmospheric processes. From improving weather forecasts to safeguarding marine biodiversity and informing climate policy, SST data delivers wide-reaching benefits across science, industry, and society.

To strengthen the global SST monitoring capability, this agenda item proposes the consideration of new frequency allocations for passive sensing in the 4 200-4 400 MHz and 8 400-8 500 MHz bands. These bands would complement existing systems and help address potential coverage gaps caused by changing atmospheric or orbital conditions.

The regulatory challenge in this context is twofold: not only does it involve establishing a new passive allocation in the 4 200–4 400 MHz and 8 400–8 500 MHz frequency bands that can coexist with existing services, but it also requires navigating competition from the IMT and broader mobile communications community, which is actively seeking access to additional spectrum in similar frequency ranges.

E. Agenda Item 1.7 – Potential IMT Encroachment

Agenda Item 1.7 is perhaps the most contentious item for satellite community, as it relates to the possible identification of new frequency bands for International Mobile Telecommunications (IMT) systems. The bands under consideration include 4 400–4 800 MHz, 7 125–8 400 MHz (or portions thereof), and 14.8–15.35 GHz. Each of these bands is either currently used by or adjacent to frequencies used by Earth observation satellites scientific instruments or space-based passive sensors, but also Fixed-Satellite services.

These frequency bands are under consideration in response to the growing global demand for mobile broadband connectivity, which is widely recognized as essential for expanding digital infrastructure and enabling emerging technologies. However, the deployment of IMT systems in or near these bands introduces significant technical and regulatory challenges.

In densely populated urban areas, IMT systems often involve a high concentration of user terminals operating at elevated power levels and utilizing antennas with low directivity. These characteristics can result in substantial levels of unwanted electromagnetic emissions. Such emissions pose a significant risk of interference with sensitive satellite instruments; particularly those onboard EESS platforms and other passive space-based services that rely on detecting extremely weak natural signals.

This interference can degrade the quality, accuracy, and reliability of the scientific data critical to climate change monitoring, atmospheric and oceanographic research, and natural disaster prediction and mitigation. Given the vital role of these services in supporting environmental sustainability, public safety, and global scientific progress, it is essential that the regulatory process achieves a balanced approach. Spectrum policy must accommodate the growth of mobile broadband while preserving the integrity of passive and scientific satellite operations.

Moreover, it is important to recognize that the radiofrequency spectrum is not the only constrained resource in the domain of space activities.

Orbital space, particularly in low Earth orbit (LEO), is also finite and subject to mounting pressure. The rapid proliferation of satellite constellations, driven by commercial and governmental initiatives, has significantly increased orbital congestion. This growing density heightens the risks associated with orbital debris, collision avoidance, and long-term sustainability of space operations.

As with spectrum management, ensuring the responsible and equitable use of orbital space requires coordinated international action and robust regulatory frameworks. Preserving these shared resources is essential to maintaining the safety, accessibility, and sustainability of outer space for current and future generations.

IV. Sustainable Access to Space

In addition to spectrum concerns, the increasing density of satellites in low Earth orbit has raised serious questions about the long-term sustainability of orbital environments. The proliferation of satellite constellations has increased the risk of collisions, orbital congestion, and space debris generation. The possibility of a cascading series of collisions, known as the Kessler Syndrome, poses an existential threat to the safe and continued use of LEO.

Recognizing these risks, the ITU Radiocommunication Assembly in 2023 adopted Resolution **74**, which emphasizes the need for sustainable use of both spectrum and associated orbital resources. This resolution encourages administrations and space operators to coordinate more effectively, adopt best practices for debris mitigation, and consider the cumulative impact of their systems on the orbital environment.

Small satellite operators, despite the relative simplicity of their missions, share the same responsibilities as larger operators in preserving space for future use. This includes submitting accurate filings, complying with end-of-life disposal guidelines, and supporting international efforts to ensure safe, predictable operations in shared orbital regimes.

V. Conclusion

Small satellites have transformed the space industry by democratizing access, enabling rapid innovation, and providing a flexible platform for a wide range of missions. However, these benefits come with regulatory responsibilities that are no less stringent than those faced by their larger counterparts.

The lead-up to WRC-27 represents a critical moment for the small satellite community. Active engagement in the ITU process, combined with a clear understanding of the applicable regulatory framework, will be essential to securing continued access to spectrum and orbital resources. Common misconceptions about regulatory exemptions based on size must be addressed through education and outreach.

By participating constructively in international discussions and advocating for their needs within established procedures, small satellite stakeholders can help shape a regulatory environment that is fair, efficient, and sustainable. In doing so, they will ensure that their contributions to space exploration, science, and connectivity continue to grow without compromising the long-term viability of the space domain.