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Agenda Items of the World Radiocommunication Conference 2023 With a Potential Impact on Microwave Remote Sensing

Remote sensing is the scientific discipline of measuring radiation emitted or reflected from an object or area to study its physical characteristics. In particular, microwave remote sensing uses the portion of the electromagnetic spectrum called the *radio-frequency spectrum*, which is defined as the range of frequencies from 9 kHz to 3,000 GHz by the International Telecommunication Union (ITU), a specialized agency of the United Nations.

Rules governing the usage of the radio-frequency spectrum at the international level are contained in a treaty called *Radio Regulations* (*RR*) [1]. The Radiocommunication Sector of the ITU (ITU-R) is responsible for updating the RR at a World Radiocommunication Conference (WRC) that is held approximately every four years [2]. The next WRC will be held in November 2023 and is referred to as WRC-23.

During a WRC, in addition to considering and deliberating on revisions to the RR proposed by the ITU members, the agenda for the following WRC is set. WRC agendas are composed of focused topics whose scope is described by accompanying resolutions. A First Conference Preparatory Meeting (CPM-1) is held to coordinate the work on the agenda items among six Study Groups of the ITU-R, which carry out technical studies with the contribution of the ITU Member States and Sector Members. Approximately six months before the WRC, a Second Conference Preparatory Meeting (CPM-2) takes place to consolidate the technical input for all study groups into one CPM Report that will then be used as a guideline in making decisions at the WRC [3].

The ITU-R study groups perform studies through their Working Parties (WPs), with each WP focusing on specific radiocommunication services and systems [1]. WP 7C, which falls under Study Group 7 (Science Services), is responsible for remote sensing systems. In ITU terminology, the radiocommunication service associated with spaceborne remote sensing instruments is called the Earth exploration-satellite Service (EESS), and it can be either active or passive.

Figure 1 is a graphical illustration of the WRC-23 agenda items for which WP 7C is responsible and those to which WP 7C is contributing technical studies, as discussed during the CPM-1 [4] that followed WRC-19 and in subsequent study group meetings. Note that some of the WRC-23 agenda items do not seek to change existing regulations globally, but only in some specific geographical areas. The ITU refers to them as ITU Regions [1]. These regions are shown in Figure 2 and will be used in the brief descriptions of the agenda items in the next section.

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AGENDA ITEMS

AI 1.2: INTERNATIONAL MOBILE TELECOMMUNICATIONS BETWEEN 3.3 AND 10.5 GHz

This agenda item will consider identification of the following frequency bands for international mobile telecommunications (IMT):

- 3,600–3,800 MHz and 3,300–3,400 MHz (in Region 2)
- 3,300–3,400 MHz (amend footnote RR No. 5.458 in Region 1)
- 6,425–7,025 MHz (in Region 1)
- 7,025–7,125 MHz (globally)
- 10,000–10,500 MHz (in Region 2).

Resolution 245 (WRC-19) invites ITU-R to conduct sharing and compatibility studies that also consider protection of other coprimary services using these bands as well as services operating in adjacent bands.

The remote sensing bands that could be affected are

- 6,425–7,250 MHz used by passive sensors without allocation (footnote RR No. 5.458)
- 10–10.4 GHz used by active sensors with a primary allocation
- 10.6–10.7 GHz used by passive sensors with a primary allocation.

Footnote RR No. 5.458 indicates that administrations should keep in mind the needs of the remote sensing passive instruments in their future planning of the bands 6,425–7,075 MHz and 7,075–7,250 MHz as passive microwave sensor measurements are made in these frequency bands.

AI 1.4: HIGH-ALTITUDE PLATFORM STATIONS AS INTERNATIONAL MOBILE TELECOMMUNICATIONS BASE STATIONS BELOW 2.7 GHz

This agenda item seeks to extend the opportunities for the use of high-altitude platform stations as IMT base stations

(HIBSs) in certain bands below 2.7 GHz already identified for IMT. The frequency bands under consideration are 694–960 MHz, 1,710–1,885 MHz, 1,885–1,980 MHz, 2,010–2,025 MHz, 2,110–2,170 MHz, and 2,500–2,690 MHz. The HIBSs are a combination of two types of systems, IMT and high-altitude platform stations, which individually have a high potential for interference.

Concerns for remote sensing related to this agenda item are the following:

- The adjacent 2,690–2,700-MHz band is allocated to passive scientific services, i.e., EESS (passive), and radio astronomy (RAS).
- Secondary harmonics from portions of the 694–960-MHz band place the L-band at 1,400–1,427 MHz at risk of interference.

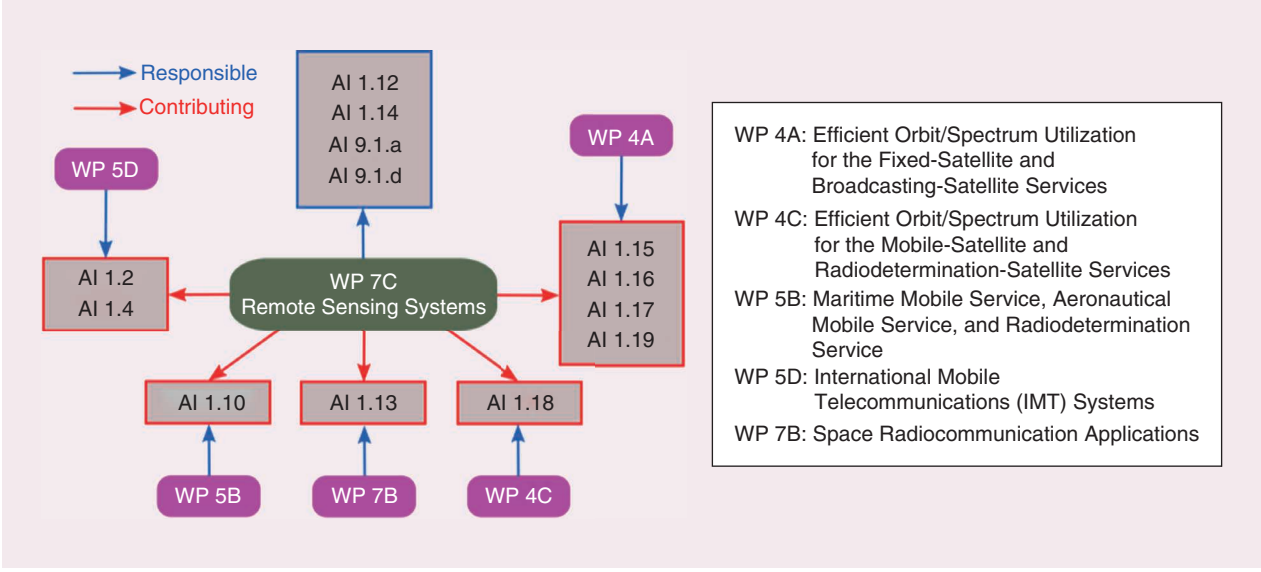

FIGURE 1. The WRC-23 agenda item assignments to WP 7C.

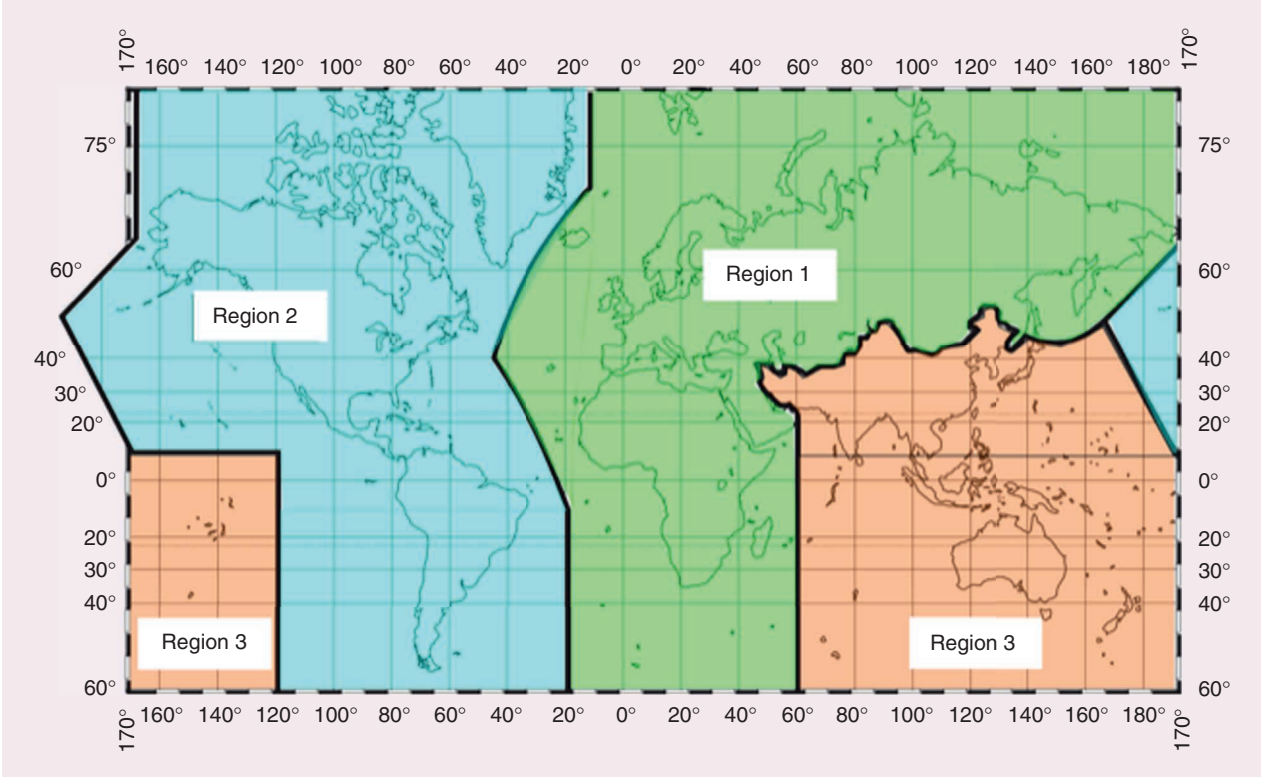

FIGURE 2. The ITU Regions.

Also note that some passive instruments (e.g., wideband radiometers for cryosphere and salinity studies [5], [6]) are planned to operate at 0.5–2.0 GHz without allocation.

AI 1.10: SHARING/COMPATIBILITY FOR AERONAUTICAL MOBILE AT 15.4–15.7 AND 22.21–22.5 GHz

Resolution 430 (WRC-19) invites ITU-R to conduct studies on spectrum needs for new nonsafety aeronautical mobile applications for air–air, ground–air, and air–ground communications of aircraft systems, particularly for

- possible new primary allocations to the aeronautical mobile service in the frequency band 15.4–15.7 GHz
- changing the primary 22–22.21 GHz allocation from "mobile except aeronautical mobile" to "mobile" service, which includes aeronautical mobile.

The bands 15.35–15.4 GHz and 22.21–22.5 GHz are allocated to passive remote sensing systems as primary and are adjacent to the frequency ranges considered in this agenda item. However, currently no known missions have used or are using the 15.4–15.7-GHz band. The 22.21–22.5-GHz band is widely used for water vapor measurements.

AI 1.12: POSSIBLE NEW SECONDARY ALLOCATION TO EARTH EXPLORATION-SATELLITE SERVICE (ACTIVE) AROUND 45 MHz

Resolution 656 (WRC-19) invites one to study a new secondary allocation to the EESS (active) for spaceborne radar sounders in the 40–50-MHz band. These sensors would be used for investigating subsurface properties of polar ice and arid regions.

The instruments would be spaceborne on a low Sun-synchronous orbit at an altitude of around 400 km and be subject to additional operational constraints, i.e., the radar is to transmit only over some geographic areas (Antarctica, Greenland, and the Sahara) at night between 3 a.m. and 6 a.m. local time to minimize errors due to ionospheric perturbations and limit any impact on other radiocommunication services.

Technical parameters are still being discussed for an update of Report ITU-R RS.2455, "Preliminary Results of Sharing Studies Between a 45-MHz Radar Sounder and Incumbent Fixed, Mobile, Broadcasting, and Space Research Services Operating in the 40–50-MHz Frequency Range."

AI 1.13: POSSIBLE UPGRADE OF 14.8–15.35 GHz TO THE SPACE RESEARCH SERVICE

Resolution 661 (WRC-19) invites ITU-R to conduct sharing and compatibility studies to determine the feasibility of upgrading the space research service (SRS) allocation to primary status in the frequency band 14.8–15.35 GHz, while still ensuring protection of the primary services fixed and mobile within the band and RAS, EESS (passive), and SRS (passive) in the adjacent band 15.35–15.4 GHz.

Since the band would be used for transmitting and receiving scientific data and related telemetry information, this agenda item falls under the responsibility of WP 7B. The 14.8–15.35-GHz band is already a primary allocation for SRS in the U.S. Table of Allocations under RR 5.340, and no emissions are allowed in the frequency range of 15.35–15.4 GHz. The primary concern is the potential for radio-frequency interference from out-of-band emission (OOBE) caused by transmissions from the adjacent band.

AI 1.14: ALLOCATIONS TO PASSIVE REMOTE SENSING IN THE 231.5–252-GHz RANGE

This agenda item considers possible adjustments of the existing or potential new primary frequency allocations to the EESS (passive) in the frequency range 231.5–252 GHz, with the purpose of better aligning the EESS (passive) allocations created 20 years ago with updated passive sensor design requirements or adding possible new allocations to the EESS (passive).

Current EESS (passive) allocations are 235–238 GHz and 250–252 GHz. The band 237.9–238 GHz is also allocated to the EESS (active) for spaceborne cloud radars only. These frequencies can be used for measurement of ice cloud properties, and the 243.2-GHz band is being considered for future ice cloud imaging passive sensors.

AI 1.15: GEOSTATIONARY EARTH STATIONS IN MOTION AT 12.75–13.25 GHz

Agenda Item 1.15 is "to harmonize the use of the frequency band 12.75–13.25 GHz (Earth-to-space) by Earth stations on aircraft and vessels communicating with geostationary space stations in the fixed-satellite service globally, in accordance with Resolution 172 (WRC-19)."

The potential for OOBEs into the adjacent EESS (active) allocation at 13.25–13.75 GHz is of particular concern for the scientific services. Resolution 172 (WRC-19) also mentions space-to-Earth operations at 10.7–10.95 GHz, which is adjacent to the 10.6–10.7-GHz EESS (passive) frequency band.

AI 1.16: EARTH STATIONS IN MOTION NEAR 18.6–18.8 GHz AND OTHER BANDS

Resolution 662 (WRC-19) invites the ITU-R to study and develop technical, operational, and regulatory measures for the use of the frequency bands 17.7–18.6, 18.8–19.3, 19.7–20.2 (space-to-Earth), and 27.5–29.1 and 29.5–30 GHz (Earth-to-space) by Earth stations in motion (ESIM) in nongeostationary orbit (non-GSO).

The ESIM operations are intended to provide broadband data services to aeronautical (commercial and business aviation) and maritime routes (passenger cruise and merchant ships, fishing vessels, and so on) on a global basis. Within the frequency bands under consideration, the bands

17.7–18.6 GHz and 18.8–19.3 GHz are adjacent to the band 18.6–18.8 GHz, which is allocated to the EESS (passive).

Instruments, such as the Advanced Microwave Scanning Radiometer 2 (AMSR-2) and global precipitation measurement microwave imager (GPM-GMI) sensor, operating at 18.6–18.8 GHz are already experiencing interference from reflections off the ocean surface of broadcast signals from geostationary satellites, so particular attention needs to be paid to this issue.

AI 1.17: INTERSATELLITE LINKS AT 11.7–12.7, 18.1–18.6, 18.8–20.2, AND 27.5–30 GHz

This agenda item calls for studies on provisions to allow satellite-to-satellite links to be operated in several frequency bands allocated to fixed satellite services. Some of these bands are adjacent to 18.6–18.8 GHz, where EESS (passive) systems also operate. Similarly to AI 1.16, there are concerns for interference due to reflection off Earth's surface as well as from the direct path to the remote sensing sensor.

AI 1.18: SPECTRUM NEEDS AND POTENTIAL NEW ALLOCATIONS TO THE MOBILE SATELLITE SERVICE FOR FUTURE DEVELOPMENT OF NARROWBAND MOBILE SATELLITE SYSTEMS

This agenda item calls for consideration of new allocations to the mobile satellite service to be used by low-data-rate systems for the collection and management of data from terrestrial devices in the following bands:

- 1,695–1,710 MHz in Region 2
- 2,010–2,025 MHz in Region 1
- 3,300–3,315 MHz, 3,385–3,400 MHz in Region 2.

The main concern for scientific services is that the frequency band 1,695–1,710 MHz is allocated to the meteorological satellite service and is primarily used for downlink of meteorological data from non-GSO meteorological satellites to ground stations around the world, thus potentially affecting other regions beside Region 2. Also, this frequency band is allocated to the meteorological aids on a primary basis in all three regions.

The frequency band 3,100–3,300 MHz, adjacent to 3,300–3,400 MHz, is allocated on a secondary basis to the EESS (active), with a potential for out-of-band interference affecting active remote sensing instruments operating in this band.

AI 1.19: NEW PRIMARY ALLOCATION TO THE FIXED SATELLITE SERVICE IN THE SPACE-TO-EARTH DIRECTION IN THE FREQUENCY BAND 17.3–17.7 GHz IN REGION 2

Remote sensing has primary EESS (active) allocation in the 17.2–17.3-GHz band, and new fixed satellite service operations at 17.3–17.7 GHz could potentially result in increased adjacent band interference.

AI 9.1.a: SPACE WEATHER SENSORS

Resolution 657 (WRC-19) calls for studies on technical and operational characteristics, spectrum requirements, and appropriate radio service designations for space weather sensors to achieve appropriate recognition and protection in the RR without placing additional constraints on incumbent services.

No regulatory action is to be taken at WRC-23 as an outcome of this agenda item. ITU-R WP 7C has prepared a comprehensive Report ITU-R RS.2456, "Space Weather Sensor Systems Using Radio Spectrum."

The following two other documents are under development:

- spectrum requirements and applicable radio service designations for receive-only space weather sensors that provide data critical for predictions and warnings
- interference criteria of receive-only space weather sensors.

AI 9.1.d: PROTECTION OF EARTH EXPLORATION-SATELLITE SERVICE (PASSIVE) AT 36–37 GHz

A preliminary study was performed for WRC-19 Agenda Item 1.6 on the protection of EESS (passive) sensors operating in the band 36–37 GHz from space stations on non-GSO in large constellations at 37.5–38 GHz. As a result, WRC-19 invited the ITU-R to conduct further analyses on this topic.

The nearby EESS (passive) 36–37-GHz band is critical for satellite passive microwave measurements primarily of precipitation and sea ice. AMSR-2, GMI, and WindSat operate in this band, and the planned European Space Agency mission Copernicus Imaging Microwave Radiometer will also use it. OOBEs into 36–37 GHz can arise in several ways:

- reflections off Earth's surface, particularly from the ocean and ice
- direct coupling into the sensor receiving antenna
- interference with cold-sky calibration.

THE FREQUENCY ALLOCATIONS IN REMOTE SENSING TECHNICAL COMMITTEE AND THE IEEE GEOSCIENCE AND REMOTE SENSING SOCIETY VIEWS ON WRC-23 AGENDA ITEMS DOCUMENT

The Frequency Allocations in Remote Sensing (FARS) Technical Committee was established by the IEEE Geoscience and Remote Sensing Society (GRSS) in 2000. It is intended as a means for the GRSS community to discuss spectrum management issues that affect the remote sensing field and defend the interests of the remote sensing community in matters relevant to frequency allocations. Its membership includes scientists and engineers working in remote sensing at a variety of institutions worldwide.

The mission of the FARS Technical Committee is to serve as an interface between the GRSS and the radio-frequency regulatory world by

- educating the remote sensing community on spectrum management processes and issues
- promoting the development of radio-frequency interference detection and mitigation technology
- organizing technical sessions at conferences, workshops, and so on regarding the preceding processes, issues, and technologies

- providing spectrum managers and regulators with technical input and perspective from remote sensing scientists and engineers
- fostering the exchange of information between researchers in different fields, such as remote sensing, radio astronomy, and telecommunications, with the common scope of minimizing harmful interference between systems.

The FARS Technical Committee is working on a document providing views on international regulatory issues affecting remote sensing operations. In particular, the GRSS Views document includes the WRC-23 agenda items that could have a potential impact on remote sensing operations that have been introduced here and on other ITU-R topics that could also affect remote sensing. The purpose of this document is to be a tool enabling GRSS members to familiarize themselves with these issues and inform remote sensing scientists and engineers of these concerns so that they may engage in their administrations' decision-making process to consider them. The FARS Technical Committee encourages the participation of the entire remote sensing community in developing this document. If you are interested in participating in this effort, please contact the Technical Committee chair and cochairs at fars_chairs@grss-ieee.org.

THE GRSS VIEWS DOCUMENT INCLUDES THE WRC-23 AGENDA ITEMS THAT COULD HAVE A POTENTIAL IMPACT ON REMOTE SENSING OPERATIONS THAT HAVE BEEN INTRODUCED HERE AND ON OTHER ITU-R TOPICS THAT COULD ALSO AFFECT REMOTE SENSING.

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WOMEN IN GRSS

(continued from p. 273)

fact that she chose to embrace her fears, and through them found her calling."

Expanding on her ILC experience, Dr. Onyia was also "honestly surprised with how much I related to the experiences and realities shared by speakers at the conference. From tips on how to advance as a woman of color in STEM entrepreneurship, to tips on promoting a psychologically safe space at your workplace (my first time coming across this concept), to rocking difficult conversations, I found these topics very relevant to my current situation with my company and my other job role." On the virtual experience, she adds that she would still prefer the face-to-face event, especially the networking aspect, but that it was a good compromise considering the situation. She had attended a previous ILC in person and adds it was a really eye-opening experience for her, even beyond her expectations: "The topics addressed were so contemporary and relevant to current work environments, and they provided handy tools for easy implementation."

At IDEA, our mission goal is to inspire, develop, empower, and advance all GRSS members. IDEA has developed an amazing team of dedicated volunteers. The sponsorship of attendance at the ILC has proved to be an inspirational experience for our IDEA members. The ILC speakers shared experiences, insights, and advice that will stay with our four attendees as they continue to pursue their incredible careers. We are a global community, and this coming together of women leaders is helping all women feel inspired and empowered. The IDEA committee is grateful to be able to support our core-initiative coleads in their journeys.

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