PROCEEDINGS OF SCIENCE

WRC-27 Scientific Agenda Items
The Future of Science Services

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The World Radiocommunication Conference 2023 (WRC-23) established a comprehensive agenda for WRC-27, addressing critical issues in satellite, terrestrial, and scientific services. Among the 19 agenda items, five focus on scientific services, including lunar communications, radio astronomy protection, space weather sensors, and Earth exploration services. This paper examines these agenda items, detailing the studies mandated by resolutions to ensure efficient spectrum allocation and protection against harmful interference. Key topics include the development of lunar communication systems, safeguarding radio astronomy through Radio Quiet Zones (RQZs), protecting passive sensors for space weather and Earth observation, and optimizing allocations for sea surface temperature (SST) measurements. The studies, guided by ITU-R study groups, aim to balance technological advancements with the protection of critical scientific activities. By promoting international cooperation and sustainable spectrum use, these efforts will support future regulatory decisions and enable a resilient global radiocommunication ecosystem.

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1. Introduction

The World Radiocommunication Conference 2023 (WRC-23) approved Resolution 813 [1], setting the agenda for WRC-27 with 19 items related to satellite, terrestrial, and scientific services to be studied in the 2024-2027 cycle. The five scientific agenda items (1.15 to 1.19) focus on Lunar Communications, Radio Astronomy Protection, Space Weather Sensors, Protection of Earth Exploration Services, and Allocations for Earth Exploration.

These topics highlight the ITU's [2] commitment to advancing space technologies and protecting scientific services, ensuring benefits for space and Earth activities. This paper examines the key scientific agenda items of WRC-27 and the necessary studies to protect and enhance space science services.

2. International Telecommunications Union (ITU)

The ITU, through its Radiocommunication Sector (ITU-R), manages the radio-frequency spectrum and satellite orbits, guided by the Radio Regulations (RR) [3], an international treaty updated every four years during the World Radiocommunication Conference (WRC). This process ensures global communications are efficient, interference-free, and aligned with technological advancements.

The WRC is of paramount importance, as it convenes ITU Member States to review and amend the RR, ensuring they address emerging challenges and evolving demands. International cooperation at the WRC is vital to tackling critical issues such as satellite usage, expansion of mobile communications, advancements in space science, meteorological services, and sustainability in space operations.

2.1 WRC-27 Study Cycle (2024-2027)

The WRC-27 study cycle began after the conclusion of WRC-23, with the first Conference Preparatory Meeting (CPM27-1) held in December 2023 in Dubai. During this cycle, ITU-R study groups will analyze spectrum sharing and compatibility across 19 agenda items, ensuring a comprehensive review of key technical and regulatory issues.

This process supports updates to the RR and culminates in a second CPM session, six months before WRC-27, where technical and regulatory proposals will be finalized to assist Member States in decision-making.

3. Science Services Agenda Items for WRC-27

The WRC-27 scientific agenda focuses on enhancing lunar communications, protecting radio astronomy, Earth observation, and space weather services, and exploring new spectrum allocations. These efforts support scientific exploration and sustainable spectrum use.

3.1 Lunar Communications Developments

Lunar exploration is advancing with numerous planned missions, emphasizing collaboration among spacefaring entities [4]. This approach addresses challenges, advancing lunar settlements, commercial ventures, and robust communications for surface operations, data transfer, and human presence.

In response to increasing interest in lunar exploration, the WRC-23 approved Resolution 680 - Studies on frequency-related matters, including possible new or modified space research

service (space-to-space) allocations [1]. This defines studies under Agenda Item 1.15 for WRC-27, focusing on developing radiocommunication services tailored to lunar operations. Spectrum requirements will be evaluated for various frequency ranges: 390–406.1 MHz, 420–430 MHz, 440–450 MHz, 2 400–2 690 MHz, 3 500–3 800 MHz, 5 150–5 570 MHz, 5 570–5 725 MHz, 5 775–5 925 MHz, 7 190–7 235 MHz, 8 450–8 500 MHz, and 25.25–28.35 GHz.

Studies will evaluate lunar system compatibility with existing services, ensuring protection for radio astronomy in the Shielded Zone of the Moon (SZM), while also analyzing technical needs and spectrum sharing to mitigate interference. Exploring new allocations is crucial for advancing space communications and safeguarding critical services reliant on protected spectrum.

3.2 Radio Astronomy Protection

Radio astronomy, as defined by the RR, studies cosmic phenomena through radio waves, aiding in understanding stars, galaxies, and the universe's evolution [5]. It also supports space weather forecasting, issuing solar activity alerts that impact satellites, communications, and power grids. Its advancements, such as high-gain antennas, low-noise receivers, and VLBI, have driven innovations in telecommunications, Wi-Fi, GPS, and medical imaging technologies.

However, radio astronomy faces challenges due to its extremely weak signals, making it highly vulnerable to interference. To protect Radio Astronomy Services (RAS) from non-GSO satellite interference, WRC-23 adopted Resolution 681 under Agenda Item 1.16 [1]. This resolution establishes Radio Quiet Zones (RQZs) with modified spectrum management to reduce interference in bands like 10.6–10.7 GHz, 42.5–43.5 GHz, 76–77.5 GHz, 94.1–95 GHz, 100–102 GHz, 114.25–116 GHz, and 130–134 GHz.

The resolution also supports the formal recognition of SKAO in South Africa and ALMA in Chile, ensuring their role in pioneering research. Studies will evaluate non-GSO satellite emissions, define separation distances, and propose coexistence strategies. Incorporating RQZ protections into global regulations balances satellite growth with safeguarding vital scientific observations.

3.3 Passive Space Weather Sensors (SWS)

Space weather, as defined by Resolution 675 (WRC-23) [3], involves natural phenomena from solar activity beyond Earth’s atmosphere. Passive EESS sensors monitor it by measuring radio emissions and solar radiation without transmitting [6]. Their data is essential for tracking the ionosphere, forecasting weather, and predicting solar storms that threaten telecommunications, satellites, power grids, and aviation, highlighting the need to protect these sensors from interference.

To achieve this protection, WRC-23 approved Resolution 682 [1], which mandates studies on spectrum needs and protection criteria for receive-only SWS. Key frequency bands include 27.5–28.0 MHz, 29.7–30.2 MHz, 32.2–32.6 MHz, 37.5–38.325 MHz, 73.0–74.6 MHz, and 608–614 MHz. These studies aim to ensure coexistence with other services while avoiding interference.

Additionally, integrating passive SWS into the Master International Frequency Register (MIFR) will provide long-term protection and recognition. Suspending frequency assignments until WRC-27 prevents conflicts and supports space weather operations. These initiatives will

safeguard critical sensors, enhance telecommunications safety, and sustain solar activity monitoring essential for societal resilience.

3.4 Protecting EESS and RAS Above 76 GHz

The EESS (passive) and the RAS are critical for environmental monitoring and scientific research in frequency bands above 76 GHz. EESS (passive) uses non-emitting sensors to collect data on atmospheric composition and climate, essential for climate modeling and disaster mitigation [7]. RAS, in contrast, detects weak radio waves from distant cosmic sources, requiring highly sensitive systems. Active services like Fixed-Satellite Service (FSS), Mobile-Satellite Service (MSS), and Radionavigation-Satellite Service (RNSS) also operate in adjacent bands, supporting global communications and navigation.

To ensure compatibility, WRC-23 approved Agenda Item 1.18 under Resolution 712, mandating studies on the impact of unwanted emissions in EESS bands (86–92 GHz, 114.25–116 GHz, 164–167 GHz, and 200–209 GHz) and RAS bands (76–81 GHz, 130–134 GHz, 164–167 GHz, and 226–231 GHz) [1]. These studies will establish protection criteria, including emission thresholds, to safeguard passive observations and radio astronomy.

The results, to be reviewed at WRC-27, may lead to updates in existing resolutions like Resolution 750 (Rev.WRC-19) [3]. Protecting these services is essential to ensure coexistence between observational and communication systems, avoiding interference and preserving the integrity of scientific research.

3.5 Sea Surface Temperature Measurements - EESS Allocations

Sea Surface Temperature (SST) measurements, conducted using passive microwave radiometers, are essential for climate modeling, forecasting extreme weather events, and understanding ocean-atmosphere interactions, global warming, and climatic phenomena like El Niño and La Niña that affect weather patterns [7, 8,].

The WRC-23, considering the use of 6,425–7,250 MHz for SST measurements, approved Agenda Item 1.18 under Resolution 674 [1], proposing new primary allocations in the 4,200–4,400 MHz and 8,400–8,500 MHz bands to enhance SST capabilities. These studies will assess the feasibility of these allocations, ensuring SST monitoring improves without interfering with existing services. Furthermore, the use of these complementary frequency bands will enhance SST data quality and reduce the risk of radio-frequency interference.

These enhancements ensure accurate SST measurements for long-term climate monitoring, even under cloud cover. Preventing interference and optimizing allocations strengthens SST's role in climate variability detection and extreme weather prediction.

4. Status of discussions and next steps

In the first year of the WRC-27 cycle, discussions for all agenda items have focused on gathering technical characteristics for future sharing and compatibility studies. Starting in 2025, these studies will provide detailed analyses and regulatory measures to ensure effective and interference-free operation of various radiocommunication services. Each agenda item will be managed by its respective ITU-R study group to guarantee specialized attention.

The studies will address operational concepts for lunar communications, protection of RQZ for the RAS, protection criteria for passive SWS, protection of EESS and RAS above 76 GHz,

and updates to frequency bands for SST measurements. Utilizing simulation tools, field tests, and analysis, these studies aim to enhance service compatibility and mitigate interference.

Strict adherence to guidelines outlined in relevant resolutions is essential for the success and approval of these studies at WRC-27. The outcomes will inform future decisions and regulatory actions, ensuring effective coexistence and integrity of various radiocommunication services.

5. Conclusions

In conclusion, addressing the WRC-27 scientific issues are crucial for advancing space communications, protecting scientific services, and ensuring the sustainable use of spectrum, all of which are vital for global technological progress. Consensus among ITU Member States will ensure the RR are updated to support sustainable spectrum use and meet the demands of an increasingly connected and data-driven world.

The WRC-27 agenda tackles critical challenges, such as protecting scientific services, including radio astronomy and meteorological monitoring, from harmful interference, while fostering international cooperation to align global regulatory efforts. These efforts safeguard services and drive innovation for priorities like disaster response and sustainable development.

The studies on lunar communications, radio astronomy protection, space weather sensors, and Earth exploration-satellite service allocations will guide future regulatory decisions to balance technological advancements with environmental and scientific needs. By ensuring a harmonious and equitable use of the spectrum, these initiatives will empower nations to address current and emerging challenges.

Conducted by ITU-R study groups, these efforts aim to create a safer and more sustainable global radiocommunication environment. The collaboration of Member States is essential to implement effective regulatory frameworks that support not only immediate priorities but also the long-term vision for a thriving and inclusive space ecosystem.

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