An Overview of Scientific Services and their access to the frequency spectrum in WRC 2015

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Abstract

In view of the impending World Radiocommunication Conference (WRC 2015) the Study Group «Scientific services» (SG7) of ITU-R is working on the agenda items (AI) of its attribution.

The aim of the paper is to give an overview on the ongoing subject matters. The authors reminds scientists of the continuous efforts to be made not only on the AIs attributed to SG7 but also on numerous subjects in co-operation with other Study Groups in order to establish common rules of sharing frequency bands. Scientists are invited to fully collaborate to this common task.

1. Introduction

For Martin Heidegger «Science is the theory of the real» [1]; it is not surprising that researchers thursty for knowledge wanted to explore the real world thanks to the electromagnetic field. However after H.Hertz made his famous discovery, there was a multiplication of applications in the frequency spectrum with the result that the field of research has regularly schrunk. Therefore scientists now have to co-operate with an ever increasing and diversified number of users of the frequency spectrum. Thank God ITU set up the rules mainly with respect to the Radio Regulations (RR) [2] updated during the WRCs every 3/4 years.

It is therefore the task of SG 7 «Scientific services» of ITU-R to prepare the subjects on the agenda of each WRC attributed partly in full responsability and partly in co-operation with other SGs. Indeed certain subjects come directly under scientific activities whereas others are connected to them in particular with regard to other Services which have common spectral or spatial borders. It is therefore up to the Spectrum management Agencies of the 189 ITU-R member countries to conduct these works.

The present paper shows the AI of the coming WRC 2015 under the responsability of SG 7, describes the state of ongoing work and illustrates the importance of other subjects to which SG 7 has to contribute so as to establish common rules for a smooth and harmonious functionning with neighbouring frequency bands and/or those which have to be shared.

Other less outstanding but nonetheless important subjects give rise to «Questions»; they are attributed to each relevant SG and the results of their corresponding work are produced in the form of Resolutions or Reports. Example: Question ITU-R 251/7 «Ground-based passive sensors».

Even if the final decision belongs to the WRCs, the pace they impose must not hide the considerable and continuous work accomplished by competent international teams conducted by the Agencies, teams which benefit of contributions from all the « Sector members» of ITU-R such as URSI although they have no voting rights.

2. Primary allocation for the Earth Exploration-Satellite Service

The agenda item (AI) 1.11 considers the provision of a new primary allocation to the Earth Exploration Satellite Service EESS (Earth-to-space) in the 7-8 GHz range in order to complement telemetry operations of EESS (space-to-Earth) in the 8 025-8 400 MHz band.

The high concentration of satellites (several hundreds) using the band 2025-2110 MHz (E-s) and 2200-2290 MHz (s-E) for Tracking, Telemetry and Control (TT&C) is making the satellites coordination in these bands rather difficult.

Among the various satellite services using this band, the Earth exploration-satellite service (EESS) currently can only use the allocation at 2 025-2 110 MHz for the Earth-to-space transmissions, because no other Earth-to-space allocations are available at higher frequencies. The EESS (s-E) allocations at higher frequencies (8025-8400 MHz and 25.5-27 GHz) do not have any corresponding EESS (E-s) allocation and therefore in practice can be used only for payload data transmission and not for TT&C.

An EESS (E-s) allocation in the 7-8 GHz range would allow its use for TT&C in combination with the existing EESS (s-E) allocation in the band 8 025-8 400 MHz, thereby alleviating the congestion problem in S-Band, mitigating the frequency coordination problem, and eventually leading to a simplified on-board architecture and operational concept for future EESS missions. By this way some EESS new missions that already have to use the 8025-8400 MHz band for payload downlink, may use this band at these higher frequencies also for TT&C. It is to be noted that only some EESS missions may be able to migrate to the higher frequency for TT&C. And also these ones may still need using the bands 2025 – 2110 MHz and 2200-2290 MHz during LEOP (Launch and Early Orbital Phase) and in case of emergency, as other satellite systems using the space operation allocation in this band.Nevertheless a new EESS allocation would allow limiting the use of these very congested bands at 2 GHz in a way similar to what is done for many telecommunications satellites.

The frequency range 7145-7235 MHz was identified at the WRC 12 as the most promising frequency range for this potential new EESS (E-s) allocation. This range is sufficiently close to the existing EESS (s-E) allocation at 8025-8400 MHz and has been shared for more than 15 years between the Space Research Service (SRS) (E-s) worldwide and furthermore with the Space Operation Service (E-s) in the Russian Federation, and systems of the Fixed/Mobile services with no specific sharing problems being reported. Several compatibility studies between the potential new allocation of EESS and the existing in band or adjacent services was presented. Some of them are completed and show that the compatibility is possible and others are still on going.

3. Extension of the current allocation to the EESS (active) in X-band

During the study cycle for WRC-07, studies were performed by ITU-R to investigate the conditions for the extension of the EESS (active) allocation by 200 MHz above or below the former allocation 9 500 – 9 800 MHz. Based on the results and conclusions in report ITU-R RS.2094, WRC-07 finally decided to extend the allocation to 9 300- 9 900 MHz. The frequency band 9 300-9 500 MHz was allocated to EESS (active) on a primary basis and the frequency band 9 800-9 900 MHz on a secondary basis. This was possible because the overall sharing conditions were found to be acceptable if certain conditions are obeyed. These conditions are regulated in some footnotes of the RR to protect other radio services in countries mentioned in the footnotes. That is the objective of studies under the AI 1.12.

Space-borne radars operating in the EESS (active) in this band have demonstrated their important contributions to a large number of scientific and geo-information applications which is also recognised in **Resolution 673 (rev. WRC-12)**. The growing demand for higher resolution radar picture raises the need to further increase the transmission bandwidth of the next generation of EESS-radars in this band because the effectively used transmission bandwidth has a direct correspondence to the achievable picture resolution.

The SARs operating around 9.6 GHz are controlled via ground command to turn on and off as required to view only specific areas on the Earth in spotlight mode.

4. Communications with an orbiting manned space vehicule

The AI 1.13 proposes to review the RR. No. 5.268 with a view to examining the possibility for increasing the 5 km distance limitation and allowing space research service (space-to-space) use for proximity operations by space vehicles communicating with an orbiting manned space vehicle, in accordance with Resolution 652 (WRC 12);

Resolution 652 (WRC-12) resolves to invite WRC-15 to review No. 5.268, taking into account the results of ITU-R studies, including the possible removal or relaxation of the 5 km distance limitation without modifying the current pfd limits.

Furthermore WRC-15 is invited to allow a more general use of the 410-420 MHz band for SRS (space-to-space) systems beyond extra-vehicular activities (EVA).

Most of administrations support the removal of both the 5 km distance limitation and restriction to EVA operation if the studies performed in accordance with Resolution **652 (WRC-12)**, demonstrate that space vehicle links operating around a manned vehicle beyond 5 km can meet the pfd limits in No. **5.268**. Removal of these two restrictions will allow for greater flexibility in using the band 410-420 MHz for space research activities while maintaining protection of the terrestrial services

5. Future of the Coordinated Universal Time (UTC) time-scale

The extraordinary precision and stability of atomic clocks since 1955 led to adopt in 1971 the «Temps Atomique International» (TAI, International atomic time) and so as to set up the definition of the second [3]. UTC was decided upon in 1972 and being used ever since. It relies on a large number of atomic clocks located in several institutes worlwide -- extreme reliability and long-term frequency stability being essential for an international reference.

Historically, timekeeping was based on the rotation of The Earth. Nowadays some applications require to keep a time scale based on the rotation of the Earth. The measure of this rotation is using a worlwide network of radio telescopes and results in a time-like quantity called UT1 [4,5].

To ensure a synchronisation between time based on atomic clocks and time based on Earth rotation it was decided to avoid a time difference, UTC-UT1, of more than 0.9 second ; this leads to introduce a «leap second» from time to time (2/3 years) due to a rotation speed variable of the Earth, in accordance with the Recommandation ITU-R TF. 460-6.

However all kinds of applications currently use the UTC time-scale and naturally their users prefer not to have discontinuities in their functionning given the inherent error risks: they therefore favor a continuous time-scale. See the remarquable Special edition of ITU on «The future of time» [6]. The simplicity of the question should not conceal the difficulty of a answer given the practical complexity of the subject and the number of implied bodies: the International Earth Rotation and Reference Systems Service (IERS), the International Union of Geodesy and Geophysics (IUGG), the Bureau International des poids et mesures (BIPM), the International Astronomical Union (IAU), the Consultative Committee for Time and Frequency (CCTF), the International Civil Aviation Organisation (ICAO), the International Maritime Organisation (IMO), The International Organisation for Standardisation (ISO), the World Meteorological Organisation (WMO) and the International Union of Radio Science (URSI).

6. Regulatory aspects on nano- and pico satellites

WRC-12 adopted Resolution **757 (WRC-12)** which *resolves* to invite WRC-18 to consider whether modifications to the regulatory procedures for notifying satellite networks are needed to facilitate the deployment and operation of nanosatellites and picosatellites, and to take the appropriate actions, and *invites* ITU-R to examine the procedures for notifying space networks and consider possible modifications to enable the deployment and operation of nanosatellites and picosatellites, taking into account the short development time, short mission time and unique orbital characteristics.

The work was allocated to Working Party 7B as the responsible group. Working Party 4A and the Special Committee are contributing groups, and Working Parties 5A and 6A are interested groups.

Nanosatellites and picosatellites are being used for a wide variety of missions and applications, including remote sensing, space weather research, upper atmosphere research, astronomy, communications, technology demonstration and education, as well as commercial applications, and therefore may operate under various radiocommunication services.

There is an interest in utilizing the potential benefits offered by small satellites, including those referred to as nanosatellites or picosatellites. These technologies allow many projects to be developed quickly and deployed with lower cost than with traditional satellites.

Recent system developer experiences have shown that the development, deployment and launch arrangement timelines for nanosatellite and picosatellite systems may be much shorter than for traditional satellite systems thus creating a challenge for early identification of the mission specific orbital parameters to enable timely filing of information required for international coordination.

Furthermore, some nanosatellites and picosatellites currently use spectrum allocated to the amateur satellite service and the MetSat service although their missions are potentially inconsistent with these services.
Many of these nano/pico satellites use amateur satellites, but now, due to the shortage of available spectrum and increased needs, operators intend to use other frequency bands such as Mobile Satellite Service, Earth Exploration Satellite (Earth-to-Space or Space-to-Earth) below or above 1 GHz. Some nano/pico satellite operators envisage using EESS uplink bands below 1 GHz for telecommand operations (Earth-to-Space), and it is to be noted the corresponding output powers envisaged for this kind operation are much higher than the moderate/low powers traditionally used for service links in this band. It is of the utmost importance that the deployed nano/pico satellite networks deployed in this EESS band for telecommand purposes shall not cause interference to the existing and future EESS systems implementing Data Collection Platform (DCP) applications having moderate/low powers for their uplinks. Recent static and dynamic accurate calculations on concrete cases have shown that telecommand links could cause a total blindness -

during significant amounts of time - of the traditional satellite DCP type receivers when interfered by telecommand links in the same frequency band.

7. Conclusion

The disinterested knowledge of the real world is today surpassed by a large variety of every day systems. Apart from a few protected bands [7], the increasing number of users and the complexity of both situations and signals will require new solutions so as to access the spectrum. Scientists are therefore sollicited to find efficient solutions , based on solid scientific criteria. Namely the mitigation formulae should be less and less heuristics [8] : this represents a challenge for scientists in general and URSI correspondents in particular.

8. References

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6) ITU News, n°7, September 2013, Special edition
7) RR Footnote 5.340 «All emissions are prohibited in the following bands«.
8) W.J. Blackwell, I. Adam, A. Camps, D. Kunkee, Foreword on the special issue on radio frequency interference: Identification, Mitigation and Impact assessement, IEEE Trans. on Geoscience and Remote Sensing, vol.15, n° 10, October 2013