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Committee on Radio Astronomy Frequencies (CRAF)

CRAF OBJECTIVES FOR THE WRC-23 AGENDA ITEMS RELEVANT TO RADIO ASTRONOMY

Introduction

The Expert Committee on Radio Astronomy Frequencies (CRAF) of the European Science Foundation (ESF) represents European radio astronomers and observatories in matters of spectrum management. This document presents the objectives of CRAF concerning issues affecting radio astronomy on the agenda of the World Radiocommunication Conference 2023 (WRC-23).

CRAF, among four sector members representing the radio astronomy service at ITU, i.e., IUCAF, CRAF, SKAO and IAU, presents in this document the positions specific for the European RAS in Region 1. As astronomy is an international science with mostly the same requirements for protection at all observatories, there will be no major differences between the positions of these four organisations. The few differences might exist for agenda items where large separation distances are required around RAS telescopes, which requires cross border coordination for the case of densely populated Europe.

In the next section, CRAF positions on WRC-23 agenda items related to RAS in Region 1 is summarized. It is noted that for all agenda items the default preferred method would normally be 'No Change' (NOC) for RAS as a victim passive service without any (commercial) interest in the use of active transmitters. For agenda items where the WRC decision could be inclined towards non-NOC, the preferred methods for RAS will be stated with justifications. For easier readability, the numbering follows the agenda item numbers.

In section 2, the preliminary agenda items under Resolution 812 for WRC-27 is summarized in relation to RAS (Agenda item 10). Views on additional items proposed during CPM2 and 3rd ITU Inter-regional Workshop on WRC-23 that have direct impact on European RAS are also included in subsection 2.2.

WRC-23 agenda items relevant to RAS

CRAF identified 9 WRC-23 agenda items that directly impact RAS frequency bands in Region 1, in addition to agenda item 10. The following table lists the agenda items by category:

Agenda item	Category	Subject
1.2	Mobile	IMT identifications in mid-band frequencies
1.4	Mobile	HIBS
1.5	Mobile	UHF Review
1.6	Aeronautical	Suborbital vehicles
1.8	Aeronautical	Use of FSS by UAS
1.10	Aeronautical	Aeronautical mobile
1.13	Science	SRS upgrade
9.1 a)	Science	Space weather sensors
4	General	Previous ITU-R resolutions

Agenda item 1.2 – New IMT allocations

The agenda item represents the spectrum needs of IMT in the mid-band frequency ranges. For Region 1, identification of the frequency bands 3 300-3 400 MHz, 3 600-3 800 MHz, 6 425-7 025 MHz and 7 025-7 125 MHz are considered.

AI 1.2 Impact on RAS

ITU-R Resolution 245 limited the sharing and compatibility studies to the services that have primary allocation. There are no primary allocations for RAS in the candidate bands. The bands 3 300–3 400 MHz and 6 425–7 025 MHz are overlapping with the radio astronomy bands 3 332–3 339 MHz, 3 345.8–3 352.5 MHz and 6 650–6 675.2 MHz protected by RR No. **5.149**. The footnote urges administrations to take all practicable steps to protect the radio astronomy service from harmful interference. Both bands are widely observed by European RAS stations with single dishes, the British MERLIN interferometer and within European and global VLBI campaigns.

CEPT has identified the 3 400–3 800 MHz band as European 5G pioneering band a few years ago and IMT has acquired licenses in several countries recently. ECC Report 281 contains the relevant compatibility studies for the adjacent frequencies including RAS. The report indicates that national coordination between both services is required, within a few tens of kilometres of RAS stations. The RAS bands 3 332–3 339 MHz and 3 345.8–3 352.5 MHz cover two spectral lines of the CH molecule. The study of interstellar CH is of importance in understanding the chemistry of the interstellar medium. The presence of CH suggests the existence of the methane molecule CH_4 which is considered one of the basic molecules for the initial stages of the formation of life.

The band 6 650–6 675.2 MHz is an extremely important band for RAS and is used for observations of methanol CH_3OH. This transition of methanol gives rise to powerful cosmic maser activity, found in regions where massive stars form, which gives astronomers the possibility to study the cosmic star formation through the history of the universe and also to derive cosmological parameters.

Compatibility studies with the RAS band at 6.6 GHz showed that separation distances of hundreds of kilometres would be necessary for the protection of RAS observations, even if a major fraction of IMT base stations was below rooftops and thus affected by large clutter losses. The studies, although not considered by WP5D within the scope of the agenda item, are currently included in a working document at WP7D (RAS at 6-7 GHz).

While not within the scope of the agenda item, CRAF took note of the CEPT activities to study the possible use of WiFi in the upper 6-GHz band. Preliminary studies of low-power outdoor and indoor devices, which was submitted to CEPT project team SE45, suggest that much smaller separation distances would be required for WiFi equipment than for IMT (in particular base stations). However, this should not be understood as an endorsement for WiFi deployment, as coordination and RAS protection measures for the (most likely) generally licensed WiFi devices is also not yet studied.

AI 1.2 CPM methods

For the band 4: 6 425–7 025 MHz (Region 1):

- Method 4A: No change.
- Method 4B: Identification of the frequency band 6 425–7 025 MHz in Region 1 for IMT without any additional conditions or constraints to the IMT deployment other than those existing in the RRs.
- Method 4C: Identification of the frequency band 6 425–7 025 MHz in Region 1 for IMT with conditions contained in a draft new WRC Resolution.
- Method 4D: Identification of the frequency band 6 425–7 025 MHz in Region 1 for IMT with conditions contained in a draft new WRC Resolution, applied only within a portion of the band.
- Method 4E: Identification of the frequency band 6 425–7 025 MHz in Region 1 for IMT with conditions contained in a draft new WRC Resolution, with use expected as of 2030.

AI 1.2 CRAF Position

CRAF supports no change for the band 6 425–7 025 MHz (Method 4A). Although the CRAF studies for the protection of the RAS band 6 650–6 675.2 MHz under RR No. 5.149 were deemed out of the scope of the agenda item, the potential impact of new allocations to IMT in these bands should be considered in order to protect European RAS operations. Studies initiated at WP7D can provide assistance in evaluating the impact.

Any IMT identification in Region 1 in the band 6 425–7 025 MHz should include the necessary provisions to ensure the continuity of the important RAS operations in the 6 650–6 675.2 MHz band. Methods 4C and 4E are favoured in case of identification, with preference of 4E due to the later operating date.

Agenda item 1.4 – HIBS

The use of high-altitude platform stations as IMT base stations (HIBS) in the mobile service in certain frequency bands below 2.7 GHz already identified for IMT, on a global or regional level.

Four frequency categories are considered:

- Band A – 694–960 MHz.
- Band B – 1 710–1 885 MHz.
- Bands C – 1 885–1 980 MHz, 2 010–2 025 MHz, and 2 110–2 170 MHz.
- Band D – 2 500–2 690 MHz.

AI 1.4 Impact on RAS

The band 2 500–2 690 MHz is adjacent to the RAS primary band 2 690–2 700 MHz (**5.340**). The bands 1 718.8–1 722.2 MHz and 2 655–2 690 MHz are listed under RR No. **5.149**, which urges administrations to protect RAS in these bands when making assignments to services. Unfortunately, both bands are currently used by MFCN in CEPT and RAS observations are hardly possible.

Second harmonics spurious emissions from the systems operating in the band 694–960 MHz may fall into the important RAS bands 1 330–1 400 MHz (secondary in some CEPT countries, **5.149**), 1 400–1 427 MHz (primary, passive, **5.340**) 1 610.6–1 613.8 MHz and 1 660–1 670 MHz (primary, **5.149**). However, only the 1 610.6–1 613.8 MHz band was studied (second harmonic emissions of 805.3–806.9 MHz). The other base frequencies are not foreseen for downlink connections (HIBS-to-ground) in the current band plan described in the FDD arrangements of Recommendation ITU-R M.1036 (A4-A11).

Studies for the band 1 610.6–1 613.8 MHz indicates that the impact on RAS from HIBS operating in the frequency range 694–960 MHz could be mitigated under certain circumstances, such as with antenna pointing, RF filters, and geographical separation. 2nd harmonic emissions from HIBS need to be reduced significantly (up to 42 dB), and/or very large separation distances up to hundreds of km need to be applied. Large areas of the sky around the direction of the HIBS will be blocked for astronomical observations if these measures are not enforced.

Compatibility between the radio astronomy service (RAS) in the adjacent frequency band 2 690–2 700 MHz and HIBS operating in the frequency range 2 500–2 690 MHz may be feasible under certain circumstances, such as more stringent HIBS OOBE values, antenna pointing, guard bands, RF filters or geographical separation as reflected in a pfd limit in regulatory text. However, studies by IUCAF show that 50 dB or more additional attenuation in the OOB would be required for co-existence of HIBS and RAS in this band.

AI 1.4 CPM methods

Issue A: HIBS in the frequency band 694–960 MHz:

- Method A1: No changes.
- Method A2: HIBS in 694–960 MHz.
- Method A3: HIBS in 694–960 MHz not claiming protection and additional provisions.
- Method A4: HIBS in 694–862 MHz and 862–960 MHz per Region.
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Issue D: HIBS in the frequency band 2 500–2 690 MHz:

- Method D1: No changes.
- Method D2: HIBS in 2 500–2 690 MHz.
- Method D3: HIBS in the frequency band 2 500–2 690 MHz not claiming protection and additional provisions.
- Method D4: HIBS in 2 500–2 690 MHz per Region.

AI 1.4 CRAF position

CRAF supports no change for the bands 694–960 MHz and 2 500–2 690 MHz (Methods A1 and D1).

For the band A 694–960 MHz, a note still exists in the CPM report section 1/1.4/3.2.7 stating that studies for protection from second harmonics into the RAS band 1 610.6–1 613.8 MHz was not agreed by some administrations. CRAF strongly supports the inclusion of the studies for consideration by WRC-23.

In methods A2, A3 and A4, example 2 for *recognizing f* of Resolution [A14-HIBS 694–960 MHZ] is supported. Associated with recognizing *f*, example 2 for *resolves* 6.3 and 6.4 is supported for these methods.

The protection measures are conditional to the FDD arrangements as stated in Recommendation ITU-R M.1036 (A4-A11). Any changes to these arrangements should consider the second harmonics into the other RAS primary bands 1 400–1 427 MHz and 1 660–1 670 MHz.

For the band D 2 500-2 690 MHz, in methods D2, D3 and D4, inclusion of example 1 for *resolves* 1.7 and 1.8 of resolution [B14-HIBS 2 500–2 690 MHz] that provides protection via a hard PFD limit is supported.

Agenda item 1.5 – UHF review

The agenda item invites ITU-R to review the spectrum use and study the spectrum needs of existing services within the frequency band 470–960 MHz in Region 1. The band is currently allocated to the broadcasting service on a primary basis. Several other services such as Mobile and fixed services are also allocated portions of the band on a primary basis. A proposed allocation for IMT in the band 470–694 MHz will require sharing and compatibility studies with the broadcasting services and other existing services as well.

AI 1.5 Impact on RAS

Radio astronomy gives considerable importance to the 608–614 MHz band. because without it, there would be a large gap between the 410 MHz and 1 400 MHz RAS allocations, in one of the most interesting parts of the spectrum. The band is also widely used for continuum VLBI observations and solar radio astronomy. In the European part of Region 1 and in Region 3 (Asia), radio astronomy has a secondary allocation in this band according to RR No. **5.306**. Whereas in the African Broadcasting Area of Region 1, the band 606–614 MHz has a primary allocation, according to RR No. **5.304**. Also, according to RR No. **5.149**, administrations are urged to take all practicable steps to protect the radio astronomy service in this band from harmful interference when making assignments to stations of other services.

According to Report ITU-R RA.2332-0 on the compatibility and sharing studies between the radio astronomy service and IMT systems in the frequency band 608–614 MHz, coexistence between RAS and IMT in this band will require stringent protection measures. In addition, new studies were performed at ITU-R by TG 6/1. For in-band operation, separation distances of up to 1000 km or more were determined. This raises the question whether sharing between RAS and IMT could be possible at all in the densely populated environment that we find in CEPT countries. Furthermore, even for adjacent bands or the spurious domain IMT emissions, relatively large coordination zones with radii in excess of 100 km are needed.

The protection of European RAS from the existing broadcasting service is currently covered by specific provisions in the GE06 agreement. Hence, no additional protection measures would be required for protection from existing services.

AI 1.5 CPM methods

- Method A: No Change. For this method, two alternatives are developed.
- Method B: Primary allocation to the mobile service in the frequency band 470–694 MHz with or without IMT identification in the frequency band 470–694 MHz or parts thereof in Region 1. Suppression of Resolution **235 (WRC-15)**. For this method, three alternatives are developed.
- Method C: Primary allocation to the mobile, except aeronautical mobile, service in the frequency band 470–694 MHz and identification to IMT in the frequency band 470–694 MHz or parts thereof in Region 1. Suppression of Resolution **235 (WRC-15)**. For this method, nine alternatives are developed.
- Method D: Primary allocation to the mobile, except aeronautical mobile, service within the band 470–694 MHz without IMT identification. Suppression of Resolution **235 (WRC-15)**. For this method, five alternatives are developed.
- Method E: Primary allocation to the mobile, except aeronautical mobile, service of the band 470–694 MHz in Region 1 with technical conditions limiting mobile service operations to downlink in this band. Suppression of Resolution **235 (WRC-15)**.
- Method F: Secondary allocation to the mobile, except aeronautical mobile, service in the band 470–694 MHz in Region 1. For this method three alternatives are developed.
- Method G: Considerations of the radio astronomy service. Associated with methods B, C, D, E.

AI 1.5 CRAF position

At the beginning of agenda item 1.5 section in the CPM report, two views are presented regarding whether the scope of Resolution **235 (WRC-15)** includes or not consideration of secondary services. CRAF does not find any indication in Resolution **235** that secondary services are excluded. Hence, view 2 including secondary services in the studies is supported. This is also supported by the Legal Affairs Unit (LAU) conclusion that "*the wording of resolves to invite ITU-R 3 is sufficiently clear and that, in the absence of an explicit limitation by the legislator to this effect, the phrase "other existing services" should include both primary and secondary services"*.

CRAF supports the protection of the radio astronomy service in the frequency band 606–614 MHz to ensure its continued operation. In case of regulatory changes decided by WRC-23 with mobile service primary allocations, the necessary protection can be achieved by upgrading the RAS secondary allocation to a primary status. This should not change the status of the RAS relative to the broadcasting service as both services are already coordinated in the Geneva Agreement GE-06 provisions.

Method G considers upgrade of the RAS band 606–614 MHz conditional to any primary allocations to the mobile service in methods B, C, D, E. Two views are also attached to this method in the CPM text with respect to the "applicability" and "appropriateness" of this method. View 1 states that "*band upgrade should not set a precedent for any other WRC agenda items unless such actions are specifically called out in the associated Resolutions"*. While view 2 states that "*upgrade of an incumbent service has often been decided by a competent WRC as a regulatory consequence of a WRC decision, in particular a new or upgraded allocation".* CRAF is in full agreement with view 2 given that it is not the first time an upgrade results as a solution to protect an existing radiocommunication service from a new allocation in the same band. There are several examples

from previous conferences that were mentioned during the discussions and which can be recalled if needed. Therefore, the conditional RAS upgrade would not set any precedence in this context. The proposed upgrade is optional and per country through modifications of RR **5.304** and RR **5.306**.

Agenda item 1.6 – Suborbital vehicles

The purpose of this agenda item is to study the spectrum needs for communication between stations on board sub-orbital vehicles and terrestrial/space stations for communication with air traffic management systems and relevant ground control facilities for voice/data communications, navigation, surveillance, and telemetry, tracking and command (TT&C).

AI 1.6 Impact on RAS

The impact on RAS will depend on whether these "sub-orbital" stations will be treated as terrestrial or space service considering the fact that the regulatory procedure for each of these two are different in nature and in application. From the technical point of view, emissions from stations on board sub-orbital vehicles may seriously impact RAS observations, when operating in the same and adjacent or nearby frequency bands.

AI 1.6 CPM methods

- Method A: No changes.
- Method B: New WRC Resolution containing the provisions to operate radiocommunications for sub-orbital vehicles. There are four alternative approaches to this method.
- Method C: Revision of Resolution **772 (WRC-19)** in order to clarify the list of necessary studies and to extend their duration.

AI 1.6 CRAF position

CRAF prefers the generic method B, approach A in case a new WRC resolution will be developed, with conditions to not have impact on existing services more adversely than they would if the same station were fitted and operated on board a conventional aircraft.

Methods that include recognition of suborbital vehicle operations under specific radio communication services operating in the same and adjacent or nearby frequency bands to the RAS, e.g., MSS and aeronautical mobile, need to clearly state corresponding protection provisions for RAS as an existing service.

Agenda item 1.8 – Use of FSS networks by UAS

The use of fixed-satellite service (FSS) networks by control and non-payload communications of unmanned aircraft systems (UAS). Several frequency bands are proposed for usage of UAS Control and Non-Payload Communications (CNPC) links.

AI 1.8 Impact on RAS

One of the proposed frequency bands for uplink communications is the frequency band 14–14.47 GHz that is adjacent to the RAS secondary allocation in the band 14.47–14.5 GHz (RR No. 5.149). The 14.47–14.5 GHz RAS band is mainly used for spectral line observations. At 14.4885 GHz, an important formaldehyde (H_2CO) spectral line exists, which has been observed in the direction of many galactic sources. Observation of this spectral line gives valuable information on the physical conditions of the interstellar medium.

AI 1.8 CPM methods

- Method A: Suppression of RR No. **5.484B**, Resolution **155 (Rev.WRC-19)** and Resolution **171 (WRC-19)**.
- Method B: Revise Resolution **155 (Rev.WRC-19)** in accordance with Resolution **171 (WRC-19)** and consequently suppress Resolution **171 (WRC-19)**. In addition, this method contains the revision of RR No. **5.484B** as an option. Three alternative texts are provided under this method.

AI 1.8 CRAF position

The protection of the RAS secondary allocation 14.47–14.5 GHz from possible use of the band 14–14.47 GHz by earth-to-space UAS CNPC links must be ensured. No compatibility or sharing studies have been conducted. Case by case studies will be required at the national level.

CRAF supports Method A to avoid the use of the adjacent band by UAS. For Method B, the addition of regulatory provisions in the revised Resolution **155** to protect RAS band will be required. Method B2, *resolves* 18 and Method B3, *resolves* 15 state the protection limits required for the RAS band.

Agenda item 1.10 – Aeronautical Mobile

The agenda item invites to study possible additional allocations for new non-safety aeronautical mobile applications for air-air, ground-air and air-ground communications of aircraft systems. The primary mobile global allocation at the band 22–22.21 GHz will be a candidate for these applications by studying possible revision or deletion of the "except aeronautical mobile" restriction in the allocation table. Additionally, a new allocation is proposed in the band 15.4–15.7 GHz, a band that is already used by aeronautical radio navigation.

AI 1.10 Impact on RAS

The H_2O-band 22.21–22.5 GHz is one of the most important for spectroscopy observations in radio astronomy. The band 15.35–15.4 GHz is an important radio astronomy band in the continuum series that provides some of the best angular resolutions for monitoring the intensity variability of active galactic nuclei, allowing to study e.g. accretion processes of matter into the central supermassive black holes of galaxies.

The frequency band 22–22.21 GHz is adjacent to the frequency band 22.21–22.5 GHz which is allocated to the RAS, the Earth exploration-satellite service (passive) and the space research service (passive) on a primary basis. The frequency band 15.4–15.7 GHz is adjacent to the frequency band 15.35–15.4 GHz which is allocated to the RAS on a primary basis. RR No. **5.340** also applies.

The frequency band 22.01–22.21 GHz is not allocated to the RAS. However, in making assignments to stations of other services to which the band 22.01–22.21 GHz is allocated, administrations are urged to take all practicable steps to protect the RAS from harmful interference, according to RR No. **5.149**.

The band 15.35–15.4 GHz is already subject to 2% data loss by the use of radiolocation services under RR No. **5.511F** adjacent to this band. Any allocation must be accompanied by strict operational constraints to avoid additional data loss to the radio astronomy operations in the band.

Passive ground-based water-vapour radiometers operating in the frequency band 22–22.5 GHz are also used worldwide to characterize vertical profiles of water-vapour concentrations for applications including, but not limited to, studies of Earth's atmosphere, climatology, and meteorology.

Studies showed that the aggregate incident power from steerable synthetic aperture antennas will be dominated by aircraft at large nadir distances and steering of directional aircraft antenna beams should be used to avoid the direction to the RAS station. The requirements of RR No. **5.340** may be satisfied if the mean incident power flux-density in the frequency band 15.35–15.4 GHz from aggregated AM(OR)S non-safety applications does not exceed −233 dB($W/m^2/Hz$) at RAS stations operating in 15.35–15.4 GHz, and −231 dB($W/m^2/Hz$) at RAS stations operating in 22.21–22.5 GHz. Also, introducing 10 MHz guard band is required to meet the protection criterion of the RAS in the four studied operational scenarios and at all studied radio astronomy sites.

AI 1.10 CPM methods

- Method A: No change to Radio Regulations.
- Method B: New primary aeronautical mobile (off-route) service allocation in the frequency band 15.4–15.7 GHz.
- Method C: Remove the exception of aeronautical mobile (off-route) service in the frequency band 22–22.21 GHz.
- Method D: Combination of Methods B and C.
- Method E: Combination of Methods B and C with 10 MHz guard bands.

AI 1.10 CRAF position

Method A is fully supported.

A new primary allocation in the band 15.4–15.7 GHz would be less damaging than a primary allocation in the band 22–22.21 GHz. Therefore, Method B is the second acceptable option with a protective footnote considering limits for the PFD received in the primary adjacent band at any RAS station. The proposed footnotes 5.A110-BD2 or 5.A110-BD3 are supported for method B. A guard band of 10 MHz will be also required for method B.

Other methods C, D, E including a primary allocation in the 22 GHz band are not supported. If it is inevitable, a protective footnote for RAS with hard limits on the PFD levels received in the primary adjacent band at any RAS station will be required, with 10 MHz guard band. The proposed footnotes 5.I110 or 5.N110 are supported in that case. Consideration must be given to the in-band sharing with RAS under RR **5.149** and water-vapor radiometers operating in the 22 GHz band. For water-vapor radiometers, the proposed footnotes 5.G110 or 5.P110 are supported.

Agenda item 1.13 – SRS Upgrade

The frequency band 14.8–15.35 GHz is currently allocated to the space research service (SRS) on a secondary basis. There is a need for broadband communication downlinks in the SRS for the purpose of transmitting future scientific data at high data transmission speeds. Also, a number of space agencies are already considering the possibility of using this frequency band for next-generation SRS satellites. Upgrading to primary status, the allocation of the frequency band 14.8–15.35 GHz for the SRS could provide certainty for administrations and space agencies participating in satellite space programs. The agenda item invites ITU to study the feasibility of this upgrade with a view to ensuring protection of the impacted primary services.

AI 1.13 Impact on RAS

The frequency band 14.8–15.35 GHz is adjacent to the RAS primary band 15.35–15.4 GHz, which is also subject to RR No. **5.340**. This is the second agenda item impacting this RAS band in addition to the aeronautical mobile agenda item 1.10

As noted in agenda item 1.10, the band 15.35–15.4 GHz is already subject to 2% data loss by the use of radiolocation services under RR No. **5.511F**. A possible upgrade to the SRS 14.8–15.35 GHz in adjacent band must be accompanied by strict operational constraints to avoid additional data loss to the radio astronomy operations in the band.

Studies on RAS compatibility could only be carried out under certain assumptions due to the lack of information on characteristics of SRS systems, as proponents of the agenda item failed to provide the required parameters. The results of the studies indicate that significant out-of-band suppression is necessary to protect the RAS.

AI 1.13 CPM methods

- Method A: No change to Radio Regulations.
- Method B: Upgrade the secondary SRS (space-to-space) allocation to primary and retain the secondary allocation to SRS (space-to-Earth) and (Earth-to-space).
- Method C: Upgrade the secondary SRS allocation, except SRS active and SRS passive applications.
- Method D: Upgrading to primary status the allocation of the frequency band 14.8-15.35 GHz for the SRS with provisions to avoid imposing constraints on existing systems of primary services in the frequency band 14.8–15.35 GHz.
- Method E: Upgrading to primary status the allocation of the frequency band 14.8–15.35 GHz for the SRS with provisions to both protect and avoid imposing constraints on existing and future systems of primary services in the frequency band 14.8–15.35 GHz and to ensure the protection of all primary services in the same frequency band and the radio astronomy service in the adjacent frequency band 15.35–15.4 GHz.

AI 1.13 CRAF position

Method A is supported. Method B is the second supported option because it limits the upgrade to space-to-space links, which will impact RAS at somewhat lower levels. In case methods C, D or E are chosen, new footnotes to protect RAS will be required for both downlink and uplink directions.

As the compatibility of SRS and RAS operations was not established by studies, the proposed footnotes 5.C113, 5.F113 and 5.N113 for methods C, D and E respectively will be the most appropriate.

Agenda item 9.1 a) – Space Weather Sensors

The agenda item studies the technical and operational characteristics, spectrum requirements and appropriate radio service designations for space weather sensors with a view to describing appropriate recognition and protection in the Radio Regulations without placing additional constraints on incumbent services.

AI 9.1 a) Impact on RAS

Some of the receive-only space weather sensors systems described in the Report ITU-R RS.2456-0 are radio telescopes operating under the RAS, and with overlapping radio astronomy scientific objectives.

Also, some receive-only space weather applications operate in protected RAS bands with primary status. By considering the ITU-R definitions of radio astronomy "based on the reception of radio waves of cosmic origin", the following categories of receive-only space weather sensors will fall under the RAS definition:

- Solar Flux Monitors
- Solar Spectrometers
- Solar Imager
- Riometers
- IPS

AI 9.1 a) CRAF position

Owing to the fact that there are other receive-only space weather sensor categories that will not fall under the RAS definition, a more practical approach would be to designate all the categories under one service. Given that the definition of MetAids is broad enough to accommodate the above-mentioned categories, MetAids could be the most appropriate service. The inclusion of space weather systems under the MetAids, with a subset of the MetAids (space weather) should ensure that there will be no negative impact on any space weather observations currently using RAS allocations.

The interference criteria for receive-only space weather applications under the MetAids service RAS could be customized based on the calculation procedure used in Rec. ITU-R RA.769 to take into account the space weather sensor characteristics. A new ITU-R recommendation would be required during the next cycle to develop the appropriate protection criteria.

The choice of priority allocations for receive-only space weather sensors under the MetAids service should still take into account the spectrum needs of the RAS related categories; solar Flux Monitors, solar Spectrometers, solar Imagers, Riometers, and IPS. For these categories the following frequency bands are considered the top priority:

- 27.5–28.0 MHz
- 37.5–38.25 MHz
- 51–54 MHz,
- 73.0–74.6 MHz,

- 153–154 MHz,
- 218.28–248.28 MHz,
- 606–614 MHz

Finally, CRAF supports the continuation of work towards the recognition of receive-only space weather sensors during the next cycle through a WRC-27 agenda item.

Agenda item 4 –ITU-R Resolutions review

A standing agenda item to review the Resolutions and Recommendations of previous conferences that are not related to any other agenda item of the conference.

AI 4 CRAF position

CRAF supports a revision to Resolution **731** on the consideration of sharing and adjacent-band compatibility between passive and active services above 71 GHz. CRAF supports modifications to the resolution to clarify that in band sharing studies cannot be performed in the bands covered by RR No. **5.340**, stating that all emissions are prohibited. Under *recognizing* a statement on RR No. **5.340** needs to be added:

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*x) that several frequency bands above 71 GHz are subject to No. **5.340**, and all emissions are prohibited in these bands;*

Moreover, the bands under RR No. **5.340** need to be removed from invites 1, i.e, 100–102 GHz, 148.5–151.5 GHz and 226–231.5 GHz.

Agenda item 10 (WRC-27)

Preliminary agenda items under Resolution 812

WRC-27 preliminary agenda item 2.1

The agenda item aims to study additional spectrum allocations to the radiolocation service on a co-primary basis in the frequency band 231.5–275 GHz and an identification for radiolocation applications in frequency bands in the frequency range 275–700 GHz for millimetre and sub-millimetre wave imaging systems.

In the band of interest 231.5–275 GHz a very important series of spectral lines for radio astronomy is frequently observed. No. **5.340** applies in the band 250–252 GHz, prohibiting all emissions in this frequency band. Primary allocations for RAS exist in the bands 241–248 GHz and 252–275 GHz, in addition to a secondary allocation in the 248–250 GHz band. The frequency bands 241–250 GHz and 252–275 GHz are listed under RR **5.149**, urging administrations to take all practicable steps to protect radio astronomy from harmful interference.

The bands above 275 GHz are currently not allocated to RAS. In several regions, bands between 275 GHz and 1000 GHz have been identified for use by administrations for passive service applications. Active services are urged to take all practicable steps to protect the identified passive services from harmful interference, in accordance with RR **5.565**.

Provisions need to be added to Resolution **663** that recognizes the RAS usage in the above-mentioned bands, and to invite for determining, based on the results of studies, the possibility to upgrade the RAS secondary band 248–250 GHz to a primary allocation.

WRC-27 preliminary agenda item 2.2

Agenda Item 2.2 considers the use of the frequency bands 37.5–39.5 GHz (space-to-Earth), 40.5–42.5 GHz (space-to-Earth), 47.2–50.2 GHz (Earth-to-space), and 50.4–51.4 GHz (Earth-to-space) by aeronautical and maritime Earth stations in motion with geostationary space stations in the fixed satellite service.

Adjacent and in-band transmissions will have an impact on the RAS frequency bands at 42.5–43.5 GHz and 48.94–49.04 GHz, respectively. As noted in RR **5.149**, radio astronomy is particularly vulnerable to spaceborne radio interference. Further regulations regarding acceptable power levels are mandated by RR **5.551I** and RR **5.551H**.

The band 42.5–43.5 GHz is used for observations of silicon monoxide (SiO) masers that have rest-frame emission lines at 42.519, 42.821, 43.122, and 43.424 GHz. The narrow RAS frequency allocation at 48.94–49.04 GHz is used to observe carbon monosulfide (CS) in the Milky Way galaxy. In this band, administrations are urged to take all practicable steps to protect the RAS from harmful interference (RR **5.149**), and all airborne emissions are prohibited (RR **5.340**). Furthermore, additional protections are stated in RR **5.555B**, as follows: “the power flux density in the band 48.94-49.04 GHz produced by any geostationary space station in the FSS (space-to-Earth) operating in the bands 48.2–48.54 GHz and 49.44–50.2 GHz shall not exceed −51.8 dB (W/m^2) in any 500 kHz band at the site of any radio astronomy station.” Also of concern, as noted in Resolution **159 (WRC-15)**, is the frequency range 51.4–54.25 GHz, which is used by RAS in some nations (RR **5.556**).

Provisions to recognize the RAS usage in the abovementioned bands will need to be added to Resolution **176**, in addition to invite for compatibility studies with RAS in these bands, including the secondary band 51.4–54.25 GHz.

WRC-27 preliminary agenda item 2.3

Studies relating to spectrum needs and possible allocation of the frequency band 43.5–45.5 GHz to the fixed-satellite service.

As described in the previous agenda item 2.2, the band 42.5–43.5 GHz is one of the important bands for RAS. The proposed agenda item increases the pressure on the band by space service allocations in the upper and lower bands.

CRAF is opposing a new allocation to FSS in the band 43.5–45.5 GHz because the RAS primary band 42.5–43.5 GHz will be sandwiched between two FSS downlinks in that case.

WRC-27 preliminary agenda item 2.5

The original scope of the agenda item is studying the conditions for the use of the frequency bands 71–76 GHz and 81–86 GHz by stations in the satellite services to ensure compatibility with passive services.

The frequency range 71–94 GHz covers some of the most important high-frequency ranges for both continuum and line observations of celestial objects. RAS has a primary allocation in the bands 76–77.5 GHz and 79–86 GHz, with a secondary allocation in between in the band 77.5–79 GHz, covered also by RR **5.149**. The 86–92 GHz band is co-primary between EESS, RAS, and SRS (passive) with RR **5.340** prohibiting all emissions.

CRAF submitted an alternative proposal through CEPT where RAS is separated from other passive services in a new resolution. The scope of the alternative agenda item is the protection from space services for RAS bands above 76 GHz with a view to revise and update Resolution **739**. Provisions for RAS protection from downlink transmissions in the band 71–76 GHz will be required. Protection from uplinks in the band 81–86 GHz will need to be studied to decide whether it can be achieved on the national level on a case by case basis.

Resolution **739** in its current form does not provide any obligations on satellite operators to coordinate compatibility with RAS telescopes. To ensure RAS protection, the proposed agenda item also aims at revising the regulatory provisions in Res 739.

There could be a link between agenda items 2.4, 2.5 and 2.7 as they are all involving the same frequency ranges for satellite networks. Any technical or regulatory studies under agenda items 2.4 and 2.7 will still require considering RAS protection in the range 71–94 GHz.

WRC-27 preliminary agenda item 2.6

The agenda item considers regulatory provisions for appropriate recognition of space weather sensors and their protection in the Radio Regulations, taking into account the results of ITU Radiocommunication Sector studies reported to WRC-23 under agenda item 9.1. In light of the results of studies under agenda item 9.1, CRAF supports the continuation of space weather studies into the regulatory framework under this agenda item. Several issues are still required to be developed such as priority frequency bands and protection criteria for space weather sensors.

WRC-27 preliminary agenda item 2.8

The agenda item invites to study the technical and operational characteristics of different types of non-GSO MSS space stations that operate or plan to operate space-to-space links with GSO MSS networks in the following frequency bands:

a) Earth-to-space direction in the frequency bands [1 626.5–1 645.5 MHz and 1 646.5–1 660.5 MHz]; and,

b) space-to-Earth direction in the frequency bands [1 525–1 544 MHz and 1 545–1 559 MHz];

Also, to study the technical and operational characteristics of different types of non-GSO MSS space stations that operate or plan to operate space-to-space links with non-GSO and GSO MSS networks in the following frequency bands:

a) Earth-to-space direction in the frequency band [1 610–1 626.5 MHz]; and

b) space-to-Earth direction in the frequency bands [1 613.8–1 626.5 MHz and 2 483.5–2 500 MHz];

RAS has co-primary allocations at 1 610.6–1 613.8 MHz and 1 660–1670 MHz. RR **5.402** notes that "*the use of the band 2 483.5–2 500 MHz by the mobile-satellite and the radiodetermination-satellite services is subject to coordination under No **9.11A**. Administrations are urged to take all practicable steps to prevent harmful interference to the radio astronomy service from emissions in the 2 483.5–2 500 MHz band, especially those caused by second-harmonic radiation that would fall into the 4 990–5 000 MHz band allocated to the radio astronomy service worldwide*."

Space-to-space links in the space-to-earth direction could have a footprint on earth affecting the radio astronomy observations within the cone concept. Accordingly, CRAF is opposing any considerations of the bands 1 613.8–1 626.5 MHz and 2 483.5–2 500 MHz for that purpose.

WRC-27 preliminary agenda item 2.9

This preliminary agenda item is considering development of technical and operational characteristics of LMS systems in the frequency band 1 300–1 350 MHz and sharing and compatibility studies to ensure protection of those services to which the frequency band is allocated on a primary basis, and adjacent frequency bands as appropriate. Resolution **250** recognizes No. **5.149** in the frequency band 1 330–1 400 MHz, which includes spectral lines of importance for RAS. However, it invites for sharing and compatibility studies with services with primary allocations only. Studies for RAS protection will also need to be included under the agenda item.

WRC-27 preliminary agenda item 2.12

The agenda item considers the removal of the limitation "except aeronautical mobile" within the frequency range 694–960 MHz for non-safety applications. This should allow IMT networks to provide connectivity to helicopters, small aircraft and unmanned aircraft systems (UAS). The integration of aeronautical mobile into IMT networks provides similar scope to agenda item 1.4 in the WRC-23 agenda for HIBS. Second harmonics spurious emissions from the systems operating in the band 694–960 MHz may fall into the important RAS bands 1 330–1 400 MHz (secondary in some CEPT countries, **5.149**), 1 400–1 427 MHz (primary, passive, **5.340**) 1 610.6–1 613.8 MHz and 1 660–1 670 MHz (primary, **5.149**).

Resolution **251** does not mention RAS or studies for protection from spurious emissions. In order to avoid similar scope issues to those raised during WRC-23 agenda item 1.4, the protection of RAS from spurious emissions needs to be explicitly stated in the scope of studies.

Views on new agenda items proposed during CPM23-2 and 3rd ITU Inter-regional Workshop on WRC-23 Preparation

Some suggestions for agenda items were submitted for inclusion on the agenda for WRC-27 during the CPM23-2 meeting and 3rd ITU Inter-regional Workshop on WRC-23 Preparation. Some of these will have direct impact on RAS. The following are the items proposed related to RAS with CRAF views included on each of them.

Development of a regulatory framework for non-GSO FSS satellite systems

The proposed agenda item invites to conduct studies on the technical measures and regulatory frameworks to ensure the protection of GSO systems

The initiative to regulate the development of large NGSO FSS networks is aligned with the radio astronomy objectives. The concerns for RAS are similar to the concerns for GSO systems under the proposed agenda item. CRAF would support the agenda item with a view to study methodologies that could benefit similar situations for RAS.

Non-GSO MSS for satellite component of IMT

The proposal suggests to establish a new WRC-27 agenda item to study the feasibility of additional allocations of MSS for satellite component of IMT in the frequency bands below 7 GHz which are identified to IMT and/or allocated to mobile service on a primary basis.

CRAF is of the view that non-terrestrial networks, such as direct-to-cell and direct-to-device equipment, pose an increasing threat to radio astronomy. While existing IMT networks have been widely studied, the inclusion of a satellite component (base stations) in an IMT network was never investigated, such that all previous compatibility and sharing studies with the IMT would cease to apply. Below 7 GHz, RAS has primary and secondary allocations, and administrations are invited to protect radio astronomy through RR Footnotes, e.g., **5.149** and **5.340**, in bands adjacent to MSS/IMT bands. Owing to the visibility of spacecraft over enormous distances (can be in line-of-sight over thousands of kilometers), MSS usually requires multilateral coordination. From the experience with land and aerial base station deployments, it is extremely likely that necessary coordination or exclusion zones sizes would exceed current values by far for satellite components. Thus, multilateral coordination cannot be avoided and should be carried out. Should systems be filed under Article 4.4 of the Radio Regulations, only, it would significantly increase the burden of organising and coordinating RAS protection for administrations and stakeholders. The necessary studies and calculations should better be carried out at ITU-R level, e.g. under a new agenda item.

Potential RAS allocations in frequency range 275–325 GHz

This topic was briefly introduced and intends to consider new allocations to fixed, mobile, radio astronomy services and earth exploration-satellite service (passive) in the frequency range 275–325 GHz on a co-primary basis with the consequential update of RR Nos. **5.138**, **5.149**, **5.340**, **5.564A** and **5.565**.

CRAF supports new allocations for RAS in the range 275–325 GHz. With the fast technological developments with active services in the upper frequency bands, the priority for passive services should be maintained.

Possible additional identification for IMT within the range 7–24 GHz(with a particular focus on bands in the 7–15 GHz range)

The proposed agenda item invites to study of the identification of additional frequency bands for IMT including additional allocation to mobile service on a primary basis. The possible additional identification for IMT was stated within the range 7–24 GHz, with a particular focus on bands in the 7–15 GHz range. There was no mention of how contiguous the bandwidth required would be, but it is expected to aim for broad channel bandwidths to cover the needs for 6G future networks.

From the RAS perspective, previous studies at 6.6 GHz showed that coexistence with IMT would require large separation distance and cross-border coordination. The adjacent range 7–15 GHz is not expected to result in major differences. Furthermore, huge portions of the spectrum had previously been identified for IMT, e.g., in the mm-wave domain and the huge demand that was predicted by the IMT proponents does not seem to have materialized in practice, even several years after WRC-19. Therefore, CRAF does not support additional allocations to IMT in the above-mentioned range.

Revision of Resolution 739

Resolution 776 (WRC-19) calls for studies to define the conditions for the use of the frequency bands 71-76 GHz and 81-86 GHz by stations in the satellites services to ensure compatibility with passive services.

Based on this initial framework for studies, a proposal is made for a new WRC-27 agenda item that addresses the protection of a number of bands above 76 GHz allocated to RAS on a primary basis from downlink emissions of active space services operating in adjacent and nearby frequency bands, where no related provision exist to protect RAS, with a view to amend Resolution 739 (Rev. WRC-19). The Annex to Resolution 739 (Rev. WRC-19) defines thresholds that apply to any GSO space station (Table 1) and to all space stations of a non-GSO satellite system (Table 2) with respect to radio astronomy sites.

CRAF does not support the preliminary agenda item 2.5 as included in Resolution 812 (WRC-19) for the agenda of WRC-27 and supports the suppression of Resolution 776 (WRC-19). CRAF supports the CEPT proposal to alternatively revise Resolution 739 to cover additional bands above 76 GHz.

Impact of large non-GSO constellations on RAS

In recent years, the number of satellites in Earth’s orbits, especially in low-Earth orbit (LEO) has seen an enormous increase. This is increasingly affecting the interference environment around RAS telescopes, where the RAS protection addressed in the radio regulations and other ITU-R documents could be insufficent in that case. For the case of large satellite constellations, unwanted emissions from transmitters on space stations need to be controlled through careful design methods and appropriate testing from the design phase and before launch.

Currently, the regulatory processes for coordinating non-GSO satellite systems with RAS during the satellite filings are very limited. Administrations, which wish to protect their RAS stations, can only do this in the commenting phase, while the ITU-R Bureau has no mandate to assess even the most basic compatibility metrics when following the procedure outlined in Articles 9 and 11. This leads to unnecessary and redundant work when every single administration has to repeat the same calculations for every RAS station in the world that should be protected. Furthermore, even for actual cases of

interference of existing non-GSO systems the potential solutions, which are outlined in Resolution 739 (Rev. WRC-19) that allows affected administrations to initiate a consultation process with the responsible administration, apply to a small subset of RAS bands only: the bands employed by the non-GSO satellite services (mainly in the frequency range 10-50 GHz) are not listed in the non-GSO table in the Annex of Resolution 739 (Rev.WRC-19). CRAF strongly supports the agenda item for the agenda of WRC-27 as a matter of urgence for the European radio astronomy operations.