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Attention:
Mr Mandla Mchunu
Email: mmchunu@icasa.org.za
Date: 12 November 2024

Dear Mr. Mchunu,

RE: Consultation on the proposed new Licensing Framework for Satellite Services

Thank you for the invitation to submit written representations regarding the recently published consultation on the proposed new licensing framework for Satellite Services. The attached submission is provided by the South African Radio Astronomy Observatory (SARAO), which is the business unit of the National Research Foundation (NRF) established in terms of the National Research Foundation Act, Act 23 of 1998.

Given the recent developments in the non-GSO industry and deployment of numerous LEO satellites, there are significant risks to maintaining a favourable RFI environment for radio astronomy in the Karoo Central Astronomy Advantage Area. This is, therefore, a matter of utmost importance for radio astronomy in South Africa and SARAO appreciates the opportunity to share its views and concerns on this matter.

We hope you find our contribution valuable to your process and confirm that we would require an opportunity to make oral presentation to the Authority should the consultation be extended by the Authority to undertake public hearings.

Regards,

Adrian Tiplady

Adrian Tiplady (Nov 12, 2024 09:26 GMT+2)

Dr. Adrian Tiplady
Deputy Managing Director
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Introduction

In terms of section 8(1)(a) read with Section 7(1) of the Infrastructure Development Act, as amended, 2014 (Act no.23 of 2014), the Presidential Infrastructure Coordinating Commission designated the MeerKAT and SKA radio telescopes as key Strategic Infrastructure Projects (SIP) of the government. The SKA radio telescope project is of paramount importance to South Africa, as a beacon of our pride in global scientific research, as a gateway to advanced science for the African continent and most importantly as an instrument that will help expand humanities' knowledge and understanding of space.

To support the scientific design goals for the SKA, the regulations on the protection of the Karoo Central Astronomy Advantage Areas (KCAAAs) have been promulgated and currently implemented by Astronomy Management Authority directorate within the Department of Science, Technology and Innovation (DSTI). The regulations are underpinned by the Astronomy Geographic Advantage Act (AGA Act) and the powers vested in the Minister of science, technology and innovation. The legislative and regulatory framework provides for the preservation and protection of the KCAAA as measures to advance radio astronomy and scientific endeavours in South Africa.

While SARAO recognises the perceived benefits of Low Earth Orbit (LEO) satellites, such as their extended reach to difficult terrains, reduced latency and quick deployment in rural areas, our submission aims to emphasise the risk posed to radio astronomy in general, and to the SKA radio telescope in particular. As LEO satellite networks continue to be deployed, it is important to consider the impact on radio astronomy and develop mitigation measures at national, regional and international fraternity.

To articulate our concerns clearly, our submission in structured into three distinct sections. The first section provides an overview of the characteristics of the KCAAA, which is fundamental in maintaining the integrity of cosmic observational data by establishing an environment suitable for the SKA radio telescope to meet its technical design objectives.

In the second section, we will discuss the challenges posed by satellite mega constellations operating within non-GSO services. The large networks of satellite can significantly increase the risk of Radio Frequency Interference (RFI), jeopardizing the highly sensitive SKA receiver equipment and possibly damaging it. Understanding of these challenges is important for developing a framework that promotes cooperation between the non-GSO systems and radio astronomy in South Africa.

The third section will address some of the specific questions that are relevant to radio astronomy, posed in the consultation document. We also address the specific issues relating to the AGA Act and explain further the spectrum management within the KCAAAs as it relates to the prosed licensing framework and the discourse on satellite regulations.

SECTION 1
THE CHARACTERISTICS OF THE KAROO CENTRAL ASTRONOMY ADVANTAGE AREA

1. The principle of a Radio Quite Zone

Radio astronomy observations from the surface of the Earth are intrinsically sensitive to interference from man-made sources. A radio telescope studies objects by detecting faint electromagnetic radiation of the particular object. These objects are extremely far away, produce faint emissions and on the Earth's surface, they have to be detected in the presence of high powered radio communication transmissions. In addition, to fully study these scientific phenomena, radio astronomy requires much larger bandwidth than those currently allocated in the International Telecommunication Union Radiocommunications Sector's (ITU-R) Table of Frequency Allocation.

The bands allocated for radio astronomy services in Article 5 of the Radio Regulations mainly allows for scientific studies of the cosmic objects in their static format. When changes occur to the object, a much larger bandwidth is required to fully understand the dynamic of the change. In order to create a suitable environment for advanced radio astronomy, different countries established what is known as Radio Quite Zones (RQZs), which are areas of optimum environment for radio astronomy established by creating a special geographic area in which the usual spectrum management procedures are modified in benefit to radio astronomy observations.

Report ITU-R RA.2259-1 outlines some of the international best practices used to and several control measures to establish RQZs. The report outlines a number of different control methods that can be used to establish RQZ, which may apply to specific frequency bands, specific period of time and various classes of interference sources. The RQZ established by South Africa for the SKA radio telescope is called the KCAAA and it is also included in Annexure 10 of Report ITU-R RA.2259-1.

2. Overview Karoo Central Astronomy Advantage Area

Figure 1 below, outlines the KCAAAs, established through a legislative declaration by the Minister of Science, Technology and Innovation to protect radio astronomy undertaken by the Square Kilometer Array (SKA) and MeerKAT radio telescopes in South Africa.

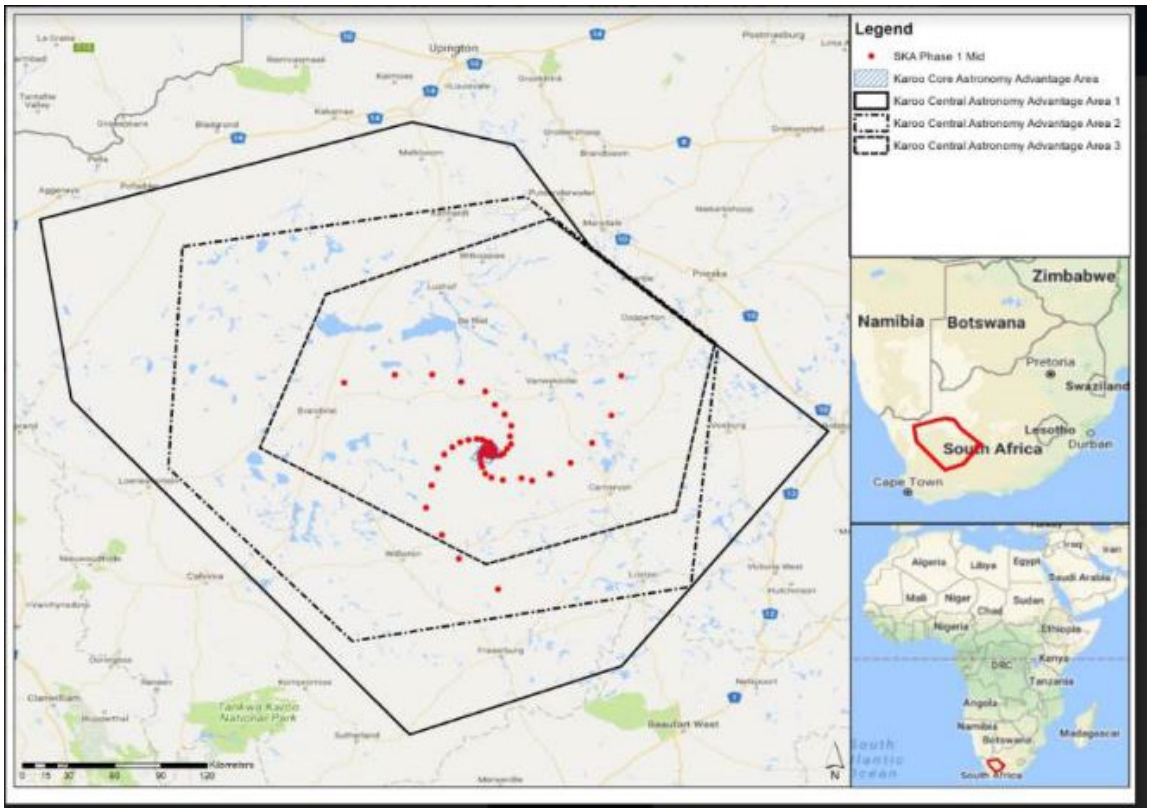

Figure 1: Declared Karoo Central Astronomy Advantage Areas (KCAAAs)

Some of the protection characteristics and regulatory initiatives for the KCAAA and the SKA radio telescopes are as follows.

- The KCAAA is a recognised international best practice RQZ as outlined in Annexure 10 of Report ITU-R RA.2259-1.
- In terms of the KCAAA regulations, the frequency band used by terrestrial services between 100 MHz and 25.5 GHz is reserved for radio astronomy in the KCAAA. The exception to this provision is a list of frequency bands, reviewed time and again, that are published by the DSTI for continuation of essential radiocommunication in the KCAAA and well as services in the Aeronautical services.
- The use of frequency spectrum, which in not prohibited, requires acquisition of a Permit from the AMA directorate, within the DSTI.

- The protection criteria for the KCAAA is based on a maximum received level of -100 dBm and a liner best fit of pfd values provided in Table 2 of Recommendation ITU-R RA.769 and it is illustrated in figure 2, below.

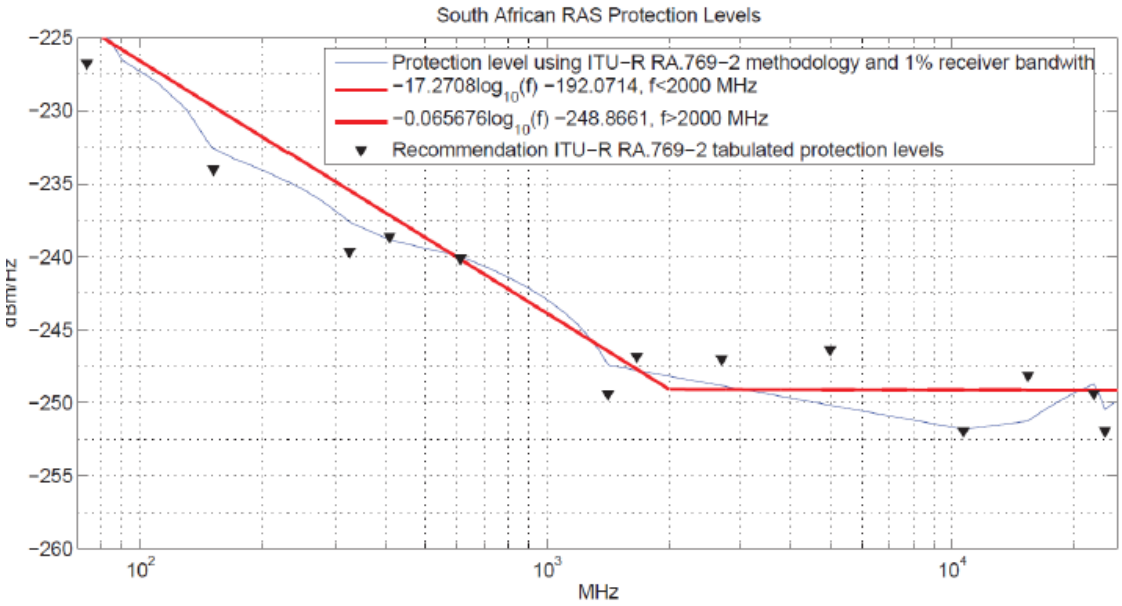

Figure 2: Protection Criteria for radio astronomy stations in the KCAAA.

- All the frequency bands between 100 MHz and 50 GHz have been notified for use by the SKA in the ITU-R MIFR and receive international protection on Radio Astronomy Service (RAS) primary bands and some recognition in other frequency bands used as secondary, under provisions of No.5.149 of the Radio Regulations or strictly under No. 4.4.
- The possible international recognition of the KCAAA, together with studies on technical measures to mitigate the effect of non-GSO satellite constellations on the SKA radio telescope will be discussed in the ITU-R World Radiocommunication Conference 2027 (WRC-27), under agenda item 1.16 in accordance with Resolution **681 (WRC-23)**.

The above mentioned non-exhaustive measures underline a dedicated commitment from SARAO and AMA, with strong support from National Government and ICASA, to establish and maintain an optimal radio frequency environment for the SKA. These initiatives are crucial for ensuring the integrity of scientific research and maximizing the potential of this groundbreaking project.

Section 2
Overview of the LEO mega-constellation

1. Developments in the non-GSO satellite industry

The past decade has seen witnessed an unprecedented surge in the launch of commercial satellite constellations, with thousands of satellites now populating LEO. In just five years, more than seven thousand (7 000) constellation satellites have been launched into orbit and transformed the landscape and trajectory of satellite communications. The rapid growth of satellites is illustrated in Figure 1 below, which shows the significant number of LEO satellites currently traversing the South African sky in real time. Rocket launches have become a regular occurrence, every two to three weeks and delivering 20 to 23 satellites at a time.

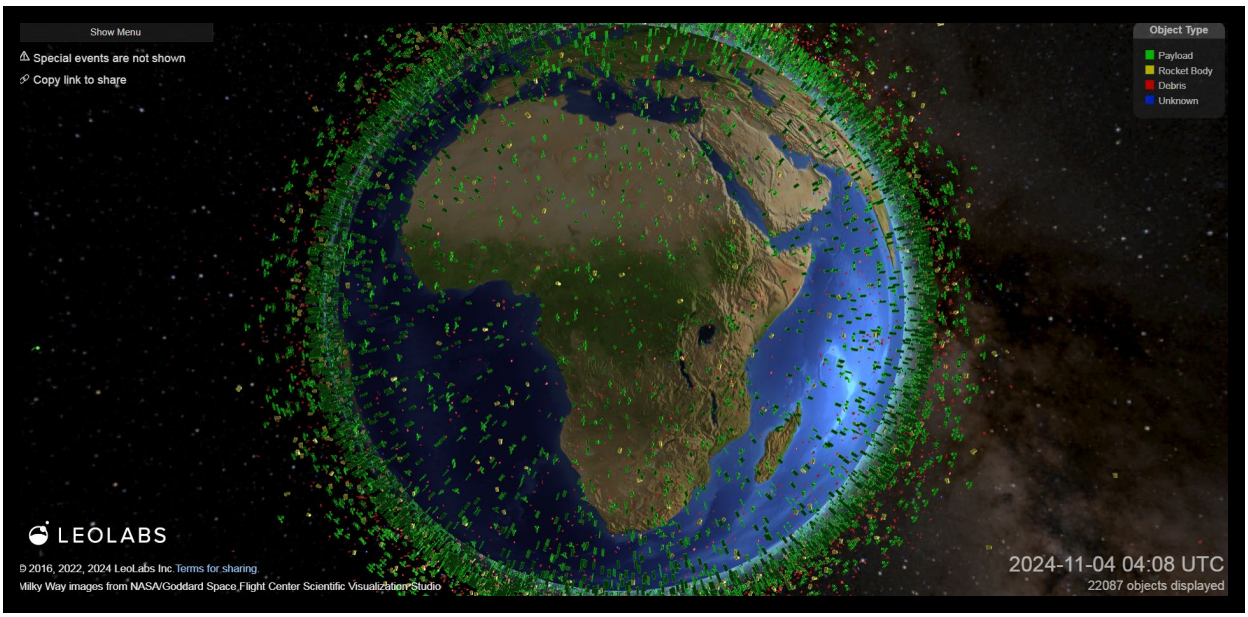

Figure 2: Real time illustration of satellite locations at a given time, above the South African sky

Figure 3 below, gives a comprehensive overview of the radio frequency spectrum utilised by various satellite services and applications. Table 1, below outlines some of the main LEO satellite mega-constellation industry players, alongside their planned deployment numbers.

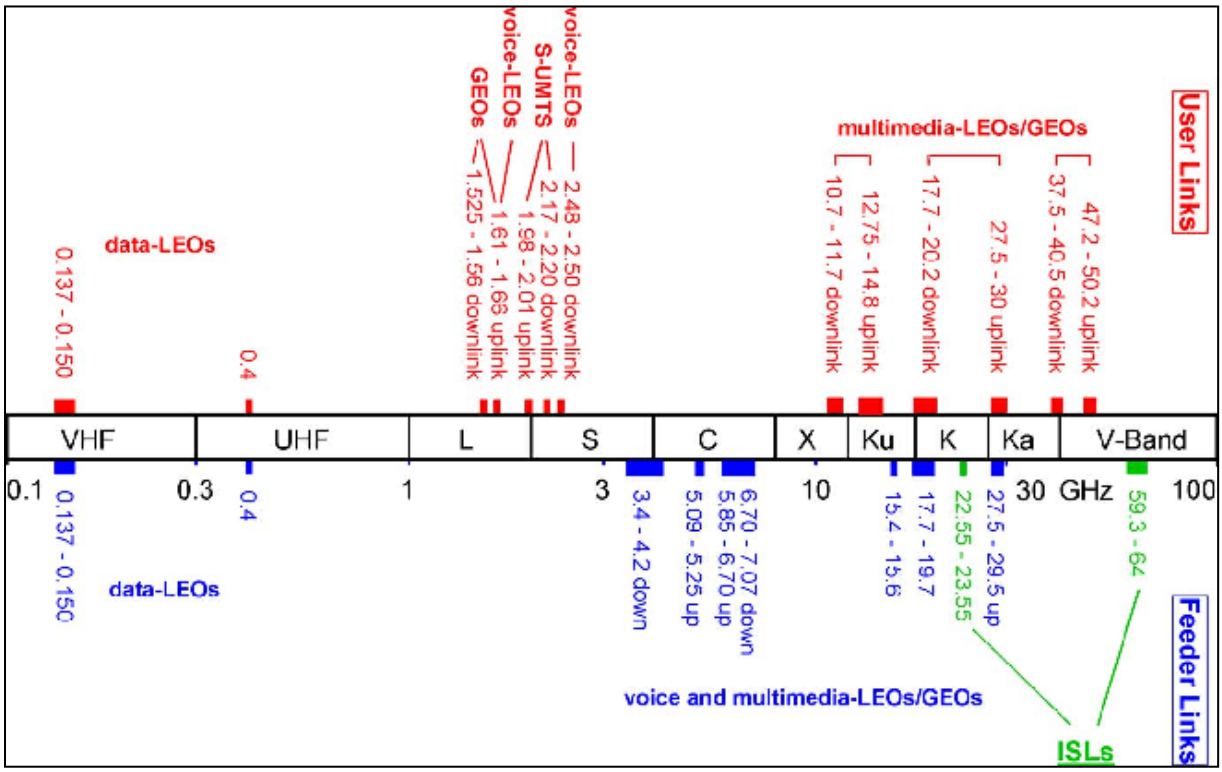

Figure 3: Spectrum utilisation of FSS and MSS satellite services

Organisation	No. of Launched Satellites	No. of Planned Satellites	Operating bands	Services Offered
Starlink	5650	30000	Ku and Ka	FS Internet
Project Kuiper	3200	3200	Ku	Backhaul
Shangai Spacecom	1300	15000	Ku and Ka	Internet
OneWeb	630	630	Ku and Ka	Backhaul

Table 1: The number of deployed satellites by leading industry players

The satellite numbers reflected in Table 1, gives the provides the numbers of launched satellites as well as planned satellites from the leading industry players. The number currently recorded in the ITU-R MIFR are far more than what is currently reflected. The MIFR contains the following recordings:

- 70 000 MSS recordings in the 137 – 150 MHz band
- 5 700 MSS recordings in the 400 – 401 MHz band
- 110 000 FSS recordings the 10.7 – 11.7 GHz
- 296 000 FSS recordings in the 17.7 – 20.2 GHz

The high numbers of the MIFR recordings and the rapid deployment of satellites is a reflection of the industry's potential to drive further advancement in satellite technologies. The ITU-R's agenda item 1.13 of WRC studies the possible allocation to the MSS in the frequency range between 694/698 MHz and 2.7 GHz for direct connectivity between space stations and IMT user equipment. There is, therefore, no reason to believe that non-GSO system cannot be used to further support other radiocommunication markets, outside the traditional FSS and MSS allocations.

SECTION 3

RESPONSES TO THE CONSULATION DOCUMENT

SARAO's response to the consultation document will be limited to matter that may have direct impact on KCAAA radio frequency environment.

1. African Telecommunications Union Policy Principles (Question 1)

Harmonized Licensing process (No. (a))

SARAO understands African Telecommunications Union's (ATU) position with regard to the harmonization of the licensing process aimed at promoting international cooperation and reducing the regulatory burden on the satellite operators. Such a harmonized framework will align regulatory, technical and operational policies across the ATU member states. However, the South African policy framework should prioritize its own national security, economic interests and national strategic goals. Aligning our licensing process may be a significant challenge given the unique priorities of each country with regards to spectrum usage or operational restrictions.

SARAO therefore supports that the same licensing principles that existed for other services should be extended to apply to satellite services, especially in issues relating to promotion of sovereignty and national interest. The creation of licensing framework database of ATU member states and provision of contact details of regulation authorities can support and reduce the burden on satellite operators in terms of licensing processes across the region. In addition, in the interest of a converged satellite/terrestrial licensing framework, it is not clear why satellites are subjected to a different regime.

ITU Instruments and regulatory procedures (No. (b))

SARAO support that the licensing process should follow the procedures described in Article 9 and other provisions of the radio regulations. The Rules of Procedures (9.50) makes provisions for the territory of an administrations to be excluded from the service area of a space station. We believe that this is a crucial instrument for ICASA to utilize in order to ensure that all its national requirements are met, prior to any national licensing. There is therefore, an imperative requirement to establish a dedicated resource to study the BRIFIC publications and response to the Special Section publications.

When the BR receives our intention to exclude SA from the territory of a space station, they communicate such information, together with the reasons, to the notifying administrations and that opens a communication channel for cooperation between the concerned administrations.

Transparent regulatory framework (No. (c))

SARAO supports transparency of the licensing processes as well as providing regulatory certainty to support long term investment in south Africa. This should however, be balanced with protection of national interest and safeguarding national strategic targets.

Licensing of user terminals (No. (d))

SARAO supports the envisaged blanket licensing for user terminals to ease the administrative burden of individual licensing. Perhaps a framework for user terminals can be undertaken within the type approval licensing framework. In the D2D market, it is difficult to see how a blanket licensing can be effected outside a type approval process. User terminals are particularly difficult to control in the KCAAA and effort to ensure prohibition of unauthorized usage is expensive in terms of monitoring equipment, surveillance and enforcement. Therefore, SARAO proposed that Licence conditions in the space segment may include geo-lock provisions to prevent prohibited devices in areas they are not required, for the protection of radio astronomy as well as to ensure that the coverage they provide is indeed supplementary.

Publication of procedures for Authorisation of user terminal (No. (e))

SARAO support the initiative to encourage member states to publish the procedure for authorizing user terminals. As stated in No. (a) above, we also believe that a database hosted by ATU, that aggregates the rules of authorization, including those of user terminals and any other rules would promote transparency and reduce the burden on the satellite operators.

Designation of frequency bands for national, regional and international use (No. (f))

SARAO supports the designation of frequencies to promote harmonized use, especially for international carriers. However, the risk of impact on national interest should be adequately studied and mitigation measures put in place in collaboration between the affected parties. Measures such as the geo-lock or technical measures in the space segment, could be also be employed to ensure compliance with national rules.

2. Exclusion of other satellite services from the Consultation process (Question 2)

SARAO agree with the proposed exclusion of other satellite services from this licensing enquiry. In particular, we believe radio astronomy on the surface of the earth is not a satellite or space service and should not be part of this consultation.

Registration of a space segment

We support that there should be a list of registered space segment for transparence and awareness of the space transmissions in the country. However, this procedure can be combined with the response to the special section of the BRIFIC publication. Once the coordination has been completed with the registering space station, then that space station can be automatically registered to serve in the territory of South Africa.

3. Measures to protect radio astronomy in South Africa (Question 8)

The recent development in the non-GSO services represent a clear and present risk to the future of terrestrial radio astronomy. As outlined in section 2 of this submissions, the technology uses extremely large amounts of emitting satellites. While today they are transmitting primarily in the MSS and FSS, there is substantial evidence, as per the studies in agenda item 1.13 in the IMT bands below 2.7 GHz, these services will extend to support other services outside the traditional FSS and MSS markets. Very large satellite constellations, with tens of thousands of satellites in LEO orbits, could have hundreds of satellites above the horizon at any given moment in time. This will cause an increase in the probability of main beam coupling, and in total aggregated interference, potentially causing receiver saturation, inter-modulations and a constant baseline of low level RFI. This completely changes the environment for the SKA radio telescope as the restrictions and prohibitions implemented in the KCAAA framework are limited to terrestrial transmitters.

To make matters even more difficult, satellites and space systems are coordinated internationally making it difficult for the Authority to control transmission for the purpose of protecting the SKA radio telescope. It is necessary to extend the KCAAA protections to afford some level of protection from satellite system, both at national and international level.

Frequency bands affecting radio astronomy in the KCAAA

Radio astronomy observations in the **14.47 – 14.5 GHz** band will be carried out by the SKA radio telescope in the KCAAA. The band is mainly used for spectral line observations. Observation of this spectral line (H2CO) gives valuable information on the physical conditions of the interstellar medium and produces excitation energies different from the line observed in the lower frequency of 4 829.66 MHz.

The **10.6 – 10.7 GHz** band is allocated to radio astronomy on a primary basis and it is used for continuum observations of galactic and extra-galactic radio sources, as well as to investigate radio pulsars. Portion of this band, 10.68 – 10.7 GHz, is a passive band and protected by No. 5.340, which prohibits all emissions in the band.

The frequency range between **100 MHz to 25.5 GHz** is prohibited, unless through prescribed conditions, limited services are permitted with some technical restriction on their usage. It is important that the authority understands that within the national framework, the SKA radio telescope should be protected beyond primary radio astronomy allocations. In bullet point (f) of section 10.1 of the consultation documents, the Authority proposes measures to protect the 10.6 – 10.7 GHz band from unwanted emission of satellite services operating in the 10.7 – 12.75 GHz. Such a measure is applicable to a radio astronomy stations that are outside the RQZ. As per *considering l)* of Resolution **681 (WRC-23)** read together with *recognizing b),* radio astronomy stations such as the SKA, should be able to operate in much larger bandwidth outside the primary radio astronomy frequency bands. This is the entire essence of agenda item 1.16 of WRC-27, it cannot be over-emphasized and it is important that ICASA is fully aware of this matter.

Proposed Mitigation measures to protect SKA operating in the bands above.

- To protect the SKA from the FSS uplink emissions operating in the 12.75 – 14.8 GHz, such service will be subjected to AMA Permit application process. Exclusions zones will be created around the telescope where deployment will be prohibited. The band usage will be limited to 13.75 – 14.5 GHz. SARAO will also encourage the use of the Ka band for operations around the KCAAA.

- To protect the SKA from the FSS downlink emissions operating in the 10.7 – 12.75 GHz, SARAO supports the proposed mitigation by ICASA to suppress the emissions of non-GSO satellites in the band immediately adjacent to 10.7 GHz. This will ensure the protection of the primary RAS band in 10.7-10.68 GHz and especially the passive band in the 10.68 – 10.7 GHz, which undertakes important observations in the continuum line.
- To protect the SKA telescope from all other in-band emissions of non-GSO satellite services in the MSS and FSS, SARAO recommends Licence conditions that protects the SKA to be implemented to minimize the received power by telescopes in the KCAAA from satellite transmissions. Satellite emissions operating in accordance with the ITU-R table of frequency allocation, must be subjected to national compliance in their Licence or authorization conditions. It is recommended that one condition in a satellite license is to establish a coordination agreement with SARAO, this agreement could include different mitigation measures to be implemented by the satellite operator to minimize the negative effects on SKA observations, such as:

    - Avoiding direct illumination of the telescope sites to place the downlink beams far away from the radio telescope site. Given the sensitivity of the SKA telescope, even interference into the side lobes of the antenna can be harmful to radio astronomy.
    - For additional protection, satellites should be able to momentarily redirect the beam or completely disable downlink channels while they pass within some minimum angular separation of the pointing direction of the telescope, in what it is known as telescope boresight avoidance. In recent studies by Starlink and NRAO, satellites that passes within 2 degree of the boresight could steer their beams no closer than 180 km from a radio telescope.
    - Establish a channel usage coordination with the telescopes to allow observation of some channels while others are used by the satellite constellation.
    - Where possible, satellite transmission can hop to or permanently use the Ka band channel when they pass over the KCAAA.
    - Reduce the level of emissions to a minimum required in order to meet the satellite link network quality performance requirements.

For decades the RQZ have been an effective measure to ensure that radio telescopes can undertake advanced science and expand our knowledge of the universe. The scheme has been very effective to control terrestrial RFI, however, the recent growth of large satellite constellations has significantly challenged this framework and requires collaborative effort to ensure the coexistence of the two service in order to national strategy for broadband services and scientific discoveries.

binder

Final Audit Report 2024-11-12

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