EUROPEAN SCIENCE FOUNDATION

30 CRAF News

The newsletter of the ESF Expert Committee on Radio Astronomy Frequencies

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Contents

Editorial

As the new CRAF chairman, I would first of all like to start by thanking my predecessor, Hans van der Marel, for everything he has done for our Committee during the past three years. During his mandate, besides numerous other activities, CRAF recruited a new Frequency Manager, saw our host organisation, the European Science Foundation, redefine itself, participated very actively in the ITU World Radio Communications Conference 2015, and all this in pursuit of CRAF's mission, i.e. to keep the frequency bands used for radio astronomical observations free from interference.

I have been involved in international spectrum management for 20 years, joining CRAF as representative of the Paris Observatory in 1998. In 1999 I joined IUCAF, the worldwide organisation which represents the scientific radio astronomy community in matters of spectrum management. I was CRAF chairman from 2001 to 2003 and was IUCAF chairman from 2003 to 2009. I have also chaired the Task Force on Regulatory Issues relating to the Square Kilometre Array Site Characterization Working Group and I was President of Commission 50 "Protection of Existing and Potential Observing Sites" of the International Astronomical Union.

Protecting radio astronomical observations is an ever-continuing activity. It concerns the important infrastructure that our community has built and continues to enlarge. Looking at our current "to do" list, I see some specific items that were already there when I started twenty years ago, but also a myriad of new issues, driven by developments in radio technology and the ever-increasing clamour for new frequency allocations by other radio spectrum users. It is necessary to keep educating other spectrum users and spectrum management administrations on the importance of radio astronomical research, why our protection levels are so low, the need for compatibility studies for all new proposed spectrum use that poses a potential threat to the Radio Astronomy Service and the need to attend many meetings to make our case.

CRAF has a number of very good and competent people for the tasks at hand, who interact with administrations at the national, European and worldwide levels, and also with our scientific community, all of which is essential. Let me end with my favourite saying by Benjamin Franklin, which is closely linked to CRAF's mission "We must all hang together or, most assuredly, we shall all hang separately".

Wim van Driel, *CRAF chairman*

Cover
The photo shows 4 (3 in the foreground, 1 in the background) of the 36 dishes, each of 12 m in diameter, of the Australian Square Kilometre Array (SKA) Pathfinder Telescope (ASKAP), located at the Murchison Radio Astronomy Observatory in Western Australia. The dishes are equipped with phased-array feeds, which provide 36 beams on the sky at 1.4 GHz, covering a field of view of ~30 sq. degrees The radio quiet zones (RQZs) in South Africa and Western Australia are extremely important aspects of the SKA spectrum management environment (See article by Harry Smith).
CREDIT: ATNF, CSIRO, Epping NSW 1710, Australia.

CRAF FM report of WRC-15 (2nd – 27th November, 2015)

The World Radio-communication Conference (WRC-15) was opened on 2nd November 2015 at the ITU premises in Geneva. The CRAF members present at the conference were Talayeh Hezareh, Hans van der Marel, Wim van Driel and Ivan Thomas. The agenda items relevant to the Radio Astronomy Service (RAS), CRAF's position on them and the final outcome of each agenda item (AI) for Region 1 is summarised below.

AI 1.1: considering additional spectrum allocations to the mobile service and identification of additional frequency bands for International Mobile Telecommunications (IMT)
CRAF position: opposing: 608-614 MHz, 1330-1400 MHz, 1427-1518 MHz, 2700-2900 MHz, 4800-5000 MHz bands.

Final outcome:

- *Lower UHF band* (470-694 MHz) Region 1: No change to the RR at WRC-15, but a WRC-23 agenda item has been created addressing a review of the spectrum use of the frequency band 470-960 MHz.
- *L Band:*
  - The bands 1427-1452 and 1492-1518 MHz have been identified for IMT worldwide.
  - The band 1452-1 492 MHz was identified for IMT in Regions 2 and 3. In Region 1, the IMT identification of 1452-1492 MHz is limited to some African and Middle-East countries.
- *C-Band:*
  - 3400-3600 MHz: The band has been identified in Regions 1 and 2 for IMT with a pfd limit of -154.5 dB ($W.m^{-2}.(4\ kHz)^{-1}$) produced at 3 metres above ground level for 20% of the time for the protection of FSS.
  - 3600-3700 MHz: the band has only been identified for a few Region 2 countries with associated provisions to protect FSS as specified above for the lower part of C-band.
- *Other bands:* agreement has been reached on no changes in the allocation table for the frequency bands: 410-450 MHz, 1164-1215 MHz, 1215-1300 MHz, 1300-1350 MHz, 1350-1400 MHz, 1518-1525 MHz, 1559-1610 MHz, 1695-1710 MHz, 2025-2110 MHz, 2200-2290 MHz, 2700-2900 MHz, 2900-3100 MHz, 3300-3400 MHz (in Region 1), 3700-3800 MHz; 3800-4200 MHz, 4400-4500 MHz for Regions 1 and 2, 4500-4800 MHz, 4800-4990 MHz (in Region 1) 4990-5000 MHz, 5350-5470 MHz, 5725-5850 MHz, 5850-5925 MHz and 5925-6425 MHz.

  The band 3300-3400 MHz has been identified for some African countries in Region 1 and for some countries in Regions 2 and 3. The band 4800-4990 MHz is only identified for IMT in one Region 2 and three Region 3 countries.

AI 1.3: to review and revise Resolution 646 (Rev.WRC-12) for broadband public protection and disaster relief (PPDR)
CRAF position: opposing the use of broadband PPDR within and immediately adjacent to the RAS band 406.1-410 MHz unless acceptable compatibility criteria for the RAS are developed and included in subsequent regulation. CRAF was of the opinion that Resolution 646 should explicitly mention the primary RAS allocation in the band 406.1-410 MHz.
Final outcome: WRC Resolution 646 on PPDR was revised, encouraging administrations to consider parts of the frequency range 694-894 MHz for PPDR in all regions, and confirmed the range 380-470 MHz as suitable for PPDR in Region 1. Resolution 646 includes the following text: *"…that the radio astronomy service (RAS) operates on a primary basis in the 406.1- 410 MHz band and there may be PPDR operations adjacent to that band"*

AI 1.5: to consider the use of frequency bands allocated to the fixed-satellite service for the control and non-payload communications (CNPC) of unmanned aircraft systems (UAS) in non-segregated airspaces.
CRAF Position: The proximity of the proposed FSS bands to the 10.68-10,70 MHz and 14.47-14,50 MHz RAS bands means that CRAF strongly opposes the use of the FSS (Earth-to-space) bands by UAS until regulations have been developed to protect the existing RAS allocations.
Final outcome: This AI resulted in huge political pressure from the stakeholders. However, a consensus was eventually reached on the last day of the Conference for CNPC usage for UAS, and WRC-15 made a provisional footnote allocation in a number of FSS bands and ICAO was invited to start developing the necessary standard and recommended practices. The provisional allocation will come into force if there is WRC-19 approval of technical conditions for CNPC link usage of those bands. In the resolves section of the approved Resolution the following text for the protection of radio astronomy is included:
"that, in order to protect the radio astronomy service in the frequency band 14.47-14.5 GHz, administrations operating UAS in accordance with this resolution in the frequency band 14-14.47 GHz within line-of-sight of radio astronomy stations are urged to take all practicable steps to ensure that the emissions from the UA in the frequency band 14.47-14.5 GHz do not exceed the levels and percentage of data loss given in the most recent versions of Recommendations ITU-R RA.769 and ITU-R RA.1513;"

AI 1.6: (1.6.1) to consider possible additional primary allocations to the FSS (Earth-to-space and space-to-Earth) of 250 MHz in the range between 10 GHz and 17 GHz in Region 1;
CRAF position: CRAF approved the allocation of the 13.4-13.75 GHz band to the FSS in both the earth-space and space-earth directions. CRAF strongly opposed allocating the band 14.5-14.8 GHz in the space-earth direction because no compatibility studies with the RAS allocation in the adjacent band, 14.47-14.5 GHz, (used for VLBI), had been conducted. CRAF also strongly opposed allocation of the band 14.8-15.35 GHz in the space-earth direction because this band is directly adjacent to the 15.35-15.4 GHz primary RAS allocation and because of the secondary SRS allocation in this band that is also used for VLBI.
Final outcome: The Conference agreed on an additional

primary allocation of 250 MHz to the FSS (space-to-Earth) in Region 1 in the frequency band 13.40-13.65 GHz. After long and difficult discussions the Conference agreed to an additional allocation in Region 1 (excluding Europe) in the frequency band 14.5-14.75 GHz and in Region 3 in the 14.5-14.8 GHz for the FSS (Earth-to-space) in a number of countries specified in the corresponding Resolutions with certain technical and operational limitations.

AI 1.8: to review the provisions relating to earth stations located on board vessels (ESVs), based on studies conducted in accordance with Resolution 909 (WRC-12);
CRAF position: Supported no change in the Radio Regulations.
Final outcome: A compromise was reached in that ESVs with a minimum antenna diameter of 1.2 m would be allowed to operate in the band 5925-6425 MHz without prior agreement of any administration if located at least 330 km away from the low-water mark as officially recognised by the coastal State. Other current provisions of Resolution 902 are still applicable; no modification to the procedures applicable to Ku-band have been made.

AI 1.9: (1.9.1) possible new allocations to the fixed-satellite service in the frequency bands 7150-7250 MHz (space-to-Earth) and 8400-8500 MHz (Earth-to-space), subject to appropriate sharing conditions; **Issue 1.9.2** the possibility of allocating the bands 7375-7750 MHz and 8025-8400 MHz to the maritime-mobile satellite service and additional regulatory measures, depending on the results of appropriate studies;
CRAF position: supported no change to the Radio Regulations because of a lack of a satisfactory solution to ensure compatibility between SRS and FSS in the proposed bands.
Final outcome: for 1.9.1, Strong opposition from two regional groups resulted in no new allocation to the FSS and no new studies will be performed. For 1.9.2 WRC-15 approved a new primary allocation to the MMSS (space-to-Earth) in the 7375-7750 MHz band under the conditions initially proposed by CEPT.

AI 1.10: to consider spectrum requirements and possible additional spectrum allocations for the MSS in the Earth-to-space and space-to-Earth directions, including the satellite component for broadband applications, including IMT, within the frequency range 22 GHz to 26 GHz;
CRAF position: No change to the Radio Regulations
Final outcome: One regional organisation and one administration insisted on the additional MSS allocation. Proponents of new MSS allocations in the frequency range 22-26 GHz proffered different solutions to solve this issue, but these did not alleviate the concerns of the regional organisations (including CEPT), which therefore firmly kept a NOC option. As a result, no new allocation was made to the MSS under AI 1.10 and no new studies will be performed.

AI 1.12: to consider an extension of the current worldwide allocation to the Earth exploration-satellite (active) service in the frequency band 9300-9900 MHz by up to 600 MHz within the frequency bands 8700-9300 MHz and/or 9900-10500 MHz;
CRAF position: accepted allocation of 9200-9300 MHz and 9.9-10.4 GHz for Earth EESS (active).
Final outcome: WRC-15 agreed new allocations to the EESS (active) in the bands 9.2-9.3 and 9.9-10.4 GHz, as proposed by CEPT. The protection of the RAS in the nearby band 10.6-10.7 GHz is addressed in a new ITU-R Recommendation ITU-R RS.2066, which is incorporated by reference via the new footnote in the RR, including a list of radio astronomy stations that will not be illuminated by SAR using the new allocation except with advance coordination initiated by the satellite operators.

AI 1.14: to consider the feasibility of achieving a continuous reference time-scale, whether by the modification of coordinated universal time (UTC) or some other method. CRAF had no common position on this AI.
Final outcome: An agreement was reached on this contentious topic through the adoption of a new Resolution, which provides a framework for further study including wider collaboration with relevant international bodies such as the International Bureau of Weights and Measures (BIPM), International Committee for Weights and Measures (CIPM) and General Conference on Weights and Measures (CGPM) etc. and will report on the progress of this Resolution to WRC-23. Meanwhile the current UTC (with leap seconds) as described in ITU Recommendation TF 460-6, will continue to apply.

AI 1.16: to consider regulatory provisions and spectrum allocations to enable possible new Automatic Identification System (AIS) technology applications and possible new applications to improve maritime radio communication;
CRAF position: CRAF supported a possible new MMSS allocation (space-Earth) in (parts of) the frequency band 156-162 MHz as long as an attenuation of 85 dB and the pfd mask described in the CPM15-2 report as proposed by the MMSS would be implemented for the nearby radio astronomy band.
Final outcome: A consensus was reached, in line with

the proposals from CEPT, on the identification of ASM Channels, the protection of the existing AIS, the identification of the terrestrial component of the VDES and the international VDES channels. Concerning the satellite component of the VDES, it was agreed to revise the associated Resolution 360 and to consider the issue further at WRC-19.

AI 1.18: to consider a primary allocation to the radiolocation service for automotive applications in the 77.5-78.0 GHz frequency band in accordance with Resolution 654 (WRC-12);
CRAF position: CRAF did not approve the new allocation as long as no protection criteria for RAS were considered and reflected in appropriate regulation.
Final outcome: WRC-15 agreed on a primary allocation to the radiolocation service in the 77.5-78.0 GHz band for ground-based applications, including automotive radars. A new Resolution was approved, calling for further studies to assist administrations in ensuring compatibility between new RLS applications and the incumbent services, including radio astronomy, operating in the 76-81 GHz frequency range.

Talayeh Hezareh

CRAF's Preliminary Positions on WRC-19

Agenda Items Relevant to Radio Astronomy

The next World Radio Conference in 2019 (WRC-19) involves a number of agenda items (AIs) that deal with frequency bands relevant to the RAS. The new study cycle of the Conference Preparatory Group (CPG) and ITU-R levels has started and CRAF will be involved with the development of studies on the above agenda items to ensure compatibility of the newly proposed applications with the RAS. Some of the most important agenda items for the RAS and CRAF's viewpoint are summarized below. CRAF will monitor these AIs very carefully and its position on these will undoubtedly evolve with the progress of the study cycle. Updates will be provided in future newsletter issues.

AI 1.2 considers setting in-band power limits for earth stations of the mobile-satellite service, meteorological-satellite service and Earth exploration-satellite service in the frequency bands 401-403 MHz and 399.9-400.05 MHz. The RAS has a primary allocation, 406.1-410 MHz, and the effects of the power levels of the emissions from earth stations in the nearby frequency bands 401-403 MHz and 399.9-400.05 MHz must be investigated to ensure the protection of RAS.

AI 1.6 considers the development of a regulatory framework for non-GSO FSS satellite systems that may operate in the frequency bands 37.5-39.5 GHz (space-to-Earth), 39.5-42.5 GHz (space-to-Earth), 47.2-50.2 GHz (Earth-to-space) and 50.4-51.4 GHz (Earth-to-space). CRAF is concerned for the RAS and EESS (passive) allocations in the frequency bands 42.5-43.5 GHz, 48.94-49.04 GHz and 51.4-54.25 GHz and asks for no changes to the Radio Regulations unless acceptable sharing and compatibility criteria are developed with the RAS and EESS.

AI 1.7 studies the spectrum needs for telemetry, tracking and command in the space operation service for non-GSO satellites with short duration missions within the frequency ranges 150.05-174 MHz and 400.15-420 MHz. RAS has allocations in the 150.05-153.0 MHz and 406.1-410.0 MHz bands. CRAF opposes any new allocation unless acceptable sharing and compatibility criteria are developed with the RAS.

AI 1.8 considers possible regulatory actions to support Global Maritime Distress Safety Systems (GMDSS) modernisation and to support the introduction of additional satellite systems into the GMDSS. The International Maritime Organization (IMO) has received an application for the recognition of an existing satellite system (Iridium) as part of the GMDSS, and consequential regulatory actions may need to be considered. GMDSS satellite systems need to provide protection of incumbent services in accordance with the Radio Regulations, including those in adjacent frequency bands from harmful interference. CRAF supports the protection of the primary RAS allocation in the 1610.6-1613.8 MHz band and opposes the recognition of Iridium as a new GMDSS provider unless acceptable sharing and compatibility criteria are developed with the RAS and that the RAS band becomes free from harmful interference.

AI 1.13 considers identification and possible additional allocations of frequency bands for the International Mobile Telecommunications (IMT). The AI asks for compatibility studies to be conducted, including studies with respect to services in adjacent bands in the frequency range between 24.25 GHz and 86 GHz for the frequency bands: 24.25-27.5 GHz, 37-40.5 GHz, 42.5-43.5 GHz, 45.5-47 GHz, 47.2-50.2 GHz, 50.4-52.6 GHz, 66-76 GHz and 81-86 GHz, which have allocations to the mobile service on a primary basis and 31.8-33.4 GHz, 40.5-42.5 GHz and 47-47.2 GHz, which may require additional allocations to the mobile service on a primary basis. The frequency bands allocated to passive services on an exclusive basis are not considered for allocation to the mobile service. However, there are a number of RAS and passive frequency bands, which may be affected by future IMT allocations. CRAF will therefore be heavily involved in conducting compatibility studies to ensure the protection of the concerned RAS bands.

AI 1.14 considers regulatory actions for high-altitude platform stations (HAPS) within the existing fixed service (FS) allocations. HAPS will be located at an altitude of 20-50 km and at a specified, nominal fixed-point relative to the Earth. WRC-97 identified possible frequency bands of 47.2-47.5 GHz and 47.9-48.2 GHz for HAPS, but WRC-2000 considered that the bands 27.9-28.2 GHz (fixed downlink), paired with the frequency band 31.0-31.3 GHz (fixed uplink) would be better outside Region 2 because of concerns with rain fade. At WRC-12 HAPS had the bands 6440-6520 MHz (downlink) and 6560-6640 MHz (uplink) in the FS allocation designated for it in some countries. This AI asks for a study for additional spectrum for HAPS for broadband connectivity within the FS frequency bands on a primary basis within the range 38-39.5 GHz for global use and within the ranges 21.4-22 GHz and 24.25-27.5 GHz in region 2.

The frequency band considered in Region 1 for studies regarding this agenda item is not of concern to CRAF. However, CRAF supports the RAS operations in other regions as well and requests compatibility studies to ensure the protection of RAS in Region 2 from unwanted emissions of HAPS links.

AI 1.15 considers the identification of frequency bands for the land-mobile and FS applications operating in the frequency range 275-450 GHz. A number of bands in the frequency range 275-1000 GHz are identified for passive services, such as RAS, EESS (passive) and SRS (passive). However, this does not preclude the use of this range by active services. This AI asks for the identification of technical and operational characteristics of systems in the land-mobile and FS operating at frequencies above 275 GHz, for the study of the spectrum needs of systems in the land-mobile and fixed services, and for the development of propagation models within the frequency range 275-450 GHz to enable sharing and compatibility studies between the land-mobile and fixed and passive services in this frequency range, while maintaining protection of passive services. CRAF supports the development of propagation models for this frequency range and opposes any new allocations unless acceptable sharing and compatibility criteria are developed to ensure the protection of RAS, SRS and EESS (passive) from future services and applications above 275 GHz.

Talayeh Hezareh

Update on the SKA

The Square Kilometre Array (SKA) Project – Introduction

In September 1993 the International Union of Radio Science (URSI) established the 'Large Telescope Working Group' to begin a worldwide effort to develop scientific goals and technical specifications for a next-generation international radio observatory. Some years of development of technical and programmatic aspects of various frameworks followed, with a notable milestone in the process being 1 January 2005 when a Memorandum of Agreement came into force between a number of organisations to collaborate in the development of a "Square Kilometre Array". Moving forward to the present day, there is now a multi-million Euro project that is an international effort to build the world's largest radio telescope. It will eventually have over one million square metres (a square kilometre) of collecting area to monitor the sky in unprecedented detail and survey large areas of sky much faster than any system currently in existence.

The project is currently led by the SKA Organisation (SKAO), a not-for-profit company, established in December 2011 to formalise relationships between the international partners and centralise the leadership of the project. The SKAO is based at Jodrell Bank Observatory in the UK. Organisations from ten countries are currently members of SKAO – Australia, Canada, China, India, Italy, New Zealand, South Africa, Sweden, the Netherlands and the United Kingdom. A number of other countries have also expressed their interest in joining the organisation, which will continue to expand. Over the coming few years, it is intended that the SKAO transitions into an Inter-Governmental Organisation (IGO), which will operate in a similar way to other long-established IGOs such as CERN, ESA and ESO. It will move from its current commercial status to that of a treaty-level organisation registered with the United Nations, and will be governed by a Council appointed by the member states.

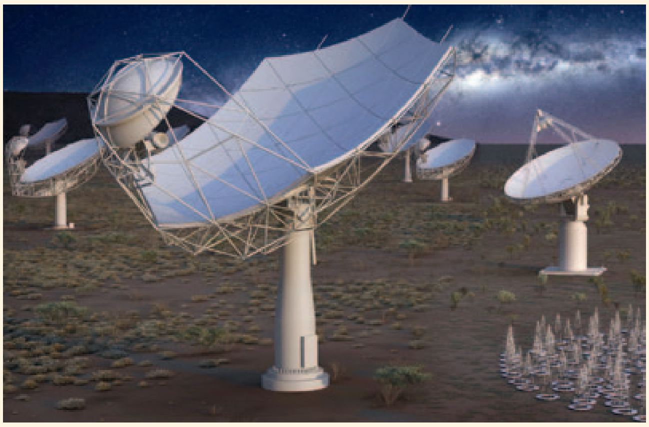

Figure 1. The Square Kilometre Array (SKA) project is an international effort to build the world's largest radio telescope in South Africa and Australia.

The SKA Telescope

The Square Kilometre Array (SKA) telescope will be developed and built over a phased timeline. Pre-construction development started in 2012 and will last until the latter half of this decade, involving the detailed design, implementation, R & D work and contract preparation needed to bring the SKA's first phase to construction readiness. The bulk of the SKA will be built in two main phases between 2018 and the late 2020s, the first phase involving testing the full system in a 'proof of concept' manner. The SKA will start conducting science observations in 2020 with a partial array.

In 2012 an important decision was taken to build the Square Kilometre Array on two sites, one in South Africa's Karoo region and the other in Western Australia's Murchison Shire. The sites were chosen for a number of scientific and technical reasons, from the atmospherics above the desert sites through to their inherent 'radio quietness', the result being some of the most remote locations on Earth. For SKA Phase 1, Australia will host the low-frequency instrument covering frequencies between 50 MHz and 350 MHz with more than 500 stations, each containing approximately 250 individual antennas, whilst South Africa will host an array of some 200 dishes covering frequencies between 350 MHz and 14 GHz.

Phase 2 will result in the completion of the telescope arrays at both sites and the SKA will become fully operational in the late 2020s, by which time it will consist of some 2 000 dishes, not just in South Africa, but also some in Botswana, Ghana, Kenya, Madagascar, Mauritius, Mozambique, Namibia and Zambia, whilst in Australia there will be up to one million low frequency antennas in operation.

Spectrum use

A wideband radio quiet spectrum is crucial for the existence and long-term operational potential of the SKA. In today's world of modern telecommunication systems and ubiquitous RF noisy consumer devices, there are many potential interference issues. Neither is this environment static. In future there will probably be many more new telecommunications systems - terrestrial, airborne and satellite – some with the potential to cause harmful interference to radio astronomy observations at the intended frequencies of operation of the SKA telescope.

To date, portions of the spectrum at the frequencies of the most important natural emission features have been allocated by international agreement for use by radio astronomy and other passive scientific services within the framework of the International Telecommunication Union's Radio Communications Sector (ITU-R). However, these bands are often too narrow for many current highly-sensitive, astronomical observations to be completed efficiently. The SKA will have a large, distributed collecting area and extremely sensitive wideband receivers routinely operating in bands outside those normally identified for radio astronomy use by the ITU-R. Recognising the need for wide-bandwidth, radio-quiet areas to facilitate the SKA, the Australian & South African governments have offered to host the telescope and provide stable radio regulatory conditions for the benefit of all stakeholders via

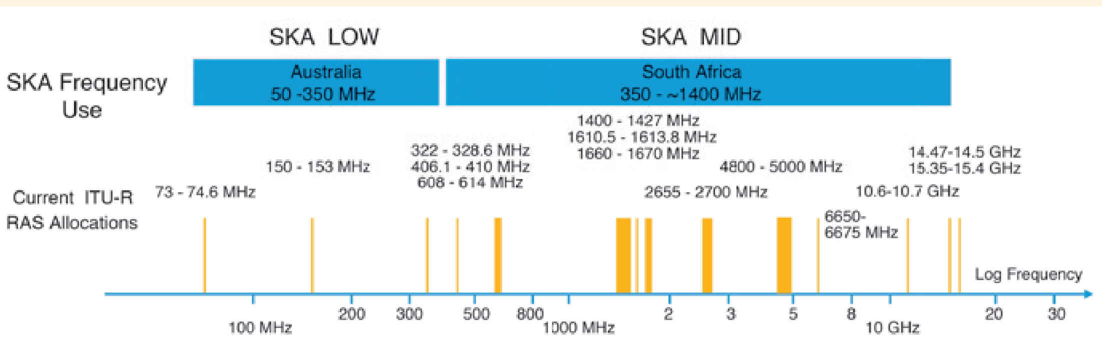

Figure 2. SKA frequency use and ITU-R Radio Astronomy Service (RAS) Allocations

robust legislative frameworks. These frameworks also ensure local residents are not adversely affected by the regulations by making provision for appropriate alternative measures. In Australia, the Radio communications Act 1992 and in South Africa, the Astronomy Geographic Advantage Act of 2007 enshrine the creation of Radio Quiet Zones (RQZs) covering the chosen sites to facilitate the managed use of the spectrum required to support the SKA. These provide for control of radio emissions at frequencies between 70 MHz and 25.25 GHz in Australia and 100 MHz and 25.5 GHz in South Africa.

The SKA project is also continually working to push forward capabilities in interference mitigation in its own analogue, digital and data processing systems.

Spectrum management activities within SKAO

The radio quiet zones (RQZs) in South Africa and Australia are an extremely important aspect of the SKA spectrum management environment that will allow a stable, spectrum-occupancy environment for stakeholders in the host areas well into the future. However, RQZs provide only the potential to effectively regulate local, terrestrial, telecommunications development in a sympathetic way for radio astronomy; they do not seek to actually provide a 'no emissions' environment (a more informative description would be 'Radio Quieter Zone') and cannot seek to effectively regulate satellite and many airborne systems. The international nature of the representation required to address many of the likely compatibility and co-existence issues, and of the SKA project itself, combined with the importance of the availability of usable spectrum to facilitate the planned, challenging, scientific observations, has meant that the SKA Organisation commit internal resources to a broad range of spectrum management activities. This resource is dedicated in two areas:

- firstly, on matters internal to the project such as:
  - supporting site hosting organisations in implementing & maintaining RQZs
  - promoting early consideration of RFI/EMI related issues in the design/development
  - supporting work towards SKA site registration with the ITU
- secondly, on outward facing representation of the SKA's requirements to the international radio regulatory community, such as:
  - establishing direct links with governmental, radio administrations of the SKA's member states.
  - participating in the regulatory work of the International Telecommunications Union to represent and promote the SKA's and radio astronomy's perspectives.
  - collaborating with international radio astronomy and radio-science, spectrum-management organisations to push forward common, spectrum-protection positions.

Engaging in dialogues with stakeholders to work together to resolve potential issues.

The SKAO has recently joined CRAF as an observer organisation and the ITU-R as a sector member; it looks forward to strengthening radio astronomy's representation in ITU-R committees, working in close collaboration with CRAF & IUCAF.

Future updates

As the project develops over the coming years, reports on SKA related matters of interest to the RAS spectrum management community will be included in future CRAF newsletters, as will updates on the project's progress. For more in-depth information on the SKA see: https:\\www.skatelescope.org

Harry Smith

The LOw Frequency ARray (LOFAR) expands westwards:

New Irish station to be constructed in Birr, Ireland

Irish radio astronomy received a boost earlier this year with the announcement of a Science Foundation Ireland (SFI) award to part fund the construction of a LOFAR radio telescope at the Rosse Observatory at Birr Castle in Ireland. This I-LOFAR telescope (designation IE613) is being funded by SFI, philanthropic contributions and an I-LOFAR consortium (consisting of several third level institutions from the island of Ireland).

Site preparation is due to commence in autumn 2016 with the construction of flood defences and installation of infrastructure. After a pause during the winter period, the station hardware will be installed in spring 2017. First light is expected by summer 2017. The Birr station will extend the current maximum LOFAR baseline from 1 516 km (Baldy (Poland) – Chilbolton (U.K.) to 1 883 km (Baldy – Birr) (See Figure 3).

A solar radio observatory has been operated at the Rosse Observatory (www.rosseobservatory.ie) by the School of Physics in Trinity College, Dublin since 2010

Figure 3. Locations of the LOFAR sites.

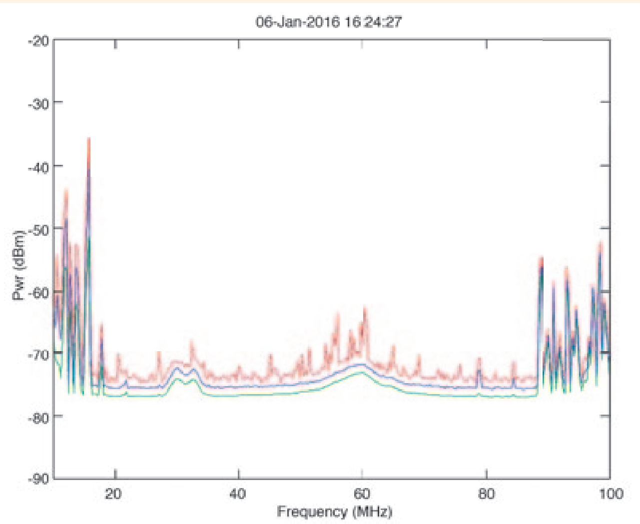

Figure 4. LBA spectrum (peak, mean and 95th percentile, N-S direction)

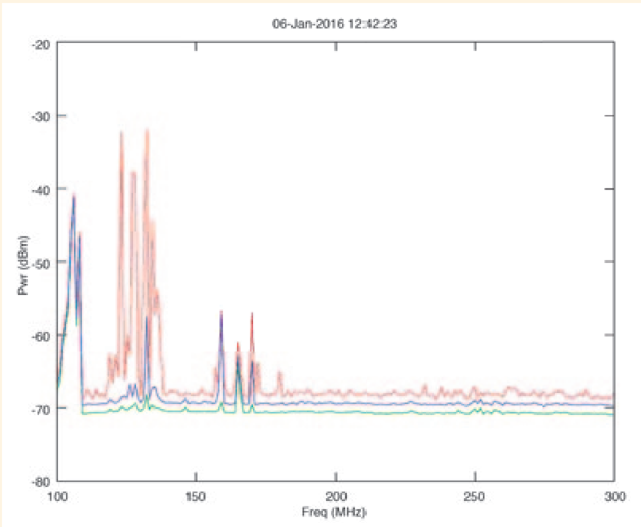

Figure 5. HBA spectrum (peak, mean and 95th percentile, N-S direction)

using Callisto spectrometers developed at ETH, Zurich. The site was initially identified as being relatively free of RFI in the LOFAR frequency range and re-confirmed by a team from AstroTec in January 2016 on their first site visit (See Figs. 4 and 5). There are no Digital Audio Broadcast signals in the spectrum. At present DAB is mainly confined to larger coastal cities, but the Irish telecommunications regulator COMREG indicated to I-LOFAR that, whereas they are obliged under legislation to provide licences as required, they have had no indication from DAB operators in Ireland of any plans to extend DAB services beyond those currently available in the near future.

It is to be hoped that at least the early years of operation of EI-613 will be DAB free.

Joe McCauley

RFI situation in Sardinia

Introduction

The Sardinia Radio Telescope[1] (SRT, Lat. 39°29'34"N – Long. 9°14'42"E) is located in a valley, but at 600 m above sea level, approximately 40 km North of Cagliari, the administrative capital of Sardinia. SRT is a 64-m, general-purpose, fully-steerable, wheel-and-track, quasi-Gregorian antenna designed to operate in the frequency range from 300 MHz to 116 GHz, (see Figure 6).

1. http://www.srt.inaf.it/

Figure 6. SRT panoramic view looking South

In its full operational mode SRT will be equipped with more than 15 radio astronomical receivers to assure an almost continuous, frequency coverage within its frequency range. The primary-, secondary- and tertiary-focus receivers are hosted in three remotely and automatically controlled assemblies. This makes the antenna frequency agile, with the ability to be switched between all the observing bands in a fast and remotely controlled way (the switching time for changing receivers is less than 5 minutes).

Following the antenna's astronomical validation, the SRT, with its large aperture and versatility (multi-frequency agility and wide, frequency coverage), started operating in 2016 as a single dish (continuum, full Stokes and spectroscopy) and also as a part of the Very Long Baseline Interferometry (VLBI) network, even though its operation was still (and still is) on a shared-risk basis. So, at the present time early-science observations are being made, with the SRT able to operate using three receivers: a coaxial, L-, P- band one at the primary focus, a C-band one at a tertiary focus and a K-band, 7-feed one at the Gregorian focus. In addition to the above receivers, a coaxial receiver operating in X- and Ka-bands has been installed and tested for a future use of the SRT in Space Science. Its scientific validation for this is soon to be carried out. In addition to the above receivers, three others are under construction; an S-band, 7-feed one, a low, C-band one and a Q-band, 19-feed one for the primary-, tertiary- and Gregorian foci respectively.

Observations as a part of the European and space VLBI networks and the European pulsar timing array are now routinely also being scheduled at SRT, as are molecular line (methanol, ammonia and H_2O) surveys of nearby galaxies.

RFI monitoring at SRT

Since 2008 the Radio Frequency Interference (RFI) occupancy of the SRT frequency bands has been routinely monitored, and in particular much more frequently since the telescope started scientific observations. In fact, an

Figure 7. The RFI mobile laboratory during RFI monitoring (in the foreground) close to the SRT (in the background)

RFI team from the Astronomical Observatory of Cagliari has been carrying out spectrum monitoring at SRT using a mobile laboratory[2] (see Figure 7) since 2009. This RFI van is equipped with instrumentation allowing spectrum measurements from 50 MHz to 40 GHz. Periodic maintenance, an upgrade of the radio frequency components, and a recent improvement in the software for the antenna-pointing control and data acquisition have resulted in a mobile laboratory with state-of-the-art technology.

In addition to the above, the same team has recently developed a tool, now available in the antenna control room (CR), for real-time RFI monitoring of the SRT receiver bands. This RFI, CR station is able to perform continuous monitoring of the SRT intermediate frequency (IF) baseband, which extends from 100 to 2 100 MHz. Basically, the IF baseband of each SRT receiver can be acquired in a piggyback mode (without interfering with the telescope schedule) using a spectrum analyser and processed in real-time thanks to ad-hoc, LabVIEW software. The software can recognise the receiver in use and its settings (attenuation, polarisation and backend) and acquire spectra (at least 50 per second) and save them in a data-log file, together with the corresponding antenna pointing position and a time-stamp. Consequently, astronomers can ascertain in real-time the state of the RFI during their astronomical observations. Post-processing of the data-log files can also result in a 3D map with axes of frequency, time and pointing angle, very useful for recognising RFI

2. The Mobile Laboratory for Radio-Frequency Interference Monitoring at the Sardinia Radio Telescope. http://ieeexplore.ieee.org

features in particular, solid-angle directions. This system has already been tested successfully and will be fully operational by the end of 2016. Both RFI systems (the mobile laboratory and the CR station) can also provide general support to the SRT observations by continuously monitoring the bands allocated to the Radio Astronomy Service (RAS).

RFI occupancy of the SRT receiver bands

Up to now the local team has carried out at least 160 RFI measurement campaigns using the mobile laboratory in the area around the radio astronomical site, allowing monitoring and characterisation of the frequency bands of the SRT receivers up to 40 GHz (see Table 1). This characterisation has turned out to be very useful for extending the astronomical experiments to use frequencies beyond the RAS bands, which appear to be clear of other signals (RFI as far as the measurements are concerned). Table 1 presents the results, summarised in terms of the percentage occupancy with respect to the whole bandwidth, for each receiver band obtained in a recent RFI measurement campaign. It can be seen that the most polluted frequency bands turn out to be those of the coaxial P-, L- receivers with an RFI occupancy of 52% and 57% respectively for the two bands. These bands are affected by different kinds of RFI signals such as sporadic RF emission from power lines and aeronautical digital links in P- band and radar, satellite downlinks and cell phone networks in L-band.

The frequency bands of the other receivers appear to be essentially clean except for some RFI arising from HiperLan (C-band and Low C- band) and WLAN (Low C-band) services, some digital links (C-band, K-band, S-band, Low C-band and X-band) and also a surveillance radar service in Ka-band. In the worst case (C- band and Low C-band), the band occupancy is approximately 10% and in the other cases it is at or below 7%. Finally, Q-band turned out to be completely clean, at least up to 40 GHz; i.e. the maximum monitoring frequency of the RFI mobile laboratory.

Other RFI sources appear to be generated by electronic devices installed on the SRT site (from here on called auto-interference). However, it is to be noted that in the last few years most of the auto-interference (detected mainly in P-, L- and C bands) has already been attenuated or switched off. Almost all of those that still remain will effectively be removed when most of the offending electronic devices are put in a shielded room. This task has been scheduled to take place before the end of 2017.

Conclusion

The SRT receiver bands continue to be monitored using the mobile laboratory and the CR station which, when it comes on-line, will also enable continuous investigation of the SRT IF-band. Moreover, a lot of effort by the local RFI team is ongoing and mainly devoted to:

a) a reduction in the RFI occupancy of the SRT receiver bands, in particular those of the P- and L-Band receivers;

b) removal of "today's" auto-interference and thus avoidance of possible future auto-interference by ensuring that people, wandering close to the SRT site, are made aware of the RFI effects on radio astronomical measurements.

Francesco Gaudiomonte and Giampaolo Serra

Receiver (focus)	Frequency Band [MHz]	Status	RFI occupancy [%]	Notes
P-L (primary)	305-410	Working	52	sporadic RF emissions from power lines, aeronautical digital links, auto-interference
	1300-1800	Working	57	Radar, satellite and cell phone network, auto-interference
C (tertiary)	5700-7700	Working	10	HiperLAN, digital links
K (Gregorian)	18000-26000	Working	7	Cell phone network digital links
S (primary)	3000-4500	Under Construction	6	Digital links, naval radar
Low-C (tertiary)	4200-5600	Under Construction	10	Digital links, HiperLAN and WLAN
X-Ka (primary)	8200-8600	Under scientific validation	3	Digital links
	31800-32300	Under scientific validation	2	Surveillance radar
Q (Gregorian)	33000-50000	Under Construction	Clean	Monitoring only up to 40 GHz

Table 1. Frequency bands of the SRT receivers and their RFI occupancy

The European Science Foundation hosts five Expert Boards and Committees:

- The European Space Sciences Committee (ESSC)
- The Nuclear Physics European Collaboration Committee (NuPECC)
- The European Marine Board (EMB)
- The Committee on Radio Astronomy Frequencies (CRAF)
- The Materials Science and Engineering Expert Committee (MatSEEC)

In the statutory review of the Expert Boards and Committees conducted in 2011, the Review Panel concluded unanimously that all Boards and Committees provide multidisciplinary scientific services in the European and in some cases global framework that are indispensable for Europe's scientific landscape, and therefore confirmed the need for their continuation.

The largely autonomous Expert Boards and Committees are vitally important to provide in-depth and focused scientific expertise, targeted scientific and policy advice, and to initiate strategic developments in areas of research, infrastructure, environment and society in Europe.

The views expressed in this newsletter are those of the authors and do not necessarily represent those of the European Science Foundation.

Committee on Radio Astronomy Frequencies (CRAF)

CRAF is an Expert Committee of the European Science Foundation. Established in 1988, it represents all the major radio astronomical observatories in Europe. Its mission is to coordinate activities to keep the frequency bands used by radio astronomers in Europe free from interference.

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