

34 CRAF News

**The newsletter of the ESF Expert Committee
on Radio Astronomy Frequencies**

Autumn 2021

Contents

- 2 • Editorial (Peter Thomasson)
- 3 • Report from the 66th CRAF Meeting
- 5 • The VLBI Global Observing System (VGOS) –
Developments and Questions to the ITU-R

- 7 • Two Events attended by the CRAF VGOS Group
- 9 • RF Monitoring and localisation at Jodrell
Bank Observatory
- 10 • WRC23

Editorial

It seems that one of the major topics on the agenda of the ECC Frequency Management group (WGFM) is to investigate possible criteria / conditions under which requests relating to Ultra Wide Band (UWB) usage of the passive bands under RR No. 5.340 may be considered. This is of VERY GREAT CONCERN to radio astronomers. As far as I and all my colleagues are concerned, it is very important that the passive bands remain passive; i.e. there are no allowed transmissions at all in these bands. Radio astronomers will acknowledge that they will endeavour to make observations at frequencies outside of the passive bands in order to effectively increase the bandwidth used for their observations, and therefore increase their effective system sensitivity. However, the existence of the passive bands enables telescope & receiver systems to be very accurately and truly calibrated, which is very important when looking for extremely weak signals, perhaps from the extremities of the Universe. The discovery of many phenomena, which have enormously increased our knowledge of our Universe, have relied upon a confidence in the calibration of our systems. Thus, the fortuitous discovery of the Cosmic Microwave Background (CMB) with a value of 2.72548 ± 0.00057 degrees Kelvin (commonly referred to as the 3 degrees background), would not have been possible without extremely good calibration of the receiver and system built by Penzias & Wilson, for which they received the Nobel prize. In the EC Radio Spectrum Policy Group document, RSPG 05-67, dated 4th February 2005, when referring to the RR 5.340 bands it states:

“Even low levels of interference received by passive sensors may have a degrading impact on the sensor/receiver performance and thus on passive service bands usage. In most cases the sensors/receivers are not able to discriminate between these natural radiations and man-made radiations”.



Cover

The VGOS Radio Telescope (13.2m) at Metsähovi Observatory in Finland. The radio telescope construction makes use of the ring focus design for the secondary reflector in conjunction with the broadband VGOS-receiver. The radio telescope was built by MT-Mechatronics GmbH, Germany. Credit: Markku Poutanen (Geodetic Institute of Finland).

When considering UWB transmissions, not only would these transmissions be much less distinguishable from receiver noise than would narrow band communications transmissions, but they would effectively increase the receiver noise temperature. The receivers of most radio telescopes nowadays are cooled down to absolute temperatures of 15 to 20 degrees Kelvin (i.e. -258 to -253 degrees C) in order to reduce the thermal noise of the receivers themselves, which could ‘drown out’ the extremely weak astronomical signals.

Peter Thomasson

Report from the 66th CRAF Meeting

The 66th CRAF Meeting, which was a 'virtual' meeting because of the coronavirus situation, was organised by the CRAF Chairman together with the CRAF Management team. It took place during the days of 30 November and 1st December, 2020. There were 18 CRAF members and 10 Directors of observatories or their representatives present at the meeting in addition to Nicolas Walter, representing the ESF. There were two observers present; F. DiVruno from the SKA and H. Smith, a consultant to CRAF. In addition to the above there were two global representatives, L. van Zee (USA CORF Chair) and T. Tzoumis, (Chairman of ITU WP 7D), who were present for a part of the meeting, and also 8 guests present for the 'open' part of the meeting. Two of these latter were 'incoming' CRAF members, Susanne Wampfler and Axel Murk, both representing Switzerland.

The meeting was organised in three sections:

1. Closed Meeting for CRAF Members only
2. Closed Meeting for CRAF Members and Directors
3. Open Meeting with CRAF Members, Observers, Global Representatives and Guests.

This report will only consider the Open Meeting, with reference as appropriate to the two closed meetings.

There were 'round-table' introductions by all present during which Christian Monstein, the outgoing CRAF member for Switzerland, introduced Susanne Wampfler, who is an astronomer, and Axel Murk, who works in microwave instrumentation. Both, who are from the University of Berne and who were approved for membership of CRAF, would share the work involved in the replacement of Christian as the CRAF member for Switzerland. Michael Lindqvist, the current Chairman of CRAF, thanked Christian for his many years of service.

Following a review of the Action Items from the CRAF 65 Web meeting, its minutes were reviewed and approved.

The CRAF Budget

Pietro Bolli gave a review of the state of the CRAF Budget, which, although there were still a number of invoices to be issued, was shown to have a sound basis. The increases in the contributions of the full-paying institutes a year ago should ensure that all contributions should be able to remain at their present level until 2025. In accordance with this, it was agreed that the contribution to the ESF should remain at a constant level from 2022 to 2025. Travel restrictions because of the Covid19 had resulted in less expenditure than in years prior to the appearance of the virus. This was particularly the case for the frequency man-

ager. Not surprisingly, another outcome of this was that, as the RadioNet project was ending at the end of 2020, this resulted in € 22,000 of the grant from RadioNet being returned for other work packages to use. Although there had been significant savings in the travel budget because of Covid19, this had come at a cost and it was becoming clearer that a lack of physical interaction outside of, but associated with formal meetings, had hindered CRAF participants in their efforts to maintain the radio astronomy bands free of interference.

Work Items (WI) Teams' Reports

a) CRAF Management

Benjamin Winkel and Michael Lindqvist, together with contributions from the CRAF Management Team, gave a brief summary of the organisation and of the work currently being undertaken by the Work Item Teams. It was stressed that all CRAF members should have an ITU TIES account to be able to access relevant ITU information. It was also important that all CRAF members should have contact with their own National Administrations. Waleed Madkour, the CRAF frequency manager, had introduced the Redmine and Mattermost tools to provide assistance in the management of the work being undertaken by the Teams. Figure 1 shows the current CRAF work item team structure.

b) CRAF-SE-nn

Pietro Bolli gave an extensive report on the activities of the Spectrum Engineering (SE) group, which covered radio location and other applications at frequencies in the range 116-260 GHz. Other short range device applications such as high-definition, ground-based, synthetic aperture radars, ultra wideband systems operating between 6 and 9 GHz, security cameras and ground-based vehicular applications in the frequency range 77-81 GHz were of concern. Many other issues being considered by CEPT SE19 & SE21, and ECC SE7, SE24 and SE SRD/MG were also being followed by this team.

c) Satellite Services – WI-Sat

The satellites work item team was set up to follow threats from satellites to radio astronomy. The team:

- Maintains a database of existing and planned systems that pose a threat to radio astronomy
- Follows SE40 and FM44 reviewing studies presented at SE40 and generating studies for SE40 on behalf of CRAF.

The main issues for this Work Item Team have been narrowband mobile satellite systems (MSS) in connection

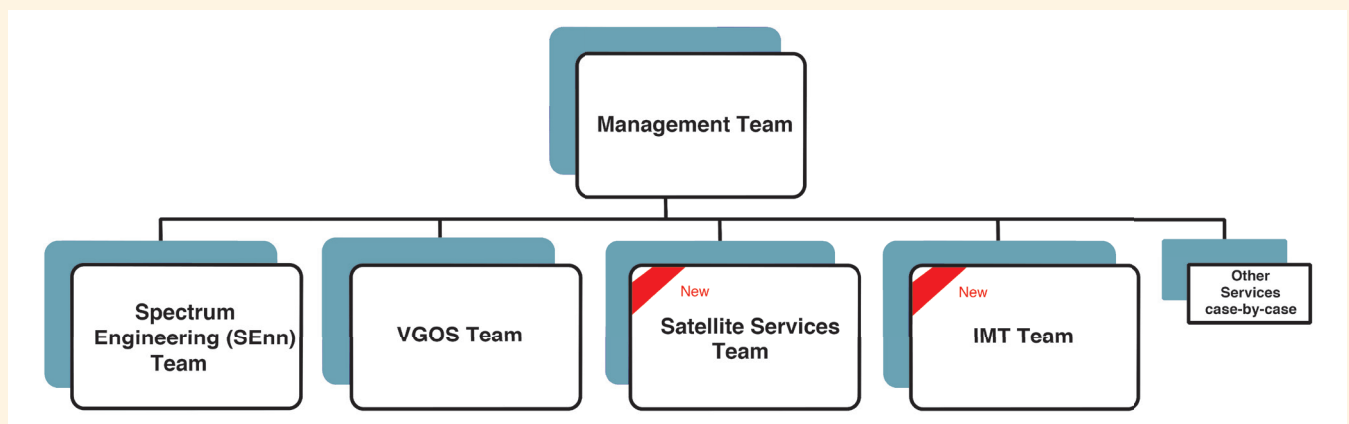


Figure 1. The Current Work Item Teams structure.

with the Internet of Things (IoT), Mega Constellations and Iridium. Potentially the IoT can affect the radio astronomy protected bands (150.05-153 MHz and 406.1-410 MHz).

There is concern that mega constellations operating between 10.7 and 12.75 GHz will result in interference to the RR 5.340 passive band at 10.68-10.70 GHz. In connection with this, CRAF has participated in the Dark and Quiet Skies radio astronomy protection report.

Concerning the Iridium interference situation, it would appear that a final measurement campaign at Leeheim has still not been made or completed because of a number of problems.

In addition to the above, three relevant agenda items for WRC23 have been identified, which are of concern to radio astronomy. These are:

- AI 1.8 UAS-FSS communications in the band 14.47-14.5 GHz
- AI 1.11 GMDSS - causing interference to the 1 612 MHz
- AI 1.13 Space Research Services (SRS) operating in the band 15.35-15.4 GHz

d) International Mobile Telecommunications – WI-IMT

This team monitors and contributes to IMT working groups such as:

- ITU-R WP5D and WP7D (scientific group at ITU-R)
- CEPT/ECC PT1, which is regularly attended.

Work in the IMT group is divided into 2 sections, one for new allocations resulting from WRC19 and the other for candidate new allocations for WRC23. For the former, work is ongoing to include the proper protection in the ECC decision update concerning the 26 GHz band as well as the new decision on 40.5-43.5 GHz.

The issues of greatest concern for WRC23 are:

- High Altitude Platforms as IMT base stations (HIBS) at 694-960 MHz, 1710-1855 MHz and 2500-2690 MHz. CRAF has requested that second harmonic studies be car-

ried out at frequencies of 694-960 MHz (potential impact on 14xx-16xx MHz), which was eventually accepted.

- A new proposed IMT allocation at ~6 GHz. Radio astronomy has difficulty with this as the text of the ITU resolution on this limits studies to primary services. After extensive lobbying, CRAF has received support from many administrations to note the interest of radio astronomy in this band under a footnote.

At ECC PT1 a report on Mobile / Fixed communication networks (MFCN) for command and control and payload links of unmanned aircraft system (UAS) in the range 700-800 MHz has been completed. CRAF is also following new investigations concerned with Adaptive Antenna Systems (AAS) to see what these can bring to radio astronomy protection.

CRAF has provided support to CRAF members in negotiating protection from 5G deployment. A 5G questionnaire has been produced and a 5G toolbox installed on Redmine.

Assistance from Harry Smith, the CRAF consultant, and Axel Jessner, a former CRAF Chairman, has been invaluable.

e) WI-VGOS

A separate article concerning VGOS appears later in this Newsletter. In addition to what is included in that, there has been a Global Geospatial Information Management Meeting (GGIM), which took place from August 26th to September 4th, 2020. At this meeting the foundation of a Global Geodetic Centre of Excellence (GGCE) was proposed. A call for countries to host this resulted in a German offer to host it in Bonn, which was accepted.

Formal Contributions by Non-CRAF Members

In order to provide additional information concerning international spectrum management for all the CRAF

members present, there were a number of contributions by the Global Representatives and Guests to the Meeting:

- Tasso Tzioumis, the WP 7D Chairman provided a brief, but nevertheless informative, description of the functioning of ITU WP7D.
- Professor Liese van Zee, the current Chair of CORF, gave an introduction to the USA Committee on Radio Frequencies, CORF, and also spectrum management developments in the USA. Emerging issues were highlighted and areas of common interest in both ITU Regions 1 & 2 were discussed.
- Marta Bautista from Yebes Observatory, Spain, spoke on the important topic of the proper registration of observatories with the ITU. It is essential that details of all antennas and their frequencies of operation are included. A full description of the process was provided.
- Francisco Colomer, the Director of JIVE, reported on a discussion with the CRAF Chairman (Michael Lindqvist) and the CRAF Frequency Manager (Waleed Madkour) concerning Communication and Outreach. Good practice in Communication and Outreach were important, and it was clear that, in addition to the CRAF Newsletter and Website, a new Work Item dealing with communication to the community and the general public should be introduced. This was done.

WRC23 Status update

A separate article concerning WRC23 status and an update appear later in this Newsletter.

Observatory Reports

As at every CRAF plenary meeting, each CRAF member present gave a report on new or ongoing interference from which their observatories were suffering.

Newsletter

Items for the next Newsletter were proposed. It was left to Peter Thomasson, the Newsletter editor, and the new Communication and Outreach Work Item team to decide on the content of the next Newsletter.

Date of Next Meeting

It was too early to decide if the next meeting would be face-to-face or not because of the Covid19 situation. In the event, all further CRAF meetings in 2020 & 2021 have been 'virtual' meetings.

.....
Joe McCauley & Peter Thomasson

The VLBI Global Observing System (VGOS) – Developments and Questions to the ITU-R

Introduction

The United Nations (UN) General Assembly's Resolution 69/266 recognised the importance of a Global Geodetic Reference Frame for sustainability and development, and that the use of Very Long Baseline Interferometry (VLBI) radio astronomy was probably the only means to achieve a demanded 1.0 mm accuracy of reference frames on global dimensions. Even so, it would be a hard challenge. The work of the International VLBI Service for Geodesy and Astrometry (IVS) consists of a multi-national cooperation to provide timely essential data on Earth rotation parameters, data for the International Celestial Reference Frame (ICRF) and for the Global Geodetic Reference Frame (GGRF).

A description of the VLBI Global Observing System (VGOS) being introduced to provide greater sensitivity and continuous observations every day of a year was given in CRAF Newsletter 32 (see <https://www.craf.eu/newsletter>) in which it was shown that it will play a major role in the determination of the most precise Global Geodetic Reference Frame (GGRF), linked to the celestial reference frame. As examples of its use, this GGRF is considered to be essential for all satellite missions and aircraft journeys. At a number of VGOS telescope sites two 'identical' telescopes have been constructed, both of which cover the wide frequency range (~1 or 2 GHz to ~12 or 14 GHz), but in a different manner. This helps to provide continuous daily operation at each site. It is also the case that one of the antennas has an S-/X-/Ka-triband horn to be compatible with the legacy S-/X- systems of the original network, whereas the other antenna uses a broadband eleven-feed system capable of receiving all the frequency bands with bandwidths ranging from 512 MHz to 1 GHz. As an example of the latter, a photograph of the VGOS Radio Telescope (13.2 m) at Metsähovi Observatory in Finland is shown as the cover image of this newsletter. A Technical drawing of the VGOS broadband feed is shown in Figure 2.

An overview of the current globally distributed VGOS-sites and VGOS projects for each ITU-R region is given in Table 1. All the telescopes are of size 12.0 or ~13.2 metres except those at Westford (USA) and Jatiluhur (Indonesia), which are 18.3 metres. In CRAF Newsletter 33 an update to the development of VGOS showed that, although the

ITU-Region	Country	Location	N Latitude			E Longitude			Reflector Size [m]
			[°	'	"]	[°	'	"]	
R1	Finland	Metsähovi	60	13	04.8	24	23	38.4	13.2
R1	Germany	Wettzell North	49	08	38.4	12	52	40.8	13.2
R1	Germany	Wettzell South	49	08	34.4	12	52	40.8	13.2
R1	Italy	Matera (project)	40	38	56.4	16	42	18.0	13.2
R1	Norway	Ny Ålesund	78	56	36.1	11	51	17.1	13.2
R1	Norway	Ny Ålesund	78	56	33.4	11	51	19.5	13.2
R1	Portugal	Flores (project)	39	22	34.0	-31	11	42.0	13.2
R1	Portugal	Santa Maria	36	59	06.0	-25	07	33.6	13.2
R1	Russia	Badary	51	46	12.0	102	14	02.4	13.2
R1	Russia	Svetloe	60	31	48.0	29	46	48.0	13.2
R1	Russia	Zelenchukskaya	43	47	16.8	41	33	54.0	13.2
R1	South Africa	Hartebeesthoek	-25	53	16.8	27	41	09.6	13.2
R1	Spain	Gran Canaria (project)	27	53	58.4	-15	30	28.6	13.2
R1	Spain	Yebes	40	31	22.8	-03	05	16.8	13.2
R1	Sweden	Onsala NE	57	23	38.4	11	55	12.0	13.2
R1	Sweden	Onsala SW	57	23	34.8	11	55	08.4	13.2
R2	Brazil	Fortaleza (project)	-03	52	41.6	-38	25	31.4	12.0
R2	USA	GGAO	39	01	19.2	-76	49	38.3	12.0
R2	USA	Kokee Park	22	07	35.3	-159	39	53.9	12.0
R2	USA	McDonald	30	40	49.4	-104	01	25.1	12.0
R2	USA	Westford	42	36	46.8	-71	29	37.7	18.3
R3	Australia	Hobart	-42	36	46.8	147	26	16.8	12.0
R3	Australia	Katherine	-14	22	30.0	132	09	07.2	12.0
R3	Australia	Yarragadee	-29	02	49.2	115	20	45.6	12.0
R3	China	Seshan	31	05	58.4	121	11	57.6	13.2
R3	China	Tianma	31	05	26.3	121	08	12.3	13.2
R3	China	Urumqi	43	28	20.1	87	10	25.1	13.2
R3	Japan	Ishioka	36	06	10.8	140	05	20.4	13.2
R3	France	Tahiti (project)	-17	39	03.1	-149	25	33.5	12.0?
R3	India	Kanpur (project)	26	31	09.3	80	13	55.2	13.2
R3	Indonesia	Jatiluhur (project)	-06	31	16.5	107	24	39.4	18.3
R3	Malaysia	Jebebu (project)	03	03	10.8	102	03	50.4	13.2
R3	Thailand	Chiang Mai (project)	18	51	56.0	99	13	03.4	13.0
R3	Thailand	Songkhla (project)	07	09	23.7	100	36	48.0	13.2

Table 1. Location of Current and Planned VGOS sites and Projects

introduction of fast moving, high gain 13.2 m radio telescopes with wider accessible bandwidth receivers would improve their sensitivity, the introduction of new satellite and other communication systems would result in VGOS facing a potential loss of the radio spectrum that it had been using for observations. It was also clear that even more spectrum was required to provide the necessary improved positional accuracy.

The International Telecommunications Union (ITU) is the organisation dealing with spectrum allocations, and a first interaction with this organisation involving

the allocation of radio spectrum in this particular case, for which there was a lack of suitable documents for the radio regulators, is the submission of a 'Question' to the ITU Radio Communication Sector Study Group 7 (SG 7-Science Services) to be considered initially by the ITU Working Party (WP) 7D (radio astronomy). (Officially a 'Question' to the ITU is a statement of a technical, operational or procedural problem, generally seeking a Recommendation, Handbook or Report.) The technical characteristics of VGOS are not well known outside the astrometric and geodetic communities, but

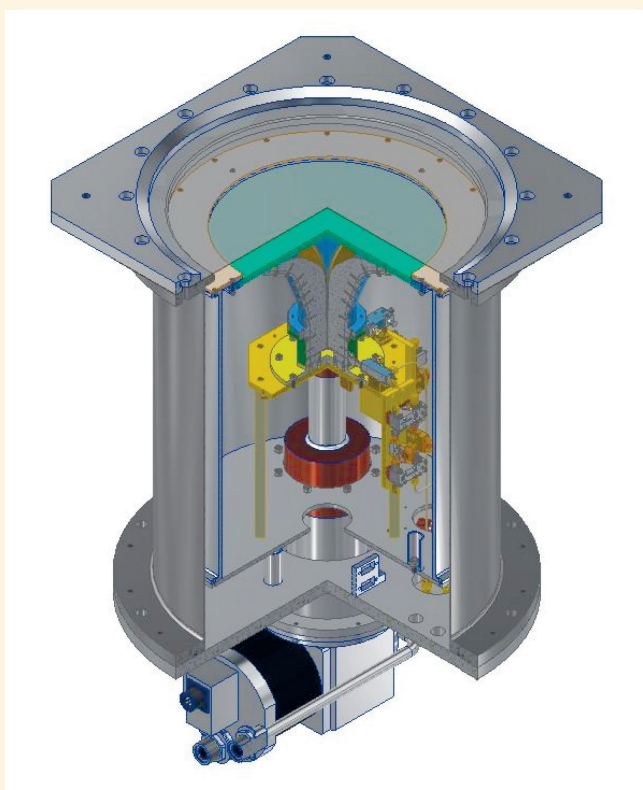


Figure 2. Technical Drawing of the VGOS broadband feed for 12-14 GHz. The entire feed and the HEMT amplifier are cryogenically cooled and mounted in a dewar. The shown front end has been developed by the Yebes Observatory of the Instituto Geográfico Nacional, Spain

need to be understood by those who plan to use the spectrum for transmission. Thus, two questions:

1. What are the technical and operational characteristics of geodetic VLBI?
 2. How does geodetic VLBI use the radio spectrum to achieve the accuracy needed to fulfil its mission?
- were submitted to WP 7D for detailed examination, with a view to producing a Report giving answers to the 2 questions, ultimately to be approved by SG 7 before consideration at the next World Radio Conference (WRC). The two questions have been approved both by WP7D and SG7 and a start on the Preliminary Draft New Report (PDNR) was undertaken by the U.S. delegation to WP 7D. At the latest WP7D meeting, Germany has proposed an amendment to the current version of the PDNR and it is expected that there will be further inputs from the U.S. Dr. Hayo Hase, representing the Geodetic Community, has been elected to be the Chairman of a correspondence group considering the PDNR, the main task of which is to bring the report to completion by 2027 to hopefully be approved at WRC27.

Hayo Hase

Two Events attended by the CRAF VGOS Group

1. 25th European VLBI Meeting for Geodesy and Astrometry (EVGA2021)

The European VLBI Group for Geodesy and Astrometry (EVGA) has held working meetings on a bi-annual basis for the last two decades. During this year of 2021 the 25th Working Meeting, managed by the Chalmers University of Technology and Onsala Space Observatory (Figure 3), Sweden, had to be held ‘virtually’ (from the 14th to 18th March), because of the Coronavirus situation. The meeting had the highest number of participants ever – 170 colleagues from all over the world. The programme was organised as usual into 3 main sessions: Technology, Observations and Analysis, which resulted in a total of 48 oral presentations, 18 posters and 4 videos. Contributions to the ongoing VLBI technology developments, in particular for the VGOS network – feed horns, backends, recording systems, data transfer, correlation and post-correlation – were presented and discussed.

Future plans for activities at VLBI stations relating to networks, correlators and data centres were presented for the improvement of VLBI and VGOS observations. These included scheduling and simulations, local tie-vector determination and VLBI observations of satellite signals. The analysis session of VLBI/VGOS data concerned geodesy, astrometry and ongoing, unresolved problems. Examples of the scientific results relating to the Terrestrial Reference Frame, Earth Rotation Parameters, the Celestial Reference Frame and astrophysical and geophysical models were presented. More detailed information on the meeting and presented material can be found at <https://www.chalmers.se/en/conference/EVGA2021/>.

A splinter meeting dealing with source selection and scheduling was organised to take place on March 17. Discussions on calibrator sources to be observed during VGOS campaigns was one of the main issues; e.g. the ideal characteristics of the calibrator sources, optimisation of scan lengths and the repetition rate of calibration observations were considered whilst taking into account both modelling simulations and the results from recent VGOS experiments. The impact of the radio source structure at different VGOS frequencies was discussed, together with the selection criteria for most point like sources and the mitigation of ionospheric effects.

An International VLBI Service (IVS) Analysis Workshop (Figure 4 [Left]) took place on March 18. The main topics discussed by the participants related



Figure 3. Onsala Space Observatory and EVGA2021.
Credit: <https://www.chalmers.se/en/conference/EVGA3021/Pages/default.aspx>

to an understanding and correction of errors for failed observation sessions and the non-participation of stations involved in the planned network. The need for a Primary Investigator (P.I.) for each IVS session became apparent, as did an EOP file format for the data. The IVS contribution to ITRF2020, refringing sessions, 'Fourfit' software & phase mis-closure and the need for Dual/Circular polarisation and short baseline sessions were clearly important items for consultation. Also debated were scheduling, observing modes and correlation of more frequent VGOS observations, VGOS network dimension and mixed mode sessions (Legacy-VGOS).

The CRAF/VGOS group focused its contribution to the EVGA meeting on the needs of Spectrum management for the VLBI Global Observing System (VGOS) and the necessity to ensure the absence of radio frequency interference. A basic action each nation was invited to carry out was registration at the ITU-R of each new VGOS radio telescope. Information was presented relating to the initiatives being taken to achieve more protection of the worldwide distributed VGOS-sites on a regulatory basis.

Rüdiger Haas was re-elected as EVGA chair and Susanna García-Espada as the Secretary of the group for a period of 4 years (2021-2025). It was announced that the 26th Working Meeting of the EVGA in 2023 is planned to be organised by GFZ Potsdam, Germany.

2. 11th IVS-Technical Operations Workshop (TOW2021)

The hands-on Technical Operations Workshop (TOW) for station operators, usually hosted by MIT Haystack Observatory, has taken place every two years (odd years) for very many years. The 11th Technical Operations Workshop (TOW2021) – Figure 4 (Right), took place as an online event for the first time in its history (from Monday May 3 to Wednesday May 5 2021) because of coronavirus concerns. It was immediately followed by a mixed-mode correlator workshop, also held virtually. The TOW has usually been orientated towards training

and problem resolution in VLBI operations. Its main aim is the support of radio telescope operators worldwide to minimise human errors in system setup and operation, and for them to learn how to quickly recover from equipment failures to ensure the recording of high-quality data whilst minimising data loss as much as possible. The format of TOW sessions has normally been arranged to enable live interactive discussions, focusing on station setup, operations and problems. However, during this year of 2021 it has been a considerable challenge to translate the hands-on training of technical staff of stations into a virtual format from the organisational point of view. The programme had to be reduced compared with previous workshops. Thus, this workshop consisted of live presentations held via Zoom followed by a Q&A session. There were no 'parallel' classes, but there were some pre-recorded lectures for pre-meeting viewing. Of course, the hands-on part of the TOW had to be considerably reduced.

The focus of this TOW was on VGOS as, during the last few years, new VGOS telescopes have been included in observations with the VGOS test network and several VGOS sites are currently under construction or being planned. VLBI operators have much to learn of the technical details of VGOS telescopes and to become familiar with the new VGOS system. During this workshop new



Figure 4 (Left). IVS Logo.
Credit: https://vlbi.org/wp-content/uploads/2019/12/ivs_logo_2019
Figure 4 (Right). Logo of TOW2021.
Credit: https://vlbi.org/wp-content/uploads/2019/12/ivs_logo_2019_square_final_small.png

insights into how to handle VGOS-related equipment were given: e.g. on topics such as Mark 6, Flexbuff, R2DBE and DBBC3. Virtual presentations covered three half-days. Following each presentation there were also some pre-recorded lectures for pre-meeting viewing. Although not as extensive as with the face-to-face events, people did have time to ask questions and become acquainted with possible contacts for further discussions. The concept of receiving feedback from operators and stations relating to correlators and developers also continued in this form.

There were more than 115 registered participants from 20 different countries, which was an increase of approximately 50 to 60% compared with previous face-to-face TOWs. This meant that there were many 'new faces' attending the workshop from places from which it was normally not possible to send a representative to attend in person. The experience gained in holding this workshop showed the advantages and disadvantages of participation in workshops either face-to-face or online, which will be of great benefit for the organisation of future workshops.

The CRAF/VGOS group produced and provided for the TOW2021 three video courses on (1) radio telescope registration, (2) radio frequency interference and mitigation and (3) radio regulation and spectrum management. These resources and all the teaching material of TOW2021 are now available from <https://www.haystack.mit.edu/conference-2/past-conferences/tow2021/>.

Vincenza Tornatore

RF Monitoring and localisation at Jodrell Bank Observatory

Recently Anritsu Remote Spectrum Monitors have been installed at Jodrell Bank Observatory (JBO) and two of the e-MERLIN remote sites for continuous monitoring of that part of the spectrum at L-Band where e-MERLIN and the Lovell Telescope normally observe (1.25-1.75 GHz). These spectrum monitors are connected to omni-directional antennas mounted on high masts (50 m at Jodrell Bank – see Figure 5). Custom-made 1.25-1.75 GHz filters are used together with a Low Noise Amplifier (LNA) for additional sensitivity. Although the Anritsu devices have their own software, observatory staff have written some simple scripts to acquire, store, plot and analyse the data. The set-up has proved relatively robust. It has enabled the JBO staff to build up a much better picture of the L-band environment on timescales from seconds to months.



Figure 5.

View of a part of the Jodrell Bank Observatory site showing the 76-m Lovell telescope in the background and the 32x25-m Mk2 telescope in the foreground. The 50-m mast, on which is mounted the monitoring equipment, is visible in the image, located between the Lovell and Mk2 telescopes.

With this system it is possible to follow the diurnal and other variations in IMT equipment (hand sets and the new 4G+ base-stations recently deployed in the UK), and to monitor longer term changes, as well as transient events down to a few seconds (See Figure 6).

Having deployed this system, the possibility of using e-MERLIN for localising terrestrial emissions has also started to be investigated. By disabling the normal delay compensation and fringe-rotation in the correlator, it is possible to measure the relative delays of signals arriving at the e-MERLIN antennas with a precision of the reciprocal bandwidth (or better depending on the signal-to-noise). These delays can then be used to solve for the transmitter position (Figure 7): an established technique known as multi-lateration or TDOA (time difference of arrival) geo-location. Solving for the position is not always straightforward with small numbers of antennas or sensors, and various closed-form and iterative techniques, which have been developed for other applications, have been used.

As an initial test a signal at 1 318 MHz, whose origin was unknown at the time, was observed and it was then possible to locate this to within 200 m at a distance of 25-75 km from the 4 antennas used. The antennas were pointed at the zenith for this observation. The signal is a low-power amateur TV repeater. The position determination was based on the raw un-calibrated delays - accurate calibration should allow terrestrial positions with accuracies of a few metres to be determined. For these long, near horizontal paths, the tropospheric propagation delay is an issue, and for which it is harder to compensate than for high elevation paths.

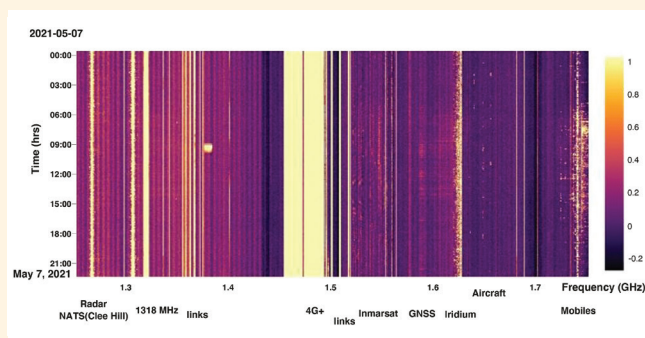


Figure 6. Plots of signal level vs. frequency and time for 7th May 2021.

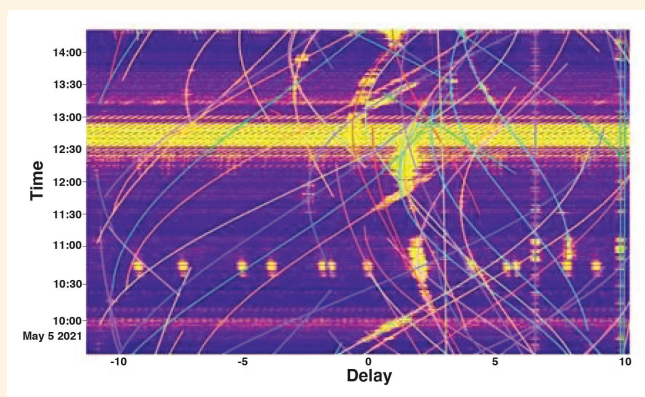


Figure 7. Plots showing variations in delay and therefore in positions of satellites vs. time for 5 May 2021

There are several advantages of using an interferometer array such as e-MERLIN for such observations. The correlation infrastructure is already established, and there is significant flexibility in tuning, bandwidth selection and integration times. The signals are well-synchronised (e-MERLIN has a dedicated fibre synchronisation system at the pico-second level) and if appropriate, the antennas can be pointed at known targets and their high gain can be used.

The JBO monitoring had shown some occasional, distinct transmissions in the RR 5.340 '1 420 MHz' protected band. Many attempts had been made in the past to locate these signals with little success; a multi-port monitor with Yagi antennas in different directions had also been used, but with no conclusive results. The multi-lateration technique allowed this transmission to be located to within 1 km at up to 200 km from JBO. Following discussion with the operator this 'interfering signal' has now been moved out of the protected band.

This technique can also be used for satellite transmissions, allowing multiple satellites in the same band to be separated in delay space. As an example the GNSS band near 1 575 MHz was observed, again with no delay compensation and with the antennas in the zenith. A short observation shows delay tracks resulting from GPS, Galileo, Beidou and geostationary EGNOS satellites. The

delay tracks can be predicted using published Two-Line Element (TLE) data and aligned with the measurements (to within the TLE accuracy).

Tests so far have used blind searches with all delay compensation disabled, which strongly limits the bandwidth that can be used. Any serious measurements of known or predictable sources should use a terrestrial delay model, which could include satellites and other moving targets. Such an approach then becomes more similar to 'near-field VLBI' as developed by JIVE, JPL, CAS and other groups for spacecraft measurements.

Simon Garrington

WRC23

Almost midway towards the World Radiocommunication Conference (WRC23), CRAF continues its participation in the preparatory work for the various agenda items that are related to radio astronomy frequencies. At the regional CEPT-ECC level, CRAF has submitted its preliminary views to the ECC's Conference Preparatory Group (CPG) responsible for developing briefs, studies and European Common Proposals (ECPs) for the WRC. CRAF has also actively participated in the relevant International Telecommunication Union (ITU) working party meetings, particularly working party 7D (WP7D) meetings that cover the radio astronomy service.

Discussions concerned with International Mobile Telecommunications (IMT) related agenda items have been a significant part of CRAF's activities. Thus, the 6 GHz band is being considered for IMT in the ITU-R Region 1 under agenda item 1.2. A part of this band is extremely important for radio astronomy for the study of methanol spectral lines, but is not allocated to the Radio Astronomy Service (RAS) on a primary basis. The band is protected via a footnote in the Radio Regulations (RR No. 5.149), which urges administrations to take all practicable steps to protect the RAS in a number of bands. The WRC19 Resolution text for this agenda item has limited the studies to only services with primary allocations versus the candidate IMT allocation. Many administrations are of the view that the 6 GHz band cannot be studied with respect to RAS protection under the defined scope of the agenda item. CRAF prepared an input document with a preliminary study in which it is clearly demonstrated that an IMT sharing with radio astronomy is impossible (separation distances of several 100 km would be necessary). ECC Project Team 1 (PT1) agreed to include RAS protection in the scope of the correspondence group

created to determine the CEPT position for the 6 GHz band. Given the difficulty found in initiating studies for RAS protection under this agenda item, CRAF's position remains to support no change for the 6 GHz band.

Another IMT-related topic is the potential use of high altitude platforms (between 20 and 50 km altitude) as mobile communication base stations (HIBS). As these installations can be in the line-of-sight of radio telescopes for hundreds of kilometres, the potential threat to the RAS is very high. Even if not directly in the main beam of a telescope, the number of visible platforms could be high enough that contributions through the side lobes of RAS antennas exceed the permitted threshold levels significantly. A preliminary evaluation has shown that second harmonics from candidate frequencies below 1 GHz could arise in some of the radio astronomy L-band allocations. Once again several administrations have been extremely reluctant to accept any studies with respect to second harmonics, which is why CRAF also produced an input document on this issue for the PT1 meeting. A preliminary analysis demonstrates that necessary separation distances can be very large, up to hundreds of kilometres. There is also the potential for receiver saturation for 18 cm systems installed at many RAS stations. The RAS allocated band at ~2.7 GHz is also adjacent to one of the candidate bands for HIBS. Compatibility studies for RAS protection for the 2.7 GHz band should start after the IMT parameters and HIBS characteristics have been finally settled at ITU WP 5D.

CRAF regularly participated in the meetings of Project Team D (PTD), one of the project teams of ECC-CPG, which is addressing WRC-23 agenda item 1.5. This Agenda Item is concerned with a review of the UHF band in region 1. In its input contributions to the meeting, CRAF proposed a harmonised position for CEPT for an upgrade to the RAS band 606-614 MHz to a primary status in region 1, similar to the situation in region 3 and the African broadcasting area in region 1.

A potential IMT usage in or adjacent to the RAS band 606-614 MHz must be considered with care. According to Report ITU-R RA.2332-0 on the compatibility and sharing studies between the RAS and IMT systems in the frequency band 608-614 MHz, coexistence between RAS and IMT in this band will require stringent protection measures. In particular, for in-band operation, separation distances of up to 1 000 km or more were determined, which raises the question whether sharing between RAS and IMT would be possible at all in the densely populated environment that exists 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. For the case of a new mobile allocation as a primary service, RAS would have a significantly lower status. Hence, to ensure that RAS operations will continue in the future, an upgrade of the RAS allocation from a secondary to a primary could be an appropriate solution.

Possible additional allocations for new, non-safety aeronautical mobile applications for air-air, ground-air and air-ground communications of aircraft systems are proposed under agenda item 1.10 in the bands 22.0-22.21 GHz and 15.4-15.7 GHz. The frequency band 22.0-22.21 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). The requirement of RAS protection is mentioned in the CEPT preliminary position for the agenda item. Also, WP7D has provided the RAS protection criteria to the responsible working party (WP5B).

One agenda item of interest to radio astronomers using the low VHF bands is '9.1 issue A' for space weather sensors. The receive-only space weather sensors share common sites and also common frequencies with the RAS. CRAF proposed a liaison statement from WP7D to the responsible working group WP7C during the April 2021 meeting. The statement contained the information of common sites and a list of radio astronomy frequencies overlapping with the operation frequencies of space weather sensors. Discussions are ongoing to answer the open questions: To which radio service should the space weather sensors belong at the ITU and what level of protection should be defined for their frequencies? CRAF has the view that the RAS could be the most appropriate radio communication service for receive-only space weather sensors.

Several other agenda items of interest to radio astronomy are currently at the stage of information gathering and the specification of service characteristics. The full list of agenda items of interest and CRAF preliminary positions can be found on the CRAF website and the ECC-CPG server web page.

Waleed Madkour

The European Science Foundation hosts six Scientific Platforms:

- COAlition S
<https://www.coalition-s.org/>
- The Committee on Radio Astronomy Frequencies (CRAF)
<https://www.craf.eu/>
- The European Astrobiology Institute (EAI)
<https://europeanastrobiology.eu/>
- The Europlanet Society (EPS)
<https://www.europlanet-society.org/>
- The European Space Sciences Committee (ESSC)
<https://www.essc.esf.org/>
- The Nuclear Physics European Collaboration Committee (NuPECC)
<http://www.nupecc.org/>

ESF-hosted scientific platforms are largely autonomous. They 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. By providing access to its legal structure, staff, support services and facilities, ESF facilitates their work and operations.

• • •

Editorial Board:

Dr. Peter Thomasson (Chief)
Dr. Vincenza Tornatore

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.

Chairman:

Dr Benjamin Winkel, Germany

• • •

ESF Science Support Office

Head:

Mr Nicolas Walter

Administrator:

Ms Mariette Vandermersch

Tel: +33 (0)3 88 76 71 19

Email: mvandermersch@esf.org

www.craf.eu

The European Science Foundation (ESF, www.esf.org) is a non-governmental, internationally oriented, non-profit association established in France in 1974. ESF is committed to promoting the highest quality science in Europe to drive progress in research and innovation. ESF implements high-quality, independent science operations on the European Research Area. It partners with its members and diverse institutions by leading successful projects and facilitating informed decision-making through a broad range of science support partnerships: Research Project Grant Evaluation, coordination of European projects, funding programmes and the administration of scientific platforms. The ESF Community of Experts plays a vital role in sustaining scientific collaboration and supporting excellence in grant and programmatic evaluation. Today it comprises over 8,000 key experts across all scientific disciplines.

European Science Foundation

1 quai Lezay-Marnésia • BP 90015 67080

Strasbourg cedex • France

Tel: +33 (0)3 88 76 71 00

Fax: +33 (0)3 88 37 05 32

www.esf.org

Graphic design: Dans les villes
Autumn 2021 – Print run: 350