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CRAF Meetings – Report 1

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1 Introduction

The science of radio astronomy plays a key role in increasing our understanding of the environment and the universe in which we live. By its nature it is a passive service, so it never causes interference to other users of the radio spectrum. It is becoming more and more difficult to protect radio astronomy operations from radio interference because of the increasing pressure on the finite resource of the electromagnetic spectrum from active spectrum users. On behalf of European radio astronomy observatories, the Committee on Radio Astronomy Frequencies (CRAF) of the European Science Foundation coordinates activities to protect the frequency bands used by radio astronomy. It works towards this aim by:

- Co-ordinating the case for radio astronomy in Europe in discussions with the major public and private telecommunications agencies.
- Acting as the European voice in concert with other groups of radio astronomers in discussions within the international bodies that decide on the use of radio spectrum.
- Initiating and encouraging scientific studies aimed at reducing interference at its source and the effects of interference.

CRAF employs a full-time frequency manager who is paid from the contributions made by the participating radio astronomy observatories or national institutes. The frequency manager is the primary representative of CRAF at international spectrum management meetings. In addition to the frequency manager, CRAF members also frequently represent CRAF at international spectrum management meetings. Once or twice per year CRAF organises face-to-face meetings for its members to report on current interference issues and possible solutions, and to discuss international developments that may have an effect on radio astronomy and how to react to them. RadioNet support is used for the organisation of CRAF meetings and to support CRAF members to attend them, and also to support CRAF members who represent CRAF at international spectrum management meetings.

During the period from 1 January 2017 until 15 November 2018 the following activities have been supported by RadioNet from which short reports are provided in the subsequent sections:

1. 60th CRAF meeting, 3 – 5 May 2017, Bonn and Effelsberg, Germany
2. 61st CRAF meeting, 13 – 15 June 2018, Budapest and Bercel, Hungary

And attendance to the following meetings

3. CEPT PT1, 16 – 20 January 2017, Lisbon, Portugal
4. ITU-R TG 5/1, 14 – 23 May 2017, Geneva, Switzerland
5. CEPT PT1, 4 – 8 September 2017, Lyon, France
6. ITU-R TG 5/1, 17 – 26 January 2018, Geneva, Switzerland
7. CEPT PT1, 16 – 20 April 2018, Prague, Czech Republic
8. CEPT SE40, 27 April 2018, Paris, France
9. ITU-R TG 5/1, 2 – 11 May 2018, Geneva, Switzerland

2 60th CRAF meeting

2.1 Summary

The 60th plenary face-to-face meeting of CRAF, the Expert Committee on Radio Astronomy Frequencies of the European Science Foundation was held from 3 to 5 May 2018 in Bonn and Effelsberg, Germany. At this meeting, CRAF members and observers, who are experts in the field of protection of radio frequencies used by the European radio astronomical scientific community, met to discuss their common strategy in achieving the mission of CRAF, which includes "to keep the frequency bands for radio astronomical observations free from interference".

As an organisation, CRAF is formally accredited to represent the interests of the Radio Astronomy Service in matters of frequency protection at international fora, specifically at a European level at the CEPT (Conference of European Post and Telecommunication agencies; 48 countries) and at a global level at the ITU (International Telecommunication Union). The individual expert members of CRAF participate in meetings of their national spectrum agencies. This link between international and national activities is crucial for CRAF's activities - at international meetings, national administrations (who have the right to vote, if required) support us and at a national level it is important to show that the international radio astronomy community has a common strategy.

CRAF has representatives from all European countries in which radio telescopes are being operated, plus South Africa. A few other European countries are also represented as are a number of international organisations: ESA, IRAM, IVS and SKAO.

This meeting was attended by 22 representatives from 15 different countries and three organisations. CRAF welcomed new expert members from two countries, which were not yet represented on CRAF: Austria and the Ukraine.

At the meeting, the expert members gave reports on the RFI situation in their observatories and their interactions with their national spectrum authorities. The CRAF Frequency Manager reported on her activities of the last year, on issues of interest to the Radio Astronomy Service that are currently being discussed at CEPT and/or ITU, and presented the plans for CRAF attendance at the 42 international meetings where CRAF needs to be represented. She also gave an update on the preliminary CRAF positions on relevant Agenda Items for the 2019 World Radiocommunication Conference (WRC-19) of the ITU, a huge four-week long meeting which is organised every 3 to 4 years. The CRAF chairman presented CRAF manpower and budget overviews, and led the preparations for the meeting with directors on 5 May.

An item specific to this meeting was a discussion with directors of key Member Institutions of CRAF, i.e. the observatories, national scientific academies and funding agencies who pay for the annual operational budget of CRAF. The objective was a revision of the 2004 CRAF Charter and MoU between the ESF and institutional Members, but no conclusion could be reached on this issue, and the revision will continue in close collaboration between directors and the expert representatives of their Institutions.

CRAF represents all radio telescopes in Europe in matters of radio frequency protection, which is to the obvious benefit of the entire RadioNet community.

2.2 Agenda of the event

Presenters:

Hezareh: CRAF Frequency Manager (MPIfR, DE), Thomasson - CRAF expert member (UMAN, UK), van der Marel - CRAF expert member (ASTRON, NL), van Driel: CRAF chairman (OBSPARIS, FR)

3 May 2017:

Introduction

Opening of the meeting - van Driel

Adoption of the agenda

Evaluation of Meeting Minutes of the Nov 2016 CRAF web-meeting - van Driel

Review of action items, and ideas to improve CRAF operations - van Driel, Hezareh

Communications concerning CRAF - van Driel

New CRAF expert members

CRAF budget - van Driel

CRAF Charter explanatory document - van Driel

Preparation for the Stakeholder Council meeting - van Driel

CRAF Frequency Manager report - Hezareh

CEPT/ITU meetings of interest to CRAF and attendance - Hezareh

Issues of concern to the RAS in CEPT/ITU - Hezareh

Status of WRC-19 Agenda Items and position of CRAF

RadioNet H2020 - van der Marel

CRAF Newsletter - Thomasson

4 May:

Continuation of meeting at the Effelsberg radio observatory, including a guided tour

Presentations by invited guests:

Alex Kraus (MPIfR, DE): Science with Effelsberg

Jürgen Nitschke (BNetzA, DE): BNetzA, the Federal Network Agency

Markus Dreis (EUMETSAT): EUMETSAT - Science and current issues in spectrum management

Ralf Ewald (DLR, Germany): DLR - Science projects and current issues in spectrum management

Observatory reports on RFI situation - all

5 May:

Meeting with institutional Member directors; planned first Stakeholder Council meeting - all

Conclusion of the meeting - van Driel

Date and location of next meeting

Any other business

2.3 Participants

The 22 CRAF expert members come from 15 different countries, three of them are young researchers, two are female, and six of them received RadioNet support.

The following 22 CRAF expert members took part in the meeting: Pietro Bolli (IT), Hayo Hase (IVS), Talayeh Hezareh (DE), Axel Jessner (DE), Karel Jirička (CZ), Juha Kallunki (FI) [through Skype], Christophe Marqué

(BE), Joe McCauley (IR), Christian Monstein (CH), Vincent Piétu (FR), John Seiradakis (GR), Serge Yerin (UR), Harry Smith (SKAO), Marian Soida (PL), Ivan Thomas (FR), Peter Thomasson (UK), Viktor Tóth (HU), Adrian Tiplady (ZA), Vincenza Tornatore (IT), Hans van der Marel (NL), Wim van Driel (FR) and Benjamin Winkel (DE).

The seven directors, or their representatives, who participated on 5 May come from seven different countries. None are young researchers, one is female, and none received RadioNet support.

The following directors of CRAF Member Institutions, or their delegates, attended the session on 5 May: Stéphane Corbel (CNRS, FR), Simon Garrington (UMAN, UK), Hans Olofsson (OSO, SE), Adrian Tiplady (SKA and HartRAO, ZA), Tiziana Venturi (INAF, IT) [through Skype], René Vermeulen (ASTRON, NL) and Anton Zensus (MPIfR, DE).

Also participating were the CRAF Frequency Manager, Talayeh Hezareh (DE) and, for the meeting with the directors, the Executive Director of the ESF, Jean-Claude Worms.



Figure 1 Meeting picture: the CRAF expert members dwarfed by the sheer size of the 100 metre Effelsberg radio telescope - one of the telescopes they strive to protect from harmful radio interference

2.4 Publications

On the CRAF website, there is a news item under <https://www.craf.eu/annual-craf-meeting-in-bonn/>, but the input and output documents are not publicly accessible, as they concern internal CRAF strategies for the protection of radio astronomy frequencies.

In the Minutes of the meeting RadioNet support is duly acknowledged.

The Minutes will not be made publicly available, as they contain information on the CRAF strategy for the protection of radio astronomy frequency bands, which should not be shared with other spectrum users such as operators of satellite communication systems and mobile phone systems.

3 61st CRAF meeting

3.1 Summary

The 61st plenary face-to-face meeting of CRAF, the Expert Committee on Radio Astronomy Frequencies of the European Science Foundation was held from 13 to 15 June 2018 in Budapest and Bercel, Hungary.

This meeting was attended by 20 representatives from 13 different countries and four organisations. ESO was represented for the first time in a CRAF meeting. CRAF also welcomed a new representative from the Netherlands.

The CRAF Frequency Manager (FM), Talayeh Hezareh, provided a report of her activities covering the period 01 May 2017 to 31 May 2018. The current status of the main spectrum management issues was also presented, which included a request for assistance from CRAF members to ensure that CRAF was represented at upcoming CEPT / ITU meetings, which were deemed to be of importance to CRAF. Inevitably, the problem of interference from the Iridium communications satellites, in particular the current status of the assessment of the newly launched satellites, was discussed. There was also an update on the progress of the WRC-19 Agenda Items, which were relevant to radio astronomy, as a result of the outcomes from recent meetings.

In the absence of the FM, CRAF assessed her work during the past 2 years. CRAF endorsed the FM's report, which was considered to be fully satisfactory. It was recommended that the FM keeps the new Management Team well informed concerning her various activities and discusses with them appropriate strategies to be followed to ensure as best as possible the protection of radio astronomy.

As at every CRAF plenary meeting, each CRAF member present gave a report on new or ongoing interference problems from which their observatories were suffering. Of particular interest was perhaps that a workshop had been organised at MPIfR to teach CRAF participants how compatibility studies can be performed using the new Pycraf software package, introduced a year ago by MPIfR.

Ideas to make CRAF more effective were discussed, such as organising seminars within the radio astronomical institutes on the hot topics from spectrum management on a regular basis. The Stakeholder Forum made recommendations for a CRAF management/coordination team.

CRAF represents all radio telescopes in Europe in matters of radio frequency protection, which is to the obvious benefit of the entire RadioNet community.

3.2 Agenda of the event

13 June 2018, ELTE Budapest

Introduction and welcome by Prof. Dr. Imre M. Jánosi as Vice-Dean of ELTE Faculty of Science

Opening of the meeting (Thomasson)

Adoption of the agenda

Status of action items (Thomasson, Hezareh)

Evaluation of Meeting Minutes of the 31 October 2017 CRAF web-meeting and CRAF Update Telecon (25 April 2018) (Thomasson)

Communications concerning CRAF (Thomasson)

CRAF budget (Thomasson, Van Driel)

RadioNet H2020 (Lindqvist, Van der Marel)

Appointment of new CRAF Chairman & vice-Chairman (Thomasson)

CRAF Frequency Manager report (Hezareh)

Upcoming CEPT/ITU meetings of interest to CRAF and CRAF attendance (all)

Status of WRC-19 Agenda Items and position of CRAF (Hezareh)
 CRAF Newsletter (Thomasson)
 Terms of Reference of the CRAF Stakeholder Forum (Thomasson, Van Driel)

14 June 2018, ELTE Budapest

Improving work distribution within CRAF (Winkel)
 Start on Interference problems in Europe (all) (Continue on Friday)
 Funders Circle working lunch [closed]
 2nd meeting of the Stakeholder Forum (chaired by Vermeulen)
 discussing the Terms of Reference and future management structure
 review and approval of the financial budget by the Stakeholders Forum

15 June 2018, Full-day visit to Bercel Castle

BEST – a multi-purpose radio research station initiative (Tóth)
 Continue Observatory reports on Interference problems in Europe (all)
 Discussion of the frequency manager's report (Thomasson)
 Evaluation of the report
 Conclusion of the CRAF meeting (Thomasson)
 Date and location of next meeting
 End of the meeting

3.3 Participants

The following 20 CRAF expert members took part in the meeting:

Pietro Bolli (INAF, IT), Federico Di Vruno (SKAO, UK), Hayo Hase (IVS), Talayeh Hezareh (MPIfR, DE), Karel Jirička (Ondrejov Astronomical Observatory, CZ), Michael Lindqvist (OSO, SE), José Antonio López Pérez (UAH-IGN, ES), Joe McCauley (TCD, IR), Marat Mignaliev (Special Astrophysical Observatory Nizhnij Arkhyz, RU), Christian Monstein (ETH Zürich, CH), Vincent Piétu (IRAM, FR), Antonis Polatidis (ASTRON/NWO-I, NL), Serge Yerin (National Academy of Sciences, UR), Gie Han Tan (ESO, DE), Ivan Thomas (OBSPARIS, FR), Peter Thomasson (UMAN, UK), Vincenza Tornatore (Politecnico di Milano, IT), L. Viktor Tóth (Eötvös Loránd University Budapest, HU), Wim van Driel (OBSPARIS, FR) and Benjamin Winkel (MPIfR, DE).

They represented 13 different countries and 4 international institutions, 3 of them are young researchers, two are female, and 6 of them received RadioNet support.

The directors of CRAF Member Institutions who attended the closed Funders Circle meeting and the 2nd meeting of the Stakeholder Forum (on Thursday June 14) are: Stéphane Corbel (CNRS-INSU, FR), Michael Kramer (MPIfR, Germany), René Vermeulen (ASTRON, NL), John Conway (OSO, SE), Simon Garrington (UMAN, UK), Valdis Avotins (VUC, Latvia)

Further, Tiziana Venturi (INAF, IT) and Taurio Ritva (Academy of Finland, FI) attended the meeting through Skype. Also participating were the CRAF Frequency Manager, Talayeh Hezareh (DE) and, for the meeting with the directors, the Executive Director of the ESF, Jean-Claude Worms.

The eight directors who participated in this part of the meeting came from eight different countries. None of them are young researchers, two are female, and none of them received RadioNet support.



Figure 2 Conference picture: the CRAF expert members in front of the venue of the meeting, the physics and astronomy building of the faculty of sciences of the Eötvös Loránd University.

3.4 Publications

On the CRAF website, there is a news item under <https://www.craf.eu/category/craf-meetings/> but the input and output documents are not publicly accessible, as they concern internal CRAF strategies for the protection of radio astronomy frequencies.

In the Minutes of the meeting RadioNet support is acknowledged.

The Minutes will not be made publicly available, as they contain information on the CRAF strategy for the protection of radio astronomy frequency bands, which should not be shared with other spectrum users such as operators of satellite communication systems and mobile phone systems. However, a summary report will be available to all stakeholders and interested people.

4 CEPT PT1 meeting, January 2017

4.1 Summary

On behalf of CRAF, Wim van Driel attended the PT1 meeting to participate in deliberations on the following issue: at the 2015 World Radiocommunication Conference (WRC-15) of the International Telecommunication Union (ITU), which reviews and updates the Radio Regulations on the worldwide use of the radio spectrum, an Agenda Item AI 1.13 was defined for the next WRC in 2019, the objectives of which include the identification of additional frequency bands in the range 24-86 GHz to be allocated to International Mobile Telecommunications (IMT) for the development of terrestrial mobile broadband application. Apart from this WRC-19 agenda item deployment issues for the currently allocated IMT bands were discussed such as for the 1427 – 1452 MHz band.

Some of the frequency bands considered for the new IMT allocations are either shared with, or adjacent to 11 bands used for radio astronomical observations. This indicates that there are potential threats of harmful interference to some of the commonly used radio astronomy bands from these potential new allocations, which could render those bands unusable for radio astronomy.

At a European level, the CEPT is charged with coordinating proposals for new IMT frequency allocations, compatibility studies between the IMT applications and other spectrum users like the Radio Astronomy Service, and preparing European position documents for WRC-19, where final decisions on new frequency allocations will be made.

In broad terms, CRAF attends the meetings to present technical studies on the compatibility of the newly proposed IMT applications with high-sensitivity radio astronomical observations, based on the protection criteria described in the ITU Radio Regulations, Recommendations and Reports. Furthermore, CRAF members actively liaise for support with national spectrum management Agencies and with kindred scientific organisations such as ESA, whose Earth exploration satellites share a number of frequency bands with radio astronomy.

4.2 Agenda of the event

The ultimate purpose of the series of CEPT PT1 meetings over a three-year period (2016-2019) is to draft a European Common Proposal on the issue at hand, to reach consensus on a list of frequency bands supported for the new mobile broadband IMT communication applications, together with a list of protection criteria for potential victim services such as the Radio Astronomy Service - whose protection criteria are much more strict than for other services because of the extremely weak radio signals we need to detect for our research.

Almost all radio services participate in these discussions, as the broad range of proposed new frequency allocations can potentially cause unwanted interference with many other spectrum users who already have a frequency allocation and the right to be protected from new allocations.

This was the second meeting of PT1. No detailed compatibility studies could be presented at the time, as the operational details of the proposed IMT systems have not yet been made available.

CRAF submitted an input document requesting the inclusion of the "21 cm" radio astronomy band 1400-1427 MHz in the draft CEPT ECC Decision on studies to be performed on the compatibility with proposed IMT mobile broadband operations in the adjacent band 1427-1452 MHz, as in some cases this could involve cross-border interference that cannot be resolved through coordination on a national basis. CRAF also proposed text for the CEPT Brief, listing the need to protect radio astronomy and the radio astronomy frequency bands for which the compatibility needs to be studied.

Neither the input nor the output documents of these meetings are publicly available, access is limited to accredited participants in CEPT fora. The CEPT has posted a public summary online at <http://www.cept.org/ecc/groups/ecc/ecc-pt1/news/latest-news-from-ecc-pt154/>

Summary of AI 1.13 from this CEPT website:

"WRC-19 preparation

AI 1.13: Frequency bands for 5G (IMT-2020)

Discussion on AI1.13 focused on the 26 GHz band (24.25-27.5 GHz) in light of the [CEPT 5G roadmap](#) and the recent [EC 5G Mandate](#), which consider this as a pioneer band.

The working document on sharing and compatibility studies was updated based on inputs and the outcome from the correspondence group. Parameters for IMT and relevant victim systems are now included. Some initial studies are included for earth exploration satellite service (EESS) and Inter Satellite Service (ISS), however it is noted that these will need to be revised once the IMT-2020 parameters are agreed by ITU-R in February 2017 (14 – 22nd February), also bringing the methodology of the various studies in line with the new Recommendation ITU-R [IMT.MODEL].

The draft CEPT Brief was updated with info from IARU and actions to be taken, including the need to ensure consistency between spectrum needs and parameters.

The work will continue by [correspondence](#) prior to the next meeting and there may be a need to hold a physical meeting in order to draft inputs to TG 5/1."

4.3 Participants

The participants at these meetings are all experts in spectrum management, on technical and/or regulatory aspects. Some represent the national spectrum Agencies of the 48 CEPT countries, others industry involved in either the proposed new mobile broadband applications or the numerous potential victim services (broadcasting, satellite communications, etc.), and others represent scientific Member Organisations such as CRAF (radio astronomy) or ESA. No attendance list was published for this meeting by the CEPT.

4.4 Publications

This meeting will not result in scientific publications. CRAF's input consists of technical compatibility studies on the protection of the radio astronomy service and proposed modifications of CEPT's Brief and its European Common Proposal, none of which are publicly available.

5 ITU-R TG 5/1 meeting, May 2017

5.1 Summary

On behalf of CRAF, Wim van Driel attended the meeting to participate in deliberations on WRC-19 Agenda Item AI 1.13, whose objectives include the identification of additional frequency bands in the range 24-86 GHz to be allocated to International Mobile Telecommunications (IMT) for the development of terrestrial mobile broadband application.

Some of the frequency bands considered for the new IMT allocations are either shared with, or adjacent to 11 bands used for radio astronomical observations. This indicates that there are potential threats of harmful interference to some of the commonly used radio astronomy bands from these potential new allocations, which could render those bands unusable for radio astronomy.

TG 5/1 of the ITU is charged with coordinating proposals from around the world for new IMT frequency allocations, for compatibility studies between the IMT applications and other spectrum users such as the Radio Astronomy Service, and for the preparation of the position documents for WRC-19, where final decisions on new frequency allocations will be made.

In broad terms, CRAF attends the meetings to present technical studies on the compatibility of the newly proposed IMT applications with high-sensitivity, radio astronomical observations, based on the protection criteria described in the ITU Radio Regulations, Recommendations and Reports. Furthermore, it actively liaises for support with European national spectrum management Agencies and with kindred scientific organisations such as ESA, whose Earth exploration satellites share a number of frequency bands with radio astronomy.

5.2 Agenda of the event

The ultimate purpose of the series of ITU-R TG 5/1 meetings over a three-year period (2016-2019) is to reach consensus on a list of frequency bands supported for the new mobile broadband IMT communication applications, together with a list of protection criteria for potential victim services such as the Radio Astronomy Service - whose protection criteria are much more strict than for other services because of the extremely weak radio signals to be detected in order to carry out the research.

Almost all radio services participate in these discussions, as the broad range of proposed new frequency allocations can potentially cause unwanted interference for many other spectrum users who already have a frequency allocation and the right to be protected from new allocations.

This was the second meeting of TG 5/1. CRAF presented a first compatibility study on the protection of the Radio Astronomy Service in the frequency band 23.6-24 GHz - an important so-called "passive band", which is also heavily used by e.g. the Earth Exploration Satellite Service for remote sensing of the Earth.

The study indicated that exclusion zones of tens of km are required around radio telescopes, in which no IMT systems can be allowed to operate. Such information is of great importance to national administrations for the ultimate decisions on the licensing of IMT systems.

5.3 Participants

The participants at these meetings are all experts in spectrum management, on technical and/or regulatory aspects. Some represent the national spectrum Agencies of the 180+ ITU member countries, others industry involved in either the proposed new mobile broadband applications or the numerous potential victim services (broadcasting, satellite communications, etc.), and others represent accredited scientific organisations such as CRAF (radio astronomy) or ESA.

The attendance list is not publicly available. There were approximately 150 participants.

5.4 Publications

This meeting will not result in scientific publications. CRAF's input consists of technical compatibility studies on the protection of the radio astronomy service from proposed IMT systems. Neither the input nor the output documents of these meetings are publicly available and access is limited to accredited participants in TG 5/1 deliberations.

The ultimate goal is the revision in 2019 of the global Radio Regulations of the ITU regarding frequency allocations for IMT systems.

6 CEPT PT1 meeting, September 2017

6.1 Summary

On behalf of CRAF, Wim van Driel attended the meeting to participate in deliberations on WRC-19 Agenda Item AI 1.13, whose objectives include the identification of additional frequency bands in the range 24-86 GHz to be allocated to International Mobile Telecommunications (IMT) for the development of terrestrial mobile broadband application.

The deliberations in this meeting are a continuation of those that took place in the meetings of January and April 2017.

6.2 Agenda of the event

This was the fourth meeting of PT1 on these issues. CRAF presented compatibility studies on the protection of the Radio Astronomy Service in the frequency band 23.6-24 GHz - an important so-called "passive band", which is also heavily used by e.g. the Earth Exploration Satellite Service for remote sensing of the Earth, as well as for the RAS frequency bands 31.3-31.8 GHz and 42.5-43.5 GHz.

The studies indicated that exclusion zones of tens of km are required around radio telescopes, in which no IMT systems can be allowed to operate. Such information is of great importance to national administrations for the ultimate decisions on the licensing of IMT systems.

6.3 Participants

The attendance list published for this meeting by the CEPT is not publicly available. There were approximately 80 participants.

6.4 Publications

This meeting will not result in scientific publications. CRAF's input consists of technical compatibility studies on the protection of the radio astronomy service from proposed IMT systems. Neither the input nor the output documents of these meetings are publicly available and access is limited to accredited participants in PT1 deliberations. A publicly available summary can be found at <https://cept.org/ecc/groups/ecc/ecc-pt1/news/latest-news-from-ecc-pt156/>. The ultimate goal is the revision in 2019 of the global Radio Regulations of the ITU regarding frequency allocations for IMT systems.

7 ITU-R TG 5/1 meeting, January 2018

7.1 Summary

On behalf of CRAF, Wim van Driel attended the meeting to participate in deliberations on WRC-19 Agenda Item A1.13, whose objectives include the identification of additional frequency bands in the range 24-86 GHz to be allocated to International Mobile Telecommunications (IMT) for the development of terrestrial mobile broadband application.

The deliberations in this meeting are a continuation of those that took place in the meetings of May and September 2017.

7.2 Agenda of the event

This was the fourth meeting of TG 5/1. CRAF presented revised versions of its compatibility studies on the protection of the Radio Astronomy Service in the frequency bands 23.6-24 GHz, 31.3-31.8 GHz and 42.5-43.5 GHz. The band 23.6-24 GHz is a so-called "passive band", in which no active (i.e., emitting) radio services are allowed and which is also heavily used by e.g. the Earth Exploration Satellite Service for remote sensing of the Earth.

The revised studies from CRAF took into account adjustments in the methodology as (re-) defined by the ITU-R expert groups for these studies. All indicate that exclusion zones of tens of km are required around radio telescopes, in which no IMT systems can be allowed to operate - neither the fixed base station antennas nor the hand-held user equipment (future mobile phones). Such information is of great importance to national administrations for the ultimate decisions on the licensing of IMT systems and the implementation of exclusion zones around radio telescopes. At this meeting, CRAF also started assisting China. The Chinese representatives had submitted their first studies on the protection of the radio astronomy service. A future revision of these studies could certainly benefit from CRAF's expertise.

7.3 Participants

The attendance list is not publicly available. There were approximately 150 participants.

7.4 Publications

This meeting will not result in scientific publications. CRAF's input consists of technical compatibility studies on the protection of the radio astronomy service from proposed IMT systems. Neither the input nor the output documents of these meetings are publicly available, access is limited to accredited participants in TG 5/1 deliberations.

8 CEPT PT1 meeting, April 2018

8.1 Summary

On behalf of CRAF, Wim van Driel attended the meeting to participate in deliberations on WRC-19 Agenda Item A1 1.13, whose objectives include the identification of additional frequency bands in the range 24-86 GHz to be allocated to International Mobile Telecommunications (IMT) for the development of terrestrial mobile broadband application.

The deliberations in this meeting are a continuation of those that took place in the meetings of September and December 2017.

8.2 Agenda of the event

This was the sixth meeting of PT1 on these issues. CRAF presented revised compatibility studies on the protection of the Radio Astronomy Service in the frequency bands 31.3-31.8 GHz and 42.5-43.5 GHz and a new study for the frequency range 76-94 GHz. These studies concern radio astronomy sharing the same frequency band as IMT operations and/or unwanted emissions from IMT equipment from a frequency band adjacent to a band used by the RAS, as appropriate.

The studies indicated that exclusion zones of tens of km are required around radio telescopes in which no IMT systems can be allowed to operate. Such information is of great importance to national administrations for the ultimate decisions on the licensing of IMT systems.

CRAF had also submitted comments responding to a call for public consultation on a number of draft ECC and CEPT Reports and Decisions as well as draft text for the CEPT Brief that deals with possible allocations for IMT systems in the frequency range 24.25-86 GHz.

As a result, all these draft policy documents now include texts on the need to establish exclusion zones around RAS stations, plus indicative separation distance radii between IMT equipment and radio telescopes as derived from CRAF studies, where appropriate.

Besides continuing the lines of activity mentioned above, as a next step CRAF will work on draft CPM (ITU Conference Preparatory Meeting) text, the baseline working document for WRC-19 deliberations in which methods on how to put into practice proposed new IMT frequency allocations in the range 24.25-86 GHz, including the ways and means to protect radio astronomy observations, are defined.

8.3 Participants

The attendance list is not publicly available. There were over a hundred participants.

8.4 Publications

This meeting will not result in scientific publications. CRAF's input consists of technical compatibility studies on the protection of the radio astronomy service from proposed IMT systems. Neither the input nor the output documents of these meetings are publicly available, access is limited to accredited participants in PT1 deliberations. The CEPT has posted a publicly available summary of the meeting at <https://cept.org/ecc/groups/ecc/ecc-pt1/news/latest-news-from-ecc-pt158/>.

9 CEPT SE40 meeting, April 2018

9.1 Summary

The organizing body, the CEPT (European Conference of Postal and Telecommunication Administrations) deals with radio spectrum management within the 48 CEPT countries. At this meeting of its Working Group SE40 (Space Service compatibility issues) Benjamin Winkel represented CRAF, the Expert Committee on Radio Astronomy Frequencies of the European Science Foundation, which represents the European radio astronomical community in matters of radio frequency protection at the CEPT.

One recurring topic in SE40 is the IRIDIUM satellite system, which is known to cause severe radio interference for radio astronomy. Measurements of the interference were previously made at the Leeheim satellite monitoring station. Methods and software to evaluate the interference situation and to perform an EPFD simulation were developed by SE40 with the help of CRAF. The software is described in ECC Report 247. Currently, IRIDIUM is rolling out a new generation of satellites ("IRIDIUM Next") and it is claimed that these will have much lower impact on RAS.

New Leeheim measurements indeed show that IRIDIUM Next satellite leak less power into the RAS bands, but EPFD simulations based on the new numbers still lead to a data loss percentage that significantly exceeds the acceptable 2% value. However, this is in part because of the existing software package, which was never designed for processing of relatively faint emission. Several effects, such as the increase of system temperature at lower elevations (because of ground and atmosphere) have to be considered. Furthermore, improvements with regard to the statistical handling of the data seem necessary to avoid systematic biases that could lead to wrong claims.

9.2 Agenda of the event

SE40 had a dedicated one-day meeting in Paris with participants from IRIDIUM/Thales, Leeheim station and RAS, as well as representatives from administrations, to discuss potential shortcomings and possible solutions with respect to different observational strategies or new data processing methods, which could be implemented in the software package. All involved parties had prepared detailed contributions to be discussed at the meeting, which in part need new Leeheim measurements because a different observing strategy is required.

For CRAF, Benjamin Winkel presented a prototype implementation of an iterative running- median filter, which can be used to separate the ground/atmospheric contribution to the system temperature (noise floor) and the IRIDIUM emission. Based upon another proposal by CRAF, the Leeheim station had made measurements with an additional Empty-Sky-Track, which could also be used to remove the ground contribution. IRIDIUM/Thales proposed to incorporate the distance-dependent path propagation loss between satellite and Leeheim station, as well as accounting for the satellite antenna pattern. Furthermore, IRIDIUM/Thales is of the view that the "zero-clipping" feature of the current software package introduces a systematic bias, which should be replaced with a bias-free procedure. Some viable alternatives were identified during the meeting.

In the following weeks, all of the proposals will be tested and carefully examined. During a next SE40 meeting the results will be evaluated and appropriate changes to the software package will be proposed.

9.3 Participants

In total eleven participants from several administrations (France, Germany, Switzerland, CEPT/ECC European communications office), industry (IRIDIUM/Thales), the Leeheim Monitoring station, and CRAF were present. The attendance list published for this meeting by the CEPT is not publicly available.

9.4 Publications

This meeting will not result in scientific publications. CRAF's input to SE40 meetings consists of technical compatibility studies on the protection of the radio astronomy service from satellite systems, technical advice, and contribution to ECC reports. None of the input and output documents are publicly available. The CEPT has posted a publicly available summary of the meeting at <https://cept.org/ecc/groups/ecc/wg-se/se-40/client/introduction/>.

10 ITU-R TG 5/1 meeting, May 2018

10.1 Summary

At this meeting of its Task Group (TG) 5/1 Benjamin Winkel and Wim van Driel represented CRAF, the Expert Committee on Radio Astronomy Frequencies of the European Science Foundation, which represents the European radio astronomical community in matters of radio frequency protection. TG 5/1 is responsible for the development of draft CPM text under WRC-19 Agenda item 1.13.

WRC-19 Agenda item 1.13 asks to study the need for a new large-bandwidth allocation for IMT (5G technology, also IMT-2020) at frequencies between 24 and 86 GHz and to conduct appropriate sharing and compatibility studies with other services. RAS has several allocations adjacent to or overlapping with the IMT bands under investigation. Therefore, CRAF submitted several compatibility studies (for the single-interferer and aggregated scenario) to TG 5/1.

In preparation for these meetings, a large amount of work went into the development of software, which can deal with the complex deployment scenarios and 5G technologies (e.g., phased-array antennas) that are envisaged for IMT-2020, and which was used by CRAF to prepare sophisticated compatibility studies.

10.2 Agenda of the event

The meeting took place from May 2 to May 11, 2018 inclusive and two CRAF members, Wim van Driel and Benjamin Winkel (only May 2 to May 4), participated. Studies for the frequencies at 24, 31 and 43 GHz were submitted previously, but CRAF filed updates on the 31 and 43 GHz documents. A new study for the 86 GHz band was submitted, even though this frequency is currently not favoured by IMT. However, Huawei (China) presented an 86 GHz study, which was in disagreement with our methodology and thus it was decided to carry out a CRAF 86 GHz study with exactly the same software that was used for the other bands to allow a proper comparison of the various frequency ranges. So far, CRAF's studies and its results have been accepted by TG 5/1.

CRAF delegates met with the administrations of France and UK, as well as representatives of Huawei (China) to discuss the differences in the various RAS compatibility studies, which were submitted to TG 5/1. As studies were going to be finalised at this meeting, all parties agreed to accept the (slightly) different results, which stem from a different methodology and assumptions, and compile an appropriate summary for the final reports. The summary would quote a range of necessary separation distances.

Furthermore, CRAF proposed text to be incorporated into the CPM draft, which demands the protection of RAS if a new IMT allocation would be made at WRC-19. Some countries were of the view that such protection is already active (with RR footnotes 5.340 and 5.149), while others understood the rationale behind CRAF's proposal. All administrations agree, that the protection of RAS stations will be a national issue, as the predicted coordination zone sizes are less than 50-60 km in all cases.

There is only one upcoming meeting of TG 5/1 before WRC-19, at which the CPM draft text is to be finalised. CRAF will try its best to implement text into the CPM draft text, which asks for appropriate protection of RAS vs. IMT (under AI 1.13).

10.3 Participants

The attendance list is not publicly available. There were over three hundred participants.

10.4 Publications

This meeting will not result in scientific publications. CRAF's input to ITU-R meetings consists of technical compatibility studies on the protection of the radio astronomy service from other services, technical advice, and contribution to ITU-R texts (recommendations, reports, etc.). None of the input and output documents are publicly available.

11 Acronyms

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| CEPT | Conference of European Post and Telecommunication |
| CPM | Conference Preparatory Meeting |
| CRAF | Committee on Radio Astronomy Frequencies |
| ESA | European Space Agency |
| ESF | European Science Foundation |
| FM | Frequency Manager |
| HartRAO | Hartebeesthoek Radio Astronomy Observatory |
| IMT | International Mobile Communications |
| ITU | International Telecommunication Union |
| RAS | Radio Astronomy Service |
| SKAO | Square Kilometre Array Organisation |
| WRC-19 | World Radiocommunications Conference 2019 |

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