26 CRAF News

The newsletter of the ESF Expert Committee on Radio Astronomy Frequencies

December 2012

Contents

Editorial

Everybody who visits a modern city with its abundance of high-rise buildings can see that in some places land is a scarce resource. The visibility of that resource and its use shows us directly how scarce it has become and how intensively it is used. However, we don't have an innate sense of radio waves and, although the radio spectrum in a big city may be used just as intensively as the land, we are largely oblivious to it. Only sophisticated technical equipment allows us to determine the utilisation of radio waves. Land used to be a common and public resource, and in some places it still is, but nowadays it is mostly privately owned, its occupation usually being visible and strictly localised. It is different for the radio spectrum, whose occupation is invisible and not localised, except for very high frequencies or very low power transmissions. Unlike land, the radio spectrum cannot be fenced in and its occupation requires a continuous effort to prevent 'illegal' intruders. However, public land and the radio spectrum have one thing in common; both are a scarce resource that cannot be created by us and both can suffer from what is known as the 'tragedy of the commons' effect. As both can only be used and occupied, and in principle free access can be granted to everyone, individual users tend to extract maximum benefit for themselves, disregarding the needs of others and the responsibility for the maintenance of the resource.

As far as land use is concerned, the effects on the environment of intensive use, such as high rise buildings and motorways, are widely visible and obvious to all, as is the dereliction of common land and parks if no institution takes care of them. On the other hand, the use of the radio spectrum has mainly invisible effects, although overuse of licence-free devices in for example the 433 MHz band may make radio-operated car keys non-functional or result in sporadic rfi, which can cause garage doors to open and close at random.

As mobile phone companies promise their customers more and more bandwidth, and therefore raise the expectations of their users, cell sizes in densely populated regions begin to shrink, resulting in a galloping increase in infrastructure investment just to guarantee a given level of service to more and more subscribers. Land use has obvious limits to its growth, but so has the use of the radio spectrum, which, unfortunately, usually cannot be seen directly. Similar to that is the (in-)visibility of spectrum management. Only in very occasional cases of spectacular and remunerative spectrum auctions does the spectrum become visible as a valuable resource. For the remaining time, the public (and that includes politicians and also the scientific funding agencies) is blissfully unaware of the considerable efforts of a small international community of specialists who do their best to manage the scarce spectrum resource so that all can benefit from it. Without their work in the form of providing technical evidence (compatibility studies) on which regulations are based we would all be worse off, and radio astronomical research would have become impossible almost everywhere.

It is imperative that this work continues and that radio astronomers continue to be involved in it. However, its invisibility must be overcome and our efforts must be increased to make not only the general public, but also our colleagues in the scientific community, more aware of our work and the vital need for it.

Axel Jessner, *CRAF Chairman*

Cover
The Sardinia Radio Telescope is a new radio astronomical facility of the Italian National Institute for Astrophysics. SRT is a general purpose, fully steerable 64 m diameter parabolic radio telescope capable to operate with high efficiency in the 0.3-116 GHz frequency range.
Credit: Gianni Alvito (INAF-OAC).

Report from the 54th CRAF meeting

The 54th CRAF meeting, organised by the INAF – Astronomical Observatory of Cagliari – took place on 31st May and 1st June 2012 in Cagliari (Italy) at the Hotel Regina Margherita. During the afternoon of the 1st June, a guided tour of the newly constructed Sardinia Radio Telescope (SRT) was organised for interested participants. There was an informal meeting with some of the Mayors of the local villages at the SRT site, during which the Mayors welcomed the CRAF delegates on behalf of the local citizens and Axel Jessner gave a talk on spectrum protection for Radio Astronomy. The CRAF meeting was opened by Prof. Nichi D'Amico, Director of the Sardinia Radio Telescope project. Dr Andrea Possenti, Director of the INAF – Astronomical Observatory of Cagliari, also welcomed the participants and described the current status of the Sardinia Radio Telescope. The Deputy of the Sardinia Regional Government, Dr Giorgio La Spisa, who had contributed 5 000 euros to the organisation of the meeting – a most generous donation – also welcomed the participants and was in turn thanked by the CRAF chairman on behalf of CRAF. Sixteen CRAF Members plus four CRAF Observers attended the meeting, the latter being Jean-Claude Worms, the ESF Liaison Officer, Antonio Vellucci and Daniela Piendibene from the Italian Ministry of Telecommunication, and Thomas Weber (ECO; Chairman of the Short Range Devices -MG), who participated in the open sessions of the meeting.

The following lists the main topics discussed at the meeting and the motions approved by the plenary:

- **Motions approved by the plenary**

1. *ESF & Science Europe (SE)*
   "CRAF currently sees Science Europe as the optimal choice for our host organisation to succeed the ESF and hopes that this will be possible within the next three years. The transfer of responsibilities from the ESF to SE should be such that renegotiation of MoUs and contracts are avoided".
2. *EISCAT Contribution*
   "EISCAT is temporarily unable to pay its membership contribution. CRAF will permit EISCAT to delay payment of their contributions to the year 2014".
3. *CRAF FM Budget*
   "CRAF approves the budget for the FM for the period 2011-2012".
4. *CRAF FM Evaluation*
   "The work of the CRAF FM, Dr Harry Smith, during his first 18 months of office has been evaluated by a panel of seven members according to CRAF AI 10a. According to the unanimous opinion of the panel members, H. Smith's performance has been excellent and exemplary in all aspects of his work. CRAF is grateful to H. Smith for his dedication and his evidently positive impact on radio astronomical spectrum management for CRAF".
5. *CRAF FM Commuting Allowance*
   "CRAF authorises the FM to use part of his travel allowance to pay for his commuting costs between his home in Cambridge and his office at Oxford University".
6. *Annual General Meeting*
   "CRAF resolves to hold a single Annual General Meeting (AGM) which will be funded within the limits of its Radionet budget. The AGM is expected to include business items and observatory reports, and may also include items of an educational nature. The date, location and the agenda of the meeting must be finalised at least 3 months prior to this AGM."
7. *Additional CRAF Meetings*
   "CRAF resolves to hold one further meeting per year with reduced funding (i.e. no Radionet travel funds will be granted) approximately 6 months after the AGM. The dates of the meeting are to be finalised within 3 months of the closing of the previous CRAF AGM."
   Two alternatives for the meeting are to be investigated:
   a) a one-day meeting at an 'easily accessible venue'. CRAF Members would be urged to attend in person, but may attend via teleconference if possible.
   b) a solely teleconference meeting.
   To ensure that a teleconference is a viable option, CRAF resolves to trial working teleconferences (duration not exceeding 2 hours). The CRAF Frequency Manager will ensure the identification and testing of a suitable teleconferencing service as soon as practicable after the closing of CRAF-54.
8. *RadioNet RN3/WP7 leader*
   "CRAF approves Dr Michael Lindqvist (Onsala) as the new RN3/WP7 leader (Jessner will hand over this role after the CRAF-54 meeting).
9. *RadioNet budget*
   "CRAF approves the re-distribution of RadioNet funds obtained under RadioNet 3/WP7 and designates the following priorities at the discretion of the RN3/WP7 leader:
   a) payment of costs for the organisers of CRAF meetings.

b) travel support for CRAF members to ECC and ITU meetings.

c) travel support for CRAF members to CRAF meetings.

10. *FM Report*

"CRAF approves the FM's report for the period 2011-2012".

• WRC-12

The FM attended WRC-12 as a CRAF representative and reported on the conference and the new agenda items of interest to the RAS for the WRC-15. CRAF agreed that work on the development of the CRAF position on WRC-15 agenda items must start immediately.

• Iridium issue

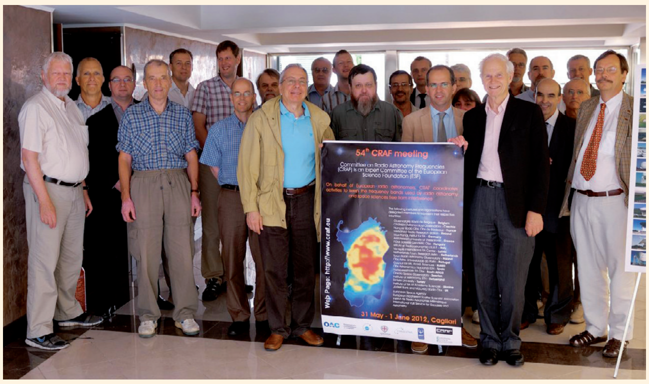
An update on the IRIDIUM issue was given. The draft reviewed ECC/DEC(09)02 is currently at the public consultation stage. The FM44 working group (maybe at a single topic 'web-meeting') will consider the responses received during that consultation so that WGFM sees a finalised document for consideration and adoption in September 2012.

• UWB on aircraft

Progress has been made on the regulation of ultra wideband communications on aircraft which could affect the 6.7 GHz band. The methodology and analysis provided by CRAF has been approved by CEPT SE24, SRD/MG and WG-FM. It is now part of an ECC decision (ECC/DEC/(12)CC), which indicates a requirement for an additional 21 dB suppression of emissions (a 'notch') in the band 6.650 -6.6752 GHz for the protection of radio astronomy. The decision is in the public consultation stage.

The date of the next 'AGM' CRAF meeting in 2013 is still to be defined; Zurich has offered to host it.

Pietro Bolli



CRAF members and observers in the Hotel Regina Margherita.

(Radio Quiet) Locations for the SKA defined!

Setting the site selection scene

The Square Kilometre Array is a concept for a huge radio telescope that has had astronomers debating for a very long time without having the prospect of actual hardware on the ground for quite some time to come. Nevertheless, a very important milestone was reached early in 2012 when an international body of scientists and funding agencies decided on the site for this game-changing future telescope. The event marked the end of an intense period of site characterisation, the result of collecting information on the two candidate sites and making in situ measurements. Ever since the two candidates (one proposed by a consortium of **South Africa** plus additional African countries and the other by **Australia** together with New Zealand) were shortlisted from four in 2006, it was clear that both sites were indeed close to the ideal for hosting the SKA. Even if some site properties may have been better covered at one site, other aspects were balancing the equation. However, it became clear that an additional aspect should be taken into consideration. In the intervening years since 2006 both candidates had embarked on designing and building precursor telescopes to provide science-capable and proof-of-concept instruments, paving the way towards the SKA.

As a result of the consideration that the overall differences in the ratings of the properties of the sites and other hosting conditions were small, and because of the wish to safeguard the investments in the two precursor telescopes, it was ultimately decided to award the SKA to **two** sites instead of just one. This was done by assigning parts of the hybrid telescope concept to the two candidate sites in a manner that best serves local focus and scientific merit. Despite the split-site decision the project remains a single entity: The SKA Observatory.

The Precursors

The Australians decided to explore wide field radio astronomy at medium frequencies by using 12 metre dishes (36 of them) equipped with a novel antenna concept. At the primary focus of each telescope multiple antenna elements sample the incoming wave front. This "Phased Array Feed" (PAF) combines the signals within the telescope focal volume using a beamformer, such that a wide patch on the sky can be imaged. If sufficient sensitivity per antenna element can be achieved, the speed at which surveys can be done will be raised dramatically. However, a reduction in the system noise temperature is a crucial aspect of the technology development to make this a viable approach.

Where	What	Frequency	Number	Extent
South Africa	SKA1-Mid (dishes)+MeerKAT	0.3-3(10 for P2) GHz	254 (190+64)	~100km
	SKA1-AIP-Mid (MFAAs)	0.4-1.5 GHz	t.b.d.	t.b.d.
Australia	SKA1-Low (LFAA)	70 (50?)-450 MHz	t.b.d.	~50km (t.b.d)
	SKA1-AIP-Survey (PAFs on dishes)+ASKAP	0.7-1.8 GHz	96 (60+36)	~50km (t.b.d)

Table 1. The distribution of the instruments and their parameters for Phase 1 of the SKA Observatory.

The first generation of these PAFs is currently being tested on the ASKAP and Parkes radio telescopes, and the second generation is being developed and engineered. Results from these initial experiments will indicate the level of astronomical and technical readiness for a full-scale deployment in ASKAP, and ultimately for a subset of SKA Phase 1, as will be described in the next section.

The application of PAFs only makes sense if, for the type of science that needs to be done, the imaging quality that can be achieved is sufficient. "Imaging dynamic range" is a term that is used in connection with this, and the system design and calibration techniques required for a high enough dynamic range is a particularly important aspect that needs to be proven. A factor affecting this is being addressed by the design of the reflecting dishes that have been chosen for the ASKAP telescopes. They each have a classical design as far as their movements in azimuth and elevation are concerned, but the entire dish can be rotated on a third axis around its centre. This makes it possible to keep the orientation of the dish structures and antenna elements constant with respect to the sky as sources are tracked across the sky, thus keeping variations in the influence of these on the image re-construction out of the equation.

Almost half a globe away in South Africa, the precursor that has been designed is MeerKAT, which builds on the experience obtained with the 7-dish Karoo Array Telescope (KAT). Unlike its predecessor, MeerKAT will use asymmetrical "offset Gregorian" dishes of 13.5m effective diameter. The infrastructure for this 64-dish telescope array is currently being constructed in the Karoo semi-desert. The science targeted by this precursor requires very high sensitivity, and for this reason the telescopes will be equipped with single pixel feeds that are cryogenically cooled.

A MeerKAT telescope dish is similar to the baseline design for the SKA dishes, and as such will provide essential information for the performance of such dishes in high quality imaging. The essential point here is that, as seen from the focal area, there are no telescope structures obstructing or interfering with the beam on the sky.

Towards SKA Phase 1

In its decision to distribute parts of the SKA over the two sites, the Board has recognised the existing investments in the precursors by assigning individual parts of the SKA according to the opportunities created by these precursors and the science cases to be addressed by them, although also taking into account SKA instrumentation still to be added. The instruments also planned to be included in the SKA Observatory are a "Low Frequency Aperture Array" (LFAA) and a "Mid Frequency Aperture Array" (MFAA). Each consists of a large number of simple stationary antennas that work together to provide instantaneous access to most of the sky overhead, unlike dishes that point to a comparatively very small area of the sky. The LOFAR "pathfinder" telescope in the Netherlands has pioneered this technique for the lower frequencies and the technology is considered to have the required level of maturity to be included in Phases 1 and 2 of the SKA. For the medium frequencies to be observed by the MFAA, no large scale pathfinder systems have been demonstrated so far, and therefore the MFAA is included only in Phase 1 as an "Advanced Instrumentation Program" (AIP), which means that the technology will have to be proven to be a viable option for delivery of the required science performance. This is also the case for the Phased Array Feeds (PAFS) of ASKAP.

The development of the SKA had already been staged in two Phases, where Phase 1 would roughly realise a 10% SKA in terms of collecting area. The partitioning of Phase 1 is shown in Table 1.

In Table 1, which shows the parts of the SKA Observatory plus their approximate parameters, the numbers listed are first order assumptions that will be defined during the System Specifications Review (SSR) that is planned to be held during 2013. The AIP parts are identified in the name.

The two non-AIP instruments that are planned, SKA1-Mid (dishes) in South Africa and SKA1-Low in Australia, can commence final design, construction and deployment as soon as the process of SSR and the awarding of contracts have been completed. For the AIP instruments intermediate development and demonstration stages will be needed before the required technology readiness levels are achieved.

The RFI environment

During the site bidding processes the two countries were requested to set up radio quiet zones around the targeted cores of the SKA and to have those firmly embedded in the local legislation. It was therefore of great importance to radio astronomy that these zones were successfully established through the Astronomy Geographic Advantage act in the case of South Africa, and a series of acts, including the Mid West Radio-Quiet Zone act in the case of Australia. The two have zoned protection levels and coordination methods in common, thus providing a solid basis for expecting that the radio environment surrounding the core locations in the two countries will be well protected.

Although RFI measurement campaigns were carried out with unprecedented sensitivity at the two locations during the site characterisation period, they need to be continued to provide an on-going record of the radio environment at the two locations. Results from the measurements indicate that both sites are very quiet in terms of radio interference. Even so, engineers will have to deal with some RFI coming from remote terrestrial sources and from sources overhead, notably aeroplanes and satellites. The measurements that have already been carried out should provide the information that engineers need to design RFI robust systems.

Plans are underway to provide rules and regulations for anyone wishing to bring hardware to the sites: systems have to be designed, built, tested and validated according to the same EMC/EMI/RFI standards. Only in this way can the valuable, quiet environment be maintained so that observations at the required, unprecedented sensitivity levels of the SKA can be carried out.

Rob Millenaar

Industrial devices and Radio Astronomy

In the past, radio observatories and other passive services have mostly been operating in remote, radio-quiet rural locations which had very low levels of man-made interference. The proliferation of fast-switching, power equipment and other digital technologies is a necessary step towards greater energy conservation and the use of renewable energy sources. This can, however, result in severe interference problems for passive services such as radio astronomy if compatibility questions are not addressed at an early stage. Regulatory administrations have recognised the problem for unlicensed and uncontrolled consumer *communications* equipment. If a radio astronomical observation is obliterated by interference, the information that could be obtained is lost and it is irrelevant whether the origin of the rfi is from industrial or communications equipment. In fact, the distinction becomes more and more artificial with the progress of digital technology, and it is now time to harmonise the emission standards for both the communications and other industries.

Current ITU regulations do not deal extensively with radiation emanating from technical equipment that isn't intended for communications. Even in the times before the ubiquitous use of digital data processing and fast power switching gear, electromagnetic interference from industrial and consumer electrical installations (EMI) was already present, but came under the heading of 'Electromagnetic Compatibility (EMC)' rather than 'radio interference' from actual radio transmitters. In the past EMI affected mainly the spectrum below 100 MHz, and Figure 1, taken from ITU-R P. 372-9, reflects this. It is to be noted that trace E of Figure 1 indicates that the contribution of EMI to the radio background in typical cities exceeds that of 'galactic radio noise' by ~20 dB, which, when converted to radio astronomical units, corresponds to an ambient noise floor of several hundred Jy[1]. This may serve to illustrate the reason why radio observatories are built in remote areas where man-made noise is expected to be less than the strength of cosmic radio signals (Figure 1, trace D). Interference emissions coming from localised concentrations of fixed installations in cities and industrial areas are attenuated by their distance from the radio observatory and intervening terrain.

However, with the increased use of high speed digital

1. Note that nowadays many observations of sources are made at the microJy level

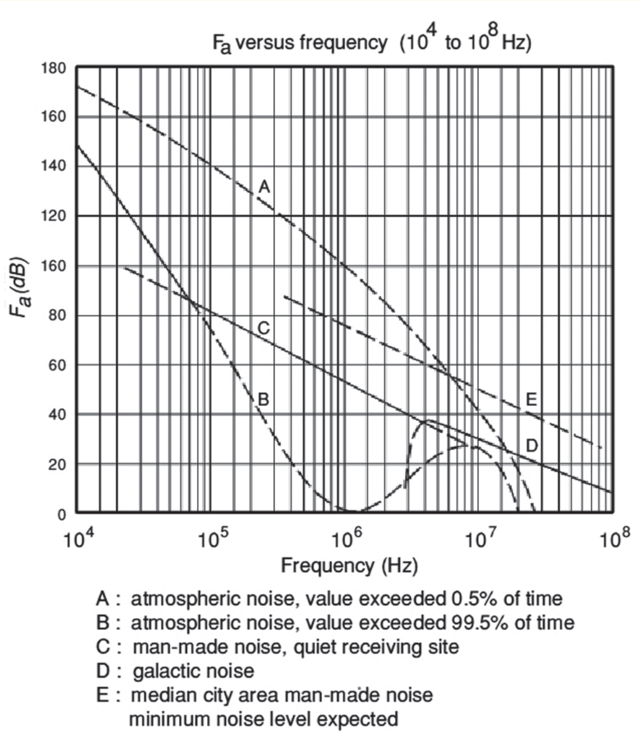


Figure 1. Contributions to the radio noise environment (from ITU-R P. 372-9).

devices contained in licence-exempt, and therefore uncontrolled and often mobile, consumer electronics, as well as the spread of efficient high-speed switching gear used in consumer and industrial power conversion equipment, the sources of industrial interference are coming closer to the radio observatories. Not only that, their interference spectra will also be broader as they are naturally related to the rise and fall times of the digital switching used and these have become much shorter with the recent advances in semiconductor electronics.

Standards limiting the emission from such devices in order to suppress interference to communication services (and also to other sensitive electrical devices) have been devised by CISPR for a range of equipment separated into different categories and classes according to their use and construction. A list is given in the CISPR guide of the IEC (http://www.iec.ch/emc/iec_emc/iec_emc_players_cispr.htm).

There are two major classes:

A) equipment intended for use in a commercial and/or light industrial environment

B) equipment intended for domestic use

Class B equipment has to fulfil more stringent requirements than that from class A.

Many different interference scenarios that were uncommon or did not exist in the past have started to appear. The domestic use of computers, microwave ovens, energy saving electric lights etc. has become common, not only in the city, but also in rural environments close to radio observatories. As another example, consider industrial switch-mode power converters in the kW to MW range, which are often found in association with wind power generators or solar power stations. Like radio observatories they are also erected in remote areas in order to avoid densely populated areas[2].

The radio disturbance characteristics and limits are given by CISPR-11 (group 1 class A) as field strengths of 30 dBμV/m for frequencies below 230 MHz and 37 dBμV/m for the range 230 MHz < f < 1 GHz. The measurement distance is 3m and the analyser bandwidth is 0.12 MHz for frequencies below 230 MHz and 1 MHz for frequencies above 230 MHz.

A quasi peak detector is to be used for the measurements and no further specification of the spectrum apart from measurement bandwidth has been made. Depending on the construction of the devices there may only be one harmonic or spectral line of maximum strength in a radio astronomical band (narrow band case) or there could be many of them up to a point where the interference occupies all of the band (broad band case). However, the effective band occupation and duration of the interference remain undefined in CISPR-11 and that makes generic compatibility assessments for radio astronomy uncertain. In compatibility studies for passive services, one is forced to err on the safe side and that may impose a greater constraint on emission levels than is actually needed if a more informative specification of interfering emissions were available.

Converting CISPR-11 field strengths into radiated powers results in e.i.r.p values of -75 and -68 dB(W), i.e. emission powers that are only fractions of a μW. This has to be compared with the 60 dBW power levels that may be processed in a heavy duty switching converters. Although it is known that the harmonics generated by fast switching decay rapidly with frequency, it is also conceivable that meeting a target of -135 dB for the emission of high frequency harmonics might be rather difficult.

ITU RA-769 gives in its table 1 the threshold power ΔP_H in dB(W) for a radio astronomical receiver that would be considered as detrimental interference. The received

2. Note that scientists, including radio astronomers, do not have a fundamental opposition to modern electronics or to the measures to save energy and energy generation from renewable sources. On the contrary, scientists see that as an important contribution to averting a climatic catastrophe and to secure a sustainable level of human civilisation.

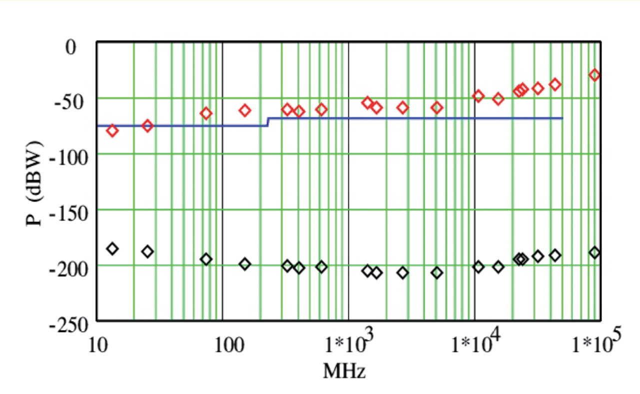


Figure 2. Emission and reception power limits as specified by CISPR-11 and ITU-R RA 769. The blue trace is the e.i.r.p. per measurement channel as given by CISPR-11, the red diamonds indicate the maximum broad-band emission within the allocated radio astronomy band and the black diamonds show the reception limits from ITU R-RA 769.

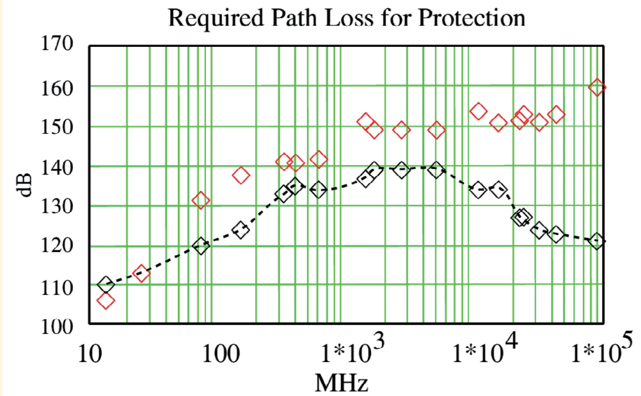


Figure 3. MCL values for the protection of radio astronomy from devices fulfilling the CISPR-11 standard. Black line: Narrow band emission spectrum with one line per radio astronomical band, red diamonds: MCL for broad band emission still within the CISPR-11 limits.

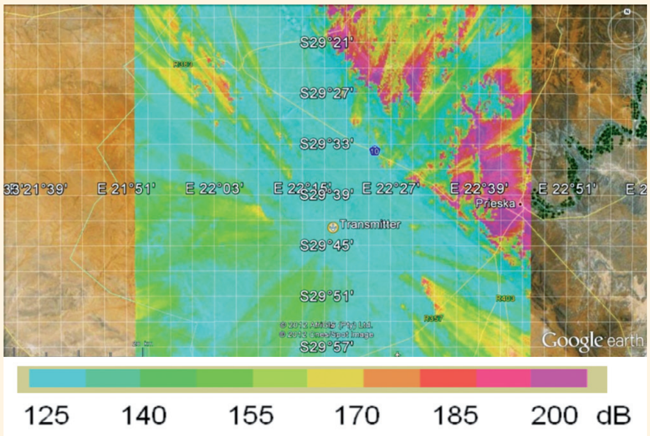


Figure 4. Path loss map calculated for a South African site (indicated by 'Transmitter') for emissions at 610 MHz and an emission height of 5 m using 'Pathprofile' (CRAF Newsletter 25). The MCL for narrow band emissions at that frequency is 134 dB and for broad band emissions it is 141 dB. All green areas are unsuitable as sites for a power station that will have emissions at approximately the CISPR-11 limits.

power is meant to be averaged over the total allocated bandwidth for a specified integration time. Figure 2 shows the emission and reception thresholds in one graph.

The difference between the emission and reception limits constitutes the minimum coupling loss (MCL) that is required to shield the radio receiver from the interferer. Here it is of the order of 140-160 dB and Figure 3 shows it as a function of frequency for narrow and broad band emissions.

The effects of uncertainty in the spectral properties of devices operating within the 'CISPR limits' result in significant variations of the MCL at frequencies above 1 GHz and even more so above 10 GHz. For large power plants high frequency emissions in the 10 GHz range are not expected to be a problem, but they can be important for other types of devices that have emission standards that are similarly defined but where there is the potential of significant broad band emissions in the GHz range. Electronic equipment complying with the industrial standard CISPR-11 has the potential to cause interference to large structures such as radio telescopes in the VHF and UHF bands over distances significantly greater than the nominal line of sight horizon of 25 km. However, the curvature of the earth and local topography will often provide additional shielding. A case by case study is required when electronic devices are to be operated within the line of sight to a radio telescope. As a result one may have to specify stricter limits than CISPR-11 for some locations but not for others.

An example of how terrain may affect local attenuation is given in Figure 4 for a solar power station close to a projected radio astronomical observatory in South Africa. The terrain is flat and there are large areas over distances of more than 30-40 km from which emissions from a power plant may degrade the measurements if emission levels actually reach the limits specified in the CISPR-11 standard.

Operational factors, such as intermittent activity, improved shielding, or a design that has inherently lower emissions will mitigate the impact of the emitted interference. However, these factors need to be carefully assessed and verified before they can be used in a compatibility study. Standard measurement techniques, such as those prescribed in the various CISPR standards, may not be sensitive enough to verify the emission levels of 20-40 dB below that required for compatibility in many cases. An ordinary spectrometer, even combined with a low-noise frontend, will usually not detect any interference at such low levels as its intrinsic noise level is too high, especially when the normally short effective integration times are used. However, radiometric measurements are always possible if the location is radio-quiet. For that one would need to subtract the integrated *linear scaled* power spec-

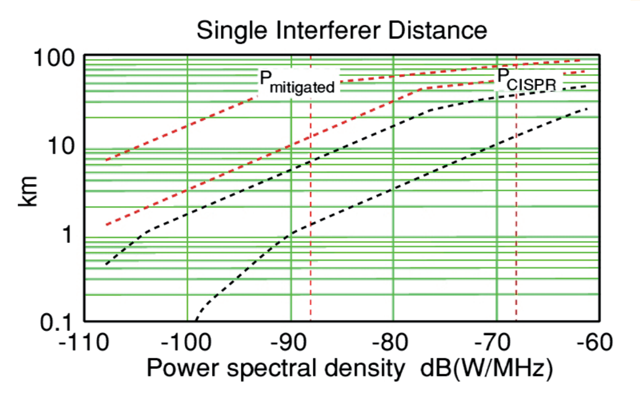


Figure 5. Single interferer separation distances calculated for f=1.41 GHz using the propagation model of ITU-R P.452 for flat terrain, but including the effects of ground clutter and curvature of the earth. Black solid line; narrow band emission at a height of 1m. Black dashed line; broad band emission. Red solid line; narrow band emission at a height of 100m. Red dashed line; broad band emission at a height of 100m.

trum of the background (device turned off) from the one taken with the device in operation.

Separation distances can change significantly and in a non-linear way with mitigation, but terrain effects clearly dominate, as can be seen in Figure 5. The graph illustrates an example of interference in the radio astronomical band 1400-1427 MHz where, according to RR footnote 5.340, 'no emissions are permitted'. No CISPR limits are prescribed for f > 1 GHz and therefore the limit of 37 dBμV/m will continue to be used. For devices on the ground, narrow band rfi may be tolerated for distances greater than 12.3 km, but broad band rfi would require a separation of 34.8 km. A 20 dB mitigation, perhaps as a result of improved shielding and intrinsically lower emissions, will reduce the distances to 1.2 km for narrow band and 6.2 km for broad band rfi. In order to have an unrestricted deployment as close as 100m from the antenna, one would require a reduction of more than 46 dB for broad band emissions down to a level of approximately -114 dB(W/MHz). For installations in the hub of a wind power generator at a height of 100 m and a distance of 2 km, the requirements are similar; a 36 dB reduction is needed for narrow-band emission and a 50 dB reduction for broad band emission if an MCL of 150 dB is required. Note that within the EU, a limit of -120 dB(W/MHz) is specified for licence-free UWB devices for frequencies below 1.6 GHz (ECC Dec. (06)04), which is 52 dB more stringent than CISPR-11. It is conceivable that a passive AC-generator combined with filtered supply cables down to a shielded power converter on the ground may achieve such a low level of emission, but verification of compliance will become rather difficult for such low emission levels.

Even if one can exclude or mitigate the effects of potential interferers close to a radio astronomy site, it could be that there is a large deployment of devices at greater distances and over a large area around the observatory, whose aggregate effect could raise the ambient noise levels as seen for the general noise background in Figure 1. The study of aggregation provides another set of threshold levels, usually derived for an idealised situation, where a large number of trials are made with devices placed randomly over an area centred around a receiver and at different heights as required for a realistic modelling of the deployment scenario. Their average distribution is set to match the average deployment values and emission levels. One then calculates the sum of their signal powers using known propagation mechanisms to obtain the received interference power for each trial. For the 1.4 GHz scenario outlined above and for an assumed deployment density of 1 km^{-2} and two possible operational heights, it is found that the average received power level would amount to -177 dB(W), exceeding the ITU-R 769 threshold of -204 dB(W) by 27 dB. In fact, the median is at -181 dB(W) and in 2% of all cases, the threshold would be exceeded by more than 36 dB!

Although emissions are not permitted in the band considered above, an aggregation study may indicate the probability of interference when the deployment density of devices is known and their emissions have already been reduced by technical or operational means. Different interference probabilities are needed depending on the allocation and protection status of the band. For shared bands (RR FN 5.149) a 2% interference probability is accepted as a practical measure. However, purely passive bands require much lower interference probabilities derivable from the threshold values and the noise statistics.

Conclusion

The radio quiet rural environment may become a thing of the past and because of that, the emission standards for consumer and industrial equipment will need to be harmonised with those for radio services if passive services such as radio astronomy are to continue to be protected. Radio waves do not know about the fine points of legal distinctions about their origin, and our regulations and standards ought to reflect this fact.

Acknowledgement

The author would like to thank Mike Willis for the use of his pathprofile program used for figure 4 and Alex Kraus and Reinhard Keller for discussions and support. This article is an extract from a larger paper appearing in the proceedings of the 2012 German National U.R.S.I. meeting in Klein-Heubach.

Axel Jessner

Report from the ITU-R WP7D meeting in Manta, Ecuador

Introduction

The Ecuadorian government offered to host the September 2012 meetings of the ITU-R Study Group 7 Working Parties (7A, 7B, 7C, 7D) in the resort town of Manta, Ecuador. Preceding these meetings a Regional Seminar on "Science services: regulatory, technical and practical implications" was organised by the ITU-R on 20-21 September 2012. The seminar was intended to provide participants with full and comprehensive information on the development of science services, focussing on the most recent studies conducted by ITU-R Study Group 7. (Details of the seminar may be found at http://www.itu.int/ITU-R/index.asp?category=conferences&rlink=itu-sem-americas&lang=en).

All presentations were of a very high standard and the Seminar provided an excellent introduction to science services, including Radio Astronomy. The presentations are available online and I highly recommend them.

The Ecuadorian institutions were excellent hosts and the Seminar was a great success. It was also a huge local event and the first meeting that I have attended at which armed police escorts accompanied the buses. A red carpet and dancing girls were literally a part of the welcome!! (see attached photo). Ecuador is a beautiful country, well worth a visit, from the capital of Quito to the unique Galapagos islands (see photo).

Although 43 delegates had registered for the WP7D meeting, the actual attendance was usually 10-15 people, somewhat less than usual. Although, as stated above, Ecuador is a beautiful place, Manta was somewhat difficult to reach. Most international participants had to travel for at least 2 days each way! Nevertheless, 30 new documents were submitted, and with documents carried forward from the previous study period, the total number of input documents exceeded 40. The attendees worked diligently and 10 output documents were produced. Details are given in the Chairman's report and its Annexes (Document 7D/32). A more informal report of the most important issues is given here.

WRC-15 Issues

Priority had to be given to issues arising from Agenda Items for WRC-15. This study cycle is rather short and the CPM draft is due mid-2014, which leaves under 2 years for any WRC-related studies!

AI 1.1, 1.2 & JTG 4-5-6-7: WRC-15 Agenda item 1.1 deals with additional spectrum allocations to the mobile service on a primary basis and identification of additional frequency bands for International Mobile Telecommunications (IMT) and related regulatory provisions to facilitate the development of terrestrial mobile broadband applications in accordance with Resolution **233 (WRC12).** This is probably the most extensive item in WRC-15, and a separate task group (JTG 4-5-6-7) has been set up and has already had a few meetings. The JTG chair has requested lists of already available technical and operational characteristics from all services. SG7 had already provided such lists for all the WPs in SG7 at its May 2012 meeting.

These items have the potential to severely impact science services and the passive bands used by RAS. Hence, radio astronomy spectrum management people need to actively participate in the JTG, and WP7D will be closely watching its deliberations.

AI 1.6 (FSS allocations in 10-17 GHz): WP4A requested technical characteristics of all science services and has commenced the development of two preliminary draft new Reports. Working Parties 7B, 7C and 7D reviewed these preliminary draft new Reports and particularly the appropriate Recommendations to be used for sharing studies with possible new FSS networks. A joint liaison statement was sent to Working Party 4A.

AI 1.18: Agenda item 1.18 invites WRC-15 "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 [COM6/23] (WRC12)**". WP7D provided RAS system characteristics to WP5B as requested. A proposal was also made to circulate a questionnaire to administrations to obtain the radio astronomy stations operating in the range near 79 GHz. WP 7D decided that only basic geographic information needs to be collected. This activity will be coordinated by the WP 7D chairman and a list will be provided by the next WP 7D meeting. CRAF and other regional groups will be asked to contribute to this list. From technical documents submitted by IUCAF a working document towards a draft Report on "Considerations related to compatibility between the radio astronomy service and automotive applications of the radiolocation service in the 76-81 GHz band" was produced and is attached to the chairman's report.

Feedback relating to the perception that the extensive RAS allocations above 70 GHz are "blocking" the development of active service systems in these bands was received from active services during the discussion. However, it was pointed out that RAS observatories above 70 GHz are few and in isolated locations and hence sharing with RAS ought to be possible.


To counter such negative perceptions and to clarify the issues about sharing with RAS, it was proposed that a New Report should be developed in WP 7D on "Sharing between RAS and active services". Inputs on this subject are strongly encouraged for the next WP 7D meeting.

Recommendations and Reports

Recommendation **RA.1417** (RQZ at the L2 point) was agreed together with WP7B and submitted to SG7. Similarly, Rec **SA.509** (Antenna patterns) was agreed in WP7B and also forwarded for SG7 approval. Note that SA.509 is used extensively in RA Recommendations and its revision may impact the RAS. The RAS community is strongly encouraged to again review these revisions. (The next SG7 meeting is in Sept 2013 and thus there is time for further inputs if needed).

The revisions of Repots **RA.2099** (Pulsar timing) and **RA.2126** (RFI mitigation) were carried forward from the previous cycle and need to be finalised. Inputs to the April 2013 WP7D meeting are encouraged.

A new Recommendation was proposed by the Netherlands on "Measurements of data loss resulting from degradation by interference in frequency bands allocated to the radio astronomy service on a primary basis", under Question ITU-R 227/7. This is a critical issue for RAS and again additional inputs are very welcome.

Discussions also addressed the issue of modern observing practices in RAS. Most RAS observatories operate receivers with bandwidths much larger than the RAS allocations in any particular band. How to manage this issue and the relevance of the narrow RAS allocations need to be further discussed and reported. It was suggested that a Recommendation or Report on this issue be developed within WP 7D.

RAS Handbook

There was extensive discussion on the revision of the RAS Handbook at this meeting and key people were identified for the reviews of the old chapters and the development of new ones. New deadlines were set to:

1) assess the scope of the required work for each chapter and notify the Rapporteur by the end of October 2012;
2) complete chapter drafts by 1 March 2013. The aim is to have a full draft for consideration by the next WP 7D meeting in April 2013.

Other Issues

There are a number of emerging issues that may require vigilance on the part of the RAS community. These include:

- Nomadic wireless access systems. A liaison was sent to SG5.
- Nano and pico satellites (AI 9.1.8). Studies under WP7B but many developments of interest to RAS.

Finally, the "2% data loss" issue in Footnote **5.B121** was briefly discussed. This arose in the last WRC and a note was inserted in the WRC plenary summary to report back the results of studies to WRC-15 via AI 9 (BR Director's report). This issue has no visibility at present and any progress will have to come via WP7D. Inputs and studies are urgently needed if this is to be progressed.

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February 2012 – Print run: 305