

Expert Panel on Radio Quiet Zone and RFI Regulation

Report

Task for the Committee:

The Expert Panel on Radio Quiet Zone and RFI Regulation is charged with reviewing the information supplied by the site proponents in response to the RFI chapter in the Request for Information. This will involve assessing the strengths and weaknesses of the responses to the Request for Information from each site. The Expert Panel is also to identify potential site-specific concerns that arise from these responses that may impact the long-term ability to conduct radio astronomy as set out in “The Square Kilometre Array Design Reference Mission: SKA Phase 1”, and beyond.

The topics that the site proponents have been requested to address in their answers to the Request for Information are, broadly:

- Radio Quiet Zone: properties, time-lines, supporting legislation;
- the spectrum management regimes in place in the host country and other countries where remote stations are situated;
- radio spectrum usage, including future developments outside the RQZ that will influence the environment at the core and remote locations;
- interaction of the candidate hosts with international spectrum management bodies.

Deliverable:

A report for the SSAC, making a direct comparison between the Radio Quiet Zone and RFI Regulation of the two sites. This report should highlight any perceived shortcomings in the RFI Regulation and any limitations to the RQZ that may affect an individual site’s suitability to host the SKA.

Response of the Committee:

General:

The expert panel reviewed the very extensive information received in response to the Request for Information. We were impressed by the thoroughness and depth of detail with which the issues were addressed by both site proponents.

The acronyms **AMWRQZ** and **SAKRQZ** are used throughout this Report for the Australian Mid West Radio Quiet Zone and the South African Karoo Radio Quiet Zone, respectively.

1) Radio Quiet Zone: properties, time-lines, supporting legislation

1.a Properties

Size and shape of the protected areas:

AMWRQZ:

Core Area:

- 70 km radius circle centered on reference point (Area ~15,400 km²), with an inner core:
 - Murchison Radio Observatory (MRO) Area: 12,674 ha – No map of the area has been supplied. (Area equivalent to that of a circle of ~6.35 km radius)
 - Extremely stringent equipment standards (see below) between 70 MHz and 5 GHz, extending 10 km outwards from MRO limits
 - (Ref: Radio-Quiet Zone Report for Australia and New Zealand, and Attachment 6 to same)

Coordination area:

- 70 - 150 km radius circular annulus, centered on the above coordinates. (Area ~ 55,292 km²)
- Frequency range (both, core and coordination areas): 70 MHz -25.25 GHz
- Reference Point: Lat. 26.704167 deg South; Lon. 116.658889 deg East
- (Ref: Radiocommunications (Mid-West Radio Quiet Zone) Frequency Band Plan 2011)
- Height: 15 m (Ref: RALI: MS32, page 6)

SAKRQZ:

Karoo Core Astronomy Advantage Area:

- No map of this area (comprised of two farms) has been supplied; Area: 14,000 ha
- (Annexure E1.7.1 – Declaration- Section 3)
- (This area is equivalent to that of a circle of ~6.7 km radius)
- Reference Point: Lat. 30.7148 deg South, Lon. 21.38880 deg East
- (Ref. Annexure E.1.9.2)
- Height: 10 m (Ref: South African Response to the SSG Request for Information)
- Frequency range: 9 kHz - 3 000 GHz

Karoo Central Astronomy Advantage Areas (KCAAAAs):

KCAAA1:

- Irregular polygon; Area: 123,456 km² (circle of ~ 200 km radius)
- Frequency range: 70 - 1710 MHz

KCAAA2:

- Irregular polygon; Area: 79,963 km² (circle of ~ 160 km radius)
- Frequency range: 1710 - 6000 MHz

KCAAA3:

- Irregular polygon; Area: 44,602 km² (circle of ~ 120 km radius)
- Frequency range: 6000 MHz - 25.5 GHz

Karoo Coordinated Astronomy Advantage Areas (KCooAAAs):

KCooAAA1:

Irregular- Most of North Cape Town Province- surrounds KCAAA1- see map

Area: 372,889 km²

Frequency range: 70 - 1710 MHz

(Ref. Annexure E.1.9.2)

KCooAAA2:

Irregular polygon – surrounds KCAAA2

Frequency range: 1710 - 6000 MHz

Area: 43,493 km²

Reference Point and Height: s Karoo Core Astronomy Advantage Area

1.b Power levels

1.b.1) Core Areas

AMWRQZ

Within the MRO and 10 km outwards, variable, in the 70 MHz to 5 GHz range more stringent than Recommendation ITU-R RA.769-2, depending on distance from center, MRO exercises control. (Ref: Table 1, Attachment 6 to Radio-Quiet Zone Report for Australia and New Zealand)

Within the restricted zone (RQZ inner zone; 70 km radius circle):

- Radio Astronomy is declared the primary service in the range 70 MHz - 25.25 GHz
- Existing stations are grandfathered
- No new licenses are to be issued to coordinated terrestrial stations (Fixed stations) and to Earth stations
- No expansion or modification of existing stations is allowed
- Exceptions may be granted by the Manager, Broadcasting Section, possibly subject to Observatory (CSIRO) approval. It is presumed, that the observatory would grant an exception to transmitters meeting the Recommendation ITU-R RA.769-2 detrimental threshold levels at the reference point.

(References: Radiocommunications (Mid-West Radio Quiet Zone) Frequency Band Plan 2011 and RALI: MS 32)

SAKRQZ:

Within the Karoo Core Astronomy Advantage Area (defined in Annexure E1.7.1)

- Radio astronomy and related activities are the only allowed users of the spectrum in the range 9 kHz to 3000 GHz
- Construction, expansion or operation of fixed services prohibited
- Activities that may interfere with radio astronomy observations prohibited
- No separately stated permissible power flux level allowed within the core area is stated, the SARAS protection levels (see below) apply
- No provision for exceptions

(References: Annexures E1.7.1 and 1.7.3, South African Response)

1.b.2) Coordination Areas

AMWRQZ

Within the Coordination Area (RQZ outer zone, 70 - 150 km radius circular annulus):

- Assessment of transmitters based on evaluation of transmitter power minus propagation path loss. For equations, see section 4.2.1 of the RALI: MS32

Assumptions:

- Uniform emission level over transmitter bandwidth (except in certain cases)
- Propagation loss determined based on methods described in Recommendation ITU-R P.526
- 9 sec digital elevation terrain model (or better)
- Ultimate licensing authority retained by the Australian Communications and Media Authority (ACMA), in consultation with CSIRO

SAKRQZ

Within the KCAAA Central Areas (see above)

After promulgation of regulations no transmissions allowed in KCAAAAs, except for:

- Transmitters that do not exceed the SARAS spfd level at the reference point
- 87.5-100 MHz portion of the FM band is excepted for broadcasting services and may operate in all KCAAAAs,
- Two (unspecified) 8 MHz blocks of spectrum in UHF band (470-862 MHz) excepted for TV broadcasting and may operate in KCAAA1- Analogue transmissions are prohibited after migration deadline to Digital TV (aim: 100% migration by late 2013; Ref. Annexure E.5.6.2, *draft policy only*)
- FM and UHF TV operations also have to comply with the SARAS level at the reference point
- No transmitter may exceed 60 dBm of effective radiated power
- No transmitter can cause saturation to any radio astronomy receiver within the KCAAA (Saturation level defined as: -120dBm/Hz)
- Essential services, as determined by the management authority, may operate above the detrimental level, upon request

Within the (surrounding) KCooAAAs:

For Fixed RFI sources operating in the band 70-1710 MHz (KCooAAA1) and 1710-6000 MHz (KCooAAA2) that exceed the protection levels for the Karoo Core Centre (KCC)

The applicable standards and conditions are:

Within the KCooAAA1:

- If the effective radiated power level of a source exceeds 60 dBm, its effective radiated power level
 - within the KCAAAA1 may not exceed 60 dBm
 - within the direction of the KCC may not exceed the applicable protection levels prescribed in the KCC
- FM band broadcasting limited to the band 87.5-100 MHz
- TV broadcasting
 - limited to the band 470-854 MHz
 - analogue transmissions must use co-channel frequency assignments and digital transmissions must use single frequency networks, as far as is practicably possible

Within the KCooAAA2:

- No transmissions may exceed an effective radiated power of 60 dBm
- Even if the effective radiated power level is at or below 60 dBm, the RFI may not exceed the applicable protection levels prescribed in the KCC

(Ref: Annexure E.1.9.2)

1.b.3) Remote stations

AMWRQZ

- To be sited avoiding areas of high mineral and petroleum prospectivity.
- Siting will comply with radio-quiet requirements, sites to be located outside buffer zones for relevant transmitters and existing infrastructure.
- Determination of sites and protection for them will proceed once SKA requirements are determined and remote station numbers are confirmed.

(Ref: Radio-Quiet Zone Report for Australia and New Zealand, Section 3)

SAKRQZ

The remote stations:

- Located within the KCAAAA or KCooAAA will be subject to the protection conditions in force within these areas;
 - however, in general, the protection level will decrease with distance from the KCC
 - therefore, other protection techniques need to be applied for the remote stations in the other parts of South Africa or in the other participating African countries
- Are located so as to seek to minimize impact from existing RFI sources.

- Have a protected operating frequency range of 300 MHz – 10 GHz
- Will have as a preferred protected zone an area with a radius of 50 km, within which no new radio communication transmissions are to be established, or the use of existing transmissions extended or increased. The radius can be amended depending on local circumstances.
- Within South Africa will be protected according to the terms of the AGA Act.
 - Other areas in South Africa may also be designated as an AAA, subject to conditions
 - Within these areas, Core and Central AAAs may be declared, where the Core AAA would be used to accommodate the remote station, and the Central AAA would constitute the protected area of, in principle, 50 km radius. In the other African participating countries the protection sought will be the same as that stated above. An arrangement based on local law would be made with the local government and regulator as and when required (see also Sect. 2a of the present report)

(Ref: South African Response, Sect. 1.5.4)

1.b.4) Protection levels

The SKA Task Force on Regulatory Issues considered that three distinct protection levels were needed for different portions of the SKA (SKA Memo 73; November 2005):

- **core area:** the highest level of protection, as given in Tables 1 and 2 (for, respectively, single-dish continuum and spectral line observations) of Annex 1 to Recommendation ITU-R RA.769-2 is required;
- **intermediate region** (up to 150km from the centre of the array): the approximate level of required protection is 15 dB less stringent than the continuum threshold level in the core area;
- **remote stations** (beyond 150 km): protection at VLBI levels given in Recommendation ITU-R RA.769-2 Annex 1, Table 3 should be sufficient.

In Recommendation ITU-R RA.769-2, the threshold levels for interference detrimental to radio astronomy are given in terms of power flux density (pfd), in units of dB(W/m²) or in terms of spectral power flux density (spfd), in units of dB(W/(m²·Hz)), for both continuum (Table 1 of Annex 1 to the Recommendation) and spectral line observations (Table 2 of Annex 1).

In both the Radio-Quiet Zone Report from Australia and New Zealand and the South African Response to the SSG Request for Information the units used in Recommendation ITU-R RA.769-2 have been converted to dBm/Hz. The conversion formulas between these units are:

- dB(W/(m²·Hz)) to dBm : $\text{dBm} = \text{spfd} - 20\log(f) + 10\log(\Delta f) + 188.5$
- dB(W/m²) to dBm : $\text{dBm} = \text{pfd} - 20\log(f) + 188.5$

where f is the centre frequency and Δf is the bandwidth, both in Hz.

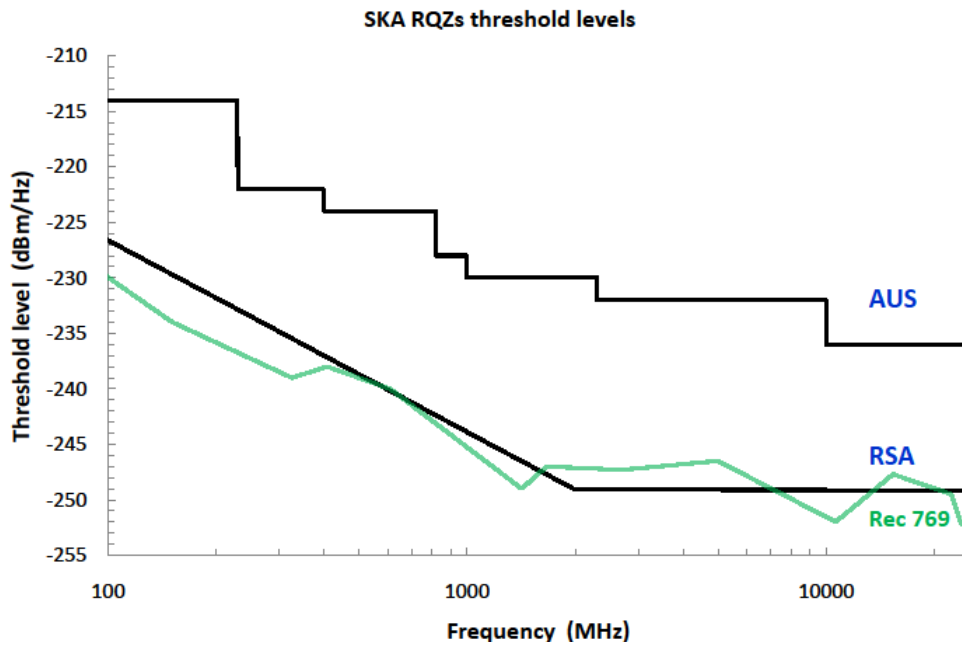


Fig. 1: Graphic representation of the threshold levels for detrimental RFI listed in the Australian and the South African documents, labeled as **AUS** and **RSA**, respectively. Also shown is a line (labeled **Rec 769**) connecting levels from Recommendation ITU-R RA.769-2 for the frequency bands allocated to the radio astronomy service in the ITU-R Radio Regulations.

In the Radio-Quiet Zone Report for Australia and New Zealand, Table 2 lists the power spectral density threshold levels received at the SKA core in a series of frequency ranges, from 100 MHz to 25.25 GHz, together with the corresponding radii of the restricted and coordination zones of the AMWRQZ. The level listed there for the band 100-230 MHz has since then been extended down to 70 MHz (Ref. Mid-West Radio Quiet Zone Frequency Band Plan 2011).

In the South African Response, the SARAS standard threshold levels were derived using the methodology of Recommendation ITU-R RA.769-2, assuming 1% receiver bandwidths in order to derive a continuous function for levels across the entire band 70 MHz – 25.25 GHz. A piecewise linear function was used to describe the levels.

The South African threshold levels correspond globally to those given for single-dish continuum observations in Recommendation ITU-R RA.769-2, whereas the Australian levels are on average ~15 dB less stringent, and correspond to the levels for a linked interferometer with a compact configuration, like the D configuration of the VLA (e.g., ITU-R Handbook on Radio astronomy).

1.c) Timelines and supporting legislation

RQZ related legislation and timelines have been mostly established jointly and are described so below.

SAKRQZ

Efforts to establish protected areas for radio astronomy in the Republic of South Africa (RSA) were initiated in 2003. These efforts culminated in the promulgation of the Astronomy Geographic Advantage Act of 2007, the framework legislation promoting astronomy activities, establishment of RQZs and the preservation of RFI free environment within the same. The official entry in force of the AGA is June 17, 2008, the date of its publication in the Government Gazette (Ref: Annexure E1.2).

The AGA Act can only be repealed or amended by the National Assembly (Parliament) of South Africa, but such a process will also be governed by the South African Constitution in terms of any vested rights and by other legislation. The declarations made in terms of the AGA Act can be withdrawn or a part of a declared area can be excluded by the Minister where the purpose of the declaration is no longer necessary. Regulations may also be repealed or amended by the Minister.

A specific timeline of regulations for the establishment and protection of the various Astronomy Advantage Areas (AAAs) is given in Table 1 of the South African Response to the SSG. An abbreviated Table of the expected timeline for the establishment of the RQZ is shown below:

Action	Date
Northern Cape Province declared Astronomy Advantage Area, with exception of one township	19 February, 2010
Core AAA declared; public comments/regulations due in July, 2011	20 August, 2010
Public comments due on SARAS protection levels	July, 2011
Public comments due on Karoo Central AAA declaration, regulations	July- August, 2011
Public comments due on Karoo Coordinated AAA declaration, regulations	November-December, 2011
Remote stations	No date given

AMWRQZ

The Radiocommunications Act 1992, which provides the legislative backbone for the Mid West RQZ, can only be amended or overturned through a motion to the full Parliament of the Australian Government.

A frequency band plan, such as Mid-West Radio Quiet Zone Frequency Band Plan 2011, is a legislative instrument under the Radiocommunications Act 1992. It is a so-called disallowable instrument and must therefore be tabled in, and be subject to disallowance (veto) by the Australian Parliament.

The Australian Communications and Media Authority (ACMA) regulates the radio spectrum in Australia. Unless otherwise noted, the actions referenced in the Table below, that provides a timeline for the establishment of the AMWRQZ, were taken by ACMA. The entire AMWRQZ (up to 150 km from the reference point) is dealt with in all the actions in the Table.

Action	Date
Embargo 41 issued. Prohibits new assignments of fixed terrestrial stations and Earth stations within 150 km of the reference point in the 100-230 MHz range and within 100 km of the reference point in the 230 MHz-25.25 GHz range.	11 April, 2005
RALI:MS32 confirms the embargo and establishes further regulations	24 September, 2007
MoU between the Australian and Western Australian governments signed on Radio Quiet Matters	June, 2011
New Arrangements for the AMWRQZ issued. Extends lower frequency range to 70 MHz, establishes inner radius at 70km, outer radius at 150 km for all frequencies, maintains fundamental aspects of RALI:MS 32	11 July, 2011
No substantial modifications to the New Arrangements document are expected Some further detailed regulations, and changes to the RALI, consequential to the increase in the lower range of the spectrum and reduced radius of the inner zone of the RQZ are expected.	No date given
Remote stations	No date given

2) Spectrum management in the host country and other countries where remote stations are situated.

2.a) Spectrum Management

South Africa

Radio Frequency Spectrum Policy for South Africa was promulgated by the Minister of Communications, in April, 2010. Spectrum authority is vested in the Minister, who decides over spectrum policy, is responsible for the allocation plan and other allocation related matters, and represents South Africa at the ITU. Day-to-day management of the spectrum and implementation of policy is delegated to the Independent Communication Authority of South Africa (ICASA).

The use of spectrum for scientific research is one of the designated objectives of South African national spectrum policy. The Astronomy Geographic Advantage Act (Annexure E1.0) made

operational in April, 2009 empowers the Minister of Science and Technology to regulate spectrum usage (including retroactively, if needed), in areas identified as Astronomy Advantage Areas (AAA) for the benefit of astronomy activities. The Minister must, however, assign the management of the AAAs to an Astronomy Management Authority. In areas identified as AAA, the AGA prevails, in case of conflict.

South Africa's partner countries where remote stations are to be located.

Remote stations are proposed to be located in South Africa's eight partner countries: Botswana, Ghana, Kenya, Madagascar, Mauritius, Mozambique, Namibia and Zambia. The spectrum management regimes in force in these countries are described in Annexure E5.0. While these regimes vary from one country to the other, most of them appear to be fairly simple, with a basic law (e.g. the Ghana Electronic Communications Act; Annexure E2.3.2) and another law, establishing some regulations and a Communications Authority, the responsibilities of which include the administration of spectrum licenses and, should harmful interference occur, dispute resolution (e.g. the Ghana National Communications Authority Act; Annexure E2.3.1)

Australia

Spectrum use in Australia is governed by the Radiocommunications Act 1992 that contains the Australian Radiofrequency Plan. The Australian Communications and Media Authority (ACMA) is the regulatory agency responsible for administration of the spectrum and for issuing licenses; it is overseen by the Minister for Broadband, Communications and the Digital Economy.

The basic instrument for the preservation of the radio quiet environment in the core and coordination region of the site proposed for the SKA is the Radiocommunications Assignment and Licensing Instruction: MS 32 (RALI: MS 32), that took effect in September 2007. Some recent changes (extending the reach of the RALI down to 70 MHz and reducing the coordination area to a radius of 150 km from the reference point), will be reflected in a revised RALI. The Commonwealth of Australia and the State of Western Australia, that intends to host the SKA core and coordination areas, concluded a Memorandum of Understanding on Radio Quiet Matters. The objective of this MoU is the preservation of an environment that is RFI-free from local activities.

New Zealand

In New Zealand, that wishes to host some SKA remote stations, the radio spectrum is managed by the Ministry of Economic Development (MED); the legislative instruments are the Radiocommunications Act 1989 and the Radiocommunications Regulations 2001. The New Zealand MED maintains an extensive website, detailing spectrum management practices in the country.

(Ref: Radio-Quiet Zone Report for Australia and New Zealand and <http://www.rsm.govt.nz/cms>)

2.b) Dispute Resolution

A clear and easy to follow process to resolve conflicts or disputes is particularly important for the preservation of an RFI-free environment. The following arrangements are in effect:

South Africa and partner countries

Within the Core and Central AAAs, spectrum authority has been transferred to the Minister of Science and Technology, who must be represented in turn by an Astronomy Management Authority (See AGA Act; Annexure E1.0); in other areas of the country, spectrum authority is exercised by ICASA. A cooperation agreement has been signed (see Annexure E6.0) between the Dept of Science and Technology and ICASA, but it is conceivable that disputes could arise between these entities; in fact, the Agreement provides for just such a possibility (see Article 8 of Annexure E6.0). No adequate dispute resolution process seems to be in place, should such a conflict arise – it is left to amicable settlement through consultation or negotiation between the Parties. Conflict resolution for remote stations is not addressed, but presumably the general conflict resolution process in force in each country would apply.

Australia and New Zealand

CSIRO is the entity that would currently represent radio astronomy interests in case of a conflict. An extremely clear description of the conflict resolution process, that includes flowcharts indicating the maximum duration of various stages of the process, is provided in the Management Framework for the Midwest Radio Quiet Zone (MoU on Radio Quiet Matters... between the Commonwealth of Australia and the State of Western Australia- Appendix C - Mid West Radio Quiet Zone Management Framework). Separate processes are shown for the core and the coordination regions; in both cases the power of decision is retained by ACMA in those cases when no satisfactory agreement is reached between the parties. It is indicated that, should Australia/New Zealand be chosen to site the SKA, CSIRO may be replaced as the entity representing radio astronomy interests by a successor entity representing the SKA.

No specific conflict resolution process appears to be available at this time for stations that would be located outside the AMWRQZ. Those that would be located in another Australian state would presumably still come under the authority of ACMA.

2.c) Enforcement and Penalties

ACMA is responsible for enforcing spectrum regulations within Australia and has the authority to suspend or cancel licenses. A magistrate may authorize ACMA to search, seize and confiscate radio equipment in violation of the regulations.

Persons operating transmitters in violation of the AGA in South Africa may be issued a compliance notice. If they do not comply, their license may be suspended or revoked. Upon non-compliance, repeat offenders in violation of the AGA may also be fined and even imprisoned

3) Radio spectrum usage, including future developments outside the ROZ that will influence the environment at the core and at remote locations.

South Africa:

Current usage and future improvements or termination of services:

- Broadcasting: radio FM (87.5-108 MHz): staged termination of transmissions in the band 100-108 MHz in the Karoo region.
- Broadcasting: TV (174-254 MHz, 470-862 MHz): of relevance to the Core and Central AAAs: discontinuation of the use of the band 174-254 MHz, and discontinuation of the use of the band 470-862 MHz, except for two 8 MHz wide bands.
- GSM Mobile Cellular Communications (880-915 MHz, 925-960 MHz): base stations within the KCAAAAs will restrict their radiation towards the Karoo Core by using phased antenna systems.
- Private radio communications (146-174 MHz, 406-470 MHz): migrate use in the KCAAA1 to the band 66-88 MHz.
- Public trunked radio communications (254-259.4 MHz, 262-267.4 MHz): obsolete technology, destined to be phased out, in practice migration to GSM mobile networks.
- Railways (160 MHz, in band 440-466 MHz): focus transmissions on railway line, minimize transmissions towards the Karoo Core.
- Aviation (108-137 MHz, 1030/1090/1019/1021 MHz): intention to impose flight restrictions over at least the KCAAA
- Microwave radio communication links (in the 4, 6, 7, 8, 10 and 22/23 GHz bands): their use is being phased out and replaced by the use of fiber optics links.

Expected New Services:

- Development and growth of personal communications is radio based and has spread beyond voice and SMS communications to internet access:
 - in the bands 900 and 1800 MHz, and 2.1, 2.6 and 3.4 GHz: mainly in high density areas
 - digital dividend from migration to digital TV transmissions will open up the band 790-862 MHz for other commercial applications, but demand is very low in the Northern Cape Province and will be restricted by the requirements of the AGA Act.
- Replacement of obsolete and uneconomical open wire telephone systems with radio communications in rural areas

(Ref: South African Response, Sect. 1.6)

Australia:

ACMA continually monitors future spectrum developments, and has identified a number of planned changes in radio spectrum usage over the coming years, which are described in their 5-year Spectrum Outlook, issued annually. The following relevant issues are taken from the 2011 – 2015 Spectrum Outlook:

- Digital television transition: end of all analogue TV transmissions by the end of 2013. ACMA will work with the SKA entity on the preference to restack the digital channels into the VHF or the UHF band within the AMWRQZ.

- Digital dividend and mobile broadband:
 - the band 694-820 MHz will be reallocated for other applications; it is expected that the bands 703-748 MHz and 758-803 MHz will be auctioned.
 - the bands 2500-2570 MHz and 2620-2690 MHz are being considered for new spectrum uses, such as wireless access
- National Broadband Network: will provide high-capacity optic fiber connectivity over 93 of Australian homes etc., and will thus relieve radio frequency spectrum pressure
- 400 MHz review: the 403-520 MHz band is one of the most heavily used in the radio spectrum. Arrangements will be made for harmonized spectrum use, reduction of channel bandwidths, etc.

(Ref: Radio-Quiet Zone Report for Australia and New Zealand, Sect. 5)

4) Interaction of the hosts with international spectrum management bodies.

(Ref: Section 6 of the Radio-Quiet Zone Report for Australia and New Zealand and Section 1.7.3 of the South African Response to the SSG Request for Information)

Australia and New Zealand have long been active in international spectrum management in the general radiocommunication area, and more specifically in the management of spectrum for radio astronomy and the space sciences. A past Secretary General of the ITU was an Australian (1983 – 1989) and Australians and New Zealanders do chair, or have chaired, numerous important committees at World Radiocommunication Conferences (WRCs) and ITU-R (or, in the past CCIR) Study Groups (SGs) and Working Parties (WPs).

In the specific area of radio astronomy, Dr. J. Whiteoak, from the Australia National Telescope Facility (ATNF) chaired ITU-R WP 7D (Radio astronomy) for many years; the current chair is also Australian, from the same institution. Australians are also active in RAFCAP and IUCAF, the Asia-Pacific regional and worldwide organizations, respectively, that defend radio astronomers' access to the spectrum in regional and worldwide telecommunications fora. To the committee's knowledge, there has been no New Zealand participation in spectrum management for the science services.

While South African involvement in international spectrum management, particularly for radio astronomy, is relatively recent, the country currently participates actively in international spectrum management bodies. At WRC-07 the South African delegation was very supportive of radio astronomy interests, and it participates actively in the activities of WP 7D, in the European Science Foundation's Committee on Radio Astronomy Frequencies (CRAF) and in IUCAF.

5) Perceived shortcomings (and advantages) in the RFI Regulation and any limitations to the RQZ that may affect an individual site's suitability to host the SKA.

A direct comparison between the properties of the Australian Mid West RQZ (AMWRQZ) and the South African Karoo Astronomy Advantage Areas (SAKRQZ) is not possible. The two prospective

sites differ in too many ways, including their physical characteristics and the regulatory regime at each, for such a comparison to be meaningful. It should be kept in mind that the regulatory environment of each prospective host country reflects the local culture and the institutions that evolved in it, and it should be interpreted in that context. For example, while spectrum management is organized quite differently in Australia and in South Africa, reflecting the culture of each country, they may be equally efficient.

Although we will venture to point out some perceived shortcomings and strengths, of the proposed sites and the regulations covering them based on the above descriptive summary, our conclusions should be taken with extreme caution. We wish to emphasize that both proponents have done an enormous amount of work towards establishing an effective RQZ that provides an RFI free environment that may successfully host the SKA. We believe that any perceived regulatory shortcoming or advantage of either site is minor and does not confer a definitive advantage that would disqualify the other site.

5.a) Power levels allowed within the SKA core area

The detrimental power flux level threshold within the core area of either site has been established with reference to a fixed point located at the center of the area (as is the case with the quiet zones in existence, e.g. the US National Radio Quiet Zone- NRQZ). RQZs in existence were, however, established for the protection of single dish telescopes, not arrays, and RFI levels may vary considerably within an area of, say 5 km radius, that will house each of the three envisioned SKA core. Experience also shows that license holders balk at requests of mitigation measures beyond what is strictly in the regulations and that when such requests are made, they usually give rise to hard to solve disputes.

Consequently, the committee believes that a distributed system, such as the SKA, should be protected to the same power flux level within the entire core area. We realize, of course, that there is no precedent for a RQZ that is established under those conditions, and that establishing such an area is a difficult task.

The regulations for the core SKA areas currently in place at either of the sites makes it very difficult for new, licensed transmitters to be established. It is to be expected that this condition will result in the preservation of the present RFI (or, rather, RFI-free) situation in the core areas for the foreseeable future, thus making an assessment of their present condition even more important.

5.b) RQZ boundaries and regulatory regime

The AMWRQZ consists of an inner circle (core area) and an outer circular annulus (coordination area), defined over a common frequency range. The SAKRQZ is irregular in shape and segmented into Core, Central and Coordinated Astronomy Advantage Areas, that are further segmented by frequency ranges. There may be advantages to the simpler structure of the AMWRQZ, particularly when communicating the requirements to other spectrum users or to the public. Likewise, the regulatory regime of the AMWRQZ is relatively simple, as only one agency (ACMA) appears to be involved. In the case of the SAKRQZ there may be a potential for conflict between the Astronomy

Management Authority to whom the Minister of Science and Technology must transfer the task of spectrum oversight and ICASA.

5.c) General Power Flux Density level threshold in the RQZs

The allowable power flux density levels are considerable lower (more restrictive- by a margin of about 15 dB within the core and coordination areas of the SAKRQZ than within the AMWRQZ. It appears however that the SAKRQZ thresholds reflect the protection level requirements at the core, whereas the levels provided for the AMWRQZ reflect the requirements of the intermediate region, as the inner core region is controlled by the MRO. We believe however that this difference should be clarified.

5.d) Airborne, mobile and unlicensed transmitters

Airborne transmitters up to a height of 18500 m may, by order of the Minister, be excluded from airspace above the core and central AAAs in the SAKRQZ (AGA Act, Art. 21). No such limitation exists in the AMWRQZ (RALI: MS 32).

With certain exceptions, mobile, transportable, unlicensed and even short range transmitters or devices may be illegal to carry in, or operate in, core and central AAAs in the SAKRQZ (AGA Act, Art. 20).

While no such limitation exists in the RALI, we believe that overflights of the MRO are prohibited. In any event, while prohibiting overflights over, e.g. the inner core region is helpful, high flying aircraft will be line of sight to the telescope for many hundreds of kilometers

5.e) Coordination of spectrum management at remote stations

We believe that effective spectrum management at remote stations that are going to be located outside the SKA core host country will require establishing a central coordinating authority and unified regulations. An Australia/New Zealand SKA Coordination Committee (ANZSCC) exists (see introduction to the Radio-Quiet Zone Report for Australia and New Zealand), and this committee would, presumably, deal with such issues. No similar committee or mechanism appears to exist between South Africa and its SKA partners, but we believe that such a spectrum management coordination committee should also be established between South Africa and its partners, should South Africa be selected as the host country for the SKA.

Summary:

We reviewed in considerable detail the regulations covering both prospective SKA sites, based on the very extensive documentation provided.

We did identify one shortcoming that appears to be common to both sites, namely that the maximum tolerable interference level in the SKA core area is established with reference to a central point, and not with respect to the entire core area. Put differently, we believe that the central core region of the SKA should be protected to the same power flux level at any point within this geographic area.

We also identified a few advantages or shortcomings of each site from a regulatory point of view. We do not believe that:

- a) Any of the disadvantages identified could be a showstopper at either site.
- b) Any of the advantages identified confers a clear superiority to one site over the other from a regulatory point of view.

We believe that both sites have done extensive and highly effective work from a regulatory point of view and that, based purely on the regulatory environment, either site could provide an adequate home to the SKA.

12 October, 2011

Annex 1

Membership of the Committee

The Committee consisted mainly of members of the Site Characterization Working Group's Task Force on Regulatory Issues, excluding members directly connected to either of the candidate sites.

The membership consisted of Wim van Driel (France, chair), Tomas Gergely (USA), Harvey Liszt (USA) and Masatoshi Ohishi (Japan).

All members of the Committee want to emphasize that they took part in this work purely on a personal basis, and that the opinions expressed by the Committee do not, in any way, reflect the views of, nor should be attributed to, the institution or agency to which they belong.

Annex 2

List of acronyms used

AAA: Astronomy Advantage Area (South Africa)

ACMA: Australian Communications and Media Authority

AGA Act: Astronomy Geographic Advantage Act (South Africa)

AMWRQZ: Australian Mid West Radio Quiet Zone

CRAF: Expert Committee on Radio Astronomy Frequencies (European Science Foundation)

CSIRO: Commonwealth Scientific and Industrial Research Organisation (Australia)

ICASA: Independent Communication Authority of South Africa

IUCAF: Scientific Committee on Frequency Allocations for Radio Astronomy and Space Science

ITU: International Telecommunication Union

KCAA: Karoo Central Astronomy Advantage Area

KCooAAA: Karoo Coordinated Astronomy Advantage Area

KCC: Karoo Core Centre

MRO: Murchison Radio Observatory (Australia)

RAFCAP: Radio Astronomy Frequency Committee in the Asia-Pacific region

RALI: Radiocommunications Assignment and Licensing Instruction (Australia)

RFI: Radio Frequency Interference

RQZ: Radio Quiet Zone

SAKRQZ: South African Karoo Radio Quiet Zone

SARAS: South African Radio Astronomy Service

SSAC: SKA Site Advisory Committee (SKA)

SSG: Site Selection Group (SKA)