Submission to the Productivity Commission
'Review of the Radiocommunications Acts and the Role of the Australian Communications Authority'.

Australia Telescope National Facility CSIRO
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THE PROTECTION OF AUSTRALIAN RADIO ASTRONOMY AS PROVIDED WITHIN THE AUSTRALIAN RADIOCOMMUNICATIONS ACT

Background

(General reference: "ITU Handbook on Radio Astronomy", Radiocommunication Bureau, Geneva 1995)

For the purposes of management of the radio spectrum, the International Telecommunication Service (ITU) has accepted the science of Radio Astronomy as a radiocommunication service (the "Radio Astronomy Service"). This service is defined in Article 1 of the international Radio Regulations as being astronomy based on the reception of cosmic radio waves. It is considered as a "passive" service in that it does not involve the transmission of radio waves in the frequency bands allocated to it in the Table of Frequency Allocations of the Radio Regulations; radio astronomy use of these bands cannot cause interference to any other service. On the other hand, the received cosmic signals are extremely weak relative to the emitted signals of some services, and are therefore very susceptible to interference by such emissions.

Internationally, considerable efforts are being made to lessen the potential for interference to radio astronomy. The sharing of frequency bands with transmitting services is rather difficult; it is not usually possible to share when there is a direct line-of-sight between a radio astronomy antenna and a transmitter operating in the same band. A further problem, which is becoming more common, is emission introduced into radio astronomy bands by active services operating in other bands.

Currently, radio astronomy utilises the radio spectrum at frequencies from below 1 MHz to about 1,000 GHz, well beyond the frequency limit of 275 GHz considered in the Radio Regulations. Radio astronomers cannot always choose their frequencies arbitrarily. The emissions from atoms and molecules of interest in the interstellar medium have frequencies which are fundamentally set by atomic and molecular structure and vary according to the line-of-sight motions of the gas clouds. In addition, the expansion of the universe "shifts" these frequencies to other parts of the spectrum. Thus, a considerable proportion of the radio spectrum, greatly in excess of the frequencies allocated to radio astronomy in the Radio Regulations, is of potential scientific interest. Because of the frequency restrictions and sharing difficulties, radio astronomy is not easily accommodated within the system of allocations and regulations.

At the June 1999 OECD Science Ministers Summit Meeting, a Recommendation on spectrum management was adopted, as proposed by the OECD Megascience forum (which included policy makers from all OECD countries). This Recommendation is

directed towards increasing the awareness within Science Ministries of the problems confronting the scientific use of the radio spectrum and it states:
"The radio spectrum is a valuable public resource that is managed by national Administrations. Governments should exercise this authority to promote the continued expansion of global telecommunications and, at the same time, to protect scientist's ability to study the Universe. To this end, Governments should sponsor and promote a constructive dialogue involving the scientific community, the telecommunications industry, science funding agencies, national regulatory bodies, and the International Telecommunications Union. The goal of this activity should be to develop technological and regulatory solutions that ensure the continued access of scientists to portions of the radio spectrum at existing observatories, and that enable the limited number of new observatories to access most of the radio spectrum for significant periods of time, with minimum impact on the telecommunications industry".
The OECD Global Science Forum (previously the Megascience Forum) has established a "Task Force on Radio Astronomy and the Radio Spectrum" to work towards these goals, to identify technological and regulatory solutions, and to formulate a long-range strategic plan.

Radio Astronomy Facilities in Australia

Radio astronomy carried out using Australian facilities is at the forefront of the science and represents the result of a considerable Government investment in the facilities. The largest facility is the Australia Telescope (AT), operated as a National Research Facility by the Australia Telescope National Facility CSIRO (ATNF) on behalf of the scientific community in Australia. It is also accessible to overseas scientists on a quid pro quo basis involving Australian use of major overseas facilities. The AT includes three observatories in NSW, containing the 64-m diameter radiotelescope near Parkes, the six-antenna Australia Telescope Compact Array near Narrabri, and a 22-m diameter millimetre-wavelength antenna near Coonabarabran. This represents a financial capital investment of around $170 million by the Australian Government; and to demonstrate its continuing support of this prestigious national facility the government has recently made a contribution of some $9 million for upgrading the instruments. The technology developed for the AT has been of considerable value to the Australian telecommunications industry, and will continue to do so, and it is possible that ATNF technology, sensitivity and international connections could be of future value to the Australian spectrum management community.

Other facilities used for radio astronomy in Australia include the University of Sydney Molonglo Observatory Synthesis Telescope (MOST), University of Tasmania Mount Pleasant and Ceduna Observatories, and antennas of NASA's Canberra Deep Space Communication Complex (CDSCC).

To maintain its dominant position on the international stage, Australia has joined an international consortium in planning the construction of a state-of-art array telescope with a collecting area of a square kilometre, the Square Kilometre Array (SKA). If this instrument, costed at some $1 billion, were sited in Australia, there would be considerable economic spin-offs to this country. To further Australia's involvement

in the SKA, the Government has recently allocated about $13 million to radio astronomy, as part of the Major National Research Facilities Program announced in August 2001.

Spectrum use by Radio Astronomy Facilities

The frequency bands allocated to the Radio Astronomy Service on a primary or secondary basis are specified in the Australian Frequency Spectrum Plan. Unfortunately, in order to measure the faint cosmic signals needed to meet the demands of today's frontline radio astronomy research, the allocated radio astronomy bandwidths at centimetre wavelengths are far too narrow. Wider bands in unutilised parts of the spectrum must be used and the main frequency bands currently used by Australian radio astronomy facilities are given in footnote AUS87 of the Table of Frequency Allocations. This is consistent with the international Radio Regulations, which sanction use of spectrum allocated to other users provided that no interference is caused to allocated services.

Although it had been hoped that AUS87 would draw attention to the operation of the Australia Telescope, experience has shown that the Australian Radiofrequency Spectrum Plan is not always consulted as part of negotiations for transmitting licences. Consequently, the ATNF has recently taken out Earth Receive Licences for allocated bands within or close to the bands used for ATNF receivers, in the hope that this will lead to discussions with the ATNF during negotiations for transmitting licences in the bands specified in AUS87.

Of course, as active services take up their allocation options, these bands will progressively include narrow-band transmissions, and significant effort is now being spent on the development of interference mitigation techniques to counter these emissions. This will be particularly important for the SKA, the successful operation of which will depend on the ability to use wide interference-free bands at frequencies between approximately 100 MHz and 20 GHz.

The Review of the Radiocommunications Acts and the Role of the ACA, as related to Radio Astronomy

Australian Radio Astronomy has no mention in the 1992 version of the Radiocommunications Act, presumably because it is a passive service and cannot cause interference to other users of the radio spectrum. However, it is a significant user of the spectrum, with allocated bands in the international Radio Regulations which require protection. The past lack of recognition in the Act may have impacted detrimentally on the operations of radio astronomy in Australia, and the review of the Act offers a good opportunity to redress the situation. As a consequence of the growing demands on the spectrum, the threat of harmful interference in the radio astronomy bands will increase. The Global Science Forum of the OECD has recently recognized this problem and a Task Force on Radio Astronomy and the Radio Spectrum has been set up.

As the major Australian radio astronomy is carried out using National Research Facilities, and open to the scientific communities of Australia and elsewhere, it should be considered as an inclusion in the "community activity" category. As a high-profile science, it should be listed amongst the most common users of the radio spectrum because, notwithstanding the actual wide bands of frequencies that are currently being used for the reception of cosmic signals, a significant amount of radio spectrum (i.e. above 10 percent at frequencies below about 50 GHz, and a considerably larger percentage at higher frequencies) is allocated to the Radio Astronomy Service in the international Radio Regulations. Irrespective of licensing conditions, it seems illogical to ignore the existence of this major passive service, which often features prominently in discussions at ITU levels where it even has a dedicated working group (Working Party 7D, until recently chaired by Dr J. Whiteoak of the ATNF).

Specific comments concerning the ISSUES PAPER of the Radiocommunications Act Review, from the point of view of Radio Astronomy, are as follows:

Section 2.2: The approach to allocating spectrum under the Radiocommunications Act

On many occasions AUS87 of the Australian Radiofrequency Spectrum Plan was not used as an alert to assigners and consultants used in the spectrum allocation process. This may have been a consequence of the system of accreditation which allows people outside the ACA to undertake assessments of licence applications.

Since footnote AUS87 does not provide an effective alert to assigners and consultants, a more effective means of achieving a better solution is still being sought.
A limited solution can be obtained through Earth Receive Licences for frequency bands allocated to the Radio Astronomy Service in the international Radio Regulations (and the Spectrum Plan). These licences for the allocated RAS frequencies within the operating bands of Australian radio telescopes at least ensure protection of these frequencies nationally. This is important in that the bands allocated to the Radio Astronomy Service contain some of the most astrophysically important frequencies. However, there is no provision within the licensing system to provide an alert mechanism which would cover the total operating bands of Australian radio telescopes (as defined in AUS87), at the same time causing no operating restrictions whatever on services licensed to operate in the bands. The lack of such a mechanism increases the potential threat to future Australian radio astronomy.

Such an alert mechanism can be provided by the designation of "radio sensitive zones" around major radio astronomy facilities. In these zones notification to the facility of all transmitter applications in the specified bands should be mandatory. Technical solutions can be found in almost all cases to permit the operation of the transmitters without severe impact to the radio astronomy facility. Such zones have operated successfully for many years in the USA e.g. at the Greenbank Telescope (*www.gb.nrao.edu/nrqz.html*) and the Arecibo observatory in Puerto Rico (*www.naic.edu/techinfo/prcz/prczinfo.html*). It should be stressed that no enforced protection is sought in these zones, only notification and consultation.

Concerning licence conditions, radio astronomy is concerned with the reception of faint signals, some many tens of decibels below transmitter levels of active services. Therefore, interference from unwanted emissions created by other services is a great potential threat. Currently, the unwanted emission levels listed in the Radio Regulations are inadequate to protect radio astronomy and other passive science services. The ITU has recognized the problem, and this matter is under review in ITU-R Task Group 1/7. In view of the extensive international efforts, radio astronomers would prefer limits applied to services within Australia to be aligned with values accepted internationally.

Section 2.3: Charging for the use of spectrum

The licensing procedures have become a very effective means of raising government revenue to fund public expenditure, because the total revenue collected far exceeds licensing costs. Notwithstanding the benefit of this extra revenue in funding public expenditure, the community would greatly benefit if some of this money were focussed on R & D to "clean" up the spectrum, for example supporting research on lowering sidelobe levels of signals (in particular wideband spread-spectrum signals), improving filtering techniques, and developing general interference mitigation techniques.

Section 2.6: Non-commercial use of the spectrum

The ATNF is a National Research Facility provided by a Commonwealth institution (CSIRO) which operates radio astronomy facilities on a no-cost recovery basis to the Australian scientific community. Following accepted international practice the ATNF does not levy charges to recover the cost of its operations as a National Facility, and this position has been endorsed by ATNF ministerial-appointed Steering Committee. In this sense it could be argued that radio astronomy has "public purpose use of the spectrum" and thus is a non-commercial user of the spectrum. Because ATNF generates no revenue from its use of the radio spectrum, it cannot use such profits to defray licensing costs. Moreover, it is given no license exemption in Clause 6 of the Radiocommunications (Charges) Determination No 1 of 1997 and Regulation 5 of the Radiocommunications (Taxes Collection) Regulations. Appropriate definition of radio astronomy as a public or community service might enable the ATNF to argue for concessions or exemptions from fees and charges in any licensing arrangements that may be set up to protect its radio astronomy operations.

Section 2.11: Looking to the future

The success of future radio astronomy facilities such as the SKA, will depend on the ability to use wide interference-free bands at frequencies between approximately 100 MHz and 20 GHz. To achieve such an interference-free environment, the concept of "Radio-quiet Zones" has been proposed and it is actively being investigated. It is being proposed that such a Zone should be located in an isolated area with low population density and hence low spectrum use in defined bands.

The technical, legal and regulatory requirements of "Radio-quiet Zones" will need to be defined and officially recognised. This is of particular importance to Australia since it is the leading candidate for an SKA site.

Summary and proposals

Radio Astronomy is a purely "passive" service which only receives radio waves and cannot cause interference to other telecommunication services but is itself very susceptible to interference. It needs to use wide bands of frequencies, often in bands used by other services.

Australia has a number of world-class radio astronomy facilities and is a leading player in the international arena. The facilities are provided free of charge to the community and radio astronomy does not fit well in the current arrangements of spectrum licensing. Mechanisms such as footnote AUS87 in the Spectrum Plan and Earth Receive Licenses have failed to provide the needed protection.

It is suggested that provisions could be made in the Radiocommunications Act to enable the following radio astronomy protection measures, without disadvantaging any other telecommunication services:

- Establish **"radio sensitive zones"** around major radio astronomical facilities, with mandatory notification and consultation requirements for any proposed radio transmitters in the specified bands.
- Include radio astronomy in the **"community activity"** category of Radiocommunication services, as it appears to be left out of current arrangements.
- Facilitate arrangements to allow the ACA to commission research in areas such as interference mitigation and sharing studies. This could be paid from income derived from spectrum licenses.

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