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| IMT and Radio Astronomy Sharing Study |
| SPP 09/2011 |
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| |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Canberra**  Purple Building  Benjamin Offices  Chan Street  Belconnen ACT  PO Box 78  Belconnen ACT 2616  T +61 2 6219 5555  F +61 2 6219 5353 | **Melbourne**  Level 44  Melbourne Central Tower  360 Elizabeth Street Melbourne VIC  PO Box 13112  Law Courts  Melbourne VIC 8010  T +61 3 9963 6800  F +61 3 9963 6899 | **Sydney**  Level 15 Tower 1  Darling Park  201 Sussex Street  Sydney NSW  PO Box Q500  Queen Victoria Building  NSW 1230  T +61 2 9334 7700  1800 226 667  F +61 2 9334 7799 |  |  | |
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List of Acronyms

ACS Adjacent Channel Selectivity

BS Base Station

CEPT European Conference of Postal and Telecommunications

CSIRO Commonwealth Scientific and Industrial Research Organisation

ECC Electronic Communications Committee of CEPT

EIRP Effective Isotropic Radiated Power

IMT International Mobile Telecommunications. 3G and 4G mobile technology

LTE Long Term Evolution. The latest generation of IMT technology

RA Radio Astronomy

RALI Radiocommunications Assignment and Licensing Instruction

WAS Wireless Access Services

WCDMA Wideband Code Division Multiple Access modulation technology

WiMAX A wireless access service technology

1. Background

The 2500 – 2690 MHz band has been identified as a candidate band for the deployment of Wireless Access Services (WAS) using International Mobile Telecommunications (IMT) technologies in Australia. The adjacent 2690 – 2700 MHz band is allocated to passive services including Radio Astronomy, Earth Exploration Satellite and Space Research. Under the international footnote 340 in the Australian Radiofrequency Spectrum Plan[[1]](#footnote-1) emissions are prohibited in this band to protect these passive services.

The only currently licenses in the Australian Register of Radiocommunications Licences in the 2690 – 2700 MHz band are the CSIRO facilities at Parkes and Narrabri[[2]](#footnote-2) in central New South Wales. The purpose of this report is to gauge the risk of harmful interference to these Radio Astronomy (RA) sites in the event of the deployment of WAS in the 2500 - 2690 MHz band and to propose options for the protection of radio astronomy at those sites.

The frequency arrangements of International Telecommunications Union Radiocommunications sector (ITU-R) Recommendation M.1036-3 for the 2500 – 2690 MHz band have been adopted internationally to support terrestrial mobile telecommunications services. Frequency arrangement C1 in M.1036-3 places the Frequency Division Duplex (FDD) base station (BS) transmit segment in the upper portion of the band 2620-2690MHz.

Therefore out-of-band BS emissions falling into the band 2690-2670 MHz have the potential to cause interference to RA receivers. This paper does not consider the interference risk to the radioastronomy sites from transmitters other than the proposed BS transmitters operating in the 2.5 GHz band.

1. Method

This report uses the same method as RALI MS31[[3]](#footnote-3) to calculate zones of potential interference. The propagation model used was chosen in accordance with ITU-R Recommendation RA. 1031 eg ITU-R P.526 adjusted for 10% time availability. RA interference threshold levels are based on those in ITU-R Recommendation RA.769.

This report investigates the effects with 5 different out of band emission levels. The levels have been chosen either to match levels adopted by the European Conference of Postal and Telecommunications (CEPT) or to test possible alternatives. The zones were calculated and presented using WRAP software package for RF planning and modelling.

* 1. Radio Astronomy Parameters

There are two RA sites currently licensed in the 2690 - 2700 MHz band in Australia, one at Parkes, and one at Narrabri, their location details can be found in Appendix A. **Error! Reference source not found.** outlines the parameters that were used to model these sites in this study. The parameters used match the parameters agreed with CSIRO for RALI MS31.

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Value** | **Source** |
| Antenna Height | 30 m Parkes 18 m Narrabri | RALI MS31 |
| Antenna Gain towards horizon | -10 dBi Parkes -15 dBi Narrabri | CSIRO |
| Bandwidth | 10 MHz | Site Licence, ITU-R RA.769-2 |
| Interference Threshold (2000s integration time) | -187 dBm/MHz -247 dBm/Hz | ITU-R RA.769, RALI MS31 |

Table : Radio Astronomy parameters used in sharing study

In addition to the parameters above two assumptions have been made for RA in this study:

* RA station antenna have no preferred azimuth direction and have been modelled as having omni directional antennas as this allows interference from all directions to be examined simultaneously;
* It is assumed that the selectivity of RA is sufficient to prevent blocking or interference from IMT BS emissions in the IMT band. That is, that the out-of-band IMT emissions are the dominant interference mechanism.
  1. IMT Parameters

The parameters used in this study suit a generic IMT deployment. The parameters are equally valid for WCDMA, LTE or WiMAX. Base Station characteristics are shown in **Error! Reference source not found.**. Mobile Station parameters are not needed as they will be at the lower end of the 2500 – 2690 MHz band and are not likely to cause interference.

Note that the out-of-band limits are on axis EIRP limits, which means that they are the maximum power transmitted from the main beam of the antenna in the 2690 – 2700 MHz band. Antenna discrimination due to downtilt will reduce the power transmitted in the direction of the RA receiver.

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | | **Source** |
| OOB EIRP Limit A | +4 dBm/MHz | ‑56 dBm/Hz | CEPT 19 |
| OOB EIRP Limit B | ‑5 dBm/MHz | ‑65 dBm/Hz | ECC Report 45[[4]](#footnote-4) |
| OOB EIRP Limit C | ‑30 dBm/MHz | ‑90 dBm/Hz | 3GPP spurious emission limit |
| OOB EIRP Limit D | ‑36 dBm/MHz | ‑96 dBm/Hz | Assumed |
| OOB EIRP Limit E | ‑45 dBm/MHz | ‑105 dBm/Hz | CEPT 19 |
| Max Antenna Gain | 17 dBi | | Assumed |
| Antenna Gain towards horizon | 14 dBi | | Assumed |
| Height | 30 m | | Report ITU-R M.2039 |
| Bandwidth | 5 MHz | | Report ITU-R M.2039 |

Table : IMT BS parameters used in sharing study

1. Results

RALI MS31 specifies that negotiation with CSIRO is triggered if the interfering power exceeds the threshold level as follows:

Where is the transmitter power spectral density and the path loss is that calculated with ITU-R P.526. The 3.9 dB figure is an adjustment for 10% time availability. The threshold level in the RALI already includes the adjustment for RA antenna gain towards the horizon. In this study it has been separated out, therefore this equation can be expanded as follows:

Where is the Radio Astronomy Antenna Gain towards the horizon. is the difference between the IMT on axis gain, and gain towards the horizon. This study uses an on axis gain is 17 dBi, while gain towards the horizon is 14 dBi, meaning is 3 dB. is then the on axis EIRP. The minimum isolation required, which includes both the pass loss and adjustment for p=10%, can be calculated by rearranging this formula.

For the four IMT emission limits specified above the following table can be calculated:

|  |  |  |  |
| --- | --- | --- | --- |
| OOB emission limit | Spectral Density | Isolation required for Parkes | Isolation required for Narrabri |
| 4 dBm/MHz | ‑56 dBm/Hz | 178 dB | 173 dB |
| -5 dBm/MHz | ‑65 dBm/Hz | 169 dB | 164 |
| -30 dBm/MHz | ‑90 dBm/Hz | 144 dB | 139 |
| -36 dBm/MHz | ‑96 dBm/Hz | 138 | 133 |
| -45 dBm/MHz | ‑105 dBm/Hz | 129 | 124 |

Table : Minimum Required Isolation

These isolation requirements match closely with those derived in European studies reported in ECC Report 45[[5]](#footnote-5). Differences are a result of using slightly varying assumptions about clutter, the IMT and radio astronomy parameters. The parameters used in this report are tailored to suit the Parkes and Narrabri observatories and potential 2.5 GHz deployments while ECC Report 45 uses generic characteristics.

The resulting zones are colour coded in the following manner.

|  |  |
| --- | --- |
|  | +4 dBm/MHz EIRP limit |
|  | -5 dBm/MHz EIRP limit |
|  | -30 dBm/MHz EIRP limit |
|  | -36 dBm/MHz EIRP limit |
|  | -45 dBm/MHz EIRP limit |

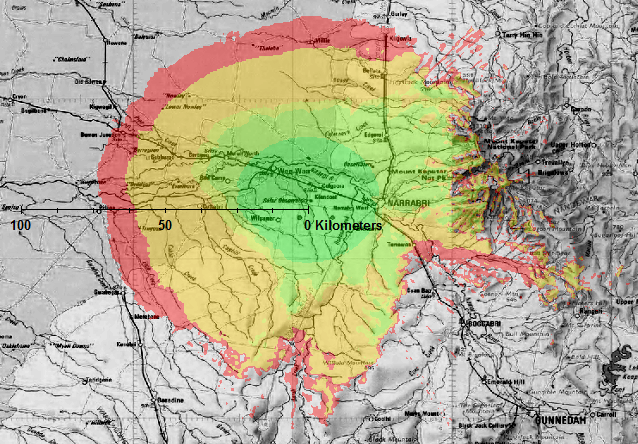


Figure : Base station interference zones around Narrabri

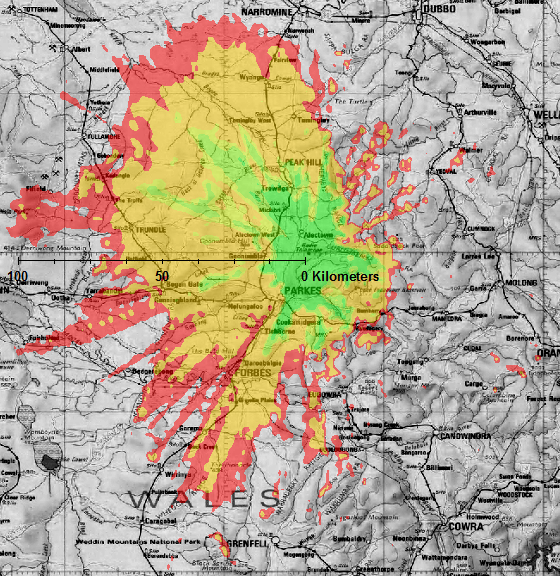


Figure : Base station interference zones around Parkes

1. Discussion of Results

The resulting zones in Figure 1 and Figure 2 extend as far as 100 km from the Radio Astronomy sites. Limiting IMT BS emissions to less than -30 dBm/MHz, the zones drop to roughly 50 km or less. This large area is due, in a large part, to the sensitivity of the equipment used at RA sites. Some noticeable overall trends are:

* The Great Dividing Range provides significant shielding to RA sites from interference to the East (the most populated areas);
* The size of the interference zones decreases rapidly with stricter emission limits;

There are numerous mitigation techniques available to reduce the potential for interference, thereby increasing protection to the RA while increasing deployment opportunities for IMT. Such techniques could be used to decrease the size of any interference zone that is created. However, it may not be practical to implement any or all of these techniques at all locations, therefore their application needs to be considered on a site by site basis. Some examples of various mitigation techniques are listed below:

* **Lower base station height**: The effects of reducing the height of the base station are highly dependent on the location of the base station, and the surrounding terrain, however in some circumstances this effect can be significant enough to eliminate the potential for interference.
* **Use clutter data in modelling:** By better modelling the effects of losses due to vegetation and even manmade obstacles, further reductions in interference can be achieved;
* **Beam forming and null steering:** This is an advanced antenna technique that takes into account that the next generation base stations can direct narrow beams in the direction of the MS, or if required direct nulls in the direction of a victim receiver. However, the impact of such technologies on interference scenarios still requires further investigation and in the case of beam forming will require statistical analysis.
* **Site engineering:** By strategically placing antennas, for example pointing antennas away from the RA sites, taking advantage of natural or manmade shielding, a significant reduction in interfering power can be achieved.
  1. Notification and Coordination Zones

The nearest band to 2690 – 2700 MHz that RALI MS31 applies to is 2200 – 2550 MHz where it specifies a notification zone of 180 km for apparatus licensed devices. A notification zone is an area in which CSIRO must be informed of any deployments that could potentially cause interference to their operations.

This study has used the same criteria and methodology as the RALI, with parameters specified for IMT operation at (or just below) 2690 MHz. The results from this study show that given worst case assumptions interference would not occur past 100 km at Parkes, or about 75-80 km at Narrabri. Therefore there is no reason to have a notification zone larger than 100 km. The notification zones are smaller in size compared to the RALI as the RALI is applicable to licensed stations with higher transmitter power densities, higher typical antenna heights and using lower frequencies than those of the IMT equipment in the 2500-2690 MHz band.

If tighter out of band emission limits are specified in licence documentation, the risk to CSIRO facilities will not eventuate until much closer to the RA facilities. A smaller coordination zone could then be chosen to suit that level of emission. A coordination zone would require the coordination of services with the RA facilities.

Given that there are plenty of mitigation methods that can be employed to prevent interference into the RA sites, the requirement to coordination with CSIRO does not imply that IMT services will not be able to operate within this zone.

1. Conclusion

With a +4 dBm limit the results show that a notification zone of roughly 100 km will be needed to the west of Parkes, and just over 75 km to the west of Narrabri. The size of these zones reduces substantially as the out of band emission limits become tighter, culminating in zones of roughly 20 kilometres with -45 dBm limits.

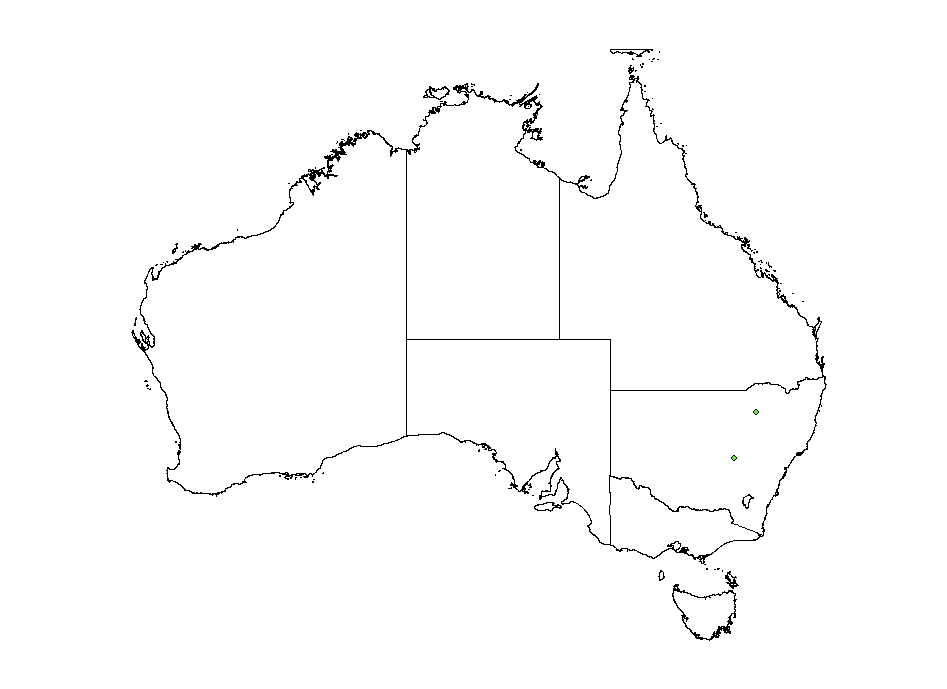
The protection of radio astronomy service will require the combined use of emission limits and coordination zones although these could be reduced somewhat by better modelling and tailoring of individual sites.

1. Radio Astronomy Sites

There were two licensed radio astronomy sites operating in the 2690-2700 MHz band in Australia as of 4/1/2011. Their details are list in Table 4 and their locations are shown in Figure 3.

| Access ID | Assigned Frequency (MHz) | Bandwidth (MHz) | Latitude | Longitude | Location | Antenna Gain (dBi) | F/B (dB) | Licensee |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1141190 | 2.695 | 10 | -32.999962 | 148.262297 | PARKES | 33 | 41 | CSIRO |
| 1141197 | 2.695 | 10 | -30.314454 | 149.548977 | NARRABRI | 33 | 41 | CSIRO |

Table : Specific Radiocommunications license data for RA sites



Parkes

Narrabri

Figure : RA site in Australia; Parkes and Narrabri

1. A copy of the plan is available at: <http://www.acma.gov.au/WEB/STANDARD/pc=PC_2713> [↑](#footnote-ref-1)
2. Further information regarding these sites can be found at: <http://www.atnf.csiro.au/> [↑](#footnote-ref-2)
3. Radiocommunications Assignment and Licensing Instruction MS31 “Notification Zones for Apparatus Licensed Services around Radio Astronomy Facilities” available from the ACMA website. [↑](#footnote-ref-3)
4. This figure is the average power an RA receiver will experience based on the spectral emission mask and calculation method outlined in Annex C of ECC Report 45. [↑](#footnote-ref-4)
5. ECC Report 45 “Sharing and adjacent Band Compatibility Between UMTS/IMT-2000 in the Band 2500-2690 MHz and other Services” Granada, February 2004 [↑](#footnote-ref-5)