



Australia's RFI-quiet site: enabling world-class radioastronomy

Kate Chow, CASS

Outline

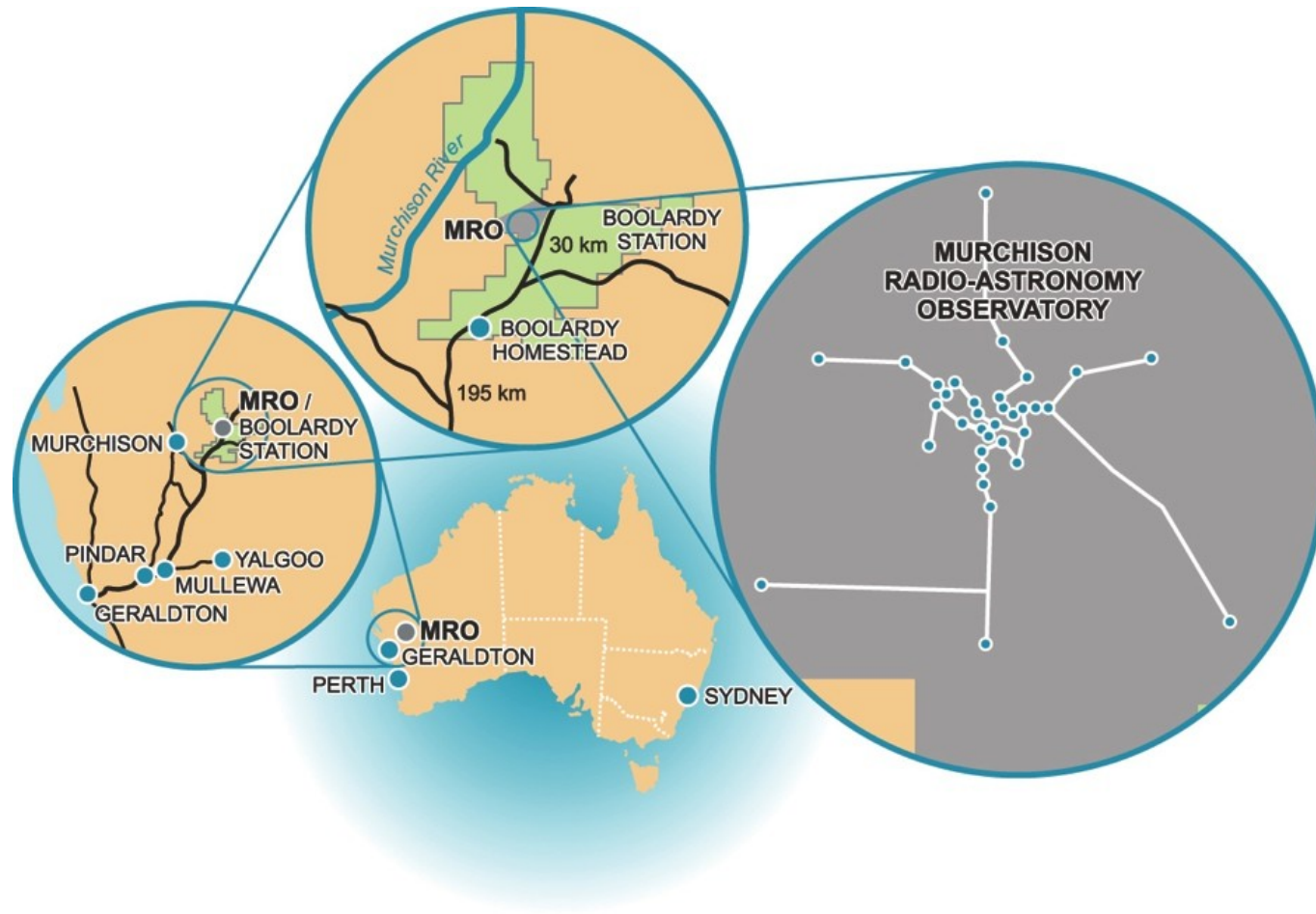
- Why the Murchison Radio-astronomy Observatory?
- What is a radio quiet zone?
- Licenses
- The ARQZWA legislation and controls
- Internal RFI
- Conclusions



Why the Murchison Radioastronomy Observatory (MRO)?

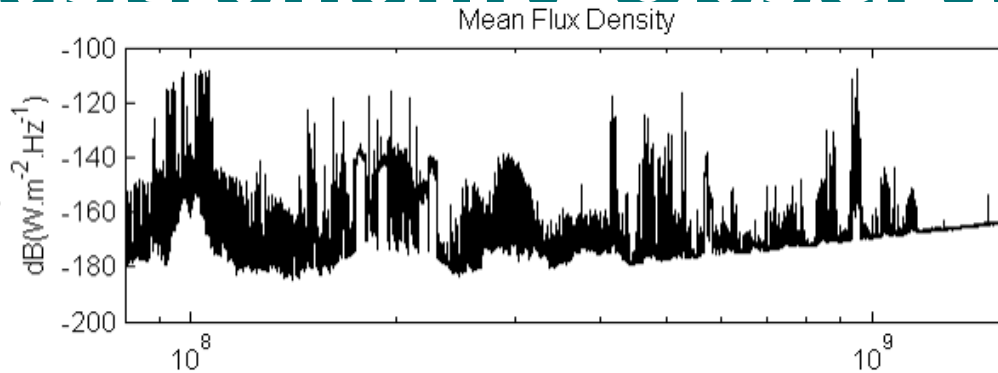
- Remote location
- Nearest town is 145km away (population 320)
- Current site of ASKAP (36 dishes, 700 – 1800 MHz)
- Current site of MWA (2048 dipoles, 80 – 300 MHz)
- Core of Australian SKA phase 1: SKA1-Low Aperture array of dipoles, 70 – 350 MHz

Why the Murchison Radioastronomy Observatory

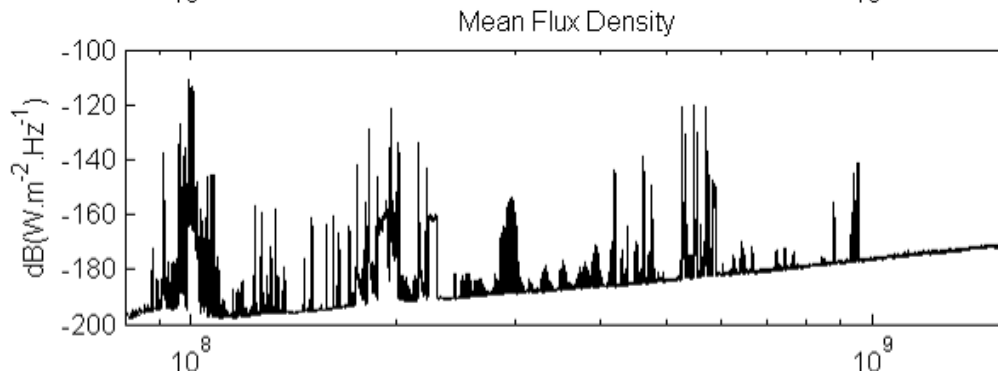


Why the Murchison Radioastronomy Observatory

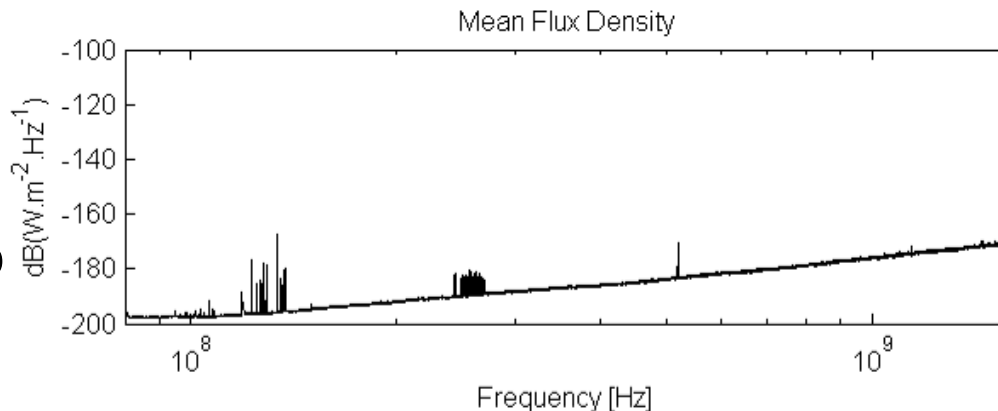
Sydney
Population 4
million



Narrabri
Population 6,000



Murchison
Population 4



What is a radio quiet zone?

- Somewhere to do world-class radioastronomy, i.e. “A radio quiet zone is a geographic area within which signal levels from radiocommunications transmitters are controlled in some way to minimise the strength of electromagnetic energy within the area”
- The MRO is the most well protected radio astronomy site in the world
- Protected radioastronomy controls



Licenses

Every radio frequency transmitter (9 kHz to 275 GHz) must be licensed.

In Australia, the ACMA issues:

- **Apparatus** licence – individual devices. Example: earth station, fixed point-to-point link, broadcasting tower.
- **Spectrum** licence – spectrum width x geographic area x time. Example: 3G mobile systems. Ideally technology-neutral.
- **Class** licence – low interference devices. “Public park” in certain frequency bands. No cost, no paperwork. No guarantee of service level. Does have restrictions on application and EIRP level.



And then there are Incidental Emissions...

Licenses and the legislation to control RFI

Radio communication transmitters

Other electrical systems

Spectrum licensed

Apparatus licensed

Class licensed

Incidental emissions

Licensed area excludes a region in the RQZ

Spectrum licences held by major mobile network carriers

Frequency Band Plan and RALI MS 32: radio transmitters secondary to radioastronomy within 70 km radius.

Limits on interference from new transmitters in zones from 70 to 260 km radius; consultation with MRO Entity required.

Once notified, users of devices within 70 km of RQZ centre must not cause interference to radioastronomy.

Mineral Resource Management Area requires mining activities within 70 km of RQZ centre to submit a Radio Emissions Management Plan

Policies in place for limits on self-generated emissions (by telescope equipment)

The Australian Radio Quiet Zone WA (ARQZWA) legislation and controls

The MRO grounds (120 km²)

- Full/self-control; standards for RFI from observatory equipment

Boolardy Pastoral Station (3467 km²/856,835 acres)

- CSIRO held and operated controls and alternatives



The Australian Radio Quiet Zone WA (ARQZWA) legislation and controls

Mineral Resource Management Area (70 km radius) – WA gov't

- Controls for non-licensed radiators (incidental)

Section 19 – WA gov't

- Embargo on new mines in the region

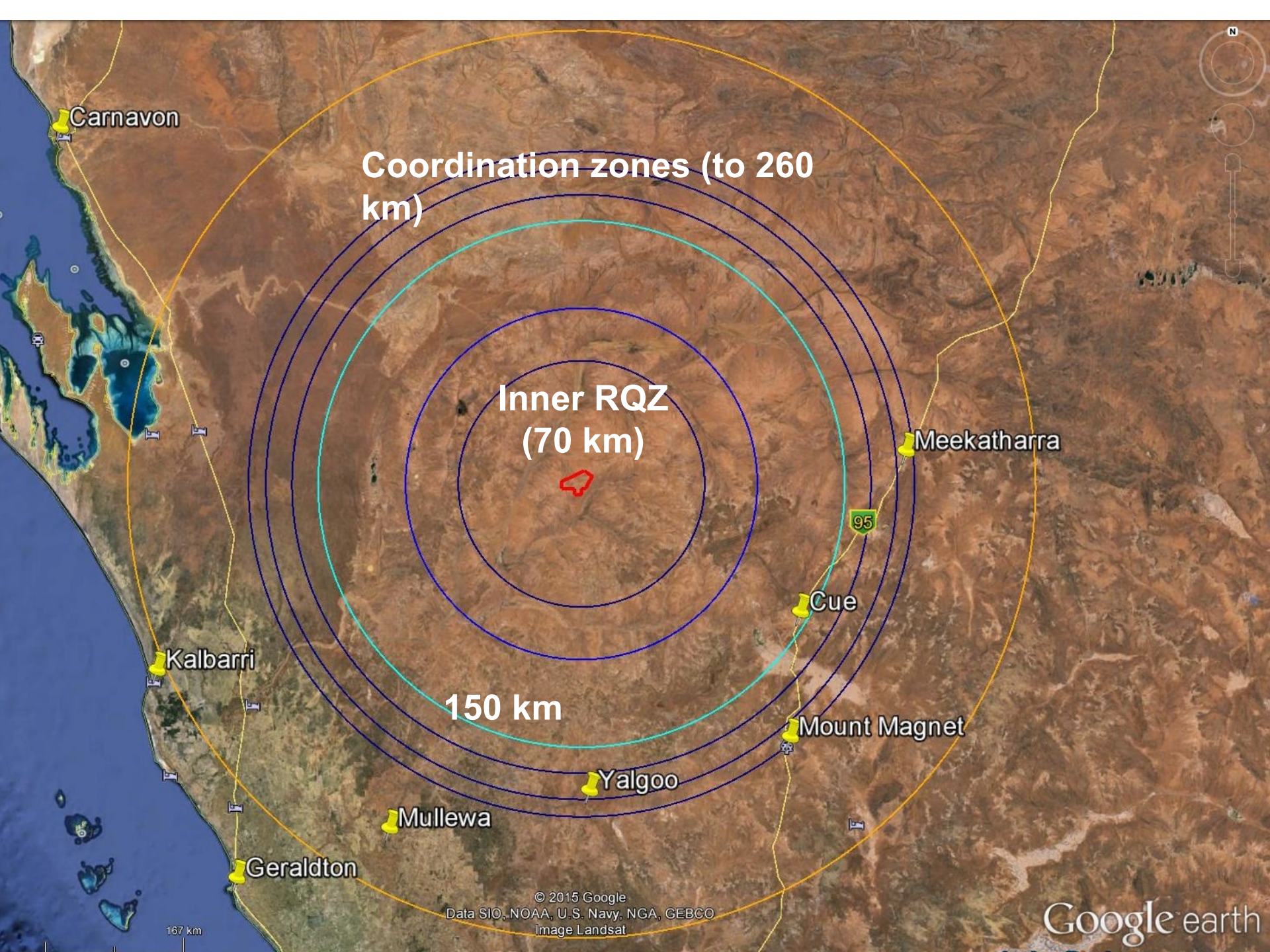
ACMA Frequency Band Plan – July 2011 – Commonwealth

- Radioastronomy is primary within 70 km; consultation within 150 km
- Class licence conditions – devices within 70 km cannot cause interference

RALI MS 32 – September 2007, updated December 2014 – Commonwealth

- Protection levels at distances up to 260 km (based on frequency)

This level of protection for a site is unprecedented!



Coordination zones (to 260 km)

Inner RQZ
(70 km)

150 km

Carnavon

Kalbarri

Geraldton

Mullewa

Yalgoo

Cue

Mount Magnet

Meekatharra

95

167 km

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Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat

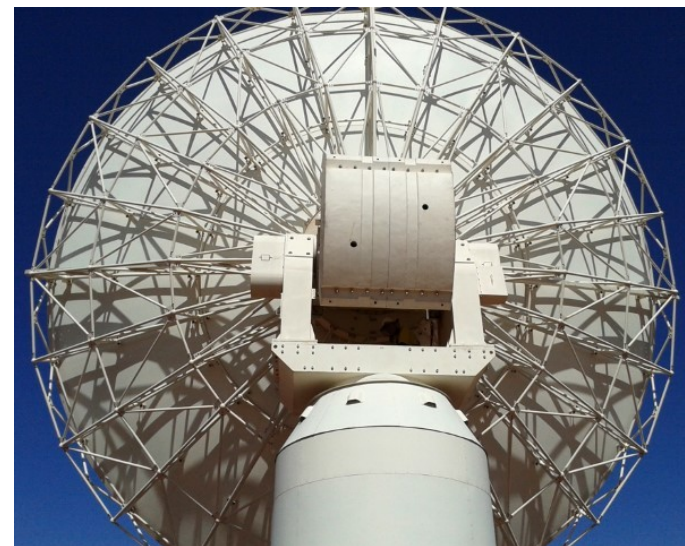
Google earth

What is not covered by the RQZ?

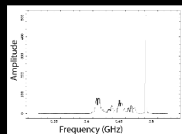
The Radio Quiet Zone does not guarantee absence of interference to radioastronomy observations.

Current regulations do not cover:

1. Frequencies below 70 MHz
2. Aircraft transmissions
3. Satellite transmissions
4. Transmitters beyond 260 km from centre of MRO



ASTRONOMY AND SPACE SCIENCE
www.csiro.au



Driving to and around the MBO



"Help us listen to whispers from space"

CSIRO's Murchison Radio-astronomy Observatory (MRO) is an excellent radio quiet place and unique observatory; it is the most protected radio astronomy site in the world.

The MRO is the site of the Australian Square Kilometre Array Pathfinder (ASKAP), the Murchison Widefield Array (MWA), and the future core site of the Australian component of the international Square Kilometre Array (SKA) telescope project.

The MRO is situated inside the Australian Mid West Radio Quiet Zone (RQZ), an area 260km in radius that is protected by Federal Government legislation and regulations to control activities that can cause radio-frequency interference to the telescopes.

To preserve the radio quiet nature of the MRO, we require you to:

- Minimise the use of vehicles on Boolardy Station and the MRO
- Minimise the use of UHF/VHF radios on Boolardy Station and the MRO
- Turn off devices such as laptops, iPads, and mobile phones
- Not stay on or near the MRO at night (i.e. no camping)

What is RFI?

Radio astronomers examine astronomical objects such as stars, galaxies and other objects by using radio telescopes to collect cosmic radio waves. Radio telescopes are designed to detect extremely faint radio signals from space, making them highly sensitive to radio-frequency interference (RFI) caused by other radio transmissions, such as signals from mobile phones, two-way radios and broadcasting towers, or by electrical equipment such as vehicles, appliances or electrical machinery.

RFI can also be emitted from many of the devices that you might otherwise expect

to use on a radio-astronomy site, such as a wireless computer mouse, microwaves, mobile phones, car engines, Bluetooth devices, keyless car entry, or electronic tablets. RFI is a major and increasingly serious issue for many radio astronomy observatories.

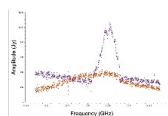
The MRO was specifically chosen to be located in an area with low population density (thus removed from TV, AM/FM radio and mobile phone towers), however many of these personal items are commonly brought with people visiting the site.

Why is RFI a problem?

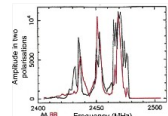
Everyday devices can emit RFI at levels that are high enough to cause damage to the highly sensitive observations of the radio telescopes at the MRO. This RFI then interferes with the detection of weak radio signals from the sky.

A typical radio telescope, such as the CSIRO Parkes 64m radio telescope (aka "The Dish"), is 15 orders of magnitude (i.e. 1,000,000,000,000,000 times) more sensitive to radio signals than a typical mobile phone.

For a radio telescope, the effect of bringing a WiFi device close is analogous to a person standing next to a jackhammer while trying to listen to music. The WiFi device creates so much 'radio noise' that the telescope can't 'hear' the weak radio signals arriving from outer space.



A TV transmitting station, even a long distance away, can also cause high levels of RFI. This figure shows a huge spike in the amplitude of a radio signal received by the Murchison Widefield Array (MWA) telescope at the MRO – representative of the detection of a TV station at 185 MHz. The spike is almost three times higher than the 'normal' level (shown in orange). Even an RFI-emitting object several hundred kilometers away can affect the radio observations at the MRO – imagine how 'radio loud' it would be if it was on site!



The effect of a microwave oven being used during standard observations on the site of CSIRO's Australia Telescope Compact Array (ATCA) in Narrabri. The microwave emits broadly across the part of the radio band, with the worst peaks at around 10,000 times higher than the 'normal' level. If you have a microwave oven with you, in a caravan for example, please do not even have the power to it turned on while you are on Boolardy Station.



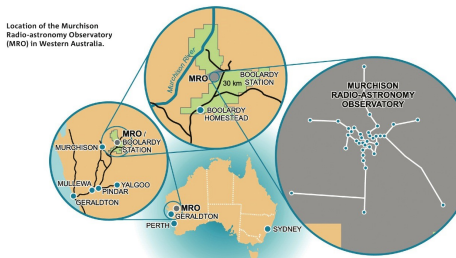
~~Mobile Phone~~ ~~Smart Phone~~ ~~Laptop~~ ~~Wi-Fi~~ ~~Bluetooth~~

- Don't**

- ✗ Use your mobile phone on Boolardy Station or the MRO (there will be no signal anyway)
- ✗ Use your laptop on the MRO (except in the shielded control building)
- ✗ Use Bluetooth or WiFi on Boolardy Station or the MRO
- ✗ Stay on or near the MRO at night (i.e. no camping)
- ✗ Use cameras unless approved by the CSIRO Site Manager
- ✗ Lock cars with the wireless remote

- Do

- ✓ Turn off your WiFi and Bluetooth capability on all devices, including phones, laptops and iPads while on Boolardy Station and the MRO
- ✓ Turn off mobile phones while on Boolardy Station or the MRO
- ✓ Minimise the use of vehicles on Boolardy Station and the MRO
- ✓ Minimise the use of UHF/VHF radios on Boolardy Station and the MRO
- ✓ Lock cars using the manual locking mechanisms.



CONTACT US
t 1300 363 400
+61 3 9545 2176
e enquiries@csiro.au
w www.csiro.au

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FOR FURTHER INFORMATION

Dr Kate Chow
t +61 2 9372 4516
e kate.chow@csiro.au
w www.atnf.csiro.au/projects/askap
www.atnf.csiro.au/ska



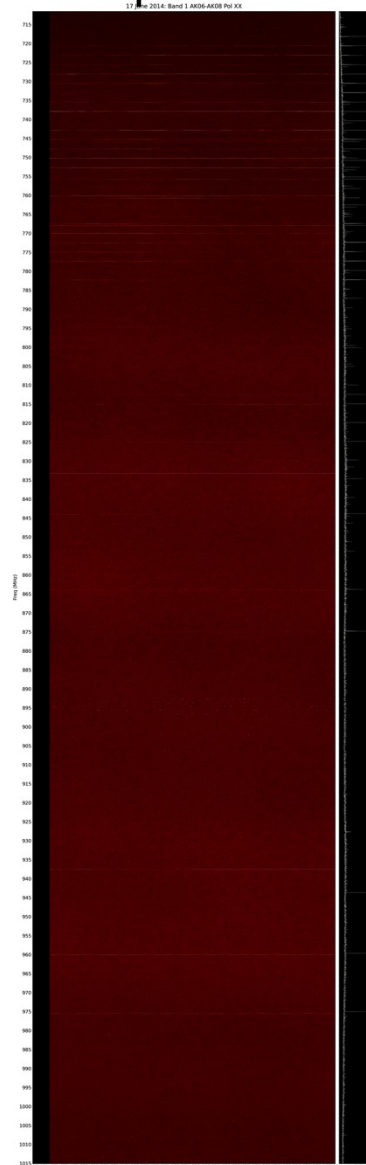
Night-time spectrum

ASKAP Band 1 Spectrum

Frequency range 715-1015 MHz

Band 1 generally free from broadband emission at night and weekends.

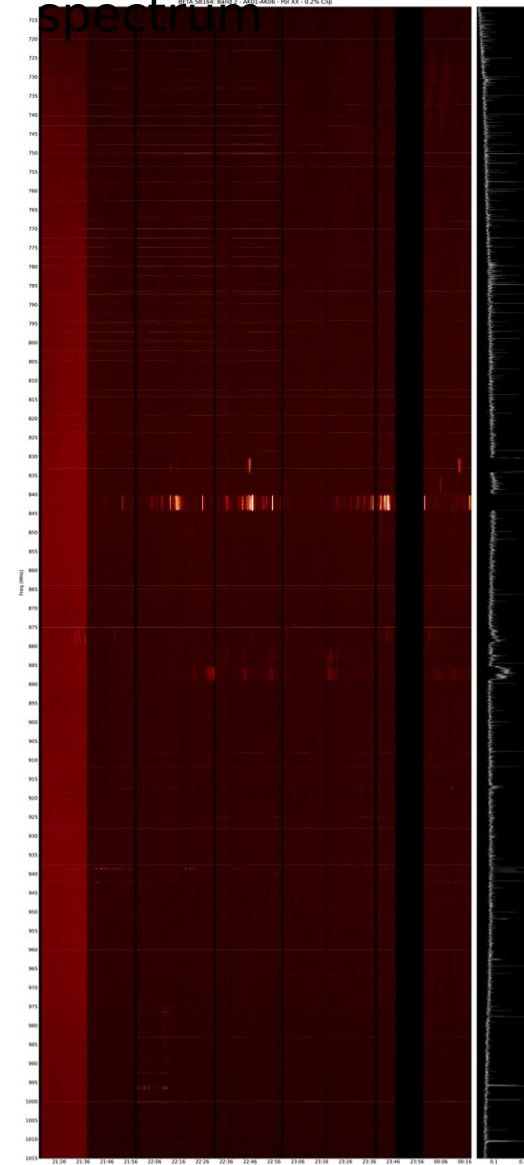
Weekday broadband RFI seen beginning around 8am in Telstra transmission bands.



1:45am

2:15am

Weekday daytime spectrum



8am

10am

Telstra
NextG
Handse
t
Telstra
tower
Meekathar
ra

Conclusions

- Radioastronomy shares spectrum with many other radio systems.
- The MRO is an unprecedented radio quiet site (the best in the world)
- Important to keep internal and external RFI to a minimum to enable world-class radioastronomy!
- More information available from CASS and from



Thank you!

CSIRO acknowledges the Wajarri Yamaji people as the traditional owners of the Observatory site.



Image credit: CSIRO (left) and Alex Cherney (right)



CSIRO RFI standards for self-compliance at the MRO

Distance (km)	Target emissions	Means of compliance	Comments
$d > 10$	Less than or equal to levels defined in Military standard MIL-STD-461F category RE102, Navy Mobile and Army	Equipment should be tested to MIL-STD-461F, and if required, additional screening provided to meet target emissions level.	
$10 > d > 1$	Less than or equal to 20 dB below Military standard MIL-STD-461F.	Equipment should be tested to MIL-STD-461F, and if required, additional screening provided to meet target emissions level.	Need to take great care with equipment connections to maintain RFI screening between tested components
$d < 1$	Less than or equal to 80 dB below Military standard MIL-STD-461F.	Equipment should be tested to MIL-STD-461F, and if required, additional screening provided to meet target emissions level.	Only permitted on a case-by-case basis with careful testing

RALI MS 32 distances and three

Frequency Range (MHz) ⁹	Coordination Radius (km)	Threshold at ARQZWA centre (dBm/Hz)	Maximum allowable power level within 50 kilometres (dBm)
70-100	260	-211	-90
100-230	260	-214	-90
230-400	180	-222	-95
400-520	165	-224	-95
520-694	190	-224	-95
694-1000	145	-228	-95
1000-2300	140	-230	-95
2300-6000	120	-232	-95
6000-10000	100	-232	-95
10000-25250	100	-236	-95

Table 1: Coordination Zone Parameters (centre latitude 26.704167 South and longitude 116.658889 East (GDA94 datum).

If the power at the MRO is above the relevant threshold, consultation with CSIRO is required