



# ACMA interim arrangements for W-band fixed satellite service earth station transmitters

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## Background

CSIRO welcomes this opportunity to provide input to the Australian Communications and Media Authority (ACMA)'s consultation relating to Interim arrangements for W-band fixed satellite service earth station transmitters.

CSIRO's Australia Telescope National Facility (ATNF) operates the Australia Telescope Compact Array (ATCA) near Narrabri, and the Mopra radio telescope near Coonabarabran, both facilities using the W-band for scientific observations of radio astronomy sources between 75 – 116 GHz.

The Australian Radio Spectrum Plan (ARSP) 2021 has the following allocations and footnotes in the W-band frequencies under consideration listed:

Table 1 FS: Fixed Service, MS: Mobile Service, RAS: Radio astronomy service, RLS: Radiolocation service, RNS: Radionavigation service, RNSS: Radionavigation satellite service, SRS: Space research service

Frequency [GHz]	Allocation	Relevant footnotes
92 – 94	FS, MS, RAS, RLS (all co-primary)	AUS87, 5.149, 5.338A
94.1 – 95	FS, MS, RAS, RLS (all co-primary)	AUS87, 5.149
95 – 100	FS, MS, RAS, RLS, RNS, RNSS (all co-primary)	AUS87, 5.149, 5.554
102 – 105	FS, MS, RAS (all co-primary)	AUS87, 5.149, 5.341
105 – 109.5	FS, MS, RAS, SRS (passive) (all co-primary)	AUS87, 5.149, 5.341, 5.562B
111.8 – 114.25	FS, MS, RAS, SRS (passive) (all co-primary)	AUS87, 5.149, 5.341, 5.562B

The relevant and applicable footnotes are:

**AUS87** Radio astronomy facilities operated by the CSIRO at the Paul Wild Observatory Narrabri (latitude 30° 18' 46.40" S, longitude 149° 33' 0.44" E), the Parkes Observatory (latitude 32° 59' 54.25" S, longitude 148° 15' 48.65" E) and the Mopra Observatory Coonabarabran (latitude 31° 16' 04.12" S, longitude 149° 05' 58.72" E) and by the University of Tasmania at the Mount Pleasant Observatory Hobart (latitude 42° 48' 12.92" S, longitude 147° 26' 25.86" E) and the Ceduna Observatory (latitude 31° 52' 03.69" S, longitude 133° 48' 35.40" E), and at the Canberra Deep Space Communication Complex (latitude 35° 23' 54.46" S, longitude 148° 58' 39.66" E) conduct passive observations in the frequency bands 1.2–1.8 GHz, 2.2–2.7 GHz, 4.5–6.7 GHz, 8–10 GHz and 16–26 GHz using receivers that are highly sensitive to interference. The Paul Wild and Mopra observatories also operate in the bands 30–50 GHz and 75–115 GHz.

**5.149** In making assignments to stations of other services to which the bands:

13 360-13 410 kHz, 25 550-25 670 kHz, 37.5-38.25 MHz, 73-74.6 MHz in Regions 1 and 3, 150.05- 53 MHz in Region 1, 322-328.6 MHz, 406.1-410 MHz, 608-614 MHz in Regions 1 and 3, 1 330-1 400 Hz, 1 610.6-1 613.8 MHz, 1 660-1 670 MHz, 1 718.8-1 722.2 MHz, 2 655-2 690 MHz, 3 260-3 267

MHz, 3 332-3 339 MHz, 3 345.8-3 352.5 MHz, 4 825-4 835 MHz, 4 950-4 990 MHz, 4 990-5 000 MHz, 6 650-6 675.2 MHz, 10.6-10.68 GHz, 14.47-14.5 GHz, 22.01-22.21 GHz, 22.21-22.5 GHz, 22.81-22.86 GHz, 23.07-23.12 GHz, 31.2-31.3 GHz, 31.5-31.8 GHz in Regions 1 and 3, 36.43-36.5 GHz, 42.5-43.5 GHz, 48.94-49.04 GHz, 76-86 GHz, 92-94 GHz, 94.1-100 GHz, 102-109.5 GHz, 111.8-114.25 GHz, 128.33-128.59 GHz, 129.23-129.49 GHz, 130-134 GHz, 136-148.5 GHz, 151.5-158.5 Hz, 168.59-168.93 GHz, 171.11-171.45 GHz, 172.31-172.65 GHz, 173.52-173.85 GHz, 195.75-196.15 GHz, 209-226 GHz, 241-250 GHz, 252-275 GHz

are allocated, administrations are urged to take all practicable steps to protect the radio astronomy service from harmful

interference. Emissions from spaceborne or airborne stations can be particularly serious sources of interference to the radio astronomy service (see Nos. 4.5 and 4.6 and Article 29). (WRC-07)

**5.338A** In the frequency bands 1 350-1 400 MHz, 1 427-1 452 MHz, 22.55-23.55 GHz, 24.25-27.5 GHz, 30-31.3 GHz, 49.7-50.2 GHz, 50.4-50.9 GHz, 51.4-52.4 GHz, 52.4-52.6 GHz, 81-86 GHz and 92-94 GHz, Resolution 750 (Rev.WRC-19) applies.

**5.341** In the bands 1 400-1 727 MHz, 101-120 GHz and 197-220 GHz, passive research is being conducted by some countries in a programme for the search for intentional emissions of extraterrestrial origin.

**5.554** In the bands 43.5-47 GHz, 66-71 GHz, 95-100 GHz, 123-130 GHz, 191.8-200 GHz and 252-265 GHz, satellite links connecting land stations at specified fixed points are also authorized when used in conjunction with the mobile-satellite service or the radionavigation-satellite service. (WRC-2000)

**5.562B** In the frequency bands 105-109.5 GHz, 111.8-114.25 GHz and 217-226 GHz, the use of this allocation is limited to space-based radio astronomy only.

In summary, RAS has co-primary allocations in the entirety of the W-band under consideration, while FSS has none.

# CSIRO's Consultation Feedback

CSIRO has four main concerns about ACMA's plan to allow earth stations to transmit to NGSO systems at these W-band frequencies, as detailed below.

## Interference to terrestrial RAS observations

Earth stations transmitting in this frequency band will cause intermittently severe interference to W-band observations made with the ATCA or Mopra telescopes by way of RF power reflected from the satellite bodies illuminated by the earth station transmitters. This is of particular concern considering the earth stations will be aiming their transmissions at the satellites and thereby fully illuminating their radar cross sections, causing reflections that can be detected at many different line-of-sight angles depending on the geometric arrangement of radar reflective surfaces on the satellite bodies.

CSIRO proposes that ACMA require that the impact of this is modelled using an equivalent power flux density (epfd) calculation method. We are not able to do such a calculation in detail at this stage as it requires information we do not currently have, such as the transmit powers and bandwidths, the satellite body radar cross sections, and the geometry of potentially reflective surfaces (e.g. solar panels, antennas, enclosure angles and materials). We can however make some assumptions for an estimate on the potential effect on RAS, shown in the following test case calculation.

### Test case calculation

This test case for an earth station transmitter in Sydney and ATCA as the receiving station, makes the following assumptions:

- Satellite assumed midway between sites (symmetric) or directly over Sydney (asymmetric).
- Earth station Tx power: 100W (20 dBW) over a bandwidth of 250 MHz.
- Earth station antenna: 50 dBi gain (typical for a 1m dish at W-band).
- Only a single earth transmitter in operation at a time.
- RCS of 40 m<sup>2</sup> for the specular radar cross section.
- ATCA/Mopra dish: 22m diameter, 55% aperture efficiency at W-band for the beam-coupling case, 0 dBi gain assumed for the general case.
- Atmospheric attenuation calculated using the ITU-R P.676 model
- No polarization mismatch losses.
- Assumes perfect reflection geometry with specular reflection toward telescope.
- To calculate the RAS margin, we use the ITU-R RA.769 spectral power density interference threshold levels applicable in these bands: -288.4 dB (W/Hz)



Under these assumptions, and using the bistatic radar equation, we calculate the following results:

Freq GHz	Asymmetric (satellite in the middle)		Symmetric (satellite over Sydney)	
	sPFD dB(W / Hz)	RAS margin dB	sPFD dB(W / Hz)	RAS margin dB
92	-225.6	-62.8	-224.3	-64.0
103.12	-225.9	-62.5	-224.6	-63.8
114.25	-228.7	-59.7	-227.2	-61.2

This shows that in the case of beam-coupling, the received power is in excess of 60 dB above the ITU-R RA.769 protection threshold, and therefore significant potential for severe RFI at ATCA and Mopra exists.

Assuming 0 dBi gain for the RAS receivers results in a margin of approximately 20 dB. This is sufficiently close to the RAS protection limits. CSIRO advises this needs to be studied with known system characteristics, to include the number of simultaneous transmitters for all three locations of earth transmitters, and for all satellites in the sky, and implemented using the epfd concept. This is a non-trivial calculation to make and will take some time to complete. CSIRO could assist with making these calculations.

## Interference to space-based SRS observations

The SRS primary allocation in the frequency band 105 – 114.25 GHz is limited to space-based radio astronomy as per the footnote 5.562B. Earth stations would be transmitting in the general direction of where any space-based SRS stations would be located, creating a potentially severe interference scenario.

There currently are several future radio astronomy missions planned that will make use of that frequency band. A non-exhaustive list includes Black Hole Explorer<sup>1</sup>, Millimetron<sup>2</sup>, LiteBIRD<sup>3</sup>, and PICO<sup>4</sup>. These missions could be jeopardised by earth stations transmitting to NGSO systems at these frequencies.

Further, these missions are planned under the assumption of a clean spectrum as per the current allocations. It will be difficult to calculate interference scenarios for these missions.

## Interference to CSIRO's Marsfield site

CSIRO develops and tests receiver systems for W-band (and other frequency bands) at the CSIRO Marsfield site in Sydney. This site is less than 2 kilometres from the proposed Sydney earth stations. Interference scenarios for this site would also need to be developed and calculated.

<sup>1</sup> <https://www.blackholeexplorer.org/>

<sup>2</sup> <https://millimetron.ru/en/general/instruments>

<sup>3</sup> <https://research.manchester.ac.uk/en/publications/the-litebird-mission-to-explore-cosmic-inflation-2/>

<sup>4</sup> [https://science.nasa.gov/wp-content/uploads/2023/04/PICO\\_Study\\_Rpt.pdf](https://science.nasa.gov/wp-content/uploads/2023/04/PICO_Study_Rpt.pdf)

## Invocation of Subsection 10(10) in the ARSP

The final concern CSIRO would like to raise is that permitting use of frequency bands allocated to other services by the fixed satellite service (FSS) in derogation of the ITU-R Radio Regulations and the ARSP could be seen as prejudicial to FSS gaining allocations in these bands.

CSIRO would like to highlight that FSS has several allocations in nearby bands 81 – 86 GHz (FSS E-s) and 123 – 130 GHz (FSS s-E) that could be used by the FSS, causing less disruption to RAS.

## Conclusion

CSIRO would like to propose that ACMA reconsider the interim arrangements and not grant these licenses until a further evaluation of the interference scenarios to all the co-primary allocations has been completed. ACMA could consider inviting all the affected services that have co-primary allocations in this band to collaborate on studies prior to authorising the use of the W band in derogation of the RRs.

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