Impact Assessment of Proposed Airspace Restriction

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Introduction

The Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory site (the Observatory) hosts several radio telescopes with extremely sensitive passive receivers. These observe in frequency ranges which are affected by licensed transmitters in use aboard aircraft, as well as by the inadvertent use of passenger's or pilot's mobile devices. The telescope facilities comprise Australian owned and operated facilities, representing significant investments of order several hundred million dollars, as well as the first international mega-science project hosted in Australia, the SKA-low. Together, these projects represent an investment well above $1b and are of national significance.

The Commonwealth Government has supported the establishment of this facility through regulatory constraints on radiocommunications, as described below. The Western Australian government has also provided support through limits on mining activities in the region, the negotiation of a lease over Boolardy pastoral station, and numerous other measures.

Justification

The predominant reason for moving radio astronomy telescopes to remote areas is to minimise the impact everyday technology has on the ability to detect faint signals from the cosmos. This impact is called "radio frequency interference", or RFI.

RFI caused by terrestrial users at the WA site is addressed by ACMA regulations[1] which prevent transmitters from being installed within 70km of the centre of the Radio Quiet Zone (RQZ) and require coordination up to a radius of 260km. These provisions keep some of the most significant interference sources away from the telescopes, particularly mobile broadband (3G/4G/5G/NBN) and Digital TV.

Licensed transmitters installed on aircraft, however, are not subject to the ACMA regulations. They include some very powerful transmitters, such as DME and ADS-B. Even the VHF voice and data transmissions are very strong as compared to the signals of cosmological origin for which the radio astronomy receivers are optimised. Depending on the distance and angle to the telescopes, these airborne transmitters can emit signals strong enough to physically damage the extremely sensitive receiving equipment in the telescopes.,

Further to this, we have in recent years discovered a significant number of mobile handset transmissions that correlate with air traffic in the area. It appears that most overflying flights carry passengers that forget to switch their phones into flight mode, rendering the morning and evening "rush hour" times - when most overflights are occurring - essentially useless for observations in the frequency bands used by mobile handsets. Pilots of small

[1] Radiocommunications Assignment and Licensing Instruction (RALI) MS 32, Dec 2014 (insert link)

aircraft also are using mobile internet devices such as tablets or phones, which at altitude can maintain a connection to mobile towers a hundred km (or more) away. While such services are useful to the pilots, this pattern of use undermines the other RQZ protections, as the telescopes are blinded in these mobile uplink frequencies from air traffic in the area.

Figure 7 shows a frequency occupancy plot, highlighting the fraction of time the spectrum is occupied by strong signals that are blinding radio astronomical receivers. That fraction of time can be lowered by increasing the distance between the aircraft transmitters and the telescope site.

For this reason, and to protect the major investment Australia has undertaken with these projects, it is desirable to accompany the already existing radio quiet zone with a smaller restricted airspace (going forward in this document referred to as 'R-MRO').

Considering the sensitivity calculations from Wilson et al[2], and taking into account the complex geometries involved, we are requesting a restricted airspace that is circular in shape and encompasses the entirety of the sensitive areas.

Ideally, R-MRO is centred on latitude/longitude S 26.7409 E 116.7269, is circular in shape with a radius of 62.1 km, and features a vertical extent SFC-FL600. This area covers and protects all the existing facilities as well as those under construction, and is a sufficiently large zone to prevent radio telescope receiver systems from being damaged or blinded by saturation.

As a result of the requested restricted airspace, CSIRO propose that the SCRUB navigation waypoint be replaced by two new waypoints as described later in this document.

R-MRO will be managed by the site entity group at CSIRO responsible for the Observatory.

Exemptions

Standing entry permits to R-MRO will need to be granted to a very small subset of airspace users:

- The FIFO operators flying observatory personnel and contractors into Boolardy ALA (located several km inside the R Area but well away from the sensitive infrastructure).
- The Royal Flying Doctors Service (RFDS) for purposes of tending to medical incidents requiring landing at Boolardy ALA, MRO Emergency ALA, and SKA Emergency ALA. This permit would not include overflights while in transit between locations outside R-MRO.
- Pastoralists affected by R-MRO that would otherwise be unable to operate their aircraft, or would be unable to do mustering work.

[2] Insert reference

In addition to these standing entry permits, short term entry permits can be granted to aircraft operators by the MRO Site Entity, in a process similar to CSIRO's Radio Emissions Management Plans (REMPs) required for activities on the ground within the RQZ.

Each of the exempted airspace users will be provided with a briefing package containing

- A detailed map of the most sensitive areas contained within R-MRO that critically must be avoided to prevent damage to the receiver systems
- Contact details to coordinate their arrivals and departures
- Approach and departure corridors that are safe to operate in

Granting of an exemption to enter R-MRO is subject to acceptance of the detailed rules set forth in the briefing package provided by MRO Site Entity.

Impact on Existing Air Traffic

Introduction

CSIRO has operated an ADS-B receiver system at the core of the RQZ since September 2017. The decoded ADS-B data is stored in a database. We have used this data to create an airspace occupancy map from September 2017 – July 2022 spanning almost 5 years (1745 days) with many millions of individual datapoints.

From this data we have extracted flight information for high and low altitude traffic to create an overview of the number of flights passing through the area and to assess the air navigation features in use.

The ANPAT and NIPEM waypoints would both fall within R-MRO, they do not appear to be under regular use by any air traffic we have measured, and we propose to suppress them.

We have further assessed how their filed and flown routes would be affected by replacing the SCRUB navigation waypoint by two new waypoints and by moving airways L514, Y44, W394, and Y60 so traffic on those airways remains outside the proposed R-MRO.

For the purposes of this analysis, we picked two proposed new waypoints as replacement waypoints for SCRUB:

1. QUIET waypoint is placed on a bearing of 274 degrees and 72.1km from the centre of R-MRO (west of SCRUB) at WGS84 coordinates S 26.6937 E 116.0042. This provides transiting traffic on AWYs Y44 and Y15 minimal detour option.
2. SKIES waypoint is placed on a bearing of 114 degrees and 72.1km from the centre of R-MRO (south east of SCRUB) at WGS84 coordinates S 27.004 E 117.3905. This provides transiting traffic on AWYs W394, Y44 and Y60 a minimal detour option.
3. Traffic on AWY L514 can pick either QUIET or SKIES for a roughly equal detour distance.

Neither of those two proposed waypoint names appear to be in use anywhere in the YMMM FIR and should therefore be available (as of January 2023). The names of course are a mere suggestion but fit their purposes nicely.

Data curation

The ADS-B data has a temporal resolution of 10 seconds, meaning one position record is saved every 10 seconds. Data without position information (e.g. Mode S only decoded data) is not retained.

For the purposes of this analysis, we have split the data into a low-altitude segment and a high-altitude segment. The altitude limit of FL130 for this division was taken from an operational rather than an airspace management perspective, where traditionally FL200 would be considered the boundary between low and high altitude traffic.

For flight above FL130 in Australia, supplemental oxygen is mandatory for both pilots and passengers as per CAO 20.4: supplemental oxygen required for flight crew operating above 10'000ft cabin pressure. Pressurised cabin equipped aircraft are rarely in use with small or private operators, and we intended to draw the distinction between large and small operators being impacted by this proposed airspace restriction.

R-MRO is far enough away from any airports serviced by regular passenger transport (RPT) operations so that no RPT aircraft would be impeded in the approach or departure segment flying through the proposed area.

In other words, we propose that any air traffic found below FL130 is either a private small airplane (such as a pastoralist), or a FIFO operator flying into Boolardy ALA, while any air traffic above FL130 is a medium or large category aircraft, predominantly engaged in RPT operations. We are thus using the FL130 altitude cut-off as a proxy measure for operator type.

A further assumption was made that virtually all aircraft today are equipped with an ADS-B transponder, and that their transponders are on and operating normally. This is based on the ADS-B mandate for aircraft flying on instrument flight rules (IFR) flight plans in Australia.

Low Altitude Findings

As shown in Figure 1, the 5-year timespan shows that the predominant traffic within R-MRO is transiting traffic, most on similar tracks. There was a total of 531 overflights that followed a NE-SW, NW-SE, or N-S path directly overhead the telescopes. While this is a small number of flights (about one flight every 3.5 days), they can potentially damage the telescope receiver systems, as their altitude could be as low as 500ft above ground - the legal altitude limit outside built-up areas. Due to the infrequent nature of those flights, it can be assumed that these airspace users represent a very small group. Furthermore, the most common flight paths appear to have origins and destinations that are a significant distance away from R-MRO, which would minimise the additional distance required to avoid R-MRO to just a few percent of the total distance. See also the calculations presented for flights in the high-altitude traffic section in that regard.

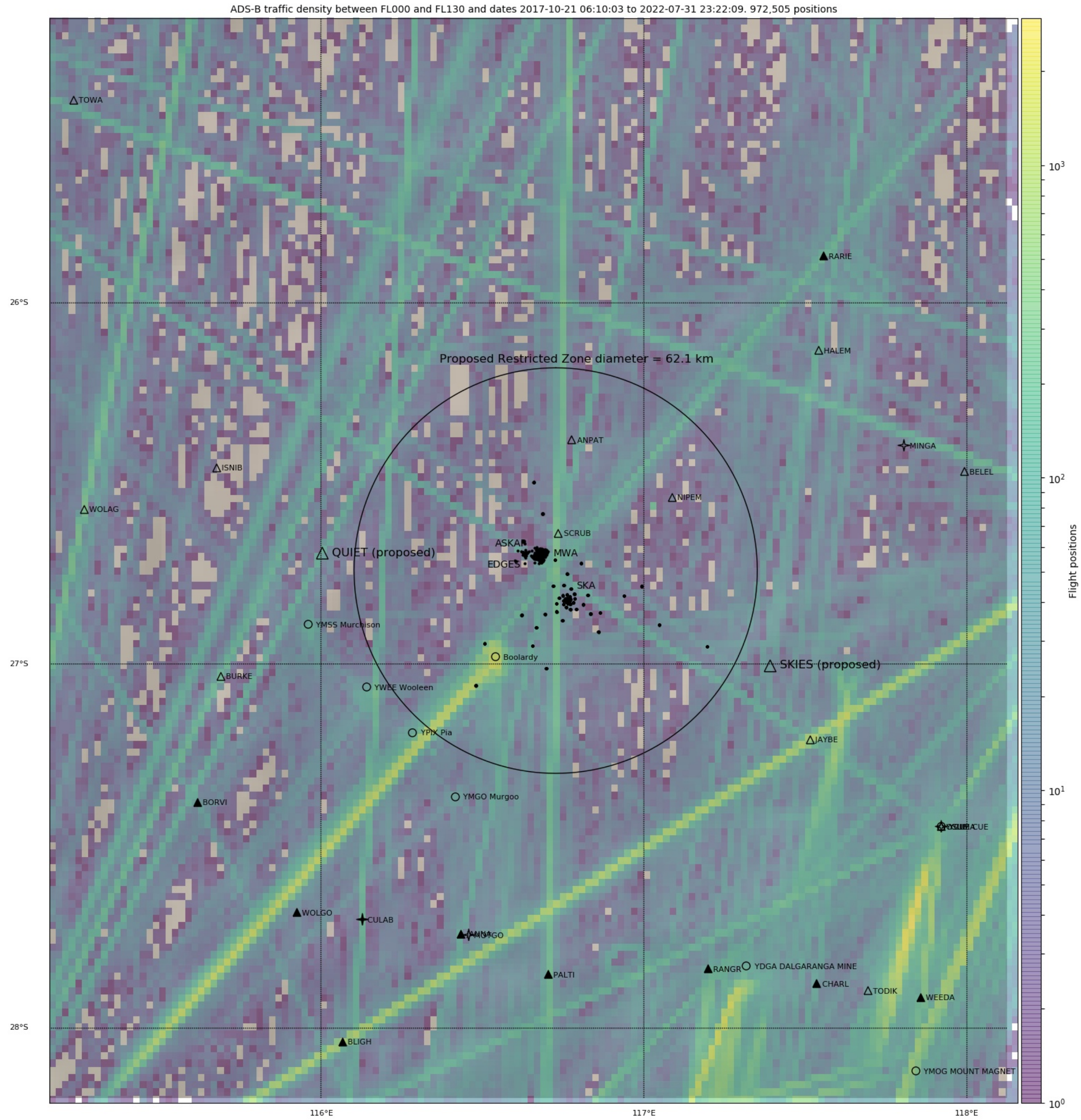

Figure 1 Low Altitude air traffic density map (Data from September 2017 – July 2022)

The predominant traffic is made up of the FIFO traffic flying in and out of Boolardy ALA in the southwest of the proposed restricted airspace R-MRO.

A total of 1291 flights were found to have entered the proposed R-MRO in the space of 5 years. This includes 637 flights flown by the Boolardy FIFO operator (chiefly VH-CJQ) and a series of other air charter operators who have performed FIFO flights into Boolardy ALA for a total of 760 FIFO flights. The remaining 531 flights appear to be overflights.

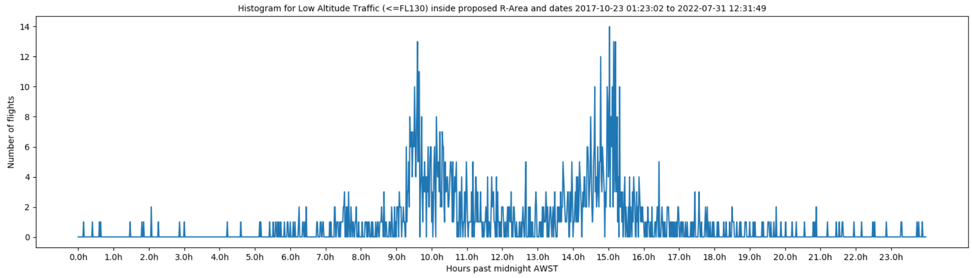

Figure 2 Time of day in AWST for all detected low altitude flights (Data from September 2017 – July 2022)

The time of the flights shows a strongly bimodal distribution, in line with the vast majority of detected flights being the Boolardy ALA FIFO Monday morning and Friday afternoon flights.

In Figure 5 we show an overlay of the approximate position and dimension R-MRO would take when projected onto the Low Altitude IFR chart.

High Altitude Findings

A total of 59161 flights have been found to enter R-MRO, amounting to 34 overflights per day on average. To assess the impact on the respective operators, the filed flight plan for each of the overflying flights was retrieved where possible using historical flight plan data from FlightAware. This data contains the flight planned route as well as the origin and destination airports. Using this information, we determined whether the flight planned route included one of the airways L514, Y44, Y60, W394, or the SCRUB waypoint. If any of those airways were part of the flight planned route, we calculated the distance in km along the great circle between origin – SCRUB - destination, and compared it to the distance that would result by flying via the proposed new waypoints to the east or west of R-MRO: SKIES to the south-south-east and QUIET due west of the current location of SCRUB.

After discounting duplicate flight plans, but retaining different operators running the same flight plans for visibility of the majority of affected RPT operators, 196 flight routings remained and were evaluated for this analysis summarised in Table 1.

The results show that if SCRUB were to be replaced by QUIET (~75km due west of the current location), the distance would increase by 1.17% on average. However, the worst case of adding 3.1% to the route is offset by a 6.8% path reduction in the best case, while being only marginally larger than the standard deviation of the distance gain. The maximum distance increase is on the route flown by QFA1384 (YPPH/PERTH INTL to YFDF/FORTESCUE DAVE FORREST) which at 1150km total length is one of the shorter routes (hence the disproportionately large effect). The largest reductions are 66.6km on the RFDS flight FD628J YCAR/CARNARVON to YPJT/JANDAKOT, due to a disproportionately large effect of the routing via SCRUB, creating a large detour against the great circle distance. It is unclear why this flight should have been required to fly via SCRUB, unless their flight plan must have been filed to detour via SCRUB for operational reasons (e.g. weather). We are not taking weather into account for this analysis and only deal with great circle distances rather than track miles.

If SCRUB were to be replaced by SKIES (~72 km southeast of the current location), the distance flown would increase by 0.06% on average, and for the extremes, a similar picture emerges as for the western displaced SCRUB. See Annex for the complete list of flight operators, origin/destination pairs and routes.

Table 1 Great circle distance increase/decrease with modified routings to avoid R-MRO

	Original Distance [km]	Via QUIET Distance increase [km]	Via QUIET Percent increase [%]	Via SKIES Distance increase [km]	Via SKIES Percent increase [%]
Average	1615.72	11.61	1.17	2.69	0.06
Maximum	12449.40	33.90	3.10	49.50	6.00
Minimum	812.40	-66.60	-6.80	-20.50	-1.80
Standard deviation	1720.08	21.37	1.66	18.25	1.45

Further to the great circle distance analysis, it is also important to note that in cases where the detour distances to avoid R-MRO cause an increase, the distance increases are comparable or smaller to what normal operations incur when weather / thunderstorms need to be avoided.

Figure 3 shows the airspace occupancy for high altitude traffic over the 5-year span of the data. We further observed that no strategic lateral offset procedure (SLOP) traffic is detected in our data, which is in line with Australia's Amendment 9, 16th Edition, 2016, Published December 2021 to the Procedures for Air Navigation Services – Air Traffic Management (PANS-ATM) ICAO Doc 4444, chapter 16.5, stating *"SLOP is not permitted in continental enroute airspace."* As a result, airway occupation appears to be two orders of magnitude higher than off-airway (or parallel to airway) routings, which simplifies our calculations considerably.

In Figure 6 we show an overlay of the approximate position and dimension R-MRO would take when projected onto the High Altitude IFR chart.

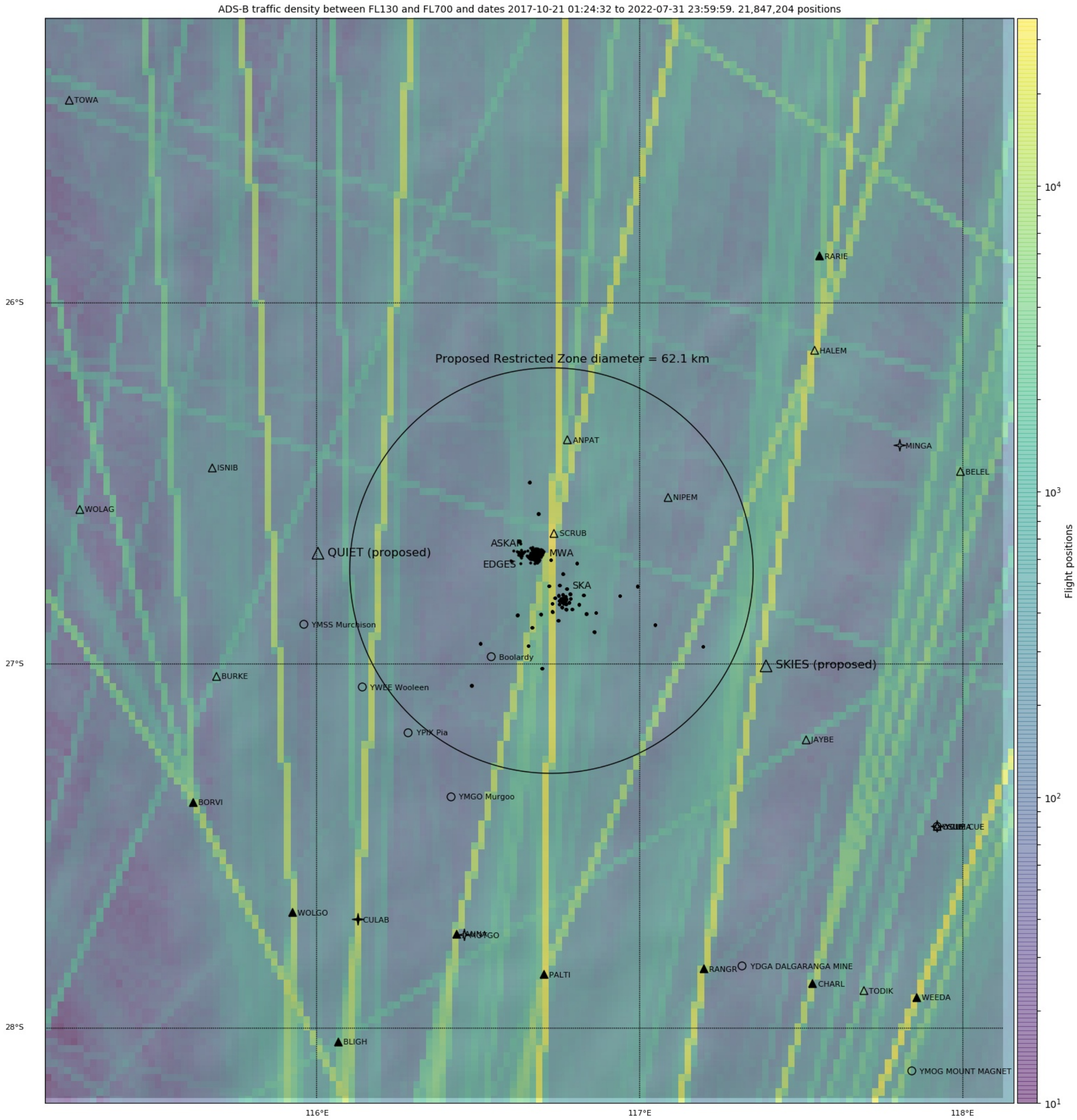

Figure 3 High altitiude traffic density map. (Data from September 2017 – July 2022)

Figure 4 shows the time of day distribution of the high altitude flights. It also shows a bimodal distribution, highlighting that the majority of high altitude air traffic is servicing remote locations with morning, afternoon, and some evening flights.

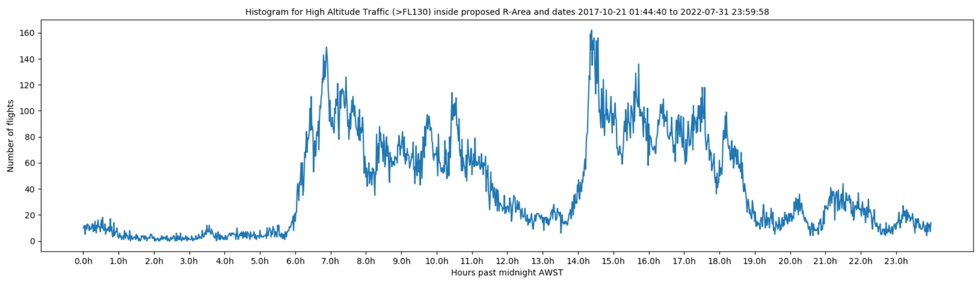

Figure 4 Time of day in AWST for all detected high altitude flights

Conclusion

Instating a restricted airspace area R-MRO with the proposed location, dimensions, and exceptions rule will result in a significant improvement of the radio frequency spectrum in which the radio astronomy telescopes located at the Observatory perform observations. Considering Australia's significant investment in this area, and taking into account the statistically negligible effect on aircraft operators using this airspace, we would argue that instating improved RFI protections for high visibility mega-science projects of national and international significance such as ASKAP and the SKA by means of flight restrictions is a sensible course of action.

Additional Figures

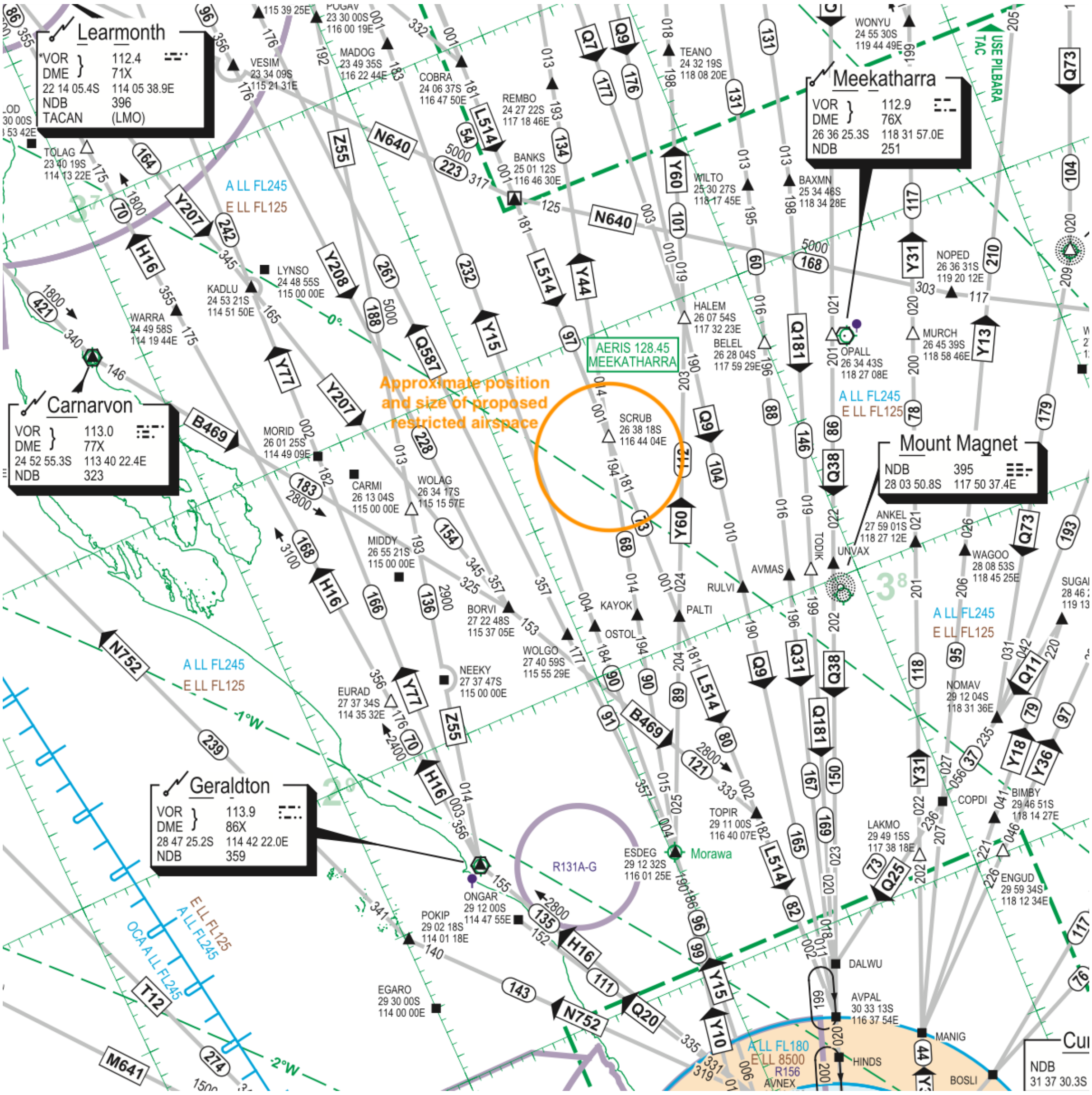

Figure 5 Approximate location and dimensions of R-MRO on the High Altitude IFR Navigation Chart ERCH3 (Dec 2022)

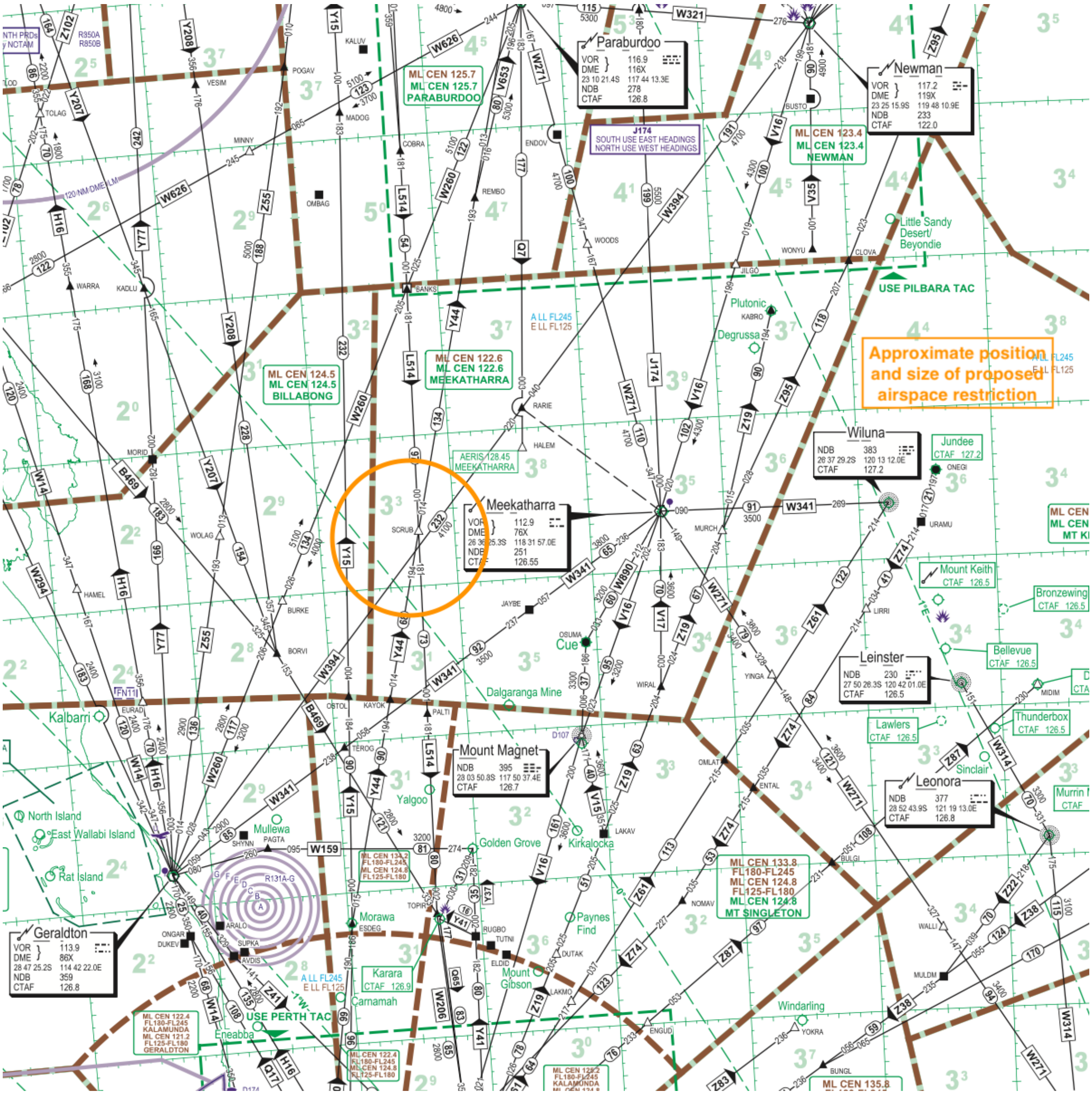

Figure 6 Approximate location and dimensions of R-MRO on the Low Altitude IFR Navigation Chart ERCL8 (Dec 2022)

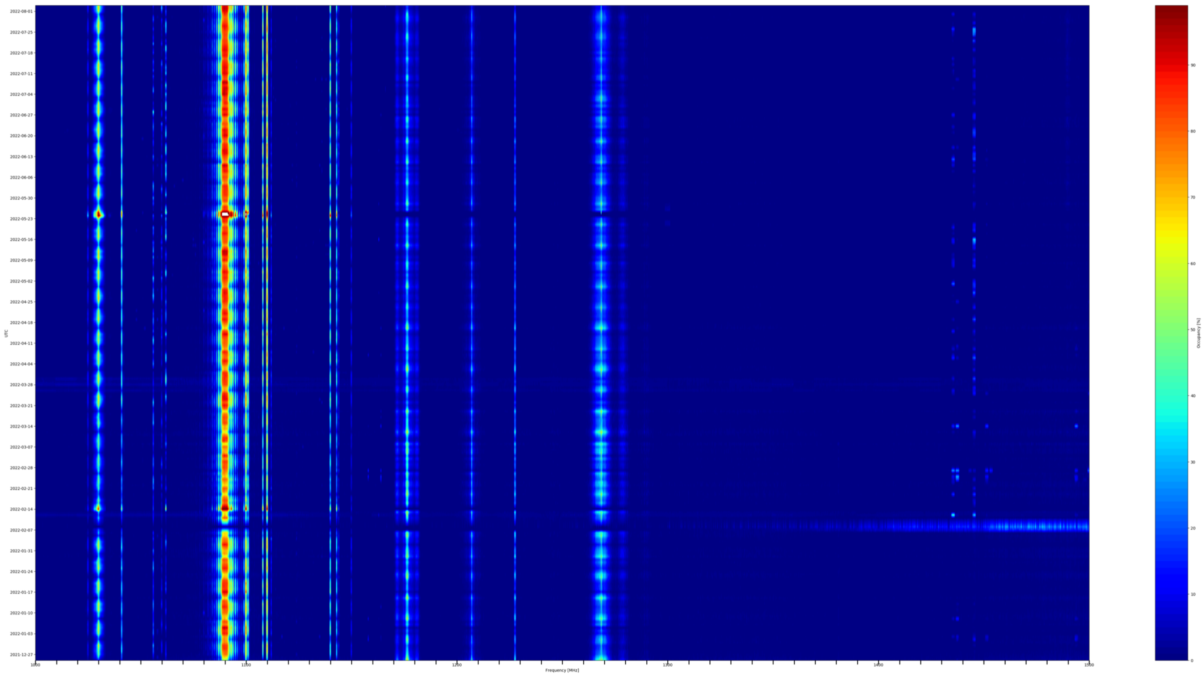

Figure 7 Radio Spectrum occupancy plot for 1000 - 1500 MHz for December 2021 – August 2022: The strongest (red >90% occupancy) line is ADS-B at 1090 MHz along with multiple DME transmissions between 960 - 1164 MHz. The pearl-string pattern clearly shows weekends with less traffic and highlights the significant benefit achievable by increasing the distance to the air traffic causing this interference.