

Radio Quiet Zones

Past, Present and Future

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Talk Outline

- General RQZ introduction
- RQZ History
 - National RQZ
 - International RQZ
- Current initiatives – OECD, ITU
- RQZ definition for SKA
 - Options and questions

Need for RQZ?

- RA systems extremely sensitive
 - very susceptible to RFI
 - RA allocated very little spectrum (~2% at cm $\lambda\lambda$)
 - Still RFI from out-of-band (OoB) emissions
 - RA operates over full radio spectrum
 - RFI from radiocommunication services
 - “prevention better than cure”
- ⇒ RQZ is 1st step of mitigation**

Radio Quiet?

- **Radio Quiet** \neq **Radio Silent**
- “Passive” bands (e.g. 1400-1427 MHz)
 - “*all emissions are prohibited*” (Fn. 5.340)
 - but OoB emissions still a problem
- **RQZ** \leftrightarrow prevent “harmful” (detrimental) **RFI**
- RFI mitigation – minimise “harm”
 - may influence RQZ limits & area

RQZ History

- National RQZ
 - Within an administration
 - Sovereign rule – can depart from ITU
 - Regulate terrestrial services
 - Little or no impact on satellite services
- International RQZ
 - Moon & L2 point

National RQZ characteristics

- 2 distinct areas of RQZ protection
 1. EMC protection
 - RFI from electrical/electronic equipment
 - Protect to few kms (5-20) – 30 for heavy industry
 - Local/State Governments
 2. Coordination zone
 - Coordinate with radio transmitters
 - 100s of km
 - Communications administration

Greenbank NRQZ

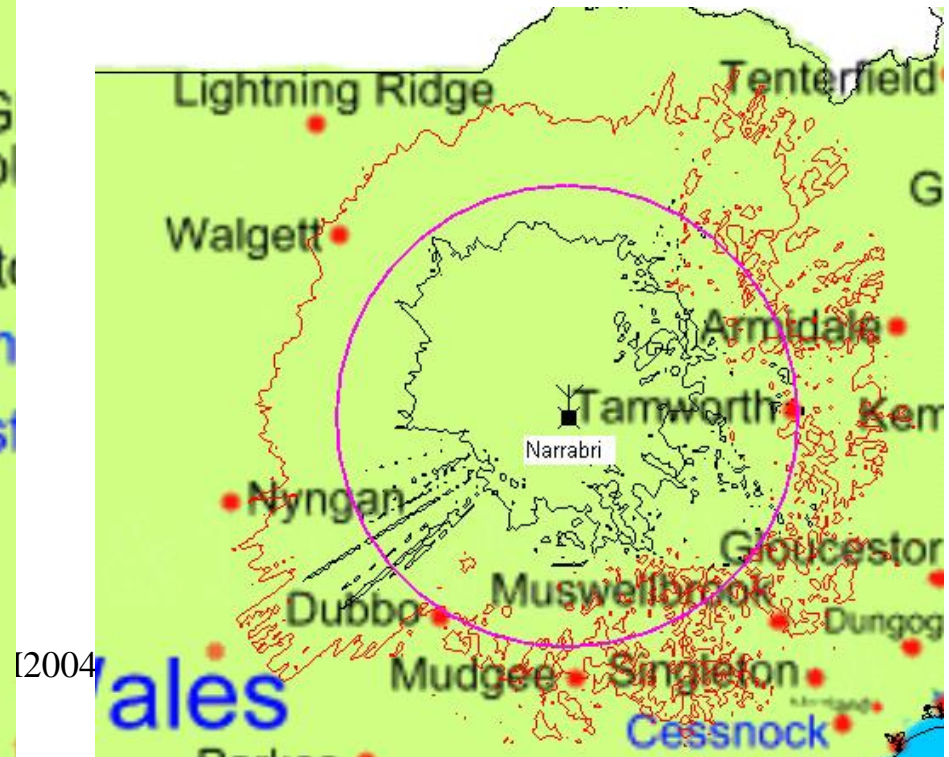
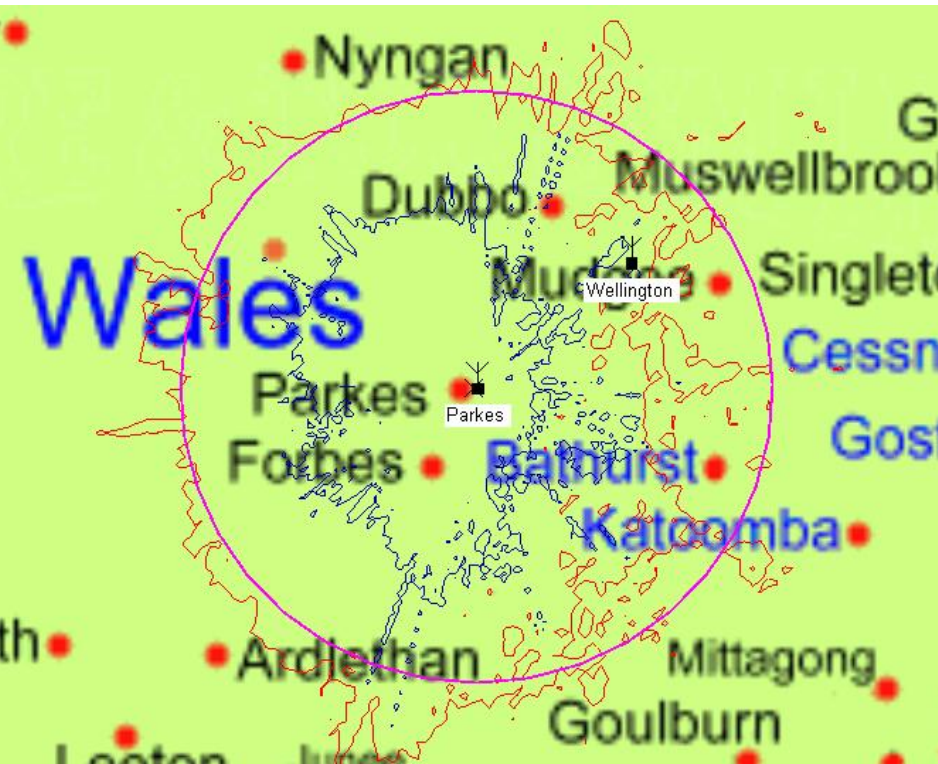
- **The original & the best RQZ - model**
- 1956 – West Virginia Radio Astronomy Zoning Act
 - Graded EMC restrictions to 10 miles
- 1958 – NTIA & FCC → National RQZ
 - 34000 sq km area
 - Coordination of all Tx with RA telescope
- Excellent protection in practice

Other National RQZs

- Arecibo PRCZ – Puerto Rico & islands
 - Coordination Zone
- Jodrell Bank & other European telescopes
 - Mainly EMC (local) & some National coordination
- GMRT
 - EMC – 10 km (light)→30 km (heavy industry)
 - National coordination up to 400 km (bands)

RQZ in Australia?

- None formally existing – local goodwill
- Radio Act review – “radio sensitive zones”
- Parkes & ATCA – in progress



International RQZs

- Shielded Zone of the Moon RQZ
 - ITU-R Rec RA.479 - Entire radio spectrum
 - No levels defined – coordination
 - **But** some RFI from spacecraft (e.g. Mars)
 - Prohibitively expensive
- Sun-Earth Lagrangian Point L2
 - ITU-R Rec RA.1417
 - 1.5 million km from Earth
 - Excellent RQZ – WMAP (CMB) already there!

OECD Global Science Forum

- OECD “Task Force on Radio Astronomy and the Radio Spectrum” (Report 2004)
 - RA and Satellite Operators
- Recommendations:
 1. Technical consultations
 2. **“Controlled Emission Zones”**
 3. ITU-R efforts
 4. Operational consultation
- Leverage for international RQZ?

ITU-R Question

- Question in WP7D to initiate studies
- Strong opposition from satellite operators
- Question delicately framed i.e.
 1. Characteristics of existing RQZ?
 2. RAS characteristics stimulating RQZ?
 3. environment characteristics stimulating RQZ?
- Work still to be done.

RQZ for SKA?

- SKA to operate 200 MHz – 25 GHz
 - Wide unprotected frequency range
 - Must have some RQZ protection
- National efforts towards SKA RQZ(s)
 - e.g. Australia PMSEIC recommendation for RQZ at SKA candidate site in WA
- BUT, definition of RQZ still not clear!
 - Discussion needed

RQZ definition?

1. Define flux density threshold levels at the antenna(s)
 - Rec RA.769 defines threshold interference levels for “single-dish”, “spectral-line” & “VLBI”
 - “core SKA” \approx “single dish” levels?
 - SKA outliers \approx “VLBI” levels?
2. Radio propagation modelling (ITU Recs?)
 - Complex and many assumptions
3. RQZ area(s) defined from levels & propagation

Threshold levels – Option 1

- Calculate needed levels a-priori
 - No reference to current ITU levels.
 - Complex calculations?
 - Different for each observing mode?
 - Different for each key science area?
- Or do a reference calculation
 - Key science areas only?
 - Worst case from key science? (e.g. HI ?)

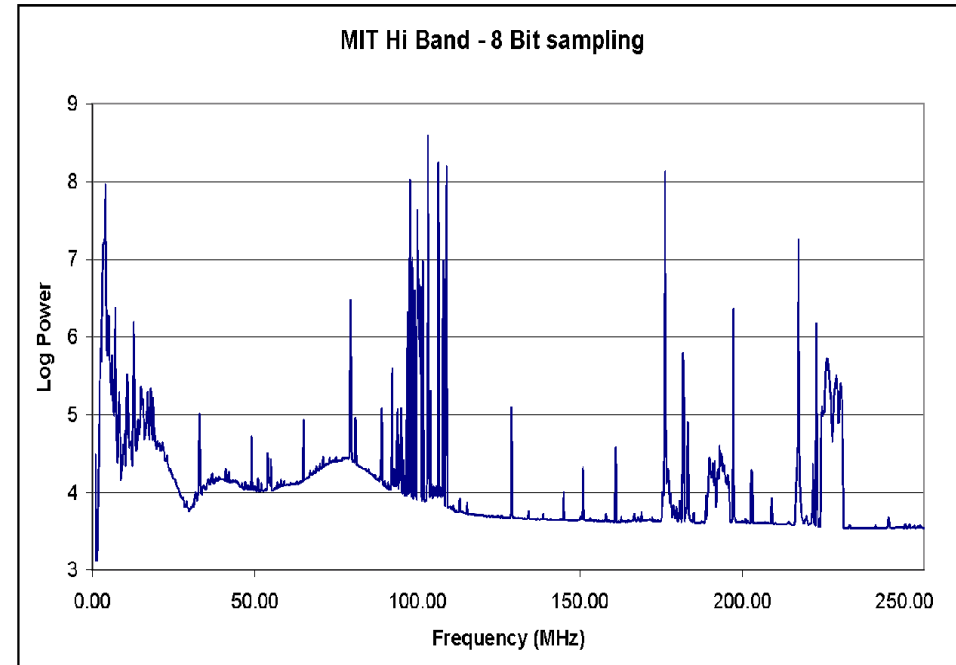
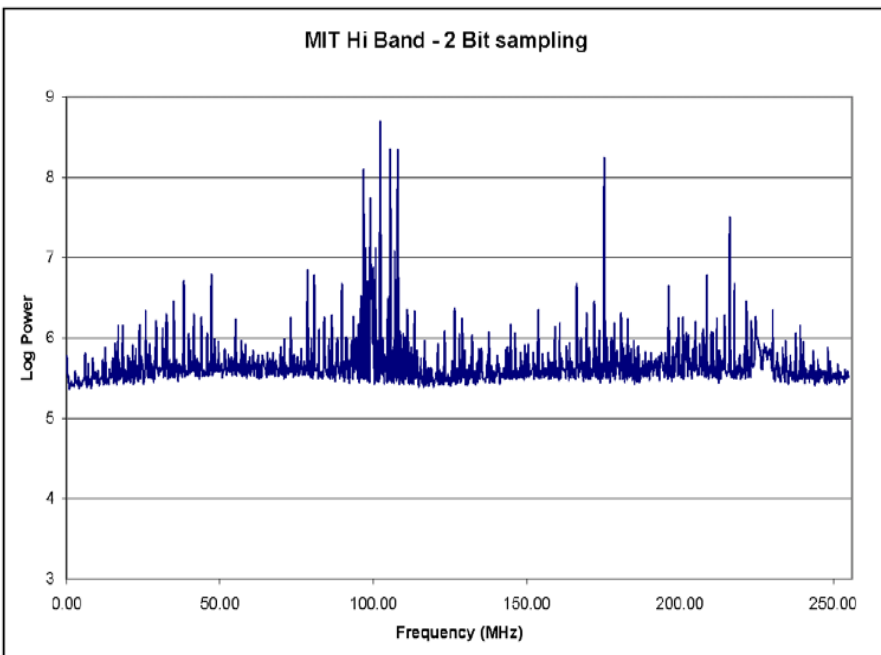
Threshold levels – Option 2

- Use ITU procedures for calculations
 - defined in RA.769 & Radio Handbook
 - Need to choose method – “single-dish” or “array”?
- Or adopt the levels in the tables of RA.769
 - Simpler but not as robust
- **Question:** Are these adequate for the SKA?
 - Too harsh or too lenient?
 - Assumptions applicable?
 - Mitigation effects?

Threshold levels – Option 3

- Measure existing levels at site and accept as baseline for RQZ?
 - “Quiet” defined as “not get worse”
 - Adequate?
- **But** Measurement problems?
 - Need sensitive measurement system
 - Noise floor high? 50+ dB above RA.769 levels?

RFI Measurement trap



Threshold levels – Option 4

- New “arbitrary” levels
 - Related to RA.769?
 - Related to measurements?
 - Based on known/expected interference?
- Or adopt “acceptable” or “realistic” levels
 - Community acceptance?
 - Radiocommunication services?
- Possibly weak or even inadequate?

SKA outlier protection?

- Just EMC levels (10-20 km)?
- Coordination but only at Rx gain compression points?
- “VLBI” levels from ITU ?- $\sim 1\%$ T_{sys}
- Q: How much do we gain from mitigation?

Summary – 1

- RQZs important for RA – 1st step in mitigation
- National RQZs (e.g. Greenbank) provide successful protection for telescopes
- International RQZs for L2 and Moon.
- OECD initiative – “controlled emission zones”
 - Include protection from satellites?
- ITU Question on RQZ – towards IRQZs?

Summary –2

- RQZ for SKA – imperative
- Clearer definition of RQZ threshold levels?
- Options:
 - Calculations from key science
 - ITU Rec RA.769 regulatory levels
 - RFI measurements at sites
 - Community “acceptable” levels
- Must make clear decisions soon
- RFI Mitigation impact?