

Spectrum Management

aka How do we manage Radio Frequency Interference?



Karen O'Neil

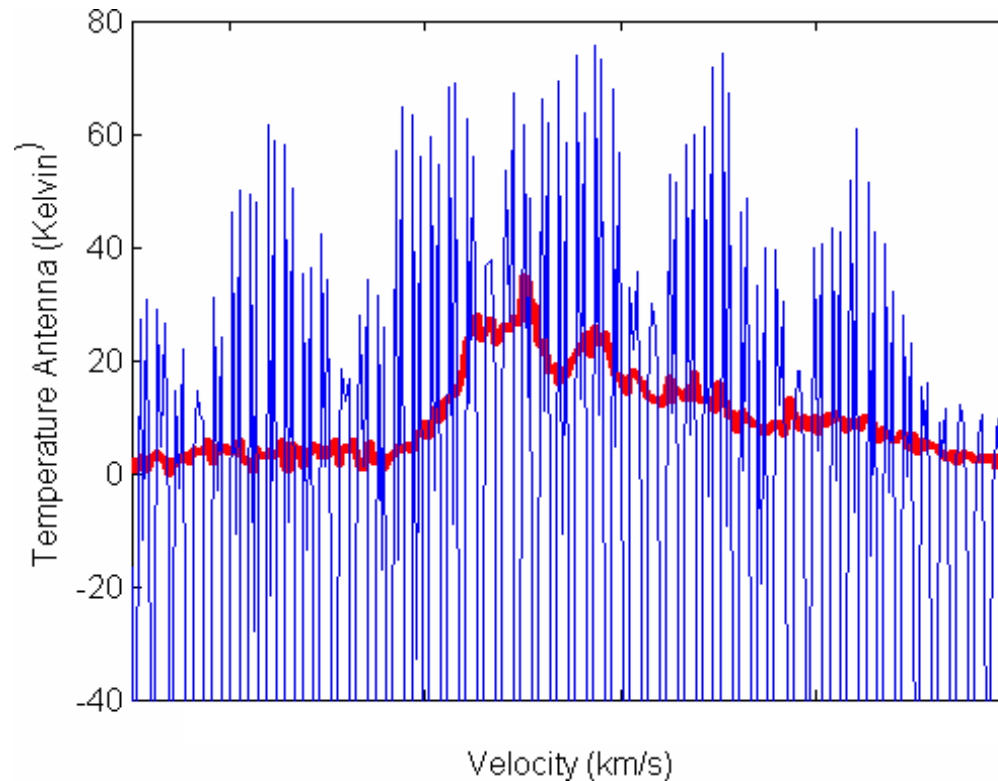
NRAO

Atacama Large Millimeter/submillimeter Array
Expanded Very Large Array
Robert C. Byrd Green Bank Telescope
Very Long Baseline Array



Why do we care about spectrum management?

RFI can obliterate astronomical signals...

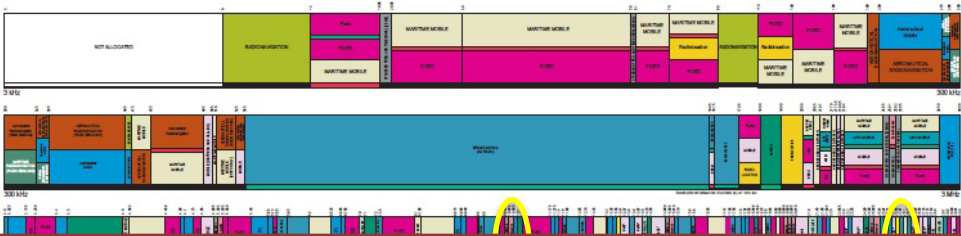


or even fool you into false detections.

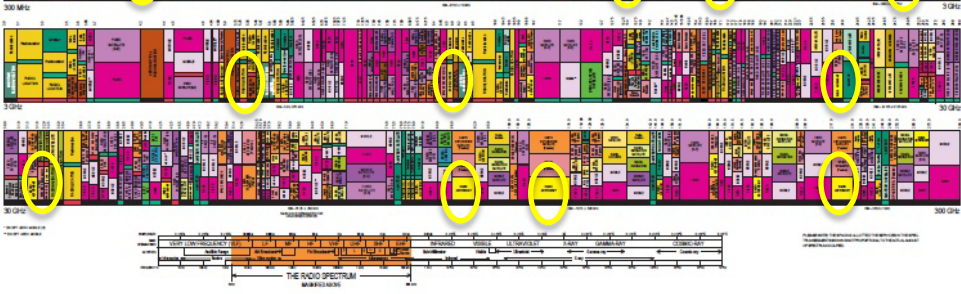
Why do we care about spectrum management?

The US Government has set aside parts of the spectrum for astronomy...

UNITED STATES FREQUENCY ALLOCATIONS



Sources are often red-shifted
 We cannot predict the lines (molecules, ,atoms) of interest
 Much of the “radio astronomy” spectrum is in shared



But the parts of the spectrum are few and far between.



Why do we care about spectrum management?

There are three ways to handle radio frequency interference:

- Legal Protection
- Community agreement
- Post-observation excision

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The art of spectrum management

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Covered in Rick's talk (next)

The art of spectrum management

Spectrum Management – Legal Protection

Many flavors of legal protection:

International/Federal agreement regarding spectrum allocation

Federal protection for geographic regions

Local protection for geographic regions

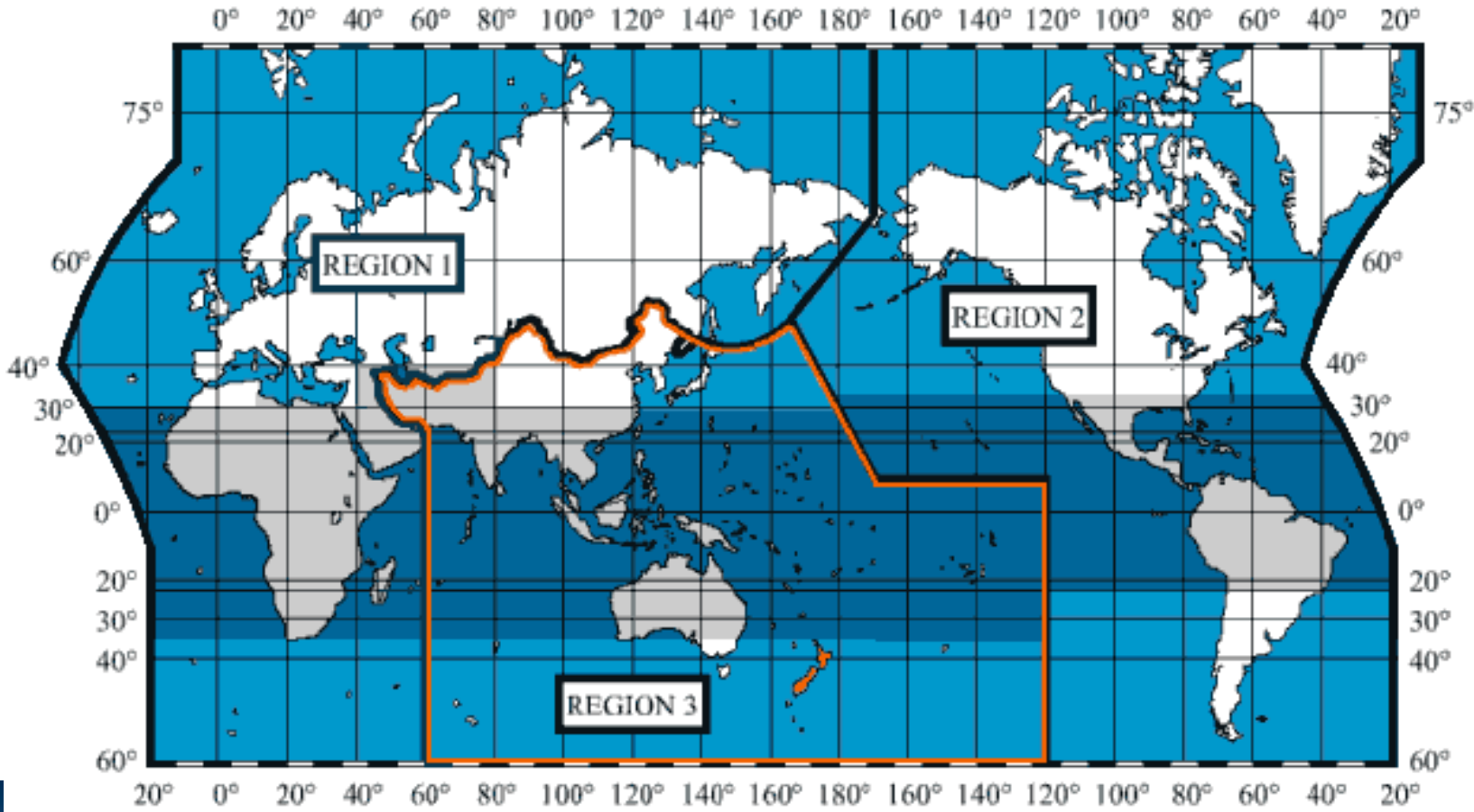
Spectrum Allocation

- Spectrum bands are allocated to 'services'
 - Service = purpose or application
 - Most services are 'active' – they transmit
- Radio astronomy and Earth-sensing are 'passive'
 - RAS and EE-SS (passive) only listen
 - Radar astronomy and EE-SS (active) also transmit but are distinct
 - Concept of “use” elusive for passive services
- Examples of “services”
 - Radiolocation = radar
 - Radionavigation/Radio Navigation Satellite Service = GPS
 - Fixed service (terrestrial point to point)
 - Fixed-satellite service (space-earth, earth-space)
 - Mobile-satellite service (satellite phones)
 - Broadcasting (TV)



How is the spectrum allocated?

Three ITU-R regions (International Telecommunications Union - Radiocommunications)



How is the spectrum allocated?

Three ITU-R regions (International Telecommunications Union - Radio)

- All countries are sovereign inside their border
 - Radio waves always know where to stop, eh?
- No country can operate a satellite transmitter without ITU-R permission
 - Border issues are often important
- Most general set of rules (Radio Regulations) is an international treaty
 - Renegotiated every 4-5 years through the UN

<http://www.itu.int/ITU-R/>

How is the spectrum allocated?

Radio Astronomy and Space Sciences represented through IUCAF:

(Scientific Committee on Frequency Allocations for Radio Astronomy and Space Science)

- Chartered for International Astronomical Union, Committee on SPACe Research, Union Radi- Scientifique Inetnationale
- Historically, the vehicle for radio astronomy/space science representation
- Now being pressured to be more interdisciplinary
- <http://www.iucaf.org>

Part of the FCC version of the frequency table

| 50-123.5875 MHz (VHF) Page 25 | | | | | |
|--|--|--|---------------------------------|--------------------------|--|
| International Table | | | United States Table | | FCC Rule Part(s) |
| Region 1 | Region 2 | Region 3 | Federal Government | Non-Federal Government | |
| See previous page for 47-68 MHz | 50-54 AMATEUR 5.162A 5.166 5.167 5.168 5.170 | | 50-73 | 50-54 AMATEUR | Amateur (97) |
| | 54-68 BROADCASTING Fixed Mobile | 54-68 FIXED MOBILE BROADCASTING | | 54-72 BROADCASTING | Broadcast Radio (TV) (73) Auxiliary Broadcasting (74) |
| | 5.172 | 5.162A | | | |
| 68-74.8 FIXED MOBILE except aeronautical mobile | 68-72 BROADCASTING Fixed Mobile | 68-74.8 FIXED MOBILE | | NG115 NG128 NG149 | |
| | 5.173 | | | | |
| | 72-73 FIXED MOBILE | | | 72-73 FIXED MOBILE | Public Mobile (22) Aviation (87) Private Land Mobile (90) Personal Radio (95) |
| | | | | NG3 NG49 NG56 | |
| | 73-74.6 RADIO ASTRONOMY | | 73-74.6 RADIO ASTRONOMY US74 | | |
| | 5.178 | | US246 | | |
| | 74.6-74.8 FIXED MOBILE | | 74.6-74.8 FIXED MOBILE | | Aviation (87) Private Land Mobile (90) |
| 5.149 5.174 5.175 5.177 5.179 | | 5.149 5.176 5.179 | US273 | | |



1400-1427
EARTH EXPLORATION-SATELLITE (passive)
RADIO ASTRONOMY
SPACE RESEARCH (passive)

5.340 5.341

1400-1427
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5.340 5.341

5.341 US246

5.340 All emissions are prohibited in the following bands:

1400-1427 MHz,
2690-2700 MHz, except those provided for by No. 5.422,
10.68-10.7 GHz, except those provided for by No. 5.483,
15.35-15.4 GHz, except those provided for by No. 5.511,
23.6-24 GHz,
31.3-31.5 GHz,
31.5-31.8 GHz, in Region 2,
48.94-49.04 GHz, from airborne stations,
50.2-50.4 GHz²,
52.6-54.25 GHz,

86-92 GHz,
100-102 GHz,
109.5-111.8 GHz,
114.25-116 GHz,
148.5-151.5 GHz,
164-167 GHz,
182-185 GHz,
190-191.8 GHz,
200-209 GHz,
226-231.5 GHz,
250-252 GHz.

→ WRC00

Allocations now
extend up to 275
GHZ

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EARTH EXPLORATION-SATELLITE (passive)
RADIO ASTRONOMY
SPACE RESEARCH (passive)

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1400-1427
EARTH EXPLORATION-SATELLITE (passive)
RADIO ASTRONOMY US74
SPACE RESEARCH (passive)

5.341 US246

US246

No station shall be authorized to transmit in the following bands:

- 73-74.6 MHz,
- 608-614 MHz, except for medical telemetry equipment,¹
- 1400-1427 MHz,
- 1660.5-1668.4 MHz,
- 2690-2700 MHz,
- 4990-5000 MHz,
- 10.68-10.7 GHz,
- 15.35-15.4 GHz,
- 23.6-24 GHz,
- 31.3-31.8 GHz,
- 50.2-50.4 GHz,
- 52.6-54.25 GHz,
- 86-92 GHz,
- 100-102 GHz,
- 109.5-111.8 GHz,
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- 250-252 GHz.



Some lesser protections

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

| | | |
|---------------------------------|-----------------------------------|--------------------|
| 13360-13410 kHz, | 4990-5000 MHz, | 94.1-100 GHz, |
| 25550-25670 kHz, | 6650-6675.2 MHz, | 102-109.5 GHz, |
| 37.5-38.25 MHz, | 10.6-10.68 GHz, | 111.8-114.25 GHz, |
| 73-74.6 MHz in Regions 1 and 3, | 14.47-14.5 GHz, | 128.33-128.59 GHz, |
| 150.05-153 MHz in Region 1, | 22.01-22.21 GHz, | 129.23-129.49 GHz, |
| 322-328.6 MHz, | 22.21-22.5 GHz, | 130-134 GHz, |
| 406.1-410 MHz, | 22.81-22.86 GHz, | 136-148.5 GHz, |
| 608-614 MHz in Regions 1 and 3, | 23.07-23.12 GHz, | 151.5-158.5 GHz, |
| 1330-1400 MHz, | 31.2-31.3 GHz, | 168.59-168.93 GHz, |
| 1610.6-1613.8 MHz, | 31.5-31.8 GHz in Regions 1 and 3, | 171.11-171.45 GHz, |
| 1660-1670 MHz, | 36.43-36.5 GHz, | 172.31-172.65 GHz, |
| 1718.8-1722.2 MHz, | 42.5-43.5 GHz, | 173.52-173.85 GHz, |
| 2655-2690 MHz, | 42.77-42.87 GHz, | 195.75-196.15 GHz, |
| 3260-3267 MHz, | 43.07-43.17 GHz, | 209-226 GHz, |
| 3332-3339 MHz, | 43.37-43.47 GHz, | 241-250 GHz, |
| 3345.8-3352.5 MHz, | 48.94-49.04 GHz, | 252-275 GHz |
| 4825-4835 MHz, | 76-86 GHz, | |
| 4950-4990 MHz, | 92-94 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).

US74 ... Catch 22?

US74 In the bands 25.55-25.67, 73.0-74.6, 406.1-410.0, 608-614, 1400-1427, 1660.5-1670.0, 2690-2700, and 4990-5000 MHz, and in the bands 10.68-10.7, 15.35-15.4, 23.6-24.0, 31.3-31.5, 86-92, 100-102, 109.5-111.8, 114.25-116, 148.5-151.5, 164-167, 200-209, and 250-252 GHz, the radio astronomy service shall be protected from extraband radiation only to the extent that such radiation exceeds the level which would be present if the offending station were operating in compliance with the technical standards or criteria applicable to the service in which it operates. Radio astronomy observations in these bands are performed at the locations listed in US311.



US74

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- FCC has considered cell phones on planes
- 2nd harmonic in 'protected' OH band @ 1665
- 300 commercial aircraft are in direct line of sight to GB at any moment during a typical day

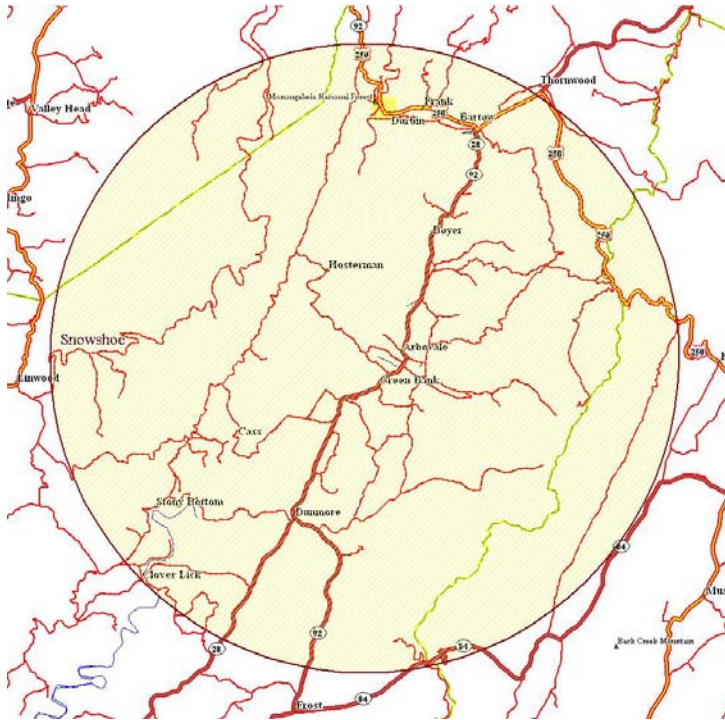


Other forms of legal protection

- Radio Quiet Zones:
 - Legal protection against some/all forms of radio frequency interference
 - Located around a geographic region
 - Green Bank is protected by two radio quiet zones...

WV Radio Astronomy Zone

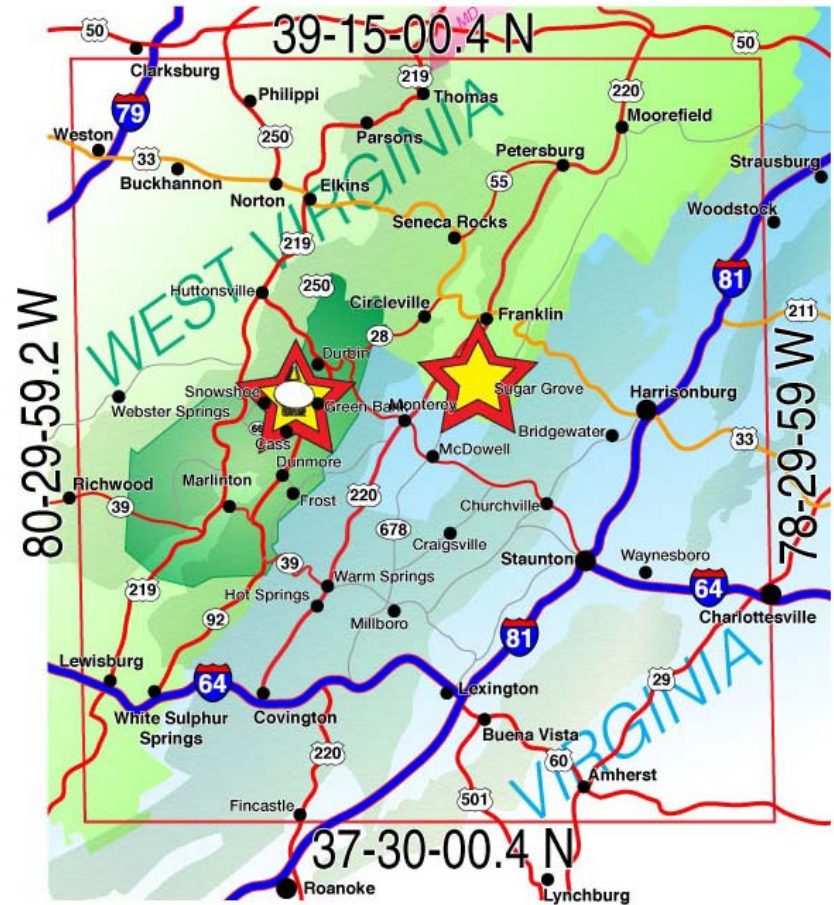
Established by the West Virginia Legislature
(1956)



Protection within ten miles
of the Observatory against all
transmitters

National Radio Quiet Zone

Established by the FCC and NTIA
(1957)



13,000 Square Miles protection against
fixed, licensed transmitters

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 - National Radio Quiet Zone
 - West Virginia Radio Astronomy Zone
 - Two new quiet zones now exist/are coming in the world:
 - South Africa (protection for MeerKAT, Kat64, SKA)
 - Australia (protection for SKA in Western Australia)

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 - Australia (protection for SKA in Western Australia)
 - Enforcement is a major challenge – must balance law and radio astronomy needs against community opinion

Community Agreement

- Even with legal protection community agreement is vital
 - Radio telescopes must work within a community, not against it
- Continuous challenge with outreach, education, and help
 - Teach the community who you are and why you needs the protection
 - Show the community the value of radio astronomy locally and scientifically
 - Help the community to mitigate the effects of the Quiet Zone(s) as possible
- This is a difficult challenge an done which must be continuously considered

Spectrum Management is a challenging issue which must be tackled for radio astronomy to flourish

Crowding of the spectrum will increase, and the space for radio astronomy will shrink

You can help!

Report RFI whenever you see it in your data

Be conscious of your use of electronic devices near radio telescopes

Work with the IAU, URSI, other organizations to protect the radio spectrum