Photograph by ISS astronaut Ron Garan

Overview of the Current Regulatory Framework

Liese van Zee
Indiana University
[Also, Chair of Committee on Radio Frequencies (CORF)]

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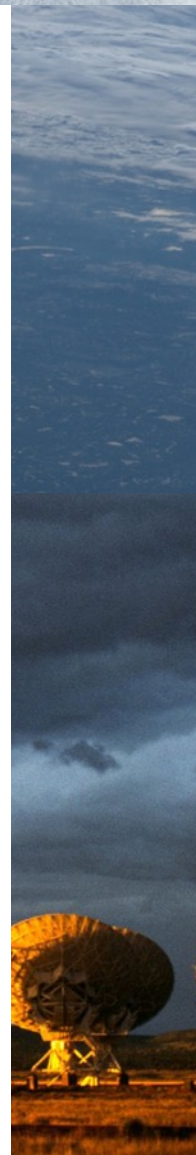
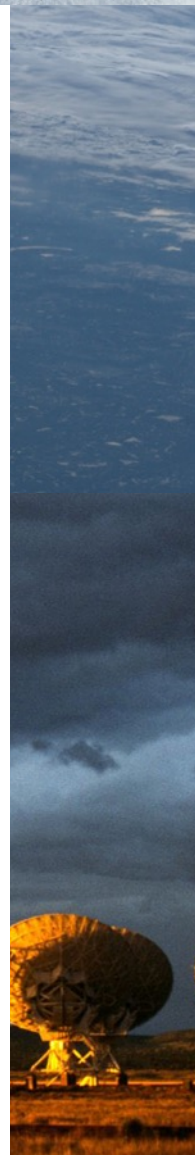
Very Large Array, A. Clegg

Spectrum Management and Policy

- Radio spectrum shared between commercial, governmental, and scientific uses.
- Currently, radio regulations cover frequencies from 8.3 kHz to 275 GHz and are both international (ITU) and domestic (e.g., FCC).
  - Radio spectrum defined as 0 – 3000 GHz.
  - IAU identified preferred bands for science below 3 THz.
- Increasing commercial demand/usage for radio frequencies due to recent advances in telecommunications technology.
- Increased need for spectral sharing and coordination.
  - However, issues with implementation of coordination agreements.
  - It is difficult to reverse regulations and recover spectrum when passive services are negatively impacted.

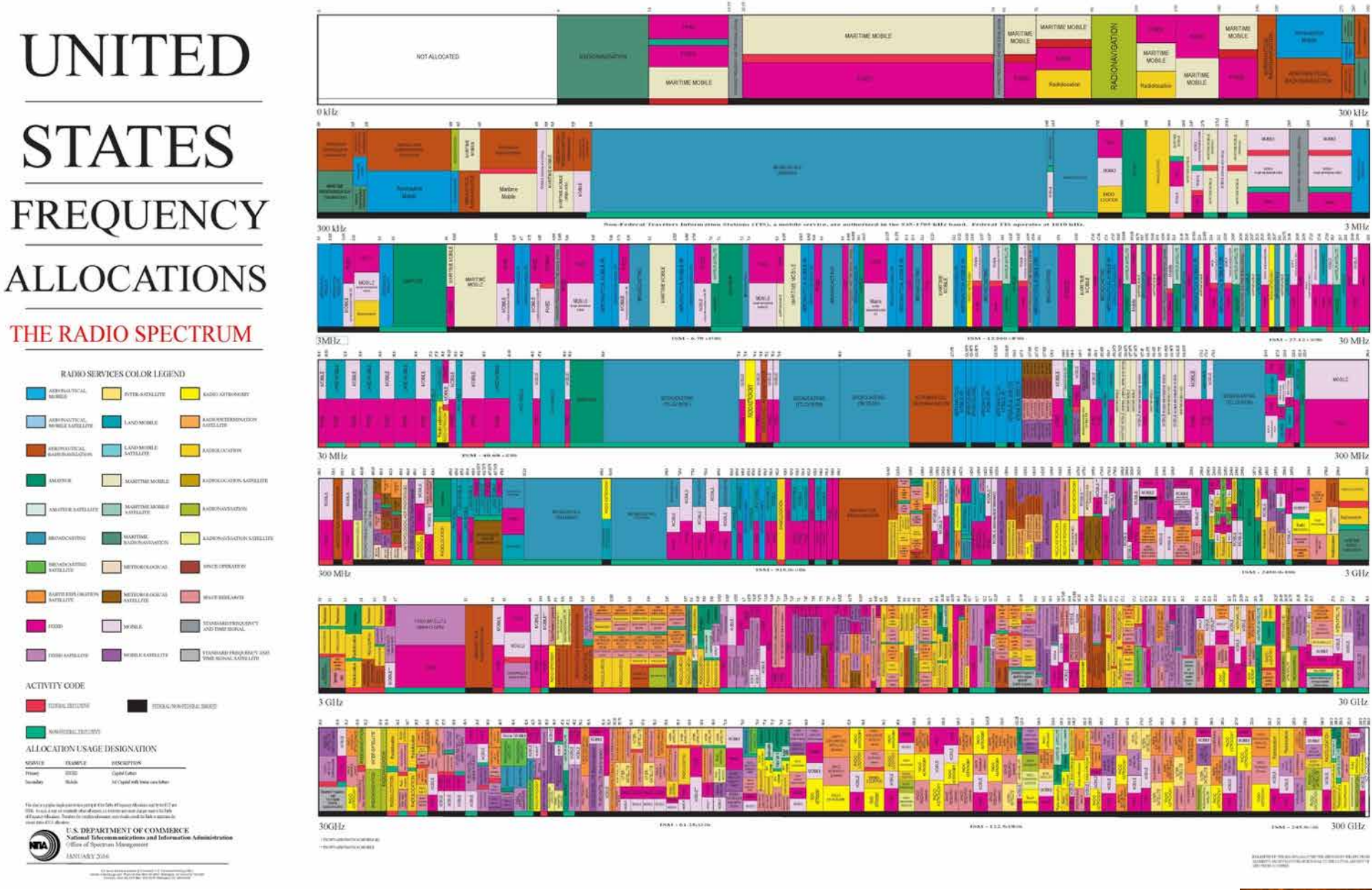


Domestic Regulatory Framework



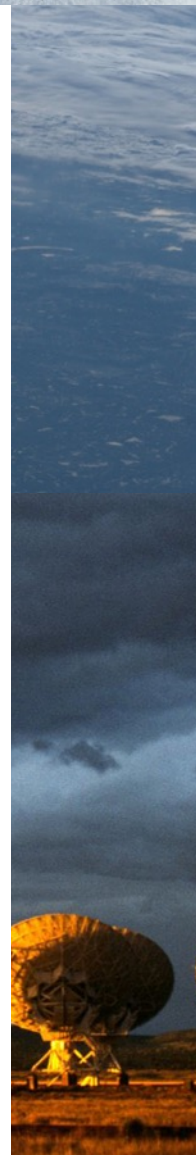
- Responsibility for regulation and management of spectrum in the US is split:
  - NTIA: Federal Government spectrum and users.
  - FCC: Regulates all other users.
  - US Congress: creates statutory framework, can set policies through legislation.
- Assignment vs Allocation of spectrum
  - Allocation: set aside specific bands of the spectrum generally for certain specific uses/services.
  - Assignment: designating a specific frequency band for use by a specific party in a specific location.

US Radio Frequency Allocations

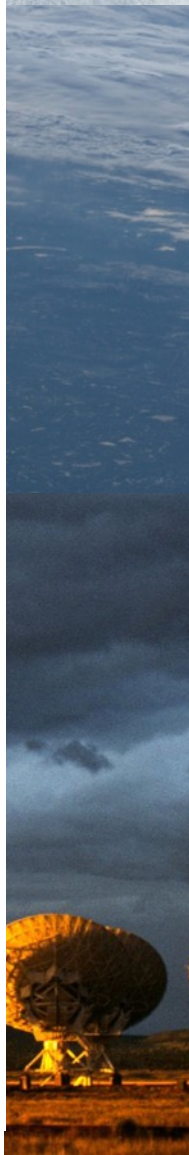


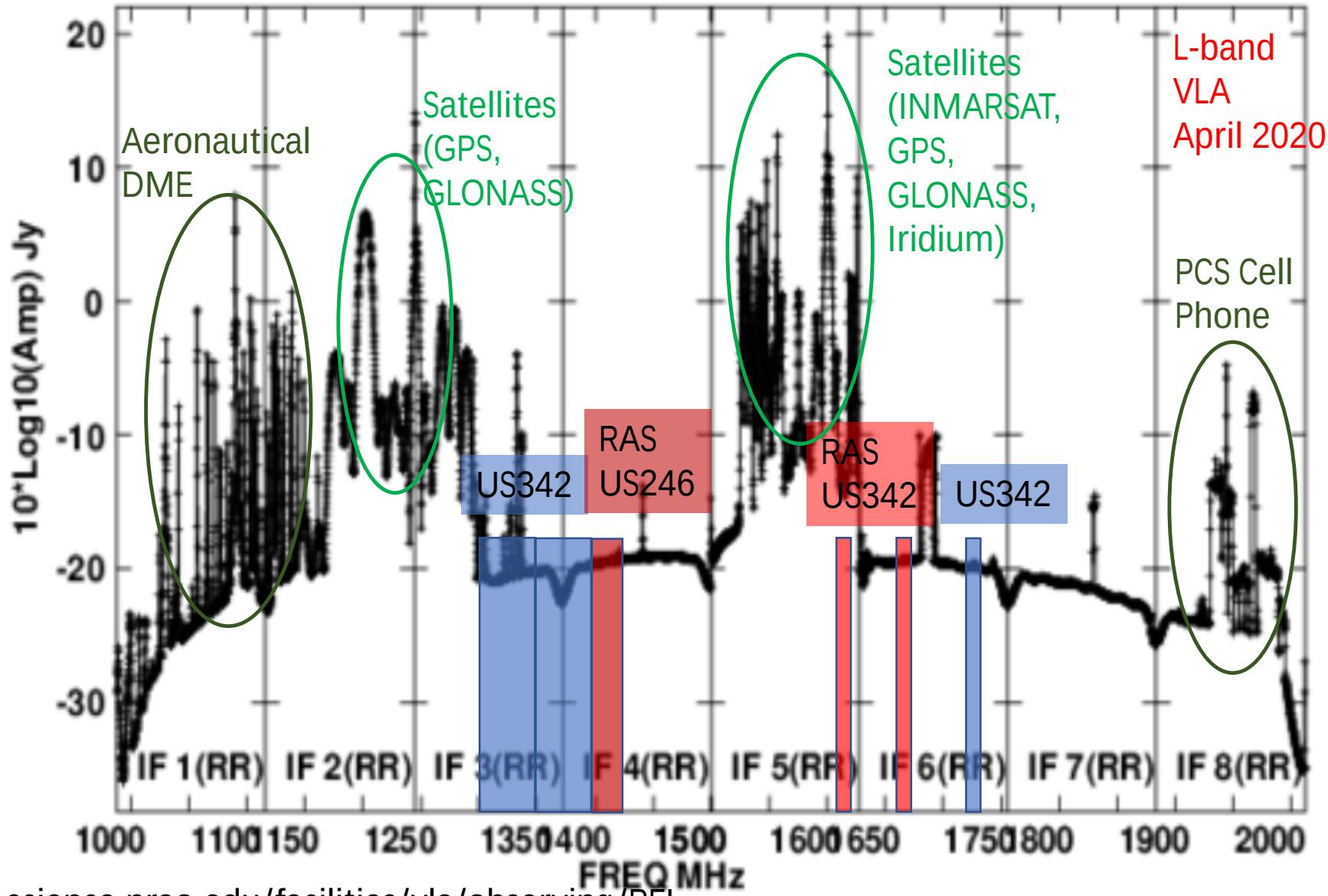
RAS Allocations – Part 1

- US Table of Frequency Allocations
  - v Primary Allocations: entitled to protection from harmful interference from any other service.
  - v Secondary Allocations: cannot claim protection from harmful interference from stations of a primary service to which frequencies are already assigned, but can claim protection from harmful interference of other secondary services.
  - v Footnotes
    - US246: "No station shall be authorized to transmit in the following bands"
    - US342: "…all practicable steps shall be taken 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…"



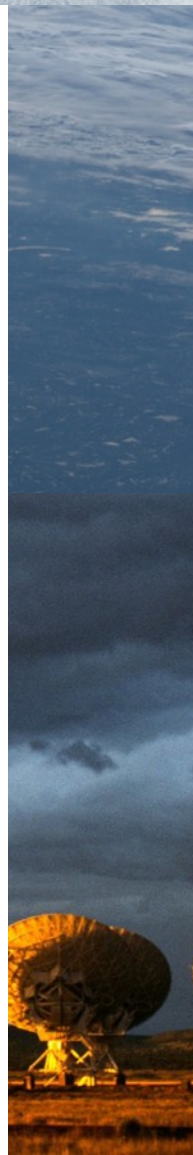
Example RAS Allocations: L-band





science.nrao.edu/facilities/vla/observing/RFI

RAS Allocations – Part 2

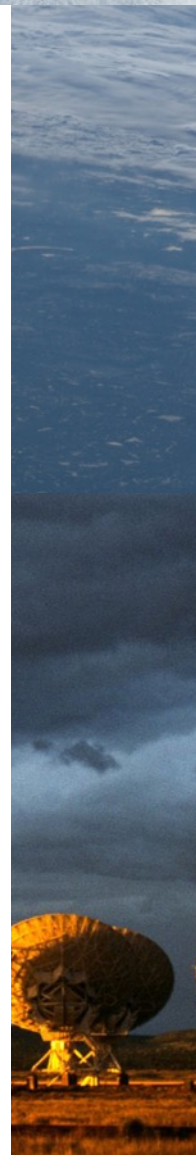


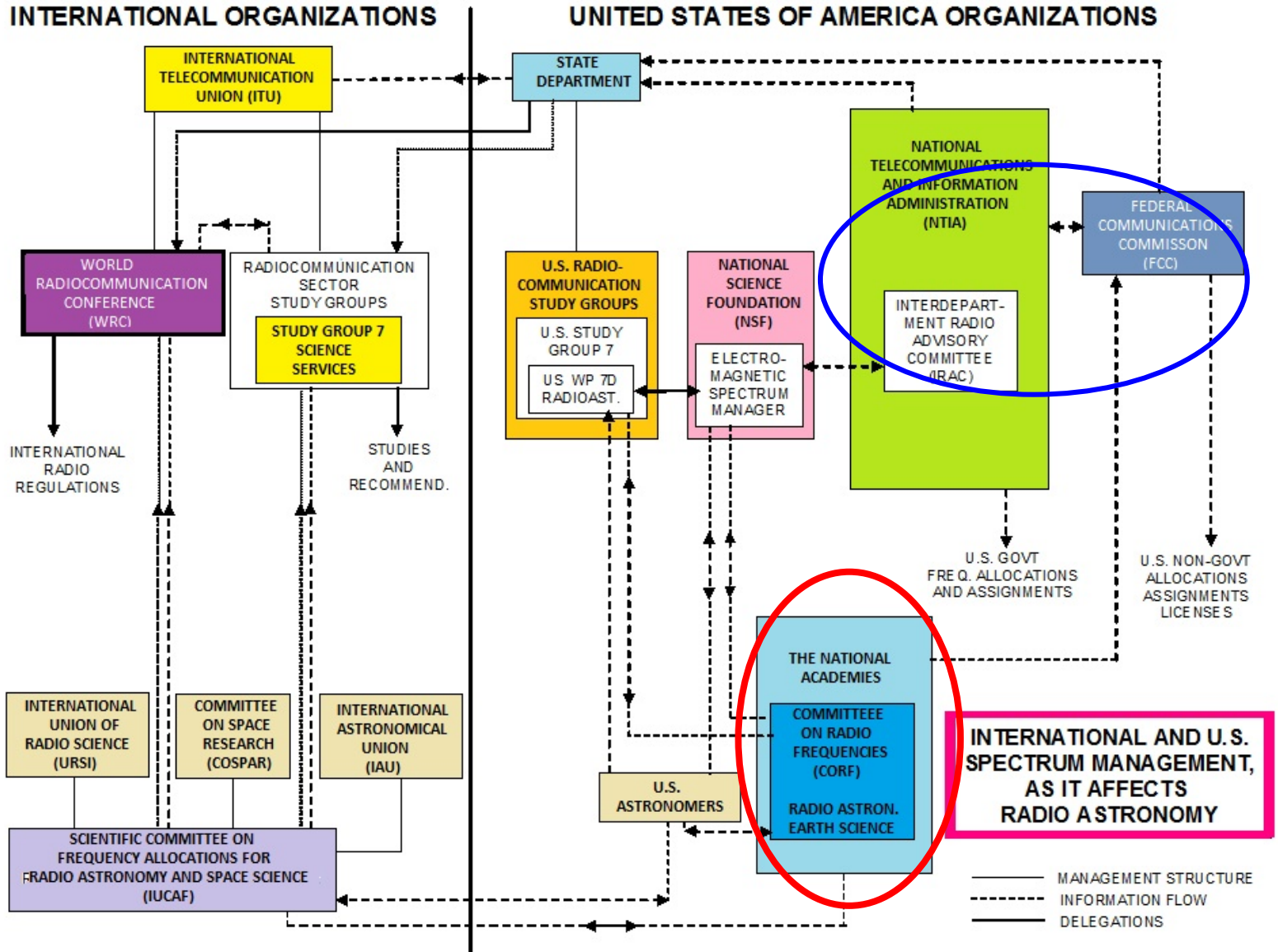
- Radio Astronomy is allocated less than 1.5% of the radio spectrum below 5 GHz
  - 1.25% is US246 (RR 5.340).
  - 5.43% includes above plus US342 bands (RR 5.149).
- Radio Astronomy is allocated 29% below 94 GHz
  - 9.6% is US246 (RR 5.340).
- Radio Astronomy is allocated more than 65% of radio spectrum between 95 – 275 GHz
  - 18.43% of 95 – 275 GHz is US246 (RR 5.340).
- No allocations above 275 GHz
  - RAS interests in 58.2% of 275 – 1000 GHz are noted in US565 (RR 5.565).

Radio Quiet Zones

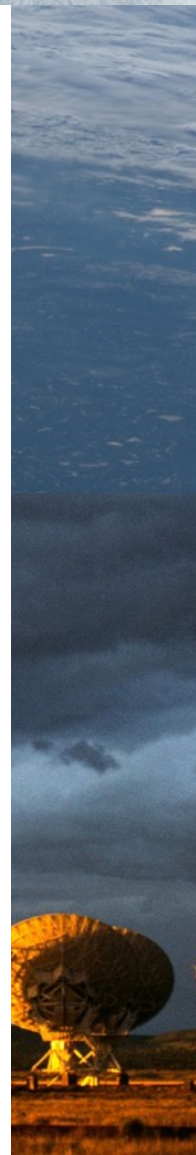
- National Radio Quiet Zone (NRQZ) in WV
  - Established in 1958; 13,000 square miles.
  - Typically, applicants coordinate with the GBO prior to filing with the FCC.
- West Virginia Radio Astronomy Zone
  - Established by WV Legislature.
  - 315 square miles (10 mile radius).
  - Applies to any electrical equipment that causes RFI.
- Puerto Rico Coordination Zone (PRCZ)
  - For new or modified stations below 15 GHz at permanent fixed locations on the islands of Puerto Rico, Desecheo, Mona, Vieques, and Culebra.
  - Notification at least 20 days in advance of applicant's planned operation.
  - Requires *reasonable* efforts to protect Arecibo Observatory from interference.

Spectrum Management and Policy





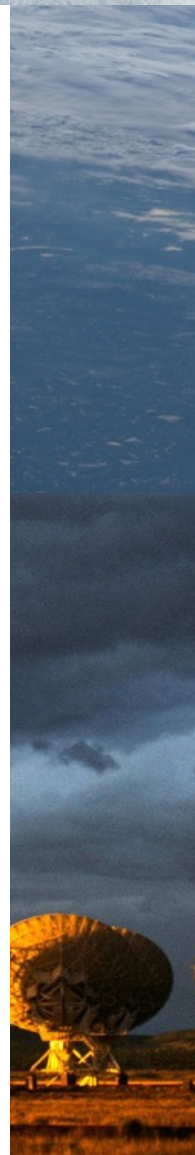
Domestic Process



- Spectrum Management by NTIA
  - v Interdepartment Radio Advisory Committee (IRAC)
    - Representatives from 19 federal agencies, including NSF and NASA.
    - Coordinates assignment of frequencies to US agencies.
    - Provides feedback to FCC on FCC rulemakings.
    - Reviews requests by non-government entities to use government spectrum.
- Spectrum Management by the FCC
  - v Regulates interstate and international communi-cations in the US.
  - v FCC regulates spectrum through *policies* and *rules* contained in *Orders.*

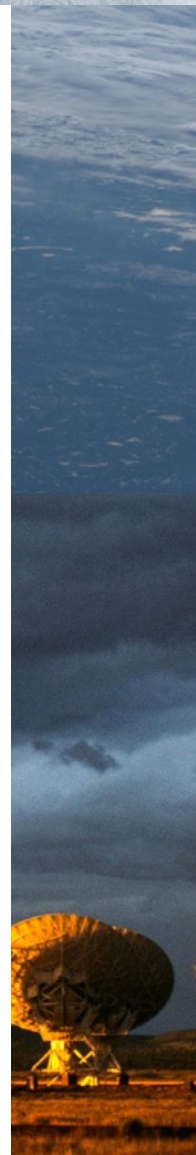
FCC Rulemaking

- FCC Rules – sections 0-101 of Title 47 of the US Code of Federal Regulations (CFR)
- Rulemaking Process:
  - v The FCC issues a Notice of Proposed Rulemaking.
  - v Public Comments through the Electronic Comment Filing System (ECFS).
    - NAS' Committee on Radio Frequencies (CORF) often files comments on NPRMs relevant to Radio Astronomy and Earth Remote Sensing.
    - NRAO's spectrum manager (currently Harvey Liszt) often files comments.
  - v FCC issues an Order containing new/modified rules.
  - v Parties may seek waivers from rules.



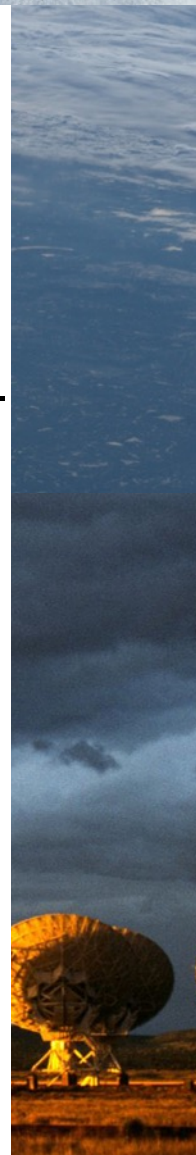
Licensed and Unlicensed

- Licensed
  - v Authorization for specific user/frequencies/locations.
  - v Typically exclusive use by 1 licensee w/in those parameters.
  - v Licensees entitled to level of protection from interference.
  - v RAS can often share with licensed applications since geographic shielding can be used to protect RAS facilities.
- Unlicensed (e.g., wi-fi, internet-of-things)
  - v Multiple users for a frequency.
  - v Shared use.
  - v Users have limited protection from interference but required to protect other licensed services.
  - v Very difficult to identify source of RFI from unlicensed devices; people often don't realized their possessions are transmitting.



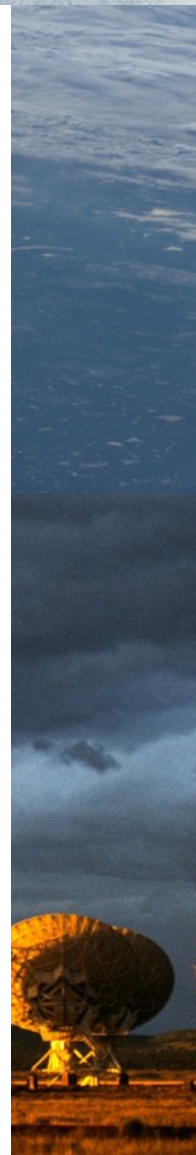
Satellites and High Altitude Platforms (HAPS)

- Airborne and satellite services have always been problematic for radio astronomy
  - v Geostationary satellites block access to the sky in a belt centered on the geostationary orbit.
  - v Non-geostationary satellite (NGSO) systems are now being deployed with tens of thousands of satellites in mega-constellations with multiple satellites above the radio horizon at all times.
  - v High Altitude Platforms will also have several stations visible at all times.
- Coordination Agreements
  - v Dedicated transmission-free times for geographical areas around radio observatories, negotiated via the NSF electromagnetic spectrum management group.
  - v These will be particularly challenging in the era of mega-satellite constellations.



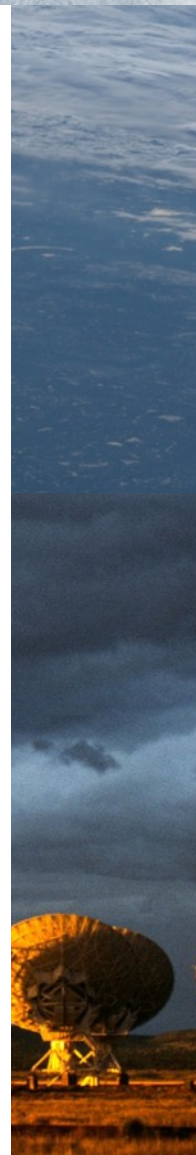
International Regulatory Framework

- International Telecommunications Union (ITU)
  - Founded in 1865 as International Telegraph Union.
  - Renamed in 1932; Part of the UN system in 1947.
  - Maintains the International Radio Regulations.
    - Updated at each World Radiocommunication Conference.
    - Encompasses allocations and service/coordination rules.
  - Three sectors (Radiocommunication; Telecommunication; Development).
  - 193 Member states, more than 700 member entities.
    - US delegations are comprised of representatives from government and industry who have worked within the US system prior to the ITU-R meetings. The US position is determined in advance.
    - IUCAF is a non-voting member.

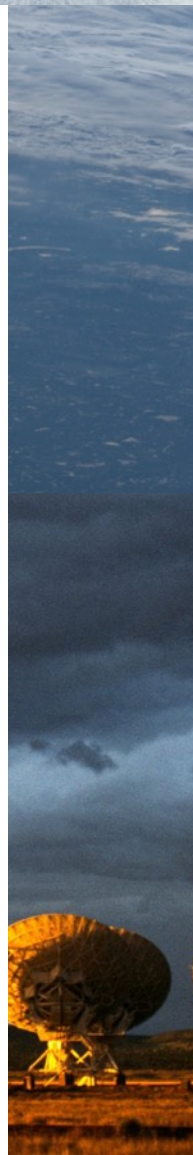


International Process

- World Radiocommunications Conference (WRC)
  - v Occur every 3-5 years. WRC-19 was last November; WRC-23 and WRC-27 are planned for the future.
  - v Prelude to each WRC are “Agenda Items.”
    - WRC-23: AI 1.1, 1.2, 1.4, 1.6, 1.8, 1.10, 1.11, 1.13, 1.14
  - v Often regional, multilateral, and bilateral discussions and agreements are made in advance of the WRC.
    - US is part of CITEL.
  - v Outcome of each WRC are “final acts” that are essentially international treaties.
- International Table of Frequency Allocations
  - v Most countries adopt similar frequency allocations.
    - US is in Region 2; FCC is currently moving at faster pace than the international community on some allocations.
  - v International footnotes.
    - RR 5.340 – all emissions prohibited.
    - RR 5.149 – all practicable steps to protect RAS.

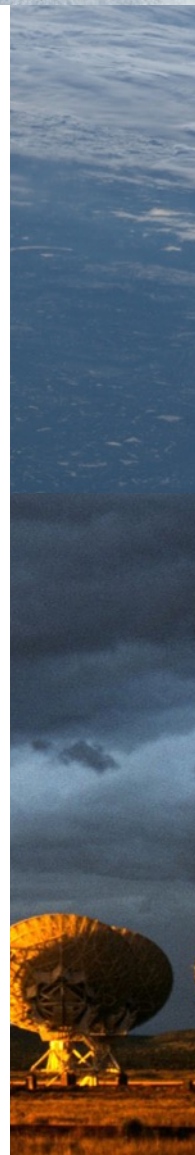


ITU-R Study Groups



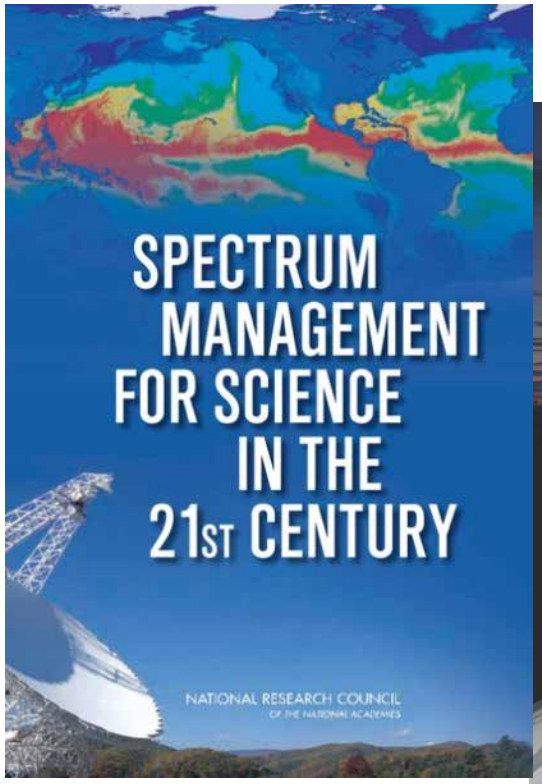
- SG1: General Spectrum Management (technical, regulatory, measurement)
- SG3: Propagation
- SG4: Satellite issues
- SG5: Terrestrial issues
- SG6: Broadcast issues
- SG7: Science Services
  - WP7A – Time signals and frequency standards
  - WP7B – Space radiocommunication applications
  - WP7C – Earth Remote Sensing (passive and active)
  - WP7D – Radio Astronomy

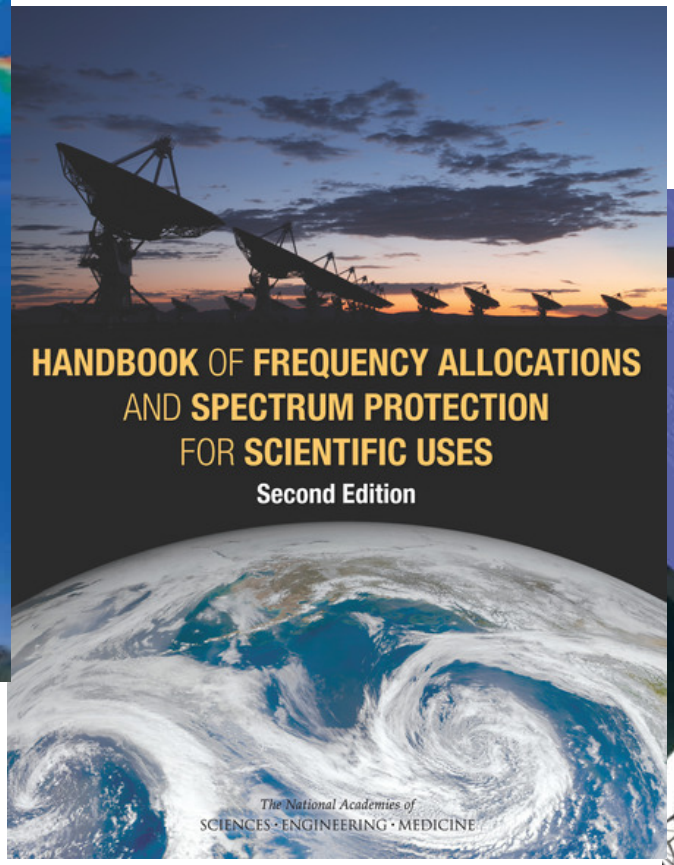
ITU-R Documents and Studies



- Resolutions: provide instructions on organization or working methods of the Union and its study groups.
- Recommendations: recommended methods and values to be used in spectrum management.
  - v May be used by some administrations in formulating their regulations.
  - v If referenced by International Radio Regulations, may have regulatory force.
  - v ITU-R RA.314: Preferred frequency bands for RAS.
  - v ITU-R RA.769: Threshold values of harmful interference for RAS.
  - v ITU-R RA.1513: Levels of data loss for RAS.
  - v ITU-R RS.2017: Interference criteria for EESS.
- Reports: technical in nature, may be referenced by other documents.
- Handbooks: provide more detailed and comprehensive technical information than reports.

Want to learn more?
CORF Publications!

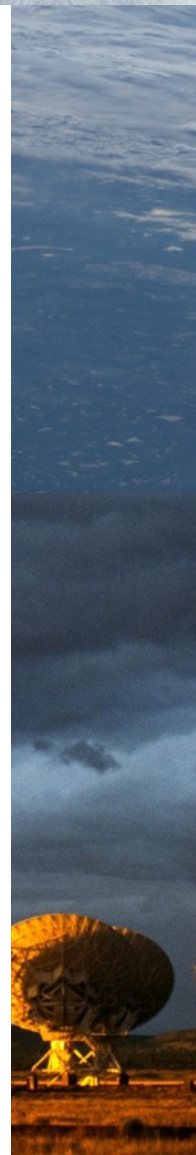




Available for download from the National Academies Press

Major Issues

- **Spectrum sharing:** geographic shielding, time sharing, frequency separation
- **Innovative spectrum zones:** dynamic quiet zone
- **Radio Frequency Interference Mitigation:** detection, excision, beam forming, identification of source, reporting
- **Technology Development:** receivers and telescopes
- **Personnel Development:** RF engineers, spectrum management



Photograph by ISS astronaut Ron Garan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Thank you!

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