NRAO Spectrum Management Update

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NAS Space Science Week (CORF) March 25, 2026

Overview

- NRAO Spectrum Management Department
  - Mission
  - Organization
- Areas of Effort
  - Zone Regulatory Services (ZRS)
  - Spectrum Monitoring & Radio Frequency Interference (RFI) Mitigation
  - Spectrum Policy
  - Special Projects
    - Operational Data Sharing (ODS)
    - Advanced Spectrum Monitor (ASM-2)
    - Dynamic Radio Interference Finding Tool (DRIFT)
    - 7 GHz Band Study
  - Spectrum Education and Awareness

NSF NRAO Mission Statement (2026)

The NSF National Radio Astronomy Observatory and NSF Green Bank Observatory enables forefront research into the Universe at radio wavelengths. In partnership with the scientific community, we:

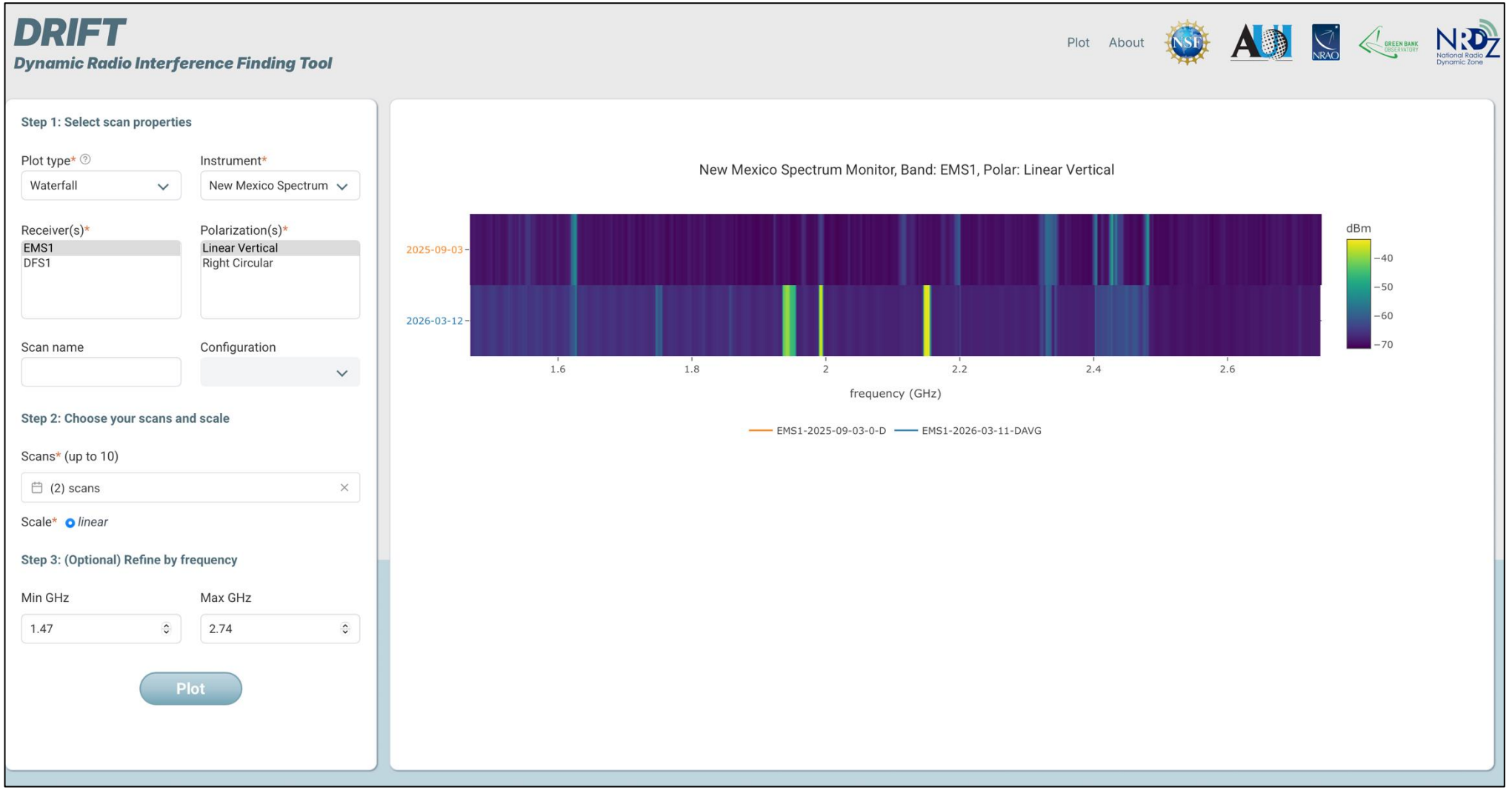
- *provide world leading telescopes, instrumentation, data and expertise;*
- *train the next generation of scientists and engineers;*
- *and promote astronomy to foster a more scientifically literate society.*

Zone Regulatory Services

Zone Regulatory Services (Sheldon Wasik, ZRS Manager)

- National Radio Quiet Zone (NRQZ)
  - Since 1958
  - West Virginia Radio Astronomy Zone (WVRAZ)
  - Home to Green Bank Observatory (GBO) and Sugar Grove Research Station (SGRS)
- Puerto Rico Coordination Zone (PRCZ)
  - Request by NSF to take on management (2023)
  - Planning to continue management until fate of Arecibo site decided
- New Mexico Radio Coordination Zone (NMRCZ)
  - No legal protections similar to NRQZ
  - Challenges with cell towers in the Plains of St. Augustin (Next Slide)
- Challenge of Satellite Transmissions to Quiet Zones

NRAO DRIFT Web-Based RFI GUI



Recent Activities: Zone Regulatory Services (ZRS)

- ZRS administers concurrence/coordination for 3 sites
  - National Radio Quiet Zone (NRQZ)
  - Puerto Rico Coordination Zone (PRCZ)
  - New Mexico Radio Coordination Zone (NMRCZ)
- NRQZ recently hired an Assistant to help with concurrence and site inspection duties
  - Assistant has allowed ZRS Manager (Wasik) to work with counties/park systems to improve safety in the NRQZ
- NRQZ now tracks and reports concurrence application data quarterly/annually (Right)
- Communicating with our neighbors
- Improving methods, concurrence letter generation
- Large numbers of applications
  - Quiet Zone Application Tool for tracking
  - Moving to Quiet Zone Application Portal (QZAP) in FY27

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National Radio Quiet Zone Applications – FY2025 Q4 Report

I. Introduction

Since January 2022, the NRAO Spectrum Management Department (SMD) has been documenting information on National Radio Quiet Zone (NRQZ) applications. This quarterly report is generated using the technical information received from applicants, with focus on the number of applications received, how many facilities were evaluated, and the breakdown of objections and concurrences. Major projects outside of typical NRQZ workflow, such as water meter projects that often result in thousands of facilities and preliminary projects that are evaluated with hundreds of possible designs, are excluded from the results and can be found in different NRAO SMD and NRQZ related presentations. This report is broken up by the recent quarterly results and the running total since January 2022, and is intended to be internal to NRAO and may not be shared externally without consulting the NRQZ Office.

II. Number of Applications Received – FY2025 Q4

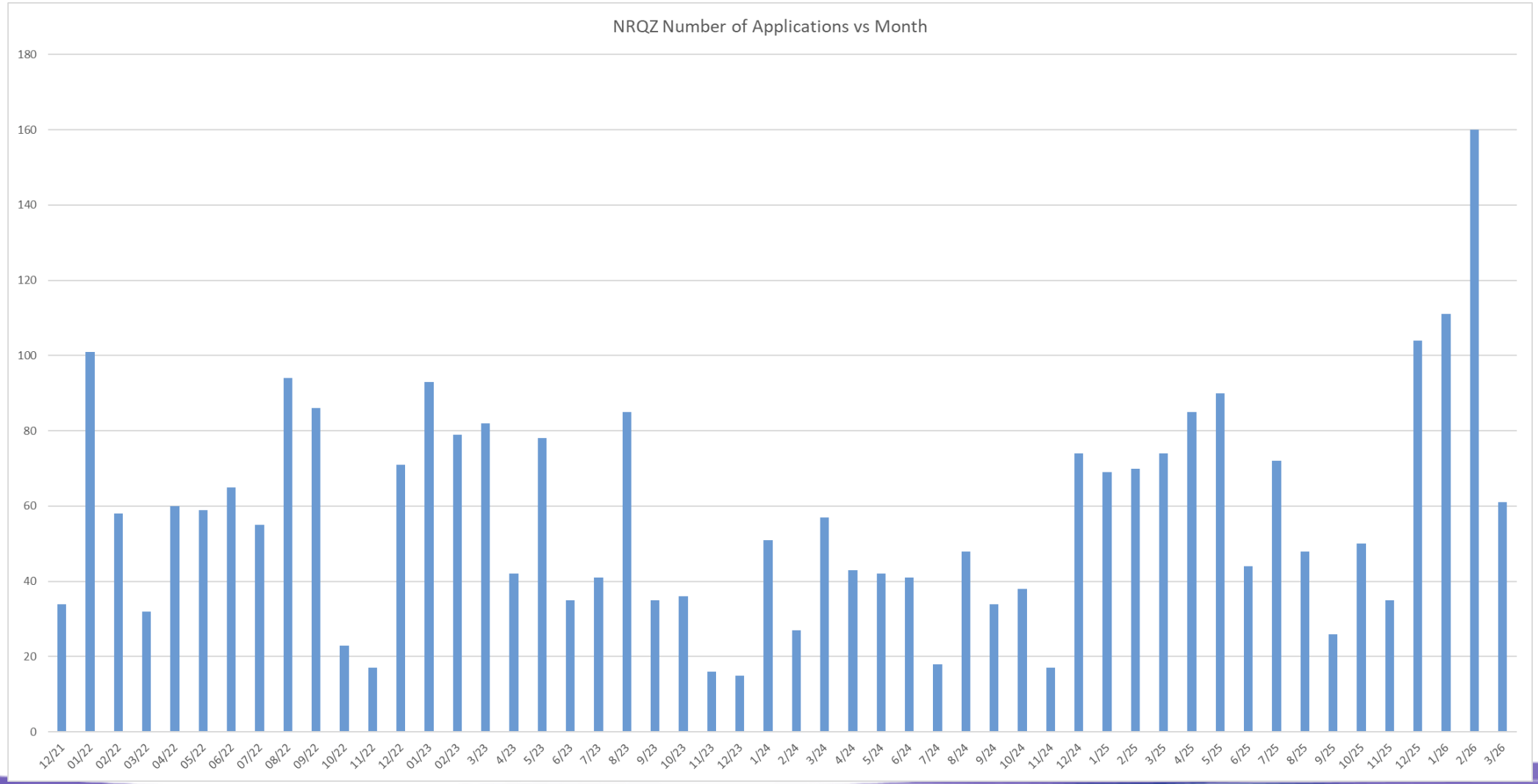
During FY2025 Q4 the NRQZ office received 146 applications, resulting in 707 facilities that needed to be evaluated. Of those applications, the percentage breakdown of applicants is:

Applicant	Number of Applications	Percent of Applications
T-Mobile	11	7.5%
Verizon Wireless	53	36.3%
AT&T	5	3.4%
US Cellular	1	0.7%
Other	76	52.1%

Of those applications, NRAO concurred on 78 and initially objected to 68 with a worst-case scenario assumption. Of those objections, NRAO received additional engineering information or planned deployment modifications demonstrating the NRAO limit will be met for 54 applications resulting in a total of 132 concurrences to be issued. This results in 14 applications pending additional information from the applicant. Figure 1 displays this information.

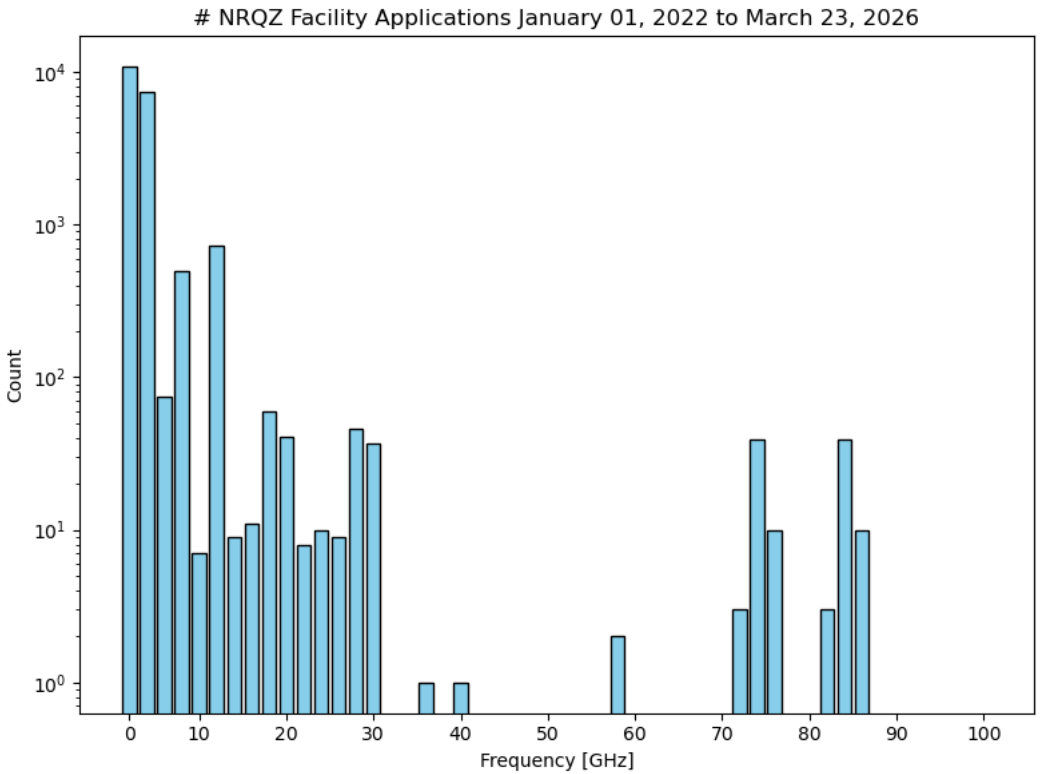
Figure 1: Application breakdown of FY2025 Q4, outlining how many applications resulted in a concurrence, an objection based on worst-case scenarios, and resolved objections based on NRAO limits.

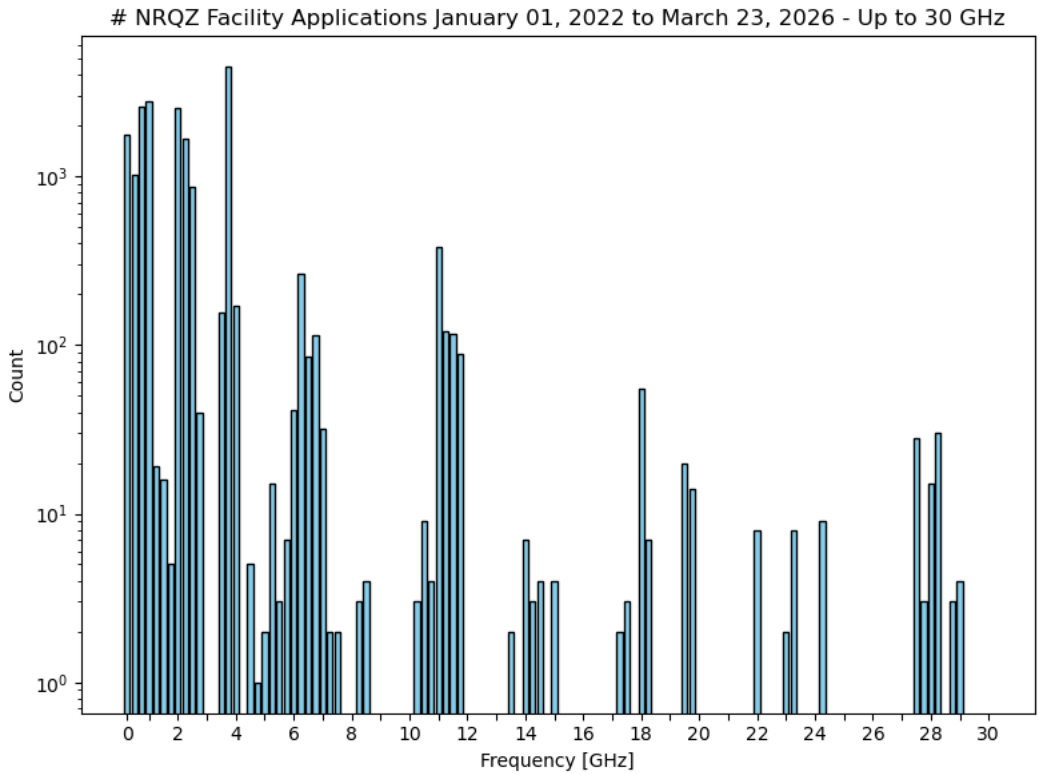
Applications per month to NRQZ (December 2021-Present)



Frequencies of applications as a measure of deployed technologies

NRQZ Applications: 99.5% are below 30 GHz (recent data below)





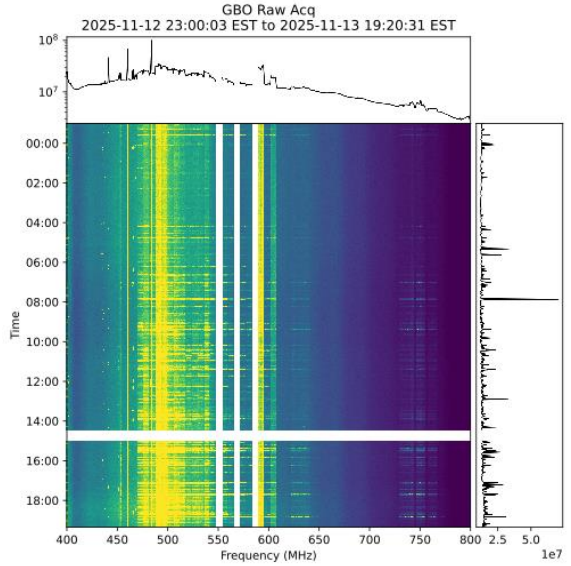
Spectrum Monitoring and RFI Mitigation

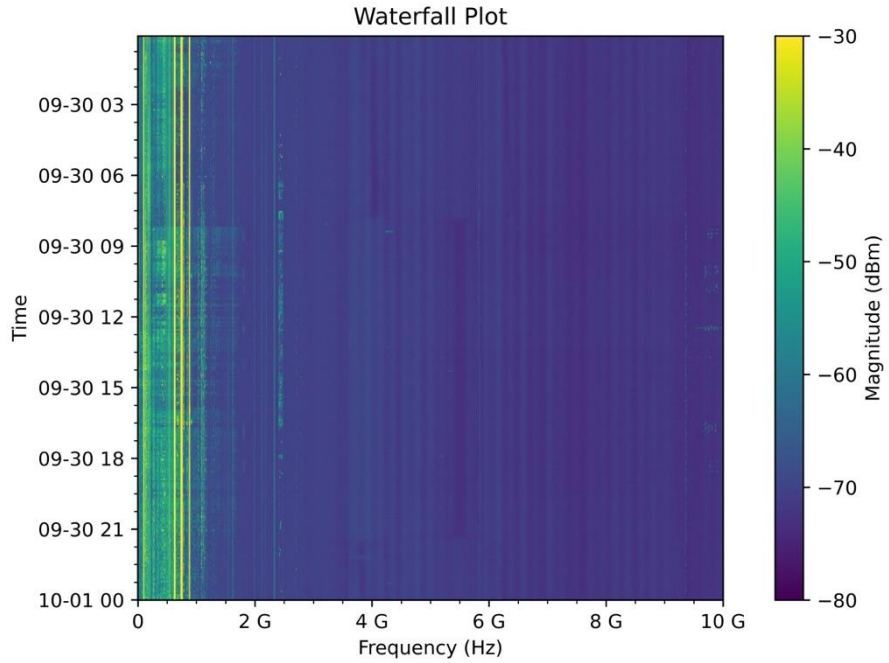
Spectrum Monitoring & RFI Mitigation

- Green Bank Interference Protection Group
  - Bi-weekly meetings
- New Mexico Interference Protection Group
  - Monthly Meetings
- IPG Duties/Membership
  - Site RFI Monitoring
  - RFI identification
  - Onsite RFI Mitigation
  - Scientists, Engineers, Data Analysts
- Tools
  - Electromagnetic Spectrum Monitor (ESM-1) – operational at VLA
  - Dynamic Interference Finding Tool (DRIFT) – deployed, backfilling data
  - Advanced Spectrum Monitor (ASM-2) – under construction at CDL
  - Anechoic chambers for testing (GBO and VLA)

Spectrum Monitoring: RFI Data from Sites

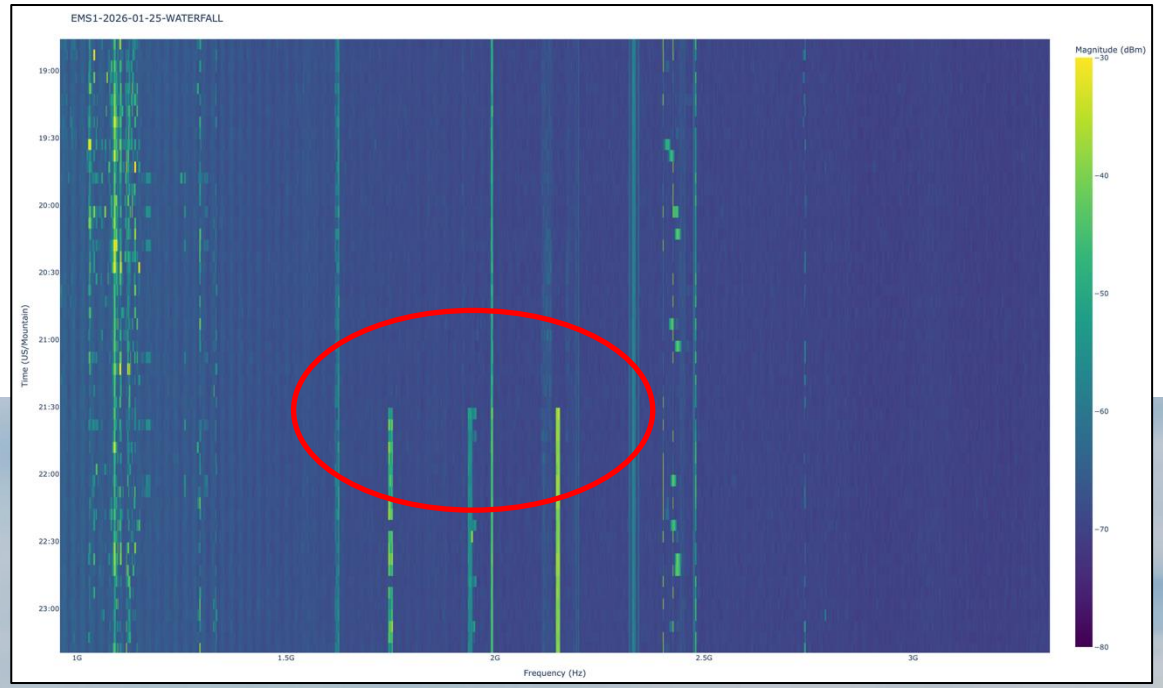
- Regular RFI Scans
  - GBO
    - GBT: regular (weekly) scans with available receivers
    - CHIME Outrigger (400-800 MHz), daily waterfall plot (R-top)
  - VLA
    - Bi-weekly (North and South) scans from 1-50 GHz
    - Once per configuration Alamo Pilot Program monitoring
      - Uplink and Downlink frequencies
    - NM-Electromagnetic Spectrum Monitor (NM-ESM)
      - Daily waterfall plots 1-10 GHz (R-bottom)
  - VLBA (scans being taken, working on integrating data reduction)
- RFI Tracking Software
  - **Dynamic Radio Interference Finding Tool (DRIFT)**
    - All NRAO site RFI data will be served to DRIFT in a common data format

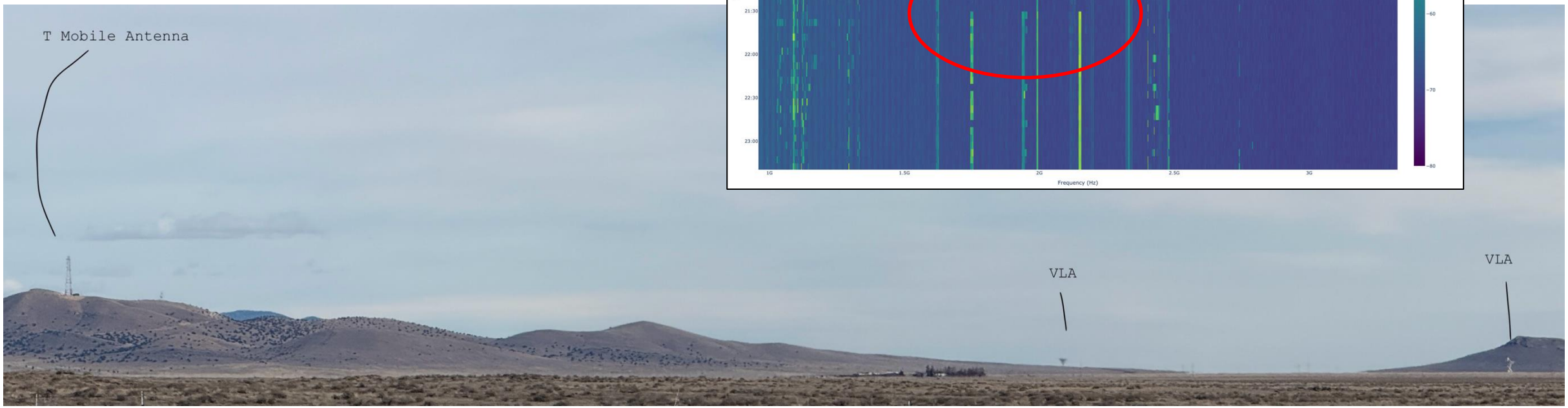




Technology Updates in the Absence of an official Quiet Zone

- January 25, 2026
  - New technology turn on detected
- All S-band observations impacted





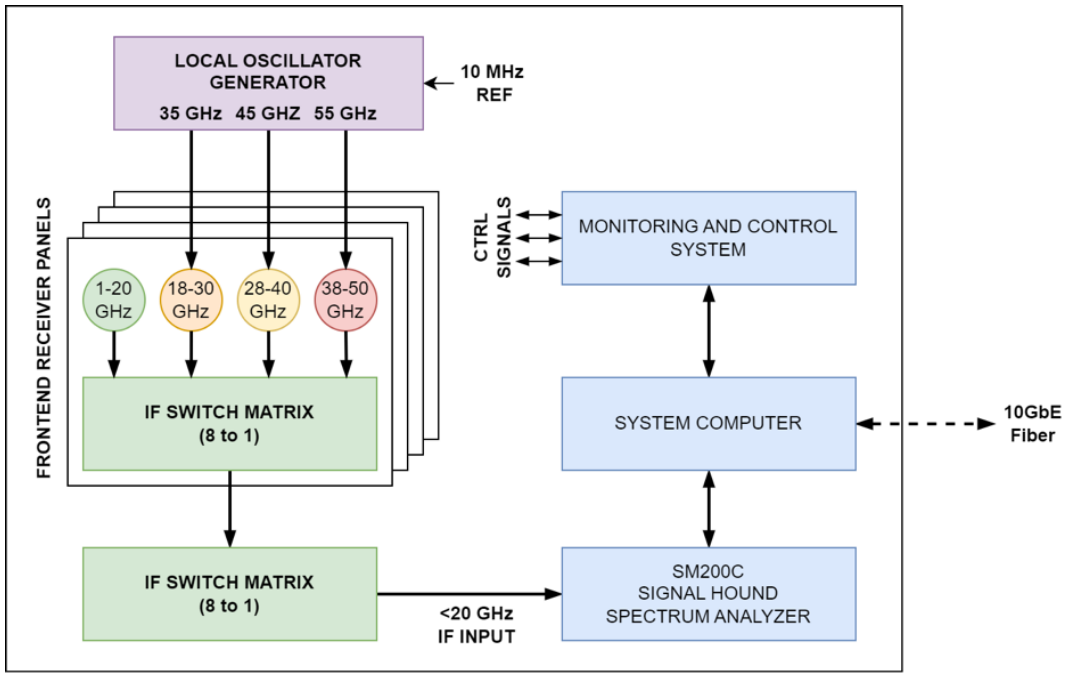
Advanced Spectrum Monitoring Device (ASM-2)

Objective of the ASM

Creation of a self-contained, autonomous, and wideband spectrum monitoring station with direction finding capabilities

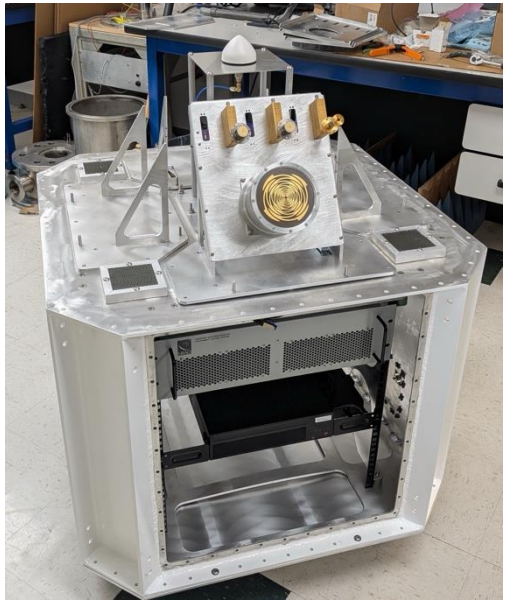
Key Design Features

- Complete Frequency Coverage 1-50 GHz
  - Separated into 4 overlapping bands: 1-20, 18-30, 28-40, 38-50 GHz
  - Full hemispherical coverage with 4 cardinal directions
- Tightly integrated antennas and receivers/low-noise block downconverters with mostly COTS components/tech
- Fixed Frequency LO generator with Harmonic Generator
- Electrically/solid-state switching of active antenna and receiver signal path for Amplitude of Arrival direction finding
- Simple network interface over fiber ethernet

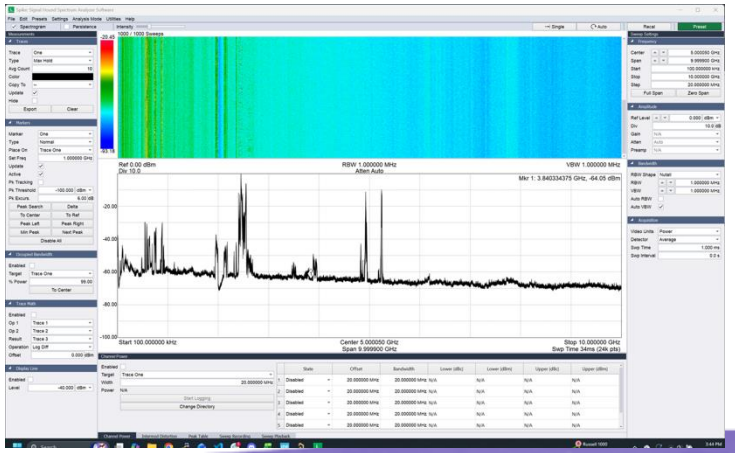


Recent Highlights & Status: ASM-2

- The development of the Advanced Spectrum Monitor (ASM-2) made steady progress through FY25
- FY25 development focused on design and implementation of subsystems that provide the core functionality to the ASM: IF routing, LO generation, monitoring & control, power distribution, and enclosures
- Modules have been tested individually and being integrated into their final production ready enclosures and assemblies
- Device under construction at CDL



The ASM-2 enclosure (L-above) is manufactured locally (in VA). ASM-2 assembly proceeding last week (R-above)



Plot shows "first light" from 1-10 GHz (L) from ASM-2.

Spectrum Policy

Spectrum Policy

- National Policy Related Work
  - 7 GHz Band Study (NTIA/NSF)
  - FCC Replies/Comments
  - CORF Representation (Bang Nhan)
- International Policy Work
  - ITU-7D work (Frank Schinzel, Harvey Liszt)
  - IUCAF (Harvey Liszt)

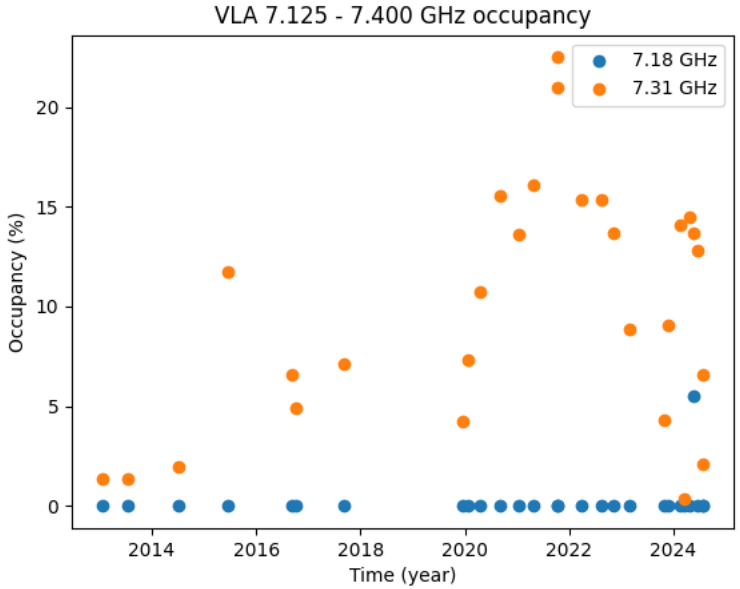
Spectrum Policy and Outreach Activities (2025-2026)

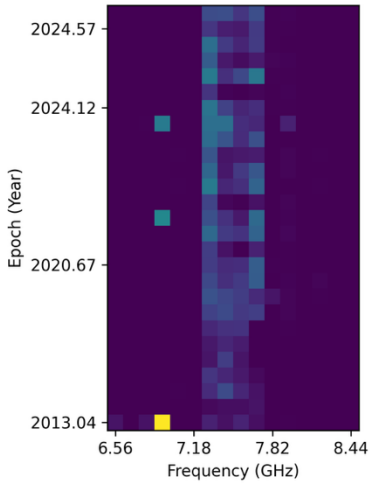
- **July 17, 2025:** Chris De Pree and Bang Nhan present on the ODS system with SpaceX to the FCC Space Bureau at FCC headquarters
- **July 24, 2025:** Daniel Bautista and Riley Dunnagan host a radio astronomy and spectrum management career session for SpectrumX Research Experience for Undergraduates participants at Green Bank Observatory, Green Bank, WV
- **September 13-14, 2025:** David Bordenave, Anja Fourie, and Bang Nhan support an NRAO exhibition at the Joint Andrews Airforce Base Air Show, Prince George's County, MD highlighting the value of radio spectrum and NRAO's work in spectrum management
- **September 19-21, 2025:** Chris De Pree presents a guest lecture during the SpectrumX Undergraduate Summer School for Wireless co-located at SUNY at the University of Albany, Albany, NY; University of Puerto Rico, Mayagüez, PR; and NRAO Headquarters, Charlottesville, VA from
- **September 29 - October 3:** Harvey Liszt serves on the Scientific Organizing Committee of the Sixth International IUCAF School in Spectrum Management for Radio Astronomy held at the Observatorio Astronómico Nacional (OAN), Alcala de Henares, Madrid, Spain held from. Harvey Liszt and Sheldon Wasik lecture during this School
- **October 7-16, 2025:** Harvey Liszt and Frank Schinzel participate in the ITU-7D meetings held in Geneva
- **October 21, 2025:** Chris De Pree participates in an industry panel discussion entitled "Satellite Spectrum Abundance" during the SpectrumX Fall Center Meeting, Madison, WI
- **March 2-13, 2026:** Harvey Liszt and Frank Schinzel participate in the ITU-7D meetings held in Geneva

Special Projects

Special Projects

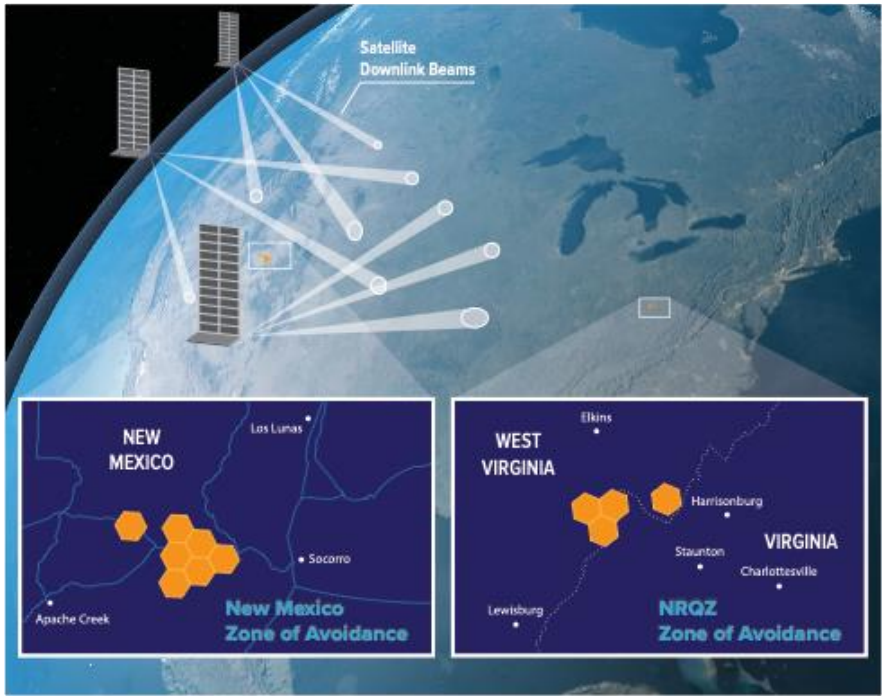
- Project/Grant based work
- Examples
  - Operational Data Sharing (ODS)
  - Advanced Spectrum Monitor (ASM-2)
  - Dynamic Radio Interference Finding Tool (DRIFT)
  - Band Study (7 GHz)
    - LNA Burnout Study (C-Band)
    - Tunable Notch Filter Development (Matt Morgan)
    - Occupancy Studies

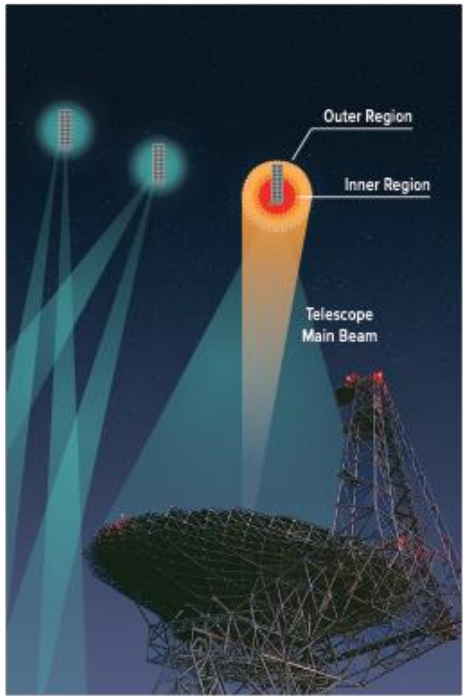




How can Radio Astronomy Coexist with Satellites?

- ***Zone avoidance***
  - Downlink beam placement to avoid radio zones
- ***Boresight avoidance***
  - Momentarily disable downlink (< 3-5 s) when close within a certain the telescope's boresight threshold
- ***Frequency avoidance***
  - Only downlink at sub-bands not being used by the telescopes



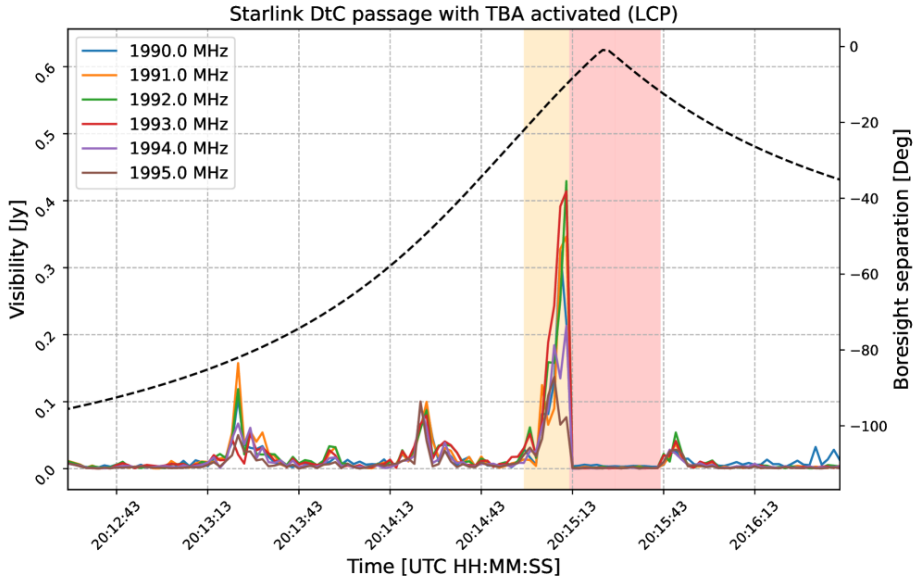


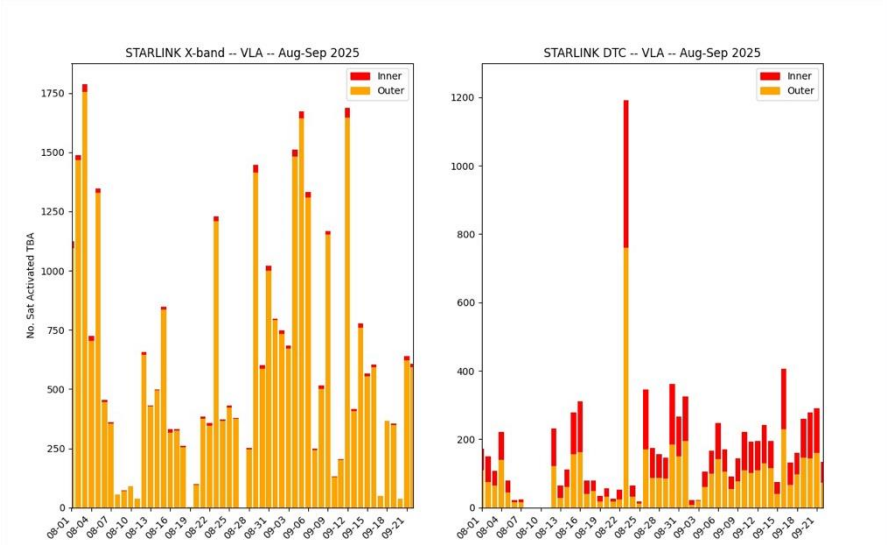
Recent Activities: Operational Data Sharing (ODS)

- One coexistence technique: Operational Data Sharing (ODS)
  - Reporting mechanism for radio telescopes to report: sky position, frequency band, bandwidth, time span
  - Satellite constellations use this information to avoid telescope boresight
  - Possible to extend this methodology to terrestrial transmitters
- Actively working/testing with SpaceX
  - In discussions with Kuiper (Amazon) and AST-SpaceMobile, testing to start 2026
- ODS has been operational at the VLA for 1-2 years (August 2024-X, January 2025-L)
  - Operational at VLBA since August 2025
  - In testing for the GBT (X-Band, S-Band)
- Independent ODS servers have been set up for CSIRO, Haystack, HCRO and others

Recent Status: ODS

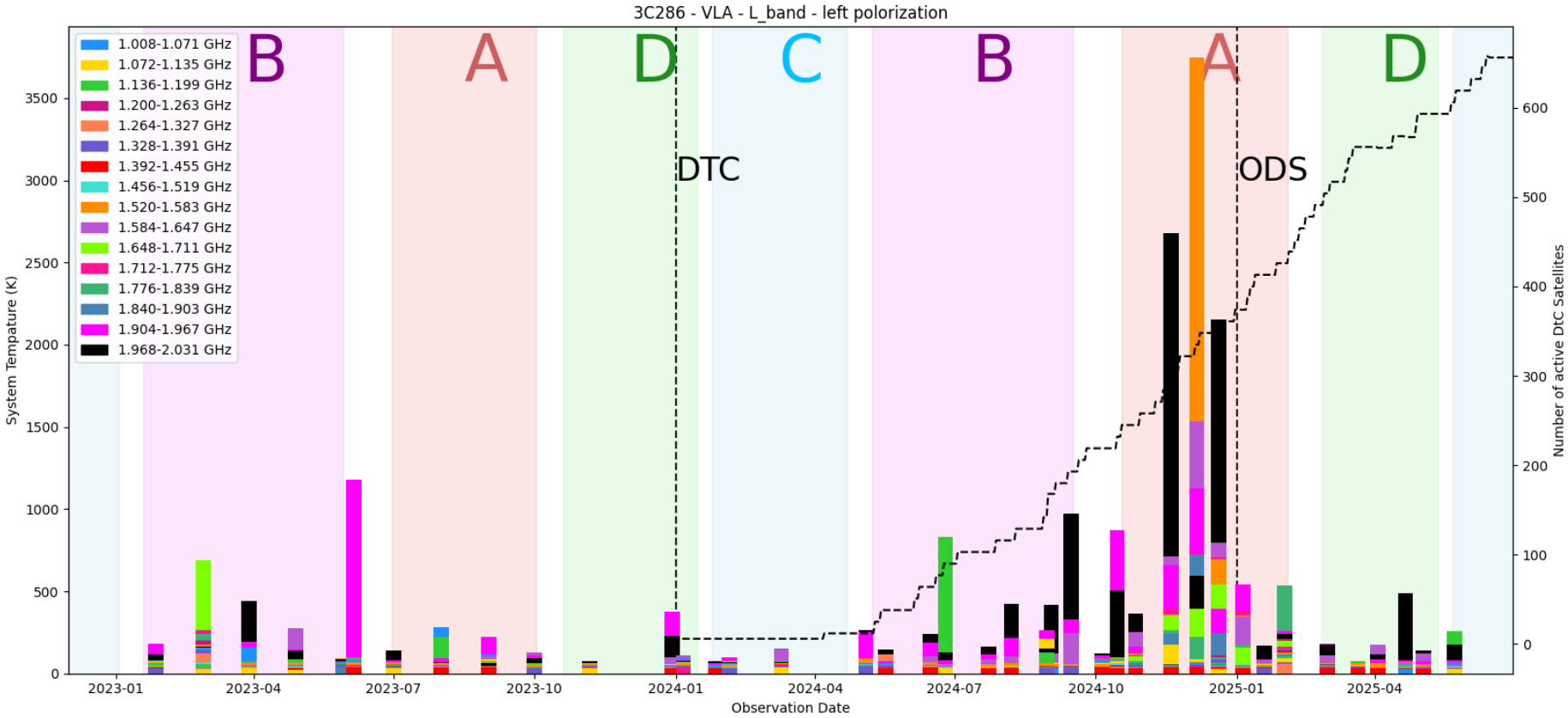
- **ODS: A self-reporting system for radio telescopes to coexist with adaptive satellite constellations** (Nhan et al., 2025, IEEE Communications)
  - Co-authored with SpaceX Engineers
- Two-way data sharing
  - Telescope Boresight Avoidance (TBA) Log Files shared by SpaceX every 3 days
  - Allows for science data to be spot-checked for effectiveness (R-top)
  - Shows the large number and variability of TBA events per day (R-bottom, showing ~2 months of data)
- New tokenized/authenticated ODS server active





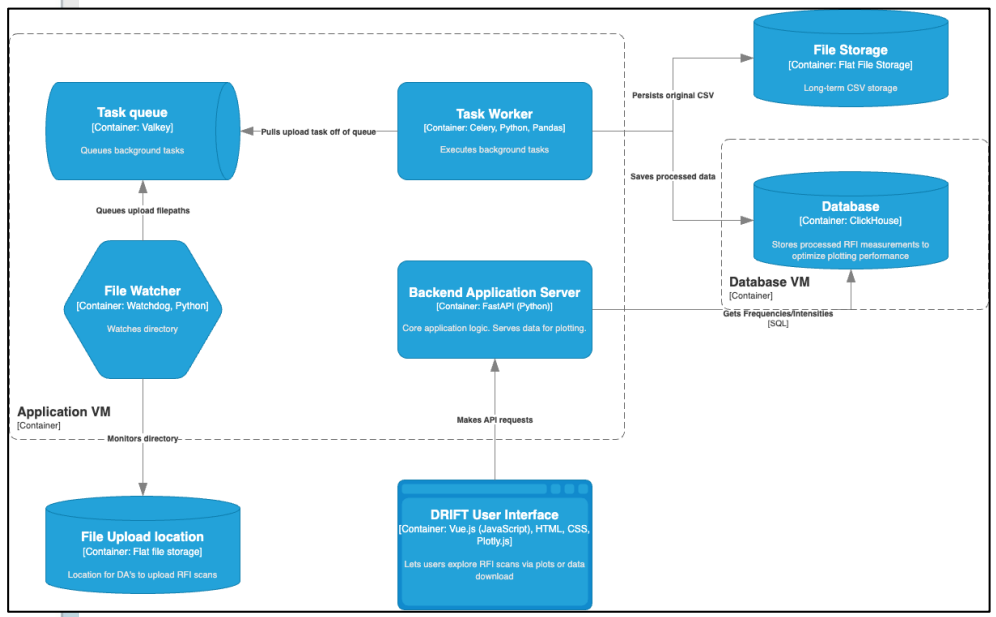
Recent Highlight: 2025 Summer Student Work

- Blake Hutchins worked with Aaron Lawson on Impact of DtC transmissons on VLA



Recent Highlight: DRIFT Development

- DRIFT can serve data from VLA, VLBA, GBT, CHIME, NMSM and other telescopes



Spectrum Education and Awareness

Spectrum Education and Awareness

- Curriculum Efforts
  - K-12 Curriculum (NRDZ)
  - Undergraduate Curriculum (SII-NRDZ)
  - Graduate Curriculum (SII-NRDZ, SWIFT-SAT)
    - Spectrum Policy Course
    - Spectrum Science Course
- Broader Impact Efforts
  - Presence at AAS Meetings
  - Participation in Science Fairs by Spectrum Management Staff
- Raising Visibility/Improving Communication

Raising Visibility/Improving Communication

- RFI/Spectrum Visibility Initiatives
  - 2022-2025: AUI RFI Working Group Meets Bi-Annually
  - 2023-2025: NRAO RFI Memo Series
  - 2024-2025: NRAO RFI Journal Club (Monthly)
  - 2025: Spectrum Management Bi-Annual Report
    - Spring/Fall 2025 Reports Published
  - Regular NRAO eNews stories related to Spectrum/RFI
  - Developed Tech Sheets with EPO on HW/SW initiatives
- RFI-Focused Science & Engineering Groups
  - Green Bank Interference Protection Group (GB-IPG; meets bi-weekly)
  - New Mexico Interference Protection Group (NM-IPG; meets monthly)
- NRAO has representation on CORF, IUCAF (Chair) and COMPASSE (AAS), ITU-R

NRAO Spectrum Management Challenges

- Expansion of satellite constellations (space-to-ground transmissions)
  - SpaceX Starlink (Internet; Direct to Cell)
  - Amazon Kuiper (Internet)
  - AST-SpaceMobile (Direct to Cell), others
- Upgrades of cell towers close to the VLA – expanding frequencies above 1 GHz
  - T-Mobile (Magdalena)
  - Verizon (Pie Town)
  - VLBA – St. Croix
- Public Safety Needs of communities near sites (esp. GBO)
- Foreign-owned satellite constellations
- Funding for continued ODS/DRIFT efforts (scaling)
- Receiver damage/burnout (main beam to main beam interaction)

Summary

NRAO Spectrum Management is…

- Supporting the NRAO mission statement by working to ensure that radio wavelengths will remain available to passive users in the coming decades
- Developing a unified approach to spectrum-related issues across AUI observatories and increasing internal communication
- Continuing to build a strong team delivering hardware, software and policy initiatives
- Developing a productive relationship with satellite constellation operators through NSF
- Increasing funding for special efforts, and working to build spectrum management capabilities into regular NRAO structures

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