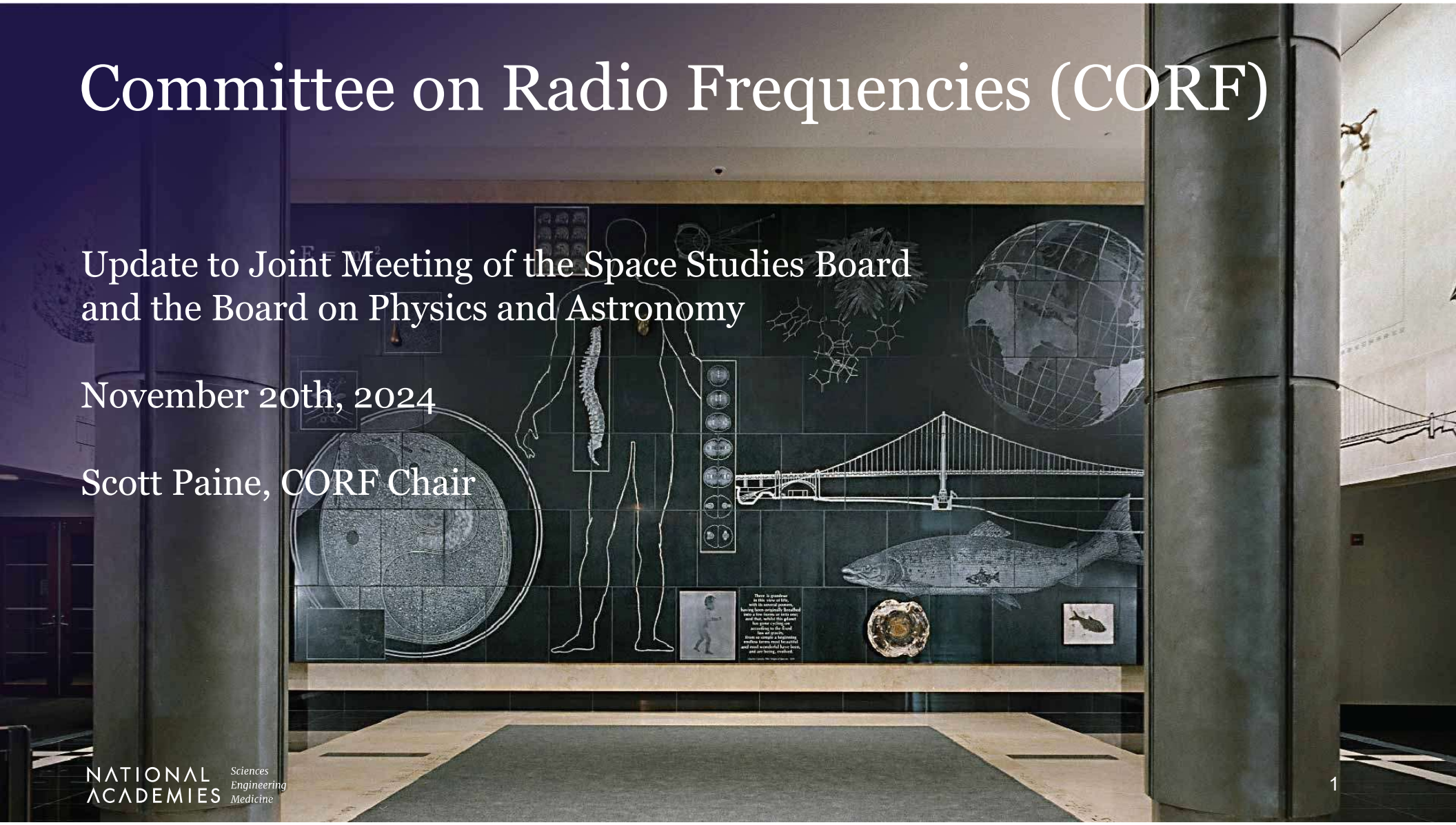
Committee on Radio Frequencies (CORF)



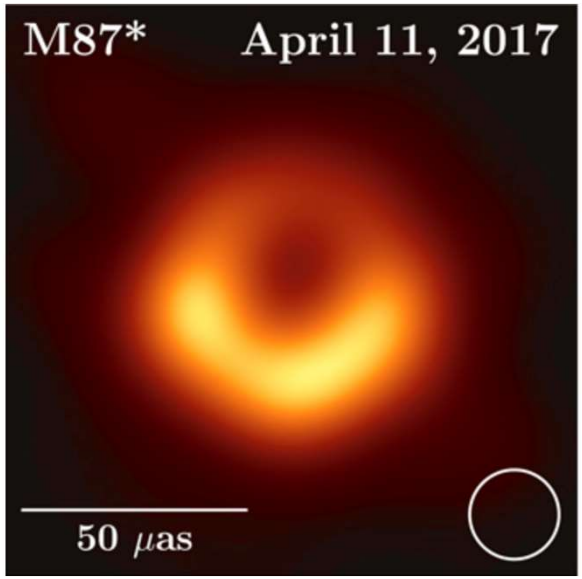
Update to Joint Meeting of the Space Studies Board and the Board on Physics and Astronomy

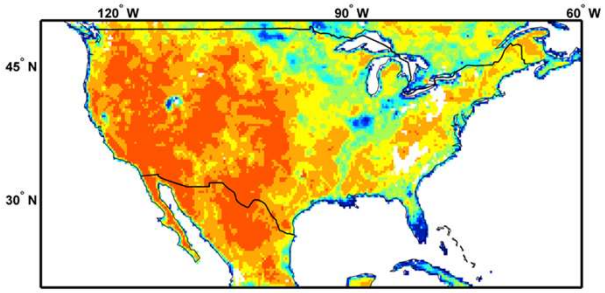
November 20th, 2024

Scott Paine, CORF Chair

NATIONAL ACADEMIES Sciences Engineering Medicine

Protecting Scientific Use of the Radio Spectrum





NATIONAL ACADEMIES Sciences Engineering Medicine

- CORF addresses the needs for, and protection of, the scientific *passive* radio *services.*
- The *Radio Astronomy Service* (RAS): origins and evolution of the Universe; chemistry and formation of stars and solar systems; matter in extreme environments; gravitational radiation; solar activity
- The *Earth Exploration Satellite Service* (EESS): critical measurements of the atmosphere, ocean, land, and cryosphere for weather, climate, and global change
- In contrast with *active services*, these passive services typically perform calibrated measurements of tiny changes in weak, noise-like natural signals.
- Together, these activities represent billions of dollars in federal investment, and have significant economic and cultural impact.

Upper image: EHT image of M87 black hole at 230 GHz.
Lower image: Soil moisture (1–10 July 2013) at 1.41 GHz.

CORF in detail

- CORF represents the interests of U.S. users of the radio spectrum for astronomy and Earth science, both basic and applied
- CORF coordinates the views of U.S. scientists and acts as a channel to represent their interests
- We recommend requirements and limits necessary to protect scientific use of the radio spectrum from interference
- This is largely through filing comments in public proceedings of Federal Communications Commission (FCC)
- Comments are drafted by CORF and its legal counsel, then reviewed per standard NAS protocols and approved and signed by the NAS President
- CORF also performs specific studies, maintains a Handbook, and conducts various forms of outreach to scientists and industry
- CORF is funded by NSF and NASA

CORF people

Current Committee

- Scott Paine, CfA (Chair) – RAS
- Hector Arce, Yale – RAS
- Nancy Baker, NRL – EESS
- Reyhan Baktur, Utah State – EESS
- Laura Chomiuk, Michigan State – RAS
- Kshitija Deshpande, Embry Riddle – EESS
- Dara Entekhabi (NAE), MIT – EESS
- Phil Erickson, Haystack Observatory – EESS
- Tomas Gergely, NSF, retd. – RAS
- Kelsey Johnson, U. Virginia – RAS
- Christopher Kidd, GSFC/UMD – EESS
- Karen Masters, Haverford – RAS
- Sidharth Misra, JPL – EESS
- Bang Nhan, NRAO – RAS
- Jeffery Puschell, Northrop Grumman – EESS

Committee members through July 2024

- Nathaniel Livesey, JPL (Chair) – EESS
- Darrel Emerson, retd. (consultant) – RAS
- Mahta Moghaddam (NAE), USC – EESS

Legal Counsel

- Paul Feldman, Esq., Fletcher, Heald and Hildreth

National Academies

- Colleen Hartman, Director, Aeronautics, Physics, and Space Science
- Christopher Jones, Senior Program Officer
- Gaybrielle Holbert, Senior Program Assistant

CORF's work is being driven by two major trends

- Growth in ubiquitous (often unlicensed) wireless devices
  - For Earth remote sensing, aggregate out-of-band emissions from thousands to millions of devices can lead to data loss or insidious interference

- Non-terrestrial networks supported by large satellite constellations
  - Collides with long trend in radio astronomy of wide band observing outside protected bands, to increase sensitivity and to accommodate cosmological redshift
  - This observing has been enabled by remote location
  - Nowhere is remote anymore

CORF filings in recent FCC proceedings

I. New emission limits in the 24 GHz band
(February 27, 2024)

II. Rules for unlicensed “very low power” (VLP) devices in the 6 GHz band
(March 27, 2024)

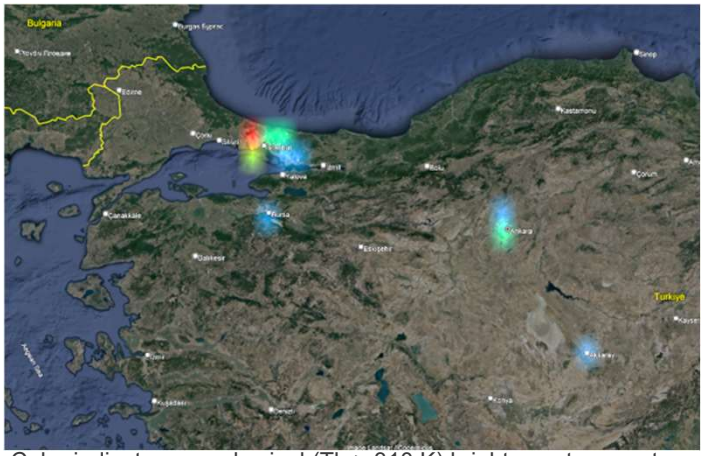
III. Bands to support in-space servicing, assembly, and manufacturing (ISAM)
(May 28, 2024)

IV. Supplemental Coverage from Space (SCS)
(May 30, 2024)

V. Sharing in the lower 37 GHz band
(September 30, 2024)

I. New emission limits in the 24 GHz band

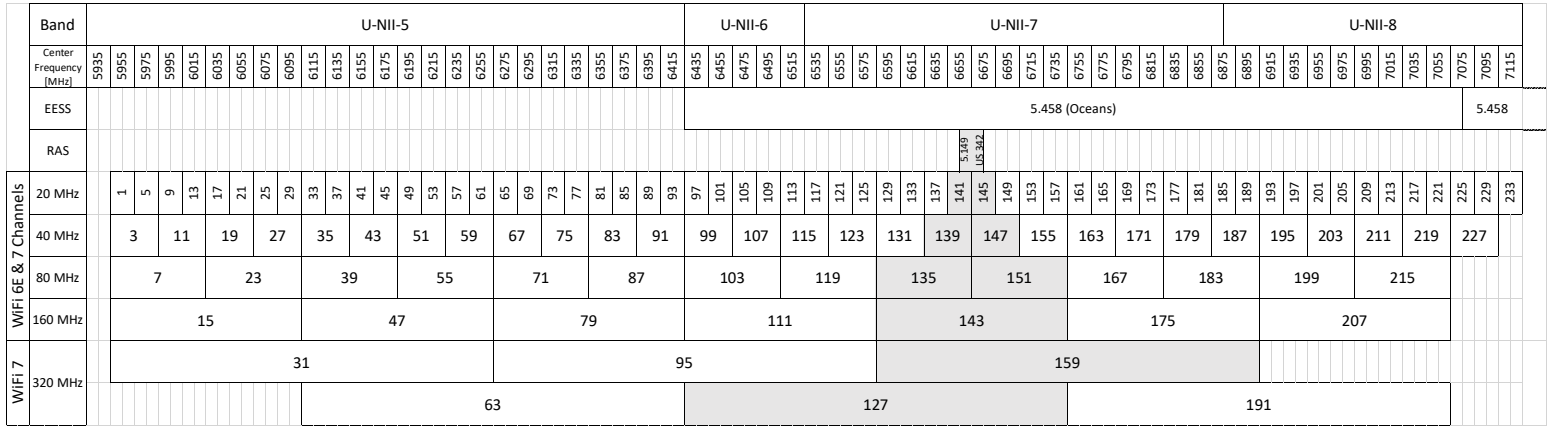
- 23.6 – 24.0 GHz is a critical protected band for EESS observations of atmospheric moisture, using 22 GHz water line wing emission.
- In 2017, the FCC auctioned mobile broadband licenses in the nearby 24.25 – 24.45 GHz and 24.75 – 25.25 GHz bands, with inadequate limits on out-of-band emissions (OOBE).
- In 2019, the ITU adopted more stringent rules. Better, but still marginally protective.
- In response to filings by CORF and others, and attention from congress, the FCC subsequently moved towards adoption of the ITU rules.
- The FCC issued a related Notice of Proposed Rulemaking (NPRM) in December 2023
- CORF filed comments welcoming the new OOBE limits while noting that they may not fully address interference issues already observed in dense urban environments.
- CORF also addressed technical questions posed by the FCC regarding device compliance testing.



Color indicates non-physical (Tb > 310 K) brightness temperature observed in the 23.8 GHz V-pol. channel of the NOAA Advanced Microwave Sounding Radiometer 2 (AMSR2).

II. Rules for unlicensed “very low power” (VLP) devices in the 6 GHz band

- In November 2023, the FCC issued an NPRM seeking comment on rules for VLP devices in the U-NII-5 – U-NII-8 bands spanning 5125 – 7125 MHz.



- CORF responded with recommendations to use device geofencing to protect RAS observatories in a band covering a key methanol maser line at 6.67 GHz, and EESS passive sensing bands used over oceans and large inland bodies of water.
- These passive bands are not protected by frequency allocations but are instead covered by footnotes to the international and US frequency allocation tables noting passive use and calling for protection.

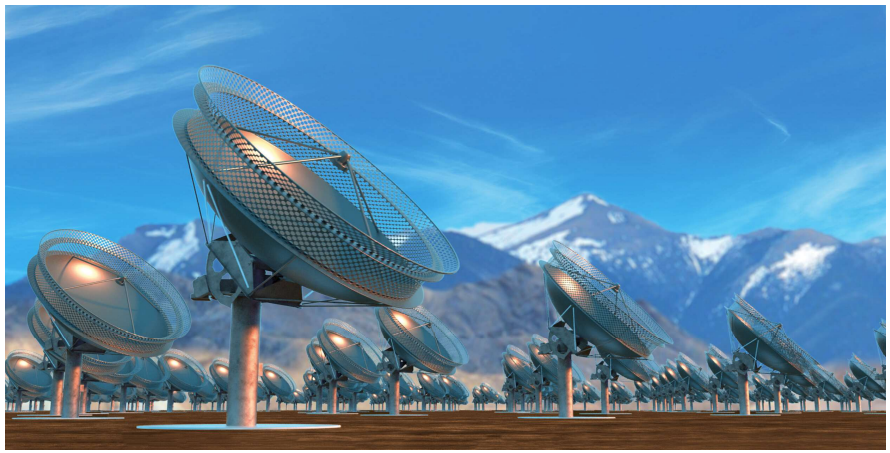
III. Bands to support in-space servicing, assembly, and manufacturing (ISAM)

- In February 2024, the FCC issued an NPRM “proposing a framework for licensing space stations engaged in in-space servicing, assembly, and manufacturing.”
- The FCC proposed “not to limit service allocation designations that might be possible for ISAM operations so long as the requested operations can justifiably fit within the service allocation definitions.”
- This could be interpreted as supporting use of passive allocations in some cases, particularly if the ISAM operation involved EESS platforms.
- CORF argued against this interpretation.
- CORF further urged careful avoidance of out-of-band emissions from ISAM bands into EESS (passive) bands exceeding ITU interference limits.

IV. Supplemental Coverage from Space (SCS)

- SCS, also known as “Direct to Cell” (DTC) is the provision of wireless service to ordinary smartphones from space, using terrestrial UHF cellular bands from 600 MHz – 2 GHz.
- This is a major threat to radio astronomy at UHF frequencies, particularly cutting-edge wide-band, wide-field observations targeting recently-discovered phenomena such as Fast Radio Bursts (FRBs) or exploiting new techniques such as high redshift line intensity mapping and pulsar timing arrays.

Credit: CHIME (https://chime-experiment.ca/)



Credit: DSA-2000 project (https://www.deepsynoptic.org)

IV. Supplemental Coverage from Space (SCS) cont'd

- In March 2024, the FCC issued a Report and Order (R&O) defining SCS service rules, and a further NPRM requesting additional comments on measures to protect radio astronomy, citing earlier comments by CORF and others, and a comprehensive NSF study.
- The R&O avoided setting specific rules to protect RAS, instead proposing that the licensing process would provide "..an opportunity for addressing concerns from federal and non-federal stakeholders related to the protection of radio astronomy.."
- CORF endorsed iterative coordination as a licensing requirement, recommending ultimate development of uniform service rules whenever possible.
- As in its 2023 comments on SCS, CORF emphasized the value of spatial over temporal or spectral coordination, to protect advances in time-domain astrophysics
- CORF advocated for formally extending radio quiet zone protections to include space-based transmitters.
- CORF additionally provided a briefing on SCS impacts to staff of the Space and Aeronautics Subcommittee of the House Committee on Science, Space, and Technology.

V. Sharing in the lower 37 GHz band

- In August 2024, the FCC issued a Public Notice seeking comment to "further develop the record for the 37.0-37.6 GHz band (Lower 37 GHz band) with the goal of informing the forthcoming report mandated by the National Spectrum Strategy (NSS) Implementation Plan."
- Use of this band is not fully defined, but likely to involve point-to-point, base station, and portable device applications.
- Citing evolving US and ITU OOBE standards for this band, the FCC sought "input on whether additional measures are needed to protect spaceborne remote passive sensors in the 36-37 GHz band." The 36-37 GHz band is an important "window channel" for Earth remote sensing.
- CORF filed comments including an analysis demonstrating that current OOBE limits are just sufficient to prevent exceeding ITU-defined interference limits in the case of a *single* active device in view of a typical EESS radiometer, and recommended setting stricter OOBE limits based on expected deployment density and duty cycle.

Takeaways

Summary

- Rapid growth of ubiquitous wireless devices and non-terrestrial networks poses a serious challenge to scientific use of the radio spectrum.
- Vigilance and engagement by the scientific community is extremely important to preserve existing capability and to enable continued advances.
- CORF plays a major role here and has had impact.

Cross-cutting issues to consider

- Science funding: Growing spectrum coordination and interference mitigation work is an added and often unfunded cost to scientific missions.
- Environment: New satellite constellations impact the environment as well as the radio spectrum.