

Before the  
FEDERAL COMMUNICATIONS COMMISSION  
Washington, DC 20554

In the Matter of ) SB Docket No. 26-54  
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Spectrum Abundance for “Weird Space )  
Stuff” )

**COMMENTS OF THE  
NATIONAL ACADEMY OF SCIENCES’  
COMMITTEE ON RADIO FREQUENCIES**

The National Academy of Sciences, through its Committee on Radio Frequencies (hereinafter CORF)<sup>1</sup>, hereby submits its comments in response to the Federal Communications Commission's (FCC's) *Notice of Proposed Rulemaking* (NPRM), FCC 26-13, released March 27, 2026, in the above-captioned docket. In these Comments, CORF urges the FCC to avoid use of frequencies allocated to the Earth Exploration Satellite Service (EESS) for communications links for the various “emergent space operations” (ESOs) described in the NPRM, particularly frequencies used for EESS passive sensing. This would serve the public interest in protecting vulnerable remote sensing operations that are critical to both weather prediction and the assessment of the Earth's climate, providing actionable weather information to decision makers in local, state, and federal government agencies, and to multiple industries including agriculture, transportation, renewable energy, and insurance/reinsurance. In addition, CORF responds to the FCC's request for comment on protection of the National Aeronautics

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<sup>1</sup> See the Appendix for the membership of the Committee on Radio Frequencies.

and Space Administration (NASA) radioastronomy site in Goldstone at 2.3 GHz. CORF concludes existing protections are adequate for Wireless Communication Service (WCS) operations and protect radio astronomy at Goldstone and encourages the FCC to consider expanding them to all Radio Astronomy Service (RAS) sites at this frequency.

## **I. The Importance and Vulnerability of Earth Remote Sensing**

CORF has a substantial interest in this proceeding, as it represents the interests of scientific users of the radio spectrum, including users of the RAS and the EESS.

The FCC has long recognized that satellite-based Earth remote sensing is a critical and uniquely valuable resource for monitoring the state of the global atmosphere, oceans, land, and cryosphere. For certain applications, satellite-based passive microwave remote sensing represents the only practical method of obtaining atmospheric and surface data for the entire planet.<sup>2</sup> EESS (passive) data have made critical contributions to the study of meteorology, atmospheric chemistry, climatology, hydrology, and oceanography. Currently, instruments operating in the EESS (passive) bands provide regular and reliable quantitative atmospheric, oceanic, land, and cryospheric operational measurements to support a variety of scientific, commercial, and government (civil and military) users. EESS (passive) satellites represent billions of dollars in investment and provide data for major governmental users, including the National Oceanic and Atmospheric Administration (NOAA), the National Science

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<sup>2</sup> For a more detailed summary of how passive Earth remote sensing (EESS) works, see National Telecommunications and Information Administration (NTIA), Office of Spectrum Management, *The Spectrum Needs of U.S. Space-Based Operations: An Inventory of Current and Projected Uses* (July 2021), pp. 13–18, <https://www.ntia.gov/report/2021/spectrum-needs-us-space-based-operations-inventory-current-and-projected-uses> (last viewed January 14, 2026).

Foundation (NSF), NASA, the military (especially the U.S. Navy and Air Force), the Department of Agriculture (including the U.S. Forest Service), the Department of Interior (U.S. Geological Survey and Bureau of Land Management), and the Federal Emergency Management Agency. These agencies use EESS data on issues impacting trillions of dollars in the U.S. economy, as well as safety of life,<sup>3</sup> national security,<sup>4</sup> and scientific investigation.

Satellite remote sensing data are an essential resource for accurate weather prediction. NOAA and its National Weather Service (NWS) are major users of these data. NOAA has estimated that about *one-third of the U.S. economy*—trillions of dollars annually—is sensitive to weather and climate.<sup>5</sup> A NOAA report<sup>6</sup> estimated that weather forecasts alone generated \$35 billion in annual economic benefits to U.S. households in 2016. NOAA has also stated that “NOAA weather forecasts and warnings are critical to people living in areas subject to severe weather and to all Americans who depend on the economic vitality that these regions contribute. Accurate predictions of extreme weather locations and severity are essential. Having advance notice from meteorological warnings provides time to prepare for extreme events and limit their

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<sup>3</sup> See, NTIA, *The Spectrum Needs of U.S. Space-Based Operations*, p. 21: “Should a disaster occur, EESS has a crucial role in disaster management. EESS data shows heat levels, as well as sea and lake ice levels, to help identify the areas affected, plan relief operations, and monitor the recovery from a disaster” (citations omitted).

<sup>4</sup> See, e.g., Irene Parker, Bryan D. Mundhenk, and Christopher Ekstrom, written testimonies before the Subcommittee on the Environment, Committee on Science, Space, and Technology, U.S. House of Representatives, “From Orbit to Operations: How Weather Satellites Support the National Security Mission,” January 13, 2026, <https://science.house.gov/2026/1/subcommittee-environment-hearing> (last viewed January 14, 2026).

<sup>5</sup> See NOAA, “Weather”, <https://www.noaa.gov/weather> (last viewed January 14, 2026).

<sup>6</sup> See NOAA, *NOAA by the Numbers*, June 2018, p. 8, <https://www.noaa.gov/sites/default/files/legacy/document/2019/Nov/NOAA-by-the-Numbers-Accessible-Version-Corrected-17-JUL-18%20%281%29.pdf> (last viewed January 14, 2026).

impact.”<sup>7</sup>

The critical research and development of applications for Earth remote sensing by scientists cannot be performed without access to interference-free bands. A report released by the National Telecommunications and Information Administration (NTIA) stated that:

[D]ue to the extreme sensitivity required to sense physical phenomena such as water vapor—in different heights of the atmosphere—and sea salinity, passive sensing bands are extremely vulnerable to interference coming from transmitters operating in adjacent bands with unwanted emissions extending into the passive band.<sup>8</sup>

The signals measured by EESS (passive) sensors are extremely weak compared to those emitted by active communication services as they correspond to thermal emission and would be considered “noise” in any active use of the radio spectrum<sup>9</sup>. Further, scientific information is obtained not so much from the signals themselves as from the yet-smaller variations (spatial and temporal) within those signals that enable quantification of meteorological and geophysical processes, natural variability, and longer-term changes. Accurate scientific interpretation of these variations in measurement for weather forecasting or Earth system research and applications

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<sup>7</sup> See, NOAA, *NOAA’s Contribution to the Economy; Powering America’s Economy and Protecting Americans*, 2018, p. 8, <https://www.noaa.gov/sites/default/files/legacy/document/2019/Nov/NOAA-Contribution-to-the-Economy-Final.pdf> (last viewed January 14, 2026).

<sup>8</sup> See NTIA, *The Spectrum Needs of U.S. Spaced-Based Operations*, p. 15.

<sup>9</sup> Paragraph 36 of the NPRM incorrectly quotes a prior CORF filing in a manner that could cause confusion. The NPRM quotes the CORF May 2024 Reply Comments in Docket 22-271 at pages 4-5 as “the signals *emitted* by EESS (passive) sensors are very weak compared to those emitted by active communication services” (emphasis added). The word “emitted” is a typographical error in the NPRM – the statement in the CORF Reply Comments actually was “the signals *measured* by EESS (passive) sensors are very weak compared to those emitted by active communication services....” (emphasis added). By definition, passive sensors do not “emit” signals; rather, they passively receive them. The problem with the typographical error in NPRM is that it incorrectly creates the impression that EESS (passive) bands are more resistant to active interference than they actually are.

demands confidence that the observed variations reflect true geophysical processes, rather than the presence of interfering emissions.

The starting point for any consideration of interference into EESS (passive) bands is the International Telecommunication Union Radiocommunication Sector (ITU-R) Recommendation RS.2017. For example, in a 200 MHz-wide region of the 24 GHz band, RS.2017 quotes an interference threshold of -166 dBW (25 billionths of a billionth of a Watt). This stringent requirement is what enables EESS (passive) measurements to be made with an accuracy of 0.05 K brightness temperature (~0.09°F), which is considered sufficient for accurate weather forecasts and reliable quantification of potential signatures of climate change.

## **II. The FCC Should Not Use EESS (Passive) Allocations for Emergent Space Operations**

CORF appreciates that the FCC has recognized, in the present NPRM and in other proceedings, the public interest in protecting EESS (passive) observations from interference. As discussed above, the natural signals in the EESS (passive) bands are extraordinarily weak, yet they must be measured with great precision by EESS (passive) sensors.

Emissions from spaceborne transmitters are a particular concern in this regard.<sup>10</sup> Firstly, there is the potential for an EESS (passive) sensor to be close to the interfering

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<sup>10</sup> For examples of this impact, see a technical analysis by SpaceX “Dynamic Simulation Methodology for EESS (Passive) Interference from NGSO Earth-to-Space Links”, <https://www.ofcom.org.uk/siteassets/resources/documents/consultations/category-3-4-weeks/consultation-temporary-ngso-gateway-access-to-e-band/starlink-dynamic-simulation-methodology-for-ees.pdf?v=397728> (last viewed April 21, 2026). See also N. Brendle, J. Chamberlain, J.T. Johnson, and D. Starobinski, “Geographic and Statistical Analysis of EESS-Passive Satellite Overpasses for Spectrum Coexistence,” *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* (2026): 1–13, <https://ieeexplore.ieee.org/document/11475054> (last viewed April 21, 2026). Both consider interference and possibilities for spectrum sharing. Numerous well-documented examples exist of interference into EESS system at 1.4 GHz and 4–8 GHz from ground-based emitters; interference

spaceborne transmitter if their orbits bring them together (closer than any EESS [passive] sensor would ever get to ground-based or airborne transmissions), significantly increasing the degree of interference from even low-level transmissions lying within the EESS (passive) sensor's field of view. Secondly, EESS (passive) sensors, viewing well away from Earth, typically calibrate their observations using the well-characterized cold space signals. Such cold-space calibration views often employ larger beamwidths than the Earthward measurements, leaving them especially vulnerable to interference from spaceborne transmitters. As each calibration view is used to interpret several minutes of Earthward observations, the potential for undetected corruption of valuable observations is significant. The FCC should also be mindful of the risk to EESS from both direct path and reflections off of the Earth from ESO in EESS (passive) bands.

The FCC has previously recognized that EESS bands are not appropriate for active space operations. For example, in the related proceeding on spectrum for in-space servicing, assembly, and manufacturing (ISAM), the FCC noted that EESS allocations “appear to be dedicated to operations that are not typically consistent with ISAM operations.”<sup>11</sup> Footnote 139 of that NPRM also cites Comments of the NTIA

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events in passive bands about 10–18 GHz or higher is much more difficult to detect and the current generation of NOAA satellites do not have the requisite onboard detection systems (which need to run on board due to the large amount of data generated as band segments are subdivided into bins for processing). Requirements are in place to add this (and the consequences this has for available power, mass, downlink bandwidth and heat dissipation on board the satellite) for the next generation operational microwave sounder that will go into service in the 2030s. The European Space Agency is also developing an onboard interference detection system, see J. Lahtinen, A. Kovanen, K. Lehtinen, et al., “Real-Time RFI Processor for the Next Generation of Satellite Radiometers,” *Proceedings of the 2018 IEEE 15<sup>th</sup> Specialist Meeting on Microwave Radiometry and Remote Sensing of the Environment (MicroRad)* (2018) pp. 71–76, <https://doi.org/10.1109/MICRORAD.2018.8430725> (last viewed April 21, 2026).

<sup>11</sup> See *In the Matter of Space Innovation Facilitating Capabilities for In-space Servicing, Assembly, and Manufacturing*, Notice of Proposed Rulemaking, 39 FCC Rcd 1864 (2024) at para. 34.

stating that “EESS is intended for Earth-centric sensing, and not aligned with imaging artificial resident space objects or performing inspection services as being considered by ISAM operators.” The same logic and facts apply to the other sorts of ESOs at issue in the present proceeding.

It also should be noted that most EESS (passive) bands are subject to protection (“All emissions are prohibited”) under International Footnote 5.340.<sup>12</sup> There is a reason for this—international recognition of the vulnerability and importance of these scientific observations. Granting active users within these bands would therefore appear to be counter to International Telecommunication Union (ITU) regulations. Accurate weather forecasting, even for limited regions such as the United States., requires global observations. Furthermore, the ITU will not register a transmitter in the International Footnote 5.340 bands, and it urges administrations to avoid assigning them. Under Article 4.4 of the Radio Regulations (RR), “Administrations of the Member States shall not assign to a station any frequency in derogation of either the Table of Frequency Allocations in this Chapter or the other provisions of these Regulations, except on the express condition that such a station, when using such a frequency assignment, shall not cause harmful interference to, and shall not claim protection from, harmful interference caused by a station operating in accordance with the provisions of the Constitution, the Convention, and these Regulations.” Thus, any non-conforming use under RR No. 4.4 is subject to the provisions of RR No. 4.4 requiring operation on a non-interference, non-protection basis with respect to (other) operations occurring in conformance with the Radio Regulations. Further, the ITU-R Rules of Procedure for RR

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<sup>12</sup> Many of the frequency bands in Footnote 5.340 are similarly protected by Footnote US246 (“No station shall be authorized to transmit in the following bands:”).

No. 4.4 state that notifications of frequency assignments in spectrum bands subject to Footnote 5.340 (such as many EESS [passive] bands) will not be accepted.

Accordingly, if the FCC chooses to make non-conforming ESO assignments, it should be a precondition that any applications for non-conforming frequencies do not contain frequency assignments in bands subject to Footnote 5.340, and it should be a further precondition that such applications demonstrate that their operations (including both intentional and unwanted emissions) will not generate harmful interference (as measured by ITU-RA.2017) in frequency bands subject to Footnote 5.340. This is yet another reason why assignment of EESS (passive) allocations for ESOs should be avoided.

The current NPRM suggests, at para. 37, that there is no harm in merely allowing ESO operators to *apply* to use EESS frequencies, since the FCC will then evaluate each application on a case-by-case basis. However, this approach can in fact result in harm to remote sensing:

1. The FCC may improperly evaluate an applicant's claim that the proposal will not cause harm to EESS (passive). Conventional criteria applicable to communications receivers will not be appropriate for use in the protection of radiometers. A comprehensive evaluation of adjacent band energy contaminating nearby passive measurements may require technical knowledge of how such radiometer sounders detect power and their operational characteristics. ITU-R Recommendations list the total amount of out-of-band energy that may radiate into protected bands, but they do not take into account how to appropriately apportion those recommended limits across potentially many users and large numbers of uplink sources.
2. Even if an application is granted on a non-interference basis, it is unclear if ESO operators would be able to turn off their transmitters if those transmitters are subsequently discovered to be causing interference. If they could, ESO operators would then need to perform their operations using alternate non-EESS frequencies. Yet, if there are alternate frequencies for operators to use, it is not clear why the alternate frequencies should not be used initially. Furthermore, when satellite

operators skirt regulations, it is often difficult if not impossible for the passive users to gain compliance.

3. ESOs may cause insidious interference that is too weak to be recognized as interference and to identify the source but strong enough to skew results of the EESS observations.<sup>13</sup> EESS receivers are exquisitely sensitive; for example, the WindSat radiometer demonstrated a sensitivity to noise of 0.027 dB. This sensitivity is required to achieve the receivers' operational measurement accuracy. Radiometers measure the total power received over their operational bandwidth. This is converted to an effective brightness temperature from which the geophysical parameters such as wind speed over the ocean are derived. Spurious or interfering signals within the (passive) band will result in incorrect brightness temperature values, which then contribute to errors in the derived geophysical parameters. For example, a 1 m/s change in wind speed (the accuracy needed for weather assessment and prediction) corresponds to change in brightness temperature of approximately 0.2 K, which corresponds to -157.7 dBW in received power. An undetected source of interference comparable to or larger than this will result in large errors in the derived wind speed, and this can adversely affect the prediction of hazardous weather conditions.

In summary, the FCC should not authorize use of EESS (passive) bands for ESOs. This includes all EESS (passive) bands protected by domestic and international footnotes, as well as any others allocated on a primary and secondary basis to EESS (passive).<sup>14</sup>

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<sup>13</sup> Emissions from active services can readily corrupt passive observations. Such corruption generally falls into three categories. In cases where interference is negligibly small (e.g., below the thresholds defined in ITU-R RS.2017) there is no impact to the measurements. At the other extreme, cases of particularly strong interference can be readily identified in the resulting data record and excised from analyses. Provided that such cases of strong interference are very infrequent, the impact to scientific research and forecasting operations can be accommodated. By far the largest challenge comes from the third category—interference that is not large enough to be readily identified yet is sufficiently strong that it distorts the observation data, masquerading as legitimate geophysical information, misleading weather forecasters, and compromising scientific deductions (“insidious interference”).

<sup>14</sup> Many, though not all, of the EESS (passive) bands are subject to protection under RR 5.340. That said, CORF urges the FCC to exclude all bands allocated to EESS (passive) from consideration for ESO regardless of their status under RR 5.340 (or the comparable Footnote US246). CORF notes that EESS satellites and Meteorological Satellites (MetSat) must also be able to communicate their mission data in a timely manner for processing to allow the scientific data to be assimilated into weather forecasting models and related Earth system applications. EESS satellites and MetSat Spacecraft providing EESS data must receive commands and downlink telemetry in support of spacecraft operations. Some data services are transmissions of near-real-time information that would be lost if subject to interference. The FCC should be mindful of these essential communications when making any new frequency assignments to ESO, particularly in bands where MetSat or Meteorological Aids have primary or co-primary allocations.

### **III. The FCC Should Be Mindful of ESO Out-of-Band Emissions Into EESS Bands**

In addition to excluding any authorization for ESO activities to transmit directly in the EESS (passive) bands, CORF urges the FCC to carefully consider the potential for out-of-band emissions (OOBEs) and spurious emissions (particularly harmonics) from orbiting ESO transmitters to corrupt measurements in EESS (passive) bands. Again, the potential for close proximity of an ESO transmitter to an orbiting EESS (passive) sensor, and the reliance of the EESS (passive) sensor on uninterrupted views to cold space, make such interference scenarios a particular concern. Protection can be ensured by the inclusion of suitable guard bands to reduce OOBE impacts, and consideration of the frequency bands likely to be affected by harmonic emissions. Compatibility should be assured by employing Monte Carlo analyses that include the appropriate orbital geometry and take into account the cold-space calibration views employed by EESS (passive) sensors. Studies should assume thresholds for such interference as defined in ITU-R RS.2017 and consider instruments such as those defined by ITU-R RS.1861.

### **IV. Protection of Radio Astronomy**

The NPRM asks at para. 81 if “additional technical or geographic restrictions [would] be necessary to protect the NASA radioastronomy site in Goldstone from harmful interference in the 2315–2320 MHz band” and whether “a requirement for prior coordination of any earth stations seeking to provide command uplinks in the 2315–2320 MHz band within 145 kilometers of Goldstone [would] be adequate to provide the same level of protection that NASA currently has for WCS operations in the 2305–2320 MHz band.”

The Deep Space Network (DSN) antennas in Goldstone were primarily designed and are mostly used for spacecraft telemetry, tracking and command (TT&C), including for the recent Artemis II mission. However, when not in use for these purposes, they can be used for passive radio astronomy observations of a vast range of astronomical sources (either as single dish or as part of a very long baseline interferometry network) or for astronomical radar research. For passive radio astronomy observations, an S-band (2.2–2.3 GHz) receiver is available.<sup>15</sup>

In response to the FCC question, CORF agrees that the restrictions and requirements to protect the NASA radioastronomy site in Goldstone, which are already in place for the use of the 2305–2320 MHz band, should be enough to also protect the 2315–2320 MHz band. In addition, CORF notes that similar restrictions and requirements at other radioastronomy sites in the United States that observe passively in the 2.3 GHz band under the geolocation allocation would be beneficial to the scientific output of these U.S. national facilities. U.S. radio observatories which observe at 2.3 GHz include: the NSF/National Radio Astronomy Observatory's (NRAO's) Very Large Array (VLA)<sup>16</sup> in New Mexico; the 12-meter telescope at the NSF Arecibo Observatory Historic District in Arecibo, Puerto Rico; the Allan Telescope Array at the Hat Creek Radio Observatory in Hat Creek, California; the Owens Valley Radio Observatory near Big Pine, California; the MIT Haystack Observatory in Westford, Massachusetts; the Deep Synoptic Array near Ely, Nevada; and the ten antenna stations of the

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<sup>15</sup> See [https://deepspace.jpl.nasa.gov/files/DSN\\_Radio\\_Astronomy\\_Users\\_Guide.pdf](https://deepspace.jpl.nasa.gov/files/DSN_Radio_Astronomy_Users_Guide.pdf) (last viewed April 13, 2026).

<sup>16</sup> VLA's S-band receiver covers 2–4 GHz. See <https://public.nrao.edu/telescopes/vla/technology/> (last viewed April 10, 2026).

NSF/NRAO's Very Long Baseline Array (VLBA).<sup>17</sup> The NSF/Green Bank Observatory's (GBO) Green Bank Telescope (GBT) in Green Bank, West Virginia also observes at this frequency range for its S-band receiver (1.73–2.60 GHz) and Ultra-Wideband Receiver (UWBR, 0.5–3.5 GHz).<sup>18</sup> Protection from interference is especially important for facilities observing as part of the international VLBI (Very Long Baseline Interferometry) Global Observing System (VGOS), which currently use this band for essential reference frame observations. Such observations are of utmost importance to the determination of essential parameters for modern navigational and other systems, including UT1-UTC or Earth Orientation Parameters needed for precision navigation. The 2–3 MHz band is important to determine and remove the ionospheric delay, a major source of error in the measurements. Facilities within the United States working in this system include VLBI antennas located in the Goddard Geophysical and Astronomical Observatory, Kōke'e Park Geophysical Observatory in Hawaii, McDonald Observatory in Texas, and the Westford Radio Telescope at the Haystack Observatory in Massachusetts. The ten antennas of the VLBA are also used for geodesy at these frequencies some of the time.

## **V. Conclusion**

In these comments, CORF urges the FCC not to assign any frequencies allocated for passive EESS remote sensing for new use in ESO. Protection of EESS passive frequencies is especially important to ensure the future accuracy of weather forecasting, including warnings of extreme weather. Many, though not all, of the EESS

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<sup>17</sup> VLBA's S-band receiver covers 2.2–2.4 GHz and stations are located in Hancock, New Hampshire; North Liberty, Iowa; Fort Davis, Texas; Kitt Peak, Arizona; Owens Vally, California; Brewster, Washington; Mauna Kea, Hawaii; Saint Croix, U.S. Virgin Islands; and Pie Town and Los Alamos, New Mexico. See <https://science.nrao.edu/facilities/vlba/docs/manuals/oss/bands-perf> (last viewed April 10, 2026).

<sup>18</sup> See the GBT receiver summary table <https://dss.gb.nrao.edu/receivers/summary> (last viewed April 10, 2026).

(passive) bands are subject to protection under RR 5.340 and should not be considered for ESO for that reason alone. CORF further urges the FCC to exclude any bands allocated to EESS (passive) from consideration for ESO regardless of their status under RR 5.340 (or the comparable Footnote US246). CORF requests the FCC also be mindful of the potential for OOBES into EESS allocations, and also of the essential need for real-time communications for some EESS active transmissions, which can result in data loss if subject to interference from other services. Finally, in response to the NPRM's request for information on protection of NASA's radioastronomy site in Goldstone at 2.3 GHz, CORF concludes that existing protections are sufficient for WCS operations and radio astronomy at Goldstone but notes many other RAS facilities in the United States that also observe at this frequency could benefit from similar protection.

Respectfully submitted,

NATIONAL ACADEMY OF  
SCIENCES' COMMITTEE ON  
RADIO FREQUENCIES

A handwritten signature in black ink that reads "Marcia McNutt". The signature is written in a cursive style with a long, sweeping horizontal line extending to the right from the end of the name.

Marcia McNutt  
President, National Academy of Sciences

Direct correspondence to:

CORF

National Academy of Sciences  
500 Fifth Street, NW, Keck 954  
Washington, DC 20001  
(202) 334-3520

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## Appendix

### Committee on Radio Frequencies

#### Members

David G. Long, Brigham Young University, *Co-Chair*

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Kshitija Deshpande, Embry-Riddle Aeronautical University

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David G. Lubar, The Aerospace Corporation (retired)

Sidharth Misra, NASA Jet Propulsion Laboratory

Bang D. Nhan, National Radio Astronomy Observatory (Virginia)

Jeffery J. Puschell (NAE), Northrop Grumman

Suzanne Staggs (NAS), Princeton University

#### Staff

Kristen Garofali, Responsible Staff Officer

Christopher J. Jones, Responsible Staff Officer