Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	IB Docket No. 22-271
	)	
Space Innovation	)	
	)	
Facilitating Capabilities for In-space Servicing, Assembly, and Manufacturing	)	IB Docket No. 22-272

REPLY COMMENTS OF THE NATIONAL ACADEMY OF SCIENCES' COMMITTEE ON RADIO FREQUENCIES

The National Academy of Sciences, through its Committee on Radio Frequencies ("CORF"[1]), hereby submits these Reply Comments on the Commission's Notice of Proposed Rulemaking ("NPRM"), FCC 24-21, released February 16, 2024, in the above-captioned dockets. In these Reply Comments, CORF urges the Commission to avoid use of frequencies allocated to the Earth Remote Sensing Service (passive) ("EESS (passive)") and the Earth Remote Sensing Service (active) ("EESS (active)") in communications links for space stations engaged in in-space servicing, assembly, and manufacturing ("ISAM"). This would serve the public interest in protecting vulnerable research and operations that are critical to both weather prediction and the study of Earth's climate, providing actionable information to decision makers in local, state, and federal government agencies, and to multiple industries including agriculture, transportation, renewable energy, and insurance/reinsurance.

[1] See the Appendix for the membership of the Committee on Radio Frequencies.

I. The Importance of Earth Remote Sensing.

The Commission 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 (EESS (passive)) represents the only practical method of obtaining atmospheric and surface data for the entire planet.[2] 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 measurements to support a variety of scientific, commercial, and government (civil and military) data 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 Foundation, the National Aeronautics and Space Administration (NASA), the Department of Defense (especially the U.S. Navy), the U.S. Department of Agriculture, the U.S. Geological Survey, the Agency for International Development, the Federal Emergency Management Agency, and the U.S. Forest Service. These agencies use EESS data on issues impacting hundreds of billions of dollars in the U.S. economy,

---

[2] For a more detailed summary of how passive Earth remote sensing/EESS works, *see* "The Spectrum Needs of U.S. Space-Based Operations: An Inventory of Current and Projected Uses," National Telecommunications and Information Administration, Office of Spectrum Management, July 2021 ("*NTIA Report*"), at pages 13-18, available at https://www.ntia.doc.gov/report/2021/spectrum-needs-us-space-based-operations-inventory-current-and-projected-uses (last viewed April 3, 2024).

as well as safety of life,[3] national security, and scientific investigation (particularly regarding climate change). Other countries, notably those within the European Union, have made comparable investments, and international agreements are in place to ensure continual sharing of EESS (passive) observations to inform operational numerical weather prediction and Earth system research.

Satellite remote sensing data are an essential resource for accurate weather prediction. NOAA and its National Weather Service are major users of these data. NOAA has estimated that about *one-third of the U.S. economy*—hundreds of billions of dollars annually—is sensitive to weather and climate.[4] A NOAA report[5] 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 location and severity are essential. Having time to prepare for extreme events limit their impact."[6] Furthermore, in rural areas where farming is the dominant source of income, accurate weather forecasting and climate prediction have been shown to have direct impact on investments and profits from agricultural products.[7]

---

[3] *See, e.g., NTIA Report* at page 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).

[4] *See* "Weather," NOAA, available at https://www.noaa.gov/weather (last viewed April 3, 2024).

[5] *See* "NOAA by the Numbers," June 2018, at page 8, available at 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 April 3, 2024).

[6] *See* "NOAA's Contribution to the Economy; Powering America's Economy and Protecting Americans," NOAA, 2018, at page 8, available at https://www.noaa.gov/sites/default/files/legacy/document/2019/Nov/NOAA-Contribution-to-the-Economy-Final.pdf (last viewed April 3, 2024).

[7] *See* "Forecasting Profitability," National Bureau of Economic Research, available at https://www.nber.org/papers/w19334 (last viewed April 3, 2024).

As the Commission knows, remote sensing using EESS (passive) bands is also critical to the study of climate change. For example, the prospect of sea-level rise in a changing climate greatly accentuates the need for uninterrupted (in both space and time) remote sensing observations of the ocean state, both for trend monitoring and for studies of key oceanic processes. The coastal zones are of particular importance in this regard, with an estimated 146 million people (2% of the world population) living in areas 1 m or less above mean high tide, and more than 40% of the population living within 100 km of the coast. Increases in sea level, as well as stronger storm systems and increased encroachment of sea water into coastal zone water tables, are under intense study by remote sensing scientists, given the profound impacts on ecosystem, societal, and economic wellbeing. Climate change is also expected to change patterns of rainfall and snow, with significant implications for agriculture and urban/regional planning.

The critical research performed by Earth remote sensing 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."[8]

The signals measured by EESS (passive) sensors are very 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. Further, the

---

[8] *See NTIA Report, supra* note 2, at page 15.

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 processes, natural variability, and longer-term changes. Accurate scientific interpretation of these measured variations for weather forecasting or Earth system research demands confidence that the observed variations reflect true geophysical processes, not the presence or absence of interfering emissions. As EESS sensors in space monitor globally and view large swaths of the surface at one time, they are subject to aggregate interference from emitters in the area scanned (both the areas on Earth and the regions of cold space used for calibration; see the third-to-last paragraph in Section II, below). The starting point for any consideration of interference into EESS passive bands is the International Telecommunication Union ("ITU") 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 (~0.09ºF), which is considered sufficient to provide accurate weather forecasts and reliable quantification of potential signatures of climate change.

II. The FCC Should Not Use EESS (passive) or EESS (active) Allocations for ISAM operations.

In paragraph 35 of the NPRM, the Commission proposes "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." At face value, this would suggest that allocations to EESS could be candidates for an ISAM

activity to assemble or service a spaceborne system, particularly one that includes an EESS component. A significant growth in the number of EESS platforms, including those developed and/or operated by commercial organizations, is anticipated over the coming decade (though, to our knowledge, none as yet are targeting an ISAM-based implementation or architecture). CORF recognizes that the bands used for Earth-to-space and space-to-Earth communication links to/from orbiting EESS satellites may, in some circumstances, be appropriately employed during ISAM activities related to such a platform, particularly for direct communications with a specific platform being assembled or serviced. CORF takes no position at this time regarding use of EESS communication bands for ISAM, as suggested by at least one commentator.[9] However, the Commission should explicitly refrain from considering any of the bands allocated to EESS (passive) or EESS (active) as candidates for ISAM usage.

As discussed above, the natural signals in the EESS (passive) bands are extraordinarily weak and must be measured with great precision by EESS (passive) sensors. Emissions from active services can readily corrupt these 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

---

[9] *See* "Comments of Varda Space Industries, Inc.," April 29, 2024, at page 4. By "EESS communications bands", CORF refers to those allocations designated as EESS (Earth-to-space) and EESS (space-to-Earth).

from the third category—interference that is not large enough to be readily identified yet is sufficiently strong that it distorts the observations, masquerading as legitimate geophysical information, misleading weather forecasts and compromising scientific deductions ("insidious interference").

Emissions from spaceborne transmitters are a particular concern in this regard. Firstly, there is the potential for an EESS (passive) sensor to be close to the interfering 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 typically calibrate their observations using views of outer space (a well-characterized signal), looking well away from Earth. Such calibration views often employ larger beamwidths than the Earthward measurements, leaving them especially vulnerable to interference from other 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. Thirdly, there are cases where space-based transmissions reflect off Earth's surface (particularly over oceans and other bodies of water) and are observed by EESS (passive) sensors, leading to interference.

In sum, the Commission should not authorize use of EESS (passive) bands for ISAM operations. This includes all bands allocated on a primary and secondary basis to EESS (passive), as well as all EESS (passive) bands protected by domestic and international footnotes.[10] Such an approach would be aligned with the Commission's

[10] Many, though not all, of the EESS (passive) bands are subject to protection under RR 5.340 ("all emissions prohibited"). That said, CORF urges the Commission to exclude the bands allocated to EESS

statement in para. 34 of the NPRM that EESS allocations "appear to be dedicated to operations that are not typically consistent with ISAM operations."[11]

CORF also urges the Commission to refrain from allowing ISAM transmissions in the EESS (active) bands. As with EESS (passive), EESS (active) measurements provide a wealth of unique information on key Earth system variables, including precipitation, clouds, sea, lake and river levels, ocean surface winds and salinity, and soil moisture. Although these measurements are less sensitive to interference than those from EESS (passive), any allocations and/or sharing studies should consider the potential for interference into these observations. Recommendation ITU-R RS.1166 details the performance and interference criteria for EESS (active) sensors, while ITU-R RS.577-7 provides typical characteristics of typical EESS (active) transmitter/receiver systems. Other ITU-R recommendations detail sharing requirements for specific bands.[12]

III. The Commission Should Be Mindful of ISAM OOBE Into EESS Bands.

In addition to excluding any authorization for ISAM activities to transmit directly in the EESS (passive) bands, CORF urges the Commission to carefully consider the potential for out-of-band emissions ("OOBEs") and spurious emissions (particularly harmonics) from orbiting ISAM services to corrupt measurements in EESS (passive) and EESS (active) bands. Again, the potential for close proximity of an ISAM transmitter

---

(passive) from consideration for ISAM activities regardless of their status under RR 5.340 (or the comparable footnote US249).

[11] The NPRM also cites therein the Reply Comments of the NTIA at page 5 ("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.")

[12] Specific EESS (active) related ITU-R recommendations include ITU-R RS.1260 (for 420-470 MHz), RS.1261 (92-95 GHz), RS.1282 (vicinity of 1260 MHz), RS.1628 (35.5-36 GHz), RS.1632 (5250-5350 MHz), and RS.1749 (1215-1300 MHz).

to an orbiting EESS sensor, and the reliance of EESS (passive) sensors on uninterrupted views to cold space, make such interference scenarios a particular concern. Protection can be ensured by the inclusion of guard bands having widths that are sufficient to reduce OOBE impacts, and by avoiding allocation to ISAM bands for which harmonic emissions that fall in EESS (passive) bands—even at levels that are compliant with applicable spurious emissions limits—that might nevertheless exceed the protection criteria established in ITU-R RS.2017. Compatibility should be assured by employing 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 Recommendation ITU-R RS.2017 for EESS (passive) and ITU-R RS.1166 for EESS (active), and consider instruments such as those defined by ITU-R RS.1861 and ITU-R RS.577-7, respectively.

IV. Conclusion.

CORF urges the Commission to exclude bands allocated to EESS (passive) and EESS (active), and also those subject to footnote protection, from consideration in licensing ISAM operations. Further, the Commission should carefully consider the potential for OOBE and/or spurious emission interference into EESS (passive) and EESS (active) bands when authorizing ISAM operations.

Respectfully submitted,

NATIONAL ACADEMY OF SCIENCES'
COMMITTEE ON RADIO FREQUENCIES

By: Marcia McNutt

Marcia McNutt
President, National Academy of Sciences

Direct correspondence to:

CORF
Keck Center of the National Academies
of Sciences, Engineering, and Medicine
500 Fifth Street, NW, Keck 954
Washington, D.C. 20001
(202) 334-3520

May 17, 2024

Appendix

Committee on Radio Frequencies

Members

Nathaniel J. Livesey, Jet Propulsion Laboratory, California Institute of Technology, *Chair*

Scott Paine, Center for Astrophysics | Harvard & Smithsonian, *Vice Chair*

Nancy L. Baker, Naval Research Laboratory

Laura B. Chomiuk, Michigan State University

Kshitija Deshpande, Embry-Riddle Aeronautical University

Dara Entekhabi, Massachusetts Institute of Technology

Philip J. Erickson, Haystack Observatory, Massachusetts Institute of Technology

Kelsey E. Johnson, University of Virginia

Christopher Kidd, University of Maryland and NASA Goddard Space Flight Center

Karen L. Masters, Haverford College

Mahta Moghaddam, University of Southern California

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

Consultants

Tomas E. Gergely, retired

Staff

Christopher J. Jones, Responsible Staff Officer