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

In the Matter of	)	
	)	
Expediting Initial Processing of Satellite and Earth Station Applications	)	IB Docket No. 22-411
	)	
Space Innovation	)	IB Docket No. 22-271

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

The National Academy of Sciences, through its Committee on Radio Frequencies (hereinafter, CORF[1]), hereby submits its comments in response to the Commission's Notice of Proposed Rulemaking ("NPRM"), released December 22, 2022, in the above-captioned dockets. In these Comments, CORF urges the Commission to properly protect use of the spectrum for critical scientific research and operational applications. CORF generally opposes grants that are inconsistent with International Telecommunication Union ("ITU") allocations, but if any waivers of ITU allocations are to be allowed in the processing of satellite applications involving transmission in bands allocated to scientific services or neighboring those allocated to scientific services (or transmissions with significant harmonics in or adjacent to bands allocated to scientific services), then the applicant must be required to demonstrate practical and effective protection of the neighboring scientific bands and scientific bands which would be impacted by harmonic emissions from the satellite transmitter. Moreover, new space-to-

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

Earth applications that are inconsistent with ITU allocations should incorporate geographic protections for RAS facilities subject to protection pursuant to certain footnotes in the United States (U.S.) and International Tables of Frequency Allocations and consider additional voluntary coordination measures to protect remotely located RAS facilities.

I. The Importance of Earth Remote Sensing and Radio Astronomy.

A. Earth Remote Sensing – The Earth Exploration Satellite Service (EESS)

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 microwave remote sensing ("EESS") represents the only practical method of obtaining atmospheric and surface data for the entire planet.[2] EESS data have made critical contributions to the study of meteorology, atmospheric chemistry, climatology, and oceanography. Currently, instruments operating in the EESS 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 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 (NSF), the National Aeronautics and Space Administration (NASA), the Department of Defense (especially

[2] For a more detailed summary of how Earth remote sensing/EESS works, *see* National Telecommunications and Information Administration, 2021, "The Spectrum Needs of U.S. Space-Based Operations: An Inventory of Current and Projected Uses," Office of Spectrum Management, July ("*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.

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, as well as safety of life,[3] national security, and scientific investigation (particularly regarding climate change). Other countries, notably those within the European Union (EU), have made comparable investments, and international agreements are in place to ensure continual sharing of EESS 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 2018 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 the location and severity of extreme weather are essential. Having time to prepare for extreme events limits their impact.[6] Furthermore, in rural areas where farming is the

[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* https://www.noaa.gov/weather (last viewed January 19, 2023).

[5] *See* NOAA, 2018, "NOAA by the Numbers", June, 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.

[6] *See* NOAA, 2018, "NOAA's Contribution to the Economy; Powering America's Economy and Protecting Americans", at page 8, available at

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]

The critical research performed by Earth remote sensing scientists cannot be performed without access to interference-free bands. EESS (passive) observations, which measure natural thermal radiation from the atmosphere and surface, are particularly sensitive to interference. A 2021 report released by the National Telecommunications and Information Administration (NTIA) stated that

> Due 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]

B. The Radio Astronomy Service (RAS)

As the Commission has long recognized, radio astronomy is a vitally important tool used by scientists to study the universe. The Nobel Prize–winning discovery of pulsars by radio astronomers has led to the recognition of a widespread population of rapidly spinning neutron stars with surface gravitational fields up to 100 billion times stronger than that on Earth. Subsequent radio observations of pulsars have revolutionized understanding of the physics of neutron stars and have resulted in the first experimental evidence for gravitational radiation, which was recognized with the awarding of another Nobel Prize. It was through the use of radio astronomy that

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https://www.noaa.gov/sites/default/files/legacy/document/2019/Nov/NOAA-Contribution-to-the-Economy-Final.pdf.

7 *See* National Bureau of Economic Research, "Forecasting Profitability," available at https://www.nber.org/papers/w19334 (last viewed Jan 19, 2023).

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

scientists discovered the first planets outside the solar system, circling a distant pulsar.

Radio astronomy has also enabled the discovery of organic matter and prebiotic molecules outside our solar system, leading to new insights into the potential existence of life elsewhere in the Milky Way Galaxy. Radio spectroscopy and broadband continuum observations have identified and characterized the birth sites of stars in the Milky Way, the processes by which stars slowly die, and the complex distribution and evolution of galaxies in the Universe. The enormous energies contained in the enigmatic quasars and radio galaxies discovered by radio astronomers have led to the recognition that most galaxies, including our own Milky Way Galaxy, contain supermassive black holes at their centers, a phenomenon that appears to be crucial to the creation and evolution of galaxies. Indeed, the first image of a supermassive black hole, in the M87 galaxy, and its shadow was obtained by an array of radio telescopes,[9] followed, most recently, by observations of the black hole at the center of the Milky Way Galaxy.[10] Synchronized observations using widely spaced radio telescopes around the world give extraordinarily high angular resolution, far superior to that which can be obtained using the largest optical telescopes on the ground or in space.

The critical scientific research undertaken by RAS observers, however, cannot be performed without access to interference-free bands. Notably, the emissions that radio astronomers receive are extremely weak—a radio telescope receives less than 1

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[9] *See* The Event Horizon Collaboration, 2019, *Astrophysical Journal Letters*, 875: L1. https://doi.org/10.3847/2041-8213/ab0ec7. *See also* https://www.washingtonpost.com/opinions/2019/04/12/black-hole-photo-was-no-big-surprise-scientists-heres-why-its-still-big-deal/; https://www.washingtonpost.com/science/2019/04/10/see-black-hole-first-time-images-event-horizon-telescope/; and https://www.nytimes.com/2019/04/10/science/black-hole-picture.html.

[10] *See* The Event Horizon Collaboration, 2022, *Astrophysical Journal Letters*, 930: L2. https://doi.org/10.3847/2041-8213/ac6674.

percent of one-billionth of one-billionth of a watt (10^{-20} W) from a typical cosmic object. Because radio astronomy receivers are designed to pick up such remarkably weak signals, radio observatories are particularly vulnerable to interference from in-band emissions, spurious and out-of-band emissions (OOBE) from licensed and unlicensed users of neighboring bands, and emissions that produce harmonic signals in the RAS bands, even if those human-made emissions are weak and distant.

II. The Impact of Massive Satellite Constellations

A. Impacts to RAS

The advent of large low-Earth orbit (LEO) constellations poses a significant challenge to established modes of protection for RAS observatories. Current regulatory protection of radio quiet zones is not designed to address satellite transmissions, and the de facto protection once enjoyed by observatories in remote locations can no longer be assured. A 2022 Government Accountability Office (GAO) technology assessment noted that

> Transmission effects from satellites are not a new problem for radio astronomy, and astronomers have been able to mitigate those effects to some degree. However, as the number of satellites in LEO increases significantly, satellite transmissions may increasingly challenge radio astronomy's ability to detect faint cosmic signals. … As the number of satellites rapidly increases in LEO, there is an increased probability that there could be a satellite in the path of a radio telescope antenna no matter where it points in the sky.[11]

The final point holds true because unwanted emissions can couple at a high level via the near sidelobes of a RAS antenna, which can extend to several degrees from the axis of the narrow primary beam. Recent technical advances, including array receivers

[11] US Government Accountability Office, 2022, *Large Constellations of Satellites: Mitigating Environmental and Other Effects*, Congressional Publications, at Section 3.3.1.

supporting multiple beams on the sky and wide-field interferometers composed of many electrically small antennas with wide primary beamwidths, further increase the likelihood of receiving unwanted emissions from space-borne transmitters.

Because of the high probability of near-main-beam encounters with the satellites of a large non-geostationary orbit (NGSO) constellation, the isotropic (0dBi) far-sidelobe model used to determine interference thresholds in ITU-R RA.769 is inappropriate, and instead the ITU recommends the more realistic statistical modeling procedure defined in Recommendations ITU-R M.1583 and ITU-R S.1586, which combines the orbital characteristics of a given satellite constellation with a more realistic sidelobe model for the RAS antenna. However, a 2021 MITRE study commissioned by the National Science Foundation (NSF) noted that, for large satellite constellations in LEO, RAS interference thresholds may not be sufficiently protective even when computed with these more sophisticated methods, writing:

> ITU limits are insufficient to protect radio astronomy in bands where some radio telescopes operate, for instance for X-band (8-12 GHz) and K-band (18-27 GHz) and particularly for single dish, single feed telescopes.[12]

The reason for this is that the averaging procedure employed in ITU-R M.1583 and ITU-R S.1586 does not account for the fluctuations in the interfering emissions as the satellites move across the telescope sidelobes. Instead, it treats the interference as equivalent to stationary thermal noise, which is more readily removed by modulation and scanning techniques. In view of the present explosive growth in large LEO constellations, more accurate methods of analyzing their impact on RAS and other

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[12] *The Impact of Large Constellations of Satellites,* Document No. JSR-20-2H (JASON Program Office, Mitre Corporation, 2021) at Section 3.4.1.

services will need to be developed. This will inform future technical and regulatory developments that will be needed to enable vital RAS science to remain possible.

In the context of this state of affairs, the Commission proposes in this NPRM to revise its rules for processing satellite and Earth station applications “to formally allow consideration of satellite applications and petitions that request waiver of the Table of Frequency Allocations to operate in a frequency band without an international allocation.” This proposed change has significant potential to exacerbate the concerns noted above, and CORF urges caution. The Commission also seeks comment in paragraph 14 of the NPRM on guidance that it might offer on conditions under which a waiver would be considered. CORF recommends that these conditions include the following:

a) No waivers should be granted for space-to-Earth transmissions at or immediately adjacent to frequencies where RAS has a primary or secondary allocation, nor at or immediately adjacent to frequencies listed in footnote 5.149 of the International Table or footnote US342 of the US Table.

b) Licensed systems should be engineered with spatial, spectral, and temporal geofencing capability that enables suppression or coordination of transmissions into radio quiet zones and within a certain radius of RAS observatories[13] with geographic footnote protection, with reasonable exceptions such as intermittent safety-of-life applications. For example, within a spot beam covering a RAS observatory, channel occupancy could be dynamically controlled—or transmission completely disabled—in real-time coordination with the observatory.

[13] The protection radius could correspond to the projected radius, suitably defined, of a satellite spot beam on the ground.

Geofencing could be used to prevent a satellite transmitter from responding to non-emergency downlink requests from user devices located within a coordinated radius of a protected RAS facility or in the National Radio Quiet Zone. CORF notes that for satellite systems granted a waiver to use a non-conforming allocation, the operational capabilities necessary to protect RAS observatories would also be highly desirable to protect the rights of other administrations under Article 4.4 of the Radio Regulations and to enable the system to respond to related claims of interference in as fine-grained a manner as possible.

c) As one possible condition for granting a waiver, the Commission suggests in paragraph 14 that "waiver applicants should provide a sufficient electromagnetic compatibility analysis to support a Commission finding that the intended use of the frequency assignment will not cause harmful interference to other stations operating in conformance with the ITU Radio Regulations." CORF strongly endorses this. Analyses should quantify both the time average and variability of the aggregate equivalent spectral power flux density of all emissions, including unwanted emissions, for realistic RAS antenna and satellite spot beam sidelobe models. As noted above, ITU methods assume that interference integrates down like thermal noise, and it is reasonable to expect that more realistic interference models could result in more stringent limits. Given the complexity of such analyses, they should be open to public review and comment for a period long enough to enable meaningful technical evaluation.

A recent agreement reached between NSF and SpaceX includes commitments to voluntary dynamic coordination with RAS observatories and joint coexistence studies.[14] This is a significant step towards realization of protections such as those suggested above.

B. Impacts to EESS

As discussed above, EESS observations provide uniquely valuable inputs to societally critical weather forecasting systems and Earth system research and applications. As noted above, EESS (passive) observations are particularly vulnerable to interference and will be our focus here, though EESS (active) sensors are also susceptible to interference at higher levels. Despite nearly all passive observations being made in bands subject to RR 5.340 “All emissions prohibited” protection (and the equivalent domestic protection under footnote US342), many measurements are affected by documented radiofrequency interference from both ground-based and spaceborne emitters.[15]

Broadly speaking, the impacts of Radio Frequency Interference (RFI) on EESS (passive) observations fall into three categories. Firstly, there are cases where the interference is of such a high level that it is readily identifiable. These must be cataloged, and the affected observations excised from the record. Such excision reduces efficiency and spatial sampling, and the associated irrevocable loss of the

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[14] *See* National Science Foundation, “NSF statement on NSF and SpaceX Astronomy Coordination Agreement, Jan 10, 2023,” available at https://beta.nsf.gov/news/statement-nsf-astronomy-coordination-agreement (last viewed on January 18, 2023).

[15] *See, e.g.,* D. McKague, J. Puckett, and C. Ruf, 2010, “Characterization of K-band radio frequency Interference from AMSR-E, WindSat and SSM/I,” in 2010 IEEE International Geoscience and Remote Sensing Symposium (IGARSS), pp. 2492–2494, https://doi.org/10.1109/IGARSS.2010.5651860.

affected measurements reduces scientific information yield and thus, for example, weather forecasting skill. Secondly, there are cases of extremely weak RFI that do not impact the observations and are of no consequence. The greatest challenge is in fact presented by the third category, cases between these two extremes. In these situations, unwanted signals captured by passive receivers are at a moderate level and are thus not easily recognizable as RFI. The affected observations therefore can masquerade as valid scientific data. Such interference creates an “insidious” corruption of observations that can significantly skew the validity of the conclusions drawn (including poor or misleading operational weather forecasts).[16]

Spaceborne transmissions have the potential to impact EESS (passive) observations through at least three routes. The most obvious is direct beam-to-beam transmissions into an EESS passive field of view. This is expected to be a relatively rare occurrence, as EESS instruments mostly view downwards from LEO (though concepts for EESS sensors in Geostationary orbit are under development for consideration by both NASA and NOAA). For interference to occur, the associated transmitter would thus need to be below the EESS observatory with some fraction of its beam directed towards the EESS (passive) sensor—thus space-to-space transmissions would be the cause for greatest concern. The second route is associated with the views of cold space used as a calibration source for most EESS (passive) sensors, typically on a rapidly repeating (several times a minute) cadence. These observations are made through viewports looking in directions expected to be free of all emissions other than the cosmic microwave background and are thus directed well above the Earth, and typically

[16] *See, e.g.,* Comments of IEEE Geoscience and Remote Sensing Society in GN Docket No. 14-177, filed June 28, 2021, at page 3.

oriented such that they never or rarely see the Sun or Moon. Further, these calibration observations are often made with a broader beam than the Earth-viewing observations (e.g., as large as 10–30 degrees across), meaning that a potentially large area of the sky must be kept free from emissions for reliable observations. Each calibration observation is applied to multiple Earth measurements, so RFI into these calibration views has the potential to have more pervasive impacts than RFI into the Earth observations.

As an aside, CORF notes that, for both of these first two RFI geometries, a particular concern relates to the admittedly unlikely but potentially catastrophic case where a high-powered transmission is made in the immediate environs of, and directed at, an EESS sensor. Such cases could result in permanent damage to the sensitive EESS receivers.

The third, and most likely, scenario where RFI impacts EESS (passive) observations is where spaceborne emissions reflect off the Earth's surface and into the field of view of the passive sensor. The natural thermal emission signatures being observed are particularly small. Further, the scientific objective is to track small changes in such signatures. For example, a 1ºF change in surface temperature is a scientifically important amount for both weather and climate. However, this corresponds to a very small (~0.2 percent) variation in the signal received by an EESS (passive) receiver, and an even smaller change in its output including receiver noise. Accordingly, even such seemingly indirect interference as reflections off the surface of the Earth have a documented harmful effect. Such reflections are particularly strong and clear from bodies of water and ice sheets, as these relatively flat surfaces exhibit strong specular reflections. However, reflections also occur off ground, buildings, etc., typically in a non-specular manner that is harder to characterize[17].

Cases of insidious RFI can be easier to detect and excise if they occur in a repeatable manner. This can be the case for the scenario where signals from a transmitter in geostationary orbit (GSO) reflect off the Earth's surface and are seen by an EESS (passive) sensor in LEO. The fixed nature of the GSO transmitter with respect to the Earth's surface and the regular orbital geometry of the LEO sensor result in reflections that tend to occur at the same points on the Earth and for the sensor.

In the case of NGSO transmitters, the emission-reflection-observation geometries will be far more variable, with both the transmitter and EESS (passive) satellite being in constant and unsynchronized motion with respect to each other. This, combined with the large number of satellites associated with recent and anticipated NGSO constellations, makes for a much more challenging RFI landscape for EESS (passive) sensors to operate within, with the prospect of far more pervasive insidious RFI unless steps are taken to safeguard the observations.

Although EESS sensors and spacecraft are developed by national agencies (e.g., NASA, NOAA, and the Department of Defense in the United States) or multinational bodies (e.g., EUMetSat), they observe globally and their data are shared and used on an international basis under various agreements and multilateral open data

[17] Reflections off ocean and land surfaces are described in recommendation ITU-R-P.527-5. For reflections off buildings etc., extensive literature exists. For example: S. S. Zhekov, O. Franek and G. F. Pedersen, "Dielectric Properties of Common Building Materials for Ultrawideband Propagation Studies [Measurements Corner]," in *IEEE Antennas and Propagation Magazine*, vol. 62, no. 1, pp. 72-81, Feb. 2020, doi: 10.1109/MAP.2019.2955680, and also: Romain Damez, Philippe Artillan, Arthur Hellouin de Menibus, Cédric Bermond, Pascal Xavier, Effect of water content on microwave dielectric properties of building materials, in *Construction and Building Materials*, Volume 263, 2020, doi:10.1016/j.conbuildmat.2020.120107

access policies. Such shared usage and global coverage are essential for both operational weather forecasting (e.g., U.S. weather forecasts are critically dependent on obtaining accurate observations over Canada and vice versa, and beyond) and Earth system research.

Given the global nature of the EESS and weather/climate enterprise, the ITU process is the natural vehicle for ensuring that the EESS observing system continues to receive adequate protection from other services. In contrast with RAS, there are no useful means by which geographical separation can protect EESS observations from spaceborne interference. Similarly, CORF is not aware of any regulatory framework for temporal separation (and such an approach is arguably not sustainable, as the EESS (passive) community continues to work toward having denser and more frequent observations—e.g., continuously from a sensor in GSO in the coming decades). Accordingly, the only sure means whereby EESS (passive) observations can continue to be protected is through frequency separation. This involves having well-chosen band allocations (including guard bands where necessary) and OOBE masks that are consistent with meeting the limits recommended by ITU-R RS.2017 based on realistic assumptions of both surface reflections and aggregate emissions (including from large constellations). Applicants should be required to account for aggregate emissions from multiple transmitters within their own constellations (both those proposed and any already approved) as well as from other pending proposals and active operations in the same band.[18]

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[18] *See, e.g., Amendment of Parts 2 and 25 of the Commission's Rules to Enable GSO Fixed-Satellite Service (Space-to-Earth) Operations in the 17.3-17.8 GHz Band, to Modernize Certain Rules Applicable to 17/24 GHz BSS Space Stations, and to Establish Off-Axis Uplink Power Limits for Extended Ka-Band FSS Operations,* Report and Order, FCC 22-63 (Aug. 3, 2022) at paras. 26 and 35. Regarding

CORF also remains concerned as to whether or how the United States would be in violation of ITU treaties in cases where emissions from a U.S.-licensed spaceborne transmitter interfere with non-U.S. EESS observations. Perhaps if the interference only precludes observations over U.S. territory, as damaging as that might be for U.S. national interests, there might be no ramifications for ITU compliance. However, as other countries' weather forecasts rely on global observations that are shared by international agreements,[19] it is possible some other non-ITU-based international agreements come into play. Observations over the United States are essential to the accuracy of short-term weather forecasts for its immediate neighbors. Further, the accuracy of the medium-range (e.g., 3 to 5 day) to extended, greater range (greater than 5 days) weather forecasts over Europe depends on the weather observations taken elsewhere, including in the United States. CORF notes that these complex international situations can be avoided if the Commission grants spaceborne transmission licenses only in cases where requested transmission bands (and their harmonics) are well away from bands allocated to EESS (passive).

In response to the Commission's request in paragraph 14 of the NRPM for comments on guidance that it might offer to potential applicants, CORF makes the following recommendations:

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calculation of the aggregate impact from multiple operators, s*ee, e.g., In the Matter of Space X Services, Inc. and Kepler Communications, Inc.,* DA 22-695 (June 30, 2022) at para. 34.

[19] For example, the national/international weather centers/countries/agencies that participate in the International ATOVS Working Group, develop numerical weather prediction systems, and use at least NOAA AMSU-A/ATMS microwave sounders include the following: Canada, Europe (via ECMWF), Norway, US (NOAA, NASA, DoD), Germany, UK Met Office, Denmark, Japan, France, Brazil, Australia, New Zealand, Hungary, Italy, Singapore, S. Korea, Russia, Sweden, China, Czech Republic. There has also been a marked growth in commercial weather forecasting enterprises, including commercially developed Earth observing satellites.

a) No waivers should be granted for space-to-Earth, Earth-to-space, or space-to-space transmissions at frequencies where EESS (passive) has a primary or secondary allocation.

b) Proposed systems should be engineered with guard bands, OOBE masks, and spurious emission limits sufficient to ensure that the interference levels in recommendations ITU-R RS.2017 for EESS (passive) and ITU-R RS.1166 for EESS (active) are not exceeded. This specifically includes interference from surface reflections. The level of protection should, at a minimum, be consistent with realistic assumptions about aggregate emissions from transmitters within the constellation(s) operated by the licensee. Ideally, aggregate emissions encompassing those from other operators should also be factored in.

c) For EESS as for RAS, CORF strongly endorses the Commission's statement in paragraph 14 of the NPRM that "...waiver applicants should provide a sufficient electromagnetic compatibility analysis to support a Commission finding that the intended use of the frequency assignment will not cause harmful interference to other stations operating in conformance with the ITU Radio Regulations." Applicants should relate their proposals to any specific relevant publicly available ITU literature or peer-reviewed literature. Applications, including all such material, should be open to public review and comment for a period long enough to enable meaningful technical evaluation.

III. The Dangers of Ignoring of ITU Allocations

Both RAS and EESS are global and international enterprises. RAS observatories are located on all continents, funded and operated by multiple countries and international organizations. Similarly, multiple suites of EESS sensors exist, funded and operated by both individual countries and multi-country agencies. Both services support international scientific and operational applications that benefit society worldwide. Emissions from spaceborne transmitters can, by their very nature, cross national boundaries, and thus need to be considered in an international context. The ITU is, accordingly, the natural forum for work to identify and manage potential incompatibilities between new spaceborne applications of the radio spectrum and existing services, including RAS and EESS.

CORF recognizes that in carrying out its role, the Commission seeks to balance this need for international harmonization with the need to encourage useful innovation and promote national economic interest. Here, CORF urges that any waivers granted by the Federal Communications Commission be considered provisional and intended as prototypes towards eventual international standards developed within the ITU process. Moreover, an investment undertaken under grant of waiver must be understood as necessarily being at risk, rather than as a *fait accompli* that serves to coercively influence the ITU process.

IV. Conclusion

Both RAS and EESS observations require continued protection from interference from spaceborne emissions, especially those associated with current and future deployments of large LEO satellite constellations. As a general principle, waivers for satellites to operate in bands not allocated by the ITU to satellite services should be avoided, due to the uncertain and unstudied nature of the impact to other spectrum users, particularly passive scientific services. The Commission’s proposal to expedite processing of satellite and Earth station applications would open a door to a great threat to critical scientific use of the spectrum, but if the Commission chooses to do so, it should be coupled with leadership in developing new modes of protection.

Given the international nature of the RAS and EESS services, and the communities and societal needs their measurements benefit, CORF recommends that the Commission continue to issue licenses in a manner that is consistent with ITU allocations, agreements, frameworks, and processes. Should the Commission, however, decide to issue licenses for spaceborne transmission in bands not allocated for such services in the ITU tables, CORF urges the Commission to bear the recommendations detailed above in mind. In summary,

a) No waivers should be granted for space-to-Earth transmissions in RAS primary or secondary bands, or at frequencies listed in footnotes 5.149 of the International Table or footnote US342 of the U.S. Table.
b) No waivers should be granted for space-to-Earth, Earth-to-space, or space-to-space transmissions at frequencies where EESS (passive) has a primary or secondary allocation.
c) Licensed systems should be engineered with spatial, spectral, and temporal geofencing capability to protect radio quiet zones and RAS observatories with geographic footnote protection.
d) Licensed systems should be engineered with guard bands, OOBE masks, and spurious emission limits sufficient to ensure that the interference levels in ITU-R RS.2017 are not exceeded in aggregate for either direct or Earth-reflected coupling into EESS (passive) systems.

e) CORF strongly endorses the Commission’s statement in paragraph 14 of the NPRM that “waiver applicants should provide a sufficient electromagnetic compatibility analysis to support a Commission finding that the intended use of the frequency assignment will not cause harmful interference to other stations operating in conformance with the ITU Radio Regulations,” further noting that current ITU recommendations modeling interference as stationary noise may not be sufficiently stringent. These analyses should be open to public review and comment for a period long enough to enable meaningful technical evaluation.

Respectfully submitted,

NATIONAL ACADEMY OF SCIENCES'
COMMITTEE ON RADIO FREQUENCIES

By: ______________________________
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

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Appendix: Committee on Radio Frequencies

Members

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

Scott Paine, Center for Astrophysics | Harvard & Smithsonian

Nancy L. Baker, Naval Research Laboratory

Laura B. Chomiuk, Michigan State 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

Frank Schinzel, National Radio Astronomy Observatory

Consultants

Darrel Emerson

Tomas E. Gergely

Staff

Neeraj P. Gorkhaly, Study Director