Before the
Federal Communications Commission
Washington, DC 20554

In the Matter of	)	
Unlicensed Use of the 6 GHz Band	)	ET Docket No. 18-295
	)	
Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz	))	GN Docket No. 17-183

REPLY 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 Reply Comments[2] in response to the Federal Communications Commission's (FCC's) *Third Further Notice of Proposed Rulemaking* (FNPRM) in the above-captioned docket, FCC 26-1 (released January 30, 2026). In these comments, CORF discusses the importance of remote sensing/Earth Exploration Satellite Service observations of the oceans at 6 GHz, and the potential impact of the operation of so-called Low Power Indoor 6 GHz (LPI) devices on cruise ships in the ocean. Initial calculations suggest that use of a single LPI device inside cruise ships should not significantly harm important remote sensing observations; however, extensive use of many such devices on cruise ship decks, or within indoor ship locations without the attenuation of thick metal walls, could significantly impact remote

[1] *See* the Appendix for the membership of the Committee on Radio Frequencies.
[2] CORF herein replies to the Comments filed in this proceeding on March 23, 2026 by Cisco Systems, Inc., Consumer Technology Association, Wi-Fi Alliance, Cruise Lines International Association, and Intel Corporation.

{01791807-1 }

sensing, as well as radio astronomy. Examples of short-term signal leakage from indoor use of LPI devices could include open doors, or pools or lounges with retractable or other thinner covers. Accordingly, if the FCC authorizes the use of LPI devices on cruise ships, it should take the steps necessary to ensure that such devices are not used on decks or in locations as discussed above. If LPI devices support multiple frequency ranges on board cruise ships, then prioritizing the use of different frequency spectrum within the device's capability should be considered.

I. Introduction

CORF has a substantial interest in this proceeding, as it represents the scientific interests of users of the radio spectrum, including users of the Earth Exploration Satellite Service (EESS) and the Radio Astronomy Service (RAS).

A. Earth Remote Sensing at 6 GHz

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.[3] 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

[3] 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*"), 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).

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 (NSF), the National Aeronautics and Space Administration (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 the safety of life,[4] national security,[5] and scientific investigation.

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*—trillions of dollars annually—is sensitive to weather and climate.[6] A NOAA report[7] 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

[4] *See, e.g., NTIA Report,* 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).
[5] *See*, *e.g.,* "From Orbit to Operations: How Weather Satellites Support the National Security Mission," Hearing before the Subcommittee on the Environment, Committee on Science, Space and Technology, U.S. House of Representatives, January 13, 2026; written testimonies of Irene Parker, Deputy Assistant Administrator, National Oceanic and Atmospheric Administration; Col. Bryan D. Mundhenk, Chief, Weather Operations Division, U.S. Air Force; and Christopher Ekstrom, Deputy Oceanographer and Navigator, U.S. Navy, https://science.house.gov/2026/1/subcommittee-environment-hearing (last viewed January 14, 2026).
[6] *See* NOAA Weather homepage, https://www.noaa.gov/weather (last viewed January 14, 2026).
[7] *See* "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).

the economic vitality that these regions contribute. Accurate predictions of extreme weather location and severity are essential. Having time to prepare for extreme events limits their impact."[8] Forecasting weather for shipping in particular is of significant commercial value, as well as for safety at sea for crew and passengers. A reduction in forecasting accuracy is therefore undesirable. Indeed, the upwelling of colder sea temperatures can have significant effects on storm tracks impacting ship routing and landfall predictions.[9]

The critical research performed by Earth remote sensing scientists, and the Earth environment monitoring used in many downstream applications 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.[10]

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. 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

---

[8] *See* "NOAA's Contribution to the Economy; Powering America's Economy and Protecting Americans" NOAA, 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).

[9] See N. Rouzegari, M. Bolboli Zadeh, C. Jimenez Arellano, V. Afzali Gorooh, P. Nguyen, H. Meng, R.R. Ferraro, S. Kalluri, S. Sorooshian, and K. Hsu, 2025, Passive Microwave Imagers, Their Applications, and Benefits: A Review, *Remote Sensing 17*(9):1654, https://doi.org/10.3390/rs17091654 (last viewed March 24, 2026).

[10] *See NTIA Report, supra* note 5, p. 15.

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 demands confidence that the observed variations reflect true geophysical processes, rather than the presence or absence of interfering emissions. As EESS sensors provide data over the entire globe compiled from broad swaths of observations, they are subject to aggregate interference from emitters in the swath area scanned (both the areas on Earth and the regions of cold space used for calibration).

In the Third FNPRM (3rd FNPRM) in this proceeding, the FCC proposes rules for Geofenced Variable Power (GVP) devices to operate in the U-NII-5 (5.925–6.425 GHz) and U-NII-7 (6.525–6.875 GHz) portions of the 6 GHz band. International Footnote 5.458 states that frequencies between 6425 and 7250 MHz are used for passive microwave measurements (with the lower fraction, 6425–7075 MHz, used for ocean remote sensing) and that administrations should bear in mind the needs of these services in their planning. Observations at these frequencies are an essential component for both weather prediction and observing climate change. EESS (passive) sensors are uniquely able to measure sea surface temperature, ocean wind speed, sea surface salinity, and sea ice concentration, all of which are classified as Essential Climate Variables.[11] Further, EESS (passive) sensors at low frequencies can make such surface measurements regardless of cloud cover. As with EESS (passive) observations generally, these ocean observations must be made in multiple bands, as no single band provides unambiguous information on any one of these variables. Rather, the

[11] *See, e.g.*, https://gcos.wmo.int/en/essential-climate-variables/ (last viewed February 23, 2026).

ocean/atmosphere state must be deduced from consideration of simultaneous observations in multiple bands. The frequencies between 6425 and 7250 MHz are particularly valuable in EESS observing systems, as measurements in this frequency range are the least affected by the atmosphere.[12] Observational approaches employing this band provide the most precise measurements.

While the 2023 World Radiocommunication Conference (WRC-23) established Agenda Item 1.19 for the 2027 World Radiocommunication Conference to investigate migrating remote sensing out of the 6 GHz band, at present this remains a critical band for ongoing and future EESS observations over the next 20 years and beyond. The WRC-23 action recommends sharing and compatibility studies, and then "examin[ing] the results of these studies with a view to considering a new primary allocation" that would be an alternative to 6 GHz;[13] however, this remains completely speculative and conditional for now. Further, there are existing EESS (passive) currently in operation onboard satellites as well as planned sensors at 6 GHz. These represent a substantial investment by the United States and other nations and are expected to continue to operate for decades to come.

CORF appreciates that the FCC has recognized the public need to protect EESS observations previously in this proceeding. In its April 24, 2020 Report and Order (*First*

---

[12] *See* L. Kilic, C. Prigent, F. Aires, J. Boutin, G. Heygster, R.T. Tonboe, et al., 2018, Expected Performances of the Copernicus Imaging Microwave Radiometer (CIMR) for an All-Weather and High Spatial Resolution Estimation of Ocean and Sea Ice Parameters, *Journal of Geophysical Research: Oceans* 123:7564–7580, p. 7566, https://doi.org/10.1029/2018JC014408 (last viewed February 23, 2026).

[13] *See* Resolution 674, Int'l Telecomm. Union, World Radio Conference 2023, https://www.itu.int/dms_pub/itu-r/oth/0c/0a/R0C0A0000110019PDFE.pdf (last viewed February 24, 2026). Notably, this resolution states that any new allocations resulting from this agenda item, even though they could be considered "primary" allocations, would not include protection for EESS (passive) from existing services within these frequency bands and in adjacent bands.

{01791807-1 }

R&O),[14] the FCC prohibited standard-power access points aboard ships and on oil platforms, in order to protect important EESS observations. Similarly, in the Fourth Report and Order in this proceeding, the FCC excluded GVP access points from oil platforms and geofenced such devices from operating co-frequency with EESS observations within ocean exclusion zones.[15] CORF urges the FCC to again be mindful of the public interest in protecting important but extremely vulnerable EESS observations.

B. Radio Astronomy at 6 GHz

As the FCC has recognized in this proceeding and many others, radio astronomers perform important research that is extremely vulnerable to interference. The emissions that radio astronomers observe are extremely weak—a radio telescope receives less than 1 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, from spurious and out-of-band emissions associated with licensed and unlicensed use of neighboring bands, and from emissions that produce harmonic signals in the RAS bands, even if those human-made emissions are weak and distant. Even when, as in the present case, a band already has incumbent fixed operations, transmissions by unlicensed devices into protected RAS bands can be particularly harmful because, due to their mobility and lack of licensing records, it is very

---

[14] *Unlicensed Use of the 6 GHz Band; Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz*, Report and Order, 35 FCC Rcd 3852, 3855 (2020).
[15] *Unlicensed Use of the 6 GHz Band; Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz*, Fourth Report and Order, FCC 26-1 (January 30, 2026) at paras. 105-106.

difficult to identify interference from such devices, to identify the operator of such devices, and to remedy the interference.

The RAS is an important and protected incumbent in the U-NII-7 (6.525–6.875 GHz) sub-band. The U-NII-7 sub-band, in addition to the U-NII-5 (5.925–6.425 GHz) portion of the 6 GHz band, is proposed for operation of GVP in this FNPRM. The 6650–6675.2 MHz band (the "6.7 GHz RAS band") is important to the RAS for observations of methanol that play a critical role in research into star formation, astrochemistry, and precision astrometry. Accordingly, this band is protected by Footnote US342, which states that "all practicable steps shall be taken to protect the radio astronomy service from harmful interference" in this band. In particular, the spectral line at 6668.518 MHz, associated with the $5_1 \rightarrow 6_0 \; A^+$ transition of the methanol molecule, is among those of greatest observational importance to RAS (*See*, International Telecommunication Union Radiocommunication Sector [ITU-R] Recommendation ITU-R RA.314–10 at Table 1).[16] This transition is widely observed in bright non-thermal maser emission in high mass star-forming regions. Such astrophysical masers are observed in only a handful of interstellar molecules that have the density, quantum structure, and environmental interaction necessary to create a state-inverted population supporting maser amplification. These masers serve as probes of the physical conditions and processes in their local environments, providing vital insight into star formation and other processes. Additionally, by virtue of their intensity, compactness, and narrowband emission, masers serve as beacons for precision mapping of the structure and

[16] *See also Handbook on Radio Astronomy* (ITU Radiocommunications Bureau, 2013), p. 37, Table 3.2, https://www.itu.int/dms_pub/itu-r/opb/hdb/R-HDB-22-2013-PDF-E.pdf (last viewed March 18, 2026).

kinematics of our galaxy. Among all observed maser transitions, the 6.7 GHz methanol line stands out for its ubiquity and intensity. This unique role amply justifies its explicit protection in Footnote US342 and Footnote 5.149 of the international table.

In addition, very high-resolution radio astronomy observations enable unique and unrivaled monitoring of Earth Orientation Parameters (EOP) through the science of geodesy, which is critical for maintaining the International Celestial Reference Frame and linking it to the International Terrestrial Reference Frame. The worldwide VLBI Geodetic Operating System (VGOS) performs these observations at frequencies from 2–14 GHz. High precision of celestial and terrestrial reference frames is necessary for accurate tracking and navigation of spacecraft, for improving location accuracy on Earth beyond what Global Navigation Satellite Systems (GNSS) currently provide, and for tracking tectonic plates.

In paragraph 104 of the Fourth Report and Order in this proceeding, the FCC enacted protections for radio astronomy by prohibiting GVP access points from operating inside of certain exclusion zones. CORF urges the FCC to again be mindful of the public interest in protecting important but extremely vulnerable RAS observations from ship-borne LPI transmissions, as discussed below.

II. <u>Protection of EESS—LPI Devices on Cruise Ships</u>

In the 3rd FNPRM, the FCC notes that it previously prohibited LPI operations on ships, in response to prior CORF Comments noting that the 6.425–7.075 GHz and 7.075–7.250 GHz bands were critical for remote sensing observations of oceans. The FCC explains that the LPI prohibition was based on lack of walls to attenuate the LPI signal, and thus to protect these remote sensing observations.[17] However, based on a subsequent submission,[18] which suggests that the walls of large cruise ships would provide significant building entry loss, the FCC now proposes to amend its rules to allow LPI operations on cruise ships.

In response, CORF has performed an initial analysis of potential interference to the third Advanced Microwave Scanning Radiometer (AMSR3)[19] from small 6 GHz transmitters on cruise ships. The AMSR3 was launched as part of the Global Observing SATellite for Greenhouse gases and Water cycle (GOSAT-GW) mission by the Japanese Aerospace Exploration Agency in 2025 and has been operational since July 1, 2025. AMSR3 continues the climate record created by earlier AMSR-E, AMSR and Multi-frequency Scanning Microwave Radiometer instruments, which complement the larger climate record built from U.S. instruments such as the Scanning Multichannel Microwave Radiometer, Special Sensor Microwave Imager, and the Special Sensor Microwave Imager Sounder.[20]

Like earlier AMSR instruments, AMSR3 includes 6.925 GHz 350 MHz dual polarization radiometer channels with a Noise Equivalent Delta Temperature (NEΔT) of 0.34 K and an instantaneous field of view of 34 x 58 km. These 6 GHz channels of the AMSR series are much less sensitive to rain and atmospheric factors, making it essential for surface observation. AMSR 6 GHz measurements are used for sea surface temperature over the ocean, sea ice extent mapping, ocean surface wind speed,

---

[17] 3rd FNPRM at para. 174.
[18] Comments of Cisco Systems Inc., April 11, 2025.
[19] *See, e.g.,* https://space.oscar.wmo.int/instruments/view/amsr3 (last visited February 24, 2026).
[20] *See, e.g.,* https://www.nesdis.noaa.gov/s3/2023-05/PrecipWkshp-KACHI.pdf (last visited February 24, 2026).

{01791807-1 }

particularly in raining conditions such as hurricanes, soil moisture, and land surface hydrology, among other applications. These AMSR measurements are crucial inputs to U.S. weather forecasting, hurricane tracking and prediction, support of fisheries, and other important applications.

AMSR3 is designed to operate from a nominal altitude of 666 km (currently it is at 696 km) and collects emissions power measurements from the surface at a nominal incidence angle of 55 degrees over a 1450 km-wide swath, with a 40 rotation-per-minute spinning antenna. Accounting for the nearly spherical Earth, the nominal path length is approximately 813 km. The free space path loss [in dB = $10\log_{10}\left(\frac{4\pi df}{c}\right)$ where d = 813 km, f = 6.925 GHz, c = 2.99×10^8 m/s] within the main beam is thus approximately 167.46 dB. Signals measured by the sensor, which would be considered noise to communications radio systems, are very small. At 6 GHz, the surface brightness temperature of the ocean ranges from 70 to 250K. The signal power of interest is thus -124.7 to -119.2 dBW [using $P = kTB$ where k = Boltzmann's constant (1.38×10^{-23} m^2 kg s^{-2} K^{-1}), T = ocean brightness temperature (70–250K), and B is the receiver bandwidth (350 MHz)]. The measurement uncertainty (1 sigma) corresponding to the NEΔT of 0.34 K is -147.8 dB which is 23.4 dB below the lowest measurement value.

The core concern here is that undetected emissions from an LPI transmitter operating in the same frequency band as the AMSR channel could adversely affect the accuracy of the AMSR observations by biasing the observed surface brightness temperature measurements, leading to errors in inputs to weather models, and other applications. To avoid bias errors, any sources of interference must be less than the measurement uncertainty, i.e., less than -147.8 dBW in the 350 MHz observation band. Ideally, it should be significantly less (3–10 dB) than this value to minimize potential observational errors.

Removing the path loss, this implies that the effective isotropic radiated power of an interference source on the surface radiating in the direction of the AMSR3 observation and within the observation band must be (significantly) less than -147.8 + 167.46 = 19.67 dBW. It seems unlikely that the combination of a *single* LPI transmitter meeting the requirements outlined in the FCC NPRM and antennas designed for wide area signal dispersion within a single cruise ship, assuming it has metal walls, could exceed this requirement due to the high attenuation of the metal structure. Signal leakage through port holes and open doors is not expected to be significant enough to change this conclusion.

Based on this initial analysis, CORF could conclude that operation of an LPI device *inside* (i.e., in the closed interior) of a cruise ship likely would not cause harmful interference to 6 GHz remote sensing of oceans.[21] This conclusion is based on the premise of significant attenuation from the walls of the cruise ship, as well as the idea that only a limited number of the vessels would meet the definition of cruise ship proposed in the 3rd FNPRM at para. 177. CORF has concerns, however, regarding the utility of the proposed definition of "cruise ship" to limit the number of ships that could cause interference to remote sensing operations. The core of the FCC's proposed definition is "any vessel over 100 gross register tons, carrying more than 12 passengers

[21] Accordingly, if the FCC acts to allow the operation of LPI devices on ocean-going vessels, CORF strongly supports limiting such operations to common commercial cruise ships, as defined in discussion below.

for hire which makes voyages lasting more than 24 hours, of which any part is on the high seas." Both the size of the ship (100 gross tons) and the number of passengers (12) are substantially smaller than the actual cruise ships that the FCC,[22] as well as parties in this proceeding, are likely considering—vessels operated by typical commercial cruise companies. For example, Royal Caribbean's most recent 28 cruise ships range in size from 78,340 to 248,633 gross tons, carrying from 1,992 to 5,734 passengers.[23] Even the smallest of those ships would be *783 times* larger than the definition proposed by the FCC. The relevance of this is that the proposed limit on the number of ships that would be authorized to allow LPI operations is nowhere near as impactful as it seems: because of the relatively small size of the "cruise ships" that meet that "limit", there will be many more of them authorized. Moreover, the assertion that cruise ships experience high building entry loss due to their "thick metal walls" appears to be based on a ship of *227,000 gross tons*, not one of 100 tons.[24] It is not clear whether ships of 100 gross tons have the same thickness of walls as those of ships two thousand times their size.

Accordingly, the FCC should revise the definition of "cruise ship" that will be allowed to have LPI operations, to limit it to a size at least equivalent to the smallest of the common cruise ships—75,000 gross tons.

---

[22] *See, Fourth Report and Order* in this proceeding, para. 3, "We also note that cruise ships need more spectrum for unlicensed device operation because they have thousands of passengers within a relatively small footprint."
[23] *See* https://www.royalcaribbean.com/guides/ships-by-age (last viewed March 10, 2026). Similarly, it appears that the carrier Carnival's 27 largest ships range in tonnage from 183,521 to 71,909, *see* https://www.cruisecritic.com/articles/what-is-the-biggest-carnival-ship (last viewed March 10, 2026).
[24] *See* 3rd FNPRM, para. 175, citing Comments of Cisco Systems, Inc., p. 8, which includes footnote 22, citing https://industry.arcelormittal.com/market-segments/steel-for-transport/stxfranceA34.

In addition, CORF notes that the best practice would be to perform tests on cruise ships prior to enactment of the new rule to verify that the walls of cruise ships, even with doors and port holes open, or within areas where retractable covers are open, provide sufficient attenuation to limit harmful interference to remote sensing/EESS operations. CORF urges the FCC to require or encourage such testing, regardless of the timing, and encourages that the results of such testing be made public.

CORF has also considered the scenario of operation of LPI devices on the outdoor deck of ships, where there would be none of the attenuation of metal walls. While operation of a single LPI would not likely have the power to negatively impact remote sensing observations, a worst-case scenario would be when a device is taken or placed outside the metal structure located in an unlikely position where the metal ship structure acts like a high gain reflector that directs a signal toward the satellite sensor. Flat decks and the 90-degree angles between decks and walls could easily provide sufficient area and reflecting geometry to potentially achieve more than 20 dB of gain. Using an idealized formula for reflector gain [$G = \frac{4\pi A f^2 n}{c^2}$ where A is reflector area and n is the efficiency], to achieve an antenna gain of (say) $f =$ 20 dB (G = 100), the effective projected reflector area can be less than a square meter, which is much smaller than a typical cruise ship deck. Higher gains could conceivably occur. Thus, it is possible to have signal interference that could adversely affect a remote sensing measurement. In isolation, only a single measurement would be affected, so the impact on weather forecasting might be small, but it could increase errors in calculating measurement uncertainty. In addition, cruise ships with thousands of passengers follow pre-determined courses, so over time, the accumulated effects of even small insidious errors could show up as biases along the routes, which could have larger effects.

Further, since the current remote sensor footprints at 6 GHz are very large, it is conceivable that multiple ships, each with possible multiple transmitting interferers, could lie within a single footprint. In this case, the total summed power of the interferers could easily approach or exceed this worst-case allowable power of -147.8 dBW when multiple such devices are operated on deck or outside the enclosed ship structure. Coupled with the fixed routing of the ships, the interference could lead to significant issues along these routes, which are common in areas critical to hurricane tracking and prediction in the Caribbean Ocean and the Gulf of Mexico.

Accordingly, CORF recommends that steps be taken to help reduce the possibility of operation of LPI devices on the deck of cruise ships. Limitation to indoor operations only should be in FCC labeling requirements, and there may be other effective requirements as well, such as notifications of the requirements to major operators of cruise ships, and a requirement that the LPI devices be installed only by professionals, or the manufacturer of the ship or its contractors.

III. <u>Protection of RAS—LPI Devices on Cruise Ships</u>

The Fourth Report and Order responds to previous CORF Comments and prohibits GVP devices from operating at 6650–6672 MHz inside of certain RAS exclusion zones. CORF appreciates the FCC's recognition of the public interest in protecting RAS observations. However, in light of the new proposal in the FNRPM to allow operation of LPI devices on cruise ships, any such FCC action should include protection for four radio astronomy observatories located in coastal regions that could be negatively impacted by operation of LPI devices on cruise ships.

As with the impact on EESS, it is not expected that a single LPI device operating inside a large cruise ship with metal walls would have any significant impact; however, multiple such devices operated on the deck, or in less shielded areas of a ship could adversely impact radio observatories located near coasts if they are operated while a cruise ship is within line of sight (los) of the observatory. Table 1 states the size of the line of sight zones for RAS sites that are near to ocean coasts, based on the recommended exclusion zones for GVP devices. The sites in question are the Very Long Baseline Array (VLBA) antenna on Mauna Kea (31 km from the northeast coast of the Big Island of Hawaii), the Arecibo Observatory (15 km from the northern coast of Puerto Rico) and the VLBA antenna on St. Croix, Virgin Islands (just 0.4 km from the coast). These locations are already listed in new Section 15.407(o) of the FCC's rules. In addition, the global Very Long Baseline Interferometry (VLBI) network, run by the International VLBI Service for Geodesy and Astrometry,[25] has NASA support for plans for new wide band 2–14 GHz receivers[26] on an antenna in Kōke'e State Park on Kauai, Hawaii. This antenna is operated at the Kōke'e Park Geophysical Observatory,[27] located 5 km from the northwest coast of Kauai Island. Thus, CORF recommends the Kōke'e Park VLBI antenna should be added to the list of radio observatories to be protected in

[25] *See* https://ivscc.gsfc.nasa.gov/ (last viewed March 30, 2026).

[26] *See* https://earth.gsfc.nasa.gov/geo/instruments/vlbi-global-observing-system-vgos (last viewed March 24, 2026).

[27] *See* https://space-geodesy.nasa.gov/NSGN/sites/KPGO/KPGO.html (last viewed March 30, 2026).

Section 15.407, as well as in Footnote US385. Other radio observatories in the United States are significantly further from coastlines and not expected to be impacted.

The exclusion zone sizes for GVP are based on the radio line of sight and determined using $\frac{4}{3}$ earth curvature formula in Section 15.407(o):

$$d\text{km\_los} = 4.12 \times \sqrt{H_{tx}} + \sqrt{H_{rx}},$$

where H_{tx} is the height of the unlicensed standard power access point or fixed client device and H_{rx} is the height of the radio astronomy antenna in meters above ground level. H_{tx} is 10 meters for an unlicensed GVP access point, and the calculations that follow assume H_{tx} = 10 m for unlicensed devices on board cruise ships. The height of a steerable radio astronomy antenna is not a well-defined quantity, so the maximum height of VLBA radio antennas above the ground of 31.6 m is assumed.[28] While the main antenna at the Arecibo Observatory is not currently operational, the site is still an active radio observatory with several smaller radio telescopes, and the Puerto Rico Coordination Zone (PRCZ) remains active as plans develop to rebuild and add additional radio antennas at this observatory that will operate at 6 GHz. As such, with no specific antenna height available, 10 m is assumed. The VLBI antenna at Kōke'e Park, HI is 20 m. Table 1 provides ranges for $d\text{km\_los}$ for each observatory based on these assumptions for H_{rx} and the elevation of the observatories above sea level.

[28] J. A. Zensus, P. J. Diamond, and P. J. Napier, eds., 1995, Very Long Baseline Interferometry and the VLBA, *ASP Conference Series*, vol. 82, https://www.aspbooks.org/publications/82/59.pdf (last viewed March 18, 2026).

As can be seen in Table 1, in any estimate, these four observatories have GVP exclusion zones ($d$km_los) that are partially intersecting with the seas around their nearest coastline.

Table 1 GVP Exclusion Zone ($d$km_los) Ranges Around Four Radio Observatories

Radio Observatory	**Location**	**Location in US385**	**Distance to Nearest Coastline (km)**	**Height of Site Above Sea Level (m)**	H_{rx} **(m), Height of Antenna**	$d$km_los **Based on Antenna Height**	$d$km_los **Based on Elevation**
VLBA antenna, Mauna Kea	Mauna Kea, HI	19° 48' 155° 27	31	3730	31.6	36.2	264.7
Arecibo	Arecibo, PR (PRCZ)	Rectangle between latitudes 17° 30' N and 19° 00' N and between longitudes 65° 10' W and 68° 00' W.	15	480	10	26.1	103.3
VLBA antenna, St Croix	St Croix, VI	17° 45' 64° 35'	0.4	0	31.6	36.2	13.0
VLBI antenna, Kōke'e Park	Kōke'e Park, HI	not listed	5	1100	20	31.5	149.7

If CORF's recommendations suggested in Section II to limit use of LPI devices to interior enclosed spaces in cruise ships only are implemented, there should be minimal impact on these radio observatories, regardless of line of sight distance. However, CORF has significant concerns about adverse effects on these radio observatories if a significant number of LPI devices are in use on the decks of cruise ships in these exclusion zones. CORF urges the FCC to use the above information to clarify or construct a rule that requires that LPI devices on cruise ships not operate on decks. To protect radio astronomy, particular attention should be paid to not allowing operation of LPI devices at 6 GHz on cruise ship decks in these exclusion zones around RAS sites close to an ocean coast. Such a rule would serve the public interest in protecting vulnerable radio astronomy observations, as recognized by the FCC in the Fourth Report and Order and elsewhere in this proceeding.

IV. <u>Conclusion</u>

As discussed above, CORF's initial analysis suggests that use of a single LPI device inside of cruise ships should not significantly harm important remote sensing observations. CORF recommends that best practice would be to perform tests on cruise ships prior to enactment of a new LPI rule, to verify that the walls of cruise ships, even with doors and port holes open, provide sufficient attenuation to limit harmful interference to remote sensing/EESS operations. Moreover, CORF has concerns regarding the utility of the proposed definition of "cruise ship" to limit the number of ships that could cause interference. In particular, CORF's conclusion that operation of an LPI device inside a cruise ship likely would not harm important remote sensing observations is based on the premise of significant attenuation from the walls of the cruise ship, as well as the idea that only a limited number of vessels would meet the definition of cruise ship. Accordingly, CORF recommends that the FCC should revise the definition of "cruise ship" that will be allowed to have LPI operations to limit it to a size at least equivalent to the smallest of the common cruise ships. CORF's analysis also suggests that extensive use of LPI devices on the decks of cruise ships, without the attenuation of thick metal walls, could significantly impact remote sensing, as the metal ship structure could act like a high gain reflector, even for a single LPI device, or multiple ships, each with transmitting inferferers, could lie within a single remote sensor footprint at 6 GHz. In either case, signal interference could adversely affect remote sensing measurements, particularly along fixed routes for ships, and would significantly impact the operations of four radio observatories that are identified as being in coastal regions when cruise ships are sailing in waters nearby. Accordingly, CORF recommends that steps be taken to reduce the possibility of operation of LPI devices on the decks of cruise ships, and that if the FCC authorizes use of LPI devices on cruise ships, it should ensure that emissions external to the cruise ship structure strictly adhere to permitted limits.

Respectfully submitted,

NATIONAL ACADEMY OF
SCIENCES' COMMITTEE ON
RADIO FREQUENCIES

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

April 15, 2026

Appendix

Committee on Radio Frequencies

Members

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

Karen L. Masters, Haverford College, *Co-Chair*

Héctor G. Arce, Yale University

Nancy L. Baker, Naval Research Laboratory (retired)

Reyhan Baktur, Utah State University

Shamibrata Chatterjee, Cornell University

Laura B. Chomiuk, Michigan State University

Kshitija Deshpande, Embry-Riddle Aeronautical University

Tomas E. Gergely, National Science Foundation (retired)

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

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