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

In the Matter of	)	
	)	
Satellite Spectrum Abundance	)	SB Docket 25-180
	)	
Expanding Use of the 12.7-13.25 GHz Band for Mobile Broadband or Other Expanded Use	))	GN Docket 22-352
	)	
Shared Use of the 42-42.5 GHz Band	)	WT Docket No. 23-158
	)	
Use of the Spectrum Bands Above 24 GHz for Mobile Radio Services	))	GN Docket No. 14-177

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

July 28, 2025

Table of Contents

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The National Academy of Sciences, through its Committee on Radio Frequencies (hereinafter, CORF),[1] hereby submits its comments in response to the Commission's May 27, 2025, *Further Notice of Proposed Rulemaking* (FNPRM) and *Notice of Proposed Rulemaking* (NPRM) in the above-captioned dockets. In prior Orders in Docket 14-177, the Commission took a number of steps to protect spectrum for important passive scientific uses. Such protections serve the public interest, and CORF appreciates the Commission's recognition of the importance of such observations in those Orders and in the FNPRM. In these comments, CORF urges the Commission to

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

implement protections for important passive scientific use of the 12.7-13.25 GHz, 42.5-43.5 GHz, and 50-54 GHz bands and the W-Band.

I. Background - The Importance and Vulnerability of RAS and EESS

As set forth in several CORF comments previously filed in Docket 14-177,[2] CORF has a substantial interest in this proceeding because it represents the interests of the users of the passive scientific bands of the radio spectrum, specifically users of the Radio Astronomy Service ("RAS") and passive Earth Exploration-Satellite Service ("EESS (passive)") bands.

As the Commission has long recognized, radio astronomy is a vitally important tool used by scientists to study the universe. It was through the use of radio astronomy that scientists discovered the first planets outside the solar system, circling a distant pulsar. 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. Radio astronomy has also enabled the discovery of organic matter and prebiotic molecules outside the 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

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[2] *See* CORF comments filed on August 31, 2023, September 7, 2018, November 16, 2016, and September 29, 2016. The data and arguments set forth in those prior CORF comments and reply comments are incorporated herein by reference.

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 the Milky Way, contain supermassive black holes at their centers, a phenomenon that appears to be crucial to the creation and evolution of galaxies. Synchronized observations using widely spaced radio telescopes around the world with very-long-baseline interferometry (VLBI) give extraordinarily high angular resolution, far superior to that which can be obtained using the largest optical telescopes on the ground or in space. Indeed, the first image of a supermassive black hole, in the M87 galaxy, and its shadow was obtained by such an array of radio telescopes,[3] followed most recently by observations of the black hole at the center of the Milky Way Galaxy.[4]

The critical scientific research undertaken by RAS observers, however, cannot be performed without access to interference-free spectral bands and protected or heretofore remote geographic locations. Notably, the emissions that radio astronomers receive are extremely weak: a radio telescope receives less than 1 percent of one-billionth of one-billionth of a watt from a typical cosmic object. Because radio astronomy receivers are designed to pick up such remarkably weak signals, radio observatories

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[3] *See*, The Event Horizon Telescope Collaboration, 2019, The Astrophysical Journal Letters, 875, L1. https://doi.org/10.3847/2041-8213/ab0ec7. *See also* J. Greene, 2019, "Black Hole Photo Was No Big Surprise Scientists. Here's Why Its Still Big Deal," *Washington Post,* April 12; S. Kaplan and J. Achenbach, 2019, "See a black hole for the first time in a historic image from the Event Horizon Telescope," *Washington Post,* April 19; and D. Overbye, 2019, “Darkness Visible, Finally: Astronomers Capture First Ever Image of a Black Hole,” *New York Times*, April 10.
[4] *See,* The Event Horizon Telescope Collaboration, 2022, The Astrophysical Journal Letters, 930, L2. https://doi.org/10.3847/2041-8213/ac6674.

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.

Although RAS facilities have access to very limited protected spectrum allocations for dedicated passive observations, many of their receivers have been built with a wider spectral range of operation to take advantage of opportunistic passive observing in spectrum allocated to active services. Many scientific investigations, including some of those which have led to recent cutting-edge discoveries in astrophysics and cosmology, would be significantly limited, or even impossible, without this opportunistic observing of the radio spectrum enabled by the location of radio telescopes far from any terrestrial transmitters using the active service allocations in question.

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 represents the only practical method of obtaining atmospheric and surface data for the entire planet.[5] 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)

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[5] 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 .

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 (NSF), the National Aeronautics and Space Administration (NASA), the Department of Defense (especially the U.S. Navy), the 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,[6] national security, and scientific investigation (particularly regarding longer-term changes to climate). 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 (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.[7] A NOAA report[8] estimated that

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[6] *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).
[7] *See* NOAA Weather homepage, https://www.noaa.gov/weather (last viewed July 3, 2025).
[8] *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 July 3, 2025).

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."[9] 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.[10]

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."[11]

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 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

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[9] *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 July 3, 2025).
[10] *See*, "Forecasting Profitability," National Bureau of Economic Research, available at https://www.nber.org/papers/w19334 (last viewed July 3, 2025).
[11] *See*, *NTIA Report, supra* note 5, at page 15.

quantification of meteorological processes, natural variability, and longer-term changes. Accurate scientific interpretation of these measurement 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 thus subject to aggregate interference from emitters in the area scanned (both the areas on Earth and the regions of cold space used for calibration).

Of particular focus in this proceeding for RAS and EESS are observations in the 12.7-13.25 GHz, 42.5-43.5 GHz, 50-54 GHz bands, and the W-Band (92.0-94.0 GHz, 94.1-100 GHz, 102.0-109.5 GHz, and 111.8-114.25 GHz). In paragraph 9 of the FNPRM, the Commission recognizes that while there is no allocation for RAS in the 12.7-13.25 GHz band, opportunistic observations are made with the Green Bank Telescope (GBT) in the National Radio Quiet Zone (NRQZ), as well as at other radio astronomy observatories in remote locations. In para. 15 of the FNPRM, the Commission recognizes that the 42.5-43.5 GHz band is allocated to the RAS on a co-primary basis. In para. 59 of the NPRM, the Commission notes the need to protect EESS (passive) band allocations at 52.6-54.25 GHz. Para. 60 of the NPRM notes the RAS allocations between 92 and 114 GHz that are subject to protection under Footnotes US342 and US161, and para. 63 notes the need to determine limits for unwanted emission in EESS (passive) bands adjacent to the W-Band allocations under consideration.

II. 12.7 GHz Band (12.7-13.25 GHz)

A. Scientific Use

Although there are no formal RAS protections for the 12.7-13.25 GHz band, radio astronomers routinely use it opportunistically, particularly from remote sites. This band enjoys low system temperatures and system equivalent flux densities with current radio telescopes like the NSF GBT in the NRQZ in West Virginia, the NSF Karl G. Jansky Very Large Array (VLA) in New Mexico, and the Very Long Baseline Array (VLBA) and VLBI Global Operating System (VGOS) dishes spread at a limited number of sites. It is planned to be covered by the sensitive Band 3 receiver on the planned U.S. flagship observatory for radio astronomy, led by National Radio Astronomy Observatory (NRAO), and the Next Generation Very Large Array (ngVLA), which will have sites in New Mexico and elsewhere (including in the NRQZ).[12]

Astronomers use data across 12.7-13.25 GHz to obtain sensitive measurements of faint radio continuum signals from distant galaxies. This band probes thermal emissions from star-forming regions and is unaffected by dust absorption, making it one of the most reliable and unbiased tracers of star-formation activity. The high sensitivities achievable in the 12.7-13.25 GHz band make it an excellent, sensitive tracer of star formation even in high-redshift galaxies that are observable at cosmic noon: the epoch when the universe was most vigorously forming stars and when the universe was just 20 percent as old as it is today. The high angular resolutions achievable in this band mean that astronomers can image where the star formation is occurring in these distant

[12] *See ngVLA homepage*, https://ngvla.nrao.edu/ (last viewed July 3, 2025).

galaxies, determining if galaxies like the Milky Way assembled from inside-out, outside-in, or in chaotic clumps, without the confusing screen of dust extinction.[13] The 12.7-13.25 GHz band has also been used to study young solar-type stars and to test possible solutions to the "Faint Young Sun Paradox": that geologic evidence suggests that the Sun was more luminous during Earth's early history than it is today, whereas our understanding of stellar evolution implies that the Sun should have been less luminous in earlier times. Observations in the 12.7-13.25 GHz band have been used to probe thermal emission from stellar winds of young solar-like stars.[14] They placed strong constraints on the wind mass-loss rates, ruling this out as the solution to the "Faint Young Sun Paradox." Upcoming radio telescopes, if they can still access this band, will be able to do this for even low-mass stars, with important implications for our understanding of the habitability of exoplanets around these stars.

Use of the 12.7-13.25 GHz band also helps 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. High-precision monitoring of celestial and terrestrial reference frames is necessary for accurate tracking and navigation of spacecraft, and for maintaining the accuracy of global navigation satellite systems (GNSS). These data are also used to track the movement of the tectonic plates that constitute Earth's crust. The worldwide VGOS performs these observations at

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[13] *See, e.g.,* Murphy et al., Bulletin of the AAS, Vol. 51, Issue 3 (May 31, 2019)*, available at* https://baas.aas.org/pub/2020n3i471/release/1.

[14] *See, e.g.,* Fitchinger et al., Astronomy & Astrophysics, Volume 599, A127 (March 2017), *available at* https://www.aanda.org/articles/aa/full_html/2017/03/aa29886-16/aa29886-16.html.

frequencies from 2-14 GHz. Meanwhile, the NSF VLBA, operated by the NRAO, is currently building a new suite of wideband receivers (8-40 GHz) to empower the next generation of geodetic measurements.

Finally, while the focus of these comments is on protection of passive radio services, CORF notes that the 12.75-13.25 GHz band has a secondary allocation for the space research service in the international table covering use for deep space downlink communications. In the US table, footnote US251 creates a US allocation in this band for reception only at Goldstone, CA (35° 20' N, 116° 53'W). CORF's recommendations below for protecting RAS observatories are applicable to the Goldstone site as well.

B. Recommendations for Protection

In paragraph 38 of the FNPRM, the Commission notes that RAS operations within the NRQZ could be affected by changes in satellite allocations in the 12.7-13.25 GHz band, particularly if satellite downlinks are authorized in that band. Thus, the FNPRM seeks comment on maintaining RAS observations in that band at remote sites, including within the NRQZ.

To enable continued use of the 12.7-13.25 GHz band by passive services for RAS and geodesy, active users should coordinate with these observatories. Most of these observatories are in remote locations, which should ease the burden of spectrum sharing on active services. For terrestrial emissions, CORF recommends the coordination zones listed in Table 8 of Appendix B of the NTIA comments in this proceeding, which have been determined to protect RAS observatories from harmful interference at ITU-R RA.769-2 levels.[15]

Currently, some non-geostationary orbit (NGSO) satellite operators and RAS facilities have engaged in developing different mitigation techniques to ensure minimum impact on the radio telescopes from the downlink transmission. For example, SpaceX and NSF/NRAO have implemented two avoidance techniques to facilitate spectrum coexistence for the SpaceX Supplementary Coverage from Space (SCS) band (1990-1995 MHz) and Starlink Internet service band (10.7-12.7 GHz). As the basic level of protection, Zone Avoidance (ZA) provides RAS sites with protection from downlink radio frequency interference caused by the majority of Starlink satellite passages by reconfiguring their phased array antenna to direct downlink away from illuminating the radio telescopes, such as being applied currently in the NRQZ surrounding NSF's Green Bank Observatory in West Virginia and around NSF's VLA in New Mexico.

An advanced protection protocol, Telescope Boresight Avoidance (TBA), was developed by SpaceX with NRAO to cover the small fraction of satellites that, at any given time, are passing close to where the radio telescopes are pointing when direct illumination cannot be avoided. For this, NRAO's Operational Data Sharing (ODS) API (application programming interface) provides the most recent telescope pointing coordinates, observation frequency, and time ranges for SpaceX to configure its Starlink satellites to enable TBA in near-real time. This system is currently operational for the VLA and some VGOS stations (e.g., Westford, MA) and is being tested for the GBT and other sites. Without the TBA in place, such a main-beam-to-main-beam interaction can

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[15] Comments of NTIA, filed October 11, 2024, in GN Docket No. 22-352.

potentially damage or even destroy sensitive RAS receiver components. Satellite emissions well below damaging levels can nevertheless drive the telescope front-end electronics into non-linear operation, resulting in gain compression, increased electronic noise, or generation of intermodulation products, which can corrupt the clean data channels in the RAS spectrum (both protected and unprotected bands). Moreover, back-end electronics may similarly be driven into compression or saturation, with similar results. In a near-telescope-boresight encounter, even satellite antenna sidelobe emissions can produce these effects.

Building upon the existing coordination framework, CORF recommends that the Commission continue requiring a similar level of coordination effort for 12.7 GHz downlink applications. Where technically possible, adopting a real-time framework for the exchange of operational parameters, similar to that already developed between SpaceX and NRAO, between all NGSO and relevant RAS facilities should be a core element for the coordination required of all such satellite operators, and should allow for better evaluation of loss of access to the band in question. F

Regarding Earth stations in motion (ESIMs), in paragraph 28 of the FNPRM, it appears that the new authorizations proposed by the Commission for ESIMs would be limited to 12.7-12.75 GHz uplinks to geosynchronous orbit (GSO) and NGSO networks. If this is the case, the impact on radio astronomy observatories would likely be limited, although sidelobe emissions remain a concern. As the Commission well knows, and as stated in Footnote US342, "[e]missions from spaceborne or airborne stations can be particularly serious sources of interference to the radio astronomy service." CORF urges the Commission not to create new downlink authorizations for airborne ESIMs because of the difficulty of coordination between airborne ESIMs and RAS operations in the NRQZ and other sites noted in the NTIA comments in Appendix B. In particular, because of their constant yet often unscheduled motion, downlinks to ESIMs have the potential for being especially disruptive to the passive services.

TABLE 1 Suggested Coordination Distances for Radio Astronomy Service Facilities Operating in the 12.7–13.25 GHz band, Reproduced from Attachment B of NTIA Filing

RAS Observatory	Latitude (N)	Longitude (W)	Maximum Coordination Distance (km)
Single-Dish Observatory			
Green Bank Telescope/National Radio Quiet Zone (Green Bank, WV)[a]	38° 25' 59"	79° 50' 23"	84
Connected-Element Interferometers[b]			
Very Large Array (Socorro, NM)	*34° 4' 46"*	*107° 37' 7"*	*172*
Next Generation Very Large Array (Socorro, NM)	34° 4' 46"	107° 37' 7"	130
Very Long Baseline Array (VLBA) Stations			
Kitt Peak, AZ	31° 57' 22"	111° 36' 45"	200
Owens Valley, CA	37° 13' 53"	118° 16' 37"	91
Mauna Kea, HI	19° 48' 4"	155° 27' 20"	200
North Liberty, IA	41° 46' 17"	91° 34' 27"	80
Hancock, NH	42° 55' 60"	71° 59' 12"	124
Los Alamos, NM	35° 46' 30"	106° 14' 44"	168
Pie Town, NM	34° 18' 4"	108° 7' 9"	130
Fort Davis, TX	30° 38' 6"	103° 56' 41"	15
Saint Croix, VI	17° 45' 23"	64° 34' 60"	168
Brewster, WA	48° 7' 52"	119° 40' 60"	36
VLBI Global Observing System (VGOS) Stations			
Kokee Park, HI	22° 07’ 35”	159° 39’ 54”	183
Westford, MA	42° 36’ 47”	71° 29’ 38”	186
Goddard, MD	39° 01’ 19”	76° 49’ 38”	123
McDonald, TX	42° 36’ 47”	71° 29’ 38”	95

[a] The Green Bank Telescope is listed for the sake of completeness, but as noted in paragraph 39 of the NPRM, it would remain subject to the existing requirements for coordination in the National Radio Quiet Zone in Section 1.924 of the Commission’s rules.

[b] The future ngVLA upgrade (https://ngvla.nrao.edu) will expand beyond the core site in Socorro, NM, likely requiring an update to this table.

III. 42 GHz Band (42.0-42.5 GHz)

A. Scientific Use

Adjacent to the band in consideration, the 42.5-43.5 GHz band has a primary allocation to RAS, largely due to spectral lines of silicon monoxide (SiO) at these frequencies. The entire 42.0-43.5 GHz frequency range is also used extensively by radio astronomers for sensitive continuum studies (with the 42.5-43.5 GHz band explicitly allocated to RAS, and the 42.0-42.5 GHz band accessed opportunistically at RAS observatories). RAS observations at these frequencies are currently made at several observatories around the United States.[16] In addition, observations are likely to be performed with the ngVLA, which likely will include new sites primarily near the current VLA, but also throughout New Mexico and adjacent states with long baseline stations in close proximity to existing VLBA facilities.

Observations of radio continuum at 42.0-43.5 GHz probe dust and warm gas around newly forming stars and planets and can reveal how terrestrial planets like Earth form around other stars. Observations at higher frequencies yield exquisite high-resolution images of rings and gaps in protoplanetary disks, but these observations face limitations because the disks are opaque at these frequencies in their inner regions, where terrestrial planets are expected to form. However, observations in the 42.0-42.5 GHz band have been able to overcome this limitation, peering through the opaque screen to reveal the structures that represent the natal conditions for planets like

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[16] Green Bank Telescope, WV; Socorro, NM; Westford, MA (Haystack); Brewster, WA; Fort Davis, TX; Hancock, NH; Kitt Peak, AZ; Los Alamos, NM; Mauna Kea, HI; North Liberty, IA; Owens Valley, CA; Pie Town, NM; St. Croix, VI. *See* 47 CFR § 2.106, n.US131.

Earth.[17] It remains an open question how planets manage to grow to their observed masses. Over-dense structures in the shapes of spirals, rings, vortices, or blobs may help planets efficiently accumulate mass from surrounding gas, dust, and pebbles. The nature and origin of these structures remains poorly understood, and, while observations with current interferometers like the VLA are making important contributions, the resolution and sensitivity of the ngVLA will be needed to achieve significant advances toward solving this problem. This science case is perhaps the most important single driver for the development and construction of this future U.S. flagship observatory, and the 42.0-42.5 GHz band will play a crucial role in imaging these planet-forming regions.

In the 42.5-43.5 GHz band, spectral lines of SiO at 42.519, 42.821, 43.122, and 43.424 GHz are among those of greatest importance to radio astronomy.[18] These lines, corresponding to the lowest rotational transition within the first several vibrationally excited levels of SiO, are widely observed to exhibit strong maser emission pumped by radiation or collisions in astrophysical environments, including in the envelopes of evolved stars and in young star-forming regions. Measurements of these masers provide probes of stellar envelopes, yielding information on temperature, density, stellar wind velocities, and envelope geometries.

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[17] *See, e.g.,* Garufi et al., Astronomy & Astrophysics, Volume 694 (February 2025) A290, *available at*: https://www.aanda.org/articles/aa/full_html/2025/02/aa52496-24/aa52496-24.html.

[18] *See*, *Handbook on Radio Astronomy* (ITU Radiocommunication Bureau, 2013), at page 37, Table 3.2. The 42.5-43.5 GHz band is also one of the preferred RAS bands for continuum observations. *Id*. at page 35, Table 3.1.

B. Recommendations for Protection

In paragraph 54 of the FNPRM, the Commission notes that international footnotes 5.551H and 5.551I protect RAS in the 42.5-43.5 GHz band through limits on power flux density (PFD) and equivalent PFD from Fixed-Satellite Service (FSS) downlinks. In addition, ITU Resolution 743 (WRC-03) provides protection to RAS observations in this band. The FNPRM seeks comment on whether these provisions would be sufficient to protect RAS from interference from FSS downlinks at 42.0-42.5 GHz.

In June 2023, the Commission issued a Notice of Proposed Rulemaking (WT Docket 23-158) seeking comment on terrestrial use of the 42 GHz band. In response, CORF filed comments relating to protection of the adjacent RAS primary allocation from 42.5-43.5 GHz.[19] In particular, CORF provided a table of U.S. observatories operating in this band and recommended terrain-based coordination distances for terrestrial 42 GHz deployments. This table is reproduced here for reference (Table 2).

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[19] CORF comments, filed Sept. 1, 2023.

TABLE 2 Maximum Coordination Distances for Radio Astronomy Service Facilities Listed in Paragraph 39, *Notice of Proposed Rulemaking in WT Docket 23-158*

RAS Observatory	Latitude (N)	Longitude (W)	Altitude (m)	Maximum Coordination Distance (km)
Single-Dish Observatories				
Haystack Observatory (Westford, MA)	42° 37' 23"	71° 29' 18"	142	150
Green Bank Telescope (Green Bank, WV)[a]	38° 25' 59"	79° 50' 23"	904	49
Connected-Element Interferometer[b]				
Very Large Array (Socorro, NM)	34° 4' 46"	107° 37' 7"	2,159	93
Very Long Baseline Array (VLBA) Stations				
Kitt Peak, AZ	31° 57' 22"	111° 36' 45"	1,937	286
Owens Valley, CA	37° 13' 53"	118° 16' 37"	1,234	89
Mauna Kea, HI	19° 48' 4"	155° 27' 20"	3,744	52
North Liberty, IA	41° 46' 17"	91° 34' 27"	254	24
Hancock, NH	42° 55' 60"	71° 59' 12"	328	51
Los Alamos, NM	35° 46' 30"	106° 14' 44"	1,983	216
Pie Town, NM	34° 18' 4"	108° 7' 9"	2,385	117
Fort Davis, TX	30° 38' 6"	103° 56' 41"	1,645	22
Saint Croix, VI	17° 45' 23"	64° 34' 60"	35	78
Brewster, WA	48° 7' 52"	119° 40' 60"	267	38

[a] The Green Bank Telescope is listed for the sake of completeness, but as noted in paragraph 39 of the NPRM, it would remain subject to the existing requirements for coordination in the National Radio Quiet Zone in Section 1.924 of the Commission's rules.

[b] The future ngVLA upgrade (https://ngvla.nrao.edu) will expand beyond the core site in Socorro, NM, likely requiring an update to this table.

SOURCE: Data from heywhatsthat.com, accessed June 13, 2023. Viewshed and horizon computations are based on the NASA Shuttle Radar Topography Mission (SRTM) data set and assume dry air refractivity.

In consideration of possible changes in projected terrestrial needs in the 42 GHz band and requests for additional backhaul bandwidth from operators of NGSO satellite networks, the Commission now seeks comment on use of the 42 GHz band for the FSS, either in addition to or in place of terrestrial service in the same band. Although the emphasis is on FSS downlinks, the Commission nevertheless asks, in paragraph 53 of the FNPRM, how the interference environment for RAS would change if 42 GHz uplinks were permitted in addition to downlinks.

In response, CORF recommends the following. If terrestrial services are authorized in addition to FSS services, then CORF's prior comments[20] recommending coordination distances around U.S. observatories for these terrestrial services continue to apply. Further, if FSS uplinks are considered, then coordination of FSS Earth stations within these same coordination distances would likewise ensure that uplink sidelobe emissions are shielded by terrain. Practically, this would likely lead to avoidance of siting 42 GHz uplink Earth stations within the recommended coordination distances.

For downlinks, the Commission writes, in paragraph 54 of the FNPRM:

> We observe that the 42 GHz band is already allocated and used for FSS (space-to-Earth) on a primary basis outside of the United States, and that such FSS operations are already required to protect radio astronomy operations through the limits on PFD and equivalent PFD emitted by FSS space stations through the provisions of ITU Footnote 5.551H and 5.551I, as well as ITU Resolution 743 (WRC-03), Protection of single-dish radio astronomy stations in Region 2 in the 42.5-43.5 GHz band (2003). We seek comment on whether these provisions, which have been in place for over twenty years, would be sufficient to protect radio astronomy in the 42.5-43.5 GHz band from the risk of harmful interference from FSS (space-to-Earth) operations in the 42 GHz band in the United States. If FSS (space-to-Earth) operations in the 42 GHz band are limited to individually licensed gateway earth stations, would geographic separation be an additional, or alternative, method to protect radio astronomy observations in the 42.5-43.5 GHz band?

[20] CORF comments, filed Sept. 1, 2023.

CORF recommends adoption of coordination requirements consistent with the provisions of Footnotes 5.511H and 5.511I for protection of RAS observatories from 42 GHz downlinks. These are based on the interference thresholds developed in recommendation ITU-R RA.769-2 and equivalent power flux density (epfd) methodology for aggregating emissions defined in Recommendation ITU-R S.1586-1. Moreover, CORF notes that, in contrast with the considerations in its prior comments relevant to terrestrial transmitters and uplinks as noted above (and cited by the Commission in footnote 114 of the FNPRM), for downlinks, the corresponding downlink beam footprints are a critical factor in addition to geographic separation. Coordination should therefore be based on requiring that downlink beams satisfy 5.551H and 5.551I, in aggregate as well as individually, at the location of protected RAS observatory sites. This would naturally result in an implied minimum separation distance related to the dimensions and spatiotemporal statistics of downlink beams directed at a given FSS Earth station, which may exceed the terrain-based separation distances for terrestrial services and uplinks noted above.

Later in paragraph 54 (and footnote 115), the Commission references a 2011 proposal from the Satellite Industry Association to relax protection of the 42.5-43.5 GHz RAS band, applying 5.511H and 5.511I to a restricted range of frequencies from 42.7-43.5 GHz. This suggestion does not acknowledge the utility of different spectral lines of the same molecule, which involve internal quantum states with different excitation energies, to enable excitation temperature and column density of that molecule to be disentangled. It is also the case that the sensitivity of the continuum observations noted above benefits proportionately from the available clean spectral bandwidth. For these reasons, CORF urges the Commission to continue to reject this proposal.

IV. 52 GHz Band (51.4-52.4 GHz) and W-Band (92.0-94.0 GHz, 94.1-100 GHz, 102.0-109.5 GHz, and 111.8-114.25 GHz)

A. Scientific Use/50-54 GHz Band/EESS

CORF notes initially that the entire 50-60 GHz temperature sounding spectral region is critically important for weather prediction forecast accuracy, disaster management, and long-term weather and Earth system trend assessment.

The 51.4-52.4 GHz band proposed for use for satellite communications in the NPRM is proximate (on both sides) to the 50.2-50.4 GHz and 52.6-54.25 GHz oxygen absorption bands, which are essential for atmospheric temperature profiling and surface emission characterization. At the lower end of this spectral range, the adjacent 50.2-50.4 GHz oxygen absorption band is critical for the surface characterization, which is necessary for both lower atmospheric temperature profiling, and to retrieve precipitation intensity at the surface (liquid or solid). On the upper end of this spectral range, the adjacent 52.6-54.25 GHz oxygen absorption band is critical for lower atmospheric temperature profiling for nearly all weather conditions. These frequencies are protected by RR 5.340 ("all emissions prohibited").

The EESS (passive) 50.2-52.4 GHz and the 52.6-54.25 GHz bands have primary allocations for EESS (passive) and are protected under RR 5.340 ("all emissions prohibited"). This band is also associated with mandatory limits, as stated in ITU-R

Resolution 750 (Rev. WRC-19), governing the level of unwanted emissions from FSS Earth-to-space links.

The 50-60 GHz EESS (passive) bands have a very long history for operational observations, beginning in 1978, with the Microwave Sounding Unit (MSU) launched on the NOAA TIROS-N (Television and Infra-Red Observation Satellite) and extending to the current NOAA Joint Polar Satellite Series (JPSS). Multiple international space agencies currently use these frequency bands Bas well. Continuity missions are planned by the U.S. and other nations that extend at least through 2047. Together, these represent substantial investments in satellite missions that include the 52.6-54.25 GHz band.

Weather and Earth system observations have an effective usable "lifespan" far beyond their initial use in numerical weather analysis and forecasting applications. They are used in Earth system "reanalyses," which are multi-decade runs of an Earth system model that includes assimilation of data from various sensors, including many EESS (passive) instruments. Examples of such reanalyses include the NASA Modern-Era Retrospective analysis for Research and Applications, version 2 (MERRA-2) and the latest European Center for Medium-range Weather Forecasting (ECMWF) Reanalysis, version 5 (ERA-5). These reanalyses enhance our understanding of Earth system processes and how these processes evolve over time. As such, the "value" of a particular frequency band or set of observations is not ephemeral but endures forever forward in time.

CORF's primary concerns are with potential OOBE into the adjacent EESS (passive) 52.6-54.25 GHz oxygen absorption band needed for lower troposphere temperature sounding. In particular, new uplink transmissions authorized as a result of new Earth-to-space allocations would no longer be confined to those directed toward fixed points in the GSO equatorial plane but would include Earth stations tracking NGSO satellites that are constantly changing directions distributed across the sky. This significantly increases the potential for associated OOBE into the EESS (passive) temperature sounding channels and could contaminate measurements made viewing toward these Earth stations with main beam or near sidelobe coupling.[21]

Additionally, it should be noted that the 51.76 GHz passive microwave frequency band has been in operational use on the NOAA Advanced Technology Microwave Sounder (ATMS) since 2012, with current and planned missions extending out through at least 2041. This frequency band increases the sensor sensitivity to the lower atmosphere temperature profile; however, it is currently not afforded protection under RR 5.340 ("all emissions prohibited"). Numerous other current and planned EESS (passive) microwave sensors use this 52.6-54.25 GHz oxygen absorption band (see Table 3).

[21] Unwanted emissions into the 50.2–50.4 GHz EESS (passive) band that lies below the proposed 51.4-52.4 GHz uplink band are of lesser concern, given the greater spectral separation.

TABLE 3 Current and Planned Satellite Missions Utilizing the Proximate 52.6-54.25 GHz Passive Microwave Frequency Band

Satellite Series	Space Agency	End of Life	Service
Current			
DMSP-F17, -F18[a]	DoD	>2025	SSMIS
SNPP	NOAA	>2028	ATMS
NOAA-20, -21	NOAA	>2031	ATMS
FY-3D	CMA	>2025	MWTS-2
FY-3E, -3F	CMA	>2029	MWTS-3
Meteor-M N2-(2-4)	RosHydroMet	>2029	MTVZA-GY
Future			
NOAA-JPSS-3, -4	NOAA	>2041	ATMS
Metop-SG-A1, -A2, -A3	EUMETSAT	>2047	MWS
AWS PFM	ESA	>2029	MWR
Sterna-1, -2, -3	EUMETSAT	>2042	MWR
OceanSat-3A	ISRO	>2030	MATHS
FY-3H	CMA	>2033	MWTS-3
FY-3I	CMA	>2032	MWRI-RM
Meteor-M N2-(5-6)	RosHydroMet	>2031	MTVZA-GY

[a] DoD recently announced imminent termination of the Defense Meteorological Satellite Program (DMSP). In response, the user community has been advocating strongly for continued operation, reflecting the high value placed on data from these instruments.
SOURCE: Courtesy of World Meteorological Organization OSCAR (Observing System Capability Analysis and Review Tool), n.d., "Satellite Frequencies for Earth Observation, Data Transfer and Platform Communications and Control," https://space.oscar.wmo.int/satellitefrequencies (last viewed May 30, 2025).

B. *Scientific Use/W-Band/RAS and EESS*

Proposed use of W-Band spectrum in the NPRM raises concerns regarding the protection of RAS and Earth remote sensing observations.[22] The 94.1-95.0 GHz band is

[22] Contrary to a separate Statement to the FNPRM/NPRM, the W-Bands proposed for use in the NPRM are not "empty spectrum." These bands are allocated to the RAS for passive use and are in fact regularly used by radio astronomy observatories. The Commission has long recognized that passive scientific observation of the spectrum constitutes actual use of the spectrum. Such usage has wide regulatory recognition. The numerous allocations to RAS and EESS in the domestic and international tables of allocations demonstrate that the FCC and the ITU both recognize that RAS and EESS constitute "use" of the spectrum equal to that of active services. In addition to frequency allocations, the FCC has

a primary RAS allocation subject to footnotes US161 and US342; and 95.0-100.0 GHz, 102.0-109.5, and 111.8-114.25 GHz are primary RAS allocations subject to footnote US342[23]. As well as using these frequencies, many RAS receivers have been built with a wide spectral range of operation to take advantage of opportunistic passive observing in spectrum allocated to active services. For example, NSF's 100-meter GBT in West Virginia frequently observes in these frequency ranges with a selection of highly sensitive receivers, including W-Band (67-94 GHz), Argus (74-116.0 GHz), and MUSTANG2 (75-105 GHz). The Arizona Radio Observatory (ARO) 12-m telescope on Kitt Peak, Arizona, also observes at those frequency ranges with its 3 mm (84-116 GHz) receiver.

These bands are important for RAS astrochemistry research enabling detection of complex molecules and organic compounds from distant stars and galaxies. For example, the GBT survey DEGAS (Dense Extragalactic GBT+Argus Survey)[24] makes use of the fast mapping speed and high signal-to-noise sensitivity of the GBT along with its Argus (74-116.0 GHz) receiver to map dense molecular gas tracers (HCN and CO)

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recognized the passive use of the spectrum in other regulations. Examples of geographic protection include Section 1.924(a) of the Commission's rules, which creates a NRQZ designed to protect the NRAO in Green Bank, West Virginia, from interference. In sum, numerous U.S. and international regulations protect passive scientific observation of the spectrum. This clearly demonstrates that such observations are use of the spectrum, and accordingly, bands allocated to passive services such as RAS are not "empty spectrum."

[23] Footnote US342 states that "all practicable steps shall be taken to protect the radio astronomy service from harmful interference. Emissions from spaceborne or airborne stations can be particularly serious sources of interference to the radio astronomy service (see ITU Radio Regulations at Nos. 4.5 and 4.6 and Article 29)." In addition, these bands are immediately adjacent to the primary EESS/RAS allocations at 100-102 GHz, 109.5-111.8 GHz, and 114.25-116 GHz, which would thus be vulnerable to OOBE . Some of these in-band and adjacent RAS allocations are shared with primary allocations for the Space Research (passive) service, supporting space-based radio astronomy.

[24] *See DEGAS homepage,* https://greenbankobservatory.org/science/gbt-surveys/degas/ (last viewed June 30, 2025).

over the central core regions of nearby galaxies. These observations are shedding light on how stars form from gas clouds and what properties of the galactic environment set the efficiency of star formation. Additionally, as noted in Report ITU-R RA.2512-0, the interval from 72-118 GHz, encompassing the 92-114.25 GHz range in this FNPRM, is an essential band for broadband bolometric observations of the cosmic microwave background (CMB). Extremely precise measurements of the subtle spatial anisotropy across the sky of the primary CMB and its polarization provide fundamental insights into Big Bang cosmology and the high-energy physics governing the thermodynamics of the early universe. Additionally, via weak spectral distortions of the CMB caused by its interaction with matter as it has traversed the volume of the observable universe—most importantly the Sunyaev–Zeldovich (SZ) effect associated with scattering off of energetic free electrons in galaxy clusters—the formation and evolution of the large-scale structure of the universe can be traced across cosmic time. While the South Pole has been an ideal location to conduct these observations, the GBT, currently equipped with the MUSTANG2 receiver, is one of the few operating instruments within the continental United States capable of studying galaxy clusters using the SZ effect.

For Earth remote sensing/EESS, the W-Band frequencies are ideal for observing cloud properties, cloud water content, and precipitation (rain/snow/ice), due to larger hydrometeor scattering at these microwave frequencies and temperature sounding. Multiple EESS (passive) allocations, further protected by footnote US246 and international footnote 5.340 lie adjacent to the W-Band allocations proposed in the NPRM. These include a broad window band from 86-92 GHz, and multiple bands associated with the wings of the 118 GHz oxygen line, including 100-102 GHz, 109.5-

111.8 GHz, and 114.25-116 GHz. Important EESS (active) and Space Research (active) allocations from 94-94.1 GHz support spaceborne cloud radars. Additionally, as noted in greater detail below, second harmonics of the proposed uplink bands would overlap multiple EESS (passive) bands associated with the 183 GHz water line.

The 86-92 GHz band is used in conjunction with other passive microwave frequencies to retrieve cloud ice effective radius and amount; liquid water amount; sea-ice cover and type; surface snow cover, status (wet/dry), and snow water equivalent; and estimates of near-surface precipitation amounts. These multi-band retrievals exploit the frequency dependence of these particle characteristics and surface properties.

The bands around the 118 GHz oxygen and 183 GHz water vapor lines convey information on atmospheric temperature and humidity, respectively. These lines are very broad (multiple gigahertz) at Earth's surface, narrowing with increasing altitude (decreasing pressure (e.g., hundreds of megahertz in the ~15 km region)). This pressure-dependent line width enables information on different (broadly overlapping) altitude regions to be obtained by measuring closer to or further from the line center. This allows for the retrieval of vertical temperature profiles from the surface up through the stratosphere. However, this demands interference-free access to broad, contiguous bands for accurate results.

The bands around the 118.75 GHz oxygen absorption line have been receiving increased attention as they convey much the same information as the "workhorse" 50-60 GHz band while requiring a smaller antenna for a given measurement footprint size.

An increasing number of missions (space agencies and commercial) are planned or under development using these frequencies. Technology demonstration missions are already on orbit; these include the NASA TROPICS Millimeter-wave Sounder (TMS) and the Tomorrow.io constellation with the Tomorrow Microwave Sounder (TMS).

Precisely calibrated measurements are crucial for numerical weather prediction and observation/data-driven approaches to numerical weather forecasting. They are also important for retrospective Earth system reanalysis, and for monitoring and quantifying long-term trends in weather patterns and changes in weather variability. Space-borne and air-borne radiometric sensors are also used to study the evolution of severe weather events such as thunderstorms, tropical cyclones, and hurricanes. Sensors operating in W-Band channels are summarized in Tables 4 and 5 below.

TABLE 4 Current and Planned Satellite Missions Utilizing Passive Microwave Frequency Band Adjacent to 92.0-94.0 GHz

Satellite Series	Operator[a]	End of Life	Service	Center Frequency/ Bandwidth
Current				
GOSAT-GW	JAXA	>2032	AMRS3[b]	89 GHz / 3000 MHz
DMSP-F16/17/18[c]	DoD	>2025	SSMIS	91.655 GHz / 2829 MHz
Meteor-M N2-(5-6)	RosHydroMet	>2031	MTVZA-GY	91.665 GHz /2500 MHz
GPM	NASA	>2030	GMI	89 GHz / 6000 MHz
WSF-M1	DoD	>2030	WSF-M	89 GHz / 3000 MHz
Sentinel-6A	EUMETSAT	>2028	HRMR	90 GHz / 5000 MHz
TROPICS-0(5/6)	NASA	>2026	TMS	91.655 ± 1.4 GHz / 3000 MHz
Tomorrow-S-(1-6)	Tomorrow.io	>2028	TMS	91.655 ± 1.4 GHz / 3000 MHz
Meteor-M N2-(2-4)	RosHydroMet	>2029	MTVZA-GY	91.665 GHz / 2500 MHz
Future				
Metop-SG	EUMETSAT	>2048	MWI	89 GHz / 4000 MHz
WSF-M2	DoD	>2035	WSF-M2	89 GHz / 3000 MHz
Tomorrow-S-(7-10)	Tomorrow.io	>2028	TMS	91.655 ± 1.4 GHz / 3000 MHz
Sentinel-6B/C	EUMETSAT	>2036	HRMR	90 GHz / 5000 MHz
CRISTAL-A/B	ESA	>2036	HRMR	90 GHz / 5000 MHz
Meteor-M N2-(5-6)	RosHydroMet	>2031	MTVZA-GY	91.665 GHz / 2500 MHz
Meteor-MP N1-(1-2)	RosHydroMet	>2043	MTVZA-GY-MP	91.665 GHz / 2500 MHz

[a] Operator key:

DoD	Department of Defense (USA)
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
ESA	European Space Agency
JAXA	Japan Aerospace Exploration Agency
NASA (USA)	National Aeronautics and Space Administration
RosHydroMet	Federal Service for Hydrometeorology and Environmental Monitoring (Russia)
Tomorrow.io	The Tomorrow Companies Inc.

[b] Currently being commissioned on-orbit; will replace AMSR2.

§ DoD recently announced imminent termination of the Defense Meteorological Satellite Program (DMSP). In response, the user community has been advocating strongly for continued operation, reflecting the high value placed on data from these instruments.

SOURCE: Courtesy of World Meteorological Organization OSCAR (Observing System Capability Analysis and Review Tool), n.d., "Satellite Frequencies for Earth Observation, Data Transfer and Platform Communications and Control," https://space.oscar.wmo.int/satellitefrequencies (last viewed July 9, 2025).

TABLE 5 Current and Planned Satellite Missions Utilizing Passive Microwave Frequency Band Adjacent to 114.25 GHz

Satellite Series	Operator[a]	End of Life	Service	Center Frequency/Bandwidth
Current and Planned				
Metop-SG	EUMETSAT	>2048	MWI	118.75 ± 3.2 GHz / 500 MHz
TROPICS-0(5/6)	NASA	>2026	TMS	114.5 GHz / 1000 MHz
Tomorrow	Tomorrow.io	>2028	TMS	118.75 ± 3.5 GHz / 1000 MHz)

[a] Operator key:

EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
NASA (USA)	National Aeronautics and Space Administration
Tomorrow.io	The Tomorrow Companies Inc.

SOURCE: Courtesy of World Meteorological Organization OSCAR (Observing System Capability Analysis and Review Tool), n.d., “Satellite Frequencies for Earth Observation, Data Transfer and Platform Communications and Control,” https://space.oscar.wmo.int/satellitefrequencies (last viewed July 9, 2025).

As noted above, an important consideration for the proposed W-Band allocations—which was not addressed in the NPRM—is that any second harmonic emissions from these bands will overlap significantly with key EESS bands near and just above the 183.3 GHz water vapor emission line. The overlapping EESS (passive) allocations, most of which are further protected by RR 5.340 / US246, are summarized in Table 6. Because of this overlap, rules for the proposed W-Band allocations will need to set tight limits on harmonic emissions, as discussed below, and compliance with these limits will need to be reliably monitored.

TABLE 6 Overlap Between Passive Allocations and Second Harmonic Emissions Associated with Proposed W-Band Uplink Allocations

<table>
<tr><th>Proposed Satellite Band</th><th>2nd Harmonic Range</th><th>Overlapping Passive Allocations</th></tr>
<tr><td rowspan="2">92.0 - 94.0 GHz</td><td rowspan="2">184 - 188 GHz</td><td>182 - 185 GHz
EARTH EXPLORATION-SATELLITE (passive)
RADIO ASTRONOMY
SPACE RESEARCH (passive)

5.340 US246</td></tr>
<tr><td rowspan="2">185 - 190 GHz
EARTH EXPLORATION-SATELLITE (passive)
SPACE RESEARCH (passive)</td></tr>
<tr><td>94.1 - 95.0 GHz</td><td>188.2 - 190 GHz</td></tr>
<tr><td>95 - 100 GHz</td><td>190 - 200 GHz</td><td>190 - 191.8 GHz
EARTH EXPLORATION-SATELLITE (passive)
SPACE RESEARCH (passive)

5.340 US 246</td></tr>
<tr><td rowspan="2">102 - 105 GHz</td><td rowspan="2">204 - 210 GHz</td><td>200 - 209 GHz
EARTH EXPLORATION-SATELLITE (passive)
RADIO ASTRONOMY
SPACE RESEARCH (passive)

5.340 5.341 5.563A US246</td></tr>
<tr><td rowspan="2">209 - 217 GHz
RADIO ASTRONOMY

5.149 5.341 US342</td></tr>
<tr><td rowspan="2">105.0 - 109.5 GHz</td><td rowspan="2">210 - 219 GHz</td></tr>
<tr><td>217 - 226 GHz
RADIO ASTRONOMY

5.149 5.341 US342</td></tr>
</table>

111.8 - 114.25 GHz	223.6 - 228.5 GHz	226 - 231.5 GHz EARTH EXPLORATION-SATELLITE (passive) RADIO ASTRONOMY SPACE RESEARCH (passive) 5.340 US246

Table 7 summarizes current and planned Earth remote sensing missions that use these bands, which include a new generation of commercial satellites anticipated to greatly increase the spatiotemporal coverage of key meteorological variables in the future, with significant positive impact on weather-sensitive economic activity.

TABLE 7 Current and Planned[*] Remote Sensing Missions
Susceptible to interference from W-band 2nd Harmonics

Satellite	Sensor	Operator[a]	Center Frequency (GHz)	Band Width (MHz)	Overlap with W-Band 2nd Harmonics (GHz)				
					184 - 188	188.2 - 190	190 - 200	204 - 210	223.6 - 228.5
GOSAT-GW	AMSR3	JAXA	183.31 ± 3.0	4000	x	x			
			183.31 ± 7.0	4000		x	x		
NOAA SNPP NOAA 20/21 JPSS 3/4	ATMS	NOAA	183.31 ± 1.0	500	x				
			183.31 ± 1.8	1000	x				
			183.31 ± 3.0	1000	x				
			183.31 ± 4.5	2000	x	x			
			183.31 ± 7.0	2000		x	x		
GEMS2-Amethyst GEMS2-Beryl	GEMS2	Weather Stream	183.31 ± 0.3	300	x				
			183.31 ± 0.7	500	x				
			183.31 ± 1.5	1000	x				
GPM	GMI	NASA	183.31 ± 3.0	2000	x				
			183.31 ± 7.0	2000		x	x		
Metop-SG-B1/B2/B3	ICI	EUMETSAT, ESA	183.31 ± 2.0	1500	x				
			183.31 ± 3.4	1500	x				

			183.31 ± 7.0	2000		x	x		
OceanSat-3A	MATHS	ISRO	183.31 ± 1.0	—[b]	x				
			183.31 ± 1.8	—	x				
			183.31 ± 3.0	—	x				
			183.31 ± 4.5	—	x	—			
			183.31 ± 7.0	—		—	x		
			183.31 ± 15.75	—			x		
EOS-07	MHS (EOS-07)	ISRO	183.31 ± 0.96	300	x				
			183.31 ± 2.8	600	x				
			183.31 ± 4.5	1000	x	x			
			183.31 ± 5.8	700		x			
			183.31 ± 11.56	900			x		
			183.31 ± 15.75	1000			x		
Metop-B/C	MHS	EUMETSAT, ESA	183.31 ± 1.0	1000	x				
			183.31 ± 3.0	2000	x				
			190.311	2000		x	x		
Meteor-M N2-3/4 Meteor-M N2-5/6/7/8 Meteor-MP N1/N2	MTVZA-GY MTVZA-GY-MP	RosHydroMet, Roscosmos	183.31 ± 1.0	500	x				
			183.31 ± 3.0	1000	x				
			183.31 ± 7.0	1500		x	x		
FY-3D/3E/3F FY-3H/3J	MWHS-2	CMA	183.31 ± 1.0	500	x				
			183.31 ± 1.8	700	x				
			183.31 ± 3.0	1000	x				
			183.31 ± 4.5	2000	x	x			
			183.31 ± 7.0	2000		x	x		
Metop-SG-B1/B2/B3	MWI	EUMETSAT, ESA	183.31 ± 2.0	1500	x				
			183.31 ± 3.4	1500	x				
			183.31 ± 4.9	1500	x	x			
			183.31 ± 6.1	1500		x	x		
			183.31 ± 7.0	2000		x	x		
FY-3G FY-3I	MWRI-RM	CMA	183.31 ± 2.0	1500	x				
			183.31 ± 3.4	1500	x				
			183.31 ± 7.0	2000		x	x		
Metop SG-A1/A2/A3	MWS	EUMETSAT, ESA	183.31 ± 1.0	500	x				
			183.31 ± 1.8	1000	x				
			183.31 ± 3.0	1000	x				
			183.31 ± 4.5	2000		x	x		
			183.31 ± 7.0	2000		x	x		

			229.0	2000					x
DMSP-F17/F18[c]	SSMIS	DoD	183.31 ± 1.0	512.5	x				
			183.31 ± 3.0	1019	x				
			183.31 ± 6.6	1526		x	x		
TROPICS-03/05/06	TMS	NASA	184.41	2000	x				
			186.51	2000	x				
			190.31	2000		x	x		
			204.8	2000				x	
Tomorrow-S1/S2 Tomorrow-S3-S10	TMS	Tomorrow.io	184.41	2000	x				
			186.51	2000	x				
			190.31	2000		x	x		
			204.8	2000				x	

NOTE: Planned missions are denoted in italics.

[a] Operator key:

CMA	China Meteorological Administration
DoD	Department of Defense (USA)
ESA	European Space Agency
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
ISRO	Indian Space Research Organisation
JAXA	Japan Aerospace Exploration Agency
NOAA	National Oceanographic and Atmospheric Administration (USA)
NASA (USA)	National Aeronautics and Space Administration
Roscosmos	State Corporation for Space Activities (Russia)
RosHydroMet	Federal Service for Hydrometeorology and Environmental Monitoring (Russia)
Tomorrow.io	The Tomorrow Companies Inc.
Weather Stream	Weather Stream Inc.

[b] Denotes unknown bandwidth and spectral overlap.

[c] DoD recently announced imminent termination of the Defense Meteorological Satellite Program (DMSP). In response, the user community has been advocating strongly for continued operation, reflecting the high value placed on data from these instruments.

SOURCE: Columns 1-5 from World Meteorological Organization OSCAR (Observing System Capability Analysis and Review Tool), n.d., "Satellite Frequencies for Earth Observation, Data Transfer, and Platform Communications and Control," https://space.oscar.wmo.int/satellitefrequencies, (last viewed May 11, 2025); Columns 6,7 committee generated.

C. Protection of RAS

As noted in paragraphs 59 and 60 of the NPRM, the basis of the application for the proposed 52 GHz and W-Band allocations is uplink transmissions in the Earth-to-space direction. However, the NPRM does not appear to explicitly rule out consideration of space-to-Earth transmission in these bands. CORF urges the Commission not to consider space-to-Earth downlinks, particularly given that many of the bands in question have existing RAS primary allocations, as acknowledged in paragraph 60.

In regards to protection of RAS from uplinks and gateways, NGSO gateway uplinks in the NRQZ need to coordinate pursuant to NRQZ rules for fixed transmitters. That process looks like every other application, with a particular focus on the equivalent radiated power (spectral) density towards the GBO. These levels are often defined by the horizon mask of the gateway. For other, non-NRQZ gateway stations, similar coordination with protected RAS facilities within the line-of-sight horizon, as recommended above for 42 GHz, should be required. This should not be significantly burdensome, since there are only a small number of protected RAS sites, and they are typically located in rural areas.

D. Protection of EESS – Adjacent Bands and Second Harmonics

Using EESS sensor characteristics from Recommendation ITU-R RS.1861-1, it is straightforward to convert maximum interference levels for EESS sensors defined in Recommendation ITU-R RS.2017-0 into equivalent maximum effective isotropic radiated power (EIRP) levels with high accuracy. In contrast, conversion of this EIRP-based limit into an unwanted emission limit at the Earth station transmitter is uncertain, because it depends on the uplink antenna pattern and on assumptions regarding the frequency of beam encounters for an unknown deployment density of Earth stations, each supporting an unknown number of uplink beams per station. The NPRM offers no models for anticipated Earth station antenna characteristics nor for likely deployment density.

Given that the maximum interference levels in ITU-R RS.2017-0 are allowed to be exceeded for defined percentages of area or observing time, one approach to choosing a suitable gain factor for converting EIRP-based limits to transmitter-referenced limits is to use a generic ITU sidelobe model, and to choose the sidelobe level for a single uplink beam that corresponds to a large enough angle off boresight such that, on average, the exceedance fraction defined in ITU-R RS.2017-0 will be satisfied for this beam while the Earth station is in the sensor footprint.[25] For nadir and conical scanning remote sensors operating in the bands being considered here, the exceedance fraction is $f = 0.01\% = 10^{-4}$. The solid angle Ω subtended by a small angle ϑ (radians) around the uplink boresight is $\Omega = \pi\vartheta^2$. If the Earth station beam pointing is assumed to be randomly distributed across a hemispherical sky with solid angle 2π, then encounters within an angular distance ϑ will occur a fraction $\Omega/2\pi = \vartheta^2/2$ of the time. Setting $\vartheta^2/2 = f$, then for $f = 10^{-4}$, $\vartheta = 0.014\ \mathrm{rad} = 0.8\ \mathrm{deg}$. Calculating the transmitter unwanted emission level using an uplink antenna gain factor corresponding to this angle off boresight will ensure that for the remaining fraction $(1 - f)$ of the time, the unwanted emission threshold will not be exceeded for this uplink beam. The generic near sidelobe model in *recommends* **2** of Recommendation ITU-R S.465-6, for antennas with diameter D satisfying $D/\lambda \geq 50$, stipulates a near-sidelobe gain of G = 32

[25] Note that the interference level exceedance fraction in Table 2 of ITU-R RS.2017-0 is to be interpreted as a percentage of area relative to a standard reference area defined in the table, or as a percentage of time relative to 24 h, unless otherwise justified. For an exceedance fraction of 0.01%, the reference area is 2,000,000 km^2. Here, the exceedance fraction is interpreted as per encounter with the Earth station within the sensor footprint, a conservative approach that scales in aggregate to wide deployment of uplink Earth stations with multiple uplink beams per station, provided that the number of uplink beams is small compared with the number of independent satellite footprints within the ITU-R RS.2017-0 reference area.

dB at 1 degree off boresight.[26] For nadir and conical sounders, the calculations below will adopt this value for converting unwanted emissions limits expressed as EIRP to corresponding limits at the Earth station transmitter. Because it is expected that unwanted emissions limits sufficient to protect conical and nadir scanning sounders would be amply protective for limb sounders, in these comments, CORF will not address limb sounders further.[27] Table 2 of ITU-R RS.2017-0 gives maximum interference levels as power received in a specified reference bandwidth at the sensor. For conical and nadir scanning sensors in the bands considered in these comments, these are summarized in Table 8.

TABLE 8 Selected Interference Criteria for Conical and Limb Sounding Sensors from Recommendation ITU-R RS.2017, Table 2

Frequency Band(s) (GHz)	Reference Bandwidth (MHz)	Maximum Interference Level P_r (dBW)	Percentage of Area or Time Permissible Interference Level May Be Exceeded (%)
52.6 - 59.3	100	−169	0.01
86 - 92	100	−169	0.01
115.25 - 122.25[a]	200	−166	0.01
174.8 - 191.8	200	−163	0.01

[a] The tabulated range of this band in ITU-R RS.2017 may contain an error; contiguous passive allocations for EESS (passive) run from 114.25 GHz to 122.25 GHz.

[26] CORF recognizes that ITU-R S.465-6 is intended for use up to 31 GHz but notes that at present the ITU does not provide a similar recommendation for use at higher millimeter-wave frequencies.
[27] For limb sounders, the relevant sidelobe gain level from ITU-R S.645 would be a far sidelobe gain in the range −10 dB to 0 dB, much lower than the 32 dB near-sidelobe gain considered here for nadir and conical sounders. Moreover, for limb sounders the exceedance fraction stipulated in Table 2 of ITU-R RS.2017-0 is 1%, compared with 0.01% for conical and nadir sounders, and in principle, the Earth station is never within the sensor footprint. Consequently, unwanted emissions limits suitable for protecting conical and nadir sounders would be amply protective for limb sounders, despite maximum interference levels for limb sounders that are 20 dB to 34 dB lower in a given band.

To convert these interference levels to unwanted emissions limits at the uplink Earth station, a link budget can be assembled using parameters from Recommendation ITU-R RS.1861-1. Given an uplink antenna gain G_t, sensor antenna gain G_r, free space loss L_{fs}, atmospheric absorption loss L_{atm}, and unwanted uplink power P_t, the interference power P_r received at the sensor is as follows:

$$P_r = P_t + G_t + G_r - L_{fs} - L_{atm}.$$

Equivalently, for a maximum interference level P_r, the allowed unwanted emission power is as follows:

$$P_t = P_r - G_t - G_r + L_{fs} + L_{atm}.$$

Setting $G_t = 0$ dB casts P_t in terms of EIRP, whereas using the near sidelobe gain $G_t = 32$ dB as discussed above casts P_t in terms of unwanted emission power at the transmitter, albeit much more approximately in view of the assumptions made. Examples of unwanted emission limits calculated for representative sensors from Recommendation ITU-R RS.1861-1 are given in Table 9. These calculations are presented here to illustrate the scope of the potential interference issue, particularly to note that the required unwanted emission limits are likely to be quite stringent. CORF recommends that any rules governing unwanted OOBE and second harmonic emission in the proposed new uplink bands should be derived from models of proposed Earth station antenna characteristics and deployment density, and publicly vetted in a subsequent rulemaking proceeding.

TABLE 9 Unwanted Emission Levels for Representative Earth Remote Sensing Instruments

ITU-R RS.1861-1 Sensor Designation	Channel Frequency Band (GHz)	Sensor Antenna Gain, G_r (dB)	Altitude (km)	Nadir Angle (deg)	Free Space Path Distance[a] (km)	Free Space Path Loss,[a] L_{fs} (dB)	Atmospheric Absorption Loss,[a] L_{atm} (dB)	Unwanted Emission Level (dBW / ref. BW)	
								G_r = 0 dB (EIRP)	G_r = 32 dB (P_{tx})
J8	52.6 - 53.0	53.5	407	46.1	609	182.6	7.6	−32.3	−64.3
L14	86 - 92	53.8	407	48.5	642	187.6	1.2	−35.2	−67.2
M2	115.05 - 116.05	60.5	407	46.1	609	189.4	4.6	−32.5	−64.5
Q12	189.31 - 191.31	41.6	550[b]	0	550	192.8	10.9	−0.9	-32.9[c]

[a] Path geometry and loss computed using the Smithsonian Astrophysical Observatory (SAO) *am* code (see S. Paine, 2024, “The *am* Atmospheric Model,” Version 14.0, Zenodo, https://doi.org/10.5281/zenodo.13748391) for a U.S. standard atmosphere with 50% relative humidity in the troposphere.

[b]‡ Sub-satellite point for cross-track nadir scanner.

[c] 2nd harmonic limit, computed using the same approximate sidelobe model as for the fundamental band.

V. Conclusion

In prior Orders in Docket 14-177, the Commission took a number of steps to protect spectrum for important passive scientific uses. Such protections serve the public interest, and CORF appreciates the Commission’s recognition of the importance of such observations in those Orders, and in the current FNPRM and NPRM. Herein, CORF urges the Commission to implement important protections for passive scientific use of the 12.7-13.25 GHz, 42.5-43.5 GHz, and 50-54 GHz bands and the W-Band, as set forth above.

Respectfully submitted,

NATIONAL ACADEMY OF SCIENCES'
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