Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	
Modernizing and Expanding Access to the 70/80/90 GHz Bands	WT Docket No. 20-133
Amendment of Part 101 of the Commission's Rules to Facilitate the Use of Microwave for Wireless Backhaul and Other Uses and to Provide Additional Flexibility to Broadcast Auxiliary Service and Operational Fixed Microwave Licensees	WT Docket No. 10-153
Aeronet Global Communications Inc. Petitions for Rulemaking to Amend the Commission's Allocation and Service Rules for the 71-76 GHz, 81-86 GHz, and 92-95 GHz Bands to Authorize Aviation and Maritime Scheduled Dynamic Datalinks	RM-11824 (Aviation) RM-11825 (Maritime)
Requests of Aviat Networks and CBF Networks, Inc. d/b/a Fastback Networks for Waiver of Certain Antenna Requirements in the 71-76 and 81-86 GHz Bands	WT Docket No. 15-244 (Terminated)

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

The National Academy of Sciences, through its Committee on Radio Frequencies (hereinafter, CORF[1]), hereby submits its Comments in response to the Commission's June 10, 2020, Notice of Proposed Rulemaking (NPRM) in the above-captioned dockets. In these Comments, CORF discusses the nature of and the need to protect passive scientific observations by the Radio Astronomy Service (RAS) and the Earth Exploration-Satellite Service (EESS) in the 70/80/90 GHz bands. As long recognized by the Commission, airborne transmitters can be significant sources of interference for the science services.

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

Given their expected impact on the incumbent passive scientific users[2] of the 80/90 GHz bands, CORF opposes the implementation of the proposed "Scheduled Dynamic Datalinks" (SDDLs) to provide service to aircraft or ships in motion in the 80 GHz bands. However, if the Commission chooses to authorize such SDDLs, then CORF urges careful consideration of channelization (e.g., limiting the 80 GHz band to uplinks only) as well as limiting aircraft-to-aircraft transmission to only the 70 GHz band. CORF contends that, in any configuration, guard bands will be required to protect the adjacent EESS band at 86-92 GHz from off-axis out-of-band emissions (OOBEs) and spurious emissions. CORF also recommends updating the OOBE/spurious emissions limits to meet the international standard set forth in ITU-R Resolution 750. Further, to protect orbiting EESS sensors from direct-beam OOBE and spurious emission signals, either significantly more stringent OOBE and spurious emission limits will be required, or an active tracking system that nulls emissions in the direction of orbiting sensors must be developed. Due to the impact on sensitive RAS receivers, CORF opposes the proposed increase to the maximum allowable transmitter power spectral density at the 80 GHz band. Fundamentally, while CORF supports intelligent sharing of spectrum when possible, airborne transmissions should not be authorized in frequency allocations where RAS is co-primary, due to the difficulty of shielding radio astronomy observatories from aircraft with large horizon distances.

I. Introduction: Radio Astronomy and EESS/Earth Remote Sensing at 70/80/90 GHz, and the Unique Vulnerability of Passive Services to Interference.

A. Radio Astronomy

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

[2] While there may be minimal commercial use in large parts of the United States (paragraph 5), the 80 and 90 GHz bands, and the adjacent passive band at 86-92 GHz, are used extensively by the scientific community. Of particular note is that EESS applications require measurement on global scales, including the entire United States.

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 measurements led to the Nobel Prize winning discovery of the cosmic microwave background (CMB), the radiation left over from the original Big Bang that has now cooled to only 2.7 K above absolute zero. Later observations revealed the weak temperature fluctuations in the CMB of only one-thousandth of a percent—signatures of tiny density fluctuations in the early universe that were the seeds of the stars and galaxies we know today. Radio astronomy has also enabled the discovery of organic matter and prebiotic molecules outside our solar system, leading to new insights into the potential existence of life elsewhere in the Milky Way galaxy. Radio spectroscopy and broadband continuum observations have identified and characterized the birth sites of stars in the Milky Way, the processes by which stars slowly die, and the complex distribution and evolution of galaxies in the universe. The enormous energies contained in the enigmatic quasars and radio galaxies discovered by radio astronomers have led to the recognition that most galaxies, including 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 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 picture of a super massive black hole and its shadow was obtained by a globe-spanning array of ground-based millimeter-wave radio telescopes.[3]

[3] See The Event Horizon Collaboration, "First M87 Event Horizon Telescope Results. I. The Shadow of the Supermassive Black Hole," *Astrophysical Journal Letters* 875:L1, 2019, https://doi.org/10.3847/2041-8213/ab0ec7. See also J. Greene, "The Black Hole Photo Was No Big Surprise to Scientists. Here's Why It's Still a Big Deal," *Washington Post*, April 12, 2019, https://www.washingtonpost.com/opinions/2019/04/12/black-hole-photo-was-no-big-surprise-scientists-heres-why-its-still-big-deal/; S. Kaplan and J. Achenbach, "See a Black Hole for the First Time in a Historic Image from the Event Horizon Telescope," *Washington Post*, April 10, 2019, https://www.washingtonpost.com/science/2019/04/10/see-black-hole-first-time-images-event-horizon-telescope/; and D. Overbye, "Darkness Visible, Finally: Astronomers Capture First Ever Image of a Black Hole," *New York Times*, April 10, 2019, https://www.nytimes.com/2019/04/10/science/black-hole-picture.html.

The critical scientific research undertaken by RAS observers, however, cannot be performed without access to interference-free bands. Notably, the emissions that radio astronomers receive are extremely weak—a radio telescope receives less than 1 percent of one-billionth of one-billionth of a watt (10^{-20} W) from a typical cosmic object. Because radio astronomy receivers are designed to pick up such remarkably weak signals, radio observatories are particularly vulnerable to interference from in-band emissions, spurious and OOBEs 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.

The RAS has primary allocations within the 3 mm atmospheric window at 76-77.5 GHz, 79-86 GHz, 86-92 GHz, 92-94 GHz, and 94.1-100 GHz in the U.S. Table of Allocations, which are co-primary or adjacent to the frequency bands under consideration in this NPRM. Because there is relatively little absorption from atmospheric O_2 and H_2O (see Figure 1), these bands constitute some of the most important high-frequency ranges for both continuum and line observations of celestial objects. For example, in the 80 GHz band (81-86 GHz), the spectral lines of HDO, C_3H_2, and SiO at 80.578 GHz, 85.339 GHz, and 86.243 GHz, respectively, are among those of greatest importance to radio astronomy. *See*, Recommendation ITU-R RA.314-10 at Table 1.[4] Similarly, the 81-86 GHz frequency range is included in one of the bands preferred for continuum observation. *Id.* at Table 3.[5]

RAS use of these bands is very important for observations of complex organic molecules, protoplanetary disks, and the study of accretion disks surrounding supermassive black holes. The U.S. radio astronomy community has been a leader in millimeter-wavelength research, with the initial discovery of a very wide range of complex molecules in space. The understanding of star formation and evolution is critically dependent on millimeter-wave observations. It is essential that the protection presently available remain in place. As spectral line and continuum emissions from celestial objects are extremely weak, the spectral power flux density that is considered harmful to radio astronomy continuum

[4] See also *ITU Handbook on Radio Astronomy* (ITU Radiocommunications Bureau, 2013) at Table 3.2.
[5] See also *ITU Handbook on Radio Astronomy* at Table 3.1 (76-116 GHz).

observations at these frequencies is −228 dBW/(m^2 Hz) (Table 1, ITU-R RA.769, for observations at 89 GHz).

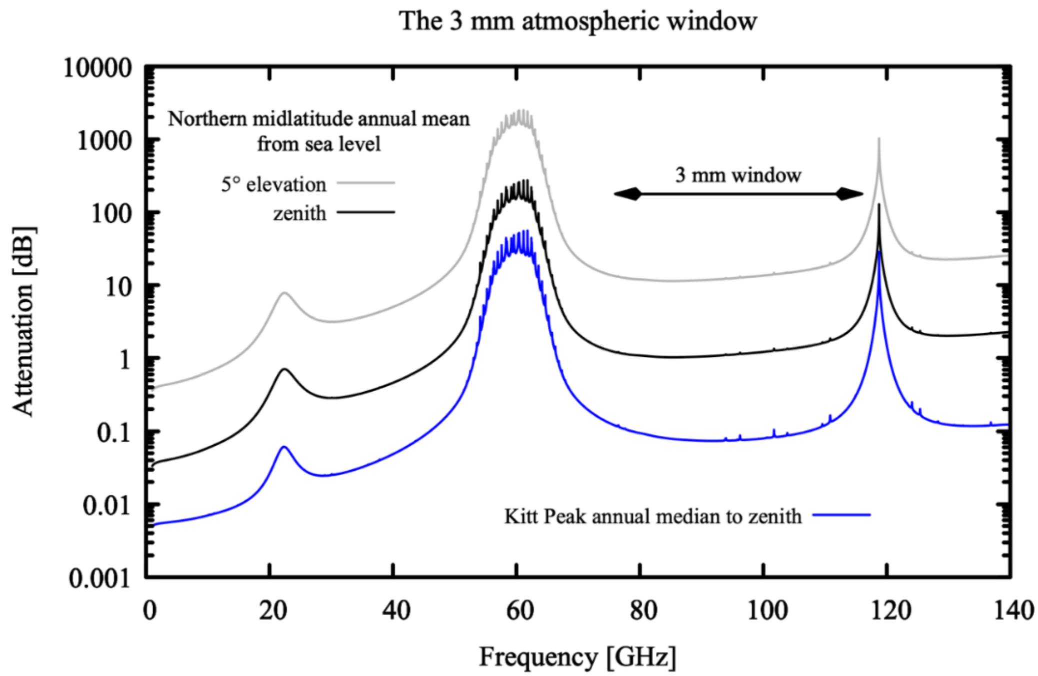

FIGURE 1 Clear sky atmospheric attenuation from sea level to zenith and for a slant path at 5 degrees elevation for a mean annual northern midlatitude atmosphere. Also shown is the median annual zenith attenuation from a representative millimeter-wave observatory site, Kitt Peak, Arizona. Note that the 3 mm atmospheric window is quite transparent even from sea level, with only 1 dB of attenuation towards zenith (radio astronomy) or towards the nadir (Earth remote sensing). Transmissions from aircraft, even at long slant-paths associated with low elevations, are particularly problematic due to their long horizon distances and relatively modest atmospheric attenuation at these frequencies. For this figure and those below, climatological data are from the NASA MERRA-2 reanalysis[6] and attenuation is computed with am-11.0.

The 80 GHz and 90 GHz (92-94 GHz, 94.1-95 GHz) bands are protected by Footnote US342, which states that "all practicable steps shall be taken to protect the radio astronomy service from harmful interference" in these bands, noting in particular that "[e]missions from spaceborne or airborne stations can be particularly serious sources of interference to the radio astronomy service." In addition, the adjacent frequency range of 86-92 GHz is protected by Footnote US246, where no stations are authorized

[6] R. Gelaro et al., The Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2), *Journal of Climate*, doi: 10.1175/JCLI-D-16-0758.1, 2017.

to transmit. Footnote US161 provides that in the 81-86 GHz, 92-94 GHz, and 94.1-95 GHz bands, assignments to allocated services shall be coordinated within 25 km of the National Radio Astronomy Observatory's Very Long Baseline Array (VLBA) stations, and within 150 km of certain other observatories.

Currently, U.S.-based RAS facilities[7] with receivers at these frequency bands include the Green Bank Observatory in West Virginia, the Kitt Peak 12m telescope in Arizona, the Haystack Observatory in Massachusetts, the Caltech Observatory at Owens Valley, California, the Yuan-Tseh Lee Array for Microwave Background Anisotropy on Mauna Loa, Hawaii, and eight stations of the VLBA.[8] In the longer term, the Next Generation Very Large Array (ngVLA) will also be capable of observations in these bands.[9] In addition, other facilities[10] listed in US161 currently operate at harmonics of these bands and have the potential for future observations in this frequency range. While the Commission's proposals related to 5G network densification for ground-based systems in urban areas are consistent with US161, there is no indication on the record as to how coordination will be possible for point-to-point links to endpoints in motion in the 80 GHz band, or in the 90 GHz band, if the proposed use is expanded to these frequencies in the future.[11]

B. <u>EESS/Earth Remote Sensing</u>

The Commission has also long recognized that satellite-based Earth remote sensing is a critical

---

[7] If implemented as proposed, and authorized by other countries, radio astronomy observatories that are funded by the United States but located in other countries are also at risk from the proposed airborne use of the 70/80/90 GHz bands. For example, the Atacama Large Millimeter Array (ALMA) in Chile is funded in part by the National Science Foundation and includes the NRAO as an operating partner (http://www.almaobservatory.org). The Large Millimeter Telescope (LMT) in Mexico is a joint project of the Instituto Nacional de Astrofísica, Óptica y Electrónica, and the University of Massachusetts (http://www.lmtgtm.org). Further, virtually all proposed experiments studying the CMB plan to make measurements within this frequency range (e.g., CMB-S4), which is planning to operate radio telescopes in Chile, the South Pole, and the northern hemisphere (http://cmb-s4.org).

[8] In the near future, the James Clerk Maxwell Telescope (JCMT) on Mauna Kea in Hawaii will be equipped with a receiver that operates in this band.

[9] See Next Generation Very Large Array (ngVLA), "ngVLA Main Array," http://ngvla.nrao.edu/image/ngvla-main-array. The ngVLA will have 214 antennas, primarily in New Mexico and Texas.

[10] The Combined Array for Research in Millimeter-wave Astronomy (CARMA) has been decommissioned, but several of the telescopes have been relocated to the main site of the Caltech Observatory in Owens Valley.

[11] While the focus of the proposed changes in this NPRM are on the 70/80 GHz bands, information regarding the 90 GHz band is also provided herein, since in paragraph 16 the Commission seeks "comment on whether any of the changes discussed in this Notice or other changes should apply to the 90 GHz band."

and uniquely valuable resource for monitoring aspects of the global atmosphere, oceans, land, and cryosphere. For certain applications, satellite-based microwave remote sensing represents the only practical method of obtaining atmospheric and surface data for the entire planet. EESS data have made important contributions to the study of meteorology, atmospheric chemistry, climatology, and oceanography. Currently, instruments operating in the EESS bands provide regular and reliable quantitative atmospheric, oceanic, land, and cryospheric measurements to support a variety of scientific, commercial, and government (civil and military) data users. EESS satellites represent billions of dollars in investment and provide data for major governmental users, including the National Oceanic and Atmospheric Administration (NOAA), the National Science Foundation, the National Aeronautics and Space Administration (NASA), the Department of Defense (DoD), 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, national security, and scientific investigation.

Satellite remote sensing data are a key 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.[12] A recent NOAA report[13] estimated that weather forecasts 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."[14] Furthermore, in rural areas,

[12] See NOAA, "Weather," https://www.noaa.gov/weather, accessed June 15, 2020.

[13] See NOAA, "NOAA by the Numbers," June 2018, p. 8, https://www.performance.noaa.gov/economics/.

[14] See NOAA, "NOAA's Contribution to the Economy; Powering America's Economy and Protecting Americans," 2018, p. 8, https://www.performance.noaa.gov/economics/.

where farming is usually the dominant source of income, accurate weather forecasting and climate prediction has been shown to have direct impact on investments and profits from agricultural products.[15]

Of primary concern in this proceeding is the EESS band at 86-92 GHz, for which threshold levels for harmful interference are −169 dBW in 100 MHz (ITU-R RS.2017). This band is heavily used by low Earth orbit (LEO) microwave remote sensing instruments for operational meteorology (e.g., NOAA's Advanced Technology Microwave Sounder (ATMS),[16] the Advanced Microwave Scanning Radiometer 2 (AMSR2) on the GCOM-W1 satellite,[17] the Global Precipitation Measurement Microwave Imager (GMI),[18] DoD's Special Sensor Microwave Imager/Sounder (SSMIS),[19] EUMETSAT's Microwave Humidity Sounder[20] (MHS), and the planned Microwave Imager (MWI) on the Weather System Follow-on-Microwave (WSF-M) mission (DoD), planned for launch in 2023). The unique value of this spectral band for such applications derives from its low degree of atmospheric opacity. The only factors that influence the observed signals are surface emissions (controlled by surface temperature and emissivity, both independently determined from other observations) and the degree to which thick clouds and/or precipitation are present in the atmosphere. Accordingly, these signals can be used to identify which footprints constitute views of clear sky and which are affected by signals from clouds and/or precipitation. This ability is critical for accurate weather forecasting, as clouds and precipitation also strongly affect signals in the bands used to measure humidity (e.g., around 183 GHz) and temperature (e.g., the 50 GHz bands). If any of these radiances include radio frequency interference and are assimilated in the belief that

[15] See National Bureau of Economic Research, "Forecasting Profitability," https://www.nber.org/papers/w19334, accessed June 15, 2020.

[16] See NOAA, "Advanced Technology Microwave Sounder (ATMS)," http://www.jpss.noaa.gov/atms.html, accessed June 15, 2020.

[17] See NOAA, "About AMSR-2," https://www.ospo.noaa.gov/Products/atmosphere/gpds/about_amsr2.html, accessed June 23, 2020.

[18] See NASA, "GPM Microwave Imager (GMI," https://gpm.nasa.gov/GPM/flight-project/GMI, accessed June 24, 2020.

[19] See D.B. Kunkee and K. St. Germain, Foreword to the Special Issue on the DMSP SSMIS, *IEEE Transactions on Geoscience and Remote Sensing* 46(4, 1):859-861, doi: 10.1109/TGRS.2008.919866, 2018.

[20] See European Organisation for the Exploitation of Meteorological Satellites, "Microwave Humidity Sounder (MHS)," https://www.eumetsat.int/website/home/Satellites/CurrentSatellites/Metop/MetopDesign/MHS/index.html, accessed June 15, 2020. U.S. weather forecasting relies in part on instruments operated by other countries, such as the MHS.

their signals represent only natural emissions, errors in the weather forecast will result.[21] Further, in the non-clear-sky footprints, the observed signals in the 86-92 GHz region convey valuable information on cloud and precipitation structure, making them a unique resource for studies of tropical cyclones and other severe weather events. Satellite remote sensing, using the 86-92 GHz frequency band in combination with the bands around 18, 23, and 37 GHz, has been the primary tool for mapping sea ice concentration, extent, motion, and age since the late 1970s.

II. Proposals to Mitigate Interference to RAS from Communications to Ships and Aircraft.

The Commission proposes to authorize transmission in the 70/80 GHz bands to ships and aircraft. At paragraph27, the NPRM seeks to develop a record on the balance of benefits and costs of this proposal. CORF cannot evaluate the benefits, but it can speak to one potential cost: interference to important yet vulnerable RAS and EESS observations. For radio astronomy, "[e]missions from spaceborne or airborne stations can be particularly serious sources of interference," as stated in Footnote US342. Similarly, observatories near the ocean[22] are susceptible to interference from ship-to-shore transmissions, as well as those from aircraft. Indeed, any transmission within line-of-sight of a radio telescope will be a significant impediment to radio astronomy observations, even if it is not directed toward the telescope. Thus, CORF opposes the implementation of SDDLs to provide service to aircraft or ships in motion in the 80 GHz bands, for which RAS is co-primary.[23] However, if the Commission chooses to authorize such SDDLs, then CORF appreciates the Commission proposing to protect RAS in paragraph 47 of the NPRM by requiring that all SDDL operations in the 80 GHz band be *limited to uplinks*. CORF supports that proposal, subject to other protections discussed in these comments. Because

---

[21] It is critical to recognize that for remote sensing, observation of multiple bands operates as a unified system, since the measurements made at multiple frequency bands are necessary to interpret the data from any single observation. In particular, weather forecasting relies on the combination of measurements at several different radio frequencies in order to account for the many different sources of natural emission within the footprint of each instrument. It is the combination of data across the radio spectrum that enables the accurate weather forecasts that we have come to expect and rely on. In other words, radio frequency interference at any of the EESS bands can have a negative effect not only on those measurements, but on the interpretation and analysis of all measurements made by the Earth remote sensing satellites.

[22] For example, Mauna Kea, Hawaii.

[23] While the NPRM does not propose SDDL links in the 90 GHz band, CORF would oppose those as well.

coordination between aircraft and observatories will be difficult if not impossible—due to motion, altitude, and increased line-of-sight distance—this sort of frequency separation is required. Any necessary downlinks and aircraft-to-aircraft links should be limited to the 70 GHz band.[24] In all cases, use of the 80/90 GHz bands should include an interference mitigation plan that includes coordination with potentially impacted RAS observatories, as required by Footnote US161.[25]

Even uplinks can create interference to RAS observatories, though. In contrast to current fixed point-to-point links, the proposed use would include active adjustments of the transmit beam to track endpoints in motion. Transition to a system that allows for transmission to multiple, continually moving targets introduces many additional degrees of freedom, which exhibit complex interactions with each other in the phased-array antenna systems likely to be deployed. Ensuring compatibility between such transmitter systems and passive RAS systems will be a demanding process. CORF urges that, if development of such systems is to be permitted, coordination between fixed uplink stations and radio astronomy observatories include consideration of reflection and scattering off the endpoint in motion. Given the low atmospheric attenuation and long line-of-sight distances for aircraft, such consideration will require coordination for uplink stations with separation distances much larger than that specified in US161 for transmission from the station itself. CORF believes that prior to final approval a limited-scale pilot program should be instituted to demonstrate that the co-primary radio astronomy service will not experience harmful interference from such transmissions. Before any such systems are deployed, coordination should be arranged through NSF's Electromagnetic Spectrum Management Unit.

The NPRM properly asks numerous questions regarding the difficult problem of coordinating SDDL links to moving ships and aircraft. CORF cannot at this time propose solutions to that problem, but it can say that coordination is critical to protecting all users of the 80 GHz band. Coordination is

---

[24] The 70 GHz band is adjacent to the co-Primary RAS allocation at 76-77.5 GHz, which is protected by Footnote US342. Thus, OOBE is a significant concern for downlinks and aircraft-to-aircraft transmissions that could be either directly transmitted or scattered into a radio astronomy receiver. Guard bands at the upper end of the 70 GHz band could mitigate this concern.

[25] CORF recommends that coordination be arranged through the Electromagnetic Spectrum Management Unit of the National Science Foundation, esm@nsf.gov.

necessary to prevent interference before commencement of operation of new SDDL links, and as set forth in paragraph 36 of the NPRM, to be able to effectively identify the source of any links that cause prohibited interference. Coordination must be required for *all* SDDL links, including links between ships and links between nodes and ships There is a suggestion in paragraph 43 of the NPRM that aircraft-to-aircraft links would "pose little interference risk to fixed links when operating near horizontally because they can only intersect the main-beam of FS receivers at very low or negative elevation angles," and thus there would be no need to coordinate such links. This argument is clearly flawed, however, because all aircraft pitch and roll, and in those common situations, the transmissions would no longer be "horizontal" to receivers on the ground. More critically, cases where a transmitting aircraft is cruising at a higher flight level than the receiving aircraft will necessarily involve additional illumination of the ground.

There is discussion in paragraphs 43 and 44 of the NPRM of the diameter of coordination zones vis a vis fixed terrestrial links. In regards to coordination with RAS observatories raised in paragraph 45, the first principle is that the coordination zone must be designed to protect observatories to the levels set forth in ITU-R RA.769-2. Furthermore, even for uplinks (and if the Federal Communications Commission so chooses, downlinks), coordination must take into account whether or not the transmitter is in line-of-sight of a radio astronomy observatory. Footnote US161 requires coordination within 150 km of single-dish radio telescopes, such as Haystack Observatory, which is located close to the flight path for several major commercial airports. Indeed, there are more than 450 airports, airfields, heliports, balloonports, glideports, and ultralight landing facilities within 150 km of Haystack Observatory.[26] However, radio frequency interference from airborne emitters will require greater separation distances

[26] See Appendix B of CORF Comments filed August 30, 2019, in WT Docket No. 19-140, for a listing of major airports within the coordination zones of radio astronomy observatories listed in US161. It also should be noted that at pages 22-23 of the February 6, 2019, Petition for Rulemaking that led to the NPRM ("Petition"), Aeronet Global Communications, Inc. ("Aeronet") suggests that it could "mitigate any risk of interference to … the 18 Federal radio astronomy observatories" by placing its uplink facilities in rural areas. However, except for the Haystack Observatory, all of the potentially impacted observatories are located in rural areas, in order to reduce the amount of ambient interference.

from radio astronomy facilities than terrestrial, fixed, point-to-point emitters, since airborne transmitters have a significantly greater line-of-sight coverage area, and geographic shielding cannot be employed.[27]

Furthermore, CORF notes that because millimeter-wave radio astronomy observatories are usually located in high, dry sites, increasing the maximum equivalent isotropically radiated power (EIRP) for the 70/80 GHz bands has the potential to introduce harmful interference to the radio astronomy service. For example, a single emitter with maximum EIRP of +57 dBW, with a corresponding transmit power spectral density of 500 mW per 100 MHz (NPRM at paragraph 42), would require a separation distance well beyond 150 km under typical atmospheric conditions at the Kitt Peak 12m telescope (see Figure 2). Thus, CORF opposes the proposal to increase the maximum EIRP or transmit power at these frequencies.

In Section III.A of the NPRM, the Commission seeks comments on proposed changes to standards for antennas to be used for 5G backhaul. In paragraph 17, comments are sought regarding the potential impact of such changes on Federal operations in the 70/80/90 GHz bands. CORF notes that in regards to protecting federal radio astronomy facilities, coordination zones set forth in Footnote US161, and any related coordination agreements, may need to be reconsidered if increased power or larger beam size results in a higher percentage of time loss at the facilities.[28]

---

[27] Aeronet's Petition (at pages 2 and 10) also mentions the use of revised rules sought in this proceeding to provide avionics. Use of the proposed bands for airborne wireless avionics intra-communication (WAIC) would raise substantial additional concerns. Such systems may be located outside the aircraft and radiate isotropically, virtually guaranteeing interference to RAS facilities within line-of-sight. CORF strongly urges the Commission to prohibit WAIC operations in the 80/90 GHz bands in any new rules in this proceeding, in order to protect radio astronomy research. *Cf.* Section 15.255(a)(2)(i) of the Commission's rules (prohibiting use of 57-71 GHz band for wireless avionics). In addition, consistent with Section 15.255(a)(2)(ii) of the Commission's rules, any new rules should provide that in the 80/90 GHz bands, "[e]quipment shall not be used on aircraft where there is little attenuation of RF signals by the body/fuselage of the aircraft. These aircraft include, but are not limited to, toy/model aircraft, unmanned aircraft, crop-spraying aircraft, aerostats, etc."

[28] See Recommendation ITU-R RA.1513-1 ("Levels of data loss to radio astronomy observations and percentage-of-time criteria resulting from degradation by interference for frequency bands allocated to the radio astronomy on a primary basis").

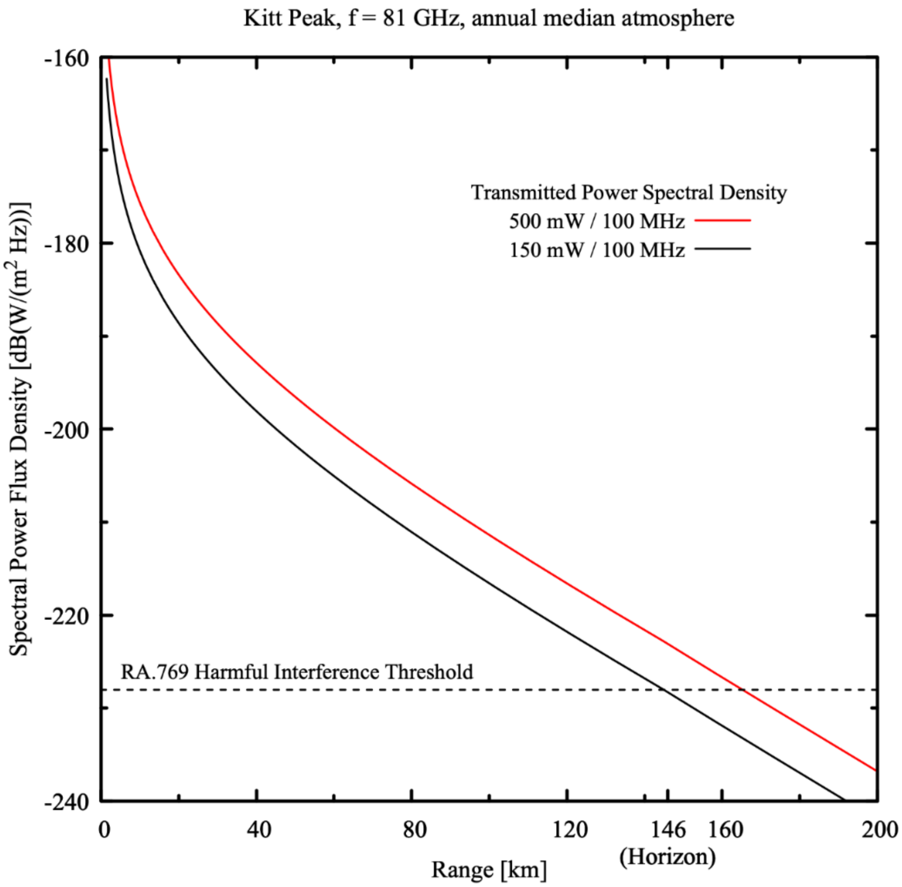

FIGURE 2 Illustration of the sensitivity of radio astronomy observatories at 81 GHz to human-made emissions expressed in terms of the signal strength received at an observatory as a function of separation distance for two different transmitted power spectral densities, accounting for free space loss and atmospheric attenuation. Under atmospheric conditions common to sites of millimeter-wave radio telescopes (illustrated here for the Kitt Peak 12m telescope), separation distances of hundreds of kilometers are required between radio astronomy observatories and ground-based transmitting devices. US Footnote 161 designates coordination zones of 150 km around each single-dish millimeter-wave radio astronomy observatory within the United States. While these sites do experience times of higher atmospheric attenuation in moist weather, median weather conditions at Kitt Peak, Arizona, require separation distances of 150 km for isotropic transmitters of 150 mW/100 MHz due to the sensitivity of radio telescopes designed to detect faint cosmic sources. Increasing the power level to 500 mW/100 MHz would substantially impact radio astronomy observatories by exceeding the ITU-R RA.769 threshold levels for harmful interference when transmitting outside of the US161 coordination zones.

III. Proposals to Mitigate Interference to EESS at 86-92 GHz.

As discussed in Section I above, EESS observations at 86-92 GHz are a unique and important resource for weather forecasting and Earth system science research. In paragraph 42, the Commission seeks comments on the potential for interference to EESS in this band and on the means to mitigate such interference. The current OOBE and spurious emission limits in these bands (detailed in 101.111 (a)(2)(ii, iii, and v)), although defined algebraically, amount effectively to a requirement to limit emissions in much of the OOBE region and for all spurious and unwanted emissions to −13 dBm in any 1 MHz band. The current emission mask reaches the −13 dBm/MHz limit at 500 MHz for the current power and power spectral density limits. Thus, at the bare minimum, a 500 MHz guard band is required to achieve the minimal protection provided in the current regulations. However, this threshold level is 18 dB above the recommended OOBE and spurious emission limit at the band edge as stated in ITU-R Resolution 750 (Rev WRC-15),[29] that applies to the band as per International Footnote 5.338A, and 32 dB above the recommended maximum emission limit for the center of the band. Thus, CORF recommends that the current regulations be revised to be in agreement with international standards. Specifically, CORF recommends that the ITU-R Res. 750 emission limits at 86–92 GHz be added to 101.111(d) to ensure EESS instruments are protected from off-axis emissions to the levels required by ITU-R RS.2017 and that the OOBE mask described in 101.111(a)(2)(ii) be truncated at −45 dBm/MHz, rather than −13 dBm/MHz, with a corresponding replacement of the current maximum attenuation of 56 dB.

Furthermore, the NPRM proposes the use of 81-86 GHz transmitters to target aircraft in flight, allows transmission between ships and aerostats, and includes the potential for transmission in the 80 GHz band between aircraft.[30] Such upward transmissions will inevitably illuminate EESS sensors on frequent occasions. In such cases, the OOBE and spurious emissions into the adjacent EESS band will be amplified by nearly all of the gain afforded by the directional antenna.[31] Accordingly, CORF contends that in such direct illumination cases, even with the above recommended revisions, the OOBE and spurious emission limits detailed in 101.111 will be woefully inadequate to protect existing and planned

---

[29] ITU-R Resolution 750 states that the recommended maximum level of unwanted emission power from active service stations into the 86 to 92 GHz band should be: $-41 - 14(f-86)$ dBW/100 MHz for $86.05 \leq f \leq 87$ GHz and −55 dBW/100 MHz for $87 \leq f \leq 91.95$ GHz where f is the center frequency for the 100 MHz reference bandwidth expressed in GHz.

[30] As discussed above, CORF opposes airborne use of the 80 GHz band.

[31] While not specified, a 50 dBi gain is estimated from the given +55 dBW EIRP and 3 W (+5 dBW) total power requirement detailed in paragraph 42. Regardless of the specific gain value, the high directionality of transmission directed toward an EESS sensor requires further consideration beyond the more general EIRP calculation.

EESS sensors, whose observations are key national assets for weather forecasting and other critical Earth System Science studies. Compliance with ITU-R RS.2017 in the adjacent 86-–92 GHz band, which is subject to US246 and International Footnote 5.340 protection, will require that one of the following two courses of action are taken:

1. The OOBE/spurious limits must be further tightened (beyond the adjustments described above) by a factor equal to the transmitter antenna gain. Further, depending on the shape of the OOBE mask adopted, it may be necessary to extend the guard band beyond the 500 MHz discussed above to ensure that OOBE/spurious emissions meet the requirements of ITU-R RS.2017 in the adjacent 86–92 GHz EESS band.
2. Licensees must be required to implement a system that is continually aware of the locations of EESS sensors and capable of ceasing any transmissions whose 86-92 GHz OOBE and spurious emissions observed at an EESS satellite exceed the levels dictated by ITU-R RS.2017. Given that the intent of the proposed systems is to target receivers in motion, either on aircraft or ships, then such devices should also be able to note the locations of operational EESS instruments (of which there are far fewer than aircraft or ships, and whose locations are known in advance).[32] The cessation of transmissions described above could take the form of nulling the relevant region(s) of the sky if that is sufficient to meet the ITU-R RS.2017 criteria. Otherwise, complete cessation should be required when the EESS sensor is above the horizon (see Figure 3 for an illustration of the only modest increase in atmospheric attenuation for off-axis emissions that are still within the footprint of an EESS instrument). Further, CORF notes that although the current generation of sensors observing in the 86-92 GHz band are in LEO , concepts for geostationary orbiting sensors

[32] As weather prediction requires global measurements, and the United States benefits from observations made by both U.S.- and foreign-sponsored satellite missions, the database should include all current satellites that make measurements in the 89 GHz band, regardless of country of origin or sponsoring agency. CORF notes that the spectrum management offices at NASA and NOAA may be able to assist with identifying currently operating EESS missions in orbit.

are under development, and it would behoove developers to anticipate cases in future years where transmissions towards these sensors in fixed regions of the sky will be forbidden permanently.

CORF notes that the above requirements are in the context of transmissions toward endpoints in motion. If the proposed use is considered "mobile," as indicated in paragraph 32, the revisions to 101.111 discussed above should also be implemented in any other corresponding rules sections covering the new service.

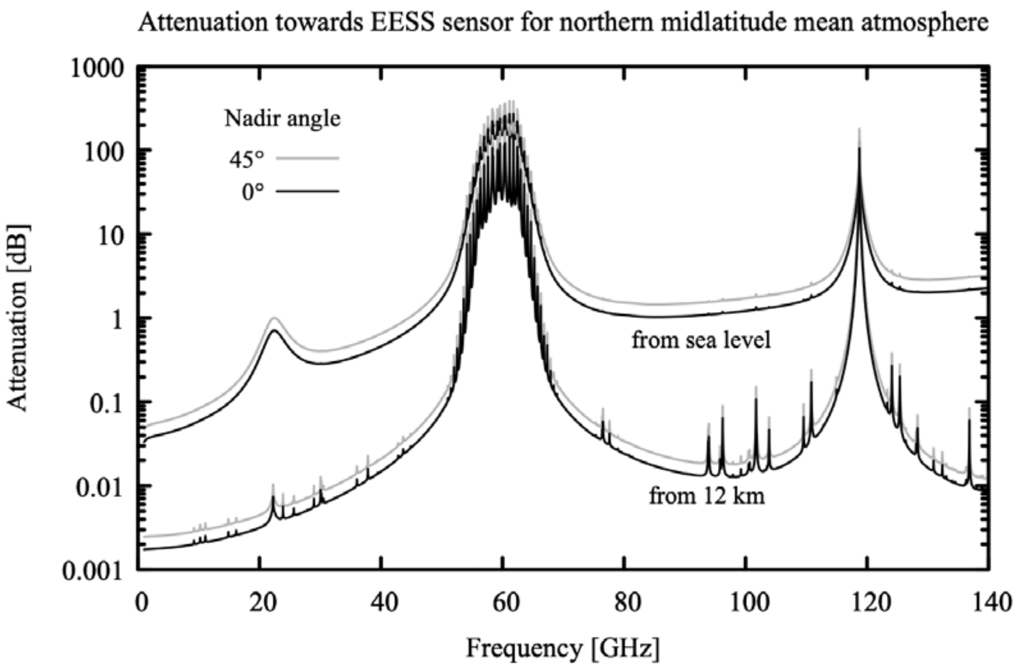

FIGURE 3 Clear sky atmospheric attenuation for two different geometries (45 degree and 0 degree nadir angle) and two different transmitter locations (sea level (ground-based) and 12 km altitude (i.e., aircraft)), for mean northern midlatitude conditions. Note the low atmospheric attenuation at 86-92 GHz, the frequency band allocated to EESS (passive), which is adjacent to the bands under discussion in this NPRM. Out-of-band and spurious emissions into the adjacent passive band from uplinks and aircraft-to-aircraft transmissions in the 80/90 GHz bands will corrupt these critical EESS measurements.

IV. Conclusion.

While CORF supports intelligent spectrum sharing where practicable, it opposes the implementation of the proposed SDDLs to provide service to aircraft or ships in motion in the 80 GHz bands. However, if the Commission chooses to authorize such SDDLs, then careful consideration of channelization, such as restricting the 80 GHz band to uplinks only, as well as limiting aircraft-to-aircraft transmission to only the 70 GHz band, will be required to protect current incumbent RAS users of the 80/90 GHz bands from airborne transmissions. In this configuration, protection of the adjacent 86-92 GHz EESS allocation from OOBE and spurious emissions by ground-based uplinks requires further measures. Specifically, at the bare minimum, 500 MHz guard bands are required at 85.5-86.0 GHz.[33] Further, CORF recommends that the OOBE/spurious emissions masks be brought up to the international standard specified in ITU-R Resolution 750. In addition, to prevent contamination of critical EESS instruments from direct-beam OOBE/spurious signals, then either (1) significantly revised OOBE and spurious emission limits must be adopted (effectively tightened by an amount equal to the forward gain of the antenna), or (2) licensees must be required to null emissions toward EESS sensors, based on real-time tracking information. If airborne use is authorized across the 70/80/90 GHz bands, additional guard bands may be required, as well as more broadly revised OOBE/spurious limits, in order to protect all the passive services in the region from 76 GHz through 95 GHz and beyond. Due to the impact on sensitive RAS millimeter-wave telescopes, CORF opposes the proposed increase to the maximum allowable transmitter power spectral density at the 80 GHz band.

Respectfully submitted,

NATIONAL ACADEMY OF SCIENCES'
COMMITTEE ON RADIO FREQUENCIES

By: Marcia McNutt
____
Marcia McNutt
President, National Academy of Sciences

Direct correspondence to:

CORF
Keck Center of the National Academies
of Sciences, Engineering, and Medicine
500 Fifth Street, NW, Keck 954

---

[33] If the Commission were to authorize similar use in the 90 GHz band, then a guard band would be required at 92.0-92.5 GHz as well.

Washington, D.C. 20001
(202) 334-3520

July 23, 2020

Appendix

Committee on Radio Frequencies

Members

Liese van Zee, Indiana University, *Chair*

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

Nancy Baker, Naval Research Laboratory

William Emery, University of Colorado, Boulder

Dara Entekhabi, Massachusetts Institute of Technology

Philip Erickson, Haystack Observatory, Massachusetts Institute of Technology

Kelsey Johnson, University of Virginia

Karen Masters, Haverford College

Mahta Moghaddam, University of Southern California

Scott Paine, Center for Astrophysics | Harvard & Smithsonian

Frank Schinzel, National Radio Astronomy Observatory

Gail Skofronick-Jackson, NASA Headquarters

Consultants

Darrel Emerson, retired

Tomas E. Gergely, retired