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

In the Matter of	)	
	)	
Amendment of Section 15.255	)	ET Dkt. No. 21-264
of the Commission's Rules	)	

**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 July 13, 2021, *Notice of Proposed Rulemaking* ("NPRM") in the above-captioned docket. CORF appreciates the Commission's statement therein of its fundamental consideration of protecting passive observations in the 57–59.3 GHz ("57 GHz") band, within which the Earth Exploration-Satellite Service (EESS) (passive) has a primary allocation. Consistent with that, in these comments, CORF expresses concerns about the damaging potential impact to such remote sensing satellite observations from *airborne* use of unlicensed field disturbance sensor (FDS) devices operating at 57 GHz. The 57 GHz EESS (passive) measurements are essential for weather forecasting and for weather and climate research and applications. The Commission should protect these observations, which constitute a unique and critical resource for understanding and predicting the evolution of the Earth system, and not authorize any further airborne use of the 57 GHz band.

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

I. Introduction: The Role of Earth Remote Sensing, and the Unique Vulnerability of Passive Services to Interference.

CORF has a substantial interest in this proceeding, because it represents the interests of the scientific users of the radio spectrum, including users of the EESS bands. These users perform vulnerable scientific operations (notably weather forecasting) and research that are extremely important to society.

The Commission has long recognized that satellite-based remote sensing of the Earth system, including sensing in the EESS bands, is an essential and uniquely valuable resource for monitoring and forecasting the evolution of the Earth system environment. Satellite-based microwave remote sensing presents a global perspective and, in many cases, is the only practical method of obtaining atmospheric and surface data for the entire planet. Instruments operating in the EESS bands provide data that are important to human welfare, safety, and security and include support for scientific research, commercial endeavors, and governmental operations in areas such as meteorology, hydrology, atmospheric chemistry, climatology, and oceanography. Examples are measurements of parameters—such as vertical profiles of atmospheric temperature (for which the 57 GHz observations are central) and humidity, along with surface temperature, cloud and precipitation information—that are essential for weather forecasting, including the prediction of severe weather such as hurricanes, wildfires, and drought and the planning of airline flight routes for fuel efficiency, safety, and passenger comfort. Additional observed parameters—such as ocean surface temperature, salinity, winds, and waves, along with over-ocean precipitation rates—are needed to understand ocean circulation and the associated global distribution of heat. EESS (passive) bands are also used for monitoring soil moisture, a parameter needed for agriculture and drought assessment, and for weather prediction (for quantifying heat exchange with the atmosphere) and even for defense (planning military deployments). EESS satellites represent billions of dollars in investment and provide data for major governmental agencies, 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 U.S. Department of Agriculture, the U.S. Geological Survey, the Agency for International Development, the Federal Emergency Management Agency, and the U.S. Forest Service. These agencies use EESS data continually for their work on issues impacting 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.[2] A recent NOAA report estimated that weather forecasts generated $35 billion in annual economic benefits to U.S. households in 2016.[3] 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

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2 *See* NOAA, "Weather," https://www.noaa.gov/weather, accessed July 1, 2021.
3 *See* "NOAA by the Numbers." June 2018, p. 8, https://www.performance.noaa.gov/economics/, accessed July 1, 2021.

limit[s] their impact."[4]

II. EESS Remote Sensing at 57–59.3 GHz.

The primary concern for remote sensing scientists in the 57–64 GHz band that is the subject of this NPRM is the 57–59.3 GHz sub-band, which is vitally important to weather forecasting and, for this reason, is covered by a primary allocation to EESS (passive). Instruments observing around 57 GHz include NASA/NOAA's Advanced Technology Microwave Sounder (ATMS),[5] the NOAA and the European Organisation for the Exploitation of Meteorological Satellites' (EUMETSAT's) Advanced Microwave Sounding Unit (AMSU-A),[6] and DoD's SSMI/S.[7] Next-generation instruments for observing in this band, employing new technology to increase performance and/or reduce the mass, power, and complexity of the orbiting sensors, are continually under development at NASA and elsewhere. All weather forecast models utilize atmospheric temperature data derived from this band to initialize and continually update their models used for operational forecasting. Recent analysis has shown that the data from microwave sounders (AMSU-A, ATMS, and SSMIS [Special Sensor Microwave Imager/Sounder]) are responsible for roughly 28 percent of weather forecast accuracy, the largest single factor (Figure 1). As detailed below, while significant atmospheric absorption in the 57–59.3 GHz band protects critical EESS (passive) observations from

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4 *See*, NOAA, "NOAA's Contribution to the Economy; Powering America's Economy and Protecting Americans," 2018, p. 8, https://www.performance.noaa.gov/economics/, accessed July 1, 2021.

5 *See* F. Weng, X. Zou, X. Wang, S. Yang, and M. Goldberg, "Introduction to Suomi NPP ATMS for NWP and Tropical Cyclone Applications," *J. Geophys. Res.* 117: D19112, 2012, doi:10.1029/2012JD018144.

6 *See* P.W. Rosenkranz, "Retrieval of Temperature and Moisture Profiles from AMSU-A and AMSU-B Measurements," *IEEE Trans. Geosci. Remote Sens.* 39(11): 2429-2435, 2001, doi:10.1109/36.964979.

7 *See* J.P. Hollinger, J.L. Peirce, and G.A. Poe, "SSM/I Instrument Evaluation," *IEEE Trans. Geosci. Remote Sens.* 28(5): 781-790,1990, doi:10.1109/36.58964.

interference from transmissions at the surface, airborne transmissions are subject to far less shielding, placing the integrity of spaceborne weather observations in jeopardy. Because of this, CORF strongly urges the Commission to refrain from making rule changes that may result in increased aeronautical transmissions at 57–59.3 GHz.

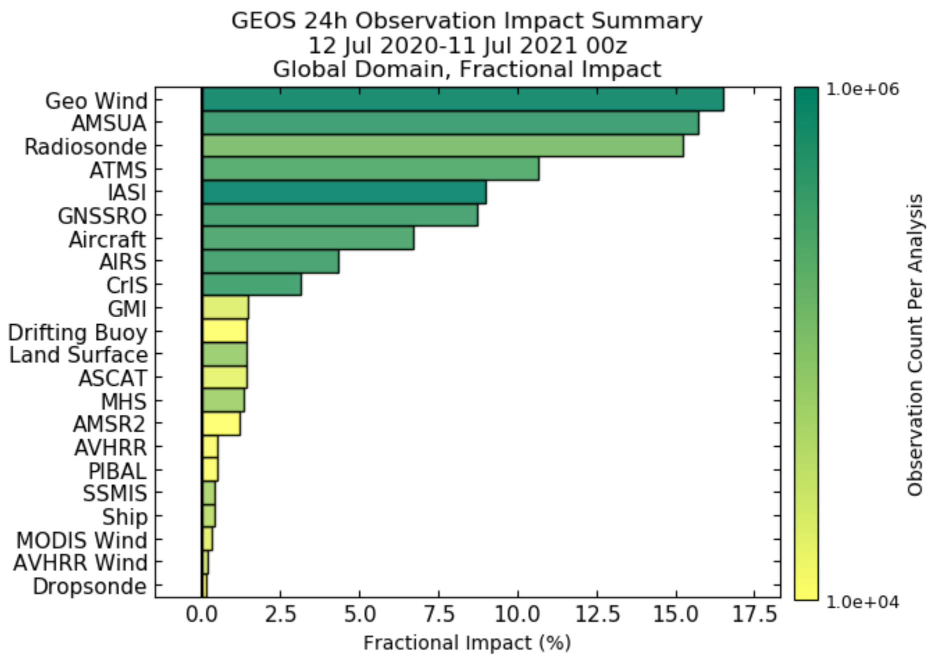

FIGURE 1 Fractional contribution of various data sources to weather forecast accuracy for the NASA Global Modeling and Assimilation Office operational model. The 28 percent total quoted in the text is the sum of the AMSUA, ATMS, and SSMIS bars. The equivalent number for the U.S. Navy operational forecast is 23 percent. SOURCE: NASA, "GEOS Observation Impact Monitoring," https://gmao.gsfc.nasa.gov/forecasts/systems/fp/obs_impact/plots/summary_all+year+global+fractional_impact.png, accessed July 12, 2021.

The microwave spectrum in the 57 GHz band is dominated by absorption from multiple strong spectral lines of molecular oxygen (Figure 2), with the strongest absorption being nearest the centers of each line (e.g., around 56.9, 57.6, 58.3, and 58.4 GHz, etc.). The spectral width of the absorption increases with increasing pressure (i.e., decreasing altitude), leading to strong absorption even in the "gaps" between the lines at the lowest altitudes. Accordingly, at sea level, the opacity of the atmosphere is such that there is no perceptible impact from terrestrial mobile or fixed transmissions on EESS (passive) observations. Thus, the spectrum in this band may be shared between spaceborne EESS (passive) sensors and low-power, ground-based users without significant concern for interference, as reflected in U.S. and international allocations in this band.

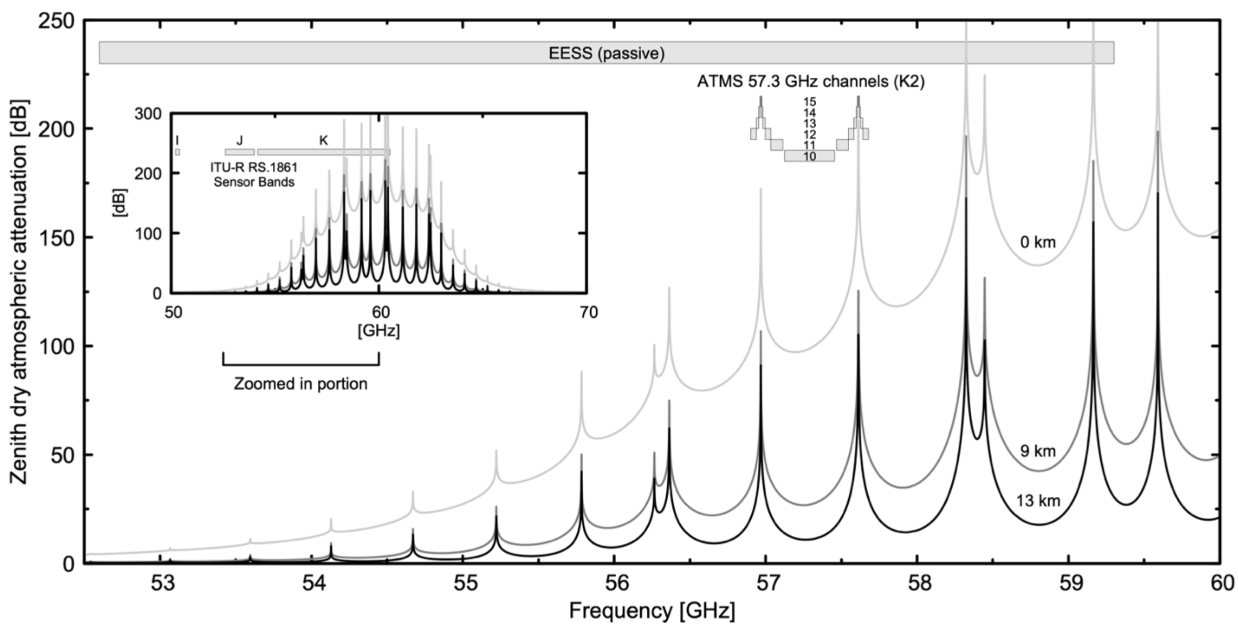

FIGURE 2 (Inner plot) Atmospheric attenuation upwards from emitters at three different altitudes (black and grey lines). Spectral coverage for the “I”, “J”, and “K” series of instruments discussed in ITU-R Recommendation RS.1861 are indicated by grey boxes. (Outer plot) zoom in of the 52–60 GHz spectral region. The EESS (passive) band is shown by the upper grey box, while narrower grey boxes show the 57 GHz channels for the ATMS-series of instruments. Note that several of the ATMS channels measure the net signal from multiple disjoint spectral regions (e.g., channel 12 reports the total signal in four 36 MHz bands centered at 56.92, 57.02, 57.56, and 57.66 GHz). Attenuation computed using the Smithsonian Astrophysical Observatory (SAO) *am* code for a mid-latitude dry atmosphere compiled from NASA MERRA-2 data. SOURCE: *SAO am code:* S. Paine, “The *am* atmospheric model (v. 11.0),” Zenodo, 2019,https://doi.org/10.5281/zenodo.3406496. *MERRA-2 data:* A. Molod, L. Takacs, M. Suarez, and J. Bacmeister, “Development of the GEOS-5 Atmospheric General Circulation Model: Evolution from MERRA to MERRA2,” *Geosci. Model Dev.* 8:1339, 2015, https://doi.org/10.5194/gmd-8-1339-2015.

As altitude increases, however, radio frequency emissions, including the natural atmospheric thermal emission measured by EESS (passive) sounders, are increasingly able to propagate beyond the atmosphere and into space. The altitudes at which such propagation is first possible are highest for frequencies close to the centers of the oxygen lines, with lower altitudes being sufficient for emission in the “gap” regions. These altitude differences are what enables orbiting sensors to obtain height-resolved measurements of atmospheric temperature.

In sum, an orbiting EESS (passive) sensor can “see” down to different depths in the atmosphere, depending on the degree of absorption at the frequency being observed. Each channel in an orbiting instrument (such as those for the ATMS instrument in Figure 2), provides a measure of the atmospheric temperature in a broad layer within which the atmospheric absorption is sufficiently strong to provide a useful thermal emission signal (fundamental physics directly couples the strength of the very small thermal emission signal for a given temperature to the degree of absorption) but not so strong that those emissions are absorbed by air higher up and thus not seen. These broad and overlapping layers are described by the “weighting functions” (examples for ATMS shown in Figure 3). For example, the ATMS channels (Figure 2), with their overlapping weighting functions (Figure 3), were specifically selected to provide temperature profile information with the needed vertical resolution, particularly under cloudy conditions. Thus, it is only with the simultaneous use of all channels that the complete picture of the full atmospheric temperature profile can be accurately deduced. Another consequence of the overlaps in these weighting functions is that interference in any one channel can adversely impact the accuracy of the temperature information over a broad vertical range.

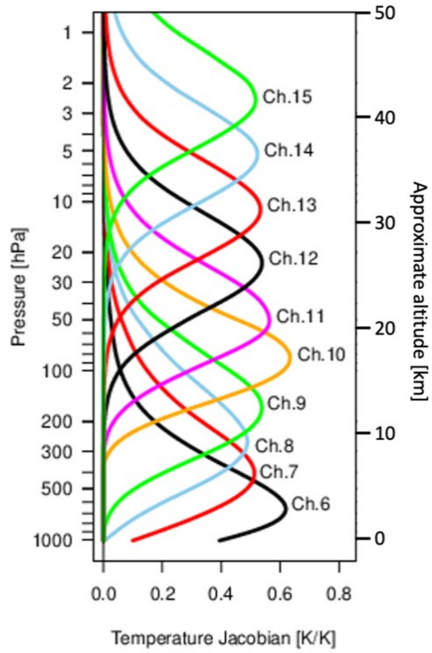

FIGURE 3 "Weighting functions" for the various ATMS channels. The lines show the sensitivity of each ATMS channel to changes in temperature at each level in the atmosphere. NOTE: Approximate altitude axis added for clarity. SOURCE: European Centre for Medium-Range Weather Forecasts, "ATMS Weighting Functions," https://www.ecmwf.int/en/forecasts/charts/obstat/atms_weighting_functions?facets=Instrument,ATMS&time=2021071000&Channel=Temperature%20channels, accessed July 12, 2021.

This strong dependence of absorption on altitude means that, while sharing between EESS (passive) and terrestrial fixed and mobile applications in the 57 GHz band is possible, airborne applications are a completely different matter. For example, the NASA/NOAA ATMS instrument observes a range of angles from 0°–45°, with the nadir view, 0°, representing the worst case. ATMS orbits at 824 km altitude and, for its 57 GHz channels, has an antenna gain of 38 dBi.[8]

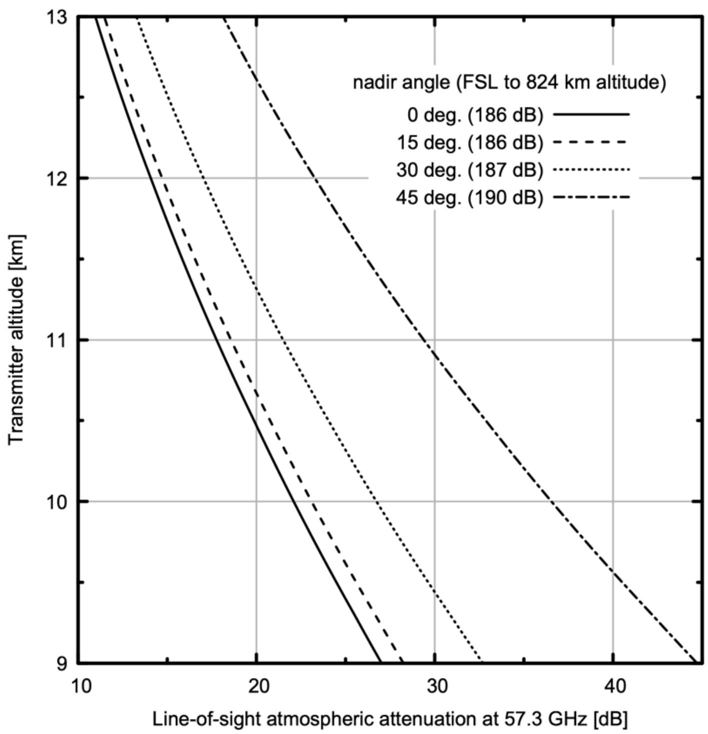

FIGURE 4 Atmospheric attenuation at 57.3 GHz as a function of transmitter altitude (within typical airliner cruise altitude range) for four different viewing angles for an EESS (passive) sensor at 824 km altitude. SOURCE: *SAO am code:* S. Paine, "The *am* Atmospheric Model (v. 11.0)," Zenodo, 2019, https://doi.org/10.5281/zenodo.3406496. *MERRA-2 data:* A. Molod, L. Takacs, M. Suarez, and J. Bacmeister, "Development of the GEOS-5 Atmospheric General Circulation Model: Evolution from MERRA to MERRA2," *Geosci. Model Dev.* 8:1339, 2015, https://doi.org/10.5194/gmd-8-1339-2015.

Referring to Figure 4, at a transmitter altitude of 12.2 km (40,000 ft) and a nadir angle of 15°, the atmospheric absorption loss is 14 dB, and the free-space loss to ATMS at 824 km altitude is 186 dB. The ATMS antenna gain of 38 dBi results in a total link loss of 14 dB + 186 dB − 38 dB = 162 dB. For this link loss, the received power from

[8] *See* E. Kim, C.-H. J. Lyu, K. Anderson, R.V. Leslie, and W.J. Blackwell, "S-NPP ATMS Instrument Prelaunch and On-Orbit Performance Evaluation," *J. Geophys. Res. Atmos.* 119 (9): 5653-5670, 2014, https://doi.org/10.1002/2013JD020483.

a single device with an effective isotropic radiated power (EIRP) of 20 dBm would be −142 dBm (−172 dBW). This is only 3 dB below the threshold for harmful interference in this band (−169 dBW in any 100 MHz) called out in ITU-R RS.2017. The proposed FDS duty cycle of 10 percent in 33 ms reduces the impact to individual ATMS observations, although not by the full 10 dB implied by a 10 percent cycle, as the ATMS integration time is only 18 ms, for which 3.3 ms (10 percent of 33 ms) corresponds to only a 7.3 dB reduction. Further, the committee notes that conically scanning instruments in this band, such as those in the SSMIS series, have only 1.2 ms integration times, rendering the FDS duty cycle immaterial when considering interference in individual EESS (passive) measurements made by these (and potential future[9] similar) sensors. More than 10 FDS devices in view of ATMS, oriented such that their beams illuminate the orbiting spacecraft, would therefore result in the threshold being exceeded in ATMS channel 10. The issue of the (small degree of) absorption of these signals by aircraft windows is discussed below. In the event of widespread airborne deployment of 57 GHz devices, there could be a large but unknown number of radiators (devices) on any given aircraft. Accordingly, if individual aircraft carried multiple devices, and there were several such aircraft within an EESS (passive) satellite footprint, the aggregate interference could rapidly exceed the ITU-R RS.2017 threshold levels for interference of −169 dBW. The resulting data loss rate could readily exceed the 0.01 percent maximum acceptable threshold for this frequency range (again, per ITU-R RS.2017). Such impacts to EESS

[9] The NOAA Broad Agency Announcement for work to develop concepts for future low Earth orbit (LEO) sounders states a 5 km horizontal resolution goal, which equates to an integration time of 0.5 ms or shorter for typical orbit altitudes. See NOAA, "Broad Agency Announcement (BAA) for Low Earth Orbit (LEO) Sounding Satellite and the Geostationary Orbit Concept Exploration (GEO)," updated October 30, 2019, https://sam.gov/opp/0f637712b9228032f3ab51fc2cdc37a0/view

(passive) observations would be particularly serious in well-travelled air corridors, where meteorological information is especially valuable.

One measure of the criticality of the EESS (passive) observations is their net 28 percent contribution to the accuracy of 24-hour weather forecasts discussed above (Figure 1). However, this number understates the importance of these observations for extreme weather events, for which the ability of the EESS (passive) bands to make measurements within clouds (where measurements at infrared and visible wavelengths cannot penetrate) is particularly important. Further, as the 28 percent metric refers to the accuracy of 24-hour forecasts, it does not reflect the additional importance of these bands for longer-term weather prediction. Accurate forecasting of the weather on timescales of days-to-weeks demands reliable predictions, and thus measurements, of the stratosphere (the region of the atmosphere from ~10–50 km altitude). The 57 GHz band is the primary source for stratospheric observations in weather forecasting systems.

III. The Commission Should Not Expand Airborne Use of 57 GHz Devices.

Para. 39 of the NPRM notes that currently, operation of 60 GHz devices on aircraft "is limited to when the aircraft is on the ground, and, for airborne use, only in closed exclusive communication networks within the aircraft. To account for the important interest in protecting passive EESS users that operate in the 57–59.3 GHz band, the rule limits this use to aircraft with a high RF [radiofrequency] attenuation body (e.g., commercial airliners), and cannot be used in wireless avionics intra-communication applications where external structural sensors or external cameras are mounted on the outside of the aircraft structure." That same paragraph notes that the Commission does "not propose to alter the existing restrictions relating to the use of 60 GHz band unlicensed devices on board aircraft which are contained in Section 15.255(b) of the rules, but we nevertheless seek comment as to whether we should expand the situations where such use is permissible." CORF strongly recommends that, in light of the significant risk to critical data used for weather forecasting and climate research, the Commission should not expand airborne use of 57 GHz devices.

A. Any Expanded Airborne Use of 57 GHz Would Create Significantly Greater Risk to EESS Observation.

CORF appreciates that the NPRM states at para. 42 that the Commission's "fundamental consideration has been and remains how to ensure that passive EESS operations in the 57–59.3 GHz band continue to be protected from harmful interference that could be caused by airborne use of unlicensed 60 GHz devices." This is a sound place to begin the inquiry. However, the NPRM goes on to state that "we nevertheless seek comment on whether we should allow for expanded use of 60 GHz radars on board aircraft and, if so, with what requirements and restrictions." Given that the NPRM defines the term "60 GHz band" to mean 57–64 GHz (NPRM at para. 1), which includes the critical 57–59.3 GHz sub-band, the answer is "no."

1. The Impact of the Current Airborne Use Standard Is Not Clear.

Section 15.255(b)(2) of the Commission's rules limits use of unlicensed wireless 57-71 GHz ("60 GHz") devices on aircraft while airborne, to closed exclusive on-board communication networks within the aircraft. This rule, crafted in the Commission's *Spectrum Frontiers* proceeding, was intended to allow a level of airborne use of such devices that would not interfere with remote sensing observations at 57 GHz.[10] Before expanding that level of airborne use, it is logical and necessary to evaluate the impact of operations under the current standard. However, the data necessary to make that evaluation does not appear to be available, or at least publicly available. For example, there appears to be no publicly available data regarding how many commercial aircraft currently operate the 60 GHz networks anticipated in the *Spectrum Frontiers Second R&O*. Indeed, it is unclear if any aircraft are currently using such networks. In the absence of such data, it is unreasonable to loosen that standard, given the significant possible negative consequences to critical data collection.

Even if it were known how many aircraft currently operate 60 GHz networks, it would likely still be very difficult to evaluate the interference impact on remote sensing observation at 57 GHz. Signals that cause a high level of interference to passive observations can be reliably identified and the affected observations excised from the record. This reduces efficiency, and the associated irrevocable loss of information from the affected measurements can lead to reductions in forecast accuracy if the degree of loss becomes large. However, an arguably greater threat comes from unwanted signals captured by passive receivers that are at a lower level and not easily recognizable, and thus can masquerade as valid scientific data. This interference creates an insidious corruption of data that can significantly skew the validity of the conclusions based on that data and mislead operational weather forecasts.[11] In the present case, the impact

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[10] *Use of Spectrum Bands Above 24 GHz For Mobile Radio Services*, GN Docket No. 14177, Second Report and Order, 32 FCC Rcd 10988, 11012-11017, at paras. 75-87 (2017) ("*Spectrum Frontiers Second R&O*").

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

would be to conclusions regarding critically important weather forecasting, as well as climate research.[12]

The NPRM indirectly raises the question of the impacts of currently allowed use at para. 42 by noting that the Commission is "not aware of any reports of harmful interference being caused by Google Soli [60 GHz] devices during airborne use." Yet there does not appear to be publicly available data regarding how many Soli devices were sold in the United States and how many of such devices have been operated in aircraft. Even if a million Soli devices were sold in the United States, CORF cannot evaluate whether or not those devices caused insidious corruption of data through low-level interference, nor does CORF believe that any other party can do so.[13] Thus, no valid nor meaningful conclusions can be drawn from the lack of reports up to this time of interference from airborne use of Soli devices, and therefore the lack of reports cannot reasonably be used to authorize a significantly looser standard for airborne use.

2. *The Commission Appears To Be Abandoning the Network Architecture Model Used to Create the Current Limited Airborne Use Standard.*

The current standard limiting airborne use of 60 GHz devices set forth in Section 15.255 was based on an architecture of access point stations affixed to the interior ceiling in commercial passenger transport aircraft to deliver Internet and entertainment products wirelessly to travelers' laptops or tablets, or to in-seat display monitors on the aircraft.[14] The revised Section 15.255, and the related actions in the *Second R&O,* were

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[12] *See* Section II *supra.*

[13] In addition to the problem of insidious corruption of data, it should be noted that for much of the time period since the Commission authorized the Soli devices, commercial air traffic has been greatly reduced due to the COVID-19 pandemic.

[14] *Spectrum Frontiers Second R&O, supra* note 9.

based on very specific findings relying on an interference study by the Aerospace Vehicle Systems Institute (AVSI) specifically exploring the potential impact of airborne 57–71 GHz radiators using that network architecture.[15] While CORF does not endorse the conclusions of the AVSI Study,[16] in any case, the technical premises of that study are not applicable to the present proposal. The NPRM discusses personal consumer devices,[17] potentially including smartphones, rather than relying on the architecture of access point stations affixed to the interior ceiling in commercial passenger transport aircraft. That access point network architecture was critical to the Commission's finding that transmissions were unlikely to go out of unshielded windows of aircraft and thus interfere with remote sensing observations.[18]

The Commission may instead be relying on an analysis, performed by Google, of potential interference from airborne Soli devices to remote sensing at 57 GHz.[19] However, in considering the transmission of Soli emissions through aircraft windows,

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15 *Id.* at para. 83. *See* Aerospace Vehicle Systems Institute (AVSI), *Analysis of Potential Interference from WiGig Radios on Aircraft to EESS Passive Sensors*, AFE 85 Project Report, by David Redman, August 30, 2017, https://ecfsapi.fcc.gov/file/10831759627379/AVSI%20WiGig%20Cover%20Letter%20and%20Report%20for%20FCC%20Filing.pdf, ("AVSI Study").

16 The AVSI Study, drafted by the Aerospace Vehicle Systems Institute ("AVSI"), assumed best-case scenarios, including the assumption that the number of aircraft flying at high altitude would not increase from then-current values. Of particular concern and relevance to the present proceeding is that the analysis assumed that most of the emission would come from the access point, not from users located in a window seat, nor from beam steering commensurate with bounces off surfaces, including windows. In addition, the reported estimate of 40 dB for the aircraft fuselage loss factor does not appear to be substantiated with peer-reviewed studies. This factor will depend on airframe construction and materials, window materials, and cabin occupancy, amongst other parameters.

17 *See, e.g., NPRM* at para. 9.

18 *Spectrum Frontiers Second R&O* at para. 83. Again, CORF does not endorse that conclusion.

19 *See* A.W. Clegg, "Compatibility between Earth Exploration-Satellite Service Sensors and Airborne Use of Project Soli Devices at 57.5 to 63.5 GHz," Attachment C, June 2018, of Google LLC letter "2018-06-08 Google Letter re Project Soli + Studies.pdf" in OET Dkt. No. 18-70, filed June 8, 2018.

Google cites[20] an analysis by Zodiac Aerospace[21] that contains several manifest errors. In computing the loss through a typical three-layer acrylic passenger aircraft window, the Zodiac Aerospace Study starts with incorrect materials parameters, using n = 1.498 for the refractive index and a = 6.03 dB/cm for the absorption coefficient, without citation. Correct values for acrylic in the 60 GHz band are approximately n = 1.61 and a = 0.9 dB/cm, respectively.[22] The study goes on to incorrectly compute the total reflection loss through the window stack by merely summing the loss at each interface (ignoring interference) and neglecting polarization effects at oblique incidence. The result of these compounded errors is that the Zodiac Aerospace Study grossly overestimates the window attenuation (11.62 dB at normal incidence and 25.82 dB at 79 degrees incidence angle) and moreover claimed that these are minimum values. In contrast, and more plausibly, the AVSI Study cited above[23] included an actual measurement of 60 GHz transmission through a typical passenger aircraft window assembly in an antenna range, finding total attenuation of only 0–1.5 dB over a ±25 degree range about normal incidence. Google cites a further erroneous assertion in the Zodiac Aerospace Study that total reflection occurs beyond 79 degrees incidence, preventing radiation at high oblique incidence from exiting the aircraft. This is based on a fundamental misunderstanding of total internal reflection (TIR), and, notably, contradicts everyday experience when looking through windows, including aircraft windows. TIR does not

[20] *Id.* Note 3.

[21] Zodiac Aerospace, "Aircraft 60 GHz BRAN," presentation to CEPT Short Range Devices Maintenance Group, April 2016, at 7-10, https://cept.org/Documents/srdmg/30181/srdmg-16-024_60-ghz-onboard-airplanes ("Zodiac Aerospace Study").

[22] M. Afsar, "Precision Millimeter-Wave Measurements of Complex Refractive Index, Complex Dielectric Permittivity, and Loss Tangent of Common Polymers," *IEEE Trans. Inst. Meas.* IM-36: 530, 1987, https://doi.org/10.1109/TIM.1987.6312733.

[23] See footnote 15, *supra*.

occur in a window (whose front and back surfaces are parallel) when radiation originates from outside the window material (in contrast with the textbook example of a prism, where total internal reflection of externally generated radiation can take place specifically because the prism's faces meet at angles). Further, neither the Zodiac Aerospace Study nor the AVSI Study appear to consider reflection off the aircraft wings. As the wings are situated below the windows in most commercial aircraft, such reflections have the potential to significantly increase emissions in the upward direction.

3. The Commission Should Not Increase Authorized Power Levels for Airborne Use of 57 GHz Devices.

Based on the AVSI Study, assuming the access point network architecture, the Commission limited transmission power levels to those set forth in the current Section 15. 255(c)(3). The NPRM proposes to significantly increase those power levels, notably a 10-fold increase in EIRP from 10 dBm to 20 dBm, leading to substantial risk of interference to EESS (passive) observations in the 57 GHz band as detailed above.

In proposing increased power, the Commission may be relying on a European Telecommunications Standards Institute (ETSI) standard for short-range devices operating in a portion of the 57–71 GHz band, specifically, ETSI Standard EN 305 550. *See* NPRM at para. 10. However, that ETSI Standard is nothing more than a technical standard designed to promote harmonization of equipment among manufacturers. It is not a regulation of a nation or of the European Union. The existence of ETSI Standard EN 305 550 does not constitute a regulatory review of the risks of, much less an approval of, aeronautical use of 60 GHz devices. Indeed, there is no mention whatsoever of airborne uses in the ETSI Standard EN 305 550 document. Accordingly, the ETSI Standard EN 305 550 provides no reasonable basis for increasing the power of 60 GHz devices used on aircraft.

Thus, CORF recommends that there be no increased power for airborne use of devices that transmit at 57 GHz.[24] Indeed, CORF is of the opinion that even the previous approval for Google Soli, with the potential for significant escape through aircraft windows, represents a critical threat to routine reliable observations in the 57 GHz band, which is one of the key pillars of operational weather forecasting. CORF strongly urges the Commission not to authorize any further airborne use of the 57 GHz band.[25]

4. The Leica Waiver Order Was Based on Specific Protections for EESS Observations and Provides No Precedent for Broader Uses.

In paragraph 43 of the NPRM, the Commission seeks comment on permitting unlicensed 60 GHz devices on board aircraft with little or no RF attenuation

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[24] At para. 38 of the NPRM, comments are sought as to whether FDS devices should be permitted to operate at a higher power throughout the entire 57-71 GHz band, including the possibility of allowing radars that incorporate a sensing technology such as listen-before-talk (LBT) to operate at the same emission limits as WLAN devices in the band—that is, 40 dBm EIRP and 27 dBm transmitter conducted output power. Since EESS is a passive service at 57 GHz, devices with LBT functionality cannot identify use of that band by remote sensing satellites, and thus higher-power FDS operations at 57 GHz cannot be justified for airborne uses.

[25] If the Commission nevertheless seeks to authorize airborne use of personal 57 GHz FDS devices, that should be preceded by full system compliance testing rather than reliance on unvalidated models for aircraft cabin exit loss for a particular idealized network architecture. Further, any airborne use of FDS or other devices in regions of the 57-71 GHz band not having a primary allocation to EESS (passive) should similarly be preceded by full compliance testing, with a particular focus on out-of-band emissions (OOBEs) into the EESS (passive) band. It is hard for CORF to judge whether existing OOBE limits, particularly that in Section 15.255 (c)(ii)(B)(2), are sufficient to ensure that airborne transmissions comply with ITU-R recommendation RS.2017, given the large disparity between the broad 57-71 GHz band over which the OOBEs are defined and the far smaller (e.g., 330 MHz for ATMS channel 10) bandwidth for EESS (passive) sensors. A more detailed OOBE emission mask, expressed in terms of maximum allowed power spectral density or power in a 100 MHz reference bandwidth (for parity with ITU-R RS.2017), would facilitate easier assessment by all concerned. In any case, CORF notes that the Section 15.255 (c)(ii)(B)(2) limit applies only to 61.0-61.5 GHz, whereas the specification of any new limit should be expanded to apply to all 57-71 GHz devices.

characteristics, such as unmanned aerial systems (UAS)/drones and light/personal aircraft. The NPRM notes the limited waiver previously granted to Leica Geosystems AG to operate a radar in the 60–64 GHz band on board a UAS to provide visual inspection of structures.[26] However, it must be emphasized that, in light of the additional risk of interference to remote sensing observations at 57 GHz resulting from operation without the attenuation from a metal fuselage, the *Leica Order* was based on specific protections to limit the use by Leica, and to protect EESS, including the following:

> - The Leica device shall be installed to transmit on a *horizontal plane* with respect to the UA on which it is mounted to limit emissions above the horizon. Operation shall be limited to *line-of-sight only*.
>
> - The Leica device shall comply with the certain technical characteristics, including: a) intentional emissions shall be contained to the *60–64 GHz band*; b) out-of-band emissions *shall not exceed –51.3 dBm EIRP/MHz*; and c) transmission shall occur only when the device is *in motion*.
>
> - Leica devices shall operate below a *maximum altitude of 400 feet above ground* level, unless the small unmanned aircraft: (1) is flown within a 400-foot radius of a structure; and (2) does not fly higher than 400 feet above the structure's immediate uppermost limit.
>
> - U.S. sales *shall not exceed 400 Leica devices* in the first year and up to 800 per year for subsequent years. The Leica device *shall not be marketed for retail consumer markets*.

(*Leica Order* at para. 10)

The Commission was particularly mindful of protecting 57 GHz EESS (and radio astronomy) observations in the *Leica Order*, noting that while device will be installed on a UAS, given its on-the-air limited operation (operation while the UAS is in motion only and not when the UAS is hovering), the choice of operating frequency band (60–64

[26] *See* FCC, "In the Matter of Leica Geosystems AG Request for Waiver of Section 15.255 of the Commission's Rules Applicable to Radars used on Unmanned Aerial Vehicles in the 60-64 GHz Frequency Band," Order, ET Docket No. 19-350, 35 FCC Rcd 7929 (2020) ("*Leica Order*").

GHz) that avoids the passive EESS band, and the limited number of devices sold and specialized (rather than consumer) use, the Leica device would not cause harmful interference to EESS observers. *Id.* at para. 7.[27]

The *Leica Order* was specifically designed to be very limited and does not constitute a rationale or precedent for broader uses. While CORF disagrees with the validity of prior calculations submitted in Docket 14-177 regarding the level of attenuation by the fuselage of commercial aircraft, there is no doubt that there is some attenuation, compared to drones and light/personal aircraft. Accordingly, given the risk to critical 57 GHz observations, the Commission should not expand airborne use of devices transmitting at 57 GHz to include UAS and personal/light aircraft. However, if the Commission choses to authorize such uses, at a minimum they should be limited with the specific protections required in the *Leica Order* as listed above in italics.

5. The Commission Should Not Consider Any Proposed Use of 57 GHz for Wireless Avionics.

Section 15.255(b)(2)(i) of the Commission's rules specifically prohibits use of the 60 GHz band for wireless avionics intra-communication (WAIC) applications where external structural sensors or external cameras are mounted on the outside of the aircraft structure. This was a specific action intended to protect passive observations:

> WAIC applications could encompass external structural sensors or external cameras mounted on the outside of the aircraft structure to monitor the different phases of aircraft operation. These externally located transmitters may generate RF signals that would not be attenuated by the fuselage while the aircraft is in flight; thus, 60 GHz signals have the potential to escape into the air at various altitudes of flight and may present a potential for harmful interference to passive sensors. We are therefore … prohibiting operation of 60 GHz transmitters in

27 In addition, the low altitude ceiling (generally 400 feet) waiver condition reduces the risk of interference to remote sensing, compared with operation of devices in commercial aircraft at up to 40,000 feet, for which the degree of upward atmospheric absorption is far less (*See* Section II, *supra*).

WAIC applications on the outside of the aircraft body/fuselage while airborne, to ensure that passive services continue to be protected.[28]

The NPRM does not seek comments on allowing 60 GHz wireless avionics, and the Commission should not consider any suggestions to do so, as any such uses would pose an unnecessary and dangerous risk to passive observations at 57 GHz.

B. Protecting Remote Sensing at 57 GHz.

For the reasons set forth above, CORF strongly recommends against expanding the allowable airborne uses of 60 GHz devices, especially those that transmit in the 57 GHz sub-band. In connection therewith, CORF supports the proposed (at para. 40 of the NPRM) compliance options of a requirement for such devices to have an “airplane mode” during flight, or sensors to disable operations when the device is greater than 400 ft height above ground level (or above the top of a structure immediately beneath). While such requirements might add a limited expense to the cost of some devices,[29] that cost is outweighed by the benefit of protecting data critical to weather forecasting, as well as to climate research.[30]

IV. Conclusion

CORF appreciates the Commission’s statement in the NPRM of its fundamental concern for protecting passive observations at 57-59.3 GHz. Consistent with that, the Commission should protect this critical weather and climate research resource, and not authorize any further airborne use of the 57 GHz band.

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28 *Spectrum Frontiers Second R&O* at para. 84.

29 CORF believes that most smartphones already have an airplane mode function.

30 To fully protect remote sensing observations at 57 GHz, the Commission could also consider modifying Section 15.255(b) to prohibit all airborne uses of 57-60 GHz (up to 59.3 GHz, plus a “guard band”). *See Leica Order* at para. 7. There is no evidence that this limited portion of the 57-71 GHz band is necessary for the FDS functionality. Even if the Commission were to limit FDS devices to below 64 GHz, per. Para. 22 of the NPRM, that would still leave use of 60-64 GHz for such devices, consistent with the *Leica Order.*

Respectfully submitted,

NATIONAL ACADEMY OF SCIENCES'
COMMITTEE ON RADIO FREQUENCIES

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August 6, 2021

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