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

In the Matter of	)	
	)	
Use of Spectrum Bands Above 24 GHz For Mobile Radio Services	)	GN Docket No. 14-177
	)	
Establishing a More Flexible Framework to Facilitate Satellite Operations in the 27.5-28.35 GHz and 37.5-40 GHz Bands	)	IB Docket No. 15-256
	)	
Petition for Rulemaking of the Fixed Wireless Communications Coalition to Create Service Rules for the 42-43.5 GHz Band	)	RM-11664
	)	
Amendment of Parts 1, 22, 24, 27, 74, 80, 90, 95, and 101 To Establish Uniform License Renewal, Discontinuance of Operation, and Geographic Partitioning and Spectrum Disaggregation Rules and Policies for Certain Wireless Radio Services	)	WT Docket No. 10-112
	)	IB Docket No. 97-95
Allocation and Designation of Spectrum for Fixed-Satellite Services in the 37.5-38.5 GHz, 40.5-41.5 GHz and 48.2-50.2 GHz Frequency Bands; Allocation of Spectrum to Upgrade Fixed and Mobile Allocations in the 40.5-42.5 GHz Frequency Band; Allocation of Spectrum in the 46.9-47.0 GHz Frequency Band for Wireless Services; and Allocation of Spectrum in the 37.0-38.0 GHz and 40.0-40.5 GHz for Government Operations	)	

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

The National Academy of Sciences, through its Committee on Radio Frequencies (hereinafter, CORF[1]), hereby submits its reply comments in response to comments filed in the above dockets pursuant to the Commission's October 23, 2015, *Notice of*

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

Proposed Rulemaking (NPRM) in the above-captioned dockets.[2] In these reply comments, CORF discusses comments filed by other parties in support of a proposal to remove the current prohibition on airborne transmissions in the 57-71 GHz band. The supportive comments that have been filed do not address the likely negative impact of interference to critical satellite remote sensing observations by instruments using spectrum in the Earth Exploration Satellite Service (EESS). Similarly, careful studies would be required to determine whether mobile operations in the 42 GHz band can be consistent with protection of the Radio Astronomy Service (RAS) facilities observing in the 42.5-43.5 GHz band and to determine where fixed or fixed-satellite service operations could operate while protecting RAS observations in this band.

I. Comments Filed Supporting Unlicensed Airborne Use of 60 GHz Devices Did Not Address the Negative Impact on Critical EESS Observations.

In CORF's opening comments (hereafter, "CORF's opening comments") in this proceeding (at pages 11-16), in light of the Commission's proposal to unify rules in the 64-71 GHz band with those for operations at 57-64 GHz, CORF noted that the 57-59.3 GHz sub-band is vitally important for weather forecasting from satellite remote sensing instruments, which cannot be moved to another frequency. CORF strongly urges the Commission to use great caution before authorizing aeronautical transmissions at 57-59.3 GHz and recommends further study of real-world transmission scenarios in aircraft prior to authorizing unlicensed airborne use of this band. Alternatively, the Commission

[2] CORF hereby moves for leave to file these Reply Comments after the filing deadline. The public interest would be served by accepting the Reply Comments, since the proposals discussed herein would directly impact radio astronomy observatories and Earth remote sensing assets, and only two other RAS or EESS parties have filed any information regarding that impact or the proposals to limit that impact. Thus, these Reply Comments will provide information important for the Commission's consideration in this proceeding. Further, no parties will be harmed by the acceptance of these Reply Comments, since the formal pleading cycle has ended, and, in any case, it is expected that some parties will continue to add to the record in ex parte filings.

should consider (1) making any service at 57-59.3 GHz licensed and requiring aircraft operator licensees to retain responsibility for ensuring that radio frequency (RF) leakage levels are below required threshold levels (for the aggregate transmissions from the aircraft) if aeronautical operations are permitted or (2) in the absence of better data, prohibiting airborne use of WiGig Channel 1 (57.24-59.4 GHz). CORF also notes that unwanted and spurious emissions of the second and third harmonics of 64-71 GHz are a concern for RAS facilities and recommends placing emission limits and/or defining exclusion (or coordination) zones, accounting for aggregate interference from multiple transmitters.

The comments submitted to the FCC by other parties in support of unlicensed use of 57-64 GHz devices on aircraft do not address the resulting interference impact on critical satellite remote sensing instruments. EESS has primary allocation at 56.9-59.3 GHz.[3] The importance of this band and the need for protection extends well beyond purely scientific uses. The 57-59.3 GHz range is used to measure global atmospheric temperature from Earth-orbiting satellites. Data from this band are assimilated into weather forecast models and, as set forth in CORF's comments (at page 12), are a large factor in weather forecast accuracy. Interference in this band would substantially degrade weather forecasts, with significant potential impacts on the U.S economy and public safety.

Commenters supporting airborne use of this band have not addressed the impact on EESS. Commenters did address very generally the potential impact on RAS

[3] The measurement of the atmospheric temperature from this band is also crucial for monitoring the atmospheric temperature over longer time scales and observing possible drifts in time. Thus, this band also plays a vital role in Earth climate studies.

observations.[4] In connection with protection of RAS, the Boeing Company comments assert (at page 13) that "modern aircraft can be expected to provide 35 dB of fuselage attenuation", based on Report ITU-R-M.2319. However, ITU-R-M.2319 obtained its data from studies in Report ITU-R-M.2283. In Section A-3.7 of ITU-R-M.2283, equations are given showing the variation of attenuation to be expected at different angles, based on experimental data. The values range from 10 dB to 60 dB, depending on the angle (see Figure 1 below). The equations also show that little or no attenuation above 10 dB is expected for a relatively large range of angles. Based on ITU-R M.2283, which provided the data for ITU-R M.2319, it is therefore more appropriate to adopt a value of 10 dB for fuselage attenuation, rather than 35 dB.

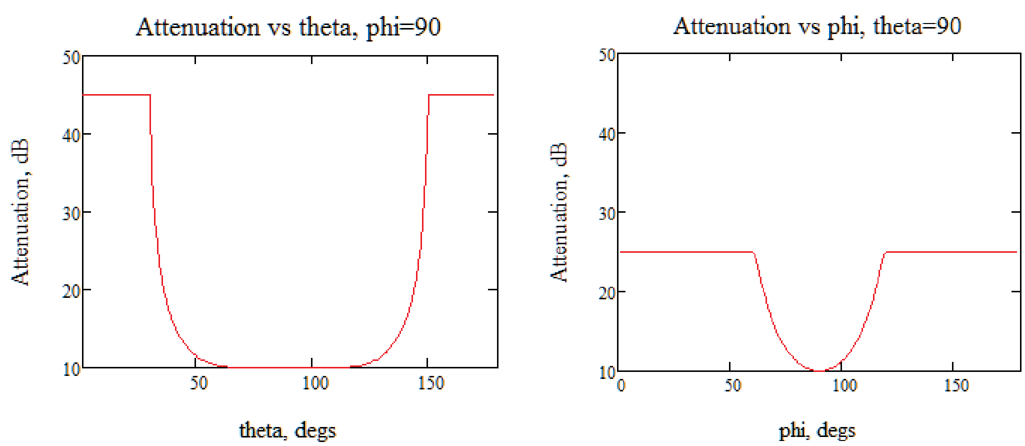

Figure 1. Attenuation through the aircraft as calculated in ITU-R-M.2283. The plots show that for a wide range of angles, particularly toward the passenger windows, there is little attenuation of signals to the outside of the plane.

[4] The concerns expressed in these Reply Comments regarding harmful interference to EESS instruments also apply to RAS observations from the harmonics of airborne transmissions in this band. While RAS does not have allocations at the 64-71 GHz Band, it does have co-primary allocations at 111.8-114.25 GHz, 130-134 GHz, 136-148.5 GHz, and 192-213 GHz. These harmonic bands are subject to protection due to allocations for RAS, as well as pursuant to Footnote US342. In addition, RAS has a co-primary allocation at 114.2-116 GHz, subject to protection pursuant to Footnote US246.

CORF also notes that the 35 dB value adopted in ITU-R-M.2319 was specified for *shielded windows* (see Table A-3.3, footnote), as described in Table 5 of ITU-R-M.2283, which Boeing made no mention of. In CORF's opening comments (at page 14), CORF recommended a requirement of RF-reflective window films as a prerequisite to permitting airborne emissions in the 57-59.3 GHz band.

In its support for airborne use of this band, Microsoft asserts (Comments at pages 12-13) that:

> "The cabin is pressurized. Additionally, there are lots of objects within the close confines of the aircraft cabin to block, scatter, and absorb 60 GHz transmissions (and harmonics) before they could exit the aircraft. Any remaining emissions must travel through a two pane acrylic window with an abrasive-resistant coating such as some representative models manufactured by GKN Aerospace 33 at an angle not only to exit the moving aircraft but one that allows the emission to be collected by a radio telescope some distance away. Additionally, there will always be a percentage of passenger window shades that are drawn."

However, cabin pressurization, even to sea level, provides atmospheric attenuation of less than 1dB/100 m at 57.3 GHz[5] and is, therefore, not a factor. Object scattering within the aircraft does nothing for line-of-sight paths and was already considered in ITU-R-M.2283. Of greater concern is that there are few direct lines of sight between centrally located access points and user terminals, which are typically located on or near the laps of users. The result is that access points will attempt to use scattered and reflected signals to maximize throughput. Walls of the aircraft near the windows are thus likely to be favored "bounce" sites. The dielectric loss tangent of PMMA (acrylic, window material) is roughly 5 x 10^{-3}, leading to minimal attenuation, while the dielectric

[5] *See,* Scott Paine, *The am Atmospheric Model*, SMA Technical Memo 152, Version 8.0, March 2014, Smithsonian Astrophysical Observatory. *Available at* https://www.cfa.harvard.edu/sma/memos/tech_no.html.

constant of acrylic is ~2.5, resulting in a normal incidence power reflection coefficient of just a few percent per reflective interface.[6] Without knowing the details of the window construction, it is difficult to calculate the net loss through the acrylic, but it is likely small (less than a few dB) based on these numbers. CORF is unaware of the materials properties of GKN Aerospace 33, but without a conductive or dissipative film, attenuation is likely small as well. Finally, the window shades are typically made of thermoplastics (exact materials are proprietary) that usually have low dielectric constants and loss tangents in the range 0.005-0.05, unless treated, making these shades a nonfactor for attenuation as well.[7] Furthermore, ITU-R-M-2283 at Section 4.3.1 already takes these factors into account, as well as the effects of incidence angles mentioned in Microsoft's response, and they therefore do not represent additional mitigation factors beyond those in ITU-R-M-2283.

Microsoft also states (Comments at page 13):

> [f]urther, with the large channels in the 60 GHz band, communications (video downloads) that might have to have been otherwise streamed at 2.4 or 5 GHz will appear to be transmitted almost instantaneously – little blips. With respect to WPAN device-to-device communications at 60 GHz, the data transmission will most likely occur when the devices are resting on the seat back table. Again the wide channel bandwidth should allow these types of communications to occur very quickly.

The relatively low duty cycle described, if true, supports the CORF proposal for allowing airborne transmission (if at all) only in WiGig bands 2-4 and prohibiting the use of 57-59.3 GHz, because the entire bandwidth is not necessary for the proposed application

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6 *See,* J. Baker-Jarvis, M.D. Janezic, B. Riddle, C.L. Holloway, N.G. Paulter, and J.E. Blendell, *Dielectric and Conductor-Loss Characterization and Measurements on Electronic Packaging Materials,* NIST Technical Note 1520, U.S. Department of Commerce, July 2001, at page 101.

7 *See*, Johnson, R.C., and Jasik, H., *Antenna Engineering Handbook 2nd Ed.,* Chapter 46, pages 4-5, McGraw-Hill, 1984.

and leaves 75% of the WiGig bandwidth for consumer applications.[8] The low band could be opened at a later date, pending the results of detailed interference studies, although as implicit in the Microsoft comments, the actual need for this bandwidth is dubious.

The Consumer Technology Association argues (Comments at page 9) that: forcing consumers to affirmatively disable Wi-Fi operation at 60 GHz (but not in the 2.4 GHz or 5 GHz frequency ranges) would cause needless confusion without reducing interference or generating another offsetting benefit. However, the Commission can protect the 57-59.3 GHz EESS band without impacting consumers by disabling the WiGig low-frequency channel on the aircraft-mounted access points. Furthermore, these access points could, in principle, automatically disable the low-frequency channel on all devices in range, eliminating the longer-term problem of device-device airborne communications. As Microsoft points out in their argument regarding the expected lowduty cycles (or "blips" as they refer to them), there will be no net impact on the user. If the FCC desires a simpler solution, it could require RF-shielding films sufficient to protect EESS instruments from harmful interference to be installed on the cabin windows as a condition of use.[9]

In its comments, the Intel Corporation states (at page 19):

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8 The WiGig standard created 4 channels, each with 2.16 GHz bandwidth, starting at 57 GHz. This creates an unfortunate overlap of 140MHz between the second WiGig channel and the EESS protected band. Our simulations show that at below 40,000 feet, the atmospheric attenuation between 59.16 GHz and 59.30 GHz is never less than 40 dB, providing an additional 30 dB of margin over the risk at 57.3 GHz. We therefore do not believe the second WiGig channel presents an interference risk for aircraft below 40,000 ft.

9 Table 5 of ITU-R-M-2283 is premised on the idea that aircraft "fitted with shielded windows" have somewhat greater attenuation than other aircraft. In any case, if the Commission authorizes airborne use of this band, any successful approach to limiting harmful interference to critical EESS weather observations will have to be based on the fact that with multiple internal network transmission nodes and passenger devices, the entire airplane will be *one aggregate* emitter.

> [a]s the Commission further notes, there are difficulties in enforcing the current prohibition [on airborne use of this band]. It essentially relies on user self-enforcement, since the devices have no way of knowing when they are onboard an aircraft, unless the user manually sets the device to airplane mode. The alternative proposal of potentially limiting the frequency range does not seem advantageous and would also require self-enforcement, since any reduced frequency range would only be enabled when aboard aircraft, and that would be manually set by the user.

CORF agrees that user self-enforcement for unlicensed devices, in general, presents some difficulties. The current situation exists because there are no 1G/2G/3G/LTE terminals on the aircraft to inform the devices that they are airborne. That is not the case, however, for WiFi and WiGig with access points installed on the aircraft. CORF therefore recommends controls on the access points, specifically disabling access point transmissions in the 57-59.3 GHz band, while permitting unrestricted use of the three higher-frequency WiGig channels. Furthermore, because the access point, in principle, can inform the devices that they are operating on an aircraft, the consumer devices can then be automatically switched to airplane mode, solving the enforcement problem. That connection to the WiGig network provides the opportunity to automatically enforce the 1G/2G/3G/LTE broadcast prohibition in flight, resolving a long-standing enforcement issue.

II. The RAS Band at 42.5-43.5 GHz Must Be Protected.

The NPRM seeks comments on what services (if any) should be allocated at 42.0-42.5 GHz and how services allocated in that band would protect the neighboring 42.5-43.5 GHz band allocated to the RAS.

As noted in CORF's opening comments in this proceeding, frequency lines at 42.519, 42.821, 43.122, and 43.424 GHz (for observations of silicon monoxide) are among those of greatest importance to radio astronomy.[10] The 42.5-43.5 GHz band is important for detection of strong silicon monoxide maser emissions from stars and star-forming regions. Measurements of these masers yield important information on stellar temperature, density, wind velocities, and other parameters. The 42.5-43.5 GHz band is also one of the preferred RAS bands for continuum observations.[11] The detrimental levels for continuum and spectral line radio astronomy observations for single dishes are -227 dBW/m^2/Hz and -210 dBW/m^2/Hz, respectively, for the average across the full 1 GHz band and the peak level in any single 500 kHz channel (ITU-R RA.769, Tables 1 and 2, respectively). For observations using the entire Very Long Baseline Array (VLBA), the corresponding limit is -175 dBW/m^2/Hz. Careful studies will be required to determine whether mobile and/or where fixed point-to-point stations in the 42 GHz band can operate consistent with protection of RAS facilities observing in the 42.5-43.5 GHz band.

Notably, there was little support in the record for additional allocations at 42.0-42.5 GHz. Boeing urged the Commission to move forward with a prior proposal to authorize Fixed Satellite Service (FSS) operations in the band. Recognizing the vulnerability of RAS observatories to satellite downlinks, Boeing states (at page 10) that "FSS gateway station locations can be selected to ensure adequate geographic separation from sensitive RAS sites." This may be challenging, in light of observations at 42.5-43.5 GHz at the 10 sites of the VLBA.

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[10] *See, Handbook on Radio Astronomy* (ITU Radiocommunications Bureau, 2013) at page 37, Table 3.2.

[11] *Id. at* page 35, Table 3.1.

The minimum distance between prospective FSS stations and RAS sites will need to be calculated for each individual case, based on factors such as altitude and surrounding terrain. Note that for high-altitude RAS or FSS sites, the Earth's curvature would provide the main screening. For Kitt Peak, Arizona, for example, using D(km) = 4.12*sqrt(H)(km), the result is a horizon distance, and thus the minimum distance for an FSS station would be about 160 km.

III. Conclusion.

CORF generally supports the sharing of frequency allocations, where practical, but protection of passive scientific observations, as discussed in its opening comments, must be addressed. CORF continues to urge the Commission to use great caution before authorizing aeronautical transmissions at 57-59.3 GHz and recommends further study of real-world transmission scenarios in aircraft prior to authorizing unlicensed airborne use of this band. Alternatively, the Commission should consider (1) making any service at 57-59.3 GHz licensed and requiring aircraft operator licensees to retain responsibility for ensuring that RF leakage levels are below required threshold levels (for the aggregate transmissions from the aircraft) if aeronautical operations are permitted or (2) in the absence of better data, prohibiting airborne use of WiGig Channel 1 (57.24-59.4 GHz). Similarly, careful studies would be required to determine whether mobile operations in the 42 GHz band can operate consistent with protection of the RAS facilities observing in the 42.5-43.5 GHz band and to determine where fixed or fixed satellite service operations could operate while protecting RAS observations in this band.

Respectfully submitted,

NATIONAL ACADEMY OF SCIENCES'
COMMITTEE ON RADIO FREQUENCIES

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DATE

Appendix

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