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

In the Matter of	)	
	)	
Request by Google LLC	)	ET Dkt. No. 18-70
For Waiver of Section 15.255(c)(3)	)	
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 March 12, 2018 *Public Notice* (PN) in the above-captioned docket.[2] While CORF supports the development of innovative technologies, in these comments, CORF expresses concerns about the potential impact of *airborne* use of the proposed Soli technologies on remote sensing satellite observations critical for weather forecasting.

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, as it represents the interests of the scientific users of the radio spectrum, including users of the Earth Exploration-Satellite Service (EESS) bands. These users perform extremely important, yet vulnerable, research.

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

2 CORF hereby moves for leave to file these comments after the filing deadline. The public interest would be served by accepting these comments, since Google's proposal could directly impact Earth remote sensing operations, and no other parties in this proceeding have filed information regarding that impact. Thus, these comments will provide information important for the Commission's consideration in this proceeding.

The Commission has also long recognized that satellite-based Earth remote sensing, including sensing by users of the EESS bands, is a critical and uniquely valuable resource for monitoring Earth and our 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 and security, and includes support for scientific research, commercial endeavor, and government operations in areas such as meteorology, atmospheric chemistry, climatology, and oceanography. Examples are measurement of parameters—such as ocean surface temperature, wind velocity, salinity, and precipitation rate over the ocean—needed to understand ocean circulation and the associated global distribution of heat. They also include monitoring soil moisture, a parameter needed for agriculture and drought assessment, and for weather prediction (heat exchange with the atmosphere) and even for defense (planning military deployment). Passive sensors provide temperature and humidity profiles of the atmosphere, information to monitor changes in the polar ice cover, and information needed in assessing hazards such as hurricanes, wildfires, and drought. Users of this data include the National Oceanic and Atmospheric Administration (NOAA), the National Science Foundation, the National Aeronautics and Space Administration (NASA), the Department of Defense, 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.

II. EESS-Remote Sensing at 57-59 GHz.

The primary concern for remote sensing scientists here is the 57-59.3 GHz sub-band, which is vitally important to weather forecasting. Instruments observing in this band include NASA/NOAA's Advanced Technology Microwave Sounder (ATMS)[3] and their Advanced Microwave Sounding Unit (AMSU-A),[4] and the Department of Defense's SSMI/S.[5] Virtually all weather forecast models utilize atmospheric temperature data derived from this band to initialize the models. Recent analysis has shown that the microwave temperature data from the AMSU-A is responsible for 17% of weather forecast accuracy, the largest single factor.[6] Because of this, CORF strongly urges the Commission to use great caution before authorizing rule changes or waivers that may result in aeronautical transmissions at 57-59.3 GHz.

Satellite observations between 50-60 GHz are used to measure the atmospheric temperature, and observations near the oxygen absorption line complex at 60 GHz are critical for the retrieval of the temperature profile. In particular, by making measurements at several frequencies along the side of the line and at points off the line, the atmospheric temperature as a function of altitude can be obtained. The algorithm depends on the variation of attenuation with altitude to retrieve the temperature profile. The potential for interference with these measurements also is a function of altitude. As observations move closer to the line, the atmosphere becomes less transparent and

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[3] *See,* http://www.jpss.noaa.gov/atms.html.

[4] *See,* http://disc.sci.gsfc.nasa.gov/AIRS/documentation/amsu_instrument_guide.shtml.

[5] *See,* https://nsidc.org/data/docs/daac/ssmis_instrument/ and http://mirs.nesdis.noaa.gov/ssmis.php.

[6] *See,* European Centre for Medium Range Weather Forecasts' weather forecast model, reprinted in National Research Council, 2012, *Earth Science and Applications from Space: A Midterm Assessment of NASA's Implementation of the Decadal Survey*, The National Academies Press, Washington, DC, https://doi.org/10.17226/13405, p. 20.

signals do not travel as great a distance. But, as altitude is increased, oxygen pressure decreases and the absorption adjacent to the line weakens. This also means that emissions from high altitudes are much less attenuated than those from low altitudes (see Fig. 1, below). For some terrestrial applications, the atmospheric attenuation may permit sharing between EESS (passive) and other services, such as mobile and fixed transmissions.

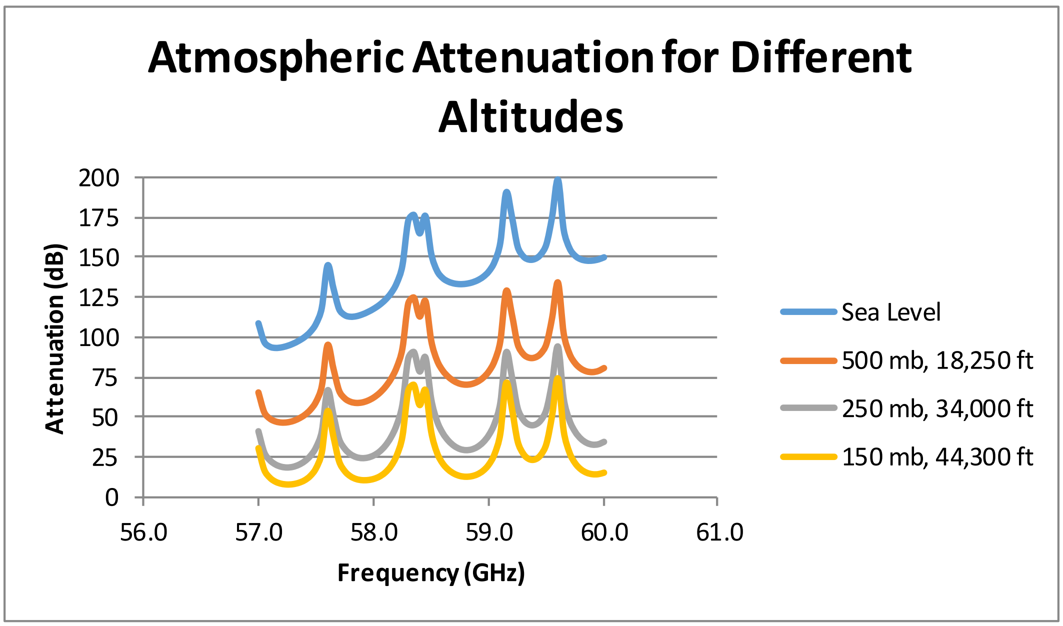

Figure 1. Atmospheric attenuation versus frequency for four different altitudes. (Data obtained using AM model, Harvard-Smithsonian Center for Astrophysics.)

However, airborne applications are a much different matter. For example, the NASA/NOAA ATMS instrument at 57 GHz observes a range of angles ranging from 0°-45°, with the nadir view 0° representing the worst case. ATMS has an antenna FWHM of 2.2° (or 38 dB gain), an orbital altitude of 824 km, a bandwidth of 330 MHz, and $\Delta T =$

$0.42K$.[7] For aircraft at 30,000 ft., the atmospheric attenuation, $e^{-\tau}$, at 57 GHz is -33dB, while at 40,000 ft. it is only -13 dB. As noted in previous filings by CORF regarding airborne use at 60 GHz,[8] for a 1 W transmitter with a dipole radiator in-band, at 30,000 ft., the ATMS would receive -149 dBm against a noise of -117 dBm for a line-of-sight (LOS) margin of 32 dB for unity signal-to-noise ratio. However, at 40,000 ft., ATMS will receive -129 dBm with a margin of only 12.5 dB.[9] While the proposed waiver would only increase the permissible peak transmit conducted power for an individual device to +10 dBm and a mean Equivalent Isotropically Radiated Power (EIRP) 20 dBm, well below the 1 W transmitter described above, there could be a large number of radiators (devices) on any given aircraft.[10] Accordingly, assuming multiple devices per aircraft, and multiple aircraft within a satellite footprint, the aggregate interference could rapidly exceed the ITU-R RS.2017 threshold levels for interference of -169 dBW, with a data loss rate of less than 0.01%, in this frequency range.[11]

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

[8] *See*, CORF Comments in GN Docket No. 14-177, filed January 21, 2016.

[9] Satellites operating at lower altitudes will have even less attenuation (e.g., satellites operating at an orbital altitude of 415 km, such as instruments hosted or released by the international space station, will have 6 dB less attenuation than high-orbital-altitude satellites).

[10] If one considers the case of only 10 users on an aircraft, each with a mean EIRP of 20 dBm, then the aggregate power approaches the 1 W case above. Indeed, if a single device were to have a line-of-sight to the satellite, through a lossless window on an older aircraft, for example, there would be a 22.5 dB margin for an aircraft at an altitude of 40,000 ft. and a satellite at 824 km. Thus, the proposed waiver to increase the permissible peak transmit power by a factor of 100 and mean EIRP by a factor of 10 has a substantial possibility of interfering with EESS (passive) observations at 57-59.3 GHz.

[11] Revisions to ITU-R RS.2017 are currently under discussion by ITU WP7C, so the current threshold levels for interference may be revised soon to reflect the improved sensitivity of EESS (passive) detectors.

III. Google Has Not Demonstrated That Its Proposal Would Not Harm Critical Remote Sensing Observations.

CORF shared all of the above information in the Commission's proceeding in GN Docket 14-177.[12] In its recent *Spectrum Frontiers Second Report and Order* in that docket, the Commission enacted rule section 15.255(c)(3), as part of a broader approach to allowing aeronautical use of unlicensed devices at 57-71 GHz.[13] However, that rule, and the related actions in the *Second Report and Order*, were based on very specific findings, relying on an interference study specifically exploring the potential impact of airborne 57-71 GHz radiators on remote sensing satellite observations.[14] While CORF does not endorse the conclusions of that study,[15] in any case, the technical premises of that study are not applicable to the Google proposal—that is, the architecture of access point stations affixed to the interior ceiling in commercial passenger transport aircraft to deliver internet/entertainment products wirelessly to travelers' laptops/tablets or to in-seat display monitors on the aircraft. This architecture was critical to the Commission's finding that transmissions were unlikely to go out

[12] In addition to the concerns regarding EESS (passive), CORF Comments on GN Docket 14-177 also raised concerns for Radio Astronomy Service (RAS) allocations from out-of-band emission at harmonic frequencies. In the context of the requested waiver of section 15.255(c)(3) at 57-64 GHz, CORF notes that RAS has co-primary allocations at the following harmonic frequencies: 114-116 GHz, 182-185 GHz, 226-231.5 GHz, 241-248 GHz, and 250-252 GHz. Of these primary allocations, all but 114.0-114.25 and 241-248 GHz are protected by international footnote 5.340, where all emissions are prohibited.

[13] *Use of Spectrum Bands Above 24GHz for Mobile Radio Services*, Second Report and Order, Second Further Notice of Proposed Rulemaking, Order on Reconsideration, and Memorandum Opinion and Order, FCC 17-152 (rel. Nov. 22, 2017)(*Spectrum Frontiers Second Report and Order*) at paras. 75-87.

[14] *Id.* at para. 83.

[15] The AVSI study assumed best case scenarios, including the assumption that the number of aircraft flying at high altitude would not increase from present day values. Of particular concern and relevance to the present filing 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, window materials, and cabin occupancy, among other parameters.

unshielded windows of aircraft and thus interfere with remote sensing observations.[16] Such a structured and limited architecture does not appear to be applicable to Google's proposal.[17]

More importantly, based on that study, the Commission limited transmission power levels to those set forth in Section 15. 255(c)(3). Google proposes to significantly increase those power levels, with peak transmit conducted power increasing from -10 dBm to +10 dBm, and peak EIRP from 10 dBm to mean EIRP 20 dBm. Yet nothing in the "Simulation Study" offered by Google addresses the potential impact on remote sensing observations.[18]

IV. Recommendation for Protection of Remote Sensing.

Google may have ignored the potential impact of its proposal on remote sensing because it does not anticipate the *aeronautical use* of the Soli-based devices for which it seeks a waiver. However, given the breadth of widespread consumer use that Google appears to seek with this technology, such use seems very likely. While the Commission could consider a prohibition on aeronautical use in granting a waiver to Google, such a prohibition would appear to be unenforceable.

CORF recommends, instead, that any grant of the waiver sought by Google specifically prohibit waiver-based transmissions at 57-59.3 GHz, where critical EESS

[16] *Id.* Again, CORF does not endorse that conclusion.

[17] *See,* https://atap.google.com/soli/ (at "Applications", viewed March 16, 2018) ("The Soli chip can be embedded in wearables, phones, computers, cars and IoT devices in our environment.")

[18] Shortly before the filing of these Comments, members of CORF and Google personnel began discussions regarding the technical issues discussed here. CORF hopes that these discussions will produce a mutually satisfactory result.

(passive) observations are at risk of interference from aeronautical use of these devices.

V. Conclusion.

CORF generally supports the sharing of frequency allocations, where practical, as well as the development of innovative technologies. However, the protection of critical remote sensing observations, as discussed herein, must be addressed.

Respectfully submitted,

NATIONAL ACADEMY OF SCIENCES'
COMMITTEE ON RADIO FREQUENCIES

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Appendix

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