Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of Request by Google LLC For Waiver of Section 15.255(c)(3) Of the Commission's Rules	ET Docket No. 18-70

REPLY COMMENTS OF GOOGLE LLC

Google respectfully responds to comments on its requested waiver[1] of Section 15.255(c)(3) of the Commission's Rules to allow for certification of devices containing Project Soli sensors at power levels consistent with European Telecommunications Standards Institute (ETSI) standard EN 305 550,[2] and offers several clarifications to address those submissions. No party's comments reflect opposition to ultimate

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[1] *See* Request by Google LLC For Waiver of Section 15.255(c)(3) of the Commn's Rules in ET Docket No. 18-70 (filed Mar. 7, 2018) (Petition). The Commission solicited comments on Google's waiver request on March 12, 2018. *See* Public Notice, *Office of Eng'g and Tech. Seeks Comment on Google's Request for Waiver of Section 15.255(c)(3) of the Comm'n's Rules for Radars Used for Interactive Motion Sensing in the 57-64 GHz Band*, ET Docket No. 18-70 (rel. Mar. 12, 2018).

[2] ETSI, *Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Short Range Devices (SRD); Radio Equipment to be Used in the 40 GHz to 246 GHz Frequency Range; Part 2: Harmonized EN Covering the Essential Requirements of Article 3.2 of the R&TTE Directive*, ETSI EN 305 550-2 V1.2.1 (Oct. 2014), *at* http://www.etsi.org/deliver/etsi_en/305500_305599/30555002/01.02.01_60/en_30555002v010201p.pdf (EN 305 550). Citation of an updated version of EN 305 550 including the same power levels in the Official Journal of the European Union is expected to occur by November 2018. *See* ETSI, *Short Range Devices (SRD); Radio Equipment to be Used in the 40 GHz to 246 GHz Frequency Range; Harmonised Standard for Access to Radio Spectrum*, EN 305 550, V2.1.0 (Oct. 2017), *at* http://www.etsi.org/deliver/etsi_en/305500_305599/305550/02.01.00_20/en_305550v020100a.pdf; ETSI, *Work Programme*, *at* https://portal.etsi.org/webapp/workProgram/Report_Schedule.asp?WKI_ID=46714.

approval of Google's requested waiver. Rather, some commenters support the waiver request,[3] while others ask that Google supplement the record with additional detail on potential interference.[4] Google here demonstrates that theoretical concerns raised by the National Radio Astronomy Observatory (NRAO) are not well-founded. With regard to coexistence between unlicensed operations and remote sensing satellite observations at 60 GHz, Google is working collaboratively with interested parties to collect additional technical data, and will update the Commission on that work at a later time.

A. Project Soli Technology Will Not Generate Negative Effects on the Radio Astronomy Service

NRAO expresses concern about the impact of spurious emissions from second and fourth harmonics from Soli operation, which theoretically could be radiated in bands allocated to the radio astronomy service. Google appreciates NRAO's engagement, but does not agree there is a basis for concern. Soli technology uses a continuous wave (CW) tone that sweeps across its 7 GHz operating bandwidth in the 57-64 GHz band. Its

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[3] *See* Comments of Cont'l Auto. Sys., Inc. in ET Docket No. 18-70 (filed Apr. 11, 2018) (stating that "[u]nless there is a reason to distinguish between the U.S. and Europe in light of the relevant circumstances involved, if a device complies with ETSI standards the risk of interference from applying the same limits in the U.S. is minimal."); OmniPreSense Corp. in ET Docket No. 18-70 (filed Apr. 11, 2018) (endorsing Google's request for waiver).

[4] *See* Comments of IEEE 802 in ET Docket No. 18-70 (filed Apr. 11, 2018) (requesting further study of potential interference caused by operation of short-range devices) (IEEE 802 Comments); Comments of Facebook, Inc. in ET Docket No. 18-70 (filed Apr. 11, 2018) (seeking further study of potential interference caused by operation of short-range devices); Comments of Nat'l Radio Astronomy Observatory in ET Docket No. 18-70 at 2 (filed Mar. 16, 2018) (saying "[i]t is possible that more study" could change its concerns); Comments of Nat'l Acad. of Sci.'s Comm. on Radio Frequencies in ET Docket No. 17-80 at 8 (filed Apr. 20, 2018) (generally supporting "sharing of frequency allocations, where practical, as well as the development of innovative technologies" but calling on Google to address the "protection of critical remote sensing observations") (CORF Comments).

second harmonic is 114-128 GHz, and its fourth harmonic is 228-256 GHz. Although Soli's harmonic emission levels have not yet been determined, the Part 15 value of 90 pW/cm^2 at a distance of 3 meters (equivalent to an EIRP of -10 dBm), which is the intentional radiator spurious emissions limit for frequencies up to 200 GHz , can be used for analysis purposes.[5]

Soli's CW instantaneous transmission during its sweep of the 57-64 GHz range is effectively zero bandwidth and, therefore, so is its harmonics. The effective power measured in a given bandwidth X, averaged over an interval greater than the Soli sweep time, is then given by

$$P_{eff}(X) = -10 \text{ dBm} - 10\log_{10}(BW_{SOLI}/X),$$

where BW_{SOLI} is the bandwidth of Soli's sweep range. This equation reduces Soli's transmit power by the fraction of time that Soli's signal is within the measurement bandwidth, given an effective power when averaged over a period of time greater than Soli's sweep rate. At the second harmonic, BW_{SOLI} = 2*7 GHz = 14 GHz, and at the fourth harmonic, BW_{SOLI} = 4*7 = 28 GHz.

Radio astronomy interference objectives are established in ITU-R Recommendation RA.769-2 (Rec. 769). There are separate objectives for continuum (broadband) observations across a reference bandwidth of 8 GHz and spectral line (narrowband) observations across a reference bandwidth of 1 MHz, based on a 2000 second integration time that is many orders of magnitude greater than Soli's sweep time. The table below shows the effective Soli power in the relevant reference

[5] *See* 47 C.F.R. § 15.255(d)(3).

bandwidth based on the effective power formula above, and the necessary isolation in dB and in distance (km) based on free space loss:

Harmonic	Rec. 769 Interference Objective	BW_{SOLI}	Rx BW (X)	$P_{eff}(X)$	Required Isolation	Isolation Distance (km)
2	-159 dBm/8 GHz	14 GHz	8 GHz	-12 dBm	147 dB	4.6
2	-179 dBm/MHz	14 GHz	1 MHz	-51 dBm	128 dB	0.5
4	-158 dBm/8 GHz	28 GHz	8 GHz	-15 dBm	143 dB	1.5
4	-177 dBm/MHz	28 GHz	1 MHz	-54 dBm	123 dB	0.1

The “Isolation Distance” column shows the separation distance between a single device integrating Soli technology and a radio astronomy facility that is needed to meet the required interference objective, based only on free space loss. Importantly, this includes no consideration for any mitigating factors. At these frequencies, however, mitigating factors can be substantial. For example, NRAO’s concerns relate specifically to airborne use. Attenuation from the inside of an airplane to the outside at 116 or 230 GHz is likely significant. To achieve a separation distance within than the values listed above, an airplane would need to be nearly overhead of the radio astronomy facility on the ground. Hence, the relevant factor is the loss from the passenger compartment, through the interior floor, through materials in the cargo hold, through the floor of the cargo hold, and out of the airplane’s bottom skin. It is reasonable to assume such losses are at *least* 10 dB, and most likely *much more*.[6]

[6] Worst-case spurious emissions of a device integrating Soli technology are likely to be out of the front of a device (where the fundamental emissions are pointed) instead of the bottom, and the user’s hand/body or a tray table (or both) below the device would add additional loss, although those factors are not included here.

If the highly conservative 10 dB factor is considered, the worst-case required isolation (i.e., protection of continuum emissions from second harmonic emissions) becomes 137 dB, which corresponds to a free space loss distance of only 1.5 km (5000 ft) between the aircraft and the radio astronomy site. For this scenario to pose a concern, a radio astronomy site would need to be located directly below the approach path to a nearby airport, in which case many other RF interference problems would also be present. No realistic scenario likely exists under which a device including Soli technology on an aircraft would interfere with an actual radio astronomy facility.

Especially given the narrow scope of the requested waiver (which covers only Google devices), it is extraordinarily unlikely that there would be multiple users simultaneously using Soli technology on an airplane during its landing directly above a radio astronomy site. Even in this implausible hypothetical situation, however, the use of more realistic mitigating factors would lead to extremely large interference margins, offsetting almost all conceivable concerns. For example, one additional mitigating factor not included is Soli's transmit duty cycle, further discussed below, which reduces its average power proportionately.

Based on these considerations, NRAO's theoretical concerns over airborne use of Soli technology pursuant to the requested waiver are unfounded for real-world operations.

B. Additional Information About Google's Request for Waiver and Soli Technology Should Alleviate Commenters' Concerns.

Google also notes several points that should alleviate other commenters' concerns.

- *Scope of the Waiver Request.* IEEE 802's arguments about co-existence between the Soli technology and other radio features in the same device seem to stem from confusion about the scope of Google's waiver request. For clarity, Google has asked to operate Soli technology at the requested power levels only in devices for which Google is the responsible party under the Commission's device authorization rules.[7] IEEE and the Commission needn't be concerned about in-device co-existence for Google's own devices. Similarly, in its late-filed comments, CORF anticipates widespread simultaneous airborne use of Soli-based devices.[8] In the context of this waiver request that encompasses only Google devices, however, CORF's concerns are particularly implausible.

- *Duty Cycle of Soli Technology.* IEEE 802 mistakenly assumes that Project Soli will operate at a 100% duty cycle.[9] This may be the result of a hypothetical scenario featuring a 100% duty cycle—presented as a conservative benchmark—included in the Lovefield Wireless report accompanying Google's request for waiver. In actual operation, however, devices incorporating Project Soli technology will operate at a much lower duty cycle. For instance, a duty cycle of 0.1% would reduce a Soli device's time-averaged output power by some 30 dB.

- *Highly conservative assumption in WiGig simulation study.* On page 14, the Lovefield Wireless report states the following "worst case assumption" underlying its analysis:

  > To sweep through one Wi-Fi channel takes less time than the duration of one Wi-Fi OFDM symbol duration (~242 us, see Table 1). Hence, a Wi-Fi data packet transmission is usually affected by multiple repeated sweeps. For this reason, the out-of-channel time is ignored and a continuous interference (worst case assumption) is assumed.

  This assumption that a single WiGig OFDM symbol will be repeatedly affected by Soli emissions, and that WiGig will be continuously affected, led Lovefield Wireless to the highly conservative results in its paper. The considerable amount of time during which Project Soli technology will not

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[7] *See* 47 C.F.R. § 2.909(a) (explaining that for equipment requiring a grant of certification, the "party to whom that grant of certification is issued is responsible for the compliance of the equipment with the applicable standards.").

[8] *See* CORF Comments at 7. Because CORF filed its initial comments only one business day before the due date for reply comments, Google will offer a fuller substantive response to CORF at a later date.

[9] IEEE 802 Comments at 1 (stating that "it is not clear whether a device operating at 100% duty cycle would cause harmful interference to IEEE 802.11 devices while operating at the proposed power levels").

interfere with the channel can be taken into account to the extent there are concerns about the requested waiver. Google's forthcoming data submission will include analysis conforming Lovefield's results to this real-world circumstance, in response to the comments received.

Google hopes that these clarifications enhance commenters' understanding of Project Soli technology and assist the Commission as it analyzes the request for waiver. Google continues to collaborate with interested parties about their concerns and will submit additional technical analyses from these efforts to the Commission.

CONCLUSION

Concerns raised by NRAO about the potentially negative effects on the radio astronomy service by airborne use of Project Soli technology are unwarranted. Other commenters' concerns arise from unrealistic assumptions as well. Grant of the requested waiver, allowing Google devices with Project Soli technology to operate at EN 305 550 power levels, will be appropriate upon the submission of forthcoming supplemental data.

Respectfully submitted,

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