facebook

July 20, 2018

VIA ELECTRONIC FILING

Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street SW
Washington, DC 20554

RE: Request by Google LLC for Waiver of Section 15.255(c)(3) of the Commission's Rules, ET Docket No. 18-70

Dear Ms. Dortch:

Facebook, Inc. ("Facebook") respectfully requests that the Commission continue to study concerns raised by the request of Google LLC ("Google") for waiver of Section 15.255(c)(3) of the Commission's rules.[1] As Facebook noted in its Reply Comments in response to the Request for Waiver,[2] Google has not demonstrated that operating Project Soli radars would not cause harmful interference and adversely impact other devices operating within the 57-64 GHz ("60 GHz") band—specifically, point-to-point communications between short-range devices ("SRDs").

Google's Request for Waiver does not demonstrate that Soli radars have a mechanism to adequately share spectrum with unlicensed SRDs in the band. Contrary to Google's recently filed supplemental analysis,[3] Facebook's own analysis, included as Appendix 1, shows that an SRD operating in close proximity to a Soli radar will be significantly more degraded than an SRD operating in close proximity with another SRD.

Accordingly, the Commission should not grant Google's Request for Waiver unless Google can meet the following conditions: *(i) Google should demonstrate that Soli radars can coexist and share spectrum fairly with 802.11ad/ay SRDs, including taking into account the SRD transmitter blocking demonstrated in Appendix 1*; and (ii) *any waiver granted should be*

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1 47 C.F.R. § 15.255(c)(3); *see* Request by Google LLC for Waiver of Section 15.255(c)(3) of the Commission's Rules, ET Docket No. 18-70 (filed Mar. 7, 2018).

2 *See* Reply Comments of Facebook, Inc. ET Docket No. 18-70 (filed Apr. 23, 2018).

3 *See* Letter from Megan Anne Stull, Counsel, Google LLC to Marlene H. Dortch, Secretary, FCC, ET Docket 18-70 at 3 (filed Jun. 8, 2018) ("Google Supplemental Analysis").

conditioned on the specific operating modes and modification to the operation of Soli radars needed to achieve coexistence and address the concerns raised in Appendix 1.

I. In Close Proximity, a Soli Radar Causes Greater Degradation to an SRD Link than the Presence of Other SRDs.

Google's supplemental analysis states that Soli technology can "cooperatively share" with SRD links in the 60 GHz band.[4] This is not the case in close proximity—within 1 meter. For example, if a person is using or wearing multiple 60 GHz 802.11ad/ay (or "WiGig") devices at the same time, the devices would be required to share spectrum within very close proximity. In the case of a person using or wearing multiple 60 GHz WiGig SRDs, the SRDs can frequency hop among three different WiGig channels in the 60 GHz band to find an open channel leading to little to no degradation for up to three devices. If a person is using one Soli device and one SRD at the same time, the Soli radar does not frequency hop. Instead, the radar sweeps the full 7 gigahertz of spectrum within the band. As discussed in more detail below, Facebook's own simulation and analysis shows that in this scenario, the Soli radar can block the SRD transmitter and as well as significantly degrade the SRD's throughput.

Facebook acknowledges that Google's supplemental analysis includes a simulation of Soli radar located at short distance from a Wi-Fi station, the "Scenario SHORT_RANGE"[5] as well as lab validation measurements.[6] In the "SHORT_RANGE" scenario, a Soli radar operates in close proximity to a Wi-Fi station, and under a theoretical duty cycle of 100%, the simulation shows no harm to Wi-Fi throughput 80% to 90% of the time.[7] This scenario analysis and Google's lab validation measurements are insufficient in three key ways. First, the simulation does not use accurate assumptions about the potentially impacted 802.11ad devices. Second, the simulation does not account for the detrimental impact of the increased packet error rate (PER), and the lab validation measurements fail to measure latency. And third, Google's lab measurements were not conducted under the operating conditions requested in Request for Waiver.

Inaccurate Assumptions about 802.11ad Coexistence Framework. Google's analysis does not adequately account for the 802.11ad devices' built-in coexistence framework (listen-before-talk or "LBT") and, therefore, fails to capture a key problem of coexistence between Soli radars and SRDs at the requested higher power. The lower measured throughput degradation among Wi-Fi transmissions in Google's analysis assumes that the transmitter is able to transmit

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4 *Id.*

5 *See id.* Attachment A at 22-24.

6 *See id.* Attachment B.

7 *See id.* Attachment A at 24.

in the first place. But, in fact, as Soli radars sweep, an 802.11 ad-based SRD would use clear channel assessment (CCA) prior to transmitting. And the end result is, that in close proximity, the operation of Soli radars at higher power levels can result in the blocking of SRD transmitters, thereby disproportionately impacting SRD performance.

Failure to Account for Impact of Decreased PER on 60 GHz SRDs. Existing mid-band (2.4 GHz and 5 GHz) Wi-Fi implementations are often designed to tolerate a PER of 10%. However, one of the benefits of the 60 GHz band is that it enables very high throughput, low latency applications, such as high-quality audio and interactive video. Because such applications are sensitive to latency, they rely on a PER of less than 1%. Google's simulation does not account for this sub 1% PER requirement. And Google's lab validation measurements track only throughput of uplink and downlink traffic and do not measure latency, thus failing to capture increased latency that would be detrimental to the latency-sensitive applications that are expected to be deployed in the band.

Inadequate Lab Validation Measurements Conditions. Google's lab validation measurements[8] were not conducted under the conditions requested in the waiver. As Google acknowledges, the duty cycle studied in the Google lab measurements is *"based on actual expected device characteristics, and is lower than the duty cycle Lovefield Wireless conservatively assumed in its simulations*."[9] The duty cycle for the Infineon device (used as the Soli device) is 37us with 1400Hz repeat rate, which translates to a 5% duty cycle spanning 6 GHz, or a 1.67% duty cycle over the 2 GHz spectrum used by WiGig devices. Such a comparison could show a higher throughput for a coexisting WiGig device than for two WiGig devices operating co-channel, as demonstrated by Google, but only under benign latency and reliability targets. Therefore, this comparison does not demonstrate that a Soli device operating to the limits of the requested waiver would share the spectrum fairly.

II. Facebook's Simulation of Close Proximity

Facebook conducted a simulation that studies the impact of a Soli radar device on 802.11ad SRD devices within close proximity (ranging from a 1 meter squared to a 4 meter squared confinement area). Within the 1 meter by 1 meter confinement area, the orientation of the SRD link and the Soli transmitter are restricted to simulate the impact of the same user using both devices simultaneously. A presentation of the simulation model and results are attached as Appendix 1. The simulation model includes analysis of the SRD link randomly distributed with respect to Soli's position. Two metrics are examined: the probabiltity of blocking an SRD transmitter and the carrier-to-interference ratio. Both metrics are needed to to give a relatively complete evaluation of SRD/Soli coexistence. Additionally, the appended simulation does not consider sophisticated MAC layer operations which may be more affected by the Soli radar. The key results of the Facebook's simulation model are as follows:

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[8] *See* Google Supplemental Analysis, Attachment B.

[9] *Id*. Attachment B at 3. (emphasis added).

SRD Transmitter Blocking. The simulation shows that the Soli radar sweep triggers the SRD's CCA mechanism, and as a result, the SRD transmitter can be blocked, resulting in increased latency and throughput degradation. The Soli radar's 7 gigahertz frequency sweep takes significantly longer than the 802.11ad slot time (600us versus 5us). And during that slot time, it is possible that the Soli sweep is the only tone generated within the SRD's 2.16 gigahertz bandwidth, thus triggering the SRD's CCA. The simulation model shows that in a 4 meter by 4 meter room the probability of blocking is 0.5 percent. But at closer proximities the probability of blocking increases rapidly. If the Soli device is on the same person using the SRD device, the probability of blocking increases to 15 percent. If an 802.11ay SRD were used, we believe that the probabilty of blocking could be twice as high because 802.11ay may use twice the bandwidth as 802.11ad.

Carrier-to-Interference Ratio (C/I) at the SRD. The appended simulation also shows the C/I at the SRD in the presence of a Soli device in the same room. In the simulations of closest proximity (*i.e.,* the same user using both devices simultaneously), the C/I degrades. When the devices are within +/- 45 degrees of each other, the SRD will attain MCS12 only 75 percent of the time. And in the worst case, when both devices are in line, the SRD's probability of attaining MCS12 drops to approximately 10 percent.[10]

III. Conclusion

In sum, Facebook requests that the Commission refrain from granting Google's Request for Waiver, as proposed. First, prior to granting any waiver, the Commission should require that Google demonstrate that Soli radars can coexist and share spectrum fairly with 802.11 ad/ay SRDs, including taking into account the SRD transmitter blocking due to 802.11ad/ay CCA mechanisms as demonstrated in the Appendix 1. Second, any waiver granted should be conditioned on the specific operating modes and any modification to the operation of Soli radars needed to achieve coexistence and address the concerns raised in Appendix 1.

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[10] Google's simulation of "SHORT_RANGE" showed similar results, but it did not include analysis of a Soli radar and SRD in close proximity with beams aligned, which increases the probability of reduced SRD throughput. *See* Google Supplemental Analysis, Attachment A, 22-24.

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Respectfully submitted by:

/s/ Alan Norman
Alan Norman
Facebook, Inc.
1 Hacker Way
Menlo Park, CA 94025

Appendix 1

Coexistence Simulation between SRD and Google Soli

Facebook, Inc.

07/16/2018

Objective

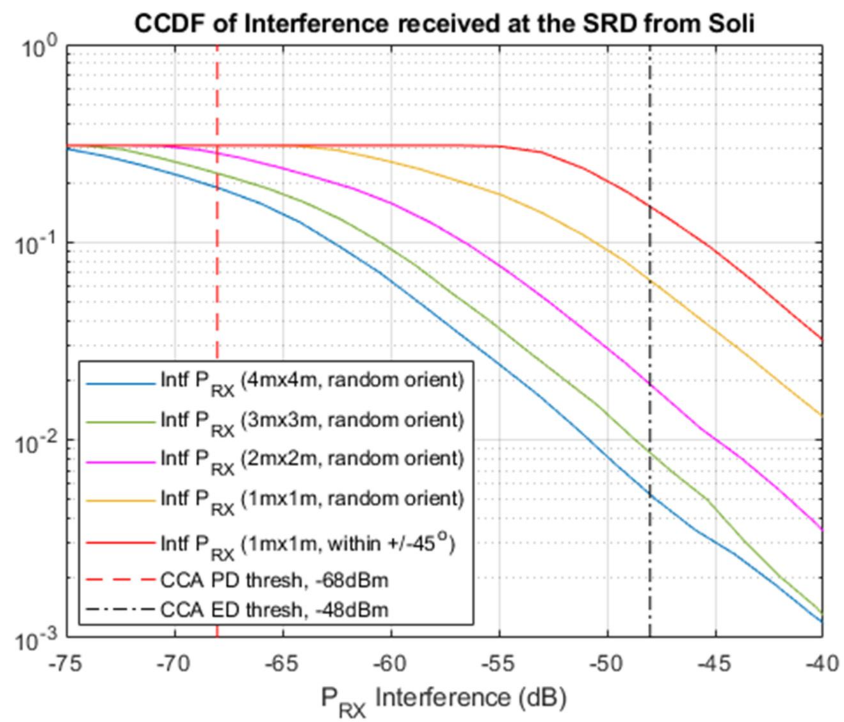
- To study the impact of Google's Soli radar device [1] on 802.11ad/ay SRD devices:
  - Show SRD blocking probability, assuming SRD receiver uses an Omni antenna pattern for clear channel assessment (CCA)
  - Show impact to C/I received at the SRD assuming SRD receiver uses directional beam for data reception

Setup

- A 4m x 4m room (maximum confinement area) in which one SRD link (TX and RX) and one Soli TX is placed randomly. The SRD link orientation is randomly distributed with respect to Solis position.
- Different smaller confinement areas (down to 1m x 1m) are applied to simulate the effect of Soli's position being correlated with SRD position. Also restriction of orientation is applied to both SRD and Soli to simulate the impact of the same user using both devices simultaneously.
- Soli Parameters
  - EIRP: 15dBm (10dBm conducted power + 5dBi antenna gain), requested EIRP is 20dBm.
  - Antenna: 5dBi patch antenna, 120deg 3dB-beamwidth, with FBR (front to back ratio) of 10dB.
  - Bandwidth: 7GHz
- SRD Parameters
  - EIRP: 25dBm (maximum), can be lower ~20dBm when higher modulations are used
  - Antenna pattern: 8x2 element phased array antenna, with 17dBi antenna gain, 12.5deg 3dB-beamwidth and 20dB FBR.
  - Bandwidth: 2.16GHz (802.11ad), 2x 2.16GHz (with 802.11ay carrier aggregation feature)

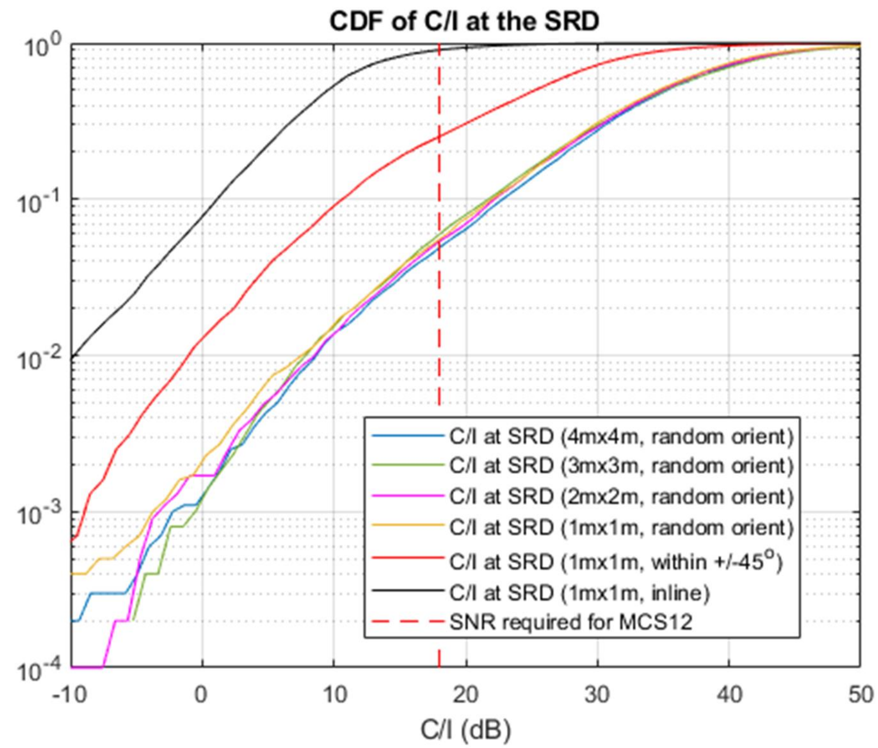
SRD blocking (CCA triggered)

- Soli performs a single frequency sweep of several CW tones across the 7GHz bandwidth in 600us [2]
- Since the 600us is significantly larger than a 802.11ad slot time (5us), only tone generated within the SRDs bandwidth (2.16GHz) is assumed to block the SRD by triggering its CCA.
- When the CW sweep instantaneously lies outside the SRDs bandwidth it is assumed that the CCA is not triggered. This provides a 70% reduction in blocking if SRD only use single carrier.
- The CCDF of the Interference received at the SRD after accounting for the bandwidth sweep is shown here, and it can be seen that the SRD is blocked
  - in 20% of the cases if Preamble Detection (PD) threshold is used.
  - But since Soli signals are non-11ad signals the Energy Detection (ED) thresholds should be used, which keeps the probability of blocking at around 0.5% for 4x4m room.
- At closer proximities (smaller room dimensions) it can be seen that the blocking probability increases rapidly.
- If the Soli device is on the same person using the SRD device, then it can be assumed that the Soli TX and SRD RX are within +/-45 of each other. In this case the blocking probability can be as high as 15%.
- Based on the ED threshold an SRD is blocked by Soli only if its within 0.6m from the Soli device.
- If 11ay SRD is used, performance may be twice worse than this.



C/I at SRD

- The plot shows the C/I at the SRD in presence of a Soli device in the same room.
- MCS12 (16QAM ¾) requires 18dB of SNR for detection with 1% PER.
- Probability of achieving MCS12 is around 95%, irrespective of room size as both interference as well as signal increases.
- However, in the case both devices are on the same person (i.e. devices within +/-45 degree of each other), then the C/I degrades, only in 75% cases will the SRD attain MCS12.
- In the worst case when both links are inline with each other, the probability of attaining MCS12 is ~10%, which is not acceptable.
- Note that this plot assumes a 25dBm EIRP from the SRD device, however if TX power backoff is required, then the curve moves left by the amount of backoff in dBs.
    - Typically, a 4-5dB backoff is applied when transmitting 16QAM, which would degrade the probability of achieving MCS12.



Impact of blocking on SRD performance

- SRDs target 10% PER (at the physical layer) for data traffic that doesn't require low latency or high reliability.
- On the other hand, for those SRDs that require high reliability and low latency the PER targets could be less than 1%.
- Soli doesn't perform LBT, and therefore, in addition to blocking SRD from initiating TX, it has the added impact that it can interfere with ongoing transmissions between SRDs.
- A 15% interfering or collision probability would prevent an SRD from attaining the targeted PER at the physical layer.
- In order to compensate for the interference, the link adaptation on the SRD adds sufficient margin to maintain the PER, which leads to selecting a lower/conservative MCS and results in a poorer throughput at the SRD.
- The margin to be added is proportional to the Soli device's proximity to the SRD device and the Soli device's transmit power, therefore keeping the power at FCC recommended values is desirable.

Reference

1. http://www.ivanpoupyrev.com/wp-content/uploads/2017/01/siggraph_final.pdf
2. https://ecfsapi.fcc.gov/file/10307158658894/2018-03-07%20Soli%20Request%20for%20Waiver%20%2B%20Simulation%20Study.pdf