April 10, 2018

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

Re: *Expanding Flexible Use in Mid-Band Spectrum between 3.7 and 24 GHz*, GN Docket No. 17-183

Dear Ms. Dortch,

On April 6, 2018, representatives from Broadcom Corporation, Cisco Systems, Inc., Facebook, Inc., Intel Corporation, Qualcomm Incorporated, and RKF Engineering Solutions, LLC, met with representatives from the Office of Engineering and Technology, the Wireless Telecommunications Bureau, and the International Bureau. A complete list of the participants in that meeting is attached to this letter. We discussed recent filings by satellite companies operating in the 6 GHz band, responding to an engineering analysis on band sharing prepared by RKF Engineering Solutions,[1] filed with the FCC on January 26, 2018. This letter responds to both *ex parte* letters, one filed jointly by Intelsat Corporation and SES Americom, Inc.[2] and one filed by Sirius XM Radio Inc.[3]

The Sirius XM letter makes broad claims about alleged deficiencies in the RKF study and the supposed interference risk, but lacks specific analysis to support those assertions. Although we have worked to surmise and evaluate the likely technical bases for Sirius XM's claims, the

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[1] RKF Engineering Services, *Frequency Sharing for Radio Local Area Networks in the 6 GHz Band* (Jan. 2018), *as attached to* Letter from Paul Margie, Counsel, Apple Inc., Broadcom Corporation, Facebook, Inc., Hewlett Packard Enterprise, and Microsoft Corporation, to Marlene H. Dortch, Secretary, Federal Communication Commission, GN Docket No. 17-183 (filed Jan. 26, 2018).

[2] Letter from Susan H. Crandall, Associate General Counsel, Intelsat Corporation, & Gerry Oberst, President, SES Americom, Inc., to Marlene H. Dortch, Secretary, Federal Communication Commission, GN Docket No. 17-183 (filed Feb. 23, 2018) ("Intelsat/SES Letter").

[3] Letter from Karis A. Hastings, Counsel for Sirius XM, to Marlene H. Dortch, Secretary, Federal Communication Commission, GN Docket No. 17-183 (filed Feb. 22, 2018) ("Sirius XM Letter").

Commission will be better served if future filers provide the details necessary to understand and evaluate them.

In contrast, Intelsat and SES constructively present specific technical objections to the RKF study. We disagree with those assertions, however, many of which appear to be based on significant misunderstandings of the study. Furthermore, Intelsat and SES do not face the most significant finding in the RKF study relating to sharing between the fixed satellite service ("FSS") and unlicensed operations in the 6 GHz band: that unlicensed operations will not add in any meaningful way to the interference that FSS already receives from fully coordinated fixed-service ("FS") deployments.

While Intelsat and SES disagree with the values RKF selected for a few simulation parameters—even though, in each case, RKF's parameters are highly conservative and based on real-world deployment data—such tinkering at the margins does not undermine the study's conclusion that the acceptable level of interference from currently deployed FS links into FSS systems dominates any interference FSS systems might receive from future unlicensed transmissions, even without employing any of the potential mitigation techniques proposed in response to the Notice of Inquiry.[4]

The RKF study thus continues to serve its intended purpose: demonstrating that unlicensed operations can share the 6 GHz band with licensed incumbents and providing the technical underpinnings for the Commission to proceed expeditiously to an NPRM.

Although Intelsat and SES question the efficacy of "unrestrained" unlicensed operations in the 6 GHz band, they do not oppose evaluating the various mitigation strategies supporters of expanded unlicensed spectrum have already included in comments in this proceeding. Rather, Intelsat and SES's central criticism of the RKF study is that it indicates that "mitigation techniques will not be necessary to accommodate sharing between unlicensed operations and satellite incumbents in the 6 GHz band."[5] We believe that Intelsat and SES's basis for criticizing this conclusion of the study is technically flawed. Nonetheless, we agree that the Commission should evaluate the necessity for mitigation measures, during the rulemaking phase of this proceeding, including techniques similar to those used in other unlicensed bands and discussed in the record.

In the following discussion, we address the specific technical points raised in the Intelsat/SES letter and how the RKF study already addresses and resolves them. We then respond briefly to the cursory assertions in Sirius XM's submission.

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4 *See* Reply Comments of Apple Inc., Broadcom Limited, Cisco Systems, Inc., Facebook, Inc., Google LLC, Hewlett Packard Enterprise, Intel Corporation, MediaTek Inc., Microsoft Corporation, and Qualcomm Incorporated at 16–23, GN Docket No. 17-183 (filed Nov. 15, 2017).

5 Intelsat/SES Letter at 3.

The RKF Study Chose a Conservative G/T Value that Is Representative of the Most Vulnerable Satellite Uplink Beams; the Higher G/T of Intelsat's Beams Is Offset by Far Smaller Geographic Coverage.

First, Intelsat and SES incorrectly claim that the gain-to-noise-temperature ("G/T") value used in the RKF study is unrealistic. As RKF explained in its report, the G/T value it selected was based on a thorough review of satellite systems with full-CONUS coverage beams (i.e., beams that cover the entire contiguous United States).[6] RKF conservatively focused on CONUS beams because such large coverage areas represent the worst-case aggregate interference to FSS systems. Wider beams generally exhibit lower G/T values while covering large areas where fewer unlicensed devices are operating on average (e.g., open water or areas of Central and South America), resulting in less overall interference. Conversely, narrower beams may exhibit higher G/T values, resulting in greater interference from unlicensed devices *within the beam*, but because they are far smaller, they capture interference from far fewer devices.

The Intelsat-35e system that Intelsat and SES highlight falls into the latter category. Although its spot beams may exhibit a higher G/T value than full-CONUS satellites, each spot beam also covers a much smaller area—and, therefore, far fewer unlicensed devices—than the worst-case CONUS beams RKF considered. According to Intelsat's technical disclosures to the FCC, Intelsat-35e uplink beams in the 6 GHz band have a -2 dB gain contour that covers only a fraction of the worst-case CONUS beams RKF considered.[7] This aligns with RKF's broader conclusion that "[a]lthough there are some higher G/T spotbeams[,] they cover small areas and see only a fraction of the total RLANs over CONUS."[8]

Intelsat and SES's Assumptions about RLAN Devices Are Either Unsupported or Less Conservative than those Used in the RKF Study.

Next, Intelsat and SES incorrectly claim that the RKF study hinges on three inaccurate assumptions about the use of RLAN devices. They assert that the study underestimates: 1) the outdoor usage rate, 2) the overall busy-hour device usage, and 3) the percentage of active on-tune devices at any given moment.

Intelsat and SES Propose an Unsupported Outdoor Usage Rate

First, in claiming that the RKF study underestimates the outdoor usage rate, Intelsat and SES point to an Electronic Communications Committee report ("ECC Report 244") to argue that the study should have used the 5.3% outdoor usage value from that report. However, the ECC

6 RKF Study at 39.

7 Intelsat and SES claim that the Intelsat-35e system produces a G/T value of 15.5 dB/K, but Intelsat's FCC filings indicate a peak G/T value in this band of only 11.0 dB/K. *See* Intelsat License LLC Application for Satellite Space Authorizations, IBFS File No. SAT-LOA-20160408-00034, at Attachment Beam Diagrams (filed Apr. 8, 2016).

8 RKF Study at 39.

report does not conclude that 5.3% of RLAN devices operate outdoors; it adopts this value for the purposes of calculation.[9] It does not conclude that this number is appropriate for the 6 GHz band—ECC Report 244 is focused on the 5 GHz band—or that it is accurate given U.S., as opposed to European, demographics and patterns of usage. Although Intelsat and SES assert that 5% is "a much more realistic estimate,"[10] they provide no support for this claim.

RKF, on the other hand, based its figure on real-world market research showing that only 1% of RLAN equipment sold, including both Wi-Fi access points and small-cell base stations, are used outdoors.[11] RKF then doubled this figure to add an additional, conservative margin, yielding a total of 2% assumed outdoor usage.[12] Intelsat and SES have provided no reason to reject this approach in favor of the 5% estimate included in ECC Report 244, for a different band. Moreover, that report incorporates a number of other assumptions that are far *less* conservative than the values and methodology that RKF used in its simulations. For example, compared to the RKF study, ECC Report 244 assumes that outdoor devices are lower power and that the average individual possesses far fewer RLAN devices. Accounting for these and other inconsistencies would forecast even less interference to FSS than the RKF study predicts. Intelsat and SES do not attempt to explain why the report's outdoor usage assumption should be adopted while other values in the same report should be ignored.

Intelsat and SES Misunderstand RKF's Busy-Hour Analysis

Second, Intelsat and SES incorrectly claim that the RKF study underestimates interference from devices being used during the so-called "busy hour," when internet usage peaks, by failing to account for the fact that different areas within a satellite's footprint will experience local busy hours at different, but partially overlapping, times.

In order to simulate worst-case interference, the RKF study focused on the one hour of the day where the entire continental United States exhibits busy-hour conditions simultaneously: 10:00 PM – 11:00 PM Eastern Time, or 7:00 PM – 8:00 PM Pacific Time. SES and Intelsat fault RKF for focusing on this worst-case interference and not also considering hours when either two or three—but not all—U.S. time zones experience local busy hours.

Adding those additional cases would make no difference to RKF's conclusions about worst-case interference. These "partial busy hour" cases would include fewer operational RLANs devices and, accordingly, less aggregate interference to FSS than the case RKF considered.

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9 Electronic Communications Committee, *ECC Report 244: Compatibility Studies Related to RLANs in the 5725-5925 MHz Band* § 2.3.3 (Jan. 29, 2016) ("ECC Report 244").

10 Intelsat/SES Letter at 2.

11 *See* RKF Study at 15 (citing Dell'Oro Group, July 2017 Wireless LAN report).

12 RKF Study at 13–14.

SES and Intelsat's Suggestion That RKF Should Assume Three Active Devices per User Would be Less Conservative than RKF's Actual Analysis Which Assumed Ten.

Intelsat and SES assert that the number of busy-hour devices should be "increased" to 3 per person, out of the 10 devices the RKF study allocates per person. But the RKF study conservatively assumed that *all ten* of the devices would be active, for every user nationwide. SES and Intelsat's claim appears to stem from a misunderstanding about RKF's division of devices into "high activity mode" and "low activity mode." Devices in "high activity mode" were assumed to exhibit activity levels equivalent to streaming a high-definition ("HD") video at a rate of 4.44 Mbps for home users, 2.22 Mbps for corporate users, and 1.11 Mbps for public hotspot users.[13] The remaining nine devices per user were also assumed to be active in a "low-activity mode." This distinction is consistent with user behavior.

In fact, RKF's assumption that every American streams HD video simultaneously and constantly during busy hour significantly overstates actual usage. For example, ECC Report 244 made the far less conservative—though potentially more realistic—assumption that only 50% – 70% of devices would be in use at all during busy hour, even though it "aim[s] to model peak RLAN activity rather than average RLAN activity."[14] Adding such a factor to RKF's analysis would have resulted in even lower levels of interference compared to RKF's actual predictions.

To the extent that Intelsat and SES claim that RKF should have assumed that three of a user's devices would be not just in use, but in high-activity mode, this assertion is clearly unrealistic. This would be equivalent to assuming that every person in the United States streams HD video on three devices at the same time, a scenario which is simply not credible.

RKF's On-Tune Percentage Figures Are Appropriate for the 6 GHz Band

Intelsat and SES incorrectly claim that the RKF study underestimates the fraction of instantaneously transmitting RLAN devices in the 6 GHz band, at 0.04%. RKF's derivation of this ratio is based on highly conservative technical considerations as described in section 3.1 and Table 3.1 of RKF's report. Intelsat and SES do not appear to take issue with any specific part of this analysis but only raise the general complaint that the results are lower than those assumed in ECC Report 244 regarding the "activity factor" of RLAN devices. That report, however, analyzed a different band, using a different methodology. It also embraced a number of assumptions that are not appropriate for the 6 GHz band and, in many cases, are inconsistent with some of Intelsat and SES's other suggestions (e.g., that each person simultaneously uses three devices during busy hour). Again, Intelsat and SES cherry-pick a few assumptions from that report, but ignore others that support RKF's analysis.

As explained above, one of the most important factors in predicting the percentage of the time that an RLAN device will transmit in the 6 GHz band is the bitrate of those devices. The

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13 RKF Letter at 14–15.

14 ECC Report 244 § 8.1.3.2.

RKF study reasonably assumes an average throughput of 1 Gbps, which is consistent with the RLAN technologies that will be used in the 6 GHz band, such as 802.11ax and 3GPP 5G NR.[15] Because 6 GHz would be a new RLAN band, it would be unrealistic to assume that it will be populated by inefficient—yet simultaneously heavily used—legacy devices. Notably, however, this accounts only for technologies available *today*. The RKF study conservatively disregards inevitable improvements in modulation and coding efficiency as technology progresses, which may be accelerated by the approval of additional spectrum. Without even considering population distribution and other differences,[16] adjusting the calculations for differences between 6 GHz RLAN technologies that the RKF report properly assumed, and the 5 GHz technologies considered in ECC Report 244, accounts for much of the difference between these two studies.

The RKF Study Incorporates Internationally Accepted Propagation Models and Only Accounts for Terrain Effects for Certain Satellites.

Surprisingly, SES and Intelsat contend that RKF should have used ITU-R P.452-16 to calculate interference from RLANs to FSS.[17] But ITU-R P.452-16 is intended only for "evaluat[ing] . . . interference between stations *on the surface of the Earth*."[18] This makes it plainly inappropriate as a general tool for modeling interference between RLANs and satellites.

The recommended ITU model for modeling Earth-to-space interference is ITU-R P.2109. RKF used this model to assess interference from urban and suburban areas. However, because P.2109 does not include clutter, uncritical use of this model for rural RLAN devices might not have a resulted in a suitably conservative result. Therefore, for rural areas, RKF used the far more conservative model that Intelsat and SES recommend—P.452—to analyze possible interference from rural RLANs. In every case, this resulted in less simulated loss due to clutter than P.2109 would have predicted, yielding, once again, a more conservative analysis.

The clutter models above were applied only for RLANs-to-FSS angles of less than 4.1 degrees. For larger angles—i.e., when the satellite is higher in the sky from the perspective of an RLAN device—RKF made the far more conservative assumption that *free space* propagation

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15 *See* RKF Study at Table 3-1. For example, the IMT-2020 peak spectral efficiency requirements for indoor hotspot downlink is 30 bits/s/Hz with an average of 9 bits/s/Hz. The next generation of RLAN technology standardized by IEEE which is expected in 2019, 802.11ax, and the 3GPP based 5G New Radio will have peak spectral efficiencies that greatly exceed this requirement. For example, 802.11ax has a peak throughput of 60 bits/s/Hz for both uplink and downlink. Even the far lower IMT-2020 average requirement of 9 bits/s/Hz implies a throughput of more than 1 Gbps in a 160 MHz channel.

16 The RKF study included nine demographic categories in its U.S.-based analysis. RKF Study at 1.

17 Intelsat/SES Letter at 2.

18 Rec. ITU-R P.452-16 at 1 (2015) (emphasis added).

conditions would apply. And in no case did RKF account for likely terrain losses, providing an even greater conservative margin.[19]

Intelsat and SES's Proposed Population Density Figure Would Not Produce Materially Different Results.

Intelsat and SES incorrectly claim that the RKF study is flawed because it assumes, based on Census Bureau data, that 90% of the U.S. population lives in 10% of the land area. Drawing on a blog post, Intelsat and SES claim that the U.S. population is actually slightly less geographically concentrated, with 90% of the people living, instead, in 15.44% of its geographic area.[20] It is not clear how the author of the blog post obtained his modestly different results. However, RKF's results are based on official U.S. Census Bureau Data and the National Aeronautical and Space Administration's Gridded Population of the World dataset. Although there may be room for disagreement at the margins in interpreting this data, Intelsat and SES have provided no reason to justify their assertion that a blog post provides more accurate data than the U.S. Government data used by RKF, which were based on the Census Bureau's own data and definitions.

In any event, while spatial distribution of RLAN devices plays a significant role in RKF's analysis, even if the Commission were to accept the figures cited by Intelsat and SES, the resulting geographic broadening of the outer edges of population centers would result only in a slight *decrease* in population concentration. This would have no material effect on the results. This minor effect would be lost in the noise when considering the extremely large margin demonstrated by the RKF report—more than 40x—between aggregate emissions from RLAN devices and those from FS transmitters.

Sirius XM Fails to Explain Why RKF's FSS Analysis Does Not Apply to Satellite-Radio FSS Systems.

Sirius XM, which uses only the top 50 MHz of the 6 GHz band for FSS uplink operations, broadly contends that the study fails to account for the "unique characteristics" of satellite radio networks in analyzing potential interference to FSS systems.[21] As a preliminary matter, the letter fails to identify any relevant unique characteristics. Although the *downlink* component of satellite radio systems may present challenges due to the unpredictable locations of its mobile receivers, the 6 GHz band is used for *uplink* transmissions. Based upon Sirius XM's own FCC filings, Sirius XM's uplink operations appear to be entirely typical of FSS systems. And although

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19 Due to a drafting error, the RKF report indicates that RLAN-to-FSS simulations employed the Irregular Terrain Model. *See* RKF Report at 32. In fact, however, this was used only for RLAN-to-FS simulations. No terrain model was used for the RLAN-to-FSS analysis.

20 Intelsat/SES Letter at 3 & n.13 (citing Joshua Tauberer's Archived Blog, *50% of the U.S. Population Lives in 1% of the Land Area*, https://joshdata.wordpress.com/2013/12/23/50-of-the-u-s-population-lives-in-1-of-the-land-area/ (Dec. 23, 2013)).

21 Sirius XM Letter at 1.

Sirius XM raises the possibility that RLAN devices might operate in close proximity to its relatively few uplink earth stations,[22] it ignores that its satellites use very wide uplink beams with nearly full-CONUS coverage, making RKF's aggregate-interference approach the most appropriate model for assessing uplink interference. Sirius XM's FM-6 satellite, for example, has a maximum gain contour—within which it exhibits no more than 2 dB reduction of the antenna's peak gain—stretching 4,600 km, approximately the distance from Los Angeles to Montreal.[23] This means that, contrary to Sirius XM's assertion, there is little difference, from an uplink interference perspective, between an RLAN transmission a few blocks from an earth station and one on the opposite coast. Therefore, the RKF study's aggregate interference analysis is a correct and conservative approach to analyzing potential interference to satellite radio systems.[24]

It is unclear from Sirius XM's filing whether it sought to raise concerns about other forms of interference. But, if so, it is difficult to discern what they could be. For example, one interpretation of Sirius XM's letter might suggest that it seeks to raise concerns about the possibility of an RLAN device operating in extreme proximity to a Sirius XM earth station uplink antenna introducing interference into the transmission directly through electromagnetic coupling, or some other similar effect. But this seems highly implausible, given the extreme power disparity between a satellite earth station uplink transmission and a low-power RLAN device, and Sirius XM's ability to control access to the earth-station facility.

Sirius XM also faults RKF for only assessing the probability of interference and not the "magnitude of the harm" on its satellite radio network or subscribers.[25] But RKF's analysis of potential RLANs interference to FSS considered in detail the magnitude of any probable interference. In particular, RKF concludes that interference from RLAN devices to FSS systems (which includes Sirius XM) will be far less than that already received from existing FS systems.

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22 *Id.* at 2.

23 Satellite CD Radio LLC Application for Space and Earth Station, IBFS File No. SAT-MOD-20110525-00099, at Attachment Technical Description § A.6, fig.A.6-2 (filed May 25, 2011). The uplink gain contour of the FM-6 satellite appears to be representative of other Sirius XM satellites. *See* Modified Application for Authority to Launch of Sirius XM Radio, Inc., Call Sign S2710, IBFS File No. SAT-MOD-20151211-00081, Completed Schedule S & Technical Narrative at 6, fig.A.6-7 (filed Dec. 11, 2015); Replacement Application for Authority to Launch of XM Radio LLC, Call Sign S2616, IBFS File No. SAT-RPL-20040212-00018, Narrative, App. A at 11-14, figs.A-2-A-5 (filed Feb. 12, 2004); Application for Authority to Launch of XM Radio LLC, Call Sign S2786, IBFS File No. SAT-LOA-20090217-00025, GXT file attachments (filed Feb. 17, 2009).

24 Notably, Sirius XM's system parameters are entirely consistent with RKF's broader G/T and coverage analysis. The Sirius XM receive beam exhibits a G/T of 2.9 dB/K with slightly less than full-CONUS coverage. This is consistent with RKF's worst-case analysis of 2 dB/K G/T with full-CONUS coverage. *See supra* p. 3.

25 Sirius XM Letter at 1–2.

Conclusion

Each of the issues raised in the Sirius XM and the Intelsat/SES filings have either already been addressed in the RKF study, are based on misunderstandings of the RKF study, or are simply incorrect. The study, which relies on conservative assumptions and realistic, well-supported parameters, supports FCC action to move ahead expeditiously with an NPRM. Even without special sharing protection, RLAN operations in the 6 GHz band are extremely unlikely to cause harmful interference to the satellite incumbents in that band. Although we agree with satellite incumbents that protection of FSS uplink operations is essential, their criticisms of RKF's study are misplaced and do not suggest that an NPRM should be delayed.

Sincerely,

Paul Margie
Counsel to Apple Inc., Broadcom Corporation, Facebook, Inc., Hewlett Packard Enterprise, and Microsoft Corporation

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