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
	)	
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	)	IB Docket No. 97-95

REPLY COMMENTS OF SAMSUNG ELECTRONICS AMERICA, INC. AND SAMSUNG RESEARCH AMERICA

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TABLE OF CONTENTS

I. INTRODUCTION AND SUMMARY 1

II. COMMENTERS AGREE THAT THE COMMISSION SHOULD MOVE FORWARD WITH ITS PROPOSALS TO UNLEASH ADDITIONAL SPECTRUM FOR MOBILE BROADBAND SERVICES 3

III. THE RECORD SHOWS THAT THE COMMISSION SHOULD CRAFT LICENSING RULES FOR THE ADDITIONAL BANDS WHICH PROMOTE FLEXIBLE AND EFFICIENT SPECTRUM USE. 6

IV. COMMENTERS SUGGEST CERTAIN ALTERATIONS TO THE COMMISSION'S PROPOSED TECHNICAL RULES..... 11

V. THE COMMISSION SHOULD CAREFULLY CONSIDER HOW TO EVALUATE SHARING MODELS IN THE MMW ENVIRONMENT..... 14

VI. CONCLUSION..... 14

APPENDIX

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REPLY COMMENTS OF SAMSUNG ELECTRONICS AMERICA, INC. AND SAMSUNG RESEARCH AMERICA

I. INTRODUCTION AND SUMMARY

Samsung commends the Commission on its commitment to accelerating the provision of Fifth Generation ("5G") mobile services in certain millimeter wave ("mmW") spectrum bands

above 24 GHz.[1] 5G technologies will revolutionize mobile, and their development is well underway. Commenters to the Commission's *Further Notice of Proposed Rulemaking*[2] broadly share Samsung's optimism about 5G's potential to transform how consumers experience mobile. In keeping with its commitment, and to secure the nation's leadership role for 5G services, the Commission should adopt a regulatory framework for the mmW bands that promotes new technologies and facilitates new services. By adopting clear rules for the additional bands consistent with the recommendations below, the Commission will improve wireless service, facilitate the growth of the "Internet of Things" ("IoT") and ensure a seamless transition to 5G.

Given the rapid evolution of 5G technologies, commenters agree that the Commission should act quickly in adopting a licensed regime for the proposed additional bands: 24.25-24.45 GHz and 24.75-25.25 GHz ("24 GHz band"), 31.8-33.4 GHz ("32 GHz band"), 42-42.5 GHz ("42 GHz band"), 47.2-50.2 GHz ("47 GHz band"), 50.4-52.6 GHz ("50 GHz band"), 71-76 GHz, and 81-86 GHz ("70/80 GHz bands"). Together, these bands offer 17.7 GHz of spectrum that will allow the next generation of wireless technologies to flourish, and the Commission should move full speed ahead to license these bands. As the Commission has noted, "[m]oving quickly to make this spectrum available in the near term will best enable potential users, technology developers, and innovators to have relative certainty about the spectrum structure in the mmW bands for these new uses."[3]

In these additional bands, the record also reflects widespread support for licensing and technical rules that promote flexible and efficient spectrum use. Millimeter wave spectrum 5G is

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[1] For purposes of these comments, "Samsung" refers to Samsung Electronics America, Inc. and Samsung Research America, collectively.

[2] Use of Spectrum Bands Above 24 GHz for Mobile Radio Services, *Report & Order & Further Notice of Proposed Rulemaking*, FCC 16-89 ("*Report & Order*" or "*FNPRM*").

[3] *Report & Order* ¶ 7.

a nascent market, and wireless ecosystem participants are eager to proceed with researching and developing new technologies. As a leading innovator in 5G technology, Samsung urges the Commission to not impose onerous requirements that would impede 5G's maturation. In particular, the Commission must tread carefully when considering cumbersome and untested sharing mechanisms in the additional bands, which may create interference issues and delay 5G deployment. Fostering the 5G ecosystem should be the Commission's top priority, as it is for the industry both in the United States and around the world.

II. COMMENTERS AGREE THAT THE COMMISSION SHOULD MOVE FORWARD WITH ITS PROPOSALS TO UNLEASH ADDITIONAL SPECTRUM FOR MOBILE BROADBAND SERVICES

5G represents the next frontier of innovation for the wireless industry, as has been well documented in this proceeding. Throughout this proceeding, industry has shared its vision of the promise of 5G: "[f]rom smart cities to connected cars to virtual reality, 5G will transform the mobile experience as we know it today, ushering in an array of paradigm-shifting applications and features."[4] 5G offers many benefits—unprecedented speeds, high data rates, and low latency—while making extremely efficient use of spectrum.[5] Millimeter wave technology will enable stunning new technological advancements in areas such as IoT, autonomous vehicles, and telemedicine. As the Commission noted, "the low latency of 5G technology will enable various IoT applications including wearables, fitness and healthcare devices, autonomous driving cars, and home and office automation."[6]

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[4] Comments of CTIA, GN Docket No. 14-177 at 2 (filed Sept. 30, 2016) ("CTIA Comments").

[5] Comments of AT&T, GN Docket No. 14-177 at 3 (filed Sept. 30, 2016) ("AT&T Comments"); Comments of Huawei, GN Docket No. 14-177 at 2-3 (filed Sept. 30, 2016) ("Huawei Comments"); Comments of Samsung, GN Docket No. 14-177 at 4-5 (filed Jan. 26, 2016) ("Samsung *NPRM* Comments").

[6] *Report & Order* ¶ 7.

Commenters applaud the Commission for its leadership in identifying additional mmW bands for mobile uses to support the evolution to 5G technologies. The meteoric rise in mobile broadband usage and the coming transition to 5G networks and services underline the need for more licensed spectrum.[7] In light of "increased consumer dependence on data-intensive applications, expanding demand for higher speeds and better connectivity, and the rapid growth of the IoT," the time is ripe for the Commission to determine how to meet the demand for mobile broadband.[8] By unlocking additional spectrum for mobile uses, the Commission will be taking an important step toward facilitating the transition to innovative 5G systems.

Commenters join Samsung in supporting the Commission's proposal to authorize flexible use licenses that would permit fixed and mobile services in the 24 GHz, 32 GHz, 42 GHz, and other bands.[9] This additional spectrum will spur development of 5G services, significantly improving the mobile experience of customers. Samsung and other commenters also see particular utility in allocating spectrum in the 24 GHz, 32 GHz, and 42 GHz bands,[10] which are in close proximity to spectrum already allocated for fixed and mobile use in the Commission's *Report & Order*. These bands "are attractive for prompt deployment because their proximity to the 28 GHz and 37-40 GHz bands presents possible opportunities for synergies and economies of

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[7] *See* Comments of T-Mobile, GN Docket No. 14-177 at 1 (filed Sept. 30, 2016) ("T-Mobile Comments").

[8] Comments of the Consumer Technology Association ("CTA"), GN Docket No. 14-177 at 3 (filed Sept. 30, 2016) ("CTA Comments"); *see also* CTIA Comments at 4-6 (discussing rise in mobile broadband usage and growth of the IoT).

[9] Comments of Samsung, GN Docket No. 14-177 at 3 (filed Sept. 30, 2016) ("Samsung Comments"); T-Mobile Comments at 3; Comments of Mobile Future, GN Docket No. 14-177 at 4 (filed Sept. 30, 2016) ("Mobile Future").

[10] *See, e.g.* Comments of Verizon, GN Docket No. 14-177 at 3 (filed Sept. 30, 2016) ("Verizon Comments"); CTIA Comments at 10.

scale."[11] Samsung believes this proximity will also accelerate technology development and minimize the number of bands user equipment will need to support.[12]

A range of commenters agree with Samsung that, in any spectrum identified by the Commission for mobile broadband use, it is vitally important to ensure that the U.S. efforts are aligned with the efforts of other governments internationally.[13] The United States should also support efforts in other countries to allocate bands for mobile that the Commission has not yet considered. Samsung notes that some spectrum bands adjacent to and including those identified by the Commission are also getting increased attention in other regions (*e.g.* "[t]he 24.25-27.5 GHz band is recommended as a pioneer band for Europe to be harmonized by 2020"[14]), and believes that similar harmonization efforts would be desirable. This conclusion is consistent with the Commission's own findings in other proceedings, where the agency has frequently highlighted international harmonization of spectrum as a key policy goal and endorsed the benefits of harmonization.[15] Indeed, for 5G in particular, "[i]nternational harmonization is crucial to enabling the most efficient deployment of next generation technology."[16] Global harmonization of spectrum bands for 5G services "reduces equipment cost, promotes greater

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[11] Verizon Comments at 3.

[12] Samsung Comments at 4-5.

[13] Huawei Comments at 2-3; AT&T Comments at 7-8; Samsung Comments at 4.

[14] European Commission (Radio Spectrum Committee), "Draft Mandate to CEPT to develop harmonised technical conditions in the Union for next-generation (5G) terrestrial wireless systems in EU-harmonised frequency bands and in frequency bands above 24 GHz" (working document), document RSCOM16-40, https://circabc.europa.eu/sd/a/2c305fdf-4265-44bf-95d2-b84a13a267d4/RSCOM16-40%205G%20draft_mandate_CEPT.pdf

[15] *See, e.g.*, Amendment of the Commission's Rules With Regard to Commercial Operations in the 1695-1710 MHz, 1755-1780 MHz, and 2155-2180 MHz Bands, *Report and Order*, 29 FCC Rcd 4610, at ¶ 42 (2014) ("International harmonization will enhance international roaming, create economies of scale that lowers device costs, speed deployment, and reduce interference potential near international borders.").

[16] CTA Comments at 4 (citation omitted).

economies of scale, and makes the use of 5G services outside of the United States more accessible."[17] In light of the benefits of international harmonization, the Commission should continue to make international alignment a priority in this proceeding.

III. THE RECORD SHOWS THAT THE COMMISSION SHOULD CRAFT LICENSING RULES FOR THE ADDITIONAL BANDS WHICH PROMOTE FLEXIBLE AND EFFICIENT SPECTRUM USE.

A. Commenters support licensing the newly allocated spectrum using Partial Economic Areas.

The Commission sought comment on licensing the additional spectrum bands aside from the 70/80 GHz band using Partial Economic Areas ("PEAs").[18] The record reflects widespread support for this idea. Commenters such as AT&T and T-Mobile agree that licensing the bands using PEAs would be optimal for 5G deployment.[19] As Samsung noted, PEA licensing would be consistent with the license areas instituted in the 39 GHz band and the upper band segment in the 37 GHz band, and maintaining consistency of the key characteristics among the already authorized mmW bands and the additional bands will enable the most effective use of the spectrum.[20] Moreover, PEA-based licensing would allow for rapid development of 5G networks under various use cases.[21] Larger license area sizes would also better accommodate the technical characteristics of the mmW spectrum and avoid administrative complexities.[22] The Commission should move forward with its proposal.

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[17] AT&T Comments at 8; *see also* Huawei Comments at 5 (harmonization will "result in important efficiencies and facilitate more rapid development and deployment and 5G network technologies, services, and devices.").

[18] *FNPRM* ¶ 375.

[19] AT&T Comments at 13; T-Mobile Comments at 7.

[20] Samsung Comments at 6.

[21] AT&T Comments at 13.

[22] Comments of 4G Americas, GN Docket No. 14-177 at 7-8 (filed Jan. 26, 2016).

B. The Commission should not overly complicate use of the millimeter wave bands by imposing a sharing requirement.

A large number of commenters strongly oppose the *FNPRM*'s proposal to institute "use-it-or-share-it," "keep what you use," or "share or use" mandates in the additional bands. Commenters expressed a variety of significant policy concerns about these types of mandates. As 5G Americas noted, the mmW bands are a nascent spectrum market where technology research and development is ongoing—in short, this is "not the time nor place to be adding the unnecessary complexity and uncertainty of a regulatory mandate" like "use-it-or-share-it."[23] Nextlink Wireless stated that such mandates "will complicate the roll-out of untested services, making deployment more time-consuming and costly," and that "a use-or-share requirement is premature given that neither the Commission nor industry knows what shape 5G services will ultimately take."[24] CCA added that "use-it-or-share-it" would both discourage both innovation and investment.[25] Indeed, in the previous round of comments, a "use-it-or-share-it" mandate was roundly rejected by commenters noting that such a mandate would inject complexity into the arduous task of deploying 5G networks and potentially harm investment.[26] Samsung agrees with the views that "use-it-or-share-it," "keep what you use," or "share or use" mandates will unduly burden this growing technology.

Commenters also widely oppose establishment of a spectrum access system ("SAS")-based regulatory framework in the additional bands. Multiple commenters warned against

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[23] Comments of 5G Americas, GN Docket No. 14-177 at 15 (filed Sept. 30, 2016) ("5G Americas Comments").

[24] Comments of Nextlink Wireless, GN Docket No. 14-177 at 23-24 (filed Sept. 30, 2016) ("Nextlink Comments").

[25] Comments of Competitive Carriers Association ("CAA"), GN Docket No. 14-177 at 6 (filed Sept. 30, 2016) ("CCA Comments").

[26] Reply Comments of Samsung, GN Docket No. 14-177 at 9-10 (filed Feb. 26, 2016) (citing opposition of "use-it-or-share-it" by AT&T, Verizon, and Nokia).

relying on "new, unproven, and complex" SAS mechanisms.[27] Many noted that the details surrounding use of an SAS in the 3.5 GHz band are unknown, and the success of the mechanism cannot yet be evaluated.[28] The record also reflects concern about the impact the establishment of an SAS framework would have on investment. CCA stated that an SAS structure "raises substantial uncertainty for CCA members, enough to deter investment and hamper innovative testing of mmW bands."[29]

Overall, the record shows that adopting a new, untested sharing mechanism would have precisely the opposite effect on investment than what the Commission is seeking in this proceeding. Rather than encouraging innovation and deployment, such a mechanism would act as a brake on 5G rollout, promoting a "wait-and-see" approach among companies that otherwise would be moving quickly to market.

Rather than rely on untested sharing frameworks, the Commission should implement sharing through existing mechanisms in those circumstances where sharing is necessary. In the Upper Band Segment of the 37 GHz band, 37.6-38.6 GHz, commenters note that future federal co-primary sharing can be implemented through established processes for sharing zones and negotiations with licensees.[30] In addition, the *Report & Order* adopted secondary market rules for the 37.6-38.6 GHz band, which permit voluntary "sharing" by a licensee of unused

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[27] Comments of Ericsson, GN Docket No. 14-177 at 14 (filed Sept. 30, 2016) ("Ericsson Comments"); *see also* Mobile Future Comments at 4; CCA Comments at 5-6.

[28] Nextlink Wireless Comments at 25; *see also* Mobile Future Comments at 4; CCA Comments at 5-6.

[29] CCA Comments at 6.

[30] 5G Americas Comments at 14-15; Samsung Comments at 9.

geographic areas and/or spectrum channels.[31] Both of these mechanisms avoid the need to develop a complex new spectrum sharing management framework such as an SAS for this band.

C. Unfettered satellite/terrestrial sharing will compromise the ability of terrestrial licensees to deploy ubiquitous networks.

While some commenters advocate for greater satellite/terrestrial sharing, Samsung continues to urge the Commission to avoid taking any actions which would compromise the ability of terrestrial licensees to make beneficial use of the mmW spectrum. Other comments in the record echoed Samsung's concern. The Commission should proceed cautiously to ensure that nascent 5G systems are not unduly constrained by onerous sharing requirements with fixed-satellite service ("FSS") operations.

First, many commenters assert that the Commission should not repeal its existing prohibition on satellite user equipment and permit the use of FSS terminals for downlink reception at 37.5-40 GHz.[32] Straight Path stated that "[a]s the Commission has long and correctly recognized . . . high-density deployment of terrestrial services and high-density deployment of FSS user equipment in the same frequency band is technically infeasible."[33] At 37.5-40 GHz, the deployment of ubiquitous satellite user equipment would mean that the "satellite beams would need to provide coverage wherever the user terminals are located, which would result in unpredictable interference to 5G base stations and mobile receivers."[34] Ericsson noted that even ViaSat's proposal to allow FSS user equipment purely on a secondary basis

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[31] 5G Americas Comments at 21.

[32] *FNPRM* ¶ 501.

[33] Comments of Straight Path Communications, GN Docket No. 14-177 at 15 (filed Sept. 30, 2016).

[34] T-Mobile Comments at 30.

presents long-term concerns, such as the difficulty of shutting down the operation of interfering user terminals, which would result in a loss of customer service.[35]

Second, the Commission should not impose new rules to limit aggregate interference to satellites. The Commission considered whether to establish any regulatory limit on aggregate power levels to prevent skyward interference to satellite receives in the *Report & Order*, concluding that "the potential for aggregate interference rising to the level of harmful interference is unlikely and thus is not a basis for refusing to authorize mobile service in the 28 GHz band."[36] There, as here, "the record does not demonstrate that the proposed rules would significantly risk harmful interference to satellite operators because of aggregate interference received at the satellite receiver."[37] In addition, the claims of some commenters regarding interference appear to rely on overly conservative assumptions.[38] An aggregate power level restriction has the potential to restrict UMFU deployment and delay delivery of the benefits of 5G to consumers and accordingly must be rejected.

Third, the Commission should not require terrestrial operators to provide information on their deployments to FSS providers through a database.[39] As many commenters have noted, making spectrum available through database access remains an untested concept.[40] Rather than

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35 Ericsson Comments at 20-21.

36 *Report & Order* ¶ 61.

37 *Id*. ¶ 65.

38 *See* CTIA *Ex Parte*, GN Docket No. 14-177 at 2 (filed June 9, 2106) ("The Commission should reject use of any static or beyond worst-case modeling suggested by the FSS industry as overly conservative and inconsistent with real-world effects."); Samsung *NPRM* Comments at 22 (describing compatibility study finding that a mobile base station does not cause significant interference to space station FSS).

39 Comments of ViaSat, GN Docket No. 14-177 at 19 (filed Sept. 30, 2016) ("ViaSat Comments").

40 *See, e.g.* T-Mobile Comments at 8.

enabling more intensive use of the spectrum, expanding satellite use of mmW spectrum designated for terrestrial would lead only to uncertainty. This would be counter to the Commission's stated goal in this proceeding of "securing the Nation's future in the next generational evolution of wireless technology" to 5G.[41] There should be no mandated sharing in the exclusively licensed bands.

Fourth, the Commission seeks comment on whether allowing higher power flux density ("PFD") levels for FSS in the 37 GHz and 39 GHz bands would be consistent with terrestrial use of those bands.[42] Although commenters used a similar method to derive a PFD limit that would protect UMFUS service, the assumptions underlying the technical studies varied considerably.[43] As described in the attached Appendix, Samsung conducted its own analysis of the impact on an increased satellite PFD limit on terrestrial operations and concluded that the PFD limit from a single satellite should be less than or equal to -116 dBW/m^2/MHz and the aggregate PFD limit, from multiple satellites, should be less than or equal to -119 dBW/m^2/MHz to protect 5G transportable station operations. The Commission should not adopt a PFD limit higher than those levels.

IV. COMMENTERS SUGGEST CERTAIN ALTERATIONS TO THE COMMISSION'S PROPOSED TECHNICAL RULES.

A number of commenters to this proceeding have offered suggestions to the Commission's proposed technical rules which would increase the utility of the additional mmW bands. The Commission can best promote the development and deployment of 5G by 1) clarifying its operability requirements; 2) adopting reasonable out of band emission ("OOBE")

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41 *Report & Order* ¶ 1.

42 *FNPRM* ¶ 369.

43 *See* Comments of Boeing, GN Docket No. 14-177 at 24-32 (filed Sept. 30, 2016); ViaSat Comments at 21-23.

limits; and 3) rejecting a digital station identification requirement. These alterations to the Commission's proposed technical rules will help unleash the benefits of 5G to consumers.

First, commenters agree that the Commission should clarify its operability requirements. Samsung and its wireless provider customers are moving rapidly toward deploying new technology in the 37.6-40 GHz band based on the new Commission rules for this spectrum. While equipment development continues, the resolution date for the final rules for the 37-37.6 GHz Lower Band Segment sharing framework announced in the *Report & Order* remains uncertain. Commenters agree that equipment developed in advance of the final rules should not be held up while the sharing requirements are finalized.[44] Specifically, the Commission should make clear that a device that is today physically capable of being operable at any frequency in the 37-40 MHz band satisfies the interoperability requirement.[45] CTA further requested that the Commission "expressly clarify that it will not require a device to meet conflicting rules if they arise in each band."[46] These clarifications will help ensure that use of the mmW bands will not be significantly delayed.

Second, the record reflects support for adoption of OOBE limits of 43+10log(P) per MHz (or an absolute power of -13 dBm/MHz) for the additional mmW spectrum bands. The Commission imposed the same OOBE limits for the 27, 37, and 39 GHz bands.[47] CTIA agreed that the Commission should adopt technical rules that align with the rules in the other mmW bands, as "establishing a simple and harmonious regulatory regime throughout the millimeter

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44 Samsung Comments at 7-8; Ericsson Comments at 17-18.

45 Samsung Comments at 8; Ericsson Comments at 18.

46 CTA Comments at 6.

47 *Report & Order* ¶ 304.

wave bands will allow licensees to focus on 5G deployment."[48] Launching 5G technologies and services will already be a challenging endeavor and the Commission should not add layers of regulatory complexity to these tasks.

Third, commenters reject imposition of a digital station identification ("digital ID") requirement.[49] The Commission has not found a digital ID to be necessary for other similarly situated services, such as cellular or PCS,[50] and nothing in the record shows that a different result is necessary here. Indeed, a requirement of this kind is particularly ill advised here as "imposition of a particular ID format will lock in place technology, potentially limiting migration to advanced or alternative transmission techniques adopted for use in the millimeter wave bands."[51] In addition, digital ID is unnecessary for licenses authorized on a geographic area basis, as proposed in this proceeding. There will only be one licensee per geographical area using the relevant mmW spectrum, and licensee information may be obtained by the Commission or other licensees using the Commission's licensing database. Finally, "[a]s a practical matter, any standards-based mobile network will transmit identifying information as part of the data stream."[52] There is no demonstrated need for the FCC to require a digital ID.

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48 CTIA Comments at 12.

49 *See, e.g.* Comments of the Telecommunications Industry Association, GN Docket No. 14-177 at 21-22 (filed Sept. 30, 2016).

50 Ericsson Comments at 21; Samsung Comments at 7.

51 T-Mobile Comments at 30.

52 Ericsson Comments at 21.

V. THE COMMISSION SHOULD CAREFULLY CONSIDER HOW TO EVALUATE SHARING MODELS IN THE MMW ENVIRONMENT.

The Commission requests comment on an appropriate sharing analysis framework for the additional mmW bands and expresses particular interest in sharing analysis and modeling.[53] 5G Americas noted that the ITU-R has appointed a task group to carry out co-existence/interference studies between the mobile service and other active as well as passive services such as FSS under Agenda Item 1.13 of the World Radiocommunication Conference 2019.[54] Samsung appreciates the Commission's participation in this work as the group evaluates various models and encourages the Commission to validate the models, particularly in the mmW frequency range. Commenters also advised the Commission that the ongoing efforts on 5G propagation modeling are focused for short range only—as propagation for co-existence and sharing are typically longer range, further work needs to be done on long-range propagation modeling.[55]

VI. CONCLUSION

Samsung commends the Commission's activities to date in adopting a licensing regime for use in the mmW bands above 24 GHz. The Commission's leadership on this issue has the potential to advance the development and timely deployment of 5G mobile wireless services and other new offerings to consumers. Going forward, the Commission should continue to facilitate access to spectrum, maximize flexibility, and encourage wireless innovation to support the development and deployment of 5G services.

Respectfully Submitted,

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53 *FNPRM* ¶¶ 512-13.

54 5G Americas Comments at 27.

55 *Id.*; Ericsson Comments at 22.

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Appendix

Even though commenters used a very similar method to derive a Power Flux Density (PFD) limit to protect UFMUS service, the baseline assumptions vary. Below we provide a representative methodology to define PFD limit from satellite operations.

$$PFD\ limit = Interference\ criteria + Noise\ floor\ in\ front\ of\ receiver\ antenna + 10x\log_{10}(4\pi/\lambda^2)$$

Where

Noise floor in front of mobile receiver antenna

$= N_T + NF - (G_{Rx} + G_{Rx_rolloff})$

N_T = *Thermal noise,* $10x\log_{10}(1.38x10^{-23}\ W\ Hz^{-1}\ K^{-1}\ x\ 290K)$

NF = *Noise figure of mobile receiver*

G_{Rx} = *main beam gain of mobile receiver antenna*

$G_{Rx_roffoff}$ = *relative gain in the direction of the arriving PFD signal from the mean beam of 5G receiver antenna*

λ = *Wave length in meter, 0.3/fc(GHz)*

We observe the following key factors:

- Satellite causes more harmful interference to mobile stations (MS) and transportable stations (TS) than base stations (BS);
- Mobile components may have better performing specifications than assumed in some analysis to enhance performance/capacity;
- Multiple satellites will result in aggregated interference to mobile receivers; and
- Protection criteria for mobile service, I/N = -6 dB, as characterized by ViaSat.

A. Satellite downlink causes more interference to MS and TS than to BS

This factor is also shown in Boeing's analysis where they find the interference level to MS to be higher than BS, as shown in Table V-1 and V-2/3 in Boeing's comments. Because the antenna direction of the BS toward the satellite is not the main beam, interference is less, while for MS and TS we expect they are more likely to be directed towards the satellite. We should

note that handsets would not be mis-pointed as characterized by Boing as they may be communicating with other terminals located on buildings.

B. Mobile components may have higher specification to enhance performance/capacity such as array antenna for beamforming.

Boeing correctly considers the higher performing components for BS described in Table V-4. We expect for TS and MS better performing characteristics will be possible with mobile systems deployed in the UMFUS bands in the future. Therefore, we recommend considering 4x4 arrays for MS and 8x8 arrays for TS in the derivation of PFD limit.

Additionally, Boeing uses 7 dB Noise figure for MS, but we expect a higher noise figure for TS due to the better receiver performance of TS than that of MS for such larger form factor devices that will generally operate with external power sources. We believe a 6dB noise figure is appropriate.

C. Multiple satellites cause aggregated interference to 5G receivers

In Boeing's comments, to account for the additional impact of aggregated interference from multiple satellites, Boeing recommends the PFD be reduced by 3dB to account for UMFUS mobile users experiencing stronger interference from an aggregate of satellites. In this sense, we agree that the analysis should consider aggregated interference from multiple satellites when determining PFD limits.

D. Conclusions

With those key factors, we can derive PFD limit with the methodology mentioned above. This results is summarized in the below table.

5G UMFUS Unit Type	MS				TS		
Array Configuration	1x4 or 2x2	1x6 or 2x3	1x8 or 2x4	4x4	4x4	4x8	8x8
Total Elements	4	6	8	16	16	32	64
G_{Rx} (dBi)	10	11.8	13	16	16	19.1	22.1
$G_{Rx_roffoff}$ (dBr)	0	0	0	0	0	0	0
Absolute Gain (dBi)	10	11.8	13	16	16	19.1	22.1
NF (dB)	7	7	7	7	6	6	6
Frequency (GHz)	28	28	28	28	28	28	28
Noise Floor in front of mobile receiver antenna (dBW/MHz)	-147.0	-148.8	-150.0	-153.0	-154.0	-157.1	-160.1
PFD limit (dBW/m^2/MHz)	-102.6	-104.4	-105.6	-108.6	-109.6	-112.7	-115.7

In summary, Samsung recommends that:

1) The PFD limit from a single satellite should be less than or equal to -116 dBW/m^2/MHz. This would limit the FCC proposal for geostationary systems in 25.208(q) to -116 dBW/m^2/MHz at angles of arrival above 9.4 degrees. For non-geostationary systems this would limit the FCC proposal in 25.208(r) to -116 dBW/m^2/MHz at angles of arrival above 10.3 degrees.
2) The aggregate PFD limit from multiple satellite should be less than or equal to -119 dBW/m^2/MHz.