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 VIASAT, INC.

Christopher Murphy
Associate General Counsel,
Regulatory Affairs
Daryl T. Hunter
Senior Director, Regulatory Affairs
Christopher Hofer
Director, Regulatory Affairs
VIASAT, INC.
6155 El Camino Real
Carlsbad, CA 92009

John P. Janka
Elizabeth R. Park
LATHAM & WATKINS LLP
555 Eleventh Street, N.W.
Suite 1000
Washington, DC 20004

Counsel for ViaSat, Inc.

February 26, 2016

SUMMARY

The comments filed in response to the *NPRM* demonstrate not only that shared satellite and terrestrial use of the 27.5-28.35 GHz band segment ("28 GHz Band") and 37.5-40 GHz band is feasible, but also that shared use is necessary to achieve the full potential for satellite broadband services in this spectrum.

More specifically, the comments in this proceeding affirm the important role of satellite services in advancing the Commission's goals of ubiquitously deployed broadband—including to homes, businesses, schools, medical facilities, airplanes, and trains. Indeed, spectrum is a key input to making these broadband services a reality for the American consumer, and ViaSat's next-generation broadband satellite network is a leading example. The ViaSat-3 network, which will begin deployment in 2019, will consist of a fleet of spacecraft, each of which will provide over 1 terabit per second of throughput, and each of which will have more capacity than all of the communications satellites in existence today, combined.

In order to realize the full potential of satellite broadband, it is essential that the framework for the 28 GHz Band and 37.5-40 GHz band promotes efficient and intensive use of the spectrum through mutual coexistence between satellite and terrestrial operations.

A number of commenters echo ViaSat's urging that the Commission protect essential earth station facilities vis-à-vis any new terrestrial mobile services that are authorized in the 28 GHz Band. Critical satellite services are being provided today that rely on the Commission's current designations and band plan for that spectrum, which provide for satellite use of the 28 GHz Band but not terrestrial mobile services, and which expressly provide satellite uses with priority over new uses such as terrestrial mobile. Moreover, the satellite industry has invested billions of dollars and is constructing additional spacecraft based on the current designations and

band plan for this band segment. Protecting essential earth station facilities must be a critical component of any new regulatory regime adopted in this proceeding.

ViaSat agrees with the commenters who propose that the protection of essential earth station facilities can be accomplished, and specifically recommends that the Commission protect (i) the aggregation, interconnection and backhaul facilities of any spacecraft that the Commission has authorized to serve the United States in the 28 GHz Band, as well as (ii) every other individually-licensed earth station in the 28 GHz Band that would not require a 5G compatibility zone extending more than a specified distance from the earth station, based on technical parameters that take into account 5G operations. Given the relatively small size of these compatibility zones, any impact on 5G deployment would be minimal, and there would be no need for satellite operators to acquire terrestrial spectrum rights in order to obtain protection. Essentially, this approach would be consistent with the recognition in the *NPRM* of the need to protect certain satellite earth stations, but it also would facilitate the protection of existing and planned earth stations, as well as the deployment of protected earth stations after the auction of any terrestrial licenses in the 28 GHz Band.

Moreover, in order to effectuate efficient and intensive utilization of the 28 GHz Band, the Commission should expand the class of earth stations that can use this spectrum to include terminals used to provide service to end users. Such additional uses by earth stations can occur on a secondary, non-interference basis and can be facilitated through the implementation of a Spectrum Access System ("SAS") database mechanism, which would help to prevent terrestrial licensees from unilaterally dictating the terms of sharing—a result that otherwise would flow from proposals by certain commenters that secondary satellite operations should only occur after coordination with terrestrial licensees. Facilitating continued satellite use of the 28 GHz Band

requires that the Commission adopt rules that balance the sharing burdens and obligations between both satellite and terrestrial users to avoid scenarios in which terrestrial licensees can unilaterally dictate the terms of sharing.

ViaSat supports those commenters who urge expanded flexibility for satellite use of the 37.5-40 GHz band, including co-primary status for essential earth stations and uses by end-user terminals on a secondary basis. Sharing in this band can be achieved in much the same manner as proposed for the 28 GHz Band. Sharing between terrestrial operations and satellite downlinks has worked successfully based on suitable downlink power flux density levels; therefore, proposals seeking to prohibit satellite operations in this band are based on a fundamental mischaracterization of the sharing environment.

In addition, in order to facilitate the types of sharing proposed in this reply and in ViaSat's opening comments, any terrestrial service rules adopted in this proceeding should be consistent with the sharing environment. ViaSat urges the Commission to refrain from adopting power limits and other technical rules that are incompatible with co-frequency satellite operations or that are unsupported by realistic 5G deployment scenarios. Specifically, ViaSat opposes proposals by some commenters to adopt unduly high power limits in the 28 GHz Band for terrestrial mobile operations.

Finally, ViaSat urges the Commission to consider rules for earth stations in motion in the 28 GHz Band in a separate rulemaking proceeding, to allow the continued development of international standards for such services over the next few years. But, in the meantime, nothing in this proceeding should foreclose the possibility of licensing earth stations in motion in the 28 GHz Band subject to the outcome of that future rulemaking.

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REPLY COMMENTS OF VIASAT, INC.

ViaSat, Inc. ("ViaSat") submits this reply to the comments filed in connection with the Commission's Notice of Proposed Rulemaking in the above-captioned proceeding, in which it is considering rules regarding the use of frequency bands above 24 GHz ("millimeter wave bands")

for 5G terrestrial mobile radio services, including modifications to its longstanding band plan for the 27.5-28.35 GHz band segment ("28 GHz Band").[1]

I. INTRODUCTION

Broad consensus exists in the record that the millimeter wave bands that are the focus of this proceeding hold great promise for unlocking the potential for a wide range of technologies that could meet burgeoning demand for broadband services with faster speeds, higher capacity and exponentially increased device connectivity. Both terrestrial and satellite broadband technologies are advancing rapidly to meet these myriad demands. And as made clear in the initial comments in response to the *NPRM*, the spectrum under consideration in this proceeding is a key input for these satellite and terrestrial technologies.

Many commenters agree that sharing among terrestrial and satellite networks is necessary to enable continued satellite deployment in the 28 GHz Band and the 37.5-40 GHz band, and thus unleash the full potential of these critical spectrum resources. The unique propagation characteristics in the 28 GHz Band and the 37.5-40 GHz band make these band segments conducive to sharing based on the types of contemplated uses by 5G. In order to achieve that result, the regulatory framework adopted here must be carefully crafted to promote efficient and intensive use of this spectrum through the coexistence of both satellite and terrestrial operations.

The record reflects a range of views on the extent of spectrum sharing and the means by which such sharing should occur. ViaSat is encouraged that, in general, commenters representing both terrestrial wireless and satellite interests are beginning to embrace sharing and coexistence in the 28 GHz Band and the 37.5-40 GHz band among a wider range of services than

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[1] *Use of Spectrum Radio Bands Above 24 GHz for Mobile Radio Services*, GN Docket No. 14-177, *et al.*, Notice of Proposed Rulemaking, FCC 15-138 (rel. Oct 23, 2015) ("*NPRM*").

previously observed in response to the Notice of Inquiry in this proceeding.[2] However, a number of commenters appear to be instinctively reverting to outdated exclusive-use paradigms that would substantially diminish the full potential of this spectrum. As the Commission establishes a new regime for next-generation terrestrial mobile and satellite networks in the 28 GHz Band and the 37.5-40 GHz band, it should allow sufficient flexibility to nurture the continued development of satellite services and recognize the need to protect the significant investments that have been made by the satellite industry based on the Commission's longstanding designations under its current band plans.

To this end, ViaSat and other satellite operators urged the Commission in the opening comments to accommodate existing and future satellite operations in the 28 GHz Band by affording protection to essential earth station facilities. Earth station facilities transmitting in this band can coexist with 5G networks due to the short distances required between such earth station facilities and 5G operations to enable compatible operations. Similarly, in the 37.5-40 GHz band, a power limit for satellite space-to-earth transmissions could be defined at a level that would sufficiently protect 5G networks while allowing any number of satellite earth stations to operate without impacting terrestrial operations.

To facilitate continued and expanded satellite operations in the 28 GHz Band and the 37.5-40 GHz band in a manner that makes full and efficient use of the spectrum, the Commission should clearly delineate the terms by which satellite operators can deploy earth station facilities, both on a primary basis for essential earth stations, and on a secondary basis for user terminals.

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2 *See generally Use of Spectrum Radio Bands Above 24 GHz for Mobile Radio Services; Petition for Rulemaking of the Fixed Wireless Communications Coalition to Create Service Rules for the 42-43.5 GHz Band*, GN Docket No. 14-177, RM-11664, Notice of Inquiry, FCC 14-154 (rel. Oct. 17, 2014).

ViaSat urges the Commission to avoid adopting licensing and sharing rules that would allow a small number of terrestrial licensees to become private gatekeepers of this spectrum.

In particular, and in order to ensure "a flexible regulatory framework that accommodates as wide a variety of services as possible,"[3] the Commission should not adopt a regime under which satellite earth stations are afforded protection only if (i) they were licensed and brought into operation before a certain date, (ii) they are coordinated with terrestrial licensees, or (iii) the operator acquires terrestrial rights in an auction. Rather, the Commission should protect (i) the aggregation, interconnection and backhaul facilities of any spacecraft that the Commission has authorized to serve the United States in the 28 GHz Band, as well as (ii) every other individually-licensed earth station in the 28 GHz Band that would not require a 5G compatibility zone extending more than a specified distance from the earth station, based on technical parameters that take into account 5G operations. Facilitating continued satellite use of the 28 GHz Band requires that the Commission adopt rules that balance the sharing burdens and obligations between both satellite and terrestrial users to avoid scenarios in which terrestrial licensees can unilaterally dictate the terms of sharing.

II. THE RECORD CONFIRMS THE IMPORTANT ROLE OF SATELLITE TECHNOLOGY IN THE BROADBAND ECOSYSTEM

Comments in the record make clear that satellite is a vital component of the solution for satisfying the ever-growing and wide-ranging demand for broadband connectivity. The record highlights the important role of satellite in the broadband marketplace, currently and in the future, made possible through the availability of Ka-band spectrum, including the 28 GHz Band

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[3] *NPRM* ¶ 23.

addressed in this proceeding.[4] Critically, the satellite industry has made significant investments in reliance on the availability of this band for use on a secondary basis to fixed terrestrial LMDS services. Moreover, next-generation satellite broadband networks are being implemented with additional capacity made possible through use of the current designations for fixed satellite service ("FSS") in the 28 GHz Band.[5]

ViaSat's advanced satellite broadband technologies illustrate exactly these important developments. By reducing the "cost per bit" of broadband service (compared to that of legacy satellite networks), ViaSat's current satellite broadband offerings are fully competitive, from a performance and a price perspective, with terrestrial alternatives such as cable and DSL. Reducing the cost per bit was achieved in large part by having access to and using the 28 GHz Band.

Satellite networks are extremely bandwidth efficient and, inherent in the design of FSS technology, allow for significant spectrum reuse by a number of geostationary ("GSO") systems

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4 *See, e.g.*, Comments of Inmarsat Mobile Networks, Inc., GN Docket No. 14-177, *et al.*, at 3 (filed Jan. 28, 2016) ("Inmarsat Comments") (describing Inmarsat's Global Xpress network as having the potential of expanding terrestrial networks, supplying high-bandwidth backhaul to remote environments, providing broadband connectivity to aeronautical and maritime networks, and emergency communications during natural disasters); Comments of O3b Limited, GN Docket No. 14-177, *et al.*, at 2-3 (filed Jan. 28, 2016) ("O3b Comments") (noting significant investments have been made to serve the U.S. government, provide middle-mile capacity and connectivity in U.S. territories and on maritime platforms); *see also* Comments of the Satellite Industry Association, GN Docket No. 14-177, *et al*., at 4 (filed Jan. 28, 2016) ("SIA Comments"); Comments of EchoStar Satellite Operating Corporation, Hughes Network Systems, LLC, and Alta Wireless, Inc., GN Docket No. 14-177, *et al.*, at 5-6 (filed Jan. 27, 2016) ("EchoStar Comments") (citing service to government, public safety, educational and health-related applications); Comments of The Boeing Company, GN Docket No. 14-177, *et al.*, at 4-5 (filed Jan. 28, 2016) ("Boeing Comments").

5 *See, e.g.*, EchoStar Comments at 13-14; Comments of SES Americom, Inc., GN Docket No. 14-177, *et al.*, at 3-4 (filed Jan. 28, 2016) ("SES Comments") (constructing SES-15, which will use the 28 GHz Band for gateway earth stations, scheduled to launch in 2017); O3b Comments at 2.

in a two-degree spaced environment and through angular separation of GSO and non-geostationary orbit ("NGSO") satellites. Contrary to the claims of Straight Path,[6] spectrum utilization by satellite is highly efficient and has proven to be capable of delivering high-value broadband services to consumer, business and government users. As an initial matter, Straight Path's attempt to compare the efficiency of satellite and terrestrial technologies fails to account for spectrum reuse by multiple satellite networks and, as detailed below, also fails to take into account the spectral efficiency of the latest generation of broadband spacecraft.[7] Over forty GSO spacecraft could use the 28 GHz Band to serve the United States, with two degree spacing, and also share the band with NGSO networks. Moreover, ViaSat's latest spacecraft design has over seven times the throughput of its first-generation broadband satellite design. Yet Straight Path focuses on a single geostationary satellite designed years ago and a single legacy non-geostationary network.

In addition, Straight Path's assumption that only 300,000 5G cell sites would need to be deployed to cover the entire population of the United States is inconsistent with the anticipated 5G deployment scenarios suggested by the comments of others in this proceeding.[8] Based on those other views regarding 5G cell coverage, it would take about 243 million cells to cover the entire United States, which could cost about $24 trillion (using Straight Path's estimated cost per

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6 *See* Comments of Straight Path Communications Inc., GN Docket No. 14-177, *et al.*, at 27-29 (filed Jan. 27, 2016) ("Straight Path Comments").

7 *See id.* (describing separate comparisons using O3b and ViaSat networks, but failing to aggregate current and potential satellite networks).

8 *See, e.g.*, Comments of Huawei Technologies, Inc., GN Docket No. 14-177, *et al.*, at 12 (filed Jan. 28, 2016) ("Huawei Comments"); *see also* Samsung Electronics America, Inc., Notice of *Ex Parte* Communication, GN Docket No. 14-177, at 6 (filed Aug. 28, 2015); Comments of Nokia, GN Docket No. 14-177, at 21 (filed Jan. 15, 2015).

base station of approximately $100,000).[9] Moreover, the level of terrestrial wireless deployment assumed in Straight Path's estimated efficiency calculation is entirely inconsistent with any currently existing deployment in the 28 GHz Band or 39 GHz band, as well as with the contemplated deployment of 5G predominantly in areas with high-density populations and not throughout the United States.[10]

ViaSat continues to innovate technology that will expand the capabilities of satellite broadband. The satellites and network architecture that ViaSat is deploying in the near term will support even higher levels of throughput and speed, translating into even higher-quality broadband service for consumers—service that will more than keep pace with the improvements implemented over time by ViaSat's competitors. ViaSat recently announced its ViaSat-3 platform, which will begin deployment in 2019, and will consist of spacecraft that each will provide over 1 terabit per second (1,000 Gbit/s) of throughput and even higher speeds, and each of which also will have more capacity than all communications satellites in existence today, combined. At the same time, the cost of constructing each of these satellites will be roughly the same as current-generation spacecraft, which will further reduce the cost-per-bit by exponentially increasing the throughput capabilities of the satellite per dollar invested, as illustrated by the chart below.

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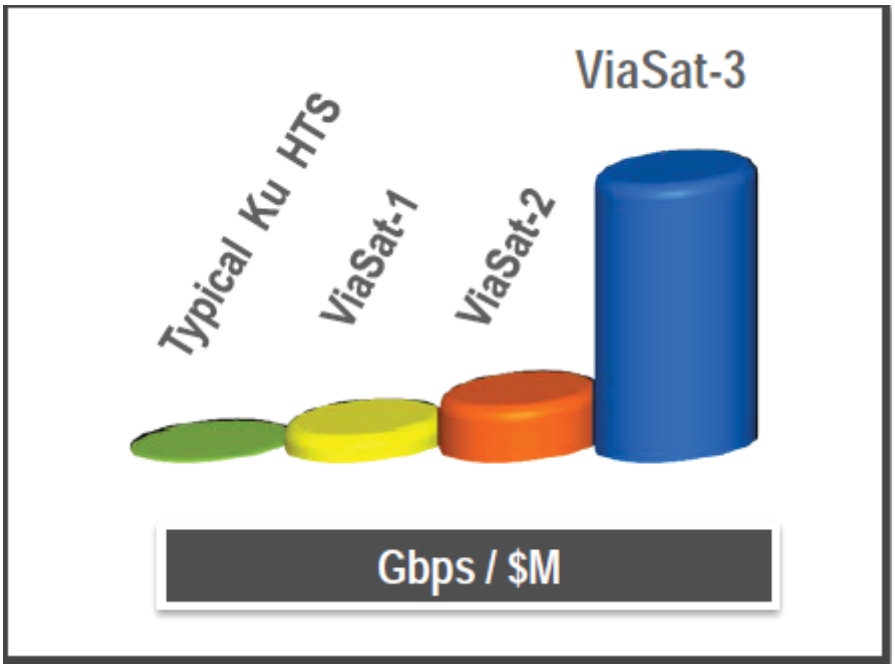
9 *See* Straight Path Comments at 29. Estimate of U.S. coverage based on an estimate of the land area of the lower 48 states and Washington, DC of 7.663 million square kilometers and assuming a cell radius for 5G base stations of 100 meters, which is in the range of scenarios suggested by other commenters. *See supra* n. 8.

10 Moreover, questions have been raised regarding the validity of buildout demonstrations and compliance with substantial service requirements under certain licenses held by Straight Path. *See, e.g., FiberTower Spectrum Holdings, LLC*, Order on Reconsideration, 29 FCC Rcd 2493, 2499 ¶ 16 n.52 (2014) (directing the Wireless Telecommunications Bureau to investigate whether any licenses held by IDT, Straight Path's predecessor in interest, are subject to cancellation for permanent discontinuance of operations).



The quality of any broadband service depends on a combination of service characteristics, but the available bandwidth is the central value proposition of a broadband service. Critically, achieving such capabilities requires access to the 28 GHz Band. To enable these significant competitive services to be brought to market and made available for the benefit of U.S. consumers, the Commission should ensure that the regulatory framework adopted in this proceeding allows the continued development and deployment of high-capacity satellite networks, including those using the 28 GHz Band, as other commenters urge.[11]

III. COMMENTERS ACKNOWLEDGE THE NEED TO PROTECT ESSENTIAL EARTH STATION FACILITIES IN THE 28 GHZ BAND WITHOUT THE ACQUISITION OF TERRESTRIAL SPECTRUM RIGHTS

A number of commenters echo ViaSat's urging that the rules adopted in this proceeding must acknowledge the reliance by the satellite industry on the existing designation for FSS, and its priority over mobile terrestrial services, which are not included under the current Ka-band

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[11] *See, e.g.*, Boeing Comments at 5; O3b Comments at 13-14; EchoStar Comments at 15, 27; Comments of Facebook, Inc., GN Docket No. 14-177, *et al.*, at 5 (filed Jan. 27, 2016) ("Facebook Comments").

band plan.[12] As discussed above, the record reflects a demonstrated need for 28 GHz Band spectrum for critical satellite networks that are operating today and providing service to consumer, business and U.S. government users.[13] Like ViaSat, other commenters emphasize that the innovative satellite designs and capabilities discussed above were developed in reliance on the current regulatory environment and the longstanding band plan for the 28 GHz Band.[14]

To the extent that the Commission alters its longstanding band plan, and introduces terrestrial mobile services into the 28 GHz Band for the first time, it is critical that the Commission ensure the continued ability to deploy essential earth station facilities necessary for aggregation, interconnection and backhaul functions. Specifically, those types of facilities should be allowed to deploy without the risk of having to shut down because of nearby terrestrial mobile operations.[15] As SIA emphasized in its comments, the proposals in the *NPRM* that would limit protection to earth stations authorized prior to the release of the *NPRM*—and even then only to those that happen to be outside of an LMDS licensed territory—do not provide adequate assurances that satellite networks will have access to the 28 GHz Band as it is used today, and for necessary expansion spectrum that satellite providers are counting on to accommodate

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12 *See, e.g.*, EchoStar Comments at 18-19; O3b Comments at 13; SIA Comments at 8-9.

13 *See, e.g.*, O3b Comments at 4-5; SIA Comments at 4-6.

14 *See* EchoStar Comments at 7 (satellite technology is complex and has a long development path, requiring considerable time and upfront costs to plan, build and launch); O3b Comments at 13-14 (any future mobile use of the 28 GHz band must be deployed in a way that does not harm satellite operations, which have relied on a previously stable regulatory regime in the U.S. and globally, and upon which very large investments in satellite networks have been made).

15 *See* EchoStar Comments at 19, 21 (proposing protection for all earth stations licensed in the 28 GHz Band prior to a terrestrial auction and for future earth stations through an established protection zone).

consumers' growing demand for bandwidth-intensive services and applications.[16] ViaSat agrees that protection should be afforded to a broader category of earth stations—whenever licensed[17]—and commenters acknowledge that greater protection for such facilities is possible.[18]

Moreover, rules adopted in this proceeding should facilitate the evolution of satellite designs and reflect the need for a larger number of essential earth station aggregation, interconnection and backhaul facilities to enable increased capacity in next-generation satellite networks. In order to achieve the exponentially higher-capacity satellite networks that will be needed to meet consumer and government demands in the years to come, the rules must accommodate and protect deployment of a greater number of essential aggregation, interconnection and backhaul facilities that will be deployed in the future—and not just in rural and remote areas. Such facilities will in fact have to be located in urban areas where end users and fiber facilities are located, as ViaSat emphasized in its comments, and as Avanti acknowledges as well.[19]

For instance, the essential earth station facilities planned for the ViaSat-2 satellite, which is expected to be launched in early 2017, and ViaSat-3, which is expected to be launched in 2019, will be located in at least 30 of the top 50 metropolitan areas, including Houston, Detroit, Atlanta, Cleveland, and Pittsburgh. These satellites, which have been authorized to serve the United States, have been designed and currently are being built in reliance on the current band

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16 SIA Comments at 7.

17 *See id.* at 18 (proposing co-primary status for individually-licensed earth stations in the 28 GHz Band, even if the application is filed after the release of the *NPRM*).

18 *See, e.g.*, Comments of AT&T, GN Docket No. 14-177, *et al.*, at 12 (filed Jan. 28, 2016) ("AT&T Comments") (agreeing with satellite operators that co-primary status could be accommodated in the 28 GHz Band); EchoStar Comments at 15-16.

19 Comments of Avanti Communications Group plc, GN Docket No. 14-177, *et al.*, at 9 (filed Jan. 27, 2016) (acknowledging that gateway facilities will be deployed in populated areas).

plan for the 28 GHz Band and the ability to locate essential earth station facilities in any urban market anywhere in the United States. This trend will continue with future broadband satellites—aggregation, interconnection and backhaul facilities for those satellites also will need to be located in and around most, if not all, of the urban areas of the country. Significantly, implementing that type of earth station deployment is fully consistent with, and is feasible under, the existing band plan for the 28 GHz Band.

In order to realize the vast potential of satellite broadband networks—as both a complement and vigorous competitor to terrestrial wireless and wireline broadband technologies—access to the 28 GHz Band must be available on a protected basis for a broader deployment of essential earth station facilities using the 28 GHz Band than is contemplated in the *NPRM*.[20] As detailed in a number of comments, this can be done without impeding the deployment of 5G services. While next-generation satellite systems may require a larger number of essential earth station facilities than current systems, and those facilities in some cases will be located in urban areas, the total number still would be relatively low.

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[20] As explained in ViaSat's comments, the *NPRM* proposal would not protect earth stations against the introduction of new terrestrial mobile operations in areas in which there is an LMDS licensee. And in areas that do not have LMDS licensees, the proposal could be interpreted as not protecting earth stations against new terrestrial mobile services unless either (i) the earth station was already licensed or applied for before the date of the *NPRM* and also is brought into operation by a date certain, or (ii) the earth station licensee seeks and obtains a waiver based on the absence of any adverse impact on future terrestrial service, such as being located in a remote area and also brings the earth station into operation by a date certain. *See NPRM* ¶¶ 129-146. Under these terms, ViaSat has no assurance that a large number of its aggregation and interconnection facilities would be protected with respect to new 5G services, even though (I) many of the earth stations for ViaSat-1 currently are successfully operating within LMDS license areas, (II) it was premature to apply for earth stations for ViaSat's authorized but unlaunched spacecraft before the *NPRM* based on the expected in-service dates of those spacecraft, and (III) ViaSat reasonably relied on the 28 GHz Band Plan and its satellite authorization conditions in developing its network. Comments of ViaSat, Inc., GN Docket No. 14-177, *et al.*, at 12 (filed Jan. 28, 2016) ("ViaSat Comments").

In addition, EchoStar's comments affirm ViaSat's preliminary analysis concluding that the distance for compatibility between a satellite earth station in the 28 GHz Band and a 5G base station would be small and can be accommodated within the 28 GHz Band without impeding 5G deployment. ViaSat estimates that the compatibility distance would be in the range of 160 meters.[21] EchoStar's preliminary analysis is consistent with ViaSat's assessment, resulting in an estimated distance of between 60 and 170 meters, depending on the path loss model assumptions used.[22] Notably, these estimated distances do not take into account additional mitigation techniques, such as shielding, that could be employed to optimize the interference environment for sharing between 5G operations and those earth stations located in urban areas, and thus would result in smaller distances.

These analyses confirm that the compatibility zones for such earth station facilities would not materially impact any contemplated terrestrial deployment, particularly as discussed in more detail below in light of the likely use cases for 5G deployment in this spectrum. The extremely small size of the compatibility zone and relatively low numbers of earth stations for aggregation, interconnection and backhaul in the 28 GHz Band, both currently and in the future, does not warrant requiring satellite operators to acquire terrestrial rights to be afforded protection. Requiring a satellite operator to acquire a terrestrial license for an entire county or census tract to be afforded protection would be economically inefficient because the rights that would have to be purchased would have no relationship to the geographic zone where the spectrum is "used," and the impact, if any, on potential terrestrial mobile deployment would be minimal.[23] Moreover, many terrestrial mobile commenters call for geographic license areas that are even

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21 ViaSat Comments at 13-14.

22 EchoStar Comments at 16.

23 *See, e.g.*, O3b Comments at 17-18; EchoStar Comments at 24, 33.

larger than a county or a census tract, which would exacerbate the problem.[24] Similarly, the prospect of combinatorial bidding by wireless carriers seeking to acquire licenses across a wide geographic area would significantly reduce the chance that a satellite operator could acquire a single license for a small geographic area (*e.g.,* in the range of 60 to 170 meters) needed to protect an earth station.[25]

ViaSat also agrees with the commenters who explain that proposals in the *NPRM* for satellite operators to acquire partitioned license areas from terrestrial licensees in the secondary market incorrectly presume that terrestrial licensees would be properly incented to fairly negotiate such transactions.[26] To the contrary, there is no reason to believe that direct competitors of satellite broadband operators (for both customers and spectrum) would have any incentive whatsoever to enable the operation of their competitors' facilities in the same area where the wireless operators provide service.[27] Moreover, since they need access to the entire 850 megahertz of the 28 GHz Band, satellite operators would need to negotiate with multiple licensees if the Commission adopts licensing proposals that would subdivide the 28 GHz Band

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24 *See, e.g.,* AT&T Comments at 18; Comments of Verizon, GN Docket No. 14-177, *et al.*, at 10 (filed Jan. 28, 2016) ("Verizon Comments"); Comments of the Fixed Wireless Communications Coalition, GN Docket No. 14-177, *et al.*, at 5 (filed Jan. 27, 2016) ("FWCC Comments"); Comments of Skyriver Communications, Inc., GN Docket No. 14-177, *et al.*, at 7 (filed Jan. 27, 2016); Straight Path Comments at 18; Comments of Telecommunications Industry Association, GN Docket No. 14-177, *et al.*, at 12, 22 (filed Jan. 27, 2016) ("TIA Comments"); Comments of XO Communications, LLC, GN Docket No. 14-177, *et al.*, at 20 (filed Jan. 28, 2016) ("XO Comments").

25 EchoStar Comments at 40-41; *see also* Verizon Comments at 12 (proposing package bidding if county-level licensing is adopted).

26 *See, e.g.,* EchoStar Comments at 23-24.

27 *Id.*; O3b Comments at 18-19 (terrestrial mobile licensees that are provided the right to exclude others from a large geographic area, likely based on the use of the spectrum in only the most densely populated portions of the license area, will have little incentive to give up the option in the future to use of the unused portions).

for licensing to multiple entities as some commenters propose.[28] And because 5G technology is still in development, with actual deployment years away, terrestrial licensees may be unwilling to sell any spectrum while they develop and implement deployment plans,[29] which would effectively forestall satellite broadband deployment in the meantime. Thus, ViaSat agrees with comments emphasizing that both satellite network and future terrestrial mobile licensees need predictability and certainty about the sharing environment in order to deploy the networks that they have already designed in reliance on the 28 GHz band plan, and also to make investments in future deployment.[30]

IV. SHARING WITH SATELLITE USER TERMINALS IN THE 28 GHZ BAND CAN BE FACILITATED THROUGH SUITABLE PLANNING BEFORE LICENSING TERRESTRIAL MOBILE SERVICES

ViaSat agrees that sharing in 28 GHz Band is a necessity for unleashing the full potential of these important spectrum resources.[31] General consensus exists in the record that satellite and terrestrial mobile stations can share and make productive use of the 28 GHz Band, and specifically, strong support exists for allowing opportunistic uses of this band segment by

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28 *See, e.g.*, Straight Path Comments 23 (indicating that the Commission could subdivide the 28 GHz band into smaller blocks): Comments of CTIA, GN Docket No. 14-177, *et al.*, at 21 (filed Jan. 28, 2016) ("CTIA Comments") (proposing to subdivide the 28 GHz Band into four blocks); Comments of 4G Americas, GN Docket No. 14-177, *et al.*, at 15 (filed Jan. 27, 2016) ("4G Americas Comments") (proposing to subdivide the 28 GHz Band into four blocks).

29 EchoStar Comments at 12, 24.

30 *See, e.g.*, SIA Comments at 9; CTIA Comments at 13.

31 *See, e.g.*, Comsearch Comments, GN Docket No. 14-177, *et al.*, at 3 (filed Jan. 27, 2016) ("Comsearch Comments"); Comments of Federated Wireless, Inc., GN Docket No. 14-177, *et al.*, at 2-3 (filed Jan. 27, 2016) ("Federated Wireless Comments").

satellite user terminals on a secondary basis.[32] However, in order to make sharing with new terrestrial mobile services possible, the regulatory framework adopted in this proceeding must facilitate and encourage deployment of both satellite and terrestrial technologies.[33] Thus, ViaSat urges the Commission to expand the secondary designation for satellite use in the 28 GHz Band and supports proposals for licensing mechanisms and rules establishing sharing mechanisms that facilitate secondary satellite user terminal operations.

As a preliminary matter, the propagation characteristics of the 28 GHz Band make this spectrum particularly conducive to sharing among the uses contemplated for this spectrum.[34] Specifically, the propagation and atmospheric absorption characteristics of these bands typically require that higher-power operations rely on directional antennas to achieve significant range, and narrow beamwidths of directional antennas to reduce interference to other users, making high-power operations suitable for intensive geographic reuse as long as secondary users can work around the primary users by taking into account their actual operations.[35] Moreover, low-power terrestrial operations will be limited in range, allowing reuse by many users as long as there is sufficient geographic separation.[36] Terrestrial wireless networks also will be unlikely to be deployed across broad geographic areas because wireless network operators generally view millimeter wave band spectrum as a supplement to their primary spectrum (such as the AWS, PCS and frequencies below 1 GHz) and emphasize the critical need for more low-band resources

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32 *See, e.g.*, Facebook at 5 (satellite earth stations can coexist with terrestrial mobile deployments in the mmW bands without harm to new mobile deployments); EchoStar Comments at 30; O3b Comments at 28.

33 *See, e.g.*, EchoStar Comments at 13; Facebook Comments at 5; Comments of Google Inc., GN Docket No. 14-177, *et al.*, at 3-4 ("Google Comments").

34 *See, e.g.*, Federated Wireless Comments at 10; Google Comments at 2-3.

35 Google Comments at 2-3.

36 *Id.* at 3.

as well.[37] Notably, these commenters confirm the expected limited deployment of terrestrial facilities in the 28 GHz Band by arguing that the geographic coverage and other performance requirements typically imposed on terrestrial wireless licensees would not be suitable in the 28 GHz Band.[38] Given these contemplated deployment scenarios for 5G operations, significant opportunities should exist for secondary operations in locations and at times when terrestrial wireless licensees are not actively using the spectrum.

Therefore, ViaSat agrees with commenters advocating for greater sharing and opportunistic use of the 28 GHz Band. In its comments to the *NPRM*, ViaSat proposed that earth station user terminals could operate on a secondary, non-interference basis by "working around" terrestrial uses, taking into account the known compatibility zone of the earth stations and the location and technical parameters of the terrestrial operations.[39] The secondary "opportunistic" uses could be coordinated through a SAS database mechanism. Other commenters concur with ViaSat's recommendation that sharing be facilitated through the use of a SAS database mechanism.[40] Employing a dynamic database mechanism that provides information about spectrum use by protected priority users and opportunistic secondary users is both

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37 *See, e.g.*, CTIA Comments at 7; AT&T Comments at 3; Comments of Mobile Future, GN Docket No. 14-177, *et al.*, at 2 (filed Jan. 27, 2016) ("Mobile Future Comments"); *see also* Google Comments at 2 (spectrum is designed specifically to provide supplemental capacity for current commercial mobile networks).

38 *See, e.g.*, TIA Comments at 26-27; FWCC Comments at 5-6; XO Comments at 21-22; Comments of Intel Corporation, GN Docket No. 14-177, *et al.*, at 24-25 (filed Jan. 27, 2016); Mobile Future Comments at 15.

39 ViaSat Comments at 17.

40 *See, e.g.*, Federated Wireless Comments at 13-14, 18-19.

technologically feasible and consistent with the direction in which spectrum policy in the United States is moving.[41]

Requiring terrestrial licensees to provide location data and other parameters would allow satellite operators to "work around" those terrestrial deployments and deploy user terminals on a non-interference basis, thereby making more efficient use of spectrum.[42] Correspondingly, requiring satellite operators to register the location and other salient parameters of their transmit earth stations would provide notice to terrestrial operators of those earth station operations and facilitate the resolution of any suspected interference events.

SAS technology also would be ideally suited to enabling opportunistic uses by satellite user terminals through developing cognitive sharing techniques, which would facilitate the efficient use of spectrum resources, in light of the contemplated deployment scenarios for 5G.[43] SAS solutions could be utilized to identify unused spectrum at the outset by detecting wherever and whenever spectrum is not actively being used.

Contrary to what some commenters suggest,[44] SAS technology does not have to be fully vetted for the Commission to adopt the use of a database mechanism in this proceeding. Commenters acknowledge that 5G specifications will not be developed by the time the Commission adopts rules for 5G in this proceeding.[45] Thus, there is no reason that the details of

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41 *Id.* at 6-8 (describing the move toward utilization of spectrum sharing technologies promoted in the President's Council of Advisors on Science and Technology ("PCAST") report, as well as legislative initiatives); *see also id.* at 5 (describing SAS capabilities).

42 O3b Comments at 28.

43 Federated Wireless Comments at 19.

44 Verizon Comments at 25; FWCC Comments at 14-15; TIA Comments at 9-10.

45 *See, e.g.*, Comments of High Tech Spectrum Coalition, GN Docket No. 14-177, at 4 (filed Jan. 28, 2016) (citing the uncertainty of in the market development for the millimeter wave).

the SAS mechanism could not also be tested and finalized in concert with the development of 5G technology, in the same way the SAS for 3.5 GHz is being developed for use in that context after the adoption of service rules.[46]

Throughout this proceeding, ViaSat has urged the Commission to move away from entrenched views on sharing between satellite and terrestrial services in the 28 GHz Band. Other commenters share this view and ask the Commission also to leave behind exclusive terrestrial licensing regimes that would preclude opportunistic use in the 28 GHz Band.[47] Following old paradigms of exclusive, wide-area terrestrial licenses would not facilitate the full use of this spectrum in all areas, and could preclude these types of opportunistic use. In contrast, non-exclusive licensing regimes could enable efficient and intensive use of 28 GHz Band spectrum. For instance, Google's proposal for "light" non-exclusive licensing would promote innovation and promote opportunities for new as well as traditional uses.[48] ViaSat also agrees with Google that the Commission should not simply default to wide geographic area exclusive licensing, as proposed.[49] Because terrestrial services in the 28 GHz Band will not be ubiquitous throughout the vast majority of the United States, granting exclusive mobile rights over a large geographic area is unnecessary to facilitate mobile services, but could give those licensees the ability to

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46 *See Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band*, Report and Order and Second Further Notice of Proposed Rulemaking, 30 FCC Rcd 3959, 4067 ¶ 370 (2015) (indicating that rules governing SAS for 3.5 GHz are high-level guidelines with specific policies, procedures and technologies to be reviewed and approved in a subsequent SAS administrator application process).

47 *See* Federated Wireless Comments at 14-15; Google Comments at 3-4.

48 *See* Google Comments at 2-3.

49 *See id.* at 4 (proposing tiered usage similar to that adopted for the 3.5 GHz band).

preclude satellite uses, including those that could coexist with, or utilize spectrum that is not being actively used by, the terrestrial licensee.[50]

ViaSat joins other commenters in urging the Commission to refrain from relying predominantly on coordination with terrestrial licensees as the mechanism for facilitating secondary satellite operations.[51] Such a regime would likely result in large geographic license areas lying fallow unless and until the licensee is required to permit shared spectrum uses. The new regulatory framework should not let terrestrial users dictate whether or not satellite operators will be permitted to operate on a secondary basis. Proposals that would require FSS operators to coordinate with the terrestrial licensee would skew any negotiations for FSS use in favor of terrestrial licensees, and could well negate any potential for sharing in this spectrum. Thus, the Commission should ensure that the regulatory regime clearly sets the boundaries in which both satellite and terrestrial can operate, such as through the calculation of compatibility zones and a SAS mechanism as discussed above.

V. SHARING BETWEEN TERRESTRIAL AND SATELLITE IN THE 37.5-40 GHZ CAN BE ACHIEVED IN SUBSTANTIALLY THE SAME MANNER AS IN THE 28 GHZ BAND

ViaSat supports proposals to expand flexibility for future satellite deployment in the 37.5-40 GHz band. Other commenters confirm ViaSat's characterization of this spectrum as providing vital expansion capabilities for satellite networks in development. Like ViaSat, other satellite operators have set forth plans for deployment in this band, and the satellite industry has invested in the development of technology to make use of this band.[52] At least one satellite operator has commenced testing of satellite payloads using this spectrum to validate the

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50 O3b Comments at 12.

51 *See, e.g., id.* at 19.

52 *See e.g.*, Inmarsat Comments at 9-10; EchoStar Comments at 25-26.

commercial use of this spectrum.[53] To facilitate commercial satellite deployment, ViaSat urges the Commission to grant co-primary status to essential earth station facilities in the 37.5-40 GHz band, and to expand the secondary designation in this band to allow operation of satellite user terminals on an opportunistic basis.[54]

ViaSat believes that satellite and terrestrial operations can share in the 37.5-40 GHz band in the same manner as proposed for the 28 GHz Band. As EchoStar proposes, sharing parameters can be established to determine the necessary compatibility zone around essential earth station facilities entitled to protection.[55] Given the small size of these compatibility zones, the spectrum would not be unreasonably encumbered for 5G operations. The parameters for determining the compatibility zones will depend on the power flux density levels established for satellite downlinks in the band.

The Commission has successfully established satellite downlink power flux density levels in other bands that enable compatibility between co-frequency, co-coverage terrestrial operations, and there is no reason why this approach would not also work in the 37.5-40 GHz band. Sharing between terrestrial operations and satellite downlink bands does not require the elimination of energy transmitted from satellites onto the earth's surface, as Straight Path presumes in arguing that satellite downlinks should be prohibited in this band.[56] Straight Path's fundamental mischaracterization of the sharing environment in the 37.5-40 GHz band is

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53 Inmarsat Comments at 10 (citing launch of Alphasat, which includes a Q/V-band payload serving Europe, the Middle East and Africa); *see also* EchoStar Comments at 26; SIA Comments at 12-13.

54 *See* EchoStar Comments at 27, 30.

55 *Id.* at 29.

56 *See* Straight Path Comments at 31-32 (mistakenly asserting that interference from FSS into terrestrial mobile devices cannot be avoided due to the size of satellite spot beams).

inconsistent with well-established and common scenarios for coexistence between terrestrial networks and satellite downlink operations.[57]

Based on the establishment of the appropriate power flux density levels for satellite networks, any number of earth stations can operate on a secondary basis without any additional impact on terrestrial operations, provided that the earth station operators accept the impact of any terrestrial operations.[58] As discussed above with respect to the 28 GHz Band, given the propagation characteristics of high-band spectrum and the likely deployment scenarios for terrestrial networks in this band, significant opportunities should exist for earth station operations in locations and at times when the spectrum is not being utilized for terrestrial operations. Therefore, proposals to exclude satellite from the 37.5-40 GHz band or to adopt exclusive licensing regimes that would preclude opportunistic uses by satellite services would result in gross underutilization of this spectrum.

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57 *See, e.g., 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*, Second Report and Order, 18 FCC Rcd 25428, 25439 ¶ 24 (2003) (establishing a pfd limit to facilitate a soft-segmentation approach that would promote satellite and terrestrial wireless services in the 37.5-42.0 GHz band segment); *Establishment of Policies and Service Rules for the Broadcasting-Satellite Service at the 17.3-17.7 GHz Frequency Band and at the 17.7-17.8 GHz Frequency Band Internationally, and at the 24.75-25.25 GHz Frequency Band for Fixed Satellite Services Providing Feeder Links for the Broadcasting-Satellite Service and for the Satellite Services Operating Bi-directionally in the 17.3-17.8 GHz Frequency Band*, Report and Order and Further Notice of Proposed Rulemaking, 22 FCC Rcd 8842, 8864-5 ¶ 55 (2007) (adopting pfd limits in the 17.7-17.8 GHz band to facilitate co-frequency satellite downlinks and terrestrial operations).

58 EchoStar Comments at 30.

VI. TECHNICAL RULES FOR TERRESTRIAL SERVICES SHOULD AFFORD PROTECTION TO CO-PRIMARY SATELLITE OPERATIONS AND REFLECT FEASIBLE AND REALISTIC 5G DEPLOYMENT SCENARIOS

In order to facilitate the types of sharing proposed in this reply and in ViaSat's opening comments, any terrestrial service rules adopted in this proceeding should be consistent with the sharing environment, and also reflect realistic 5G deployment scenarios and reasonably feasible 5G antenna technologies. In general, ViaSat believes that technical solutions exist or can be developed to enable co-existence of terrestrial wireless and satellite operations, including reasonable technical parameters to ensure compatibility. For instance, many commenters have indicated that 5G base station antennas are expected to employ MIMO techniques and will operate with a downward tilt, or will transmit highly directional signals with significant gain.[59] Given these characteristics, base station operations are less likely to interfere with satellite receivers. Similarly, 5G handsets operating in the 28 GHz Band would need to operate at sufficiently low power levels to comply with radiation exposure limits, and thus are less likely to aggregate to a level that could harm satellite receivers. However, even in these cases, suitable 5G operating parameters will need to be developed to ensure the compatibility of 5G services with satellite operations in the 28 GHz Band.

In stark contrast, high-powered 5G mobile stations that some commenters have proposed have the potential to cause harmful interference into satellites operating in the 28 GHz Band. In particular, proposals to allow mobile devices to operate at EIRP levels as high as 82 dBm in the 28 GHz Band are likely to cause harmful interference into satellite receivers,[60] as detailed in

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59 *See, e.g.,* 4G Americas Comments, Attachment, "5G Technology Evolution Recommendations," at 28-29; Huawei Comments at 14-15; *see also NPRM* ¶ 7 n.5.

60 *See, e.g.,* XO Comments at 27 (proposing an EIRP limit of 82 dBm for mobile devices); NPRM ¶ 278 (citing proposals by Straight Path for a peak EIRP limit of 43 dBm and 30

Exhibit 1. The proposed 82 dBm EIRP limit appears to be based on the existing limit in the Part 15 rules for the 60 GHz band or the limit for LMDS base stations.[61] As a threshold matter, when importing limits from other rules, careful consideration of any distinctions in spectrum characteristics, operating environment, and other uses in the same band, is warranted. For instance, unique propagation characteristics of spectrum in the 60 GHz frequency range (in which there is no FSS allocation) require higher power limits to overcome extremely high atmospheric absorption and attenuation of signals.[62] The 28 GHz Band does not exhibit these characteristics. In addition, the 85 dBm EIRP limits in Part 15 and for LMDS base stations apply to very high gain antennas intended to support point-to-point transmissions.[63] However, comments proposing this power level do not propose to subject mobile operations to any particular gain level, which suggests that the power would not be directional and could be transmitted upward toward satellite receivers in the 28 GHz Band.[64]

Significantly, the United States has obligations under international law to coordinate radiofrequency ("RF") operations within its borders with the RF operations of other nations that may be adversely affected—this is true at the Canadian and Mexican borders, and the obligations are no different at the geostationary arc or in the non-geostationary planes. Moreover, as noted in ViaSat's comments, under the Commission's current band plan, the FSS has "licensing priority vis-à-vis *any third service allocated domestically or internationally in the band*," and

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dBm maximum output power, and proposal by Samsung for a limit of 85 dBm for mobile stations operating in the 28 GHz band).

61 *NPRM* ¶¶ 276, 278; *see also* XO Comments at 27 (citing Samsung proposal to use the 85 dBm LMDS base station limit for 5G mobile stations).

62 *See, e.g., Revision of Part 15 of the Commission's Rules Regarding Operation in the 57-64 GHz Band*, Report and Order, 28 FCC Rcd 12517 ¶ 1 (2013).

63 47 C.F.R. § 15.255(b)(1)(ii) (establishing a limit of 82 dBm minus 2 dB for every dB that the antenna gain is less than 51 dBi).

64 *See, e.g.*, XO Comments at 26-27.

satellites that operate in the 28 GHz Band therefore are protected under the existing band plan against receiving interference from the terrestrial mobile service.[65]

In this case, the proposed high-powered mobile operations advocated by some commenters would likely create harmful interference into any of the spacecraft operating in the 28 GHz Band, and/or filed for at the ITU, that have beams that see the United States (in whole or in part), many of which have been granted market access under, and in reliance on, the existing band plan for the 28 GHz Band.[66] As detailed in Exhibit 1, if not appropriately addressed by suitable 5G operating parameters, the aggregate uplink interference from certain 5G operations within the United States likely would significantly exceed the limits of Recommends 4 of ITU-R Recommendation S.1432-1 regarding maximum degradation due to interference at frequencies below 30 GHz. While this risk exists with certain proposed 5G operations, it may not exist with every type of proposed 5G operation. This issue requires further study based on specific 5G operating parameters.

Furthermore, proposals to increase mobile station power limits to 82 dBm/100 MHz, as XO proposes, are unlikely to be relevant for any realistic consumer devices. As illustrated by the radiation exposure calculation provided in Exhibit 1, the amount of power into a mobile terminal required to reach this EIRP limit appears unnecessary for the types of Wi-Fi hotspot 5G devices that XO describes,[67] and would result in extremely hazardous RF exposure levels. While the power requirements could be reduced significantly by employing a directional antenna,

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65 ViaSat Comments at 11, *citing Rulemaking to Amend Parts 1, 2, 21, and 25 of the Commission's Rules to Redesignate the 27.5-29.5 GHz Frequency Band, to Reallocate the 29.5-30.0 GHz Frequency Band, to Establish Rules and Policies for Local Multipoint Distribution Service and for Fixed Satellite Services*, First Report and Order, 11 FCC Rcd 19005, 19024 ¶ 44 (1996) (emphasis supplied).

66 *See* ViaSat Comments at 11-12.

67 *See* XO Comments at 27.

increasing the directivity of an antenna typically requires a larger antenna as well as a dynamic pointing mechanism to maintain a signal toward a 5G base station, limiting the types of uses that XO contemplates in its comments for the proposed higher power levels. ViaSat urges the Commission to consider the reasonableness of power levels for new terrestrial services and reject proposed power levels that threaten satellite networks.

VII. VIASAT SUPPORTS NOT ADDRESSING EARTH STATIONS IN MOTION IN THIS RULEMAKING

ViaSat agrees with commenters acknowledging the significant opportunities for operation of earth stations in motion, particularly in the 28 GHz Band.[68] Over the past decade, applications for FSS earth stations in motion have been developed and deployed at increasing rates, first in the Ku band, and more recently in the Ka band. The record reflects that Ka band satellite networks are currently providing valuable broadband communication services to aircraft and maritime vessels.[69] However, ViaSat agrees with commenters who propose that the Commission not address earth stations in motion operating within FSS networks in the 28 GHz Band within the scope of this proceeding.[70]

Further work and study should be conducted in international fora before a rulemaking proceeding is commenced on this issue. The ITU currently is studying mobility in the 27.5-29.5 GHz band, and a rulemaking for earth stations in motion within the U.S. may best be addressed once the ITU studies have been concluded. However, nothing in this proceeding should foreclose the possibility of licensing earth stations in motion in the 28 GHz Band (or any of the other bands addressed in this proceeding). The marketplace has already indicated high demand

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68 *See* Boeing Comments at 5, 10; O3b Comments at 10-11, Inmarsat Comments at 3-4.

69 *See* Inmarsat Comments at 3-4, 8; O3b Comments at 5-6, 10-11.

70 *See* Inmarsat Comments at 8; SIA Comments at 19-20.

for satellite-delivered broadband services on moving platforms, and such demand is increasing as consumers demand broadband speeds and throughput when traveling on aircraft and on ships that are comparable to services available in the home. Opportunities should be preserved for greater growth and development of these services.

VIII. CONCLUSION

ViaSat urges the Commission to adopt a framework for the 28 GHz Band and the 37.5-40 GHz band that promotes greater opportunities for satellite networks along with the development of 5G terrestrial services.

In order to sustain advances in satellite technologies, including ViaSat's next-generation systems, continued and expanded access to the 28 GHz Band in particular is crucial. ViaSat urges the Commission to protect (i) the aggregation, interconnection and backhaul facilities of any spacecraft that the Commission has authorized to serve the United States in the 28 GHz Band, as well as (ii) every other individually-licensed earth station in the 28 GHz Band that would not require a 5G compatibility zone extending more than a specified distance from the earth station, based on parameters that will afford sufficient protection to 5G operations. Moreover, in order to effectuate efficient and intensive utilization of this important spectrum resource, the Commission should permit the operation of earth station user terminals on a secondary, non-interference basis in the 28 GHz Band.

Importantly, facilitating continued satellite use of the 28 GHz Band requires that the Commission adopt rules that balance the sharing burdens and obligations between both satellite and terrestrial users to avoid scenarios in which terrestrial licensees can unilaterally dictate the terms of sharing.

ViaSat supports expanded flexibility for satellite use of the 37.5-40 GHz band, including co-primary status for essential earth stations and for user terminals on a secondary basis. Such

operations can be accommodated in much the same manner proposed in ViaSat's comments and in these reply comments for the 28 GHz Band.

ViaSat urges the Commission to refrain from adopting power limits and other technical rules that would threaten interference into satellite receive operations.

Finally, ViaSat urges the Commission to consider rules for earth stations in motion in the 28 GHz Band in a separate rulemaking proceeding to allow the continued development of international standards for such services over the next few years. But in the meantime, nothing in this proceeding should foreclose the possibility of licensing earth stations in motion in the 28 GHz Band subject to the outcome of that future rulemaking.

Respectfully submitted,

/s/

Christopher Murphy
Associate General Counsel,
Regulatory Affairs
Daryl T. Hunter
Senior Director, Regulatory Affairs
Christopher Hofer
Director, Regulatory Affairs
VIASAT, INC.
6155 El Camino Real
Carlsbad, CA 92009

John P. Janka
Elizabeth R. Park
LATHAM & WATKINS LLP
555 Eleventh Street, N.W.
Suite 1000
Washington, DC 20004

Counsel for ViaSat, Inc.

February 26, 2016

EXHIBIT 1

5G MOBILE STATION EIRP ANALYSIS

Aggregate Interference from High EIRP 5G Mobile Stations

A number of commenters proposed higher EIRP limits for 5G mobile stations ranging from 30 dBm to 34 dBm to 43 dBm to 85 dBm in the extreme case.

Beyond the physical size and human safety concerns discussed below, these proposed higher EIRP limits are problematic with respect to the aggregate power into the satellite receiver – and in the very high EIRP cases even single entry levels are harmful.

Because no EIRP density limits toward the 28 GHz receivers located on satellites in the geostationary orbit (GSO) have been proposed, nor off-axis gain masks in directions above the horizon, significant energy may be emitted toward the GSO (or NGSO).

Assuming that 5G mobile antennas will be mounted on automobile and truck roof tops, that physical dimension must be kept small, and that omni-directional gain is desired in the horizontal plane, these antennas will have limited overall directivity in the elevation plane. Further, reflections from the vehicle roof and other objects will cause additional energy to radiate upward toward the GSO.

Millions of 5G mobile devices can be expected to be operational and with no limits toward the GSO these signals will aggregate at the satellite's receiver potentially causing significant interference.

ViaSat's ViaSat-1 satellite is in operation today providing service to US, Canada, and Mexico. The satellite's receive antenna gain is nominally 53.3 dBi, the noise temperature is 1349 K, and the noise floor at the satellite is -197.3 dBW/Hz.

Recommends 4 of ITU-R Recommendation S.1432-1 recommends "that the error performance degradation due to interference at frequencies below 30 GHz should

be allotted portions of the aggregate interference budget of 32% or 27% of the clear-sky satellite system noise in the following way:

- 25% for other FSS systems for victim systems not practicing frequency re-use;
- 20% for other FSS systems for victim systems practicing frequency re-use;
- 6% for other systems having co-primary status;
- 1% for all other sources of interference."

Accordingly, the totality of signals received at the satellite from the 5G mobile system – the other co-primary system – should not cause an impact of more than a 6% of the clear-sky satellite system noise. The 5G mobile system in this case is the entire system including all stations operating as part of that service.

To comply with this recommendation, the other co-primary system (5G) must not cause an aggregate power level at the satellite input that increases the noise floor by more than 6%. A 6% increase is equivalent to an I_o/N_o of -12.2 dB, that is the 5G system noise must not exceed -197.3 dBW/Hz – 12.2 dB = -209.5 dBW/Hz.

Most commenters indicate that the 5G base station antennas are expected to have significant gain and will employ MIMO techniques, and operate with a downward tilt. These base stations likely will not contribute significantly to the 6% number. Handsets will need to operate at low power in order to comply with RF exposure limits and absent further information on their power levels, this analysis will assume these stations will not impact the 6% limit.

While antenna patterns are not available for the 5G mobile stations, using reasonable assumptions for off-axis gain toward the GSO, individually the high EIRP mobile stations appear to comply with the 6% limit. However, once the aggregated power of all mobile stations is considered, the impact to the satellite noise floor is significant.

Table 1 gives the individual terminal on-axis EIRP density, the estimated EIRP density toward the GSO, the individual interfering power density I_o at the satellite, and the aggregate interfering power density assuming 40 million operating

terminals, the delta T/T (percent change in noise floor), and the degradation to the satellite noise floor in dB.

Station EIRP	30	43	82	dBm/100 MHz
On-axis EIRP density	-20.0	-7.0	32.0	dBW/MHz
Off-axis EIRP density	-21.5	-27.0	-33.0	dBW/MHz
Single Entry Io	-241.9	-247.4	-253.4	dBW/Hz
SE Delta T/T	0.0035	0.0010	0.0002	%
Number of stations	40.0	40.0	40.0	Million
Aggregate Io	-165.9	-171.4	-177.4	dBW/Hz
Aggregate D T/T	138599.0	39062.5	9812.1	%
Noise floor degradation	31.421	25.929	19.962	dB

Table 1

RF Exposure Risks of High EIRP 5G Mobile Stations

The higher EIRP limit of 82 dBm/MHz for 5G mobile terminals operating at 28 GHz, proposed by XO, presents a significant human safety risk due to RF exposure.

XO does not specify any minimum antenna gain required for the use of the higher EIRP of 82 dBm/MHz. Because the stations are mobile, it can be assumed that high gain and therefore highly directional antennas are undesirable due to both their size and the required tracking capability to keep them pointed at the 5G base station.

In 47 CFR 15.255 (b)(1)(ii), the 57 – 64 GHz rule part used as a reference to support the higher EIRP limit of 82 dBm/100 MHz, the minimum antenna gain associated with the 82 dBm EIRP limit is 51 dBi. The equivalent antenna area required at 28 GHz to produce a gain of 51 dBi is 1.353 m^2 assuming an aperture efficiency of 85%. This is equivalent to an antenna diameter of 1.313 m, which is rather large for mobile use on passenger vehicles and trucks on US roadways.

Assuming the full 850 MHz is to be transmitted, the total EIRP would be 82 dBm/MHz + 10*log(850 MHz/100 MHz) = 91.3 dBm. The required input power is

91.3 dBm – 51 dBi = 40.3 dBm or 10.3 dBW, which is equal to 10.7 W.

Following the guidelines given in OET 65, the RF levels 1 m away from the above nominal 1.313 m antenna above would be 26.9 W/m^2 which is 269% of the FCC's exposure guidelines for General Population/Uncontrolled Access.

Because it is not clear that XO proposes to follow the same EIRP reduction as a function of antenna gain required in Part 15.255, it is worthwhile to consider the RF exposure from a 5G mobile terminal operating at 91.3 dBm but with a lower gain antenna.

Assuming a more mobile-friendly antenna size of 10 cm x 10 cm, the area is 0.01 m^2 and assuming the same 85% efficiency, the gain is 29.7 dBi and the antenna input power is 91.3 dBm – 29.7 dBi = 61.6 dBm or 31.6 dBW, which is equal to 1447.8 W. Following the OET 65 guidelines for calculating the exposure at 1 m, the RF level is 115.2 W/m^2 which is 1150% of the FCC's exposure guidelines for General Population/Uncontrolled Access.

Conclusion

High EIRP 5G mobile terminals have the potential to cause significant harm to spacecraft operating in the 28 GHz band. Care must be taken to ensure that aggregate EIRP density in the direction of the GSO and NGSO orbital space is considered in order to comply with ITU limits.

DECLARATION

I, Daryl T. Hunter, hereby make the following declarations under penalty of perjury. I understand that this Declaration will be submitted to the Federal Communications Commission.

1. I am Senior Director, Regulatory Affairs of ViaSat, Inc.

2. I have reviewed the foregoing Reply Comments of ViaSat, Inc., and the information contained therein is true and correct to the best of my knowledge, information and belief.

Daryl T. Hunter, P.E.

Executed February 26, 2016