Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
Petition for a Declaratory Ruling Granting Access to the U.S. Market for the OneWeb System	)	IBFS File No. SAT-LOI-20160428-00041
Petition for Rulemaking to Permit MVDDS Use of the 12.2-12.7 GHz Band for Two-Way Mobile Broadband Service	)	RM-11768
Use of Spectrum Bands Above 24 GHz For Mobile Radio Service	)	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 to 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 for Spectrum in the 37.0-38.0 GHz and 40.0-40.5 GHz for Government Operations	)	IB Docket No. 97-95

PETITION TO DENY OF THE MVDDS 5G COALITION

August 15, 2016

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PETITION TO DENY OF THE MVDDS 5G COALITION

The MVDDS 5G Coalition (the "Coalition"),[1] pursuant to Section 309(d) of the Communications Act of 1934, as amended, and Section 25.154 of the Commission's rules,[2]

[1] The Coalition includes a cross-section of Multichannel Video Distribution and Data Service ("MVDDS") and Direct Broadcast Satellite ("DBS") licensees holding authorizations in the

submits this Petition to Deny the above-captioned Petition for Declaratory Ruling ("Petition") filed by WorldVu Satellites Limited ("OneWeb") requesting the grant of access to the U.S. market for a 720-satellite non-geostationary satellite orbit ("NGSO") system.

I. INTRODUCTION AND SUMMARY

OneWeb petitions the Commission for a declaratory ruling to allow it to provide Fixed-Satellite Service ("FSS") in the United States using a satellite constellation that will reportedly be authorized by the United Kingdom.[3] OneWeb proposes to operate over a total of ***<u>5,900</u>*** megahertz of spectrum covering the 10.7-12.7 GHz, 14.0-14.5 GHz, 17.8-18.6 GHz, 18.8-19.3 GHz, 27.5-28.35 GHz, 28.35-29.1 GHz, and 29.5-30.0 GHz bands.[4] The Coalition requests that the Commission deny OneWeb's Petition to the extent it seeks access to the 12.2-12.7 GHz band. A grant of authority for 720 NGSO satellites to use the 12.2-12.7 GHz band disserves the public interest for many reasons.

<u>First</u>, grant of OneWeb's Petition in the 12.2-12.7 GHz band would essentially destroy any realistic prospect of MVDDS rollout. It would likely cause harmful interference from MVDDS to NGSO satellite receivers and, depending on OneWeb's ultimate satellite

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12.2-12.7 GHz band, including: Braunston Spectrum LLC, Cass Cable TV, Inc., DISH Network L.L.C. ("DISH"), GO LONG WIRELESS, LTD., MDS Operations, Inc., MVD Number 53 Partners, Satellite Receivers, Ltd., SOUTH.COM LLC, Story Communications, LLC, Vision Broadband, LLC, and WCS Communications, Inc. Members of the Coalition hold 212 of 213 MVDDS licenses and have a vested interest in the use of the 12.2-12.7 GHz band. For these and other reasons described herein, the Coalition is a party-in-interest under Section 309(d)(1) of the Communications Act. *See* 47 U.S.C. § 309(d)(1).

[2] 47 U.S.C. § 309(d); 47 C.F.R. § 25.154.

[3] WorldVu Satellites Limited, Petition for a Declaratory Ruling Granting Access to the U.S. Market for the OneWeb System, IBFS File No. SAT-LOI-20160428-00041, at 7 (filed Apr. 28, 2016) ("Petition").

[4] *See id.* at 8. OneWeb's system will also have the capability to operate in the 12.75-13.25 GHz and 19.7-20.2 GHz band, but it is not seeking authority to use those bands in the United States. *Id.*

configuration, the potential for harmful interference from NGSO satellites into MVDDS receivers. OneWeb's operations in the band would thus thwart use of the band for MVDDS; they would also prevent any future 5G mobile broadband services from operating in the band notwithstanding a petition for rulemaking to provide 5G service pending before the Commission.[5] Indeed, given the Commission's rules aimed at mitigating interference, including the required 10 kilometer separation distance from NGSO receivers, OneWeb's proposed service would effectively preclude any operation of MVDDS service in the vicinity of a OneWeb end-user terminal.[6]

Second, OneWeb proposes *mobile*, ubiquitous service covering the entire United States, which makes the death blow to MVDDS that much more definitive. Mobile NGSO terminals would make an existing interference problem worse. Whether a mobile NGSO service is used while in motion or temporarily stationed, the precise locations and operating times for these receivers would be unknown to MVDDS operators, effectively foreclosing MVDDS from the entire country. In fact, the Commission's rules do not permit OneWeb to deploy mobile NGSO services in the 12.2-12.7 GHz band, and OneWeb's Petition is thus procedurally defective. The United States Table of Frequency Allocations does not support the deployment of satellite mobile end-user terminals in the 12.2-12.7 GHz band. OneWeb has failed to request a waiver to permit such a nonconforming use, much less proven that the prerequisites to a waiver are met. At a minimum, OneWeb's proposed use of the NGSO FSS allocation warrants consideration in a rulemaking proceeding, so the Commission and the public can fully evaluate the potential

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[5] *See* Petition of MVDDS 5G Coalition for Rulemaking, RM-11768 (filed Apr. 26, 2016) ("Coalition Petition for Rulemaking").

[6] *See* 47 C.F.R. § 101.129(b).

consequences of OneWeb's sweeping change in the use of this longstanding frequency allocation.

Third, permitting OneWeb's proposed use of the 12.2-12.7 GHz band would contravene the Commission's call for the terrestrial and satellite industries to collaborate in identifying additional spectrum for 5G services. A grant of 12.2-12.7 GHz authority for OneWeb would preclude terrestrial and satellite sharing and subtract from 5G spectrum, not add to it.

Fourth, the other 5,400 megahertz of spectrum outside of the 12.2-12.7 GHz band that OneWeb has sought should be more than enough for OneWeb to accomplish its vision. A grant of 12.2-12.7 GHz mobile NGSO authority to OneWeb would also eliminate any desire to invest in, or deploy, terrestrial services using the band. The permanent loss of the potential to deploy the 12.2-12.7 GHz band for 5G is too steep a price to pay for the mere hope of NGSO implementation. Thus, the Commission should resolve doubts over how much spectrum is needed for such a system in favor of a more efficient spectrum allocation.

Finally, grant of the Petition would prejudge the rulemaking requested by the Coalition on the subject of opening up the band for 5G services. Terrestrial 5G represents the best use of the band in addition to its current successful use for DBS services. The Commission should put the Coalition's proposal as well as OneWeb's Petition to the test in a rulemaking proceeding. To prejudge the Coalition's Petition for Rulemaking would be to thwart the substantial public interest benefits of permitting 5G use of the band.

II. THE GRANT OF 12.2-12.7 GHZ AUTHORITY WOULD DESTROY LICENSED MVDDS SERVICES AND SQUANDER THE POTENTIAL OF THIS BAND FOR 5G USE

A. Coexistence Between Currently Authorized MVDDS and OneWeb's Proposed NGSO FSS Services Is Infeasible Even Under the Current Rules.

The Commission's rules have made deployment of coexisting current generation MVDDS and NGSO FSS systems practically infeasible in light of the large distances required to control interference between the two services.[7]

MVDDS transmissions would cause harmful interference into NGSO receivers, notwithstanding the limits on MVDDS power flux density ("PFD") imposed under the current rules. Even subject to these limits, Tom Peters, the former FCC Wireless Bureau Chief Engineer, concludes that MVDDS transmissions would still produce a signal approximately 12 dB stronger than the maximum signal the NGSO FSS earth station can receive from the satellite, which creates "a high likelihood of interference between MVDDS and NGSO FSS operations."[8]

In an analysis previously submitted to the Commission, Mr. Peters determined that, using current MVDDS base station power limits and the assumption that interference power from the MVDDS base station must be equal to the maximum power on the ground from the NGSO satellite, NGSO user terminals could experience interference at separation distances of 11.5 kilometers.[9] Mr. Peters has now been able to test this conclusion by taking into account the specific characteristics of OneWeb's proposed deployment. As shown in the attached technical study, the calculated distance over which MVDDS transmitters would cause harmful interference

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[7] *See* Tom Peters, MVDDS 12.2-12.7 GHz NGSO Coexistence Study at 6 (Aug. 15, 2016) ("MVDDS/NGSO Technical Analysis") (attached as Exhibit 1).

[8] *See* Tom Peters, MVDDS 12.2-12.7 GHz Co-Primary Service Coexistence, at 34 n.88 (June 8, 2016) ("First Coexistence Study").

[9] *See id.* at 34.

to NGSO FSS receivers ranges from 22.8 to 128.4 kilometers, depending on assumptions about the minimum operational sensitivity ("MOS") of the receiver.[10] While separation distances are lower if free space path loss is not used in the calculation, separation distances using Longley-Rice calculations would still exceed 20 kilometers.[11] Separation distances of this magnitude do not portend a mutually beneficial coexistence between MVDDS and NGSO FSS; instead, they create mutual paralysis that prevents investment in, and the deployment of, both MVDDS and NGSO FSS services.

Authorizing NGSO FSS operations in the band could increase the risk of interference to MVDDS as well. OneWeb says it intends to rely on antenna discrimination to limit MVDDS interference; it would use relatively narrow beams and transmit only when over its NGSO FSS receivers to avoid the types of oblique transmission angles that would be likely to cause interference into MVDDS system.[12] Unfortunately, this interference-avoidance technique is premised on OneWeb's ability to launch, construct and operate its 720 satellite constellation. In the likely event that OneWeb launches a lower number of satellites, then in order to maintain its service, this proposed interference mitigation technique will no longer be feasible.

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[10] MVDDS/NGSO Technical Analysis at 14. MOS is the lowest signal level at the antenna necessary for the receiver to detect and demodulate the signal. When MOS is assumed to be equal to the maximum power of the satellite (which understates the interference), the resulting distance is 22.8 kilometers. When MOS is assumed to be 15 dB below the maximum power (which still understates the interference), the resulting distance is 128.4 km. *Id.*

[11] *Id.*

[12] *See* WorldVu Satellites Limited, OneWeb Non-Geostationary Satellite System - Technical Information to Supplement Schedule S, at 31 (Apr. 28, 2016) (Attachment A to the Petition) ("OneWeb Technical Narrative").

B. Mobile NGSO Use Would Further Exacerbate the Interference Issues, and a Waiver of the Table of Allocations Neither Has Been Requested Nor Is Warranted Here

OneWeb's proposed mobile use of its NGSO system in the 12.2-12.7 GHz band would only exacerbate the extent of interference between the MVDDS and NGSO FSS services. OneWeb's Petition is for mobile and portable use,[13] and its vision of extending "coverage of partner operators to reach 100% of the United States geography" can only reasonably be achieved if mobile use is allowed.[14] Yet such mobile use would result in a debilitating interference situation for both services for two reasons. First, as Mr. Peters confirms, the risk of harmful interference from MVDDS into mobile NGSO receivers is even greater than in the case of fixed NGSO antenna.[15] Second, the combination of mobile NGSO use and a requirement to protect the NGSO mobile terminals from harmful interference would foreclose MVDDS from the entire country by effectively making the whole country an exclusion zone for any MVDDS operations.[16]

Specifically, under the current rules, MVDDS transmitting antennas may not be installed within 10 kilometers of any "preexisting" NGSO FSS receiver, which the Commission defines as an NGSO FSS receiver either under construction or in use on the date an MVDDS licensee notifies the NGSO FSS licensee of its intent to construct a new MVDDS transmitting antenna.[17] But if OneWeb were to receive mobile authority, the current first-in-time rule would no longer

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[13] *See id.* at 10.

[14] *Id.* at 3.

[15] *See* MVDDS/NGSO Technical Analysis at 10-11.

[16] *See id.* at 17-18.

[17] 47 C.F.R. § 101.129(b).

function as a means of regulating MVDDS and NGSO coexistence because mobile NGSO terminals could be anywhere.

Further, as the International Bureau has already explained to OneWeb, the Commission's rules do not allow the operation of earth stations in motion communicating with NGSO space stations in frequencies allocated to FSS, and such operation would require a waiver of the Commission's rules.[18] A waiver is necessary because, among other things, the United States Table of Frequency Allocations does not support the deployment of mobile end-user terminals in the 12.2-12.7 GHz band.[19] The allocations are limited to the Fixed Service, the Broadcasting-Satellite Service, and NGSO Fixed-Satellite Service.[20] NGSO FSS and NGSO mobile satellite services are two distinct services with different network and technology requirements.

But OneWeb has neither applied for any earth station or user terminal license, nor requested the necessary waivers of the Commission's rules. In fact, OneWeb has confined itself to the assertion that those waivers would be applied for "at the time it makes applications for earth station licenses."[21] It would be imprudent for the Commission to act on OneWeb's Petition without having the requests for waiver before the agency because the costs and benefits of OneWeb's potential operations cannot be properly assessed until the entire package, including the waiver requests, is available for consideration. Indeed, the Commission's rules prohibit the

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[18] *See* Letter from Jose Albuquerque, Chief, Satellite Division, International Bureau, FCC, to Kalpak Gude, Vice President of Legal-Regulatory, WorldVu Satellites Limited, at 2 (June 10, 2016).

[19] 47 C.F.R. § 2.106.

[20] *Id.* & n.5.487A.

[21] *See* Letter from Kalpak Gude, Vice President of Legal-Regulatory, WorldVu Satellites Limited, to Marlene Dortch, Secretary, FCC (June 24, 2016). OneWeb also indicates that it intends to apply for user terminal licenses on a blanket basis pursuant to Sections 25.115 and 25.137 of the Commission's rules. *See* Petition at 8.

International Bureau from processing OneWeb's application because it does not comport with the Table of Allocations, and OneWeb failed to include in its application "a request which sets forth the reasons in support of a waiver of" the allocation.[22]

Granting OneWeb's Petition for mobile and portable devices would be a change of a generally applicable rule, namely modifying the Table of Frequency Allocations to permit mobile NGSO use of the band. A rulemaking is the more appropriate vehicle for such a change.[23]

III. THE REQUEST CONTRAVENES THE COMMISSION'S CALL FOR COLLABORATION BETWEEN THE SATELLITE AND TERRESTRIAL INDUSTRIES TO ACCOMMODATE 5G

Granting OneWeb's Petition would also frustrate the Commission's calls for collaboration between the satellite and terrestrial industries to promote the deployment of 5G wireless broadband. Chairman Wheeler has noted the "advantageous" nature of the "satellite and mobile industries [coming] together to propose realistic ideas for their coexistence . . . and to do so quickly."[24] It is such "[i]ndustry-driven win-win solutions that protect [] existing and contemplated satellite services, while also enabling new terrestrial offerings" that are deserving of regulatory approval.[25] Similarly, a bipartisan consensus exists among the FCC's

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[22] 47 C.F.R. § 25.112(a)(3); (b)(1).

[23] *See* New DBSD Satellite Services G.P., Debtor-in-Possession, TerreStar License Inc., Debtor-in-Possession Requests for Waivers and Modified Ancillary Terrestrial Component Authority, *Order*, 27 FCC Rcd. 2250, 2261-62 ¶ 29 (2012) (holding that changing the use of a band is most appropriately undertaken in the context of a rulemaking).

[24] Tom Wheeler, Chairman, FCC, Remarks at National Press Club – The Future of Wireless: A Vision for U.S. Leadership in a 5G World, at 5 (June 20, 2016), http://transition.fcc.gov/Daily_Releases/Daily_Business/2016/db0620/DOC-339920A1.pdf.

[25] Tom Wheeler, Chairman, FCC, Remarks at 19th Annual Satellite Leadership Dinner, Washington, D.C., at 4 (Mar. 7, 2016), https://apps.fcc.gov/edocs_public/attachmatch/DOC-338135A1.pdf.

Commissioners to enable flexible use of various frequency bands while protecting incumbent services.[26]

Yet the Petition undercuts any hope for such "advantageous" coexistence. If granted, OneWeb's operation in the 12.2-12.7 GHz band would preclude the future operation of MVDDS services and a path forward to 5G. The Commission should not consider the Petition in a vacuum, but instead seek to maximize coexistence and the rollout of 5G terrestrial services while affording sufficient other spectrum for testing OneWeb's NGSO fleet vision, in accordance with the Commissioners' calls to action.

IV. ONEWEB'S NGSO FSS SERVICES WOULD NOT BE UNDERMINED BY EXCLUSION OF THE 12.2-12.7 GHZ BAND

Against this backdrop of harm to the MVDDS service and the preclusion of 5G deployment in the band, OneWeb does not convincingly present any need for access to the 12.2-12.7 GHz band. The band represents only 500 megahertz of the 5,900 megahertz of spectrum that OneWeb seeks to use for service and gateway links.[27] A total of 1,500 megahertz, including 500 megahertz of primary use spectrum in the relatively uncongested 11.7-12.2 GHz band—where DBS does not operate—will remain available to OneWeb just for its satellite-to-user downlink services.

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[26] *See, e.g.*, *Use of Spectrum Bands Above 24 GHz for Mobile Radio Services*, Notice of Proposed Rulemaking, 30 FCC Rcd. 11878, 12012 (2015) (Statement of Commissioner Ajit Pai) (to ensure the United States leads the transition to 5G, we must "[g]et[] more spectrum into the hands of consumers and enabl[e] more flexible use of these bands"); *id.* at 12009 (Statement of Commissioner Jessica Rosenworcel) ("[W]e take steps to protect incumbent satellite operations that rely on this high-band spectrum. We allow for their continued growth and commit to carefully monitoring the impact of terrestrial use on their operations. This is important.").

[27] *See* Petition at 8 (proposing "satellite-to-user terminal" operations in the 10.7-12.7 GHz band).

In support of its extensive request for spectrum resources, OneWeb offers only the truism that each megahertz of spectrum increases the ability to accomplish its commercial objectives.[28] OneWeb has not supplied any spectrum-needs analysis based on take rates or throughput requirements. Nor has it provided any demand forecast to justify the 5,900 megahertz of spectrum it has requested.

NGSO systems like OneWeb's are supposed to be able to adapt. A hallmark of NGSO FSS systems is frequency agility, allowing constellations to use several bands based on the different frequency allocations in the various regions of the world.[29] Indeed, the Commission has long encouraged NGSO FSS operators to enable their receivers to dynamically switch to the 11.7-12.2 GHz band for downlink service in order to avoid MVDDS interference in the 12.2-12.7 GHz band.[30] OneWeb also explicitly recognizes in the Petition that many of the frequencies it places on its satellites will be kept dark in various countries, including some in the United States.[31]

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[28] *See id.* at 19.

[29] *See* Establishment of Policies and Service Rules for the Non-Geostationary Satellite Orbit, Fixed Satellite Service in the Ku-Band, *Report and Order, Further Notice of Proposed Rulemaking*, 17 FCC Rcd. 7841, 7850 ¶¶ 27, 30 (2002).

[30] *See* Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operation of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-Band with Frequency Range, *Memorandum Opinion and Order and Second Report and Order*, 17 FCC Rcd. 9614, 9658-89 ¶¶ 107-109 (2002) ("We find that NGSO FSS receivers operating in the 12.2-12.7 GHz band could be designed with 'frequency diversity' capability that enables dynamic switching to the lower 11.7-12.2 GHz band for downlink service to avoid potential MVDDS interference in the 12.2-12.7 GHz band.").

[31] *See* Petition at 8 (noting that "[a]lthough the OneWeb satellites have the capability to operate in the Earth-to-space direction in the 12.75-13.25 GHz band, and the space-to-Earth direction in the 19.7-20.2 GHz band, FCC authorization is not being requested for these bands at this time and they will not be used from any U.S. territories.").

OneWeb is also seeking access to the 1,000 megahertz of spectrum in the 10.7-11.7 GHz band for downlink services on a "non-interference, unprotected" basis.[32] This is a further demonstration of NGSO system adaptability, indicating the viability of spectrum where NGSO FSS use is secondary. OneWeb has not shown any unique benefits to using the 12.2-12.7 GHz band in the United States that would justify the serious terms such use would create. Furthermore, past experience with proposed NGSO systems suggests the Commission would be wise to resolve these doubts over spectrum sufficiency in favor of a more economical allotment to OneWeb.[33] OneWeb, like previous NGSO applicants, proposes an ambitious satellite constellation and has set lofty and similarly laudable service goals. Yet, substantial risk remains that these goals will not be accomplished and the 12.2-12.7 GHz band will suffer from underutilization. The Teledesic and SkyBridge examples should not necessarily result in the Commission denying authority for similarly ambitious NGSO projects without analysis. But

[32] *See id.* at 24-25.

[33] For example, Teledesic was granted 6,600 megahertz of spectrum to carry out a proposed 840-satellite constellation. *See* Application for Authority to Construct, Launch, and Operate a Low Earth Orbit Satellite System in the Domestic and International Fixed Satellite Service, *Order and Authorization*, 12 FCC Rcd. 3154, 3168-89 ¶¶ 33-35 (1997) (initially authorizing Teledesic to operate in the 18.8-19.3, 28.6-29.1, 27.6-28.4, and 17.8-18.6 GHz bands); *see* Application for Authority to Construct, Launch, and Operate a Ka-band Satellite System in the Fixed-Satellite Service, *Order and Authorization*, 16 FCC Rcd. 2501, 2504, 2506 ¶¶ 8, 14 (2001) (later granting Teledesic authority to conduct inter-satellite service links ("ISL") operations in the 66-67 and 69-70 GHz bands and decreasing its number of satellites from 840 to 288). The dénouement is well known: Teledesic never launched a single satellite, ultimately leaving its spectrum largely fallow to this day. SkyBridge, a proposed and FCC-licensed, 80-satellite system with $6 billion in capital reportedly available to it, is yet another example of an authorized satellite constellation that never launched. *See* Application of SkyBridge L.L.C. For Authority to Launch and Operate a Global Network of Low-Earth Orbit Communications Satellites Providing Broadband Services in the Fixed-Satellite Service, *Order and Authorization*, 20 FCC Rcd. 12389 (2005); Tim Furniss, *Alcatel set to scrap Skybridge project*, FLIGHTGLOBAL (Jan. 8, 2002), https://www.flightglobal.com/news/articles/alcatel-set-to-scrap-skybridge-project-140940/.

past experience should inform current decision-making and, in any event, the Commission should not foreclose the 12.2-12.7 GHz band from its 5G potential.

V. GRANT OF 12.2-12.7 GHZ AUTHORITY TO ONEWEB WOULD PREJUDGE THE RULEMAKING REQUESTED BY THE COALITION

A grant of the Petition would also at least hamper, and could well amount to a premature rejection of, 5G use proposals for the 12.2-12.7 GHz band without adequate consideration. OneWeb's effort to convince the Commission to proceed seeks to downplay the importance of 5G terrestrial to the Commission's broadband deployment agenda and prejudice the prosecution of that agenda.

Specifically, on April 26, 2016, the Coalition submitted a Petition for Rulemaking that would retain the same Equivalent Power Flux Density ("EPFD") framework that protects the DBS service; eliminate redundant and unnecessary Equivalent Isotropically Radiated Power ("EIRP") protections that have needlessly constrained MVDDS operations; and remove the NGSO FSS allocation in the band.[34] A grant of OneWeb's Petition would prematurely reject these 5G use proposals for the 12.2-12.7 GHz band without adequate consideration.

There is no gainsaying the importance of 5G deployment. As Chairman Wheeler recently noted: "Without question, 5G is a national priority. The interconnected world of the future will be the result of decisions we make today."[35] The Chairman also described the 5G networks that will be deployed:

> Coupling this ultra-fast, low-latency, high-capacity connectivity with the almost unlimited processing power of the cloud will enable super-fast wireless broadband, smart-city energy grids and water systems, immersive education and entertainment, and an unknowable number of innovations. In a 5G world, the

[34] Coalition Petition for Rulemaking at 7.

[35] *See* Use of Spectrum Bands Above 24 GHz for Mobile Radio Services, *Notice of Proposed Rulemaking*, 30 FCC Rcd. 11878, 12007 (2015) (Statement of Chairman Tom Wheeler).

> Internet of Everything will be fully realized; everything that can be connected will be connected. Most important, 5G will enable killer applications yet to be imagined.[36]

Each of the Commissioners has placed similar importance on securing spectrum resources for 5G.[37] Indeed, Commissioner Pai explained that to ensure the United States leads the transition to 5G, we must "[g]et[] more spectrum into the hands of consumers and enabl[e] more flexible use of these bands."[38]

The 12.2-12.7 GHz band is ideally suited for 5G mobile broadband services. It meets all four of the primary criteria the Commission has identified for 5G bands: (1) at least 500 megahertz of contiguous spectrum; (2) a flexible regulatory environment (if the Coalition Petition for Rulemaking is adopted); (3) international spectrum allocations; and (4) the ability to share with existing users.[39] Rather than prejudging the Coalition's proposal and taking OneWeb's assertions at face value, the Commission should put to the test both the Coalition's

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[36] *Id.*

[37] *See id.* (to "capitalize on the 5G opportunity," the Commission must "leverage [its] flexible use spectrum policies" and "make low-band, mid-band, [and] high-band … spectrum available for wireless broadband"); *see also id.* at 12008 (Statement of Commissioner Mignon L. Clyburn) (to facilitate 5G service and meet "explosive levels of consumer demand," we must "start looking for more spectrum higher up the chart"); *id.* at 12009 (Statement of Commissioner Jessica Rosenworcel) (the 5G future requires the United States "to bust through our old 3 GHz ceiling and create new possibilities for millimeter wave spectrum"); *id*. at 12014 (Statement of Commissioner Michael O'Rielly) (the Commission "must ensure that sufficient spectral resources are available" to reach the 5G potential).

[38] *Id.* at 12012 (Statement of Commissioner Ajit Pai).

[39] Use of Spectrum Bands Above 24 GHz for Mobile Radio Services, *Report and Order and Further Notice of Proposed Rulemaking,* FCC 16-89, ¶ 370 (July 14, 2016); Use of Spectrum Bands Above 24 GHz for Mobile Radio Services, *Notice of Proposed Rulemaking*, 30 FCC Rcd. 11878, 11887-88 ¶¶ 20-23 (2015).

proposal, including the technical evidence put forth in the coexistence studies,[40] and OneWeb's Petition, by launching a rulemaking proceeding.

VI. CONCLUSION

To the extent that OneWeb seeks authorization to use the 12.2-12.7 GHz band for its proposed venture, the Commission should deny OneWeb's petition. A grant would, among other things, squander the potential to use the 12.2-12.7 GHz band for 5G, and do so without the thorough consideration possible in a notice-and-comment rulemaking proceeding. It would also cut directly against the Commission's repeated calls for greater collaboration between the satellite and terrestrial industries as well as for greater flexibility to accommodate 5G.

Respectfully submitted,

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[40] *See* MVDDS/NGSO Technical Analysis; First Coexistence Study; Tom Peters, MVDDS 12.2-12.7 GHz Co-Primary Service Coexistence II (June 23, 2016) ("Second Coexistence Study").

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August 15, 2016

DECLARATION

I declare under penalty of perjury that the facts contained within the foregoing Petition to Deny and its appended material, except for those facts for which official notice may be taken, are true and correct to the best of my information, knowledge and belief.

Executed on August 15, 2016

Jeffrey H. Blum
MVDDS 5G Coalition

CERTIFICATE OF SERVICE

I, Matthew R. Friedman, hereby certify that on August 15, 2016, I caused true and correct copies of the foregoing to be served by first class mail and electronic mail upon the following:

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Sincerely,

Matthew R. Friedman
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Exhibit 1

MVDDS 12.2-12.7 GHz NGSO Coexistence Study
(MVDDS/NGSO Technical Analysis)

MVDDS 12.2-12.7 GHz
NGSO Coexistence Study

Tom Peters

August 15, 2016

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About the Author

Tom Peters is a radiofrequency engineer with more than twenty years of industry and government experience in network deployment, design and regulation. Mr. Peters currently serves as a Senior Advisor at the international law firm of Hogan Lovells US LLP. He previously served as Chief Engineer of the Wireless Telecommunications Bureau of the United States Federal Communications Commission, where he helped develop the agency's National Broadband Plan and guided numerous spectrum policy proceedings to resolution. Mr. Peters started his career in wireless at LCC International, a global engineering consulting firm, where he helped design wireless networks all over the world. At LCC, Mr. Peters was a Director and responsible for Engineering Design Services in Latin America, and later in Europe and Asia-Pacific. He subsequently addressed technical regulatory and spectrum policy matters at Nextel Communications, where he served as Director of Technology Development. He then co-founded Wireless Strategy, LLC, a strategic engineering consulting firm.

1. INTRODUCTION AND BACKGROUND

The 12.2-12.7 GHz band offers 500 megahertz of spectrum on a shared basis for three different services, and each service relies on a different network architecture to reach end-user customers. The three co-primary services in the band are: (1) geostationary (GSO) direct broadcast-satellite (DBS) receivers for satellite television viewing; (2) Multichannel Video Distribution and Data Service (MVDDS) transmitters and receivers for television viewing and internet access; and (3) non-geostationary satellite orbit (NGSO) receivers in the Fixed-Satellite Service (FSS) for global communications.[1]

In a series of notices and decisions issued between 1998 and 2002, the Commission adopted rules intended to allow these three disparate services to share the same spectrum.[2] The Commission imposed several bright-line rules to prevent harmful interference and then established a first-in-time regime for determining when and to what extent the licensees in any one service could exclude licensees from the other services from the spectrum in the event of a conflict under the rules.

We previously demonstrated how technical advances in modeling terrestrial signal attenuation allow for the Commission to relax some of the bright-line rules intended to prevent interference between DBS and MVDDS.[3] We also used a set of simple assumptions to reach an initial conclusion that even the stringent, bright-line rules intended to protect NGSO FSS from MVDDS operations would likely prove inadequate.[4] Authorizing a waiver to permit NGSO mobile-satellite service (MSS) offerings in the band would only exacerbate the already substantial likelihood of harmful interference between MVDDS and NGSO FSS.

Our prior analysis of the prospects for coexistence between MVDDS and NGSO FSS used conservative values to assess whether interference between the two services would exist. In this study, we use the same methodology, but apply actual operating values to explore the magnitude of the interference between MVDDS and NGSO FSS in greater depth. We

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[1] *See* 47 C.F.R. § 2.106.

[2] *See Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operations of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-Band Frequency Range, et al.*, Notice of Proposed Rulemaking, 14 FCC Rcd 1131 (1998) ("*NPRM*"); *Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operations of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-Band Frequency Range, et al.*, First Report and Order and Further Notice of Proposed Rulemaking, 16 FCC Rcd 4096 (2000) ("*First Report and Order and FNPRM*"); *Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operations of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-Band Frequency Range, et al.*, Memorandum Opinion and Order and Second Report and Order, 17 FCC Rcd 9614 (2002) ("*Second Report and Order*").

[3] *See* Tom Peters, MVDDS 12.2-12.7 GHZ CO-PRIMARY SERVICE COEXISTENCE (June 8, 2016), *attached to* Comments of MVDDS 5G Coalition, RM-11768 (filed June 8, 2016) ("First Coexistence Study"); Tom Peters, MVDDS 12.2-12.7 GHZ CO-PRIMARY SERVICE COEXISTENCE II(June 23, 2016), *attached to* Reply Comments of MVDDS 5G Coalition, RM-11768 (filed June 23, 2016) ("Second Coexistence Study").

[4] First Coexistence Study at 33-35.

analyze the prospects for coexistence between (i) MVDDS and NGSO FSS, in which user terminals operate at a fixed location on the ground, and (ii) MVDDS and NGSO MSS, in which user terminals are mobile or transportable from one location to another. Even after applying a standard empirical propagation model and other potential mitigating factors, our more realistic modeling produces the same answer as our initial study: sharing between current-generation MVDDS and NGSO FSS would impose severe limits on one or both services, and the potential for sharing between next-generation MVDDS and NGSO MSS is virtually non-existent. Our analysis also explains how permitting NGSO MSS to operate in the 12.2-12.7 GHz band would upend the first-in-time regime on which the Commission's nearly fifteen-year old sharing model depends.

MVDDS and NGSO FSS are, at bottom, incompatible services, and the licensees of both services seek to evolve their existing operations into more functional, consumer-friendly offerings that would make them even more incompatible with one another than they are now.

2. CURRENT PROTECTIONS

Starting in 1998, the Federal Communications Commission began proposing rules to authorize non-geostationary orbit (NGSO) fixed satellite service (FSS), and eventually Multichannel Video Distribution and Data Service (MVDDS), in the 12 GHz band.[5] In December 2000, the FCC ruled that MVDDS could operate in the 12 GHz band on a co-primary, non-harmful basis with incumbent Broadcast Satellite Service (BSS) providers and on a co-primary basis with NGSO FSS providers and sought comment on technical criteria that would allow MVDDS to successfully share the 12 GHz band spectrum with incumbent BSS and new NGSO FSS operations.[6] Less than two years later, the FCC adopted technical rules for MVDDS and NGSO FSS sharing and operations in the 12.2-12.7 GHz band.[7]

In its *Second Report and Order*, the FCC adopted technical operating criteria for both MVDDS and NGSO FSS operations in the 12.2-12.7 GHz band as well as parameters for geographic spacing of MVDDS and NGSO FSS systems.[8] The FCC's goal in adopting its rules was to afford greater and easier use of the 500 megahertz of spectrum between 12.2 and 12.7 GHz for first-in-time NGSO FSS receivers and first-in-time MVDDS transmitting systems.[9] The FCC concluded that its proposed approach was equitable to both services and consistent with the co-primary status of NGSO and MVDDS systems.[10] In addition, the FCC adopted technical criteria for MVDDS sharing of the band with incumbent BSS

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[5] *See generally NPRM*.

[6] *See First Report and Order and FNPRM*.

[7] *See Second Report and Order*.

[8] *Id.* ¶¶ 95-125.

[9] *Id.* ¶ 111.

[10] *Id.*

operations.[11] The technical operating criteria for MVDDS, NGSO FSS and BSS operations in the 12 GHz band are described in greater detail below.

A. MVDDS Protection of Qualified NGSO Receive Sites

To protect NGSO receive sites, the FCC's rules provide that the power flux density (PFD) of an MVDDS transmitting system shall not exceed -135 dBW/m² in any four kilohertz band at a reference point at the surface of the Earth at a distance greater than three kilometers from the MVDDS transmitting antenna.[12] When the FCC set this PFD limit, it found that a reference distance of three kilometers would "strike[] a reasonable balance between limiting the potential for NGSO FSS receiver saturation or reliance on frequency diversity to relatively small and predictable areas while affording MVDDS operators benefit of the maximum 14 dBm EIRP" the FCC afforded for most MVDDS systems.[13] Additionally, a three-kilometer reference distance placed a worst-case cap on the amount of interference MVDDS might cause to NGSO FSS receivers.[14]

To protect against potential interference from MVDDS transmitting antennas into NGSO FSS receiving antennas, the FCC also imposed spacing and coordination requirements. NGSO FSS receive antennas can potentially suffer from intermittent interference when they point directly at MVDDS transmitting antennas while tracking NGSO satellites.[15] NGSO FSS receive antennas can also experience interference through the back lobes of the receive antenna when in close proximity to an MVDDS transmitting antenna.[16] According to the FCC, standard mitigation techniques, such as shielding and repositioning of the NGSO FSS antenna, may not be available to address potential MVDDS interference to NGSO FSS receivers because at times the NGSO FSS antenna may point directly at an MVDDS transmitting antenna.[17]

For these reasons, MVDDS transmitting antennas may not be installed within 10 kilometers of any preexisting NGSO FSS receiver.[18] A "preexisting" NGSO FSS receiver is one that an NGSO FSS subscriber regularly uses for normal reception purposes on the date an MVDDS licensee notifies the NGSO FSS licensee of its intent to construct a new MVDDS transmitting antenna at a specified location, or which is already under construction and operational within 30 days of the date the MVDDS licensee notifies the NGSO FSS licensee of its intent to

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[11] *Id.* ¶¶ 54-94.

[12] *See* 47 C.F.R. § 101.105(a)(4); *see also Second Report and Order* ¶ 112.

[13] *Second Report and Order* ¶ 112.

[14] *Id.*

[15] *Id.* ¶ 122.

[16] *Id.*

[17] *Id.* ¶ 122-23.

[18] *See* 47 C.F.R. § 101.129(b); *see also Second Report and Order* ¶ 123.

construct the transmitting antenna.[19] The MVDDS and NGSO FSS licensees may, however, agree to a closer separation distance.[20]

The FCC enforces its MVDDS and NGSO FSS spacing rules through detailed coordination procedures. NGSO operators must maintain and share a database of existing NGSO FSS receiver locations, and for each MVDDS transmitting antenna the MVDDS licensee must notify all NGSO FSS operators within the general service area of the proposed transmitting location and disclose related technical operating parameters.[21] Within ten business days of receiving notice of the proposed MVDDS transmitting antenna, an NGSO FSS licensee must provide "sufficient information from the database to enable the MVDDS licensee to determine whether the proposed MVDDS transmitting site meets the minimum spacing requirement."[22] Alternatively, the NGSO FSS licensee must notify the MVDDS licensee if the NGSO FSS licensee does not object to the non-conforming MVDDS transmitting antenna.[23] The FCC's coordination procedures cannot function as intended absent a detailed understanding of the precise location and operating parameters of each NGSO FSS receiver.

B. NGSO Satellite Protection of MVDDS Receivers

NGSO FSS downlinks in the 12.2-12.7 GHz band are subject to low-angle PFD limits at the Earth's surface, to alleviate interference into operational MVDDS receivers.[24] Specifically, for angles between zero and two degrees above the horizon, NGSO FSS downlinks must meet a reduced PFD of -158 dB(W/m²) in any four kilohertz band.[25] For angles of arrival (δ, in degrees) between two and five degrees above the horizon, NGSO FSS downlinks must meet a reduced PFD of -158 + 3.33(δ-2) dB(W/m²) in any four kilohertz band.[26] NGSO FSS applicants must demonstrate that they meet the applicable PDF limit prior to becoming operational.[27] When the FCC adopted these limits on NGSO FSS downlinks it determined that "[w]ithout such a reduction, MVDDS coverage areas would likely be more limited . . . and the number of MVDDS transmit towers would have to correspondingly increase to compensate for the more limited coverage areas," which in turn would potentially increase the amount of interference from MVDDS to both NGSO FSS and DBS receivers.[28]

Further, NGSO FSS receivers that are installed later-in-time relative to MVDDS operations within an existing MVDDS service area must accept interference from preexisting MVDDS

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[19] 47 C.F.R. § 101.129(b)(1).

[20] *See id.*; *see also Second Report and Order* ¶ 123.

[21] *See Second Report and Order* ¶ 124; *see also* 47 C.F.R. § 25.139.

[22] 47 C.F.R. § 25.139(b).

[23] 47 C.F.R. § 25.139(c).

[24] 47 C.F.R. § 25.208(o).

[25] *Id.*

[26] *Id.*

[27] *See Second Report and Order* ¶ 121.

[28] *See First Report and Order and FNPRM* ¶ 279.

facilities.[29] The FCC found that this approach "preserves the relative rights and duties of both co-primary licensees without unduly hampering the expansion plans of either."[30]

C. Technical Criteria for NGSO/BSS Sharing

NGSO FSS and BSS share the 12.2-12.7 GHz band on a co-primary basis. At the 2000 World Radio Conference (WRC-2000), interested parties adopted a sharing arrangement for NGSO FSS and BSS, which the FCC ultimately incorporated into its rules.[31] Based on the outcome of WRC-2000, the FCC created single-entry and aggregate equivalent power-flux density limits in the space-to-Earth direction ($EPFD_{down}$) for NGSO FSS operations.[32] To protect BSS, the FCC adopted a single-entry and aggregate $EPFD_{down}$ limit of -160 dBW/m² in any forty kilohertz band at any point on the Earth's surface produced by emissions a single satellite and from all co-frequency space stations of a single NGSO system.[33]

3. INTERFERENCE ANALYSIS

A. MVDDS to NGSO Receiver - Current Rules

In the First Coexistence Study, we presented a simple example to show that the interference caused to NGSO user terminals from MVDDS operations, even under the current base station power rules, will be significant.[34] In this section, we expand on our prior analysis in light of the protection and coordination rules described above.

Our NGSO interference analysis is based on information provided in the technical narrative attached to OneWeb's Petition for Declaratory Ruling requesting access to the U.S. market for OneWeb's NGSO system.[35] OneWeb states the maximum Ku-band downlink EIRP density for its NGSO satellites is -13.4 dBW/4kHz,[36] which is equal to 40.6 dBm/MHz.[37]

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[29] *See Second Report and Order* ¶¶ 108, 123.

[30] *See id.* ¶ 125.

[31] *See First Report and Order and FNPRM* ¶ 170.

[32] *See id.*

[33] 47 C.F.R. § 25.208(l), (m). The single-entry requirement applies to each NGSO satellite, while the aggregate limit applies to the aggregate power from all satellites. The rules specify a cumulative distribution function based on the percentage of time that a limit cannot be exceeded, which is different in the single-entry and aggregate tables. However, for most reference antenna sizes, the limit that cannot be exceeded 100 percent of the time is −160 dBW/m^2. For the smallest reference antenna of 30 cm, the limit is slightly less stringent at −158.33 dBW/m^2 for both single-entry and aggregate PFD.

[34] *See* First Coexistence Study.

[35] *See* WorldVu Satellites Limited Petition for a Declaratory Ruling Granting Access to the U.S. Market for the OneWeb System, Petition for Declaratory Ruling, IBFS File No. SAT-LOI-20160428-00041 at Attachment A (filed Apr. 28, 2016) ("OneWeb Technical Narrative").

[36] OneWeb Technical Narrative at 20, 45-46.

From this value and the proposed altitude of the OneWeb satellite constellation of 1200 kilometers,[38] we can calculate the minimum loss the signal will experience when traveling from the satellite to the surface of the earth. Using free space loss,[39] the minimum path loss will be 175.9 dB.[40] From this value, we calculated that the maximum received power on the ground from OneWeb NGSO satellites will be -135.4 dBm/MHz.[41]

We also used free space loss to illustrate the magnitude of the interference to NGSO user terminals. Using current base station power limits for MVDDS of 14 dBm/24 MHz,[42] or 0.2 dBm/MHz,[43] we calculated that an MVDDS signal will need to experience at least 135.6 dB of path loss for the received power of the interfering MVDDS to be equal to the maximum received power from the NGSO satellite.[44] The free space loss formula shows that this amount of loss will occur over a distance of about 11.5 kilometers.[45] Therefore, the First Coexistence Study concluded that NGSO user terminals could experience interference at any separation distance less than or equal to 11.5 kilometers.[46] Of course, actual path loss may be greater than free space and the path between an MVDDS transmitter and an NGSO user terminal may be partially or completely obstructed. But our very conservative calculations, as further elaborated below, showed that even under the current rules there is a great possibility for interference from MVDDS to NGSO user terminals.

i. Interference Threshold

As stated above, the simple NGSO interference analysis in the First Coexistence Study assumed a conservative interference threshold.[47] It assumed the received power of an MVDDS interferer was equal to the maximum received power from the NGSO satellite.[48] This is a conservative assumption in several respects.

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[37] The calculation is −13.4 dBW/4kHz + 30 = 16.6 dBm/4kHz + 10*log(1000/4) = 40.6 dBm/MHz.

[38] OneWeb Technical Narrative at 1.

[39] Free space loss is the loss in signal strength that results from a line-of-sight path through free space without regard to any potential obstacles. *See* IEEE Standards Assoc., IEEE Standard for Definitions of Terms for Antennas, Std 145-2013.

[40] The calculation is 20*log(12450) + 20*log(1200) + 32.45 = 175.9 dB

[41] The calculation is 40.58 – 175.94 = −135.36 dBm/MHz (rounds up to −135.4)

[42] *See* 47 C.F.R. § 101.113; *Second Report and Order* ¶ 198.

[43] The calculation is 14 dBm/24 MHz + 10*log(1/24) = 0.2 dBm/MHz.

[44] That is, 0.2 – (−135.4) = 135.6 dB. The conservative assumption of equal power was assumed in the First Coexistence Study because details of the OneWeb user terminal antennas are not known. *See* First Coexistence Study at 33.

[45] The calculation is 20*log(12450) + 20*log(11. 5) + 32.45 = 135.6 dB

[46] First Coexistence Study at 34.

[47] *Id.* at 33.

[48] *Id.*

The received power levels used in the First Coexistence Study assumed that NGSO user terminals will always receive signals from the satellite at the highest possible power level.[49] In reality, the received power will vary with signal fluctuations caused by atmospheric changes, obstructions, reflections, and Rician fading.[50] At the receiver, the thermal noise floor - defined by kTB[51] and the receiver's noise figure[52] - and the minimum carrier-to-noise (C/N) ratio requirement will determine the receiver sensitivity. Adding system-level gains to the receiver sensitivity (*e.g.*, antenna gain) and subtracting system-level losses (e.g., line losses, filter insertion losses, Low Noise Amplifier gain, etc.)[53] gives the receiver's "minimum operational sensitivity" (MOS), or the lowest signal level at the antenna necessary for the receiver to detect and demodulate the signal. An NGSO user terminal receiver will support a range of power levels at which a signal can be reliably received from the satellite and at the antenna these signal levels will vary from the MOS to the maximum signal possible from the satellite. The MOS must be lower than the strongest signal possibly received from the satellite and is likely much lower.

The value of the receiver's noise floor is critical to calculating interference because any rise in the noise floor will reduce the receiver's sensitivity, and this will reduce the receiver's ability to detect and demodulate signals from a satellite. Thus, when an NGSO user terminal is receiving a signal very close to its receiver sensitivity, interfering signals are more likely to reduce the receiver's ability to decode the desired signal. That is, signals of a sufficient magnitude to increase the thermal noise floor would be considered interference. The power of a received signal fluctuates so that a receiver is not always operating near its minimum sensitivity level. But the receiver is more susceptible to interference when operating at low signal levels. Likewise, interfering signals that cause large increases in the noise floor will cause "harmful" interference more often than those that cause a small noise rise. Therefore, the choice of an interference threshold is critical to the definition of harmful interference. This aspect is discussed in more detail below.

The receiver sensitivity and MOS for OneWeb's user terminals is unknown; therefore, we very conservatively assumed in the First Coexistence Study that NGSO MOS would equal the satellite's maximum received power at the antenna.[54] In other words, we assumed that the maximum signal possible from the satellite was also the lowest signal usable by the user terminal's receiver, and thus the operating range over which usable satellite signals may

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[49] *Id.* at 33-34.

[50] Rician fading is an anomaly caused by partial cancellation of a radio signal by itself.

[51] This is the thermal noise density of an ideal receiver and includes Bolzman's Constant (k = 1.38×10^{-23} Joules/degree Kelvin), the absolute temperature of the receiver input (T = 290 degrees Kelvin), and the receiver bandwidth in Hertz. This value is commonly simplified to −174 dBm/Hz or −114 dBm/MHz.

[52] A receiver's noise figure is a measure of the noise generated by the circuitry of an actual receiver. When added to kTB, the sum gives the receiver's noise floor.

[53] The difference between the system level gains and losses gives the net system gain, which is the net gain the RF signal will experience as it follows the RF path from the antenna to the receiver.

[54] First Coexistence Study at 33.

fluctuate was conservatively (and unrealistically) assumed to be zero dB. These assumptions give results that understate the separation distance required between the two services to avoid interference. This report is based on the same methodology but dives deeper into the details to provide a more precise estimate of the magnitude of the issue.

ii. NGSO Antenna Discrimination Assumptions

As discussed above, the calculations in the First Coexistence Study only considered power levels at the antenna. We did not make any assumptions about antenna gain or antenna discrimination in the First Coexistence Study,[55] and we do not make any antenna discrimination assumptions here.[56]

The First Coexistence Study noted that an NGSO user terminal could potentially have more antenna gain in the direction of the NGSO satellite than in the direction of the MVDDS interfering signal, which would decrease the MVDDS path loss required to achieve equal power with the NGSO satellite at the user terminal's receiver.[57] Thus, directional differences in antenna gain, or antenna pattern discrimination, could decrease the separation distance required for interference-free operation of NGSO and MVDDS services.[58]

Based on OneWeb's advertised use cases and its statements to the Commission, it appears that OneWeb intends to deploy mobile user terminals in addition to standard fixed terminals for NGSO applications. For example, OneWeb's website describes a vehicular user terminal for public safety that "mounts to the top of any emergency vehicle, providing a 200m LTE coverage circle when towers aren't available."[59] Although OneWeb claims that this mobile device will be used only to extend cellular coverage where it is not available,[60] OneWeb does not explain how this limitation will work either technically or procedurally. In addition, OneWeb is but a single NGSO applicant. OneWeb or other NGSO applicants may develop other mobile use cases that require mobile devices to operate at any location in the United States.

Unlike fixed terminals, mobile terminals are more compact and must operate in multiple orientations. Therefore, the gain and directionality of a mobile device's antenna is likely to be less than that of a fixed terminal. In addition, although mobile antennas may have the ability to electrically steer beams toward a transmitting satellite, the nature of NGSO systems is that satellites will have a range of elevation angles relative to the horizon. The required

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[55] *Id.*

[56] The technical rationale for this decision is explained below.

[57] First Coexistence Study at 33.

[58] *Id.*

[59] *See* Home – OneWeb | OneWorld, http://oneweb.world/#use (last visited Aug. 8, 2016).

[60] *See* OneWeb Technical Narrative at 2-3.

elevation angle for NGSO satellites could vary from zenith (90 degrees) to only a few degrees above the horizon, depending on the number of satellites in the constellation.[61]

Because additional entities could apply to the FCC to operate space-to-Earth transmissions to mobile user terminals in the 12.2-12.7 GHz band, we cannot assume the parameters of OneWeb's proposed system will apply to all NGSO systems that may share the band. It is not unreasonable to assume that there will be times at which there is little or no antenna discrimination between the desired signal from the satellite and the undesired signal from an MVDDS transmitter. Given the fixed, deterministic nature of the interfering signal and the transient nature of NGSO satellites and user terminals, the times at which antenna discrimination is near zero could be significant. The same is true for fixed terminals of NGSO constellations with a small number of satellites, since the minimum elevation angle for these systems will be lower than OneWeb's. Based on our assumption that both the desired and undesired signal will experience the same net system gain, they will arrive at the receiver with the same power proportionality that they have at the antenna. Although the value of that gain and the characteristics of the receiver are unknown, the fact that the two signals maintain proportionality allows us to focus the analysis on the power levels at the antenna, and renders many of the internal details of the system irrelevant. For example, the exact value of the net system gain within the NGSO user terminal and the actual receiver sensitivity of the NGSO user terminal receiver are not necessary for purposes of our analysis. That said, if these values were known, we could conduct a more precise analysis, but this is not strictly necessary to demonstrate that interference between the two systems is significant under the current rules.

iii. Interference to NGSO User Terminals

Synthesizing the assumptions and analysis set forth above, by assuming in the First Coexistence Study that the power that of the interfering signal at the antenna is equal to the maximum power from the satellite, we made the extremely conservative assumption that the maximum power from the satellite was equal to the NGSO receiver's MOS. We then take this one step further and assume that the receiver's MOS is equivalent to the receiver's gain-compensated noise floor (N).[62] Thus, we conservatively assume that N = −135.4 dBm/MHz

[61] OneWeb's petition asserts that its constellation will include 720 satellites and the minimum elevation angle will be 55 degrees; however, our analysis recognizes that OneWeb may not be the only NGSO system operating in the band, and considers the more general case of an NGSO system with many fewer satellites and a lower minimum elevation angle.

[62] This is the equivalent of N at the antenna. That is, a signal at this power level arriving at the antenna would reach the receiver at a level equal to the receiver's thermal noise floor (kTB+NF), after its power was increased and decreased by the system gains and losses along the RF path. In this report, we will refer to this power level at the antenna as the "gain-compensated" receiver noise floor. This is not intended to imply any actual noise at the antenna, but rather is a conceptual power level required for the analysis. Note also that the value of MOS is additionally dependent on C/N. Assuming the MOS is equivalent to the gain-compensated value of N inherently assumes C/N = 0, or that the receiver can detect and demodulate signals down to the noise floor.

at the antenna and that the interfering signal (I) is also −135.4 dBm/MHz at the antenna.[63] Ignoring for the moment that the actual MOS and gain-compensated thermal noise floor must be lower than we have assumed for the NGSO system to function (as discussed above), this is equivalent to assuming an interference-to-noise ratio (I/N) of 0 dB (*i.e.*, I=−135.4 dBm/MHz minus N=−135.4 dBm/MHz equals I/N = 0 dB).

The fact that these assumptions overstate the power level required to cause interference is illustrated in the following diagrams. On the left is the standard framework for determining required interference power given thermal noise, receiver noise figure, carrier-to-noise ratio (C/N), and the assumed interference threshold (I/N). On the right is the same diagram, but representing the conservative assumptions made in the First Coexistence Study. Both diagrams represent the power at the antenna, but since we are assuming no antenna discrimination, the net system gain for both signals will be equal and the powers at the receiver will be in the same proportion.

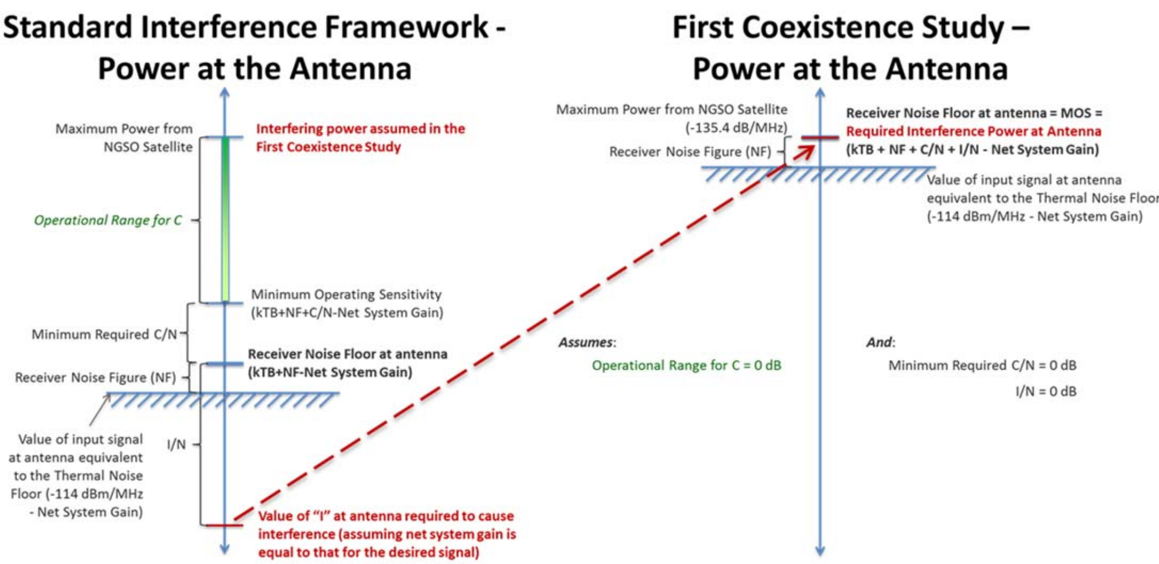

Figure 1 – Comparison of Standard Interference Framework to Assumptions Made in the First Coexistence Study

As shown in the diagrams above, the First Coexistence Study effectively assumed that the operational range of signal levels over which the NGSO user terminals can detect and demodulate a signal from the satellite was zero dB, the required C/N was zero dB, and the I/N interference threshold was also zero dB. Therefore the required interference power at the antenna was equal to the MOS which was equal to the value of the receiver's gain-compensated noise floor at the antenna. Although the values are unknown and the diagram on the left is not drawn to any scale, the three values that were assumed to be zero have a cumulative impact on the value of the required interference power at the antenna as depicted by the dashed red arrow.

[63] These power levels are at the antenna, but since the net system gain is assumed to be the same for both NGSO and MVDDS signals, the two signals will be adjusted equally when they reach the receiver. Thus, I minus N will also be zero at the receiver.

B. Supplemental Analysis

By any measure, an I/N of 0 dB is a very aggressive assumption for an interference threshold for a noise-limited system such as NGSO. This value corresponds to a noise rise of 3 dB, which equates to a 100 percent increase in the noise floor. We used this value in the First Coexistence Study merely to illustrate the magnitude of possible interference from MVDDS to NGSO user terminals. But, as noted in that report, the interfering signal need not be nearly so strong to cause interference.[64] A more typical value for an interference threshold for noise-limited receivers is a 1 dB noise rise, corresponding to an I/N of -6 dB, or roughly a 25 percent increase in the noise floor.[65] For even more interference protection, satellite operators have proposed adopting a maximum 0.25 dB noise floor rise as the appropriate threshold to protect their systems.[66] A 0.25 dB noise rise corresponds to an I/N of −12.2 dB, or a six percent increase in the noise floor.

If we adopt the interference thresholds typically used by the terrestrial wireless or satellite industry sectors, but do not account for an actual operating range of signal strengths or the user terminal's actual MOS, the calculated distance over which interference to an NGSO user terminal can occur is even greater than calculated in the First Coexistence Study, as shown below in Table 1:

Assumed Interference Threshold			Assumed NGSO Receiver Noise Floor at the Antenna [Assume C=N] (dBm/MHz)	Required Interfering Signal Level at the Antenna [I] (dBm/MHz)	Required MVDDS Path Loss (dB)	FSPL Distance Required (km)
Noise Rise (dB)	Percent Noise Floor Rise	I/N (dB)				
3.0	100%	0.0	-135.4	-135.4	135.6	11.5
1.0	25%	-6.0	-135.4	-141.3	141.5	22.8
0.25	6%	-12.2	-135.4	-147.6	147.8	46.8

Table 1 – FSPL Separation Distances Required for Various Assumed Interference Thresholds

If we also take into account that actual NGSO user terminals have a non-zero operating range over which they function, and therefore the MOS is lower than the maximum signal received from the satellite, the separation distances set out above increase even further. This is still conservative and understates the required separation distances. This is because the MOS includes a C/N which we conservatively assume is zero dB despite that typical receivers require a higher C/N to operate. While subtracting the actual required C/N from the

[64] First Coexistence Study at 33, n.87

[65] *See, e.g.*, *Service Rules for Advanced Wireless Services H Block—Implementing Section 6401 of the Middle Class Tax Relief and Job Creation Act of 2012 Related to the 1915-1920 MHz and 1995-2000 MHz Bands*, Report and Order, 28 FCC Rcd 9483, 9537 ¶ 144 (2013).

[66] *See. e.g., Ex Parte* Letter from Jennifer A. Manner, Senior Vice President, Regulatory Affairs, EchoStar Corp. to Marlene H. Dortch, Secretary, FCC, GN Docket No. 14-177, *et al.*, Attach. at 5 (filed May 12, 2016).

MOS would give the needed gain-compensated noise level at the antenna, our assumption that C/N = 0 dB results in a gain compensated noise level that is conservatively high. In using I/N as an interference threshold, this gives an interference power level that is also conservatively high, and required path loss and corresponding separation distance that are conservatively low.

Table 2 below shows how the distances would increase assuming three possible levels of MOS, as well as our baseline that MOS equals the maximum NGSO received power. The analysis assumes that MOS is equivalent to the gain-compensated receiver noise floor at the antenna (C/N=0 dB), and uses an I/N = −6 dB, rather than the more protective interference threshold proposed by satellite operators in the Spectrum Frontiers proceeding (*i.e.*, six percent noise rise or -12.2 dB):

Amount that the MOS is Below the Max Power (dB)	Assumed NGSO Receiver Noise Floor at the Antenna [MOS = N] (dBm/MHz)	Required Interfering Signal Level at the Antenna [I] (dBm/MHz)	Required MVDDS Path Loss (dB)	FSPL Distance Required (km)	Longley-Rice Distance Required (km)
0	-135.4	-141.3	141.5	22.8	10.2
5	-140.4	-146.3	146.5	40.6	13.2
10	-145.4	-151.3	151.5	72.2	16.7
15	-150.4	-156.3	156.5	128.4	20.6

Table 2 - FSPL and Longley-Rice Separation Distances Required for I/N = -6 dB (1 dB Noise Rise) and Assumed MOS Values

Table 2 illustrates that the interference risk to NGSO user terminals is significant, and that the First Coexistence Study's simple, directional analysis was quite conservative in terms of the actual separation distances between NGSO user terminals and MVDDS transmitters that may be required.

As mentioned previously, the assumption of line-of-sight propagation with free space path loss is the worst case and likely not a reasonable assumption over these distances. Table 2, therefore, includes a column showing the distances predicted by the Longley-Rice propagation model using the model parameters specified in OET-74 for ISIX Case 3 (600 MHz wireless base stations causing interference to DTV receivers).[67] The assumed antenna heights in OET-74 for Case 3 for both MVDDS transmitters (30 meters)[68] and for fixed NGSO receivers (10 meters)[69] are reasonable, although actual heights may vary.

[67] *See Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions, et al*., Third Report and Order and First Order on Reconsideration, 30 FCC Rcd 12049, 12055 ¶ 12 (2015).

[68] *Id*. at 12076-77 ¶¶ 62-63.

[69] *Id.* at 12126, Appx. D ¶ 23 n.25.

Because the distances above do not represent a specific location, we ran the *Irregular Terrain Model (ITM)*[70] in "Area Prediction Mode" with a Delta *h* of 90 meters, which, according to the *ITM* documentation offers a good representation of average terrain variability in the United States.[71] The results show that even when using a widely accepted empirical propagation model, an assumption that C/N=0 dB, and a more protective I/N, the separation distance between MVDDS transmitters and NGSO user terminals necessary to avoid interference to NGSO user terminals is significant, even when MVDDS transmitters are operating at the current required power level of 14 dBm/24 MHz.

We can test the accuracy of the assumptions in Table 2 regarding the assumed NGSO gain-compensated receiver noise floor at the antenna using well understood characteristics of NGSO user terminals and OneWeb's proposed system. Starting from the standard thermal noise definition, kTB, which is equal to −174 dBm/Hz, and OneWeb's proposed channel bandwidth of 250 megahertz, we can calculate that the thermal noise floor for an ideal receiver will be -90 dBm. The actual receiver noise floor will include the receiver's noise figure, and although this is unknown, we can estimate it based on similar satellite systems that use cascading low-noise amplifiers to lower the noise figure. Further, the gain-compensated noise floor at the antenna will be driven by the receiver noise floor and the other system gain and losses, the most significant of which is the antenna gain. Assuming a receiver noise figure of 0.5 dB, we can estimate the receiver noise floor to be about −89.5 dBm in the 250 megahertz channel. Assuming a modest system gain of 30 dB gives a "perceived" noise level at the antenna of −119.5 dBm/250 MHz. Converting this to dBm/MHz gives −143.5 dBm/MHz, or approximately a value between the second and third rows in Table 2. These assumptions result in a narrow 8 dB range from the strongest possible signal provided by the satellite to the assumed weakest usable signal (*i.e.*, the MOS). In any case, this simple exercise confirms that the values in Table 2 are representative of the likely performance characteristics of OneWeb receivers, which in turn validates the estimated separation distances.

i. Analysis of Spacing Rule

Our analyses so far have ignored the rules in 47 C.F.R. § 101.105(a)(4) and 47 C.F.R. § 101.129(b) intended to protect fixed NGSO user terminals from MVDDS transmissions. Both rules are based on specified distances between fixed stations and, therefore, were not intended to apply to NGSO mobile operations for which the distance cannot be fixed. Here, we will explore in more detail the effect of the FCC's distance-based rules on fixed NGSO terminals.

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[70] The *Irregular Terrain Model* is a software implementation of the standard Longley-Rice propagation developed by NTIA

[71] *See, e.g.*, Nat'l Telecomms. & Info. Admin., U.S. Dep't of Commerce, *A Guide to the Use of the ITS Irregular Terrain Model in the Area Prediction Mode* 8, NTIA Report 82-100 (April 1982), *available at* http://bit.ly/2b0BlpP.

As OneWeb calculated in its application, using the minimum spreading loss of 132.6 dB at 1200 kilometers separation,[72] the maximum PFD produced by OneWeb's satellites is −146.0 $dBW/m^2/4kHz$ on the ground. Assuming a "qualified" NGSO earth station is fixed (and therefore MVDDS transmitters could maintain a specific separation distance from the earth station), the FCC's rules would require the PFD from MVDDS to be −135 $dBW/m^2/4kHz$ at a distance of three kilometers from the MVDDS site.[73] While this is 11 dB stronger than the highest PFD from OneWeb's satellites and would therefore cause interference to NGSO user terminals at that location, the FCC's rules further require MVDDS transmitting antennas to be no closer than 10 kilometers from qualified NGSO earth stations.[74] The minimum additional loss across the remaining seven kilometers is about 10.5 dB using free space loss.[75] Thus, the maximum PFD from an MVDDS base station operating under the current rules at 10 kilometers will be −135 $dBW/m^2/4kHz$ – 10.5 dB = −145.5 $dBW/m^2/4kHz$. This maximum interfering PFD is 0.5 dB stronger than the strongest PFD possible from an NGSO satellite.

Furthermore, the very conservative assumptions made in the First Coexistence Study and in our more detailed analysis also apply here. The signal strength of the interfering MVDDS signal need not be nearly as strong as predicted by free space loss (as set forth above) to cause interference to NGSO user terminals. The interfering signal can be 6 dB weaker to account for an interference threshold of 1 dB noise rise, weaker by an additional margin to account for the difference between the MOS and the maximum power from the satellite, and weaker still to account for the actual C/N required by the receiver.

In our analysis, we have assumed a range of zero to 15 dB for the difference between the MOS and the maximum power from the satellite. Although we do not know exactly where the difference falls, we know that it cannot be zero and is unlikely to be at the very low end our assumed range. Therefore, we can conclude that the PFD of the interfering signal at 10 kilometers from an MVDDS transmitter can be at least several dB lower than −151.5 $dBW/m^2/4kHz$ (*i.e.*, −145.5 $dBW/m^2/4kHz$ − 6 dB I/N) and still cause interference to NGSO user terminals. This adds to the significant risk that NGSO user terminals will experience interference from MVDDS operations at 14 dBm/24 MHz.

Distance-based rules have little impact on the overall analysis because the FCC-derived values appear to be based on worst-case free space loss. For example, the MVDDS maximum PFD requirement at three kilometers is easily reproduced using free space path loss. Specifically, the maximum MVDDS EIRP of 14 dBm/24 MHz is equivalent to −53.8 dBW/4kHz.[76] Using the same calculation used by OneWeb, the worst case spreading loss at three kilometers is 80.5 $dB\text{-}m^2$. Subtracting this from the EIRP power density gives −53.8 dBW/4kHz – 80.5 $dB\text{-}m^2$ = −134.3 $dBW/m^2/4kHz$. In other words, the theoretical maximum

[72] The worst case spherical spreading loss at 1200 km is calculated as $10*\log(4\pi*1,200,000^2)$ $dB\text{-}m^2$.

[73] *See* 47 C.F.R. § 101.105(a)(4).

[74] *See* 47 C.F.R. § 101.129(b).

[75] Free space path loss for 12 GHz at 10 kilometers is 134.4 dB and at three kilometers is 123.9 dB. The difference represents the additional loss across the seven kilometer buffer and is equal to 10.5 dB.

[76] This is 14 dBm/24 MHz + 10*log(4/24000) + 10*log(1/1000) = -53.8 dBW/4kHz.

PFD from an MVDDS transmitter at three kilometers is only slightly stronger than the limit which MVDDS operators must meet by rule, which almost guarantees that the limit will be met, regardless of whether it is measured or calculated.

ii. NGSO PFD Limit

Although OneWeb states in its application that its Ku-band downlink transmissions comply with the FCC's PFD limits at low elevation angles,[77] this configuration is not necessarily true for all NGSO applicants. OneWeb may achieve compliance partially due to the ambitious number of satellites it says it plans to deploy (720),[78] which results in a high minimum elevation angle of about 55 degrees.[79] Because of this high minimum elevation angle, OneWeb is able to focus EIRP density from the satellite within a relatively small angle around nadir. As a result, "the satellite beam roll-off is at least 15 dB below peak for elevation angles of 5 degrees and less" according to OneWeb.[80]

However, other NGSO systems with more economical designs may use many fewer satellites. For example, the Iridium NGSO currently operates with only 66 satellites[81] and Globalstar with only 24.[82] With these designs, each satellite must cover a larger portion of the Earth and EIRP density cannot be as focused around nadir as it is in the OneWeb system. As a result, these systems will have higher power at low elevation angles and will need to manage this power to meet the specified PFD limits. Thus, the low elevation angle PFD limits as specified in Part 25 of the FCC's rules will be burdensome for NGSO systems with fewer satellites than proposed by OneWeb.

iii. NGSO Mobile Operations

As discussed earlier in this report, OneWeb's application states its intent to provide NGSO services to user terminals that are mobile. One example shown on their website is a "Vehicle Cell Network For First Responders." As a service that caters to the mission critical needs of "first responders, humanitarian workers and medical personnel where and when they need it most," it is reasonable to assume that OneWeb expects this service to be protected from harmful interference. Additionally, whether the service is used while the vehicle is in motion (mobile use) or only when it is parked (portable use), the precise locations and times in which this emergency response service will be needed cannot be anticipated and therefore the projected service area would cover the entire United States. Thus, to ensure this service is available "when and where" it is needed, mission critical

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[77] OneWeb Technical Narrative at 22-23

[78] *Id.* at 1

[79] *Id.* at 13

[80] *Id.* at 22.

[81] *Iridium Constellation LLC*, Stamp Grant, File No. SAT-MOD-20120813-00128 (granted Jan. 30, 2014), http://bit.ly/2aK1dab.

[82] *See* Second-Generation Satellite Constellation – Globalstar USA, http://bit.ly/2aSXndO.

mobile NGSO communications must be protected in all areas, and it follows that potentially interfering MVDDS deployments must be precluded from the 12.2-12.7 GHz band. Other solutions, such as sharing in time, are not practical for either the business case of the MVDDS licensee or the safety and reliability of the emergency response communication service anticipated by OneWeb. Geographic partitioning would also be an impractical and inefficient solution for both services, since the preceding analysis shows that the area around which an MVDDS transmitter may disrupt these emergency satellite communications is very large, and each future MVDDS deployment would eliminate thousands of square kilometers of area in which the emergency service was once able to operate. Thus, protecting mobile NGSO user terminals in the band would preclude future MVDDS deployments of any kind, and would likely necessitate the decommissioning of existing MVDDS services.

4. IMPLICATIONS AND CONCLUSIONS

The analysis above confirms that there are significant concerns of interference between NGSO and MVDDS operations; and raises questions as to whether the two services can share the band effectively and efficiently. NGSO user terminals will receive harmful interference from MVDDS base stations operating under the current rules. Under conservative assumptions in the calculations, large distances are required to protect NGSO FSS user terminals. These large separation distances will result in an inefficient use of the spectrum for both services because large geographic areas between MVDDS and NGSO stations must remain unused to control interference. At the same time, our analysis also shows the low elevation angle PFD protection limits in the rules will prove challenging for some NGSO operators to meet.

Understanding the distances necessary to permit interference-free operations of NGSO terminals is also important because OneWeb represents that its "vehicle cell network" will be sold to "first responders, humanitarian workers and medical personnel."[83] An NGSO mobile service in the band will create large and unmanageable areas of interference for mobile user terminals, even under the current power limits for MVDDS. An NGSO mobile service would be useless in many areas and, at a minimum, would harm the business case for the NGSO operator.

The MVDDS Coalition has filed a petition for rulemaking requesting a relaxation of the current MVDDS power limits for base station transmissions as well as two-way mobile service in the band to accommodate 5G use cases.[84] Although our analysis here focused on the current rules, the results demonstrate that the combined effect of higher base station power and mobile operations will greatly increase the likelihood of interference to NGSO user terminals and will expand the separation distances required to mitigate interference.

Given these findings, we conclude that MVDDS and NGSO cannot effectively share the 12.2-12.7 GHz band, either under the current rules or under any new rules that may be added in response to the Coalition's petition. Continued sharing between MVDDS and

[83] *See* Home – OneWeb | OneWorld, http://oneweb.world/#use (last visited Aug. 8, 2016).

[84] *See* Petition of MVDDS 5G Coalition for Rulemaking, RM-11768 (filed Apr. 26, 2016).

NGSO FSS would either frustrate consumer expectations of interference-free operations or require the Commission to impose a set of constraints on deployment that lock in a fifteen-year-old deployment model for both MVDDS and NGSO FSS licensees. Either of these results seems likely to frustrate innovation and stymie deployment in the 12.2-12.7 GHz band.