Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
WorldVu Satellites Limited	)	Call Sign: S2963
	)	
Petition for a Declaratory Ruling	)	File No. SAT-LOI-20160428-00041
Granting Access to the U.S. Market	)	
For the OneWeb System	)	

OPPOSITION AND RESPONSE OF WORLDVU SATELLITES LIMITED

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TABLE OF CONTENTS

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	)	
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OPPOSITION AND RESPONSE OF WORLDVU SATELLITES LIMITED

WorldVu Satellites Limited, d/b/a OneWeb ("OneWeb"), pursuant to Section 25.154(c) of the rules of the Federal Communications Commission (the "FCC" or "Commission"),[1] hereby submits this Opposition and Response to the Petitions to Deny and Comments filed in the above-captioned proceeding.[2]

[1] 47 C.F.R. § 25.154(c).

[2] Petition to Deny of The MVDDS 5G Coalition, File No. SAT-LOI-20160428-00041 (filed Aug. 15, 2016) ("MVDDS Petition"); Petition to Deny of Telesat Canada ("Telesat"), File No. SAT-LOI-20160428-00041 (filed Aug. 15, 2016) ("Telesat Petition"); Comments of The Boeing Company ("Boeing"), File No. SAT-LOI-20160428-00041 (filed Aug. 15, 2016) ("Boeing Comments"); Comments of The National Radio Astronomy Observatory ("NRAO"), File No. SAT-LOI-20160428-00041 (filed July 24, 2016) ("NRAO Comments"); Comments of SES S.A. and O3b Limited ("SES" and "O3b" respectively), File No. SAT-LOI-20160428-00041 (filed Aug. 15, 2016) ("SES and O3b Comments"); Comments of Space Exploration Technologies Corp. ("SpaceX"), File No. SAT-LOI-20160428-00041 (filed Aug. 15, 2016) ("SpaceX Comments"); Comments of the State of Alaska, File No. SAT-LOI-20160428-00041 (filed Aug. 9, 2016) ("Alaska Comments"); and Comments of ViaSat, Inc. ("ViaSat"), File No. SAT-LOI-20160428-00041 (filed Aug. 15, 2016) ("ViaSat Comments").

I. COMMENTERS AGREE THAT ONEWEB'S PROPOSED CONSTELLATION WILL BENEFIT THE PUBLIC WITH AFFORDABLE, HIGH-SPEED BROADBAND CONNECTIVITY AND JOBS IN THE UNITED STATES

OneWeb's mission is to make affordable, low latency, broadband internet available everywhere. Digital connectivity is out of reach for nearly 4.2 billion people worldwide, including millions of people right here in the United States.[3] The comments filed by Alaskan Governor Bill Walker underscore the public interest benefits of approving U.S. market access for the OneWeb system. The Governor explained, "broadband infrastructure and high speed capacity are essential to [Alaska's] successful delivery of educational, medical, and emergency response services throughout [the] state."[4] He further acknowledged that OneWeb's system "would be a game changer in Alaska's ability to participate in the federally mandated FirstNet program."[5] OneWeb's efficient, highly directive satellite antennas operate with low sidelobes and can provide very high speed bandwidth to small terminals anywhere in the world without having to construct expensive, terrestrial middle-mile connections.[6] As such, the OneWeb system will be particularly beneficial for states like Alaska with rural communities. From the

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3 *See* ITU/UNESCO BROADBAND COMMISSION FOR SUSTAINABLE DEVELOPMENT, THE STATE OF BROADBAND 2015: BROADBAND AS A FOUNDATION FOR SUSTAINABLE DEVELOPMENT AT 8 (2015), *available at* http://broadbandcommission.org/Documents/reports/bb-annualreport2015.pdf; *Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All American in a Reasonable and Timely Fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996, as Amended by the Broadband Data Improvement Act—2016 Broadband Progress Report*, 31 FCC Rcd 699, 701 (¶ 4) (2016).

4 Alaska Comments at 1.

5 *Id*.

6 *See id*. ("This is an ideal low-cost solution where the geographic isolation and environmental protection challenges make rural Alaska's middle mile infrastructure cost prohibitive.").

Kansas plains to small towns in Texas to the Maine woods, people living in rural communities in America will greatly benefit from expanded broadband access promised by the OneWeb system.

OneWeb was founded by legendary communications entrepreneur Greg Wyler and is designed first and foremost to be a technological and commercial success. In a field where many others have struggled to bring their grand ideas to fruition, Mr. Wyler has unparalleled success in conceiving, designing, funding, implementing, and commercially deploying NGSO FSS systems that break boundaries and create new services and competition. For example, as the founder of O3b, Mr. Wyler achieved the impressive feat of bringing together such stellar investors as Google, Liberty Global, SES, HSBC and others and then raising the billions of dollars necessary to turn his vision for O3b into reality in a remarkably short time. Like O3b, OneWeb starts with an impressive group of strategic partners and shareholders that support Mr. Wyler's vision, including Airbus Group, Bharti Enterprises, Hughes Network Systems, Intelsat, MacDonald, Dettwiler and Associates, Qualcomm Incorporated, the Coca-Cola Company, the Virgin Group, and Totalplay. With financing well underway, OneWeb is now poised to deliver global, satellite-based broadband connectivity under Mr. Wyler's experienced leadership. Mr. Wyler does not just dream big dreams; he makes them reality.

OneWeb is expecting to offer service as early as 2019—while also creating new jobs in the United States. A major step, for instance, is the planned opening in 2017 of the Airbus/ OneWeb joint venture, $85 million advanced aerospace manufacturing facility. This facility will create 250 high-tech manufacturing and engineering jobs. It will be the world's first and only purpose-built, high volume satellite production facility located near the Kennedy Space Center at

Exploration Park, Florida.[7] The facility will construct hundreds of low-cost, high-performance satellites initially weighing only 150 kg and ready for deployment starting in 2018.

Today, OneWeb is focused and preparing for launch. The first version of satellites has been designed and the major space hardware components have been prototype tested. The communications chip sets (designed by industry leader Qualcomm), with their state of the art 14nm process are already on the bench and have exceeded performance expectations in terms of throughput and power consumption—enabling a new level of low cost, easy to install solar powered terminals for the world's unconnected. OneWeb's launch campaign is on the manifest and the unique venetian blind shaped communications antennas have been built and tested. When utilized with OneWeb's operational techniques, this antenna will allow the OneWeb system to meet all EPFD and other regulatory requirements. Beyond the first satellite version, OneWeb's roadmap brings new satellites with exponential increases in bandwidth and reductions in cost per bit. This is the reason OneWeb has its own factory—so it can continuously implement new technologies as they prove ready for space.

II. ONEWEB DESIGNED A STATE OF THE ART SYSTEM THAT CAN COORDINATE EFFICIENTLY AND EFFECTIVELY WITH OTHERS

OneWeb wholeheartedly agrees with Boeing that "technology has developed sufficiently to enable the launch and operation of global NGSO FSS systems to make broadband communications services ubiquitously available to all locations on Earth."[8] The OneWeb system

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[7] Peter B. de Selding, *OneWeb Basking in Florida's Warm Embrace*, SPACENEWS MAGAZINE (Apr. 25, 2016), *available at* https://www.spacenewsmag.com/feature/oneweb-basking-in-floridas-warm-embrace/.

[8] Boeing Comments at 1.

uses such advanced technology, and any claim to the contrary is simply unfounded.[9] OneWeb's advanced system utilizes state of the art technologies including novel waveforms, all-electric propulsion, and novel beam patterns to achieve major benefits. OneWeb and its partners have pushed the boundaries of technologies in many fields. OneWeb has miniaturized at least seven different major satellite subcomponents, for instance moving from traveling wave tube amplifiers ("TWTAs") to purpose built state of the art semi-conductors to create an extremely compact satellite with 20 times the performance of its nearest competitor at 100 times lower production cost. OneWeb's waveform is custom-designed to enable high performance and resist interference from other systems. The scheduling systems enable handover of hundreds of thousands of connections per second without any customers losing packets.

A. Comments Support Spectrum Efficient Sharing Rather than Band Segmentation

There was no opposition to OneWeb's request for waiver of the default band segmentation rule set forth in Section 25.157(e).[10] Rather, the commenters recognize that the Commission should permit access to all available spectrum subject to good faith negotiations to avoid interference among NGSO systems. For example, Telesat stated "[b]and-splitting will provide too little spectrum to each of the applicants, resulting in no systems being launched."[11]

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[9] SpaceX Comments at 8.

[10] 47 C.F.R. § 25.157(e) (band segmentation is to be applied "[i]n the event that there is insufficient spectrum in the frequency band available to accommodate all qualified applicants in a processing round").

[11] Telesat Petition at 3. *See also* Boeing Comments at 2; SES and O3b Comments at 9 (requesting spectrum sharing condition 12 instead of band segmentation); SpaceX Comments at 15. Even ViaSat's request that the FCC defer action on OneWeb's band segmentation waiver pending "consideration of all the other NGSO applications that may be filed in this processing round" is likely to be fulfilled as a practical matter, because those applications will soon be filed this November. ViaSat Comments at 4.

Thus, the Commission should grant request for waiver of Section 25.157(e) for OneWeb's system (and others should they eventually make the request) because static band segmentation is neither desirable nor necessary, and may in fact be counterproductive to the goal of encouraging broadband deployment using NGSO systems.

B. OneWeb's Advanced System Design Enables Global Broadband While Being Able to Share Spectrum With Other NGSO FSS Systems

In its Petition, OneWeb has provided its system details to allow other NGSO aspirants to develop their own systems with non-interfering technologies.[12] Other potential NGSO operators may choose to use different waveforms, alternate polarizations, angular separation, frequency agility or a host of other technologies to operate and share the spectrum with OneWeb. While other broadband systems can creatively be developed in the same spectrum, there are also many other types of satellites and use cases which can coexist. For instance, other systems could be developed across a virtually infinite variety of orbits and system architectures. OneWeb can and will share with all of these. In fact, the Japanese global navigation satellite system ("GNSS") satellite operates in this band already, and OneWeb has no issues with coordination.

There are many different techniques for band sharing, and the NGSO designs which employ them will be able to coordinate. For instance, International Telecommunication Union ("ITU") Recommendation ITU-R S.1431 lists even more techniques beyond in-line avoidance for band sharing, such as:

- Satellite diversity;
- Satellite selection strategies;
- Satellite antenna sidelobes;
- Earth station antenna sidelobes;
- Frequency channelization and agility;
- Link balancing; and

[12] *See* SpaceX Comments at 5-6.

- Alternate polarization.[13]

These techniques and others can provide sharing opportunities between NGSO systems, including with OneWeb.

C. OneWeb Efficiently Uses Very Narrow Ka-band Gateways From Only a Limited Number of Sites to Enable Coordination with Others

In the Ka-band, OneWeb employs high-gain antennas on the satellite with excellent sidelobe rejection so it can make use of satellite selection strategies and earth station diversity.[14] In fact, these are some of the methods employed by OneWeb to protect geostationary satellite orbit ("GSO") networks and other NGSO systems like O3b's system. Such techniques ensure the link between the OneWeb satellite and its gateway earth station always avoids the GSO by an angle sufficient to ensure that FCC and ITU EPFD limits are met and similarly can avoid the O3b orbits. These avoidance angles are minimized through the use of advanced gateway earth stations designed with low sidelobes and extremely narrow beamwidths, as well as by using very narrow satellite beams.

With regard to OneWeb's Ka-band usage, SpaceX makes the general claim that OneWeb does not enable "efficient spectrum sharing,"[15] and further points to OneWeb's filtering, claiming it leaves valuable spectrum underutilized.[16] However, OneWeb's system in fact uses very few, extremely narrow Ka-beams, leaving ample room for other NGSO systems, including

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13 *See* International Telecommunication Union, Recommendation ITU-R S.1431 at 3-4 (2000).

14 *See* SpaceX Comments at 13.

15 *Id*. at 8.

16 *Id*. at 14.

active systems like O3b's system and potential future systems like Telesat's, to operate full frequency.[17]

D. OneWeb's Ku-Band Design Operates Over a Limited Range With Tight Beams Re-Using the Entire GSO Spectrum, While Allowing Other NGSO Systems To Share

In the Ku-band, OneWeb utilizes only a limited range of elevation angles for operations so alternative NGSO systems may avoid in-line interference. In addition, operators can employ a combination of other interference mitigation measures, during specific in-line events, such as frequency agility, polarization discrimination, and link balancing. The specific implementation and mitigation techniques will be thoughtfully created and chosen by the system designers and decided through bilateral coordination between operators.

OneWeb has provided significant detail about the operation of its system and satellites so other potential operators can employ techniques to protect and be protected from OneWeb's limited and spectral-spatial envelope. Future NGSO systems, as they are designed and licensed, should also provide a clear spectral-spatial usage for engineers to benchmark from and create even more innovative reuse arrangements. OneWeb notes that the spectral-spatial envelope of the GSO satellites, as articulated in the EPFD related regulations, was the starting point that allowed OneWeb to design innovative technologies to reuse this spectrum so many times.

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[17] The Commission has also recently allocated portions of the Ka-band for future 5G use, and OneWeb's design allows its system to operate and coordinate with future 5G users. In fact, OneWeb will operate its narrow Ka-beams from only a limited number of sites in the United States, which can be located well outside of urban cores where 5G use will be predominant, making coordination of OneWeb gateway earth stations with mobile operators relatively simple. Furthermore, assuming that 5G operators deploy facilities that do not transmit power skywards, as expected, they will not interfere into OneWeb satellites. In this regard, the Commission is opening a docket that will allow companies like OneWeb to provide further studies. As a result, grant of OneWeb's petition will be consistent with the Commission's recent 5G ruling.

SpaceX claims OneWeb is not advanced because its satellites steer the beams by rotating the satellite itself.[18] Actually, just the opposite is true. The progressive pitch, invented by OneWeb, is novel, economically efficient, and elegant. It is also much more spectrally efficient than a phased array and enables higher throughput at reduced transmit powers. A phased array antenna, which points its beam off boresight, does so at an oblique angle, resulting in a wider beam, higher sidelobe transmissions and higher transmit power requirements for both the satellite in its downlink *and* the terminal on its uplink. Thus, the progressive pitch solution is more efficient than other alternatives.

SpaceX further seems to be suggesting the Commission should mandate the maximum beam sizes for NGSO satellites.[19] OneWeb disagrees for several reasons. First, this would require detailed technical studies on the part of the Commission to choose very specific technology and limit future innovation. Second, forcing smaller beams would also dictate larger antenna apertures, and thus bigger spacecraft and higher launch costs.

As for the apparent suggestion that NGSO FSS systems should use ground-based cellular patterns,[20] this choice should be up to the satellite system designer, rather than imposed via Commission mandate, as Space X suggests. SpaceX appears to be choosing to dynamically form beams, which they claim will allow them to better coordinate with others including OneWeb. At such a time that SpaceX locks its system design and presents it for coordination, OneWeb will, of course, work diligently to cooperate with SpaceX engineers. However, at this point, its

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18 Space X Comments at 13 and 14

19 *See id*. at 8-11.

20 *See id*. at 8-9.

comments are full of various untested and unproven technologies, the effects of which cannot be evaluated without reviewing a comprehensive and detailed system design.

Finally, OneWeb seeks to correct some of SpaceX's misunderstandings regarding the OneWeb system.

- **Footprint**: SpaceX erroneously compares OneWeb's Ku-band beam footprint to those of certain GSO Ka-band satellite networks, ignoring the frequency difference between Ku-band and Ka-band, and the impact this has on achievable beam sizes.[21] When correctly comparing Ka-band to Ka-band, the OneWeb footprint is 30 times smaller than even the smallest GSO beam satellite variant such as Viasat-2. At Ku-band, OneWeb's footprint is significantly smaller than GSO Ku-band footprints, some of which are extremely large.[22]

- **System Capacity**: SpaceX erroneously states that the beam can only sustain 422 active users in an area the size of South Carolina.[23] SpaceX compares this number of users to the state's total population lacking access to adequate broadband.[24] These assertions are incorrect for the following reasons:

    - the link budget is performed only for users at the edge of beam and for a given small aperture terminal type which will not be used by all users. Other users will have terminals with larger apertures and therefore higher bits per hertz and data rates;

    - given that not all users would concurrently be accessing the RF channel 100% of the time, and in the same way that a cellular system or cable system can accommodate very high data rates for many users, the OneWeb system will be able to serve many more users than such simplistic static analysis would show;

    - all telecommunications systems use statistical multiplexing and the ability to do statistical multiplexing for satellites is even greater because of the diversity of use

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21 *Id*. at 10 (comparing the beam footprint of the OneWeb NGSO system Ku-band beams to GSO Ka-band satellites operated by ViaSat and EchoStar).

22 Most satellites operating in the U.S. use full CONUS beams (over 7 million km^2). Some use smaller areas such as half- or quarter CONUS, but even the smallest spot beams encircle the Hawaiian islands and surrounding sea (approximately 100,000 km^2).

23 SpaceX Comments at 10.

24 *Id*. at 10-11.

cases and peak times (home users in the evening and business users during the day, etc.); and

- SpaceX ignores the fact that beams for satellites in adjacent planes do overlap, and thus the area served by a given beam is in many cases half the size of its footprint, so the throughput per geographic area is significantly higher.

- **Number of Satellites.** SpaceX claims the OneWeb system cannot be expanded by adding satellites.[25] Although the current constellation is designed with 720 satellites to provide global coverage, it can be increased by adding satellites within a plane to improve coverage (more overlap between beams in the North-South direction), as required.[26] OneWeb's Petition corresponds only to the first generation satellites, providing a viable commercial undertaking that will serve millions of users worldwide. As demand for capacity grows, OneWeb will launch second generation spacecraft with more capacity by using smaller beams, which will be entirely backwards compatible with the first generation system, thereby offering continuous capacity increase and service improvement.

E. OneWeb Will Coordinate in Good Faith With the Radio Astronomy Service

The NRAO filed a letter in this proceeding noting the need for the OneWeb Ku-band satellite downlink transmissions to protect the Radio Astronomy and Passive Services in the adjacent 10.6-10.7 GHz band.[27] The letter points out that footnote US131 to the U.S. table of frequency allocations requires OneWeb to coordinate with the NRAO in order to provide interference protection of the radio astronomy observatories listed in that footnote.[28] The NRAO

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25 *Id*. at ii and 16.

26 OneWeb Petition, Attachment A at 1, n.1 ("The OneWeb satellite system has been designed such that more satellites beyond 720 can be added to the constellation at a future time…").

27 NRAO Comments at 1.

28 *Id.*; 47 C.F.R. § 2.106, US 131 ("In the band 10.7-11.7 GHz, non-geostationary satellite orbit licenses in the fixed-satellite service (space-to-Earth), prior to commencing operations, shall coordinate with the following radio astronomy observatories to achieve a mutually acceptable agreement regarding the protection of the radio telescope facilities operating in the band 10.6-10.7 GHz.").

also makes reference to the passive service band 10.68-10.7 GHz which is protected domestically by footnote US246 and internationally by RR No. 5.340.[29]

OneWeb's Petition also acknowledged the footnotes to the U.S Table of Frequency Allocations that address the protection of the RAS in the 10.6-10.7 GHz band, including footnote US131, and stated its intention to coordinate accordingly with the NRAO.[30] OneWeb first contacted the U.S. National Science Foundation ("NSF") to discuss the protection of the Radio Astronomy Service ("RAS") as early as July 2015. After some e-mail dialog, a meeting was held in May 2016 between OneWeb representatives and the NSF, and this included a representative of the NRAO. At that meeting OneWeb described in some detail the RAS interference analysis work it had been doing to that point using time domain simulations and the EPFD approach given in the relevant ITU-R Recommendations. At that meeting the NRAO provided useful advice on certain aspects of this analysis method. Since that time, OneWeb has been refining its interference analysis based on the NRAO's advice and using it to optimize certain aspects of the design and specification of the detailed equipment and subsystems of the OneWeb satellites, as well as the development of any necessary operational procedures, so as to fully protect the RAS. OneWeb will continue with this activity in order to ensure that the RAS is protected to the level required by the FCC rules and the ITU Radio Regulations.

F. OneWeb Will Protect Co-Frequency GSOs

In its Comments, SES requests that the FCC ask OneWeb a series of additional questions to clarify that the OneWeb system design has the ability to protect GSOs from harmful

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29 NRAO Comments at 1.

30 OneWeb Petition, Attachment A at 43.

interference.[31] OneWeb recognizes that the Commission may seek additional information related to its Petition and has already responded to one such Commission inquiry. [32] OneWeb would be pleased to answer any additional questions posed by the Commission.[33] Moreover, in the interest of facilitating prompt Commission review of and authorization for the OneWeb system to provide broadband internet connectivity in the United States, OneWeb voluntarily answers SES and O3b's questions in Appendix A.

G. The Commission Should Reject the Flawed Analysis Presented By the MVDDS 5G Coalition Seeking to Rewrite Long Established Spectrum Sharing Rules

The MVDDS 5G Coalition ("Coalition") has petitioned the FCC to deny OneWeb's Petition based essentially on its dislike of the current FCC rules that allow sharing between NGSO FSS and the Multichannel Video Distribution and Data Service ("MVDDS"). The existing MVDDS rules are, as the Coalition rightly points out, the result of exhaustive analyses and dialog between the FCC and the interested industry parties, over a four-year period from 1998 to 2002.[34] They represent what was agreed as being a fair compromise to enable the two

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31 Comments of SES and O3b at 6-7.

32 Letter from Jose P. Albuquerque, Federal Communications Commission, to Kalpak S. Gude, WorldVu Satellites Limited, IBFS File No. SAT-LOI-20160428-00041 (Jun. 10, 2016); Letter from Kalpak S. Gude, WorldVu Satellites Limited, to Marlene H. Dortch, FCC, File No. SAT-LOI-20160428-00041 at 5 (Jun. 24, 2016).

33 47 C.F.R. § 25.111(a) ("The Commission may request from any party at any time additional information concerning any application, or any other submission or pleading regarding an application, filed under this part.").

34 *See* MVDDS Petition, Exhibit 1.

services to co-exist. Moreover, those rules have existed since 2002[35] and OneWeb has diligently designed its system to follow these rules.

OneWeb has stated in its Petition that it can and will live within the constraints of the FCC's rules that relate to MVDDS.[36] These rules are clearly defined objective limitations and operational constraints imposed on MVDDS and NGSO FSS operators, as well as an operational procedure for notification of the other party.[37] The derivation of these rules took into account all the factors included in the Coalition's latest interference analysis concerning interference from MVDDS into NGSO.

Indeed, the rules in 2002 were developed exactly for an NGSO system with similar attributes to OneWeb. Like the NGSO systems that were under consideration at that time, the OneWeb system has ubiquitous Ku-band earth stations that may be located anywhere in the U.S. In fact, in certain aspects, notably the high operational elevation angles of the OneWeb Ku-band earth stations, the OneWeb system represents an NGSO system design that can in fact share more easily with MVDDS because of the large antenna gain discrimination of the Ku-band receiving earth stations towards the MVDDS transmitters. The Coalition now claims, however, that the OneWeb system is completely incompatible even with the MVDDS envisioned by the FCC rules, let alone the 5G two-way service the Coalition would like to operate.[38] It asserts that the interference into the OneWeb earth station receivers will be unacceptable and that the

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35 *See Multichannel Video Distribution and Data Service*, Memorandum Opinion and Order and Second Report and Order, 17 FCC Rcd 9614, ¶¶ 136-37 (2002).

36 OneWeb Petition, Attachment A at 22, 39-40.

37 *Id*.

38 MVDDS Petition, Exhibit 1 at 4.

downlink signals from the OneWeb satellites may well interfere with the MVDDS receivers.[39] These claims are incorrect.[40]

There is a stark inconsistency between the way the Coalition has addressed how its two-way mobile version of MVDDS can share with GSO Broadcasting-Satellite Service ("BSS") versus how even the conventional MVDDS can (or apparently, cannot, according to the Coalition) share with the OneWeb NGSO system. To address BSS sharing, the Coalition purports to bring new and more accurate analysis techniques to solve what traditional wisdom considers to be unsolvable; the Coalition's BSS interference analysis exploits every last morsel of terrain and building attenuation. These techniques exceed many of the more traditional propagation modeling techniques (based on generalized urban, semi-urban and rural environments) which themselves predict much more attenuation than the simple free space propagation model. Yet the Coalition's analysis for OneWeb/MVDDS sharing relies only on a clearly inappropriate free space interference model, resulting in theoretical separation distances as high as 128.4 km.[41] Moreover, the Coalition also ignores the extra 40 dB of isolation due to the high operational elevation angles of OneWeb's Ku-band earth stations.

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39 *Id*. at 8-9, 18-19.

40 The Coalition's additional concerns about the possible use of mobile or transportable Ku-band earth stations in the OneWeb system are inappropriate at this stage of the regulatory process. The potential use of such terminals does not in any way affect the transmissions from the OneWeb satellites, and should be addressed at the stage when OneWeb seeks FCC authorization for the use of such earth stations within the USA. This matter was fully addressed in the FCC's letter requesting additional information and OneWeb's response. *See* Letter from Jose P. Albuquerque, FCC, to Kalpak S. Gude, WorldVu Satellites Limited, File No. SAT-LOI-20160428-00041 at 2 (Jun. 10, 2016); *see* Letter from Kalpak S. Gude, WorldVu Satellites Limited, to Marlene H. Dortch, FCC, File No. SAT-LOI-20160428-00041 at 5 (Jun. 24, 2016).

41 MVDDS Petition at 6 and Exhibit 1 at 14.

The Coalition also makes an incorrect and misleading suggestion that the OneWeb satellites could interfere with the MVDDS receivers, because the satellites may need to point close to the horizon[42] and thus exceed the PFD limits of Section 25.208(o) that are designed to protect the MVDDS receivers.[43] The OneWeb Petition clearly explains that the Ku-band beams of the OneWeb satellites are fixed to the spacecraft body and therefore their pointing direction is constant, except for the north-south pitch bias.[44] Biasing the spacecraft in the north-south direction by less than 10 degrees could not possibly bring the high gain contours close to the Earth's horizon because of the high ellipticity of the OneWeb beams with the major axis being in the east-west direction. OneWeb has committed to meeting the PFD limits of Section 25.208(o) and its system design ensures that it will.[45]

Finally, the Coalition's comments concerning whether OneWeb needs access to the 12.2-12.7 GHz band are based on a lack of understanding about the demand and need for satellite broadband access.[46] The entire 2 GHz of Ku-band downlink spectrum requested by OneWeb is necessary to provide flexibility to address the various regulatory issues that OneWeb faces in different parts of the world, as well as the sharing requirements with other users of the spectrum in the United States. Moreover, in the United States the entire 10.7-11.7 GHz band is heavily used by terrestrial services which OneWeb will need to further avoid at specific locations. The Coalition's request to change their service from one-way transmissions only, as defined in the

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42 MVDDS Petition, Exhibit 1 at 10-11.

43 47 C.F.R. § 25.208(o).

44 OneWeb Petition, Attachment A at 11.

45 OneWeb Petition, Attachment A at 22.

46 MVDDS Petition at 10-12.

FCC's MVDDS rules, to a two-way 5G system, and then to ask OneWeb and other NGSOs to give up a major chunk of available spectrum is inconsistent with the FCC's rules and the public interest.

III. ROUTINE FCC CONDITIONS AND ITU COORDINATION REQUIREMENTS FULLY ADDRESS THE NON-SPECTRUM SHARING ISSUES RAISED BY COMMENTERS

A. OneWeb Will Comply with Future FCC Rules With Or Without An Express Condition To Do So

SpaceX asks the FCC to impose a condition on grant of OneWeb's Petition that will "explicitly incorporate the outcome of the [anticipated NGSO system] rulemaking."[47] OneWeb, just like any other U.S. space station licensee or recipient of U.S. market access, is required to conform to any future NGSO system rules or, upon demonstration of good cause, seek approval for waiver from the Commission.[48] As a practical matter, the FCC has not yet opened any proceeding to develop new technical or service rules for NGSO systems. It is therefore unnecessary to condition the grant of OneWeb's Petition on compliance with future rules adopted in a not-yet-pending rulemaking proceeding.[49]

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47 SpaceX Comments at 2-3.

48 *See* 47 C.F.R. § 25.160 ("A forfeiture may be imposed for failure to operate in conformance with . . . any of the Commission's rules and regulations."); 47 C.F.R. § 1.3 ("The provisions of this chapter may be suspended, revoked, amended, or waived for good cause shown, in whole or in part, at any time by the Commission, subject to the provisions of the Administrative Procedure Act and the provisions of this chapter.").

49 In contrast, the precedent cited by SpaceX for conditioning licenses on compliance with future rules all involved rulemakings pending at the time of Commission licensing. *See* SpaceX Comments at 2-3, n.7.

B. OneWeb's Orbital Debris Mitigation Plan Is Subject To Effective Oversight by the United Kingdom

The OneWeb System is subject to direct and effective regulatory oversight by the United Kingdom's regulatory authorities, just like the O3b system.[50] This satisfies the Section 24.114(d)(14)(v) requirement for an orbital debris mitigation plan. [51] Nevertheless, Telesat and SpaceX seek additional FCC review.[52] OneWeb has filed with the FCC the United Kingdom's Guidance for Applicants document, which outlines the license application and approval process for the United Kingdom.[53] OneWeb will share information with the FCC on the status of the United Kingdom's review of OneWeb's debris mitigation plans as the activity progresses. The United Kingdom regulatory authorities share the Commission's focus on ensuring safe space operations and are qualified to review OneWeb's orbital debris mitigation plan. OneWeb is discussing its plan to minimize orbital debris with those overseeing this review, including the United Kingdom Space Agency ("UKSA"). UKSA staff also participate in and Chair the Inter-Agency Space Debris Coordination Committee ("IADC"). OneWeb anticipates that the Space

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50 *See* SES and O3b Comments, at 9 (requesting FCC adoption of O3b condition 15 "finding that the system is subject to regulation by the United Kingdom with respect to mitigation of orbital debris"); O3b Limited, Stamp Grant, IBFS File No. SAT-AMD-20150116-00004, at 4 (Jan. 22, 2015).

51 47 C.F.R. § 25.114(d)(14)(v) ("For non-U.S.-licensed space stations, the requirement to describe the design and operational strategies to minimize orbital debris risk can be satisfied by demonstrating that debris mitigation plans for the space station(s) for which U.S. market access is requested are subject to direct and effective regulatory oversight by the national licensing authority.").

52 Comments of SpaceX at 17; Telesat Petition 4-5.

53 *See* Letter from Kalpak S. Gude, WorldVu Satellites Limited, to Marlene H. Dortch, FCC, File No. SAT-LOI-20160428-00041 at 5 (Jun. 24, 2016), providing Revised Guidance for Applications, Outer Space Act 1986, *available at* https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/464931/Guidance_for_applicants_-_October_2015.pdf.

Activity Licenses required for launch and space operations will be issued only after review and affirmative approval by the United Kingdom regulator of OneWeb's orbital debris mitigation plan. Following issuance, OneWeb will submit the Space Activity Licenses to the FCC.

C. OneWeb Will Work in Good Faith to Ensure Safe Operation of Its 1,200 km Orbital Constellation with Boeing's Proposed Constellation

OneWeb will engage in good faith discussions with Boeing and other proposed NGSO systems to determine the degree of separation required between large NGSO constellations to operate safely. OneWeb takes seriously its responsibility to ensure space safety and minimize any impact of the OneWeb constellation on the LEO environment. In fact, OneWeb has and continues to both participate and present at key space debris conferences including the annual Advanced Maui Optical and Space Surveillance ("AMOS") Technologies Conference and the International Astronautical Congress ("IAC"). OneWeb also actively participates within the UN Committee on the Peaceful Uses of Outer Space ("COPUOS") to promote safe space activities. OneWeb has presented its constellation and avoidance measures to its peers in the scientific community to further collaborate on new ideas as well as communicate the many techniques and capabilities embedded in the system design and architecture to ensure a limited need for avoidance activity, while validating active avoidance and de-orbit capabilities.

OneWeb is certainly concerned by the many, much larger constellation designs and their potential impact on the future availability of space. Space sustainability is critically important to the commercial satellite industry, and operating as safely as possible ensures limited and precious resources remain available for present and future satellite operators. With safety in mind, OneWeb designed its system to operate at the less-populated 1,200 km altitude, thus minimizing the likelihood of collision with uncontrolled debris. OneWeb's altitude design decisions were made years before many other constellations were announced or filed.

Just recently Boeing filed an FCC application[54] to use the same altitude as OneWeb openly acknowledging OneWeb's altitudinal presence. OneWeb would be pleased to enter into coordination discussions with Boeing to ensure collision-free operations of Boeing's proposed system with OneWeb's 1,200 km LEO constellation.

Boeing stated in its application it is "confident that OneWeb and Boeing can operate in their respective constellations at or near 1,200 kilometers by making slight adjustments upwards or downwards in their planned constellation altitudes."[55] OneWeb notes that its system orbital design has been locked for years, with tooling already underway for production of the satellites based on this design. Altitude changes at this juncture would have significant repercussions for deployment of OneWeb's system. Nevertheless, OneWeb remains committed to working with Boeing.

D. The Commission's Routine Condition On Adherence to ITU Coordination Agreements Fully Addresses Telesat's Concern

OneWeb welcomes the opportunity to work with Telesat to make sure its constellation, should it decide to build one, and OneWeb's constellation can operate without interference concerns. Telesat asks the FCC to deny OneWeb's petition for U.S. market access because, in relation to the Ka-band, "the ITU filings associated with Telesat's NGSO constellation have lower priority than the ITU filings associated with Telesat's NGSO constellation."[56] Alternatively, Telesat asks the Commission to adopt new domestic rules that "require that

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54 *See The Boeing Company*, Application, IBFS File No. SAT-LOA-20160622-00058 (June 22, 2016); Boeing Comments at 4.

55 Boeing Comments at 4.

56 Telesat Petition at 2.

systems with lower date priority coordinate their operations (and insure they do not interfere) with systems with higher date priority."[57]

On the topic of ITU priority, the Commission recently issued an order clarifying "the interrelationship between its domestic licensing framework and the international coordination framework set forth in the Radio Regulations of the International Telecommunication Union (ITU)."[58] The FCC explained that "it will license satellites at orbital locations at which another Administration has ITU priority"[59] and impose a condition requiring compliance with international coordination. If coordination is not obtained and operation of both systems creates risk of harmful interference to the system with ITU priority, "a U.S.-licensed satellite making use of an ITU filing with a later protection date would be required to cease service to the U.S. market immediately upon launch and operation of a non-U.S.- licensed satellite with an earlier protection date. . . ."[60] Moreover, the FCC has stated that it "is not responsible for the outcome of any particular satellite coordination and does not guarantee the success or failure of the required international coordination."[61] This is particularly true where, as here, the relevant ITU filings involve Canada and the United Kingdom—not the United States.

A condition requiring satellite communications with U.S. earth stations to adhere to the ITU coordination process will fully protect Telesat's interests, while not making the United

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57 *Id.* at 4.

58 *Amendment of the Commission's Space Station Licensing Rules and Policies*, Second Order on Reconsideration, IB Docket No. 02-34, FCC 16-108, ¶ 31 (rel. Aug. 16, 2016).

59 *Id.*, ¶ 32.

60 *Id*.

61 *Amendment of the Commission's Space Station Licensing Rules and Policies*, First Report and Order, 18 FCC Rcd. 10760, ¶ 96 (2003).

States the arbiter of coordination between two other administrations. OneWeb notes that after detailed analysis, it will be straight-forward to coordinate OneWeb's few pencil thin Ka-beams with either and/or both of the Telesat constellations, comprised of 72 satellites in one constellation and 44 in the other. Thus, the fact that OneWeb has some lower priority ITU filings than Telesat can be addressed through coordination. In practice, the FCC routinely imposes such a condition. For example, the FCC recently granted SES Satellites Limited's petition for U.S. market access on the condition that "[c]ommunications between U.S.-licensed earth stations and the SES-15 space station [] comply with all existing and future space station coordination agreements reached between the United Kingdom and other administrations."[62]

This is not the first time Telesat has attempted to have the ITU process supplant the FCC's domestic licensing process. In the 17/24 GHz proceeding, Telesat asked the Commission to include a condition that "would make the grant subject to the licensee coordinating with satellite operators having International Telecommunication Union ("ITU") date priority."[63] The FCC nevertheless determined to apply its domestic licensing process and to allow ITU coordination to proceed independently.[64] The same approach is warranted here.[65]

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62 *SES Satellite (Gibraltar) Limited*, Stamp Grant, IBFS File No. SAT-PPL-20160126-00007, at 2-3, n.2 (July 12, 2016).

63 Letter from Paul D. Bush, Telesat, to Marlene H. Dortch, Secretary, Federal Communications Commission, IB Docket No. 06-123, at 2 (September 12, 2007).

64 *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 to the Broadcasting-Satellite Service and for the Satellite Services Operating Bi-Directionally in the 17.3-17.8 GHz Frequency Band*, Second Order on Reconsideration, 25 FCC Rcd 15718, ¶ 11 (2010) ("In light of our existing ITU coordination rule and our prior statements on this issue, we find Telesat's contention that there 'may be confusion' regarding ITU coordination obligations to be unsupported. Thus, we find that any further condition requiring ITU coordination, as proposed by Telesat, is redundant and is otherwise unnecessary as a general matter.").

Notwithstanding the specific rules above, and in line with OneWeb's goal to work positively and constructively with other systems, OneWeb has reviewed Telesat's filings and believes there will be no coordination concern between Telesat and OneWeb. OneWeb remains committed and ready to have these coordination discussions.

E. The Software Source Code is Not Necessary to Ensure EPFD Compliance

ViaSat claims that it is necessary for OneWeb to provide the FCC with the source code for the software it used to demonstrate compliance with the single-entry EPFD validation limits, citing §25.146(a).[66] However, the source code disclosure requirement is only applicable to software not approved by the ITU. As explained in the OneWeb Petition,[67] the software OneWeb provided to the FCC and used to demonstrate EPFD compliance is the software that has been under development by the ITU for several years for this very purpose. It is a vigorously tested, executable that is available in advanced beta form on the ITU's website and soon will be released in final form.[68] The source code for this ITU software is, and will remain, proprietary to the software authors and cannot be made available to any other party, including the FCC.

The algorithm to determine whether NGSO FSS systems meet the EPFD limits in Article 22 of the Radio Regulations is defined in Recommendation ITU-R S.1503-2. These limits

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65 Indeed, Telesat has not yet sought U.S. market access in the 17/24 GHz band and thus the Commission's adoption of Telesat's proposed condition could have resulted in spectrum lying fallow for years.

66 ViaSat Comments at 6-8 (citing 47 C.F.R. § 25.146(a)(1)(iii) and (a)(2)(iii)).

67 OneWeb Petition at 21-23.

68 On 3 June 2016 the ITU-BR issued Circular Letter CR/405 which announced to administrations further details of the development of the EPFD validation software, and the availability of an advanced beta version of this software on the ITU's website. It also informed administrations that the BR plans formally to issue the final version of this software in October 2016 and to use it to then start using it to evaluate EPFD compliance for already-filed NGSO systems subject to EPFD limits.

provide the agreed level of protection for GSO networks. The algorithm is complex, and the best way—and possibly the only effective way—to test software that implements it is against another independently developed implementation. This was the approach taken by the ITU, which invested in two separate and independently developed versions from Transfinite Systems Ltd in the United Kingdom and Agenium in France.

The ITU work included an extremely vigorous test regime that involved:

- Module testing, such as orbit prediction algorithms;
- Component testing, such as the worst case geometry; and
- Test case runs, with a set of NGSO FSS systems that stretched the software by testing difficult routes through the algorithm.

The detailed testing was a success with agreement between the two tools to very high precision. The results of this testing were presented in April 2016 at the NGSO Workshop organized by the ITU-BR. Both software tools were then delivered and accepted by the ITU with no inconsistencies identified. The software was supplied in the form of executables, with no source code supplied.

OneWeb, just like any other NGSO system, is obligated to meet the EPFD limits in Article 22 of the Radio Regulations, and it is the ITU that will check these limits using the two tools mentioned above. The FCC rules contain the very same EPFD limits, and require the use of the same ITU-R Recommendation (S.1503-2) to calculate compliance. It is thus logical for the Commission to use the same software tool to verify compliance. Any other concerned party, including GSO satellite operators, can use this software provided by the ITU to test whether a NGSO FSS system meets the EPFD limits in Article 22 of the Radio Regulation—just as OneWeb did.

ViaSat also has made comments concerning the software necessary to calculate the aggregate EPFD from multiple NGSO FSS systems.[69] ViaSat seems to be suggesting that the single-entry EPFD compliance demonstration for OneWeb cannot adequately be made without knowing how the aggregate EPFD of multiple systems will be calculated. The two EPFD demonstrations are, however, separate exercises. Indeed, the methodology to calculate this aggregate EPFD from multiple systems has not been defined either in the ITU or by the FCC. This will not stop the ITU from determining whether a single NGSO system has met its obligations to comply with the EPFD limits, and neither should it prevent the FCC from doing the same. Therefore, the FCC should reject ViaSat's suggestion that the FCC delay its determination of OneWeb's EPFD compliance until the end of the processing round.

F. OneWeb Is Amenable to the FCC Imposing All Applicable O3b Conditions

The Comments of SES and O3b suggest that the "O3b Market Access Grant can be used as a template with respect to OneWeb's planned NGSO operations in Ka-band spectrum."[70] OneWeb does not object to the Commission including relevant conditions from the O3b Market Access Grant in the grant of OneWeb's request for market access. Indeed, doing so is an efficient way to ensure prompt grant of OneWeb's petition and the initiation of broadband internet access to underserved and unserved communities in the United States.

With respect to proposed condition 3—which calls for ephemeris data for each satellite—OneWeb is committed to making high-accuracy ephemeris information for all of its satellites available to those with a need to know. Specifically, OneWeb will make information, which will be frequently updated, to other satellite operators, government entities (*e.g.*, the Joint Space

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69 ViaSat Comments at 7.

70 SES and O3b Comments at 7.

Operations Center ("JSpOC")), and non-governmental entities playing a role in evaluating and coordinating collision avoidance operations (*e.g.*, the Space Data Association, the Commercial Space Operations Center ("ComSpOC"), etc.).

IV. CONCLUSION

OneWeb's proposed satellite system will bring affordable, high-speed broadband internet access to millions of people worldwide and in the United States, including rural areas and unconnected schools. As demonstrated in OneWeb's Petition, and further supported herein, OneWeb's system complies with all Commission rules and is designed to share with other NGSO systems. OneWeb urges the FCC to deny petitions filed by the MVDDS 5G Coalition and Telesat and proceed with the processing of OneWeb's application as expeditiously as possible.

Respectfully submitted,

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APPENDIX A

1. **When a OneWeb satellite approaches the equator, is the satellite as a whole turned off, or are only certain beams turned off?**

   In the context of this question, OneWeb interprets the phrase "satellite as a whole" to mean "all Ku-band user beams." To be clear, OneWeb satellites will not be intentionally turned off at any time during nominal operations. Individual beams, or all beams, may be turned off depending on the satellite latitude. In order to meet EPFD limits, as the satellite approaches the equator the downlink EIRP density of certain Ku-band user beams on the satellite will be reduced and eventually those beams will be turned off. In addition, all Ku-band user beams on the satellite will be turned off briefly as the satellite passes over the equator.

2. **If only certain beams are turned off, how does the system determine which beams to turn off and which beams can remain active?**

   The system determines which beams to turn off based on results from detailed simulations which quantify the amount of EPFD that could be caused by OneWeb satellites to GSO earth stations. In general, the beams that are powered down and turned off first are the "anti-equatorial" beams, *i.e.*, those pointed furthest away from the equator. These would be the trailing beams of the array as the satellite approaches the equator and the leading beams as the satellite moves away from the equator. These are the ones that are in closest alignment with the GSO as viewed from the surface of the Earth.

3. **At what latitude do OneWeb satellites begin turning off beams, and how was that latitude determined?**

   OneWeb satellites vary individual Ku-band user beam powers over all latitudes of operation. The power variation is done primarily for EPFD mitigation, but this also assists with onboard power management of the satellites. Detailed simulations allow OneWeb to quantify the amount of potential EPFD from the OneWeb system. The results of these simulations allow OneWeb to define the latitudes at which beams are turned off during operation such that EPFD limits are never exceeded. The control of satellite beam power is reflected in OneWeb's satellite PFD mask file submitted by the company with its Petition.

4. **Are there any redundancy mechanisms in place to prevent EPFD limits from being exceeded if a system error prevents a beam from turning off when the satellite approaches the equator?**

   The OneWeb system enables frequent commanding opportunities to each satellite, so the satellites will be controlled in a near-continuous manner. If a failure or otherwise erratic behavior that could cause unacceptable EPFD levels is detected by the network or spacecraft control center, OneWeb has the ability to power down the violating beam(s). Furthermore, a satellite user beam does not transmit unless it has an active uplink from a gateway station on the corresponding Ka-band channel, so that even if the beam cannot be turned off, the

Network Operation Center will prevent any gateway uplink transmissions in the corresponding channel.

5. **What would be the effect on protection of GSO networks if one or more beams do not turn off as planned?**

   It is extremely unlikely that a user beam would be stuck "on." However, even if OneWeb cannot turn off the SSPA for a given beam, as mentioned, a user beam that does not turn off will have no signals to transmit without a gateway transmission on the corresponding Ka-band channel which feeds that user beam. Avoiding such transmissions will prevent any signals from being transmitted from the bent-pipe satellite.

6. **How do the OneWeb system's EPFD values vary based on:**

   • satellite latitude,
   • satellite pitch value,
   • powering off beams, and
   • GSO exclusion angles?

   Can OneWeb supply plots demonstrating these relationships?

   PFD masks have been provided as part of the OneWeb application, and these masks fully capture the variation of satellite pitching, power control, and beam turn-off as they depend on sub-satellite latitude. Each parameter is used and carefully controlled in conjunction with one another to ensure EPFD compliance for the OneWeb system as a whole. EPFD is defined for the entire constellation, as per the methodology described in Recommendation ITU-R S.1503-2, and includes all of the above effects for each satellite. The OneWeb system is designed such that it will comply with EPFD limits for all geometries and all GSO ES antenna types, and OneWeb has demonstrated this in its FCC application by presenting EPFD results for the worst case geometries, as defined by the ITU-R S.1503-2 algorithms. This can be verified by the FCC, ITU, or any interested party, running the software that the ITU has recently made available to determine compliance with EPFD limits.

7. **What criteria will OneWeb use in selecting gateway earth station locations in order to effectuate its GSO arc avoidance approach?**

   One Web will select a limited number of sites for its Ka-band gateways. These gateways will be located well outside of urban cores and at locations that facilitate GSO arc avoidance. Typically, the OneWeb Global Network Operation Center will select the best gateway site to provide connection to the satellites, except when that link could result in a violation of the minimum GSO orbit avoidance. OneWeb satellites will travel in well understood and predictable orbits that can be accurately modeled. With this knowledge, applying specific geometric constraints (e.g., maintaining a defined GSO avoidance angle) to gateway selections becomes a trivial task. The OneWeb system is indeed designed with such constraints in mind.

8. What factors will be used to determine whether to permit a gateway to communicate with a OneWeb satellite at a given location in order to ensure protection of GSO networks?

The primary consideration in gateway selection will be whether the required minimum GSO avoidance angle is ensured. As previously mentioned, orbital geometry is very predictable and can be used to dynamically determine the separation angle between the GSO and the NGSO satellite for each potential OneWeb link over time.

9. Will a user terminal need to search for a new beam if the beam it has been communicating with is turned off?

No. The schedule for turning satellite beams off will be determined several hours in advance and communicated to user terminals well ahead of time. User terminals will be tracking specific satellites according to schedule and if there is an unexpected beam failure, the user terminal will remain fixed on the satellite being tracked. User terminals will not radiate in random directions for any reason. Any "search" modes that the user terminal will employ are receive only, for example when initially installed or moved, or after losing lock on their satellites so that they can receive the beacon signals that will provide them the satellite data for securing or re-acquiring their links.

10. What monitoring mechanisms will OneWeb employ to ensure that user terminal operations do not result in interference to GSO networks?

As described above, user links are scheduled ahead of time, based on analysis and simulation, and will be constrained such that link geometries will not result in EPFD limit exceedance. The OneWeb network monitoring system will detect if any equipment anomalies occur, and will take appropriate action to protect GSO networks in the event of any such anomalies.

Certificate of Service

I, Kim Riddick, hereby certify that on this 25th day of August 2016, a copy of the foregoing Opposition and Response is being sent via first class, U.S. Mail, postage paid, to the following:

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