

**Before the  
FEDERAL COMMUNICATIONS COMMISSION  
Washington, DC 20554**

In the Matter of	)	
	)	
<b>O3b Limited</b>	)	File No. SAT-AMD-2017_____
	)	Call Sign: S2935
Amendment to Application to Modify	)	
U.S. Market Access Grant for the	)	
O3b Medium Earth Orbit Satellite System	)	

**AMENDMENT**

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### **Technical Annex**

#### **Attachment 1: Information Concerning Shareholders, Officers, and Directors**

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**AMENDMENT**

O3b Limited (“O3b”), by its attorneys and pursuant to Section 25.116 of the Commission’s rules,<sup>1</sup> hereby amends its pending application to modify its authority to serve the U.S. market using a system of satellites in medium earth orbit (“MEO”).<sup>2</sup> In November, O3b filed an initial amendment (the “November Amendment”) to the Modification Application that requested additional satellites and frequencies as part of the non-geostationary satellite orbit (“NGSO”) processing round the International Bureau established for Ku- and Ka-band systems.<sup>3</sup> O3b submits the instant amendment (the “March Amendment”) for consideration as part of the processing round the International Bureau initiated for NGSO operations in V-band spectrum.<sup>4</sup>

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<sup>1</sup> See 47 C.F.R. § 25.116(a) (stating that a pending application may be amended until it has been “designated for hearing, a public notice is issued stating that a substantive disposition of the application is to be considered at a forthcoming Commission meeting, or a final order disposing of the matter is adopted by the Commission”).

<sup>2</sup> See Modification Application of O3b Limited, Call Sign S2935, IBFS File No. SAT-MOD-20160624-00060 (June 24, 2016) (“Modification Application”).

<sup>3</sup> See Amendment Application of O3b Limited, Call Sign S2935, IBFS File No. SAT-AMD-20161115-00116 (filed Nov. 15, 2016) (“November Amendment”).

<sup>4</sup> See *Boeing Application Accepted for Filing; IBFS File No. SAT-LOA-20160622-00058; Cut-Off Established for Additional NGSO-Like Satellite Applications or Petitions for Operations in the 37.5-40.0 GHz, 40.0-42.0 GHz, 47.2-50.2 GHz and 50.4-52.4 GHz Bands*, Public Notice, DA 16-1244 (rel. Nov. 1, 2016) (“V-Band Public Notice”).

This March Amendment seeks the following additional changes to the Commission's grant of U.S. market access to O3b.<sup>5</sup>

- O3b requests U.S. market access in the 37.5-42.5 GHz, 47.2-50.2 GHz, and 50.4-51.4 GHz frequency bands<sup>6</sup> for up to twenty-four new satellites (hereafter referred to as O3bN) that will operate in a circular equatorial orbit.<sup>7</sup> These satellites will also use the frequencies covered by the Market Access Grant<sup>8</sup> and the November Amendment.<sup>9</sup>

O3b's system offers low-latency, high-throughput satellite connectivity – generally ten to one-hundred times the throughput of a traditional satellite – to Internet service providers, fixed and mobile network operators, large enterprises and governments, to enable fast, flexible and affordable broadband connectivity in locations unserved or underserved by terrestrial networks.<sup>10</sup> Because the O3b satellites are at the MEO altitude of 8,062 km, users on O3b's system experience round trip latency of less than 150 milliseconds, or one quarter the latency of geostationary orbit (“GSO”) satellites. O3b uses steerable spot beams to provide middle mile capacity that enables large service providers to supply fiber-equivalent connectivity to customers on land, in the air, or at sea across the globe. The O3b architecture makes this a highly-scalable system, designed to be built incrementally as demand and markets develop, and to expand capacity and coverage at the lowest possible cost.

After commencing operations two and a half years ago, O3b already needs substantially more capacity to accommodate the growing demand for its high-throughput, high-performance connectivity. Grant of this March Amendment will allow O3b to further expand its proven technology and services in response to customer requirements,

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<sup>5</sup> See Applications of O3b Limited, Call Sign S2935, IBFS File Nos. SAT-LOI-20141029-00118 and SAT-AMD-20150115-00004 (the “Market Access Application”), granted Jan. 22, 2015 (the “Market Access Grant”).

<sup>6</sup> O3b recognizes and addresses below the fact that the Commission is not currently considering FSS applications in the 42.0-42.5 GHz band. See V-Band Public Notice.

<sup>7</sup> In addition to these frequencies, O3b plans to use the 51.4-52.4 GHz band for O3bN operations but is not seeking U.S. market access for this spectrum.

<sup>8</sup> O3b is currently authorized to use the 17.8-18.6 GHz, 18.8-19.3 GHz, 27.6-28.35 GHz, 28.35-28.4 GHz, and 28.6-29.1 GHz bands. See Market Access Grant, Attachment at 1.

<sup>9</sup> See November Amendment, Legal Narrative at 2.

<sup>10</sup> O3b can deliver connectivity comparable to fiber, making it the ideal solution to bring broadband quality Internet connectivity to places that are unserved or underserved by fiber or other terrestrial backhaul networks.

using even more advanced technology and with lower costs to customers, which will result in significant public interest benefits.

## **I. INTRODUCTION AND SUMMARY**

O3b operates a U.K.-authorized, NGSO Fixed-Satellite Service (“FSS”) system in the Ka-band. O3b has twelve satellites in orbit (collectively, the “Twelve In-Orbit Satellites”) and has satisfied all Commission milestones associated with the grant of U.S. market access for those satellites.<sup>11</sup> In its Modification Application, O3b proposed to serve the U.S. using eight satellites to be added to its existing constellation,<sup>12</sup> and in its November Amendment, O3b sought U.S. market access for two new MEO satellite constellations, O3bN and O3bI.<sup>13</sup>

In order to respond to customer demand, O3b hereby further amends the Modification Application to seek additional U.S. market access authority. As outlined above, this March Amendment requests U.S. market access for additional frequencies on the O3bN satellites that were requested in the November Amendment.

Grant of the Modification Application as updated by the November Amendment and this March Amendment will serve the public interest by allowing O3b to use additional frequencies and satellites to respond to customer demand for low latency, broadband satellite services.

## **II. O3B’S MODIFICATION APPLICATION AS AMENDED SATISFIES THE COMMISSION’S LEGAL REQUIREMENTS**

O3b showed in the Modification Application that it complies with Section 25.137(f) of the Commission’s rules,<sup>14</sup> which sets forth the requirements for seeking changes to U.S. market access authorizations. O3b incorporates that showing by reference herein. O3b demonstrates in this filing that its request to add frequencies to its system is consistent with Commission policies and is in the public interest. Accordingly, O3b’s request for a market access modification as amended should be granted.

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<sup>11</sup> See Public Notice, Report No. SES-01681, at 12 (Sept. 10, 2014); Public Notice, Report No. SAT-01065, DA 15-172 (Feb. 6, 2015).

<sup>12</sup> See generally Modification Application.

<sup>13</sup> See generally November Amendment.

<sup>14</sup> See 47 C.F.R. § 25.137.

### **A. O3b's Amendment Conforms to Section 25.137(f)**

Section 25.137(f) of the rules states that a non-U.S. licensed satellite operator may modify its grant of U.S. market access in accordance with the procedures set forth in Section 25.117(d) of the rules.<sup>15</sup> The Modification Application as amended meets the rule's requirements:

- O3b has identified all Section 25.114 information that has changed, and it hereby certifies that there has been no change to the remaining information.
- O3b demonstrates herein that the proposal to add frequencies and satellites to its system does not affect O3b's qualifications to operate a space station under the Commission's rules because:
  - the Amendment does not affect the factors relevant to the Commission's market access analysis under DISCO II;
  - the Modification Application as amended satisfies the Commission's legal and technical qualification requirements for holders of space station authorizations; and
  - the limited waivers of Commission policies and rules O3b is requesting are justified under Commission precedent.
- O3b demonstrates in this filing that grant of its market access modification request as amended would be in the public interest.

### **B. O3b Will Continue to Satisfy the DISCO II Requirements**

In its DISCO II proceeding, the Commission established a framework for considering requests for non-U.S. licensed space stations to access the U.S. market. In evaluating requests for such authority, the Commission takes into account the effect on competition in the United States; eligibility and operational requirements; concerns related to national security, law enforcement, foreign policy, and trade; and spectrum availability.<sup>16</sup> O3b demonstrated its compliance with the DISCO II criteria in the Modification Application, and the addition of spectrum proposed herein does not alter the DISCO II analysis.

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<sup>15</sup> See 47 C.F.R. § 25.117(d).

<sup>16</sup> See *Amendment of the Commission's Regulatory Policies to Allow Non-U.S. Licensed Space Stations to Provide Domestic and International Satellite Service in the United States*, Report and Order, 12 FCC Rcd 24094 ¶ 29 (1997) ("*DISCO II Order*"), on reconsideration, 15 FCC Rcd 7207 ¶ 5 (1999).

*Effect on competition in the United States.* Adding spectrum to O3b’s system will enhance competition in the United States by enabling O3b to expand its capacity and compete more effectively. In any event, under the DISCO II framework, allowing satellites licensed by WTO member countries to serve the U.S. is presumed to be pro-competitive, and O3b’s satellites are licensed by the United Kingdom, a member of the WTO.<sup>17</sup>

*Eligibility and operational requirements.* As shown in Section II.C below, O3b’s request to add frequencies is consistent with the DISCO II criteria that address eligibility and operational requirements.

*Concerns related to national security, law enforcement, foreign policy, and trade.* O3b’s Market Access Application raised no national security, law enforcement, foreign policy, and trade issues, and the addition of frequencies does not present any new concerns in these areas.

*Spectrum availability.* Operation of the O3b system as modified does not implicate spectrum availability under DISCO II<sup>18</sup> because it will not create the potential for harmful interference with U.S.-licensed satellite and terrestrial systems.

In its Market Access Application, O3b demonstrated that its Twelve In-Orbit Satellites adequately protect U.S.-licensed satellite and terrestrial systems from interference. In the Technical Annex that is included with this filing, O3b supplements that showing to address the addition of V-band frequencies to its planned O3bN satellites. In particular, the Technical Annex demonstrates that:

- O3b’s satellites will continue to comply with applicable Commission and International Telecommunication Union (“ITU”) Power Flux Density (“PFD”) limits to ensure that satellite downlink transmissions do not adversely affect terrestrial services, and O3b will take steps to protect terrestrial services where PFD limits are not in place.
- In operating its satellites, O3b will take measures to ensure that uplink and downlink transmissions from NGSO satellites will avoid unacceptable interference to GSO satellite networks.

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<sup>17</sup> See *DISCO II Order* ¶ 29. O3b is headquartered in St. John, Jersey, Channel Islands, which is a British Crown Dependency. The Commission treats British Crown Dependencies like Jersey and Guernsey as members of the WTO. See, e.g., *Intelsat Holdings, Ltd., Transferor, and Serafina Holdings Limited, Transferee, Consolidated Application for Consent to Transfer Control of Holders of Title II and Title III Authorizations*, Memorandum Opinion and Order, 22 FCC Rcd 22151 ¶ 25 n.57 (2007).

<sup>18</sup> See *DISCO II Order* ¶¶ 149-50.

- In bands in which EPFD limits do not apply, O3b is coordinating with GSO satellite operators and their administrations in accordance with the ITU Radio Regulations.
- O3b will continue to rely on angular separation between orbital arcs, satellite diversity, and (as a last resort) band segmentation to address any potential in-line interference events with other NGSO satellite systems.
- O3b will comply with rules adopted in the Spectrum Frontiers proceeding<sup>19</sup> regarding sharing with future Upper Microwave Flexible Use Service (“UMFUS”) operations as required.

Accordingly, grant of O3b’s Modification Application as amended is consistent with the Commission’s requirements for protecting U.S.-licensed satellite and terrestrial systems.

**C. O3b Will Continue to Satisfy the Commission’s Legal and Technical Qualification Requirements**

The information set forth in this legal narrative, the attached Technical Annex, Schedule S, and the accompanying FCC Form 312 demonstrates that O3b’s proposed addition of frequencies conforms to the Commission’s legal and technical qualification requirements for holders of space station authorizations. In this regard, O3b notes that it is not required to make an orbital debris mitigation showing because the Commission has already determined that O3b’s system “is and will be subject to direct and effective regulation by the United Kingdom concerning orbital debris mitigation.”<sup>20</sup>

**D. Waivers of Commission Rules and Policies Are Warranted for this O3b Amendment**

O3b seeks waivers of the Commission’s rules in connection with this March Amendment. Grant of these waivers is consistent with Commission policy:

The Commission may waive a rule for good cause shown. Waiver is appropriate if special circumstances warrant a deviation from the general rule and such deviation would better serve the public interest than would strict adherence

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<sup>19</sup> See *Use of Spectrum Bands Above 24 GHz For Mobile Radio Services*, Report and Order and Further Notice of Proposed Rulemaking, 31 FCC Rcd 8014 (2016).

<sup>20</sup> Market Access Grant ¶ 15. Pursuant to standard procedures, O3b will submit a plan with respect to its new satellites for United Kingdom review approximately six months prior to launch.



to the general rule. Generally, the Commission may grant a waiver of its rules in a particular case if the relief requested would not undermine the policy objective of the rule in question and would otherwise serve the public interest.<sup>21</sup>

O3b's proposal for additional frequencies substantially complies with the Commission's rules, but certain waivers are necessary in light of the spectrum used and the technical characteristics of the system. The Commission has granted similar waivers in other cases. As shown below, the changes to O3b's operations proposed in the Modification Application as amended herein will allow O3b to continue and expand its services, and grant of the requested waivers will therefore serve the public interest.

*Table of Frequency Allocations and Section 25.202(a)(1)*

The Table of Allocations in Section 2.106 of the Commission's rules, the associated footnotes, and the Commission's V-band frequency designations include limitations on the use of some of the frequency bands for which authority is sought in this March Amendment. O3b seeks waivers of these restrictions as discussed below. Waivers of the Table of Allocations are generally granted "when there is little potential for interference into any service authorized under the Table of Frequency Allocations and when the nonconforming operator accepts any interference from authorized services."<sup>22</sup> The O3b waiver requests meet this test.

Authorized V-Band Frequencies: The Commission has waived the U.S. Table of Allocations and the Ka-Band Plan to permit the Twelve In-Orbit Satellites to use Ka-band frequencies in which terrestrial fixed services have a primary allocation and there is no allocation for NGSO FSS operations.<sup>23</sup> This waiver should be extended to the use of the V-band frequencies by the O3bN satellites as proposed in this March Amendment. As shown in the Technical Annex, O3b's operations on a non-conforming basis would not create the potential for harmful interference to U.S.-licensed terrestrial systems. There is good cause, therefore, for extending the waiver to the V-band frequencies.

42.0-42.5 GHz: O3b proposes to use the 42.0-42.5 GHz band for gateway downlinks. This band is not allocated for FSS under the U.S. Table of Allocations but is

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<sup>21</sup> *PanAmSat Licensee Corp.*, 17 FCC Rcd 10483, 10492 (Sat. Div. 2002) (footnotes omitted).

<sup>22</sup> *See The Boeing Company*, 16 FCC Rcd 22645, 22651 & n.48 (IB & OET 2001) (citing cases).

<sup>23</sup> *See Market Access Grant* ¶ 4 (granting waiver of the Table of Allocations and the Ka-Band Plan for O3b's operations in the 17.8-18.6 GHz frequencies).

allocated for co-primary FSS (space-to-Earth) use internationally.<sup>24</sup> O3b demonstrates in the attached Technical Annex that it will not cause harmful interference to primary terrestrial services or to adjacent band Radio Astronomy Services operations. O3b recognizes that the Commission is deferring consideration of this band for FSS operations pending further decisions in the Spectrum Frontiers proceeding regarding authorizing fixed and mobile terrestrial operations in the band.<sup>25</sup> O3b is seeking access to the band subject to the outcome of the Commission’s evaluation of these issues.

50.4-51.4 GHz: O3b proposes to use the 50.4-51.4 GHz band for service and gateway uplinks. This band is allocated for FSS uplinks, but there are no service rules for FSS in the band. O3b demonstrates in the attached Technical Annex that its use of the spectrum will not cause interference to future GSO or terrestrial operations in the band. As a result, permitting O3b’s planned use of this spectrum would serve the public interest.

#### *Section 25.143(b)(2) - Geographic Coverage*

Under Section 25.217, which establishes default service rules applicable to V-band satellite networks, an applicant must demonstrate compliance with the geographic coverage requirements in Section 25.143(b)(2) of the Commission’s rules. That section requires NGSO systems to provide service coverage (i) to all locations as far north as 70 degrees North latitude and as far south as 55 degrees South latitude for at least 75% of every twenty-four-hour period and (ii) on a continuous basis throughout the fifty states, Puerto Rico, and the U.S. Virgin Islands.<sup>26</sup> The Commission previously waived the corresponding Ka-band rule for O3b, Section 25.145(c), recognizing that “there is a limit on the northernmost and southernmost latitudes that can be served by [O3b’s] system” because of look angle constraints arising from the fact that O3b’s system operates in an equatorial orbit, not an inclined orbit.<sup>27</sup>

Adding new equatorial orbit satellites has no impact on O3b’s geographic coverage or on the factors that led the Commission to waive Section 25.145(c) previously. The O3bN satellites will provide the same coverage as O3b’s Twelve In-Orbit Satellites. The Commission, therefore, should grant a waiver of Section 25.143(b)(2) for the O3bN satellites on the same terms and conditions as the waiver of Section 25.145(c) it already has granted O3b.

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<sup>24</sup> See 47 C.F.R. § 2.106.

<sup>25</sup> See V-Band Public Notice at 1 n.3.

<sup>26</sup> See 47 C.F.R. § 25.143(b)(2).

<sup>27</sup> Market Access Grant ¶ 14.

*Section 25.156(d)(5) – NGSO Access to Spectrum Previously Licensed to GSO Systems*

Section 25.156(d)(5) of the Commission rules states that:

In cases where the Commission has not adopted frequency-band specific service rules, the Commission will not consider applications for NGSO-like satellite operation after it has granted an application for GSO-like operation in the same frequency band, and it will not consider applications for GSO-like operation after it has granted an application for NGSO-like operation in the same band, unless and until the Commission establishes NGSO/GSO sharing criteria for that frequency band. In the event that the Commission receives applications for NGSO-like operation and applications for GSO-like operation at the same time, and the Commission has not adopted sharing criteria in that band, the Commission will divide the spectrum between GSO-like and NGSO-like licensees based on the proportion of qualified GSO-like and NGSO-like applicants.<sup>28</sup>

O3b requests any necessary waiver of this rule with respect to the V-band frequencies requested in this March Amendment.

A search of the Commission's IBFS database does not reveal any active GSO FSS licenses in the V-band. The Commission has granted two satellite licenses that cover portions of the band: Northrop Grumman Space & Mission Systems Corporation was authorized to operate an NGSO/GSO hybrid system in the 37.5-42.0 and 47.2-50.2 GHz bands,<sup>29</sup> and Hughes Network Systems, LLC was granted a license for a GSO satellite to operate in the 39.0-42.0 GHz and the 47.2-50.2 GHz bands.<sup>30</sup> Neither operator launched a satellite pursuant to its license.

Section 25.156(d)(5) does not specify whether it applies to surrendered licensees or systems that were never launched. Therefore, in an abundance of caution, O3b requests a waiver of this section as needed. Grant of this waiver is appropriate because

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<sup>28</sup> 47 C.F.R. § 25.156(d)(5).

<sup>29</sup> Application of Northrop Grumman Space & Mission Systems Corporation for Authority to Operate a Global Satellite System Employing Geostationary Satellite Orbit and Non-Geostationary Satellite Orbit Satellites in the Fixed-Satellite Service in the Ka-band and V-band, File Nos. SAT-LOA-19970904-00082 et al., Order and Authorization, DA 09-428 (Feb. 23, 2009).

<sup>30</sup> Application of Hughes Network Systems, LLC, for Authority to Construct, Launch and Operate a Ka-band and V-band Geostationary Orbit Space Station, Jupiter 77W, and the 77.3° W.L. Orbital Location, File No. SAT-LOA-20111223-00248, granted Aug. 3, 2012.

there are currently no licensed or operational GSO V-Band commercial FSS systems and therefore the O3bN satellites cannot cause harmful interference to any incumbent system.

*Section 25.157(e) – Bandwidth Assignments Resulting from Processing Rounds*

Section 25.157(e) provides a framework for dividing spectrum among multiple NGSO applicants in the event that insufficient spectrum is available to accommodate the requests of all qualified applicants in a processing round. Subsections 25.157(e)(1) and (e)(2) provide different approaches for apportioning the spectrum depending on whether individual applicants are seeking access to the full available bandwidth.<sup>31</sup>

O3b requests any necessary waiver of Section 25.157(e) because O3b is able to share V-band spectrum with other NGSO satellite constellations without the need for spectrum segmentation. As discussed in the Technical Annex, the O3bN constellation is particularly well-suited to sharing based on the avoidance of in-line interference events given its equatorial orbit and relatively low number of satellites. Granting a waiver to permit O3b to access the full V-band spectrum it is seeking would be in the public interest because it will enable O3b and other prospective NGSO systems to offer higher data capacity to more users.

The Commission has recognized that spectrum segmentation can be avoided by relying on avoidance of in-line interference to facilitate sharing among NGSO systems and has proposed rule revisions to specify that a system authorized based on conditions relating to avoiding in-line interference is not subject to Section 25.157(e).<sup>32</sup> In the event that the Commission acts on this March Amendment prior to adopting its proposed changes to Section 25.157, O3b respectfully requests any necessary waiver of Section 25.157(e).

*Section 25.116(b) and (c)*

Section 25.116(b) identifies the types of changes that qualify as major amendments to an application, and these include a proposed change of frequencies. Section 25.116(c) provides that with certain exceptions, filing a major amendment to an application for NGSO satellites after a “cut-off” date will cause the underlying application to be considered as newly filed.

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<sup>31</sup> 47 C.F.R. § 25.157(e)(1) and (2).

<sup>32</sup> *In the Matter of Update to Parts 2 and 25 Concerning Non-Geostationary, Fixed-Satellite Service Systems and Related Matters*, Notice of Proposed Rulemaking, IB Docket No. 16-408, 31 FCC Rcd 13651 (Dec. 15, 2016) at ¶ 23 and Appendix A, proposed Section 25.157(b)(2).

O3b's November Amendment was filed pursuant to the Commission's announcement of a processing round for Ku- and Ka-band NGSO systems. That announcement specified that November 15, 2016 was the deadline, or "cut-off" date, by which applications were required to be filed in order to be considered as part of the processing round.<sup>33</sup> As a result, the November Amendment could be viewed as ineligible for consideration as part of the Ku/Ka-band processing round if it was deemed to be newly filed as a result of the submission of this March Amendment.

O3b believes that this March Amendment falls under the exception provided in Section 25.116(c)(4) because its proposed frequency changes do not "create new or increased frequency conflicts, and [are] demonstrably necessitated by events which the applicant could not have reasonably foreseen at the time of filing." The proposed addition of V-band frequencies to the spectrum sought in the November Amendment does not create new or increased frequency conflicts with other applications in the Ku/Ka-band processing round. Further, the need to add V-band frequencies in a subsequent filing was necessitated by the short interval between the release of the V-band Public Notice on November 1, 2016, and the November 15, 2016 deadline for submission of filings in the Ku/Ka-band processing round.

However, if the Commission concludes that the filing of this March Amendment does trigger Section 25.116(c), the Commission should waive the rule for good cause. There is no reason that O3b's decision to seek V-band authority in the current processing round should retroactively disqualify O3b from having its Ka-band spectrum requests considered as part of the Ku/Ka-band processing round. The addition of V-band frequencies requested in this March Amendment does not prejudice any of the parties that filed applications in the Ku/Ka-band processing round. To the contrary, the Commission's processing round approach is specifically designed to allow the Commission to separately consider groups of applications seeking different sets of frequencies. O3b's request for V-band frequencies simply has no bearing on matters regarding the requests of O3b and others for Ka-band spectrum.

Granting a waiver is also consistent with administrative efficiency. To avoid the application of Section 25.116(c), O3b could have submitted its request for V-band spectrum as a stand-alone market access request. However, because the V-band frequencies are to be added to satellites fully described in the November Amendment, the more logical approach is for the Commission to consider the O3bN satellites as part of

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<sup>33</sup> See *OneWeb Petition Accepted for Filing; IBFS File No. SAT-LOI-20160428-00041; Cut-Off Established for Additional NGSO-Like Satellite Applications or Petitions for Operations in 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*, Public Notice, DA 16-804 (July 15, 2016).

one set of applications rather than evaluating two different applications with substantially overlapping system descriptions.

In short, because O3b's request for V-band spectrum as part of the V-band processing round does not disadvantage other participants in the Ku/Ka-band processing round, waiving Section 25.116(c) is consistent with the purpose of the Commission's "cut-off" rules, and will also promote more efficient processing of the O3b applications. For these reasons, the Commission should grant any necessary waiver of Section 25.116(c) and not consider the November Amendment to be a newly filed application as a result of the instant amendment.

### **III. GRANT OF O3B'S MODIFICATION APPLICATION AS AMENDED WOULD SERVE THE PUBLIC INTEREST**

Adding V-band frequencies to O3b's NGSO system will further enhance O3b's capabilities to serve the public. The system expansion addressed in this March Amendment builds upon O3b's proven success in providing high-throughput and low-latency NGSO satellite services in Ka-band and will allow O3b to offer an even more innovative and affordable service to its customers in the future. Grant of this March Amendment, therefore, would be in the public interest.

### **IV. CONCLUSION**

For the reasons stated herein, the Commission should modify the Market Access Grant to permit O3b to use V-band frequencies for service to U.S. customers.

Respectfully submitted,  
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March 1, 2017

# O3b Amendment

## Attachment A

### Technical Annex

#### **A.1 Scope**

This attachment contains the information required by §25.114(d) and other sections of the Commission's Part 25 rules that cannot be captured by the Schedule S software.

This amendment seeks to change the terms of U.S. market access<sup>1</sup> for the O3b non-geostationary (NGSO) satellite system by using additional frequencies to serve the U.S., 37.5-42.5 GHz, 47.2-50.2 GHz, and 50.4-51.4 GHz (collectively, the “V-Band Frequencies”), on up to twenty-four (24) satellites in an equatorial orbit (hereafter referred to as O3bN) that were requested in a November 2016 amendment<sup>2</sup> to the modification application O3b filed last June.<sup>3</sup>

#### **A.2 General Description of Overall System Facilities, Operations and Services (§25.114(d)(1))**

##### **A.2.1 Revised Frequency Plan for 24 O3bN Satellites Proposed in the November Amendment to Include the V-Band Frequencies**

In the November Amendment, O3b sought U.S. market access for additional frequencies to be deployed on eight satellites that will be part of the current O3b constellation expected to launch in late 2017 and early 2018. The November Amendment also requested U.S. market access for O3bN, consisting of up to 24 new satellites in equatorial orbit. In this amendment, O3b revises

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<sup>1</sup> O3b Limited, Call Sign S2935, IBFS File Nos. SAT-LOI-20141029-00118 and SAT-AMD-20150115-00004 (“Market Access Request”), granted Jan. 22, 2015 (“Market Access Grant”).

<sup>2</sup> See Amendment of O3b Limited, Call Sign S2935, IBFS File No. SAT-AMD-20161115-00116 (Nov. 15, 2016) (“November Amendment”).

<sup>3</sup> See Modification Application of O3b Limited, Call Sign S2935, IBFS File No. SAT-MOD-20160624-00060 (June 24, 2016) (“Modification Application”).

the frequency plan associated with O3bN to include the 37.5-42.5, 47.2-50.2 and 50.4-51.4 GHz frequencies, in addition to the 17.8-18.6, 18.8-19.3 and 19.7-20.2 GHz (space-to-Earth) and 27.6-28.4, 28.6-29.1 and 29.5-30.0 GHz (Earth-to-space) frequencies that will be used on the O3bN satellites described in the November Amendment.

Section 25.202(a)(1) of the Commission's rules designates the 37.5-40, 40-42 and 47.2-50.2 GHz frequency bands as available for use by fixed satellite systems. In Section 2.106, the 50.4-51.4 GHz band is allocated for FSS use, but the band is not included in 25.202(a)(1) as available for FSS use. The 42.0-42.5 band is not allocated for FSS in the U.S. In the legal narrative associated with the amendment, O3b requests a waiver of the applicable allocation and operational restrictions to permit its use of these bands.

Apart from the additional frequencies for O3bN satellites, the general description of the overall system facilities, operations and services set forth in the November Amendment remains unchanged.

For the Commission's convenience, O3b has included in the accompanying Schedule S the original information filed as part of the November Amendment with revisions associated with adding the 37.5-42.5, 47.2-50.2 and 50.4-51.4 GHz frequencies to O3bN. The accompanying Schedule S therefore supersedes the Schedule S submitted with the November Amendment. However, unless otherwise specified, the material contained below in this technical narrative is applicable only to the V-band portion of the O3bN satellites. The Ka-band portion remains unchanged from the November Amendment.

## **A.2.2 U.S. Market Access Request for up to 24 O3bN and 16 O3bI Satellites**

As noted above, O3b is seeking U.S. market access for additional frequency bands for its O3bN constellation. O3b intends to use the 37.5-42.5, 47.2-50.2 and 50.4-51.4 GHz frequencies for gateway operations to add capacity to the O3bN constellation.



### A.3 Frequency Plan, Channels and TT&C Characteristics (§25.114(c)(4)(i) and §25.202(g))

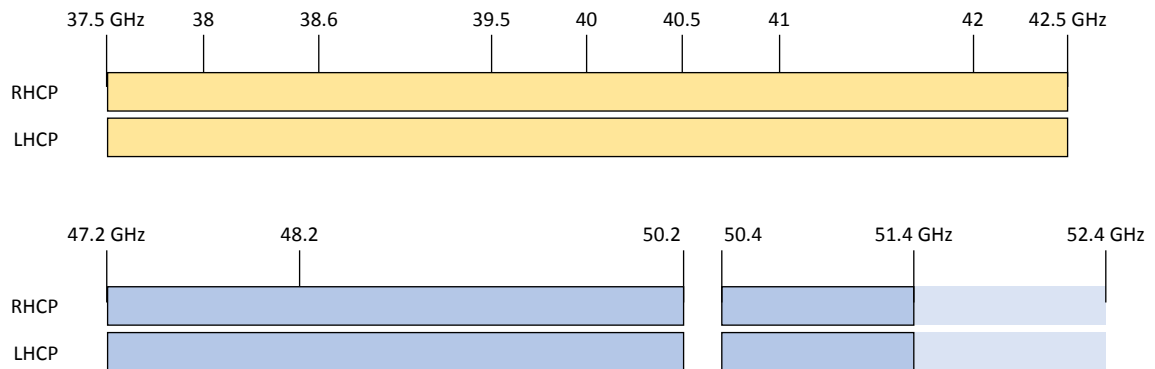
#### A.3.1 TT&C

O3b is not proposing any changes to the TT&C operations for O3bN described in the November Amendment.<sup>4</sup>

#### A.3.2 Channels and Frequency Plan

The only change proposed herein to the channel and frequency plan for the O3bN satellites set forth in the November Amendment<sup>5</sup> is the addition of the 47.2-50.2 GHz and 50.4-51.4 GHz uplink bands and the 37.5-42.5 GHz downlink bands. As noted above, TT&C operations will be performed at all phases of the mission in the Ka-band frequencies identified in O3b's previous filing.<sup>6</sup> Frequency re-use (per satellite) is achieved by a combination of dual-polarization (RHCP and LHCP), beam forming, and spatial isolation between co-frequency, co-polarized antennas. A schematic of the use of the additional V-band spectrum is given in Figure A.2-1 below.

**Figure A.3-1: O3bN V-band frequency plan**



<sup>4</sup> November Amendment, Technical Annex, Section A.3.1.

<sup>5</sup> *Id.*, Section A.3.2.

<sup>6</sup> *See id.*

As the O3bN satellites will employ a digital channelizer, there will be varying channel bandwidths over the range 37.5-42.5 GHz in the space-to-Earth direction and 47.2-50.2 GHz and 50.4-51.4 GHz in the Earth-to-space direction in both RHCP and LHCP. The channel center frequencies, bandwidths and polarization plan for the O3bN satellites using the 37.5-42.5 GHz, 47.2-50.2 GHz and 50.4-51.4 GHz bands are specified in the accompanying Schedule S.

While O3b is not seeking market access for the 51.4-52.4 GHz frequencies, the O3bN satellites are envisioned to operate in these frequencies. This band is the subject of WRC-15 Resolution 162, which addresses the possibility of creating a primary allocation for FSS in this frequency range.

#### **A.4 Maximum Satellite Transmissions (25.114(d)(4)(ii))**

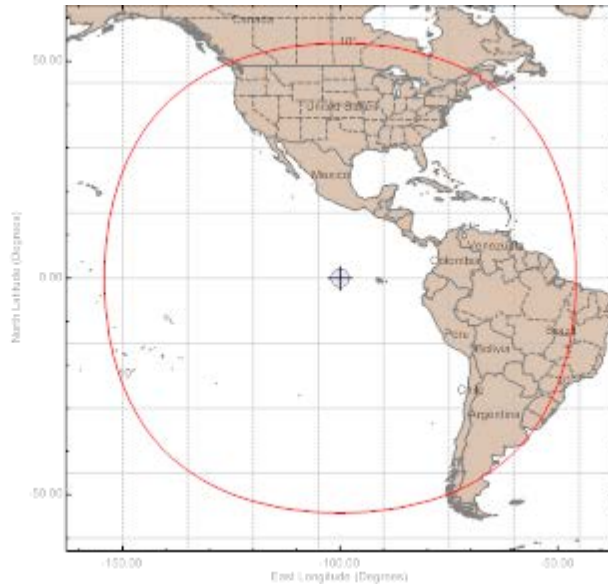
The maximum downlink EIRP per beam (stated in the accompanying Schedule S) for the O3bN satellites is 55.4 dBW. The maximum EIRP density over the United States could be as high as 44 dBW/MHz.

#### **A.5 Predicted Space Station Antenna Gain Contours (§25.114(c)(4)(vi)(B) & (D))**

The antenna gain contours for the O3bN satellite receive and transmit beams, as required by §25.114(c)(4)(vi)(B), are given in PDF format and attached to the Schedule S. For these contours, the position of the O3bN satellites is arbitrarily set at 100° W.L. and 0° N.L. These contours are representative of both a beam serving a customer earth station and a beam over an O3b gateway earth station.

As these antennas are steerable, §25.114(c)(4)(vi)(D) applies, and accordingly representative antenna gain contours for the transmit and receive antennas are provided for both a beam pointed over the United States and nadir. The 0 dB relative gain isoline for an O3bN satellite is shown in Figure A.5-1 by the 10° elevation angle. This is a representative isoline for an O3bN satellite at a longitude of 100° W.L. and latitude of 0° N.L.

**Figure A.5-1: Maximum coverage area of the 0 dB relative antenna gain isoline**



**A.6 Geographic Coverage (§25.145(c))**

As discussed in the November Amendment, the O3b equatorial satellites cannot meet §25.145(c) of the Commission’s rules for geographic coverage by NGSO FSS systems in the Ka-band. The Commission’s default service rules impose the same coverage requirements on V-band operations that apply in the Ka-band spectrum. O3b respectfully requests a waiver of these geographic service requirements for the reasons set out in the legal narrative of this Application.

**A.7 Cessation of Emissions (§25.207)**

Each satellite transmission chain (channelizer connection and HPA) can be individually turned on and off by ground telecommand, thereby causing cessation of emissions from the satellite, as required by §25.207 of the Commission's rules.

**A.8 Compliance with PFD Limits (§25.208)**

The O3b satellites comply with all applicable Commission and ITU PFD limits.

Section 25.208(r) contains PFD limits that apply in the 37.5-40 GHz portion of the V-band that will be used by the O3bN satellites. The PFD limits of §25.208(r)(1) in this band segment are as follows:

- $-132 \text{ dB(W/m}^2\text{)}$  in any 1 MHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;
- $-132+0.75(\delta-5) \text{ dB(W/m}^2\text{)}$  in any 1 MHz band for angles of arrival  $\delta$  (in degrees) between 5 and 25 degrees above the horizontal plane;
- $-117 \text{ dB(W/m}^2\text{)}$  in any 1 MHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.

The PFD limits of §25.208(r)(2) in this band segment are as follows:

- $-120 \text{ dB(W/m}^2\text{)}$  in any 1 MHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;
- $-120+0.75(\delta-5) \text{ dB(W/m}^2\text{)}$  in any 1 MHz band for angles of arrival  $\delta$  (in degrees) between 5 and 25 degrees above the horizontal plane;
- $-105 \text{ dB(W/m}^2\text{)}$  in any 1 MHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.

Section 25.208(s) contains PFD limits that apply in the 40-40.5 GHz portion of the V-band that will be used by the O3bN satellites. The PFD limits of §25.208(s) in this band segment are as follows:

- $-115 \text{ dB(W/m}^2\text{)}$  in any 1 MHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;
- $-115+0.5(\delta-5) \text{ dB(W/m}^2\text{)}$  in any 1 MHz band for angles of arrival  $\delta$  (in degrees) between 5 and 25 degrees above the horizontal plane;
- $-105 \text{ dB(W/m}^2\text{)}$  in any 1 MHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.

Section 25.208(t) contains PFD limits that apply in the 40.5-42 GHz portion of the V-band that will be used by the O3bN satellites. The PFD limits of §25.208(t) in this band segment are as follows:

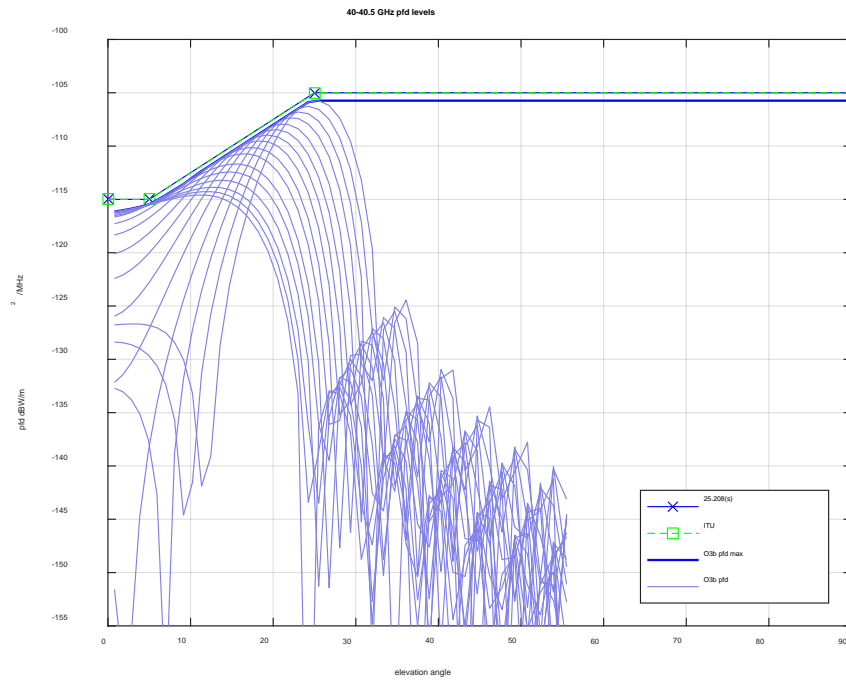
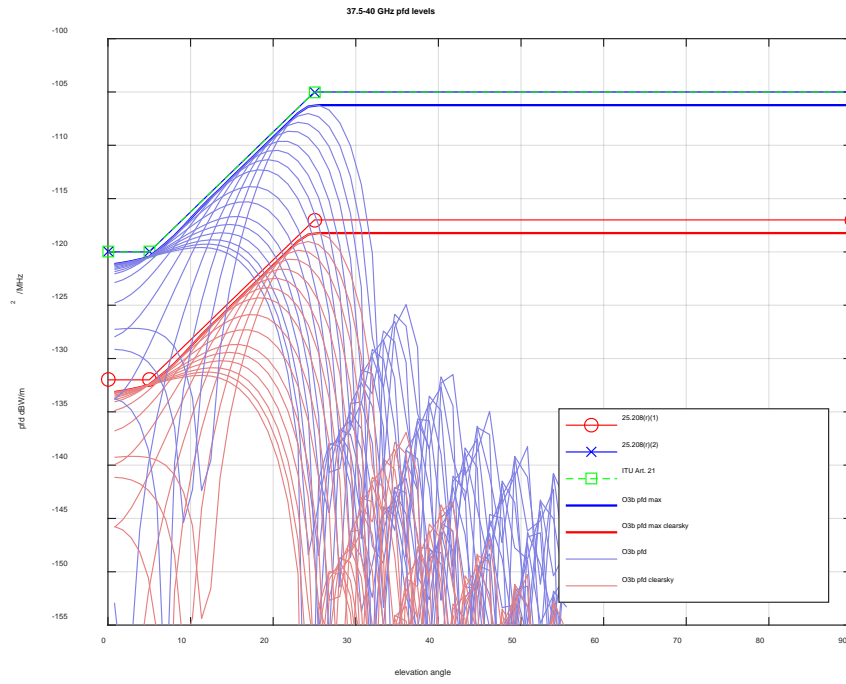
- $-115 \text{ dB(W/m}^2\text{)}$  in any 1 MHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;
- $-115+0.5(\delta-5) \text{ dB(W/m}^2\text{)}$  in any 1 MHz band for angles of arrival  $\delta$  (in degrees) between 5 and 25 degrees above the horizontal plane;
- $-105 \text{ dB(W/m}^2\text{)}$  in any 1 MHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.

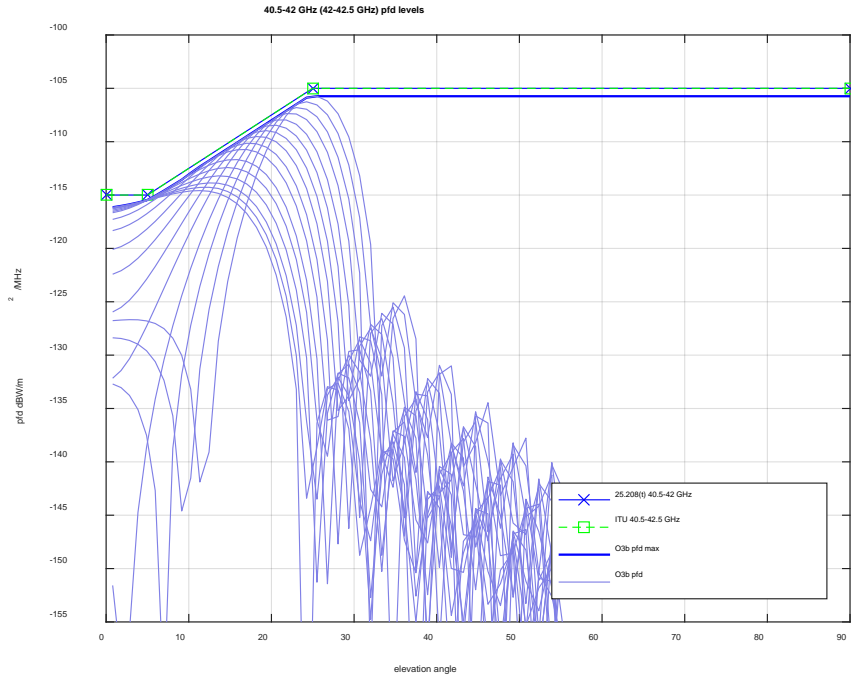
Section 25.208 does not specify PFD limits applicable to the remaining downlink frequencies used by the O3bN constellation (42-42.5 GHz). Article 21 of the ITU Radio Regulations does

provide PFD limits for this band which are the same as those in Section 25.208(t) of the Commission's rules. As the O3b satellites will operate consistently across all downlink bands, conforming to the ITU Radio Regulations and §25.208 PFD limits ensures that terrestrial operations will be protected.

Compliance with the PFD limits referenced above is demonstrated below. The maximum downlink EIRP per channel is 55.4 dBW. The maximum EIRP density is 44 dBW/MHz. This assumes the minimum channel bandwidth of 15 MHz. Calculating the spreading loss at 5 degrees in elevation to be 152.9 dB/m<sup>2</sup>, the highest PFD at the Earth's surface at this elevation angle where the satellite antenna peak gain is pointed at a minimum elevation angle of 10° (see Figure A.5-1) results in a maximum PFD of -120.5 dBW/m<sup>2</sup>/MHz for the 37.5-40 GHz band segment and -115.5 dBW/m<sup>2</sup>/MHz in the 40-42.5 GHz band segment. O3b will use satellite antenna pointing strategies and adaptive power control to adhere to the PFD limits set forth in §25.208(r)-(t) both under clear-sky and faded conditions. In the examples shown below, the satellite antenna pointing is varied assuming the target earth station elevation angle is between 10° and 25°. The resulting antenna pattern is plotted for each pointing. The resulting maximum PFD mask from the satellite is determined for each elevation angle. For satellite antenna pointings between 25° and 90° in elevation angle, the PFD from the O3bN satellites is constant assuming the beam peak could be anywhere between these elevation angles. Figure A.8-1 illustrates the O3b PFD and the applicable PFD limits from the Commission's rules along with the relevant PFD limits from Article 21 of the ITU Radio Regulations.

**Figure A.8-1: O3b PFD vs. RR Art. 21 and §25.208(r), §25.208(s) and §25.208(t) limits**





O3b notes that while the Commission does not have PFD limits for the 42-42.5 GHz frequencies, Article 21 of the ITU Radio Regulations specifies that the limits applicable to 40.5-42 GHz frequencies are also applicable to the 42-42.5 GHz frequencies.

### A.9 50.2-50.4 GHz Out-of-Band Emission Limits

As noted above, O3b is proposing to operate its O3bN satellites in the U.S. using the 47.2-50.2 GHz and 50.4-51.4 GHz bands (Earth-to-space). The 50.2-50.4 GHz band, which is adjacent to both bands, is allocated for Earth exploration-satellite and space research services. The O3b earth stations operating in the adjacent frequencies are designed to provide low out-of-band emissions through RF filtering so as to meet the limit prescribed by footnote US156 on unwanted emissions as measured at the input of the antenna flange of  $-20$  dBW/200 MHz (or  $-10$  dBW/200 MHz for certain antenna sizes). The O3bN constellation and its earth stations will comply with these limits.

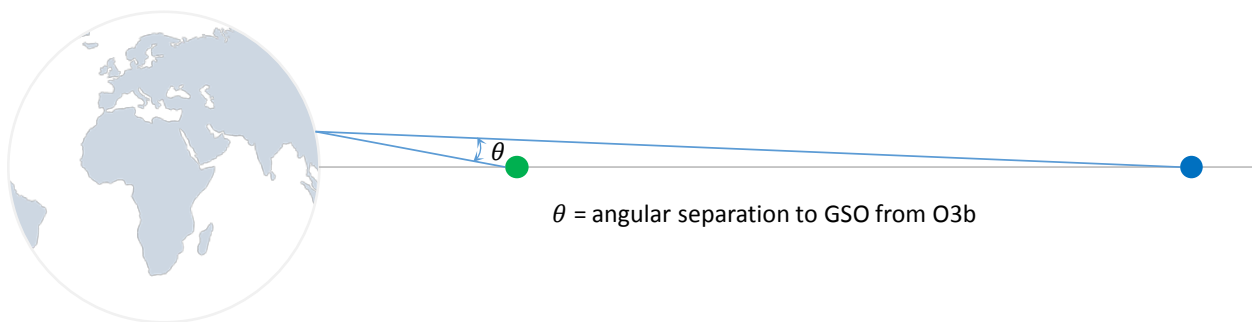
## A.10 Interference Analyses

### A.10.1 Interference with Respect to GSO Satellite Networks

While there are currently no EPFD rules in the V-band in the Commission's rules and no GSO satellite systems currently licensed by the Commission, the O3b system has been designed to provide interference protection to GSO satellite networks. O3b is also supporting the efforts pursuant to Resolution 159 (WRC-15) to develop sharing mechanisms between GSO and NGSO satellite systems in these frequencies.

O3b will facilitate sharing with GSO systems by constraining the uplink earth station EIRP density and the downlink PFD at the Earth's surface from the O3b system within these frequency ranges depending on the latitude at which the relevant beam is operating. This technique limits the interference to GSO satellite networks by exploiting the angular separation of the O3b and the GSO orbits when viewed from the surface of the Earth at latitudes away from the equator. This angular separation also protects the O3b system from interference from GSO satellite networks at latitudes away from the equator. The angular separation geometry is shown in Figure A.10-1 below, illustrating that the off-axis angle,  $\theta$ , becomes larger as the latitude of the Earth location increases (either North or South of the equator).

**Figure A.10-1: Example of angular separation angle of an equatorial O3b satellite relative to the GSO orbit for earth locations away from the equator**



#### A.10.1.1 EPFD evaluation

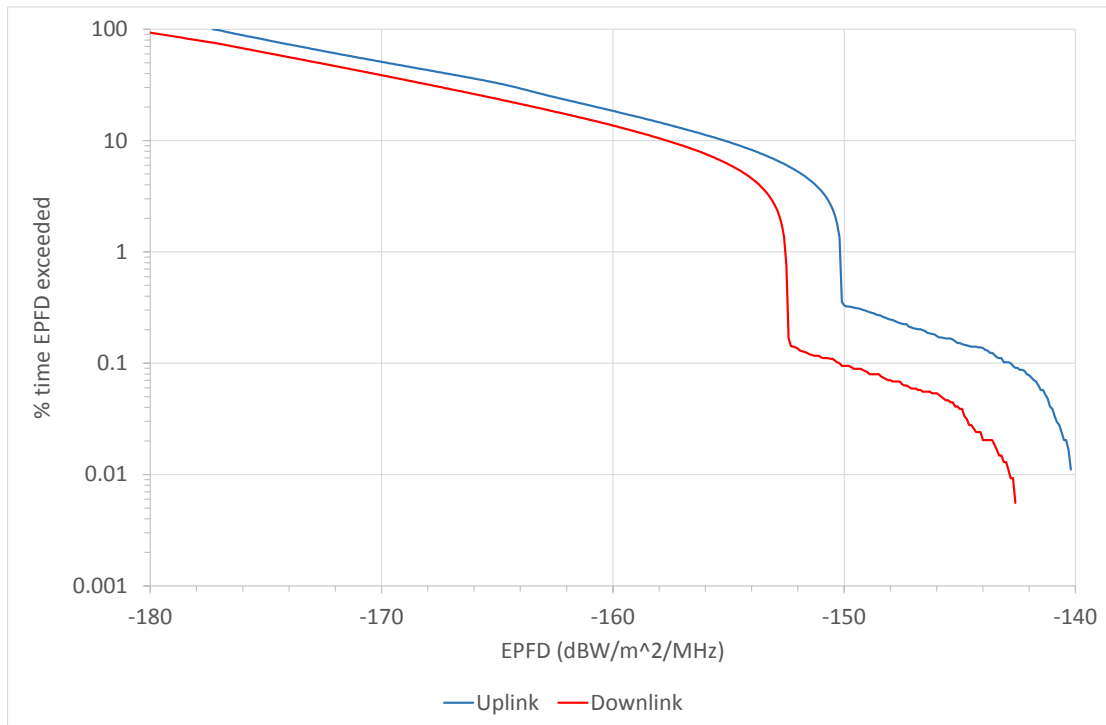
Figure A.9-3 below shows one example of the computed EPFD $\downarrow$  and EPFD $\uparrow$  levels for the O3bN satellites into a GSO system. For the downlink, a 2.4-meter reference GSO earth station antenna whose antenna pattern conforms to Recommendation ITU-R S.1428 was used. For the uplink, a



GSO satellite antenna receive gain of 52 dBi was assumed with a 0.445° beamwidth and antenna pattern that conforms to Recommendation ITU-R S.672-4,  $L_s = -25$ .

The results show that the maximum EPFD values are approximately  $-140 \text{ dBW/m}^2/\text{MHz}$ . This is similar to thresholds in Article 22 of the ITU Radio Regulations for Ka-band.

**Figure A.9-2: Demonstration of EPFD(↓) and EPFD(↑) results considering the O3bN satellites**



O3b is actively contributing to the ongoing studies at the ITU under Resolution 159 (WRC-15) where the above demonstration was also presented<sup>7</sup> and discussed. Should alternative EPFD↓ or EPFD↑ limits be determined either by the Commission or the ITU, O3b is confident that it will be able to operate the O3bN satellites in a manner that protects the GSO operations.

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<sup>7</sup> See document 4A/180 (<https://www.itu.int/md/R15-WP4A-C/en>).

### **A.10.2 Interference with Respect to Other NGSO Satellite Systems**

Currently, there are no Commission rules to protect V-band NGSO systems from one another and there are no NGSO satellite systems licensed by the Commission, or granted U.S. market access, that serve customers within the V-band frequency ranges. However, O3b is in the process of pursuing coordination arrangements with other V-band NGSO satellite applicants and their administrations. With respect to the pending Boeing V-band NGSO system application, O3b believes that a coordination arrangement can be reached between the two systems based on geographic diversity between earth stations, satellite handover during in-line events, and as a last resort, frequency segmentation.

### **A.10.3 Interference with Respect to Terrestrial Networks in the 37.5-40 GHz Bands**

The O3b system will also use the 37.5-40 GHz bands, which are allocated on a primary or co-primary basis, according to the U.S. table of frequency allocations, to terrestrial fixed service (“FS”) systems.<sup>8</sup> The Commission is also considering allocating the 42-42.5 GHz band for terrestrial services.<sup>9</sup> These systems are licensed by the Commission on a geographic basis under Parts 30 of the Commission’s rules. O3b is seeking authority to use these bands under the Commission’s rules for FSS siting in the 37.5-40 GHz band, as described in the legal narrative portion of the application. O3b’s proposed V-band operations will comply with the Commission’s PFD limitations on FSS operations in the band, which will enable O3b to protect existing and future terrestrial use of the band. As O3b will use this frequency band in the space-to-Earth direction, the only potential interference path is from the transmitting FS station into the sidelobes of the O3b receiving earth station. O3b is seeking a waiver of the current Commission rules for its use of the 42.42.5 GHz band while acknowledging that Commission may promulgate new rules for the band through the Spectrum Frontiers proceeding.

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<sup>8</sup> 47 C.F.R. §2.106.

<sup>9</sup> See *Use of Spectrum Bands Above 24 GHz For Mobile Radio Services*, Report and Order and Further Notice of Proposed Rulemaking, FCC 16-89, 31 FCC Rcd 8014 (2016) ¶¶ 400-407.

#### **A.10.4 Interference with Respect to Terrestrial Networks in the 47.2-50.2 GHz and 50.4-51.4 GHz Bands**

The O3b system also plans to use the 47.2-50.2 GHz and 50.4-51.4 GHz bands which may be allocated for terrestrial services by the Commission's Spectrum Frontiers proceeding.<sup>10</sup> O3b described in its original Market Access Request the mitigation techniques used to address any potential interference issues involving LMDS operations in the 27.5-28.35 GHz band segment.<sup>11</sup> O3b will continue to use those mitigation techniques for the additional satellites requested herein, and O3b will employ the same approach to protect terrestrial operations that may subsequently be allocated to V-band spectrum used for FSS uplink operations. Future O3b applications for earth stations will conform to any changes to the existing regulatory framework applicable to this band segment.

#### **A.10.5 Sharing with Radio Astronomy in the 42.5-43.5 GHz Band**

O3b seeks to operate in the 42-42.5 GHz band, adjacent to radio astronomy services operating in the 42.5-43.5 GHz band. O3b would comply with Footnote 5.551H and pursue the coordination process described in Resolution 743-2. O3b will complete coordination with existing radio astronomy sites that confirm observation band capabilities in the 37.5-42.5 GHz band in order to protect these observation capabilities at these sites. O3b will also manage out-of-band emissions above 42.5 GHz in compliance with the ITU Recommendation RA.769-2 protection criteria set out to protect radio astronomy observation in the 42.5-43.5 GHz band.

#### **A.11 ITU Filings for O3b (§25.111(b))**

The O3b system is registered with the ITU under the administration of the United Kingdom (O3B-D) on O3b's behalf. This satellite system has been submitted to the ITU and was published on 12 May 2015 and 13 October 2015.

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<sup>10</sup> *See id.*, ¶¶ 408-423.

<sup>11</sup> Market Access Request, Attachment A at 33-34.

## **A.12 Orbital Debris (§25.114(d)(14))**

This matter is addressed in the legal narrative.

## **A.13 Schedule S Notes**

The following notes are intended to clarify certain information contained in the Schedule S:

- a) While copying the Schedule S using the online FCC Schedule S System, the Orbital Plane information became reordered. The information remains correct, but Orbital Plane 1 from the November Amendment is now Orbital Plane 2; Orbital Plane 2 is now Orbital Plane 3; and Orbital Plane 3 is now Orbital Plane 1. The mean anomaly information has also been reordered for all Orbital Planes. The information is correct but does not appear in the correct order. For Orbital Planes 1 and 3, the mean anomalies should be ordered from low to high. In Orbital Plane 2, the mean anomalies should be ordered from low to high, noting that there are four spare satellites that are located at nominal mean anomalies of 1, 91, 181 and 271 degrees in longitude. These spares are associated with the existing twelve satellites and the pending eight satellites.
- b) The transmit beams VTR1 and VTL1 have the PFD max levels shown for faded conditions pursuant to §25.208(r)(2). The corresponding PFD max levels under clear-sky conditions would be 12 dB lower than the values shown in the Schedule S.
- c) Channels VR01, VT01 and VT02 are listed as “service links” but could also be used as “feeder links.”
- d) The VR01 channel has the ability to receive across the entire frequency range of 47.5-51.4 GHz as listed in the Schedule S. However, the associated transmitting earth stations will not transmit in the band 50.2-50.4 GHz in order to protect the passive systems operating in this band.
- e) The minimum G/T as requested by §25.114(c)(4)(v) for the VRR1 and VRL1 beams is 5.3 dB/K.

CERTIFICATION OF PERSON RESPONSIBLE FOR PREPARING  
ENGINEERING INFORMATION

I hereby certify that I am the technically qualified person responsible for preparation of the engineering information contained in this application, that I am familiar with Part 25 of the Commission's rules, that I have either prepared or reviewed the engineering information submitted in this application and that it is complete and accurate to the best of my knowledge and belief.

/s/ Zachary Rosenbaum  
Zachary Rosenbaum  
Director, Spectrum  
900 17th Street, NW  
Suite 300  
Washington, DC 20006  
(202) 813-4021

March 1, 2017

**ATTACHMENT 1:**  
**INFORMATION CONCERNING SHAREHOLDERS, OFFICERS, AND DIRECTORS**  
*Response to Form 312, Question 40*

**Ownership Information**

The applicant, O3b Limited, is a Jersey, Channel Islands company and an indirect, wholly-owned subsidiary of SES S.A. (“SES”). The intermediate companies in the ownership chain are O3b Networks Limited, also a Jersey, Channel Islands company, SES Finance Services AG (“SES Finance”), a Switzerland company, SES Asia S.A., a Luxembourg company, and SES Holdings (Netherlands) BV, a Netherlands company. See attached organizational chart.

SES is a Luxembourg company that in addition to O3b Limited, wholly owns SES ASTRA (formerly Société Européenne des Satellites S.A.), New Skies Satellites B.V., and SES Americom, Inc. Through its subsidiaries and affiliates, SES engages in the provision of satellite services in North and South America, Europe, Africa and Asia.

The registered office address for O3b Limited and O3b Networks Limited is:

3rd Floor Anley House,  
Anley Street  
St Helier, Jersey JE2 3QE  
Channel Islands

The registered office address for SES Finance is:

Acton Treuhand AG,  
Gotthardstrasse 28, CH-6304 Zug  
Switzerland

The registered office address for SES Holdings (Netherlands) BV is:

Rooseveltplantsoen 4  
2517 KR The Hague  
The Netherlands

The registered office address for SES and SES Asia S.A. is:

L-6815 Château de Betzdorf  
Luxembourg

The names, addresses, and citizenship of stockholders owning of record and/or voting 10 percent or more of SES voting stock are:

The Etat du Grand Duché de Luxembourg (the “State of Luxembourg”) – and Banque et Caisse d’Epargne de l’Etat (“BCEE”) and Société Nationale de Crédit et

d'Investissement (“SNCI”), each of which is an institution created by act of the Luxembourg Parliament and 100% owned by the State of Luxembourg – hold Class B shares of SES representing a combined effective economic interest of 16.67% and effective voting power of 33.33%. In addition, in 2007 and 2008 these entities received SES Fiduciary Deposit Receipts (“FDRs”), each of which represents one Class A share of SES. The FDRs distributed to these entities represented a combined 5.43% economic interest and effective voting power of 4.35%. SES does not know how many of these FDRs, if any, are still held by the Class B shareholders, as they are entitled to sell the FDRs without notice to SES. The principal business of both BCEE and SNCI is financial services. The addresses of BCEE and SNCI are as follows:

Banque et Caisse d’Epargne de l’Etat  
 1, place de Metz  
 L-2954 Luxembourg

Société Nationale de Crédit et d’Investissement  
 7, rue du Saint Esprit  
 BP 1207, L-1012 Luxembourg

The address for the State of Luxembourg is Ministry of State, 4 rue de la Congrégation, L-2910, Luxembourg.

**Officers and Directors**

The following individuals serve as officers and directors of O3b Limited and can be contacted at the O3b Limited address listed above:

<b>Name</b>	<b>Title</b>	<b>Nationality</b>
Steve Collar	Director, Chief Executive Officer	British
Andrew Browne	Chairman, Chief Financial Officer	Dual Irish/U.S.
Thai Rubin	Director, Executive Vice President and General Counsel	U.S.
Charles Hannaford	Chief Commercial Officer	British
Stewart Sanders	Chief Technology Officer	British
Dara McCann	Executive Vice President – Human Resources and Development	Irish
John Baughn	Chief Operations Officer	British
John Paul Hemingway	Chief Marketing Officer	British
Jonathan Leckie	Company Secretary	Australian

## ORGANIZATIONAL CHART

This is a simplified chart depicting the O3b Limited ownership structure. The percentages shown reflect equity interests on a fully diluted basis.

