Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
O3b Limited	)	File No. SAT-AMD-2016_______
	)	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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November 15, 2016

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AMENDMENT

O3b Limited ("O3b") 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").[1] O3b submits this amendment (the "Amendment") to the Modification Application pursuant to Section 25.116 of the Commission's rules[2] for consideration as part of the non-geostationary satellite orbit ("NGSO") processing round the International Bureau established on July 15, 2016.[3]

[1] *See* Modification Application of O3b Limited, Call Sign S2935, IBFS File No. SAT-MOD-20160624-00060 (June 24, 2016) ("Modification Application").

[2] 47 C.F.R. § 25.116(a) (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").

[3] *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).

This Amendment seeks three further changes to the Commission's grant of U.S. market access to O3b.[4]

- O3b is including additional frequencies, 19.7-20.2 GHz and 29.5-30.0 GHz, on four of the eight satellites proposed in the Modification Application and requests authority to serve the U.S. using those added bands.
- O3b requests U.S. market access for up to twenty-four new satellites (hereafter referred to as O3bN) that will operate in a circular equatorial orbit, using the frequencies covered by the Market Access Grant[5] as well as the 17.7-17.8 GHz, 19.3-19.7 GHz, and 29.1-29.5 GHz frequency bands.
- O3b requests U.S. market access for up to sixteen new satellites that will operate in an inclined orbit (hereafter referred to as O3bI) using the same frequencies as the O3bN system.

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.[6] 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. This architecture makes this a highly-scalable system, designed to be built incrementally as demand and our markets develop, and to expand capacity and coverage at the lowest possible cost.

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

[4] *See* 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").

[5] 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.

[6] O3b Networks 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.

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 those satellites.[7]

In its Modification Application, O3b noted that it plans to launch eight additional satellites in late 2017 and 2018, to be completed over two launch events. The Modification Application was placed on public notice, and no substantive objections or comments were filed.[8]

In order to respond to customer demand, O3b hereby amends its previous Modification Application to seek additional U.S. market access authority. As outlined above, this Amendment requests U.S. market access for additional frequencies on four of the eight satellites that were requested in the Modification Application and seeks market access for two sets of additional satellites: up to twenty-four new satellites that will operate in a circular equatorial orbit and up to sixteen new satellites that will operate in an inclined orbit.

Grant of the Modification Application as amended herein will serve the public interest by allowing O3b to use additional frequencies and satellites to respond to customer demand.[9]

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[7] *See* Public Notice, Report No. SES-01681 at 12 (Sept. 10, 2014); Public Notice, Report No. SAT-01065, DA 15-172 (Feb. 6, 2015).

[8] *See* Public Notice, Report No. SAT-01184 (Sept. 9, 2016) (accepting O3b's Modification Application for filing and placing the application on 30-day public notice). Only ViaSat, Inc. commented on the Modification Application, and it simply requested that the Commission consider the O3b submission concurrently with other applications that may be filed in the NGSO processing round. *See* Comments of ViaSat, Inc., IBFS File No. SAT-MOD-20160624-00060, Call Sign S2935 (Oct. 11, 2016).

[9] O3b anticipates that Space Activity Licenses covering launch and space operations of its next eight satellites will be issued pursuant to the UK's Outer Space Act prior to the time the Commission acts on O3b's Modification Application as amended. O3b will submit the Space Activity Licenses for these eight satellites to the Commission once they have been issued.

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,[10] 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 and satellites 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.

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.[11] 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.

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[10] 47 C.F.R. § 25.137.

[11] *See* 47 C.F.R. § 25.117(d).

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.[12] O3b demonstrated its compliance with the DISCO II criteria in the Modification Application, and the addition of spectrum and satellites proposed herein does not alter the DISCO II analysis.

Effect on competition in the United States. Adding spectrum and satellites 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.[13]

Eligibility and operational requirements. As shown in Section II.C below, O3b's request to add frequencies and satellites 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 and satellites 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[14] because it will not create the potential for harmful interference with U.S.-licensed satellite and terrestrial systems.

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[12] *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).

[13] *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).

[14] *See DISCO II Order* ¶¶ 149-50.

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 frequencies and satellites to its system. In particular, the Technical Annex demonstrates that:

- O3b's expanded system will continue to comply with applicable Commission and International Telecommunication Union ("ITU") Power Flux Density ("PFD") limits developed to ensure that satellite downlink transmissions do not adversely affect terrestrial services.
- O3b's expanded system will continue to comply with Equivalent Power Flux Density ("EPFD") limits for uplink and downlink transmissions from NGSO satellite systems that must be met in certain frequency ranges to avoid unacceptable interference to GSO satellite networks.
- 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 use the techniques described in the Market Access Request to protect terrestrial local multipoint distribution system ("LMDS") services in bands where LMDS has a primary allocation.
- O3b will comply with rules adopted in the Spectrum Frontiers proceeding[15] regarding sharing with future Upper Microwave Flexible Use Service ("UMFUS") operations as required.
- O3b will not interfere with Broadcasting-Satellite Service ("BSS") feeder links in the 17.7-17.8 GHz band.
- O3b's operations will not interfere with Iridium's Mobile-Satellite Service ("MSS") operations.
- Coordination with U.S. government satellite networks under footnote US334 of the Table of Frequency Allocations was previously completed in frequency bands used by the Twelve In-Orbit Satellites, and O3b will seek amendment of the agreement for the additional bands.

[15] *Use of Spectrum Bands Above 24 GHz For Mobile Radio Services*, GN Docket No. 14-177, *et al*., Report and Order and Further Notice of Proposed Rulemaking, FCC 16-89 (Jul. 14, 2016).

Accordingly, grant of O3b's Modification Application as amended herein 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 and satellites conforms to the Commission's legal and technical qualification requirements for holders of space station authorizations. In this regard, O3b reaffirms that it complies with the prohibition against exclusive arrangements in Section 25.145(e) of the Commission's rules[16] and 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."[17]

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

O3b seeks waivers of the Commission's rules in connection with this 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 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.[18]

O3b's proposal for additional frequencies and satellites substantially complies with the Commission's rules, but certain waivers are necessary in light of the spectrum

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[16] 47 C.F.R. § 25.145(e).

[17] Market Access Grant, ¶ 15. The United Kingdom has already approved the orbital debris mitigation plan for O3b's Twelve In-Orbit Satellites. 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.

[18] *PanAmSat Licensee Corp.*, 17 FCC Rcd 10483, 10492 (Sat. Div. 2002) (footnotes omitted).

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 Ka-band Frequency Plan

The Table of Allocations in Section 2.106 of the Commission's rules, the associated footnotes, and the designations in the Commission's Ka-band frequency plan[19] include limitations on the use of some of the frequency bands for which authority is sought in this 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."[20] The O3b waiver requests meet this test.

Authorized Ka-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.[21] This waiver should be extended to the use of these same frequencies by the new satellites proposed in this 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 new satellites.

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[19] The Ka-Band Plan is a combination of the 18 GHz band plan established in IB Docket No. 98-172 , including *In the Matter of Redesignation of the 17.7-19.7 GHz Frequency Band, Blanket Licensing of Satellite Earth Stations in the 17.7-20.2 GHz and 27.5-30.0 GHz Frequency Bands, and the Allocation of Additional Spectrum in the 17.3-17.8 GHz and 24.75-25.25 GHz Frequency Bands for Broadcast Satellite-Service Use*, 15 FCC Rcd 13430, ¶ 28 (2000) and related decisions, and the 28 GHz band plan established in CC Docket No. 92-297, including *In the Matter of Rulemaking to Amend Parts 1, 2, 21, and 25 of the Commission's Rules to Redesignate the 27.5-29.5 GHz Frequency Band, to Reallocate the 29.5-30.0 GHz Frequency Band, to Establish Rules and Policies for Local Multipoint Distribution Service and for Fixed Satellite Services*, 11 FCC Rcd 19005, ¶ 42 (1996) and related decisions. The 18 GHz band plan and the 28 GHz band plan are collectively referred to herein as the Ka-Band Plan.

[20] *See The Boeing Company*, 16 FCC Rcd 22645 (IB & OET 2001) at 22651 & n.48 (citing cases).

[21] 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).

17.7-17.8 GHz: O3b proposes to use the 17.7-17.8 GHz band for service and gateway downlinks. This band is allocated for FSS earth-to-space transmissions under the Table of Allocations, and pursuant to footnote US271, use by the FSS is limited to BSS feeder links. Under the Ka-Band Plan, terrestrial fixed services have a primary designation in this band segment. O3b demonstrates in the attached Technical Annex that its use of the spectrum will not cause interference to BSS feeder link operations or to terrestrial fixed networks. As a result, waiver of the Table of Allocations, footnote US271, and the Ka-Band Plan would serve the public interest.

19.3-19.7 GHz: O3b proposes to use the 19.3-19.7 GHz band for service and gateway downlinks. This band is allocated for FSS downlinks under the Table of Allocations, but pursuant to footnote NG166 and to the terms of the Ka-Band Plan, use by the FSS is limited to MSS feeder links. O3b demonstrates in the attached Technical Annex that its use of the spectrum will not cause interference to MSS feeder link operations. As a result, waiver of footnote NG166 to the Table of Allocations and the Ka-Band Plan would serve the public interest.

19.7-20.2 GHz: O3b proposes to use the 19.7-20.2 GHz band for service and gateway downlinks. This band is allocated for FSS downlinks, but pursuant to the terms of the Ka-Band Plan, use by the FSS is limited to GSO networks. O3b demonstrates in the attached Technical Annex that its use of the spectrum will not cause interference to GSO operations. As a result, waiver of the Ka-Band Plan would serve the public interest.

29.1-29.5 GHz: O3b proposes to use the 29.1-29.5 GHz band for service and gateway uplinks. This band is allocated for FSS uplinks. However, under the Ka-Band Plan, MSS feeder links and LMDS are designated as primary in the 29.1-29.25 GHz band segment, and MSS feeder links and GSO FSS are designated as primary in the 29.25-29.5 GHz band segment. O3b demonstrates in the attached Technical Annex that its use of the spectrum will not cause interference to MSS feeder link operations, to LMDS systems, or to GSO networks. As a result, waiver of the Ka-Band Plan would serve the public interest.

Section 25.145(c) - Geographic Coverage

Section 25.145(c) of the Commission's rules requires Ka-band NGSO systems to provide service coverage (i) to all locations as far north as 70 degrees latitude and as far south as 55 degrees 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.[22] The Commission previously waived this rule for O3b, recognizing that "there is a limit

[22] *See* 47 C.F.R. § 25.145(c).

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.[23]

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 and serve the same earth stations as its Twelve In-Orbit Satellites. The Commission, therefore, should grant a waiver of Section 25.145(c) for the O3bN satellites on the same terms and conditions as the waiver of Section 25.145(c) it already has granted O3b. No waiver is required for the new O3b satellites that will operate in an inclined orbit, as the planned configuration of that set of spacecraft will comply with the geographic coverage requirements in the rule.

III. GRANT OF O3B's MODIFICATION APPLICATION AS AMENDED WOULD SERVE THE PUBLIC INTEREST

Adding the new frequencies and satellites to O3b's NGSO system will further enhance O3b's capabilities to serve the public. The system expansion addressed in this 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 O3b's Amendment, therefore, would be in the public interest.

As noted in O3b's Modification Application, O3b has installed and operates essential components of its terrestrial infrastructure in the United States, representing several multi-million dollar investments. O3b provides large data capacity and enables real time applications, even where fiber access is limited or non-existent, driving demand from both the civilian and military arms of the U.S. government. O3b's ability to provide a connectivity comparable to fiber where there is no or limited terrestrial infrastructure has also made it an ideal solution for maritime and transportable applications, as well as for energy installations, as data and mobility demands grow. For the first time, it is possible to get fiber-equivalent performance in places only reachable by satellite.

For example, O3b's customer in American Samoa, the American Samoa Telecommunications Authority ("ASTCA"), is experiencing leaps in broadband availability and performance with the O3b service. O3b has been integral to ASTCA's delivery of affordable, state-of-the-art broadband capacity to all citizens, visitors, and businesses in American Samoa, as part of the Broadband Linking the American Samoa Territory (BLAST) Project funded in part by a U.S. Department of Agriculture grant.

[23] Market Access Grant, ¶ 14.

ASTCA has doubled the broadband capacity available to territory residents, which has significantly improved network speeds and reliability, and provided redundancy for the submarine fiber optic system. This is just one illustration of the ability of O3b's technology to extend affordable high-performance broadband connectivity to even the most remote U.S. locations. Worldwide, half of O3b's customers have contracted for additional capacity, many with substantial upgrades in throughput.

Adding frequencies and satellites, which O3b will utilize to provide an even more innovative and affordable service, will enable O3b to expand and improve upon the services described above and provide additional services to U.S. customers. Accordingly, grant of the Modification Application as amended herein is unquestionably in the public interest.

IV. CONCLUSION

For the reasons stated herein, the Commission should modify the Market Access Grant to permit O3b to use additional frequencies and satellites for service to U.S. customers.

Respectfully submitted,
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November 15, 2016

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 the following changes to the terms of U.S. market access for the O3b non-geostationary (NGSO) satellite system:

- Authorization to serve the U.S. using additional frequencies, 19.7-20.2 GHz and 29.5-30.0 GHz, that will be deployed on four (4) of the eight (8) satellites that were requested in the June 2016 O3b modification application;[1]
- Authorization to serve the U.S. using up to up to twenty-four (24) new satellites in an equatorial orbit (hereafter referred to as O3bN);
- Authorization to serve the U.S. using up to sixteen (16) new satellites in two inclined orbits (hereafter referred to as O3bI).

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[1] *See* Modification Application of O3b Limited, Call Sign S2935, IBFS File No. SAT-MOD-20160624-00060 (June 24, 2016) ("Modification Application").

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

A.2.1 Revised Frequency Plan for 4 Satellites Proposed in the Modification Application to Include the 19.7-20.2 GHz and 29.5-30 GHz Frequencies

In the Modification Application, O3b sought U.S. market access for eight satellites expected to launch in late 2017 and early 2018. The Modification Application described the eight additional satellites as technically identical to the twelve (12) satellites currently operated by O3b under its market access grant.[2] In this amendment, O3b revises the frequency plan associated with the second block of four satellites to include the 19.7-20.2 and 29.5-30 GHz frequencies, in addition to the 17.8-18.6 and 18.8-19.3 GHz (space-to-Earth) and 27.6-28.4 and 28.6-29.1 GHz (Earth-to-space) frequencies that will be used on all eight satellites described in the Modification Application.

The Commission's band plan for the Ka-band designates the 19.7-20.2 and 29.5-30 GHz frequency bands as available for use by NGSO satellite systems on a secondary basis to GSO networks, and as a result, NGSO systems may not create harmful interference into or claim protection from GSO satellite networks operating on a primary basis. As demonstrated below, O3b complies with the equivalent power flux density ("EPFD") limits defined in Article 22 of the ITU Radio Regulations, which were developed to ensure the protection of GSO networks from NGSO operations. This is addressed in greater detail in Section A.9 of this attachment.

Apart from the additional frequencies for four of the satellites, the Modification Application's general description of the overall system facilities, operations and services for the eight pending satellites remains unchanged.

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[2] O3b Limited, Call Sign S2935, IBFS File Nos. SAT-LOI-20141029-00118 and SAT-AMD-20150115-00004 (granted Jan. 22, 2015) ("Market Access Grant").

For the Commission's convenience, O3b has included in the accompanying Schedule S the original information filed with the Modification Application with revisions associated with adding the 19.7-20.2 GHz and 29.5-30.0 GHz frequency bands. The accompanying Schedule S therefore supersedes the Schedule S submitted in the Modification Application.

A.2.2 U.S. Market Access Request for up to 24 O3bN Satellites

O3b is seeking U.S. market access for up to twenty-four (24) O3bN satellites that will operate in an equatorial circular orbit at an altitude of 8,062 km. The same ground facilities and infrastructure used today with the in-flight O3b satellites will also be used to support the O3bN spacecraft. The request for U.S. market access for the O3bN satellites is separate from and in addition to the Modification Application's proposal to add eight satellites to O3b's current system in the 2017-2018 time frame, as discussed above. The combined number of satellites in the equatorial orbit requested by the Modification Application as amended herein is thirty-two (32).

The O3bN satellites are expected to be operated separately from the existing O3b satellites and the eight satellites described in the Modification Application, due to the additional technical capability to be incorporated on the O3bN satellites. This does not preclude the O3bN satellites from operating with the existing O3b satellites as there may be scenarios (for example, a satellite or launch anomaly) that require O3bN satellites to operate with the existing O3b satellites. In any event, in order to evaluate the interference environment of all O3b satellites proposed to operate in the equatorial orbit, both the existing satellites and O3bN satellites are assumed to be operating with a minimum angular separation between any two co-frequency, co-coverage satellites of ≥3.5 degrees. Note that O3b plans to have a certain number of spares placed throughout the orbit in order to provide back-up in the event of an on-orbit satellite failure. The interference analysis presented only considers the interference from active satellites. This analysis along with greater detail is provided in Section A.9.

The O3bN satellites will provide broadband communications supporting various applications including maritime, aeronautical, mobile backhaul, IP Trunk, and miscellaneous IP communications. Customer terminals will be located between latitudes of 63° North to 63° South and typically served by the active satellite having the best look angles (elevation angles) to the customer site. The O3b teleports are located at fiber connected nodes at key locations around the world to ensure full-time connectivity to the O3bN satellites. O3b currently operates gateways in Hawaii and in Texas for communications services and for command and control of the current satellites. The O3bN satellites will rely on these facilities but may also require a small number of additional ground station locations as the need for geographically diverse sites grows (*e.g.*, to enable increased capacity, redundancy, etc.).

The satellite control center for the O3bN satellites will be in Betzdorf, Luxembourg, with a back-up facility located in Manassas, Virginia. Network operations will be controlled from a facility in Manassas, VA, with a back-up facility located in Betzdorf, Luxembourg. Connectivity between these control centers and the TT&C earth stations will be implemented using terrestrial leased circuits or secure Internet virtual private networks.

A.2.3 U.S. Market Access Request for up to Sixteen O3bI Satellites

O3b is seeking U.S. market access for up to sixteen O3bI satellites that will operate in circular orbits at an altitude of 8,062 km in two planes having an inclination angle of 70 degrees and right ascension of the ascending nodes of 0 and 180 degrees. The two planes will each contain up to eight satellites. The orbital characteristics are provided in the Schedule S. The same ground facilities and infrastructure used today with the in-flight O3b satellites will also be used to support the O3bI spacecraft. In the future, it will be necessary to install additional gateway facilities at higher latitudes to support customers in areas farther north and south of the equator. These installations will be driven by business requirements. The satellite control center for the O3bI satellites will be in Betzdorf, Luxembourg, with a back-up facility located in Manassas, Virginia. Network operations will be controlled from a facility in Manassas, VA, with a back-up facility located in Betzdorf, Luxembourg. Connectivity between these control centers and the TT&C earth stations will be implemented using terrestrial leased circuits or secure Internet virtual private networks.

The request for U.S. market access for the O3bI satellites is in addition to the satellites mentioned above operating in the equatorial orbit. The O3bI satellites are planned to be operated independently from the equatorial plane satellites. However, the interference analysis presented later will consider the aggregate impact from both equatorial and inclined orbit satellites. The O3bI satellites are planned to augment the coverage and service provided by the equatorial orbit satellites by covering and serving the northern and southern areas of the Earth outside the footprints of the equatorial satellites.

Like the O3bN satellites, the O3bI satellites will provide broadband communications supporting various applications including maritime, aeronautical, mobile backhaul, IP Trunk, and miscellaneous IP communications.

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

A.3.1 TT&C

The O3b TT&C sub-system provides for communications during pre-launch, transfer orbit and on-station operations, as well as during spacecraft emergencies. The TT&C sub-system will operate at the edges of the uplink and downlink frequency ranges allocated to NGSO satellite systems during all phases of the mission. Because the O3bN and O3bI networks have additional frequencies, the TT&C channels for those satellites will not be on the edges of bands used by the system, as shown in Figure A.3-2 below. However, the TT&C transmissions cause no greater interference and require no greater protection from harmful interference than the communications traffic on the satellite network. As a result, the TT&C configuration complies with §25.202(g) of the Commission's rules.

During all phases of the mission, including transfer orbit, spacecraft emergencies and normal operations, the TT&C uplink signals will be received by the satellite using a combination of antennas on the satellite that create a near omni-directional gain pattern. The TT&C downlink signals will also be transmitted by the satellite using a combination of antennas on the satellite that create a near omni-directional gain pattern. However, for normal operations, when the spacecraft is directed towards the Earth, the minimum operational antenna gain of the TT&C downlink antenna will be higher than for safe-mode operations (i.e., during transfer orbit and spacecraft emergencies). A summary of the TT&C subsystem characteristics is given in Table A.3-1.

Table A.3-1 TT&C Performance Characteristics

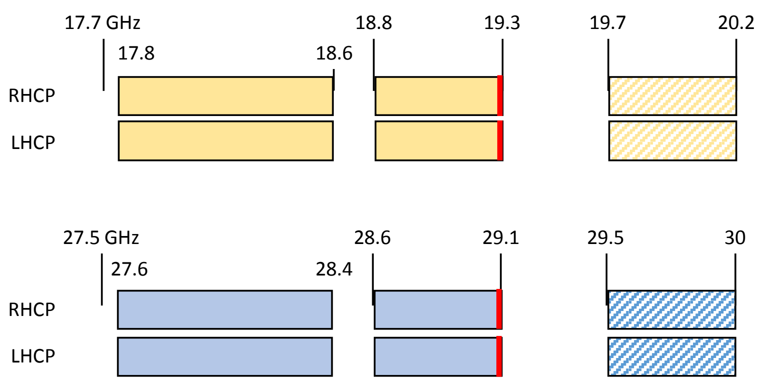
Command Modulation	PCM/PSK/APSK
Command Frequencies	29,088.5 MHz 29,097.5 MHz
Uplink Flux Density (Minimum)	−100 dBW/m^2 (Command)
Polarization of Satellite Rx/Tx Antennas	Rx: LHC or RHC Tx: LHC and RHC
Telemetry Frequencies Notes: 1. Each satellite is equipped with two of these frequencies. 2. Frequencies can be re-used between operating satellites.	19,296.6 MHz 19,296.8 MHz 19,297.0 MHz 19,297.2 MHz 19,297.4 MHz 19,297.5 MHz 19,297.6 MHz 19,297.8 MHz 19,298.0 MHz 19,298.2 MHz 19,298.4 MHz 19,298.6 MHz 19,298.8 MHz 19,299.0 MHz 19,299.2 MHz 19,299.4 MHz 19,299.6 MHz
Maximum Downlink EIRP	26.3 dBW

A.3.2 Channels and Frequency Plan

The O3bN and O3bI satellites will employ a digital channelizer that will be able to dynamically route the uplink to the downlink. The transmit and receive antennas are steerable and will have shapeable gain patterns. Each antenna beam will be pointed to a constant position on the Earth as the satellite traverses its active arc above these constant positions on the Earth. At the beginning and end of the active arc that serves each ground position, the satellite antennas will be repointed to provide the necessary connectivity for the next active arc. Handover of traffic between satellites will be handled seamlessly, as there will always be at least two satellites visible to each earth station at the times that satellite handover is required.

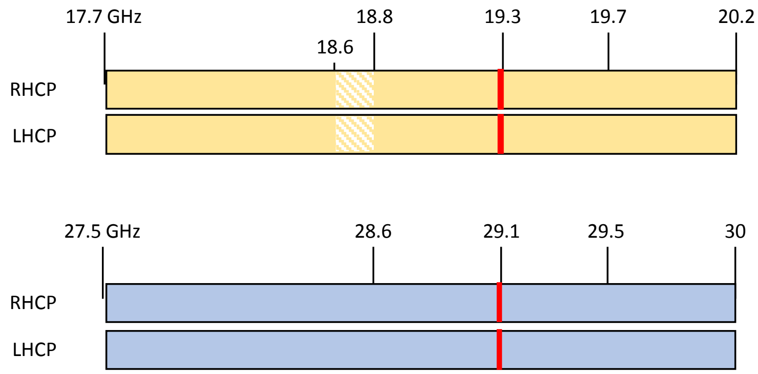
The O3bN and O3bI satellites will use the 27.5-30.0 GHz uplink bands and the 17.7-18.6 GHz and 18.8-20.2 GHz downlink bands. TT&C operations will be performed at all phases of the mission in the 5 MHz band edges just below 29.1 GHz (uplink) and 19.3 GHz (downlink). Frequency re-use (per satellite) is 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 spectrum is given in Figure A.2-1 below. The TT&C frequencies are shown by the red shaded area just below the 19.3 GHz and 29.1 GHz frequencies.

Figure A.3-1: Existing and pending eight[3] O3b satellites frequency plan with TT&C band shown in red



[3] The 19.7-20.2 GHz and 29.5-30.0 GHz band segments will only be included on the second four satellites of the pending eight.

Figure A.3-2: O3bN and O3bI frequency plan with TT&C band shown in red



The O3bN and O3bI satellites will be capable of operating across the entire 17.7-20.2 GHz spectrum range, but O3b is not seeking U.S. market access for the 18.6-18.8 GHz frequency band.

As the O3bN and O3bI satellites will employ a digital channelizer, there will be varying channel bandwidths over the range 17.7-20.2 GHz in the space-to-Earth direction and 27.5-30 GHz in the Earth-to-space direction in both RHCP and LHCP. The channel center frequencies, bandwidths and polarization plan for the second four satellites of the pending eight using the 19.7-20.2 GHz and 29.5-30 GHz are specified in the accompanying Schedule S.

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

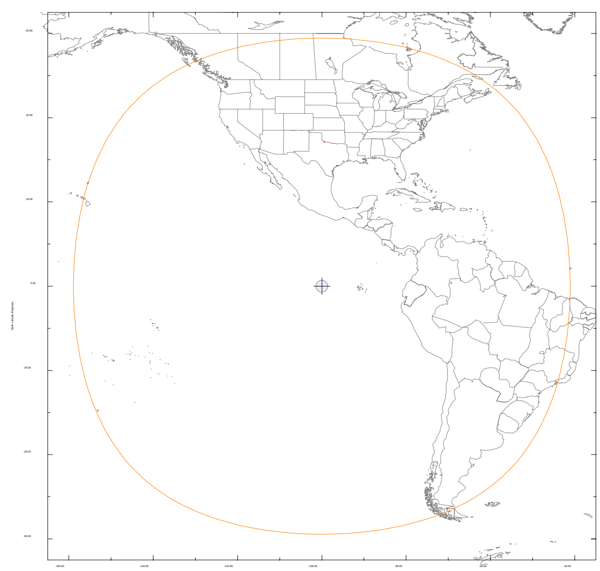
The maximum downlink EIRP per beam (stated in the accompanying Schedule S) for the O3bN and O3bI satellites is 55 dBW. The maximum EIRP density over the United States could be as high as 37.5 dBW/MHz, which corresponds to the maximum allowed power flux density ("PFD"). See Section A.8 for the demonstration of compliance with PFD limits. The maximum EIRP of the pending eight satellites remains unchanged at 49.7 dBW, as shown in the Schedule S.

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

The antenna gain contours for the O3bN and O3bI 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 and O3bI 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 and shapeable, provision 25.114(c)(4)(vi)(C) applies and so 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 or O3bI satellite is shown in Figure A.5-1 where the maximum coverage area is the 5° elevation angle. This is a representative isoline for an O3bN or O3bI 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

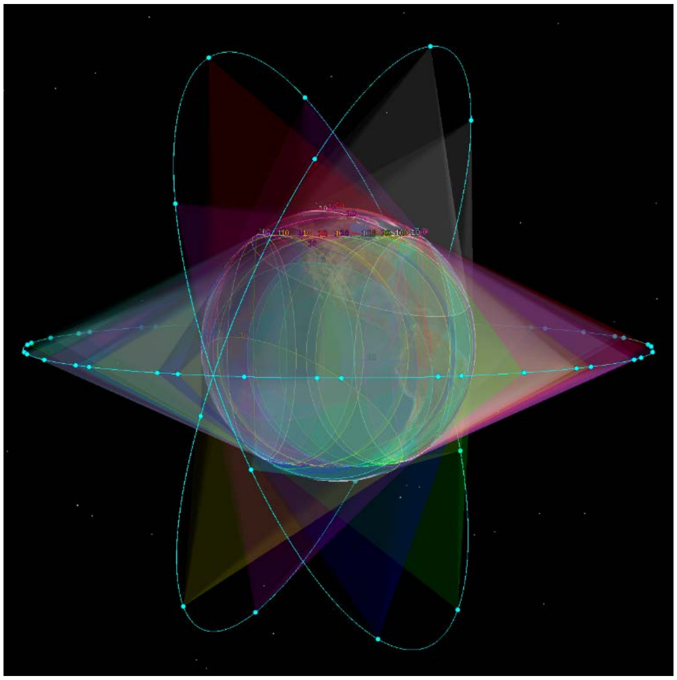


A.6 Geographic Coverage (§25.145(c))

The equatorial satellites in the O3b system have a visibility of 63° South to 63° North at all longitudes. The O3bI satellites will have coverage of the entire Earth with their inclined orbit of 70 degrees. However, it is important to note that the O3b system is designed to make efficient use of spectrum and satellite power by using bandwidth and power only where it is needed, *i.e.* where customers are located. That is to say, rather than covering the entire visible earth at all times, the steerable beams on the O3b satellites will be focused on customer locations and gateways, thus maximizing the throughput between those locations and ensuring a high-performance link into the global Internet or into the public switched telephone network while not interfering with services to other locations on the earth. As customers are added or changed, the O3b system capacity can adapt accordingly.

The graphic in Figure A.6-1 illustrates the envisioned O3b system of equatorial and inclined satellites.

Figure A.6-1. 3D visualization of O3b satellites



The O3bI satellites comply with §25.145(c)(1) of the Commission's rules for geographic coverage by NGSO FSS systems in the Ka-band, which requires coverage of latitudes between 70° North and 55° South for at least 75% of every 24-hour period. The O3bI satellites also comply with §25.145(c)(2), which requires coverage on a continuous basis throughout the fifty states, Puerto Rico and the U.S. Virgin Islands.

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(c))

The O3b satellites comply with all applicable Commission and ITU Power Flux Density ("PFD") limits. Section 25.208(c) contains PFD limits that apply in the various portions of the Ka-band used by the O3b satellites, specifically: 17.7-17.8 GHz, 18.3-18.8 GHz and 19.3-19.7 GHz. The PFD limits of §25.208(c) in this band are as follows:

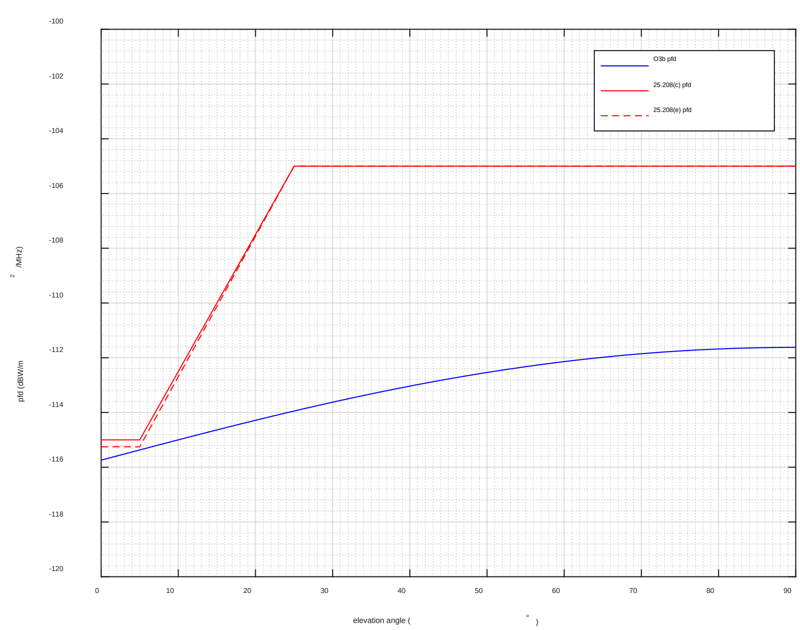
- -115 dB(W/m^2) in any 1 MHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;
- -115+(δ-5)/2 dB(W/m^2) in any 1 MHz band for angles of arrival δ (in degrees) between 5 and 25 degrees above the horizontal plane; and
- -105 dB(W/m^2) in any 1 MHz band for angles of arrival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

Section 25.208(e) contains PFD limits for the 18.8-19.3 GHz band also used by the O3b system. The PFD limits of §25.208(e) contain an additional term "X" that is a function of the number of satellites in the NGSO system, n. For $50 < n \leq 288$, X = (5/119)(n – 50) dB. In the case of O3b, n = 56 satellites (excluding spares) resulting in X = 0.25 dB. That is to say, the 0-5° and 5-25° portions of the limits should be reduced by roughly 0.25 dB.

Section 25.208 does not specify PFD limits applicable to the remaining downlink frequencies used by the O3b system (17.8-18.3 GHz), but Article 21 (Table 21-4) of the ITU Radio Regulations does include PFD limits for NGSO satellite systems in this spectrum. The limits are identical to those in §25.208(c) of the Commission rules listed above. 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 using a simple worst-case methodology. The maximum downlink EIRP per channel for the O3bN and O3bI satellites is 55 dBW. The maximum EIRP density is 37.5 dBW/MHz. Calculating the spreading loss at 5 degrees in elevation to be −152.9 dB/m^2, the highest PFD at the Earth's surface at this low elevation angle is −115.38 dBW/m^2/MHz, which is less than the −115.25 dBW/m^2/MHz PFD limit that applies at elevation angles of 5° and below. Figure A.8-1 illustrates the O3b PFD and the applicable PFD limits from the Commission's rules.

Figure A.8-1: O3b PFD vs. §25.208(c) and §25.208(e) limits



A.9 Interference Analyses

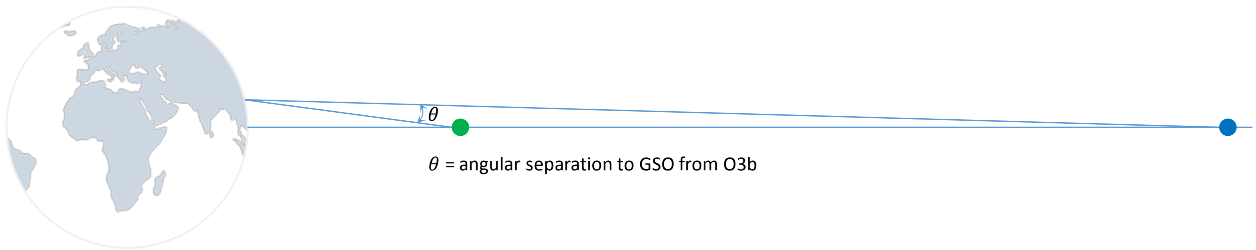
A.9.1 Interference with Respect to GSO Satellite Networks

While there are currently no EPFD rules in the Ka-band in the Commission's rules, the O3b system has been designed to provide the necessary interference protection to GSO satellite networks as required under Article 22 of the ITU Radio Regulations. Specifically, No. 22.5C defines EPFD limits for the downlink transmissions from an NGSO satellite system in certain frequency ranges that must be met in order to not cause unacceptable interference to GSO satellite networks. Similarly, No. 22.5D defines corresponding EPFD limits applicable to the uplinks from an NGSO satellite system. No. 22.5I defines operational EPFD limits also applicable to the downlinks from an NGSO satellite system. O3b will meet these EPFD limits and all other relevant obligations of the ITU Radio Regulations, including the operational limits applicable to the downlink EPFD, within the frequency ranges where such limits apply. The frequency ranges where EPFD limits apply are:

- Downlink: 17.8-18.6, 19.7-20.2 GHz
- Uplink: 27.5-28.6, 29.5-30 GHz
- Inter-satellite: 17.8-18.4 GHz

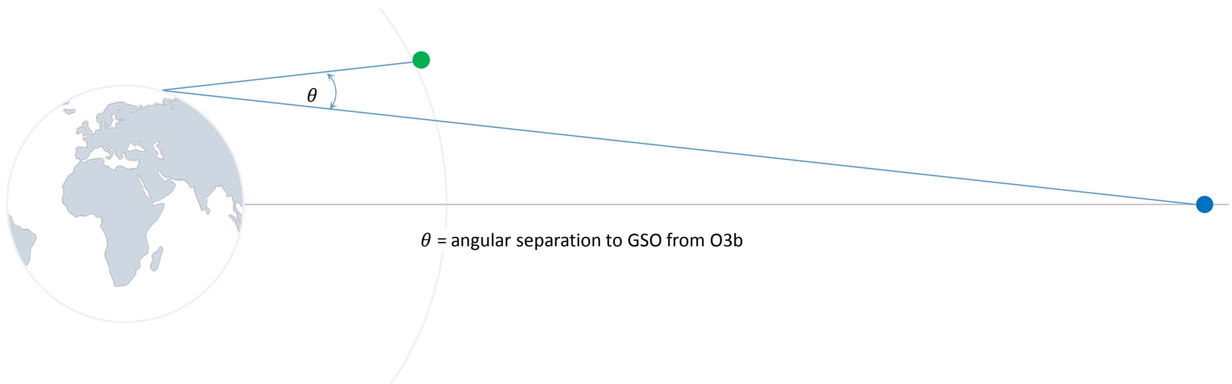
O3b will meet the EPFD limits by constraining the uplink earth station EIRP density and the downlink PFD at the Earth's surface from the O3b system within these frequency ranges depending on the Earth latitude at which the relevant beam is operating. This technique limits the interference to GSO satellite 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.9-1 below, illustrating that the off-axis angle, θ, becomes larger as the latitude of the Earth location increases (either North or South of the equator).

Figure A.9-1: Example of angular separation angle of an equatorial O3b satellite relative to the GSO orbit for earth locations away from the equator



The O3bI satellites will meet the EPFD limits by constraining the uplink earth station EIRP density and the downlink PFD at the Earth's surface from the O3bI satellites within these frequency ranges depending on the O3bI satellite latitude. This technique limits the interference to GSO satellite networks by exploiting angular separation of the O3bI inclined orbit and the GSO when viewed from the surface of the Earth at any earth station latitude. The angular separation geometry between O3bI and geosynchronous orbits is shown in Figure A.9-2.

Figure A.9-2: Example of angular separation angle of an O3bI satellite relative to the GSO orbit for earth locations away from the equator



As an example, for an earth station latitude of 20° (north or south) the minimum separation angle between the line of sight to the O3b equatorial orbit and the geosynchronous orbit, θ, varies from 7° to 11° depending on the difference in longitude between the Earth location and the equatorial

O3b satellite, with the lower value applying to the case where the O3b satellite is at a very low elevation angle (~5°) as viewed from the Earth. Thus, O3b is able to operate using higher uplink and downlink power density levels further away in latitude from the equator within these frequency ranges where EPFD limits apply. While there is no hard cut-off in terms of earth station latitude for O3b services within these frequency ranges in order to comply with the ITU EPFD limits, for latitudes greater than 20° there are no practical constraints on the equatorial O3b operations, and between latitudes of 10° and 20° the practical constraints are minimal. Between latitudes of 5° and 10° the constraints will limit the minimum earth station antenna size in order to close the link, and for latitudes less than 5° the constraints are significant and will limit certain services from the equatorial orbit in those bands where EPFD limits apply.

While not covered by the ITU rules, the 29.25-29.5 GHz band has a primary allocation to GSO FSS in the United States. The analysis provided below is applicable to the protection of GSO FSS satellites operating in this band.

A.9.1.1 EPFD Down

Figure A.9-3 and Figure A.9-4 below show one example of the computed EPFD↓ levels for the O3b system compared to the EPFD↓ mask from No. 22.5C of the ITU Radio Regulations for the 1-meter and 0.70-meter reference GSO earth station antennas, respectively. The 1-meter antenna case is for the 17.8-18.6 GHz band while the 0.70-meter antenna is for the 19.7-20.2 GHz band. As expected, these EPFD masks are found to be the most constraining on O3b operations, as they involve the smallest GSO receiving earth station antennas, which have the lowest off-axis discrimination.

As there are different numbers of O3b satellites using the frequency bands where different EPFD limits apply, the following cases are considered for evaluating the EPFD↓ compliance:

- Case 1: 17.8-18.6 GHz
    - sixteen active satellites from the existing twelve and pending eight satellites (assumes four spares)

    - twenty-four active O3bN satellites (assumes zero (0) spares)
    - sixteen active O3bI satellites (assumes zero spares)
- Case 2: 19.7-20.2 GHz
    - four active satellites from the pending eight satellites (assumes zero spares)
    - twenty-four active O3bN satellites (assumes zero spares)
    - sixteen active O3bI satellites (assumes zero spares)

It is likely that the O3bN and O3bI satellites will have spares to back up active satellites in the event of an on-orbit satellite failure. Considering all satellites as active in this analysis exaggerates the interference potential from the O3b system. As mentioned above, the existing 12 equatorial satellites and pending 8 are likely to be operated independently from the O3bN satellites. For the purposes of this analysis, the minimum angular separation between any two co-frequency, co-coverage satellites operating in the equatorial plane is assumed to be ≥ 1.5°. This assumes a nominal minimum spacing of 3.5 degrees with a ±1° longitude tolerance for each satellite.

The computed EPFD↓ in this example is for a GSO earth station operating at a latitude of 13° while the O3b beam peak of the equatorial satellites is pointed at the GSO earth station. For all cases considered, O3bI satellites increase their downlink EIRP to operational levels when: (1) their sub-satellite latitude is greater than or equal to ±20° from the equator and (2) the off-axis angle from the victim GSO earth station is greater than or equal to 5°. From Figure A.9-3 and Figure A.9-4 it can be seen that compliance is achieved for all the defined percentages of time.

Figure A.9-3: Comparison of EPFD↓ levels from O3b with ITU mask values (17.8-18.6 GHz)

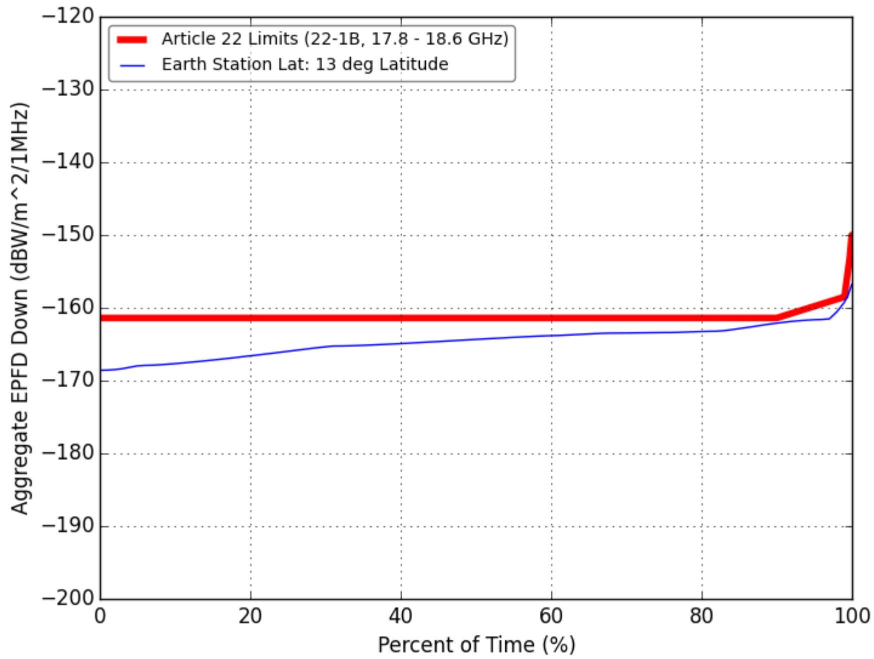
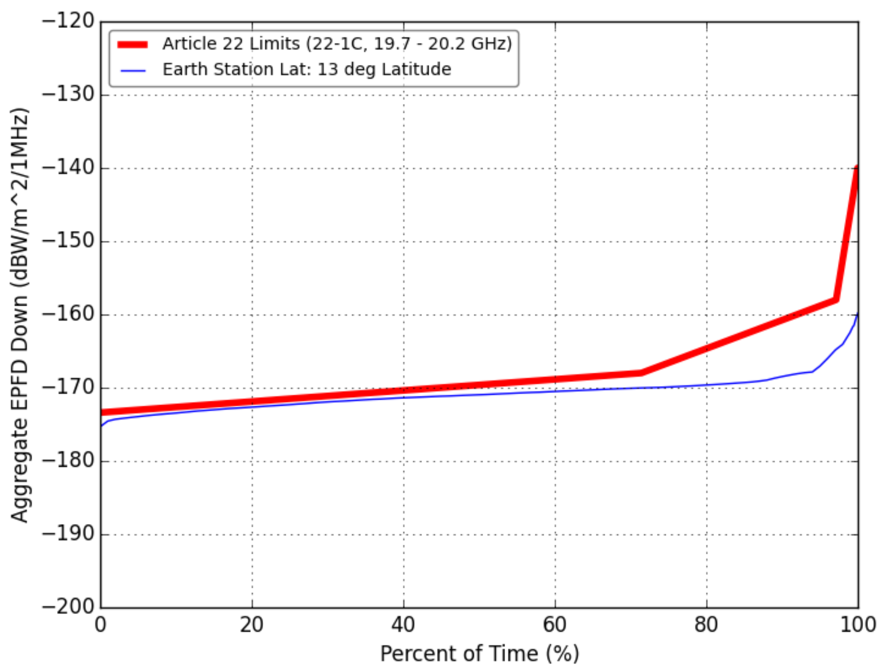


Figure A.9-4: Comparison of EPFD↓ levels from O3b with ITU mask values (19.7-20.2 GHz)



A.9.1.2 EPFD Up

The EPFD↑ limits in No. 22.5D of the Radio Regulations take the form of a single EPFD↑ value that must never be exceeded (−162 dBW/m^2/40 kHz in the 27.5-28.6 GHz and 29.5-30 GHz bands). O3b will comply with this limit in the frequency ranges where such EPFD limits apply by controlling the maximum power spectral density into transmitting earth stations as a function of their latitude and their antenna size and off-axis gain towards the GSO arc.

The following example demonstrates how the O3b equatorial satellite uplink transmissions comply with the EPFD↑ limits in the frequency ranges where such EPFD limits apply. Assume an O3b earth station is located in Hawaii and has an EIRP density of 40 dBW/4kHz, which is equivalent to 50.0 dBW/40kHz (*i.e.*, the reference bandwidth used for the EPFD↑ limit). The peak earth station antenna gain is 64.9 dBi, giving a maximum input power spectral density of −14.9 dBW/40kHz. The minimum separation angle between the O3b equatorial orbit and the GSO arc is roughly 7.4°. This results in an off-axis gain of 10.3 dBi assuming 32−25log(θ) for the transmitting earth station. The off-axis EIRP density towards the GSO is then −4.6 dBW/40kHz. Taking the range from Hawaii to the GSO orbit corresponding to the 10° elevation angle of the GSO satellite over Hawaii, the spreading loss to the GSO would be around 163.3 dB, resulting in a PFD at the GSO of −167.5 dBW/m^2/40kHz.

Assuming the next adjacent co-frequency, co-coverage O3b satellite is 3.5° away, the PFD from a second earth station will be −14.9 + 32 – 25log(11.1°) = −9.0 dBW/40kHz, yielding a PFD of −172.3 dBW/m^2/40 kHz.

The total EPFD↑ from the equatorial O3b satellites is therefore the power sum of these two individual PFDs which equals −166.3 dBW/m^2/40 kHz. This is 4.3 dB below the limit, so compliance exists with margin for this case involving low-elevation, closely spaced satellites. At higher elevation angles the increase in the separation angle between the GSO and the O3b equatorial orbit more than offsets the reduced path length to the GSO, resulting in even more margin relative to the EPFD↑ limit.

For the O3bI satellites, the same conditions apply as for the downlinks: sub-satellite latitude is greater than or equal to ±20° from the equator and the off-axis angle from a GSO earth station antenna is greater than or equal to 5°. Under these conditions, the following calculation demonstrates the EPFD↑ from earth stations operating with O3bI satellites.

Assuming an input power density of −14.9 dBW/40 kHz and off-axis antenna gain pattern of 32−25log(θ) where θ = 5°, the EIRP density towards the GSO satellite is −0.4 dBW/40 kHz. Assuming again a spreading loss of 163.3 dB to the GSO arc, the PFD at the GSO satellite resulting from an O3bI associated earth station is –163.7 dBW/m^2/40kHz. This demonstrates there is sufficient margin below the EPFD↑ limit.

A.9.1.3 EPFD(is)

In the case of the EPFD(is), the limit of −160 dBW/m^2/40 kHz applies in the band 17.8-18.4 GHz. The O3b satellites will comply with this limit by operationally steering the beams away from the limb of the Earth where the GSO satellite could be located. This is particularly the case for the equatorial satellites that are EPFD↓ limited close to the equator. This analysis is also applicable to protecting BSS feeder links in the 17.7-17.8 GHz band.

By way of an example, assume two O3b satellites in the equatorial orbit have their boresight and peak EIRP pointed to an earth station at their respective 5° elevation angle and that, in order to be compliant with the EPFD↓ limits, the off-axis gain of the O3b transmit beam in the direction of the GSO satellite along the equator is roughly 25 dB down from peak. Considering a peak EIRP density of 37.5 dBW/MHz and spreading loss of 165.7 dB/m^2, the resulting PFD at the GSO satellite is −167.2 dBW/m^2/40 kHz. If there are two O3b satellites in the field of view of the GSO satellite, the level would increase to −164.2 dBW/m^2/40 kHz which is still 4.2 dB below the EPFD(is) limit. This analysis excludes the GSO satellite receive antenna gain discrimination towards the second O3b satellite which will only improve the situation.

A.9.2 Interference with Respect to Other NGSO Satellite Systems

According to ITU procedures (No. 9.12), for all of the Ka-band frequency ranges to be used by O3b, coordination among NGSO systems is based on a first-come, first-served basis, depending on the ITU date priority of the relevant ITU filings. O3b is actively pursuing coordination arrangements with other NGSO satellite operators and their administrations.

Under Commission rules (§25.261), sharing among NGSO satellite systems in the 28.6-29.1 GHz uplink and 18.8-19.3 GHz downlink bands should be achievable, using whatever means can be coordinated between the operators to avoid in-line interference events, or by resorting to band segmentation in the absence of any such coordination agreement. The O3b equatorial orbit is inherently well isolated from in-line interference events with respect to other types of NGSO orbits, particularly those involving highly inclined orbit geometries. In the case of the O3bI satellites, there is a potential for more in-line interference events with other inclined NGSO systems. However, the O3bI satellites are relatively low in density with only sixteen satellites. This low satellite density will limit the likelihood of having in-line interference events. In the rare case of co-frequency, co-coverage in-line interference events with either the equatorial O3b satellites or O3bI satellites, O3b believes coordination can be achieved based on a time varying unavailability similar to a sun outage event or, if all else fails, a band segmentation scheme with respect to the other NGSO systems as contemplated by §25.261.

Currently there are no other NGSO satellite systems licensed by the Commission, or granted U.S. market access, that serve customers within the Ka-band frequency ranges.

With respect to the pending OneWeb Ku/Ka-band NGSO system application, O3b believes that a coordination arrangement can be reached between the two systems based on the above considerations. Furthermore, considering that the OneWeb system will use Ka-band only for gateway links, it is expected that these links will be relatively low in number, which should make it easier to determine and manage the in-line interference events between the two NGSO systems.

A.9.3 Interference with Respect to Terrestrial Networks in the 17.7-18.3 GHz and 19.3-19.7 GHz Bands

The O3b system will also use the 17.7-18.3 GHz and 19.3-19.7 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.[4] These systems are individually site licensed by the Commission under Parts 74, 78 and 101 of the Commission's rules. O3b is seeking authority to use these bands on a non-conforming basis, as described in the legal narrative portion of the application. Also, 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. Existing PFD limits in §25.208, which apply to the frequency range 18.3-18.8 GHz and to which the O3b satellites conform as demonstrated in Section A.8 of this document, are intended to adequately protect FS receivers in this band from harmful interference from satellite downlinks. As explained in Section A.8 above, the ITU PFD limits extend across the entire 17.7-18.8 GHz band with the objective of protecting terrestrial FS receivers, and therefore it can be assumed that O3b's compliance with these limits will protect FS systems across the entire 17.7-18.3 GHz band.

A.9.4 Interference with Respect to Terrestrial Networks in the 27.5-28.35 GHz and 29.1-29.25 GHz Bands

The O3b system also uses the 27.5-28.35 GHz and 29.1-29.25 GHz bands which are allocated by the Commission's 28 GHz First Report and Order to the terrestrial LMDS (Local Multipoint Distribution System) service on a primary basis and to the fixed-satellite service on a secondary basis in the U.S.[5] LMDS systems are licensed by the Commission on a geographic area basis.

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[4] Within the 18.3-18.58 GHz band, according to §101.85 of the Commission rules, terrestrial licensees are being transitioned out, but they are no longer co-primary in this band as of November 19, 2012.

[5] *See* Rulemaking to Amend Parts 1, 2, 21, and 25 of the Commission's Rules to Redesignate the 27.5-29.5 GHz Frequency Band, to Reallocate the 29.5-30.0 GHz Frequency Band, to Establish Rules and Policies for Local Multipoint Distribution Service and for Fixed Satellite Service, *First Report and Order and Fourth Notice of Proposed Rulemaking*, CC Docket No. 92-297, 11 FCC Rcd 19005 (1996) (*28 GHz First Report and Order*).

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. O3b will continue to use those mitigation techniques for the additional satellites requested herein, and O3b will employ the same approach to protect LMDS operations in the 29.1-29.25 GHz band segment.

The recent Report and Order in the Spectrum Frontiers proceeding[6] adopted new rules to permit introduction of Upper Microwave Flexible Use Service ("UMFUS") in the 27.5-28.35 GHz band segment subject to measures intended to preserve access to this spectrum for FSS operations. The O3b earth stations currently licensed in this band have been grandfathered, and future O3b applications for earth stations will conform to the new regulatory framework applicable to this band segment.

A.9.5 Interference Analysis with Respect to MSS feeder Links in the 19.3-19.7 GHz and 29.1-29.5 GHz Bands

There is a licensed NGSO satellite system (Iridium) that uses the 19.3-19.7 and 29.1-29.5 GHz bands for MSS feeder links. This is a global system of approximately seventy (70) low-earth orbit satellites operating user links in the L-band at a nominal circular altitude of 780 km. It uses 200 MHz of the Ka-band (19.4-19.6 and 29.1-29.3 GHz) for its feeder links, using RHCP for uplinks and LHCP for downlinks. The O3b system will rely on geographic separation of earth stations and angular separation between the O3b satellites and Iridium satellites to ensure protection of the Iridium system in the relevant frequencies.

By way of example, consider that the Iridium satellites have two Ka-band feeder link spot beam antennas per satellite: one is primary, while the other is on stand-by. In the uplink direction, the satellite receive antenna gain is 32.7 dBi. The protection of the Iridium satellite is ensured by the inherent off-axis gain of the Iridium satellite receive antenna in the direction of the transmitting

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6 *Use of Spectrum Bands Above 24 GHz For Mobile Radio Services,* GN Docket No. 14-177, *et al*., Report and Order and Further Notice of Proposed Rulemaking, FCC 16-89 (Jul. 14, 2016).

O3b earth station and limiting the transmit EIRP in the direction of the Iridium satellite. To ensure the first condition, O3b will not collocate any co-frequency earth stations with the Iridium gateways. With enough geographic separation, the Iridium satellite receive antenna beams will have significant roll-off towards a co-frequency transmitting earth station. If the satellite receive antenna discrimination is not enough to mitigate interference into the Iridium satellites, O3b will limit the transmit EIRP in the direction of the Iridium satellites.

For the Iridium downlinks, the two parameters that drive the potential for interference are the geographic proximity between the Iridium and O3b earth stations and the transmit EIRP of the O3b satellite transmit beams in the direction of the Iridium earth stations. Similar to the uplink case, O3b will not collocate any co-frequency earth stations with the Iridium gateways. With enough geographic separation, the O3b satellite transmit beams will be able to use beamforming to ensure that substantial roll-off towards the receiving Iridium earth station is achieved. If the O3b satellite antenna gain performance is not enough to mitigate interference into the Iridium earth stations, O3b will limit the transmit EIRP in the direction of the Iridium earth stations.

Lastly, special attention will be given to the TT&C carriers of the Iridium system at 29,102 MHz and 29,298 MHz as the Iridium satellite receive antennas have less discrimination to mitigate interference. O3b accordingly will limit the use of these frequencies in the vicinity of the Iridium TT&C earth stations.

O3b will initiate discussions with Iridium to ensure the O3b system protects the Iridium system.

A.10 ITU Filings for O3b (25.111(b))

The O3b system is registered with the ITU under the administrations of the United Kingdom (O3B-A, O3B-B and O3B-C) and France (MCSAT-2 HEO) on O3b's behalf. These satellite systems have been submitted for coordination at the ITU and were published on 19 August 2008 (modifications published on 11 November 2008 and 19 May 2009), 3 May 2011, 19 January 2016 and 7 July 2015 (modification published on 24 November 2015) respectively. There is a pending modification to O3b-C that has been submitted for coordination at the ITU but not yet published.

A.11 Coordination with U.S. Government Satellite Networks (Footnote US334 to U.S. Table of Frequency Allocations)

Footnote US334 requires coordination of the O3b system with U.S. government satellite networks, both GSO and NGSO. For the frequencies used on the in-orbit O3b satellites, coordination has been completed with U.S. government satellite networks (including both GSO and NGSO networks, as well as their associated specific earth stations filed under 9.7A and 9.7B of the ITU Radio Regulations through other administrations). In frequency bands not covered by the existing coordination, O3b will pursue a revision of the existing agreement but in the interim will conform operations in these bands to the terms of the existing agreement.

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 the information contained in the Schedule S:

a) In Orbital Plane 1, there are four spare satellites at nominal mean anomalies of 1, 91, 181 and 271 degrees in longitude. These spares are associated with the existing twelve and pending eight satellites.
b) The receive beams CMD1, CMD2, RR1 and RL1 apply to the O3bN and O3bI satellites; the remaining receive beams are associated with the pending eight satellites.
c) The transmit beams TLM1, TLM2, TR1 and TL1 apply to the O3bN and O3bI satellites; the remaining transmit beams are associated with the pending eight satellites.
d) The “UR10” and “UT10” beams are intended to read “UR10N” and “UT10N” as per the original mdb-format Schedule S. The online Schedule S form, however, does not allow for more than four characters for the beam ID.

e) The telemetry channels originally listed at “TMS1 – TMS16” in the Schedule S filed with the Modification Application are now designated as “TS1 – TS16” due to the 4-character limit for Channel ID’s in the online Schedule S form.

f) The receive beams UR11, UR12, GR3G and GR4G are for the 29.5-30 GHz band and only apply to the second four satellites of the pending eight satellites from the Modification Application.

g) The transmit beams UT11, UT12, GT3G and GT4G are for the 19.7-20.2 GHz band and only apply to the second four satellites of the pending eight satellites from the Modification Application.

h) The receive beams CMD, CMD1 and CMD2 (for command and control) do not have antenna gain contours attached to the Schedule S as they are near-omni directional, wide angle antennas whose relative gain contours do not intersect with the surface of the Earth below approximately −4 dB.

i) The transmit beams TLM1, TLM2, TLMS and TLMN (for telemetry and tracking) do not have antenna gain contours attached to the Schedule S as they are near-omni directional, wide angle antennas whose relative gain contours do not intersect with the surface of the Earth below approximately −4 dB.

j) For the transmit and receive channels, the mdb-format Schedule S had a column S9.f. for TT&C (“T”) or Comm (“C”) while the online Schedule S has three options: Feeder link, Service link or TT&C. To not replicate entries between Feeder links and Service links, only Service links were selected to replace “Comm” from the mdb-format Schedule S. However, these channels are also used by O3b gateway earth stations as what could be intended as Feeder links in the online-format Schedule S.

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

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.

<u>Officers and Directors</u>

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

Name	Title	Nationality
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.