LEGAL NARRATIVE AND RESPONSE TO QUESTIONS 35: WAIVER OF THE RULES

TABLE OF CONTENTS

LEGAL NARRATIVE AND RESPONSE TO QUESTIONS 35: WAIVER OF THE RULES

I. INTRODUCTION AND SUMMARY

O3b Limited ("O3b") will launch later this year a U.K.-authorized, non-geostationary orbit ("NGSO") Fixed-Satellite Service ("FSS") system operating in the Ka-band.[1] In this application, O3b seeks a blanket license permitting it to operate up to one hundred 2.2m and one hundred 1.2m earth stations on vessels ("ESVs") on U.S.-flagged ships[2] that will communicate with O3b's system. Up to three ESV antennas would be installed on each ship. The essential terms of O3b's application, which are discussed in additional detail further below and in the attached Technical Statement, are as follows:

Frequencies/Service. In this application, O3b seeks authority for its ESVs to transmit on frequencies in the 28.6-29.1 GHz band and to receive on frequencies in the 18.8-19.3 GHz band in order to provide fiber-quality satellite broadband service to maritime passengers and crew.

Allocation status. The Commission's Ka-band frequency plan provides that the 28.6-29.1 and 18.8-19.3 GHz bands may be used by NGSO fixed-satellite service ("FSS") systems on a primary basis.[3] Although O3b will operate an NGSO FSS system, the Ka-band frequency plan makes no provision for using

---

[1] In September 2012, the Commission granted O3b a license to operate one of the gateways for this system in Haleiwa, Hawaii. *See* FCC File No. SES-LIC-20100723-00952 (granted September 25, 2012) (the "Hawaii License"). On January 24, 2013, O3b requested authority to operate a second gateway in the United States, to be located in Vernon, Texas (the "Texas Gateway"). *See* FCC File No. SES-LIC-20130124-00089.

[2] As used in this application, the term "ships" includes all types of vessels that ESVs are permitted to serve.

[3] *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, ¶¶59-62 and 79 (1996)("*Ka-band Plan R&O*"). *See also 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)("*Redesignation of Ka-band R & O*").

such systems to communicate with mobile earth stations. O3b proposes, therefore, to operate its ESVs on a non-conforming use basis when the ships on which they are installed are in motion and on a primary basis when the ships are stationary.

Protection of other services. O3b will protect other services by employing off-axis discrimination from the GSO orbit, off-axis power spectral density limits, and PFD limits and by liaising with the regulatory authorities of other countries and complying with all applicable laws and regulations in those countries.

Operation in U.S. waters and non-U.S. waters. O3b proposes to operate its ESVs consistent with the Commission's C-band and Ku-band regulatory regime for when FCC-licensed ESVs operate in U.S. and foreign waters and when non-FCC licensed ESVs operate in U.S. waters.

Waiver requests. O3b seeks waivers of the U.S. table of frequency allocations; the Commission's Ka-band frequency plan; and the geographic coverage requirements for NGSO Ka-band systems. Out of an abundance of caution, O3b also is requesting, to the extent necessary, that the Commission extend to O3b's ESV operations certain waivers that it granted previously.

Timetable. The launch of O3b's first four satellites is scheduled for June 2013; testing of the ESV service with the satellites will be performed from August to October 2013; and commercial ESV service is scheduled to begin in November 2013. O3b respectfully requests processing of its application that is consistent with this timetable.

II. DISCUSSION

A. Description of Service

1. Overview

O3b's maritime service represents a major advance in the state of the art. O3b's Medium Earth Orbit ("MEO") satellites will provide fiber-quality maritime broadband service that will be 10-15 times faster than today's conventional C-band and Ku-band maritime service offerings and will be delivered at a fraction of the cost of these conventional services.

O3b's system is designed to enable broadband connectivity speeds of up to 500 Mbps for ships equipped with O3b's 2.2 meter ESV terminals and up to 150 Mbps for its 1.2 meter ESV terminals. In addition, because the O3b satellites will be at the MEO altitude of 8062 km, users on O3b's system will experience

round trip latency of less than 150 milliseconds, which is one quarter the latency of geostationary orbit satellites. These features will enable O3b to provide high quality, broadband Internet access to passengers and crew at sea that is comparable to the fiber-based broadband services available on land.

Sophisticated technology underlies these achievements. O3b's high speed, dedicated satellite beams can follow ships throughout their voyage. The steerable beams allow for real time tracking adjustments that will keep ships within the beam, even when their course changes.

O3b's 1.2m and 2.2m stabilized terminals can be used for providing ship-wide broadband coverage on cruise ships, naval and research vessels, ships used to provide humanitarian relief, and large yachts. The shipboard systems will have built-in redundancy. Depending on the customer's requirements, two or three O3b maritime terminals will be installed on each ship to transmit and receive the broadband communications traffic.

2. Service area

O3b's ESVs always will be located at latitudes above 7° N. Figure A.3-1 of the attached Technical Statement depicts the ESV service area for which O3b seeks authority in this application. As can be seen, the service area includes the Gulf of Mexico, the Caribbean, and the coastal regions of CONUS, southern Canada, Mexico, Central America and northern South America.[4] Anticipated ports of call initially may include Fort Lauderdale, Florida; New York City, New York; St. Thomas, U.S. Virgin Islands; San Juan, Puerto Rico; Nassau, Bahamas; Falmouth, Jamaica; and Philipsburg, St. Maarten.

3. Control of ESVs

O3b's Texas Gateway will serve as an ESV hub during normal operations. Another O3b gateway earth station, which will be located in Lurin, Peru, will serve as a back-up hub. O3b will use GPS or other location-based technology to determine the position of the ships and will be able to inhibit, through its network operations center, operations outside of its authorized service area. O3b's Network Operations Center located in Virginia (phone: 202-421-7122; e-mail: o3bnoc@o3bnetworks.com) will serve as a point of contact in the United States with the capability at all times to terminate transmissions of ESVs that cause interference or otherwise fail to comply with the FCC's requirements. This

[4] In the future O3b may provide service to ships at all latitudes, in which case it will file an application to modify its ESV authorization.

capability will be exercisable both for ESVs that are controlled by the Texas Gateway and ESVs that are controlled by the gateway in Peru.

B. Grant of O3b's Application is in the Public Interest

The Commission has recognized the many benefits associated with ESVs. Authorizing ESVs, it has found, "advances the Commission's goals and objectives for market-driven deployment of broadband technologies," which "are becoming a fundamental component of modern communications."[5] The Commission also determined that the "maritime market for broadband via satellite-based communications continues to expand," and that authorizing ESVs makes it possible to "deploy increasingly innovative broadband services … to businesses and consumers on the high seas, coastlines, and inland waterways."[6]

Grant of O3b's application will advance these important objectives by expanding the supply of maritime broadband services. Moreover, because O3b will offer faster connectivity at lower cost and with reduced latency, O3b's maritime services will also increase downward pressure on prices and foster innovation, all of which will redound to the benefit of maritime consumers and shipboard crew welfare. By any reasonable measure, grant of O3b's application is in the public interest.

C. O3b Already Has Been Granted U.S. Market Access

Under the Commission's "DISCO II" procedure, a company may obtain U.S. "landing rights" for a non-U.S. licensed space station by filing an initial earth station application that lists the space station as a "point of communication," and demonstrating that the space station meets applicable Commission requirements.[7] O3b provided such a showing, which it hereby incorporates by reference, as part of its application for a license to operate a gateway earth station in Haleiwa, Hawaii.[8] In September 2012, the Commission, by granting the Hawaii License and associated waivers, determined that O3b meets the criteria for U.S. market access.[9]

---

[5] *In the Matter of Procedures to Govern the Use of Satellite Earth Stations on Board Vessels in the 5925-6425 MHz/3700-4200 MHz Bands and 14.0-14.5 GHz/11.7-12.2 GHz Bands*, 20 FCC Rcd 674, ¶ 4 (2004) ("*ESV R&O*").

[6] *Id.*

[7] *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 ("DISCO II")*, 15 FCC Rcd 7207, ¶ 5 (1999).

[8] *See* O3b's application for a Hawaii gateway license ("O3b Hawaii Application"), FCC File No. SES-LIC-20100723-00952, narrative at Section V.

[9] *See* Hawaii License.

In its DISCO II decision, the Commission adopted requirements that apply once an initial application seeking U.S. market access for a non-U.S. satellite system has been granted. There is no need, the Commission found, for a new DISCO II showing to be made by future earth station applicants requesting authority to communicate with the non-U.S. satellite system.[10] Rather, it is sufficient that any such earth station applicant cite to the initial grant of market access; confirm that there has been no change in the services the satellite system will be used to provide; and represent that there has been no change to the satellite system's operating parameters.[11] Consistent with these requirements, O3b hereby cites to its O3b Hawaii License; confirms that there has been no change in the services its satellite system will be used to provide; and represents that there has been no change to its satellite system's operating parameters.

D. O3b's Application is Consistent with the Regulatory Regime the Commission Adopted for C-band and Ku-band ESVs on U.S.-flagged Ships

The Commission adopted rules in the ESV R&O for C-band and Ku-band ESVs that are located on U.S.-flagged ships. The requirements for these ESVs vary depending on the geographical location of the ships. O3b proposes to follow, for its Ka-band ESVs that are on U.S.-flagged ships, the regulatory regime that the Commission has adopted for C-band and Ku-band ESVs that are on U.S.-flagged ships.

Under this regulatory regime, ESVs on U.S.-registered ships must observe the Commission's technical requirements in both U.S. waters and international waters.[12] In addition, when the ESVs operate in the waters of another country, they have to operate in accordance with the FCC's requirements or those of the other country, whichever is more constraining.[13] If another country has identified geographic areas from which ESV operations would not affect the country's radio operations, then ESV operators are free to operate within those identified areas without further action.[14]

---

[10] *DISCO II,* 15 FCC Rcd 7207 at ¶ 192.

[11] *Id.*

[12] ESV R&O at ¶ 121.

[13] *Id.* ITU-R Resolution 902 (WRC-03) establishes minimum distances from the low-water mark as officially recognized by the coastal state beyond which ESVs may operate without the prior agreement of any administration: 300 km in the 5925-6425 MHz band and 125 km in the 14-14.5 GHz band. Although no minimum distance has yet been identified by the ITU for Ka-band, the distance derived by using Appendix 7 of the Radio Regulations and the ITU's software, which O3b proposes to observe, is approximately 100 km.

[14] *Id.*

E. O3b's Application is Consistent with the Regulatory Regime the Commission Adopted for C-band and Ku-band ESVs on Foreign-flagged Ships

The Commission does not license ESVs that operate on foreign-flagged ships, but it adopted policies in the ESV R&O permitting C-band and Ku-band ESVs to operate on foreign-flagged ships when they are located in U.S. waters.[15] The requirements for these ESVs vary depending on the foreign-flagged ships' countries of registry and the country in which the ESVs' hub is located. O3b proposes to follow, for its Ka-band ESVs that are on foreign-flagged ships, the regulatory regime that the Commission has adopted for C-band and Ku-band ESVs on foreign-flagged ships. O3b would follow the regime for communications with a U.S. hub when its Texas Gateway serves as O3b's ESV hub, and would follow the regime for communications with a non-U.S. hub when its back-up earth station in Lurin, Peru is called into service as O3b's ESV hub.

Foreign-flagged ships communicating with U.S.-licensed hubs. Under the rules and policies adopted in the ESV R&O, an ESV operator wishing to use a U.S.-licensed hub to communicate with ESVs on a foreign-registered ship located in U.S. waters has two options. If the United States has entered into a bilateral agreement with a foreign-flagged ship's licensing administration, then the U.S. hub may be used to communicate with the ESVs consistent with the terms of the agreement.[16] If there is no bilateral agreement, the U.S. hub nevertheless may be used to communicate with the ESVs if the ESV operator: (1) ensures that the operations of its ESVs comply with the FCC's rules; and (2) maintains a point of contact with the capability to terminate transmissions of ESVs that cause interference or otherwise fail to comply with the FCC's rules.[17]

Foreign-flagged ships communicating with non-U.S. licensed hubs. Under the rules and policies adopted in the ESV R&O, an ESV operator wishing to use a foreign-licensed hub to communicate with ESVs on a foreign-registered ship located in U.S. waters also has two options. If there is a bilateral agreement between the United States and the administration of country in which the hub is located, then the hub may be used to communicate with the ESVs consistent with

---

[15] By virtue of Section 306 of the Communications Act, the Commission lacks authority to license radio stations that are on foreign-registered ships. In the ESV R&O, however, the Commission determined that it may, consistent with Section 306, permit ESVs on foreign-flagged ships to provide service in U.S. waters. *See ESV R&O* at ¶¶ 123-26. The principles the Commission established in the ESV R&O for this purpose are not band-specific, and apply with equal force to Ka-band ESVs.

[16] *I ESV R&O* at ¶ 123.

[17] *Id.* at ¶¶ 124, 126.

the terms of the agreement.[18] If there is no bilateral agreement, the hub nevertheless may be used to communicate with the ESVs if the foreign-flagged ship's registering administration has authorized operations under ITU Radio Regulation 4.4 ("ITU RR 4.4"),[19] which "permits licensing of services that do not otherwise conform to the Radio Regulations so long as those services do not cause interference to, or claim protection from interference by, other services licensed in compliance with the Radio Regulations."[20]

F. O3b Will Protect Other Services

1. Avoidance of interference to GSO FSS systems. As discussed in the attached Technical Statement, O3b's ESVs will be located at latitudes above 7° N, so there always will be an off-axis discrimination of more than 2.6° between GSO orbits and O3b's NGSO orbit as viewed from O3b's ESV terminals.[21] As is also discussed in the Technical Statement, the uplink and downlink power density levels of O3b's ESVs will be within the limits specified in Section 25.138 of the rules for blanket licensing of GSO FSS earth stations.[22] These factors ensure that GSO FSS systems will be adequately protected.

2. Avoidance of interference to or from Fixed Service (*i.e.*, terrestrial) stations.

28 GHz band (ESV uplink frequencies). There is no allocation in the Commission's Ka-band Band Plan for Fixed Service stations operating in the 28.6-29.1 GHz band in the United States.[23] Outside the United States, O3b will protect Fixed Service stations operating in the 28.6-29.1 GHz band by liaising with the regulatory authorities of all countries whose territory is within 100 km of the ships on which O3b's ESVs are operating and by complying with all applicable laws and regulations in those countries.

18 GHz band (ESV downlink frequencies). Fixed Service stations in the United States operating in the 18.8-19.3 GHz band are no longer co-primary with FSS users in this band.[24] O3b agrees to accept any interference that its ESVs, when operating on a non-conforming use basis, may receive from these U.S.-based 18.8-19.3 GHz band Fixed Service stations. O3b will protect the 18.8-19.3

---

[18] *Id.* at ¶ 128.
[19] *Id.* at ¶ 128.
[20] *Id.* at ¶ 127.
[21] *See* attached Technical Statement, Section A.7.
[22] *See id.*, Section A.6, Annex 1, and Annex 2.
[23] *In the Matter of Verizon Washington D.C., Application for Renewal of License for Common Carrier Fixed Point to Point Microwave Station KGC79*, 26 FCC Rcd 13511, 13516 (WTB 2011).
[24] *See* 47 C.F.R. § 101.85(b)(2).

GHz band fixed service stations by complying with the space station PFD limits specified in Section 25.208 of the rules.

G. O3b's Application is Consistent with the Commission's Requirements for Use of the Ka-Band

In this application, O3b seeks a blanket license to operate earth stations on vessels on U.S.-flagged ships that will communicate with O3b's system in the 18.8-19.3 and 28.6-29.1 GHz bands.[25] Under the Commission's frequency plan for the Ka-band, NGSO FSS systems may operate on a primary basis in the 18.8-19.3 and 28.6-29.1 GHz bands.[26] The frequency plan also permits GSO FSS systems to operate on a secondary basis in the 28.6-29.1 GHz band,[27] and the Commission has authorized such systems to operate in the 18.8-19.3 GHz band on a non-conforming use basis upon a showing that harmful interference would not be caused and any harmful interference would be accepted.[28]

O3b's operations will be consistent with these precedents. Because neither the Ka-band frequency plan nor the Table of Frequency Allocations makes provision for NGSO FSS systems to have mobile earth stations as points of communication, O3b proposes to operate its ESVs on a non-conforming use basis when the ships on which they are installed are in motion. O3b demonstrates in this application that its ESVs will protect other services,[29] and O3b agrees to accept harmful interference from other services when operating on a non-conforming basis. O3b, therefore, satisfies the requirements for non-conforming operations. When the ships on which O3b's ESVs will operate are not in motion, the ESVs will have primary status consistent with the Ka-band frequency plan and the Table of Frequency Allocations.

---

[25] The Commission has stated on multiple occasions that it will accept applications for blanket licenses in these bands for earth stations that will communicate with NGSO systems. *See Redesignation of Ka-band R & O at* ¶6; *In the Matter of Northrop Grumman Space & Mission Systems Corporation; Applications 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,* 24 FCC Rcd 2330, ¶69 n.35 (Chief IB 2009) ("*Northrop Grumman*"); *In the Matter of contactMEO Communications, LLC, For Authority to Launch and Operate a Non-Geostationary Orbit Fixed-Satellite System in the Ka-band Frequencies*, 21 FCC Rcd 4035, ¶20 n.57 (Chief IB 2006)("*contactMEO*").

[26] *See* note 3, above.

[27] *See 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*, 12 FCC Rcd 22310, ¶ 42 (1997).

[28] *Northrop Grumman at* ¶90; *contactMEO at* ¶34.

[29] *See* Section II.F, above.

H. O3b Will Observe the Pointing Error and Automatic Shut-Off Requirements the Commission Adopted for C-band and Ku-band ESVs

The Commission's rules for C-band and Ku-band ESVs include a pointing accuracy requirement and a shut-off requirement. In these bands, there must be a pointing error of less than 0.2° between the orbital location of the target satellite and the axis of the main lobe of each ESV antenna.[30] In addition, emissions from each ESV must cease automatically within 100 milliseconds if the angle between the orbital location of the target satellite and the axis of the main lobe of the ESV antenna exceeds 0.5°, and transmissions must not resume until the angle is less than 0.2°.[31]

O3b will observe these requirements in its ESV operations, and the manufacturer of O3b's ESVs has certified that the terminals comply with these requirements[32]. O3b's commitment gives the Commission added assurance that O3b's ESV operations can co-exist with other services.

I. O3b Will Observe the Recordkeeping Requirements the Commission Adopted for C-band and Ku-band ESVs

The Commission's rules for C-band and Ku-band ESVs require that the following records be maintained:

(1) For each ESV transmitter a record of the ship location (*i.e.*, latitude/longitude), transmit frequency, channel bandwidth and satellite used shall be time annotated and maintained for a period of not less than 1 year. Records must be recorded at time intervals no greater than every 20 minutes while the ESV is transmitting. The ESV operator will make this data available upon request to a coordinator, fixed system operator, fixed-satellite system operator, NTIA (Ku-band only), or the Commission within 24 hours of the request.

(2) ESV operators communicating with vessels of foreign registry must maintain detailed information on each vessel's country of registry and a point of contact for the relevant administration responsible for licensing ESVs.[33]

O3b will maintain these records in connection with its ESV operations and will make the records available in accordance with the procedures the Commission previously established. O3b's commitments ensure that the records

---

[30] *See* 47 C.F.R. §§ 25.221(a)(6) and 25.222(a)(6).
[31] *See* 47 C.F.R. §§ 25.221(a)(7) and 25.222(a)(7).
[32] See attached Technical Statement, Section A.6 and Annex 2.
[33] *See* 47 C.F.R. §§ 25.221(c)(1)-(c)(2) and 25.222(c)(1)-(c)(2).

of its ESV operations will be at least as extensive as the records the Commission has determined are sufficient in the context of C-band and Ku-band ESVs.

J. Waivers Sought by O3b

Table of allocations and Ka-band frequency plan. O3b requests a waiver of the Table of Frequency Allocations[34] and the Commission's Ka-band frequency plan[35] to add ESVs in motion, on a non-conforming use basis, as authorized points of communication for its NGSO FSS system. In Section II.G above, O3b demonstrates that these non-conforming operations are consistent with FCC precedents.

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 24-hour period and (ii) on a continuous basis throughout the fifty states, Puerto Rico and the U.S. Virgin Islands.[36] The Commission has waived Section 25.145(c) for O3b's Hawaii gateway earth station but reserved judgment as to whether a waiver of Section 25.145(c) is appropriate with respect to O3b's service links.[37] The Commission based the waiver for the Hawaii earth station on the fact that the Hawaii authorization "is limited to a single earth station that is providing gateway and TT&C services only."[38] The waiver is "without prejudice to action on any waiver request filed in connection with an application to provide additional services to, from, or within the United States."[39]

O3b requests a waiver of Section 25.145(c) for its ESVs. There is good cause for waiving this provision as O3b's proposed ESV service would promote the underlying purpose of the rule, which is to ensure a seamless global communications network. O3b's satellite system with 10 steerable spot beams per satellite is designed to focus bandwidth efficiently to areas where it is needed by the customer, rather than waste satellite power purporting to serve areas already adequately served or where there is no demand. In doing so, it helps extend the seamless global communications network of very high-speed Internet to the region's maritime community.

---

[34] 47 C.F.R. § 2.106.
[35] *Ka-band Plan R&O*, at ¶42.
[36] 47 C.F.R. § 25.145(c).
[37] *See* Hawaii License, Condition 90044.
[38] *Id.*
[39] *Id.*

In any event, coverage requirements have limited significance in the case of ESVs, which are by their nature limited to maritime regions that are less extensive than the coverage areas specified in Part 25. As a result, no satellite system could satisfy a Part 25 coverage area requirement on the basis of its ESV service area.

For all of these reasons, there is good cause to waive Section 25.145(c).

Space Station Cross-polarization Isolation and Relief of Pressure Vessels. In granting the Hawaii License, the Commission found good cause to grant the O3b constellation (1) a waiver of the requirement in Section 25.210(i)(1) for FSS space station antennas to have a minimum cross-polarization isolation of 30 dB in their primary coverage area; and (2) a waiver of that portion of Section 25.283(c) relating to relief of pressure vessels aboard the O3b spacecraft at their end of life. These waiver grants were not limited to the Hawaii License. Accordingly, O3b should not need to request or obtain these waivers again for the spacecraft in the O3b constellation. However, out of an abundance of caution and to the extent necessary, O3b hereby incorporates by reference the waiver requests in its Hawaii application related to Sections 25.210(i)(1) and 25.283(c). For the reasons stated therein, which apply with equal force here, those waivers, if needed again, should be granted in this case as well.

Bond Requirement. O3b respectfully requests that it not be required, in connection with a grant of its ESV application, to post a bond to secure the implementation of the O3b satellite system, because it already has posted a bond in connection with the Hawaii License.[40] The Commission previously determined that it would be inappropriate to impose a bond requirement for a foreign-licensed satellite entrant that would have necessitated the posting of a duplicative bond.[41] The same result should obtain here.

---

[40] *See* http://licensing.fcc.gov/myibfs/download.do?attachment_key=972913.

[41] *See Telesat Canada*, DA 07-118, *Orde*r, File No. SAT-PPL-20060516-00061, at ¶ 14 (Jan. 19, 2007) ("We agree with Telesat that it is not necessary to have more than one bond posted with respect to ANIK F3 to fulfill the purposes of the bond requirement.").

Conclusion

O3b has demonstrated that its ESVs will advance the Commission's goals for wireless broadband service and will increase competition. O3b also has shown that the ESVs will provide appropriate interference protection for other services. Grant of O3b's application, therefore, is in the public interest, and O3b urges the Commission to act in accordance with O3b's timetable as outlined above.[42]

Respectfully submitted,

O3b Limited

By: /s/Joslyn Read
Joslyn Read
Vice President, Regulatory Affairs
for O3b Limited
1129 20th St, NW, #1000
Washington, DC 20036

May 28, 2013

OF COUNSEL:
Joseph A. Godles
GOLDBERG, GODLES, WIENER
& WRIGHT, LLP
1229 Nineteenth Street, N.W.
Washington, DC 20036
(202) 429-4900

[42] Based on conversations with the International Bureau staff, O3b is submitting with this application the $9,655.00 initial application filing fee for Fixed Satellite Very Small Aperture Terminal Systems (fee code BGV).

O3B NON-GEOSTATONARY SATELLITE SYSTEM

ATTACHMENT A
Technical Information related to
O3b's ESV Earth Station Application

A.1 Scope

The original Schedule S for the O3b non-geostationary satellite system was filed with the Commission as part of the license application for the Hawaii earth station. This attachment contains the modified and additional technical information related to the current O3b ESV application.

A.2 Frequency Ranges for O3b's ESV Service

The O3b ESV service will operate only in the following frequency ranges, which are a sub-set of those included in the original Schedule S that was part of the Hawaii gateway earth station application:

- Uplink: 28.6-29.1 GHz
- Downlink: 18.8-19.3 GHz

These frequency ranges are not allocated to any terrestrial services according to the FCC's detailed band plan relating to Ka-band.[1] Matters relating to any existing terrestrial licensees in these bands are addressed in more detail in Section A.9 below.

[1] The FCC's frequency plan for Ka-band 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

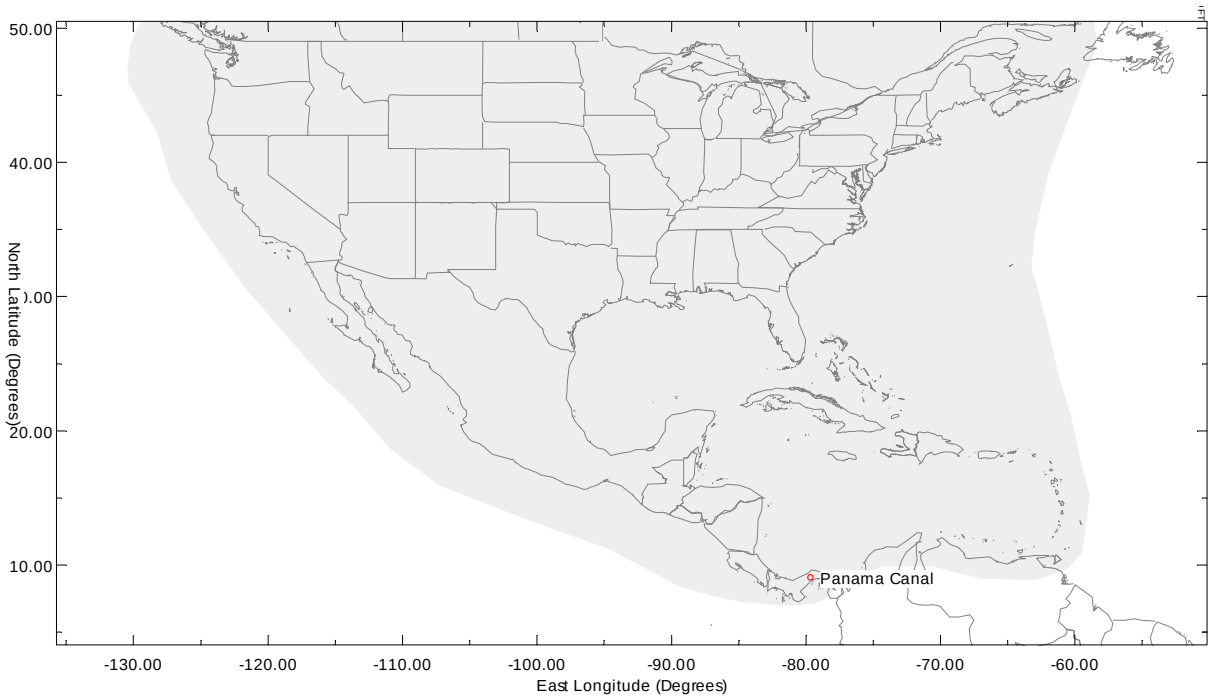
A.3 ESV Service Area

Figure A.3-1 depicts the service area for which O3b seeks authority in this application. As can be seen, the service area includes the Gulf of Mexico, the Caribbean, and the coastal regions of CONUS, southern Canada, Mexico, Central America and northern South America. All of this service area is at latitudes higher than 7°N, and with elevation angles from the active O3b satellite no less than 10°.[2] This minimum elevation angle requirement limits the most northerly latitude that a vessel can have continuous maritime communications service to approximately 50°N.

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.

[2] In practice the minimum elevation angle of 10° would likely apply only for the more northerly latitudes of the service area where the elevation to the O3b orbit is inherently lower.

Figure A.3-1: Typical ESV Service Area



Throughout this service area the ESVs will communicate with O3b's Texas gateway, but with O3b's gateway in Peru acting as a back-up.

A.4 Predicted Space Station Antenna Gain Contours

In its previous applications to the Commission for earth station licenses O3b has provided satellite antenna relative gain contours for the steerable satellite beam pointed towards the specific location of the earth station being licensed. In the case of this ESV application, where the ESV may be anywhere within the service area, we provide three example sets of antenna contours for three different positions of the ESV. The first set is for the ESV in the Caribbean (close to the Bahamas), the second when the ESV is in port in New York City and the third when it is off the California coast.

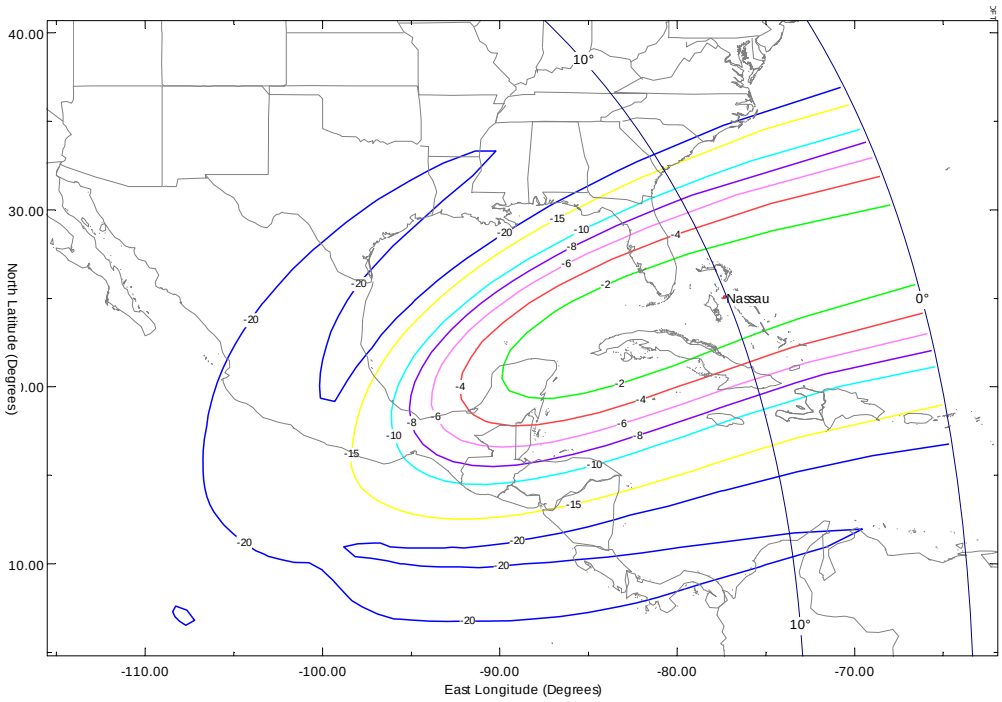
Each set of contours includes several different longitude positions of the O3b satellite relative to the longitude of the center of the beam so as to illustrate the way in which the beam contours

vary with time as the O3b satellite passes through its visible arc. These are shown for mid-band frequencies and given separately for transmit and receive frequencies. All O3b satellite transmit beams are identical and all receive beams are identical, and they are essentially the same in either of the two senses of polarization.

For each set of antenna contours the satellite positions are shown starting with the O3b satellite appearing at 10° elevation angle in the west as viewed from the sample ESV location, then when the O3b satellite is at the same longitude as the ESV and finally when the O3b satellite is disappearing below the 10° elevation angle in the east as viewed from the ESV.

Figure A.2-1: Satellite antenna gain contours for ESV at example location in the Caribbean (Bahamas) and when O3b satellite is appearing at 10° elevation in the West

(a) Transmit



(b) Receive

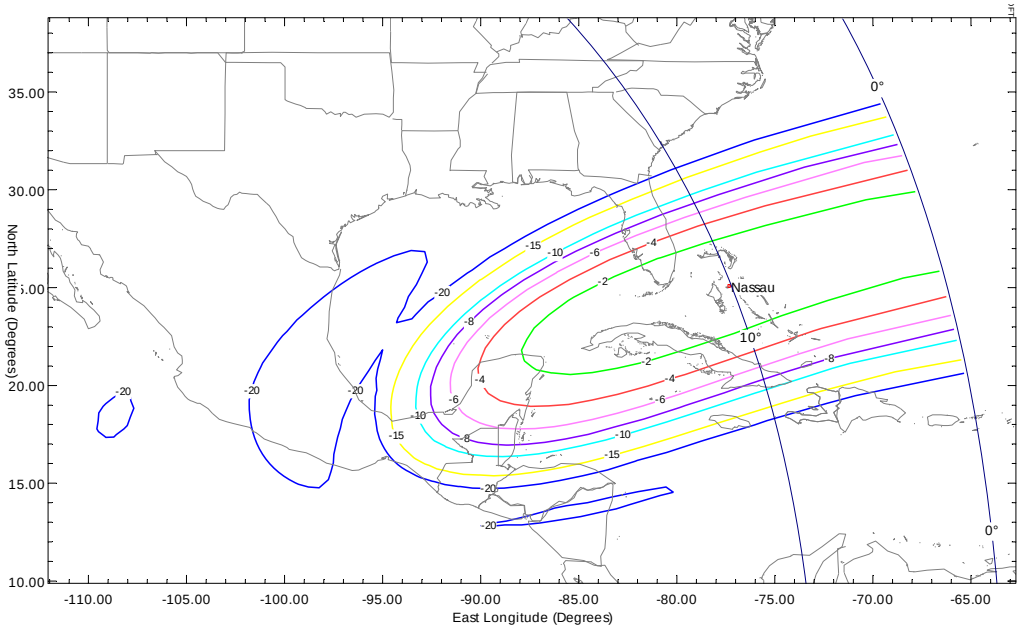
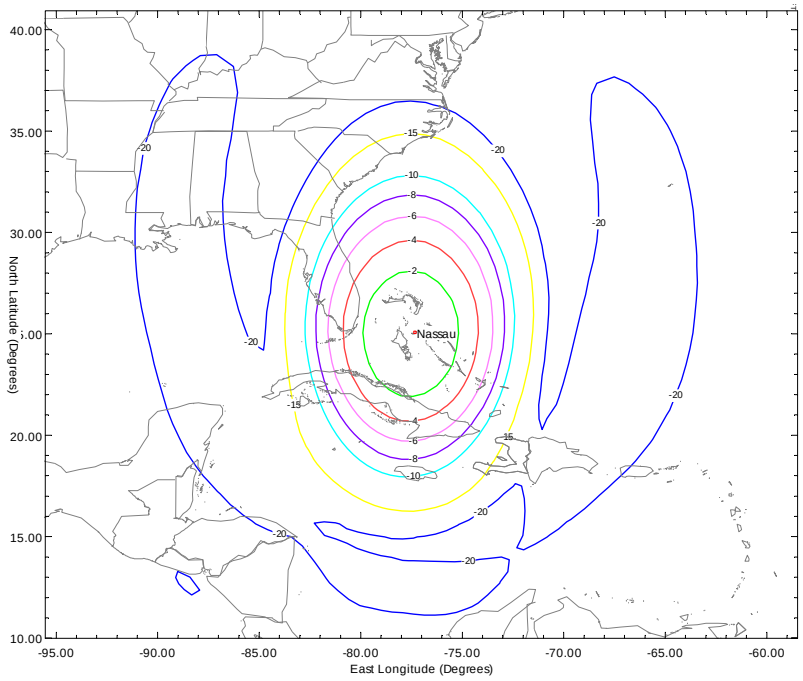


Figure A.2-2: Satellite antenna gain contours for ESV at example location in the Caribbean (Bahamas) and when O3b satellite is at the same longitude as the ESV

(a) Transmit



(b) Receive

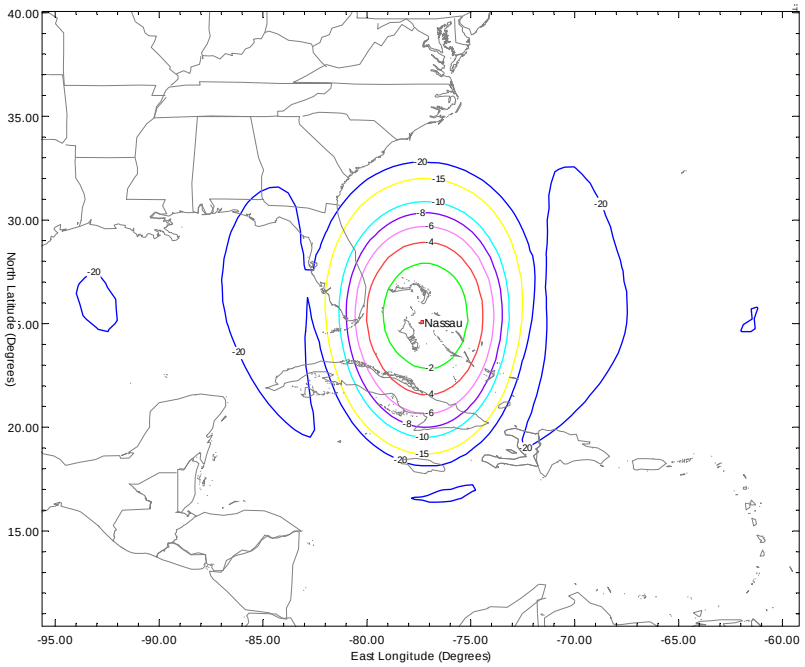
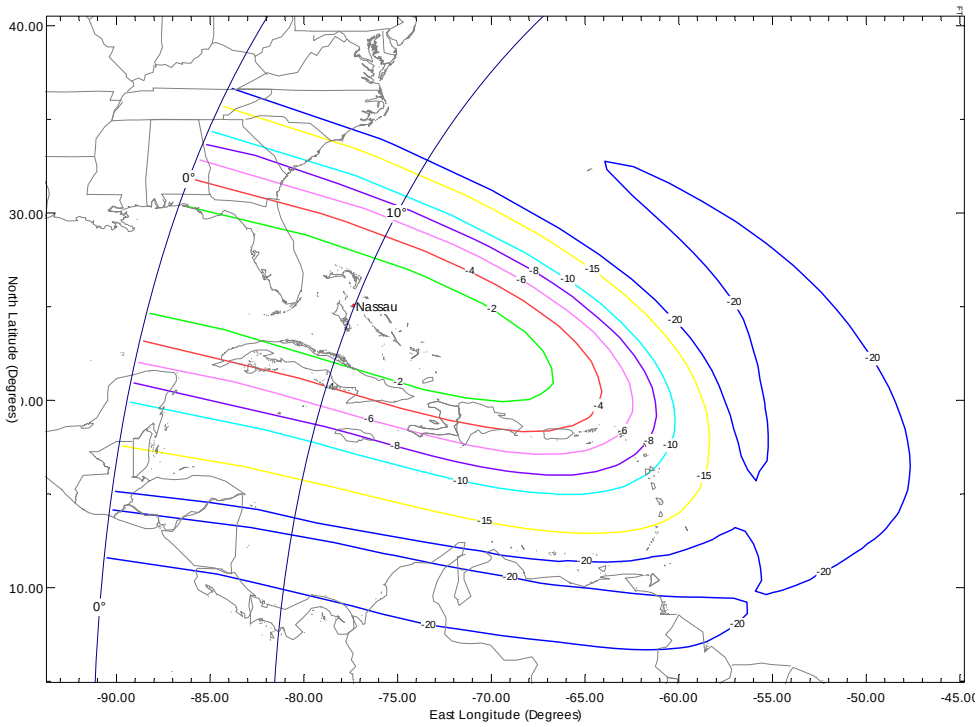


Figure A.2-3: Satellite antenna gain contours for ESV at example location in the Caribbean (Bahamas) and when O3b satellite is visible at 10° elevation in the East

(a) Transmit



(b) Receive

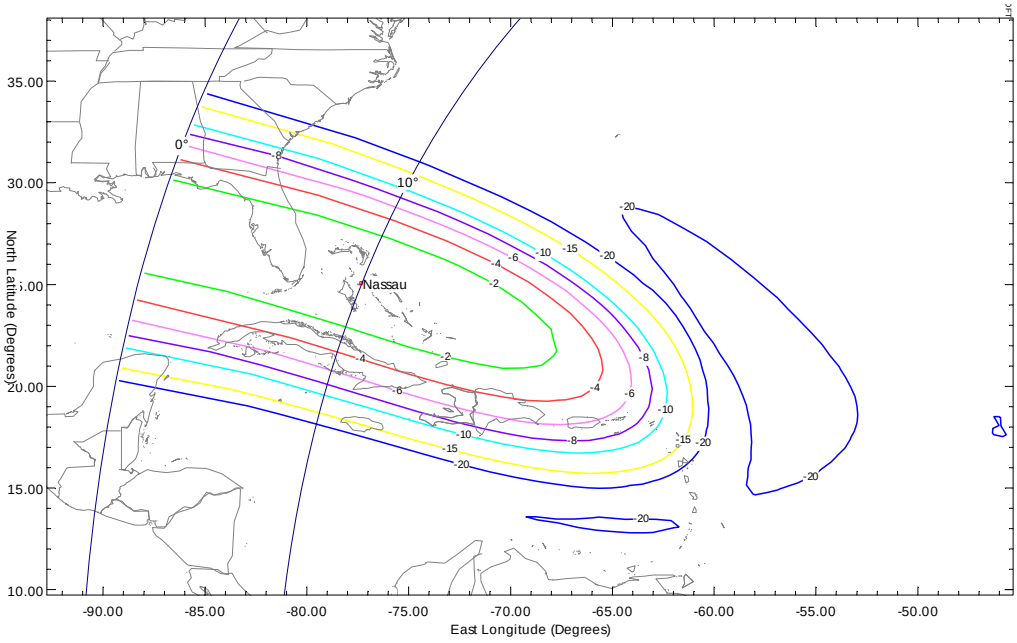
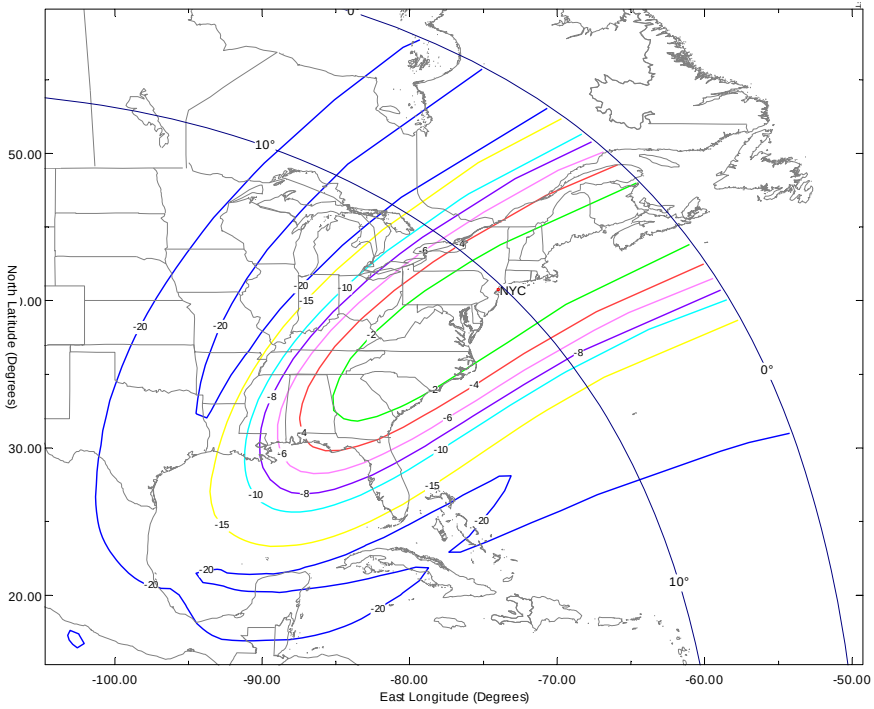


Figure A.2-4: Satellite antenna gain contours for ESV at example location docked in New York and when O3b satellite is appearing at 10° elevation in the West

(a) Transmit



(b) Receive

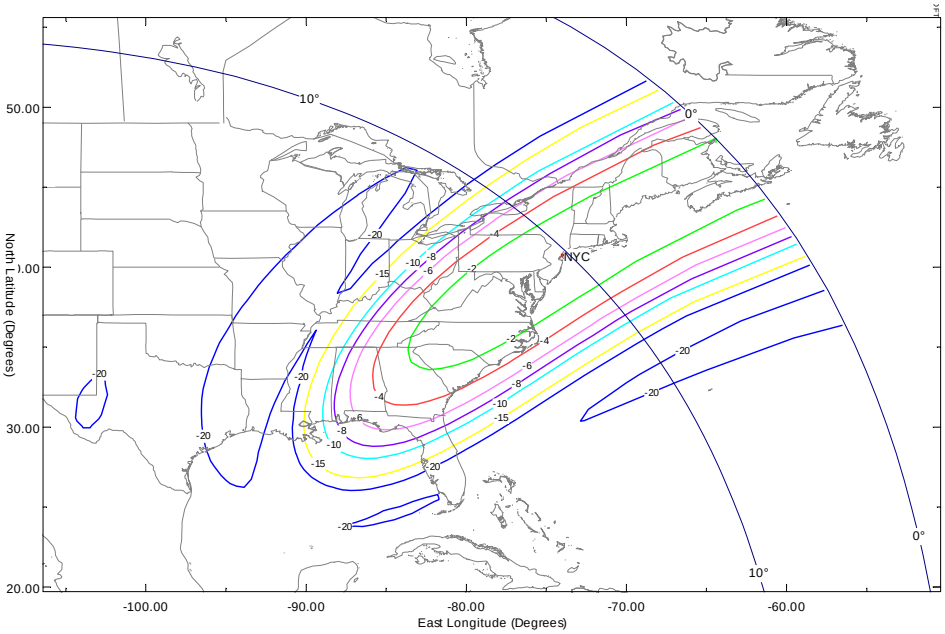
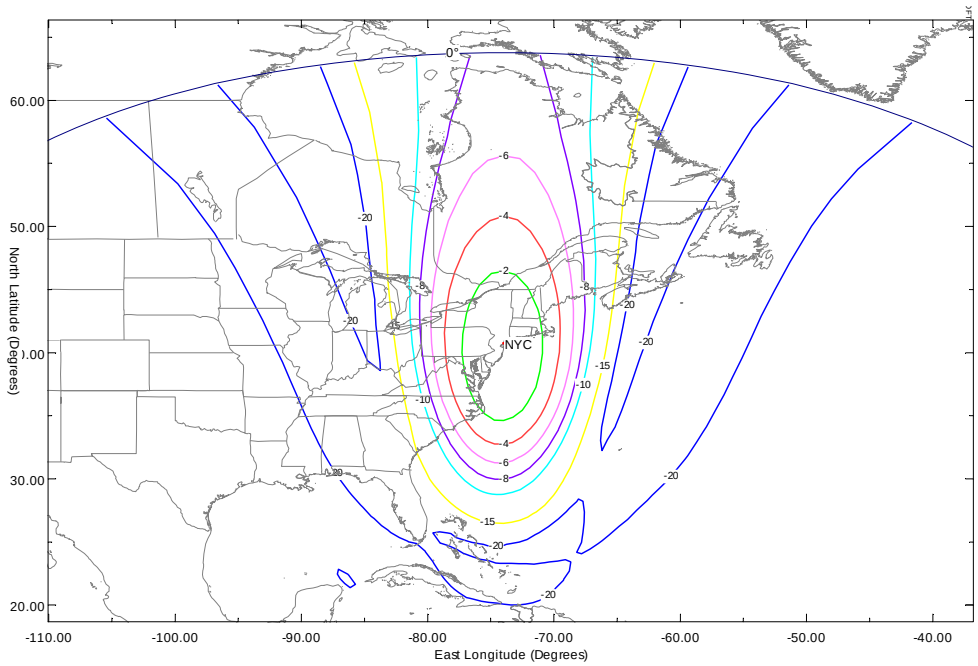


Figure A.2-5: Satellite antenna gain contours for ESV at example location docked in New York and when O3b satellite is at the same longitude as the ESV

(a) Transmit



(b) Receive

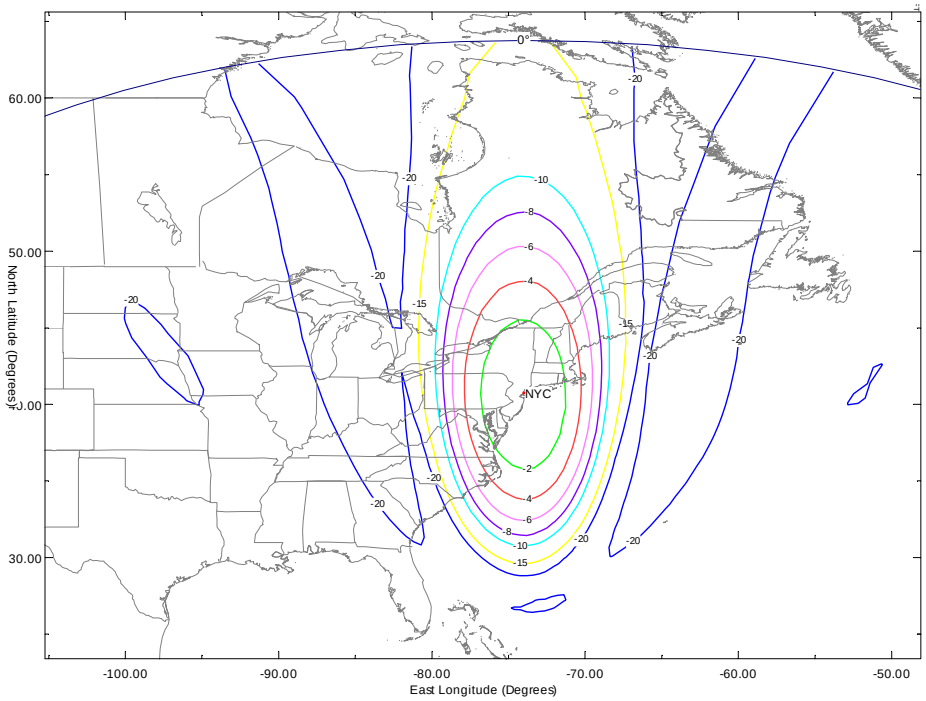
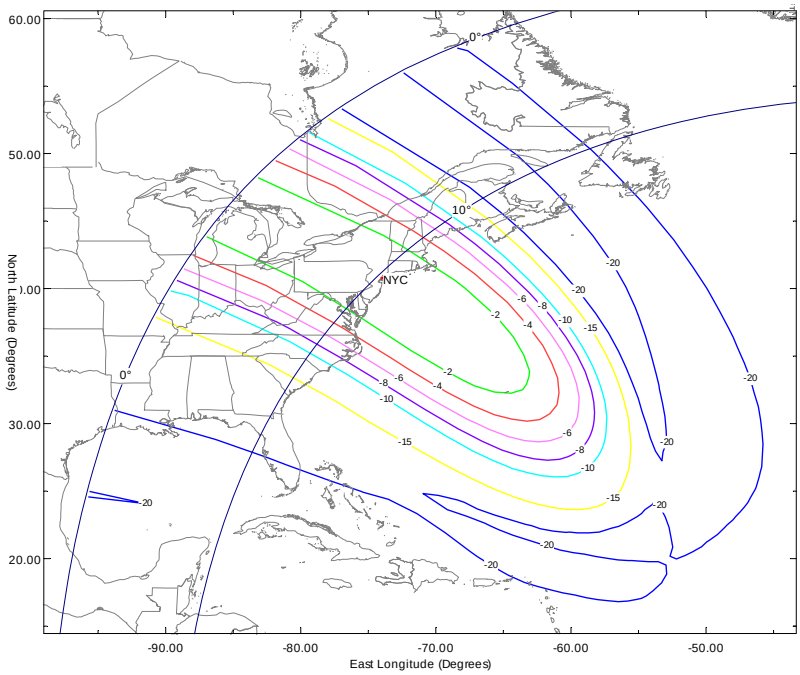


Figure A.2-6: Satellite antenna gain contours for ESV at example location docked in New York and when O3b satellite is visible at 10° elevation in the East

(a) Transmit



(b) Receive

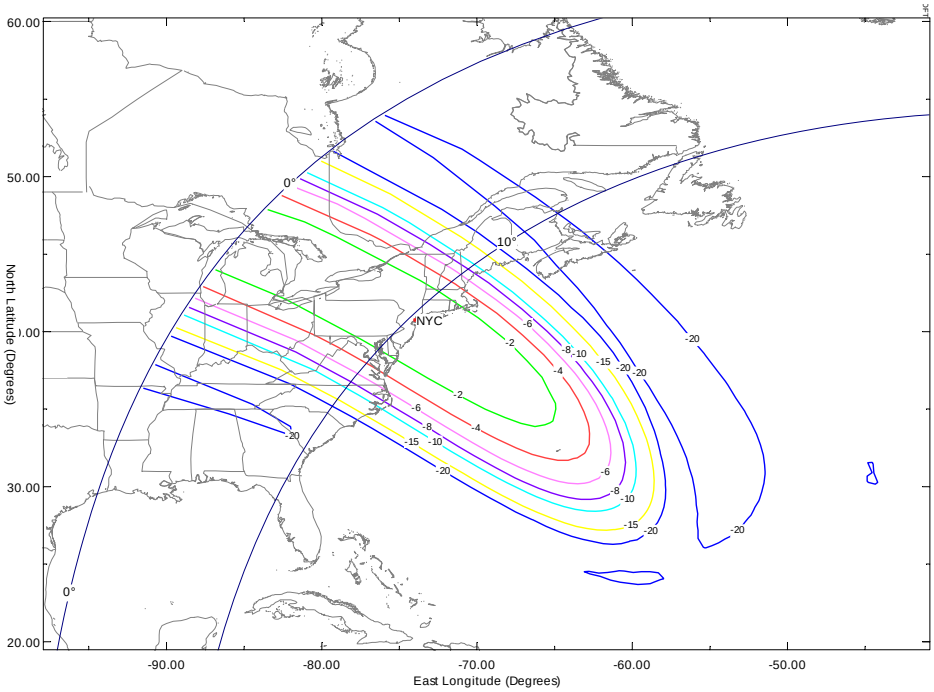
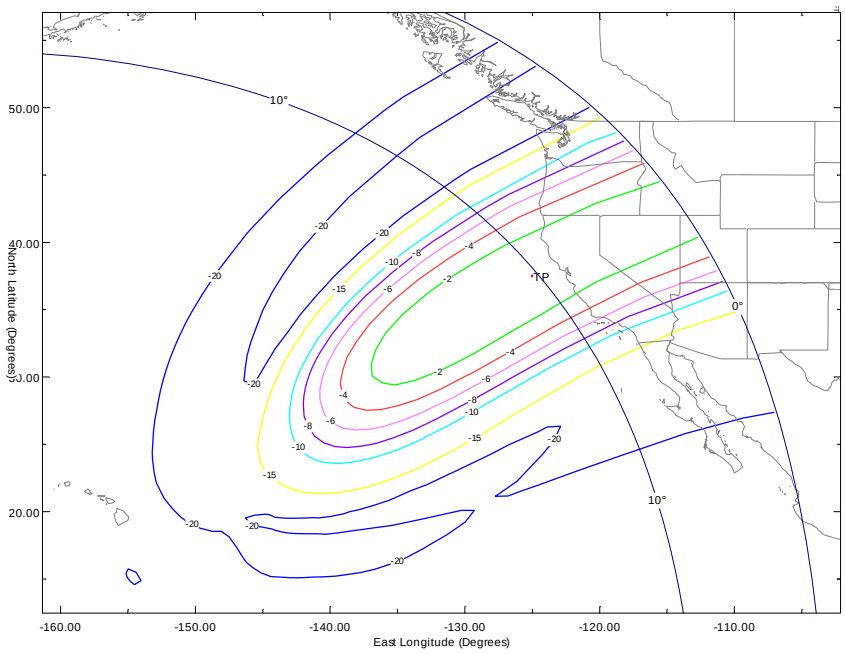


Figure A.2-7: Satellite antenna gain contours for ESV at example location off the California coast and when O3b satellite is appearing at 10° elevation in the West

(a) Transmit



(b) Receive

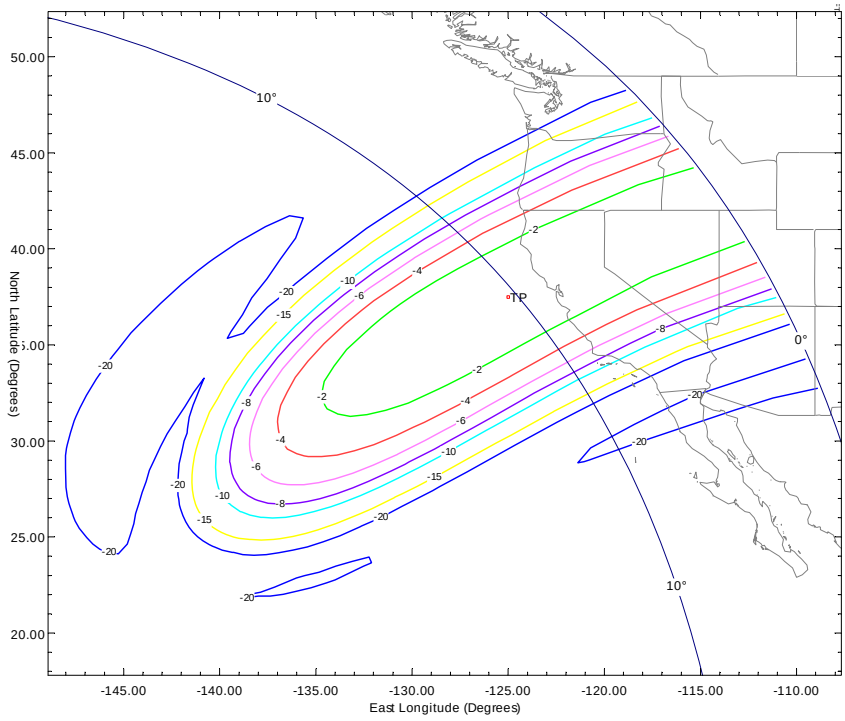
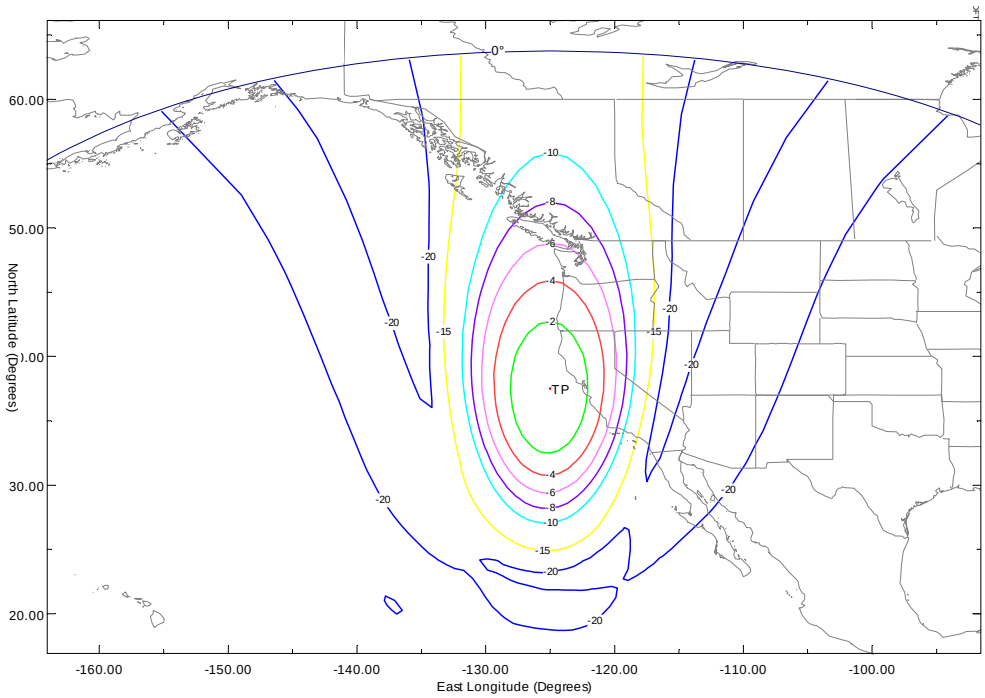


Figure A.2-8: Satellite antenna gain contours for ESV at sample location off the California coast and when O3b satellite is at the same longitude as the ESV

(a) Transmit



(b) Receive

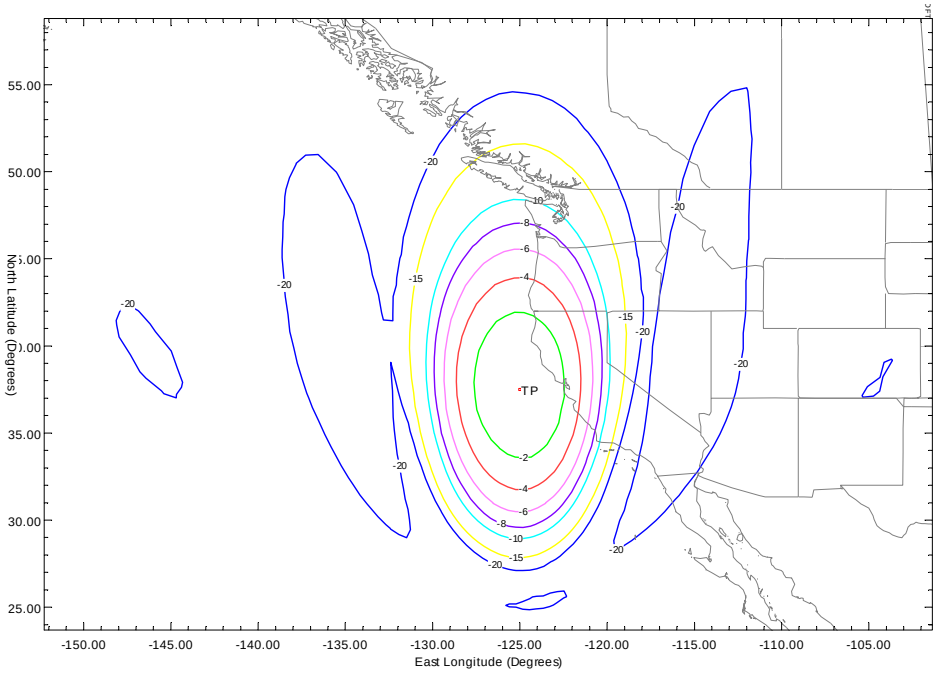
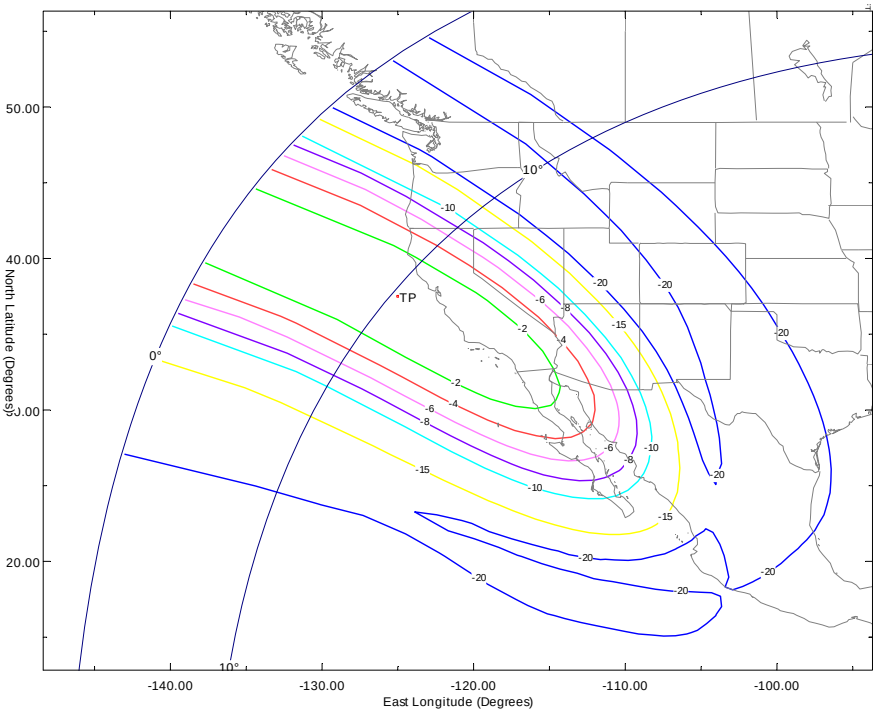
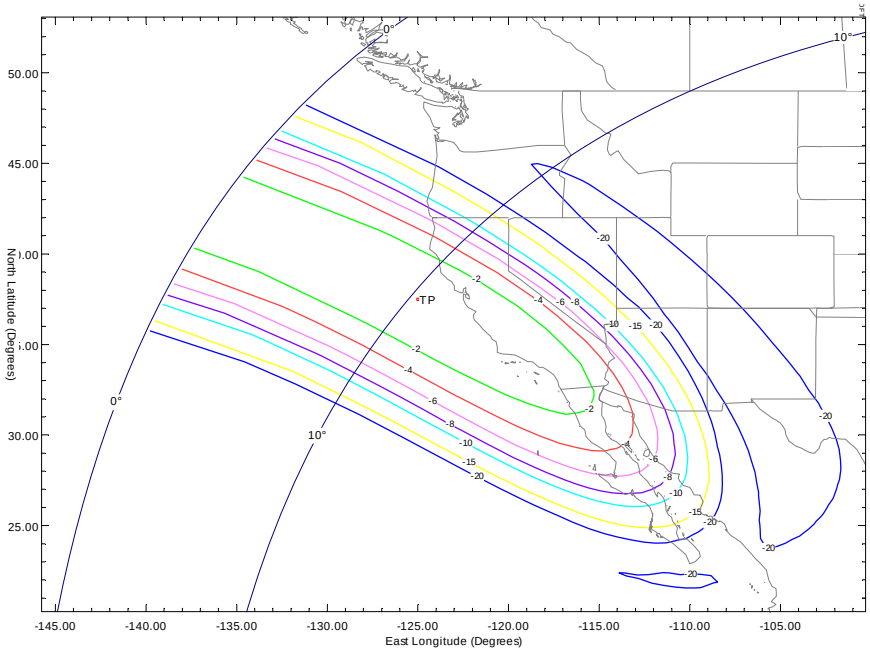


Figure A.2-9: Satellite antenna gain contours for ESV at sample location off the California coast and when O3b satellite is visible at 10° elevation in the East

(a) Transmit



(b) Receive



A.5 Compliance with PFD Limits

The O3b system complies with all applicable FCC and ITU Power Flux Density ("PFD") limits, which are designed to protect the terrestrial Fixed Service ("FS") from downlink interference from the satellite transmissions. Demonstration of O3b's compliance with the FCC Power Flux Density ("PFD") limits of §25.208(c) (which are the same as the ITU PFD limits) was provided to the Commission as part of its application for the Hawaii earth station. That demonstration is equally valid for the downlink transmissions to the ESV terminals.

§25.208(e) contains PFD limits that apply in the 18.8-19.3 GHz band, including for non-GSO systems. In the case of the O3b system these PFD limits are as follows:[3]

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

- $-115+(\delta-5)/2$ 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.

These PFD limits, insofar as they relate to the O3b system, are identical to the PFD limits in Article 21 of the ITU Radio Regulations.

Compliance with the §25.208(e) PFD limits referenced above is demonstrated below using a simple worst-case methodology. The maximum (saturated TWTA) downlink EIRP per channel (stated in the Schedule S that accompanied the Hawaii earth station application) for the O3b satellites is 49.7 dBW. Normally this EIRP is spread across the channel bandwidth of 216 MHz which results in an EIRP density of 26.4 dBW/MHz. In some situations, including for some

---

[3] For the O3b system the variable "X" given in the formulae in §25.208(e) is equal to zero because the number of satellites, "n", is less than 50.

ESV links, the spread bandwidth of this signal is reduced to 40 MHz, which increases the maximum EIRP density to 33.7 dBW/MHz. Taking the shortest distance from the O3b satellite to the Earth's surface (8,062 km) the worst case (i.e., smallest) spreading loss is 149.1 dB. Therefore the highest PFD at the Earth's surface, for the nadir situation and for the worst case EIRP density of 33.7 dBW/MHz, is -115.4 dBW/m^2/MHz, which is less than the most stringent -115 dBW/m^2/MHz PFD limit value that applies at elevation angles of 5° and below.

In practice the downlink PFD would in fact be significantly below the worst-case numbers mentioned above. A reduction of at least 3 dB would be required as output back-off below the saturation level of the satellite TWTA, resulting in a maximum downlink PFD of no greater than -118.4 dBW/m^2/MHz, based on the worst-case assessment described in the preceding paragraph. In practice the maximum downlink PFD for O3b's ESV service will likely not exceed -125 dBW/m^2/MHz, as demonstrated in the link budgets described in Section A.11.

A.6 ESV Terminal Characteristics

The O3b ESV terminals will employ two sizes of antenna diameter: 1.2 meters and 2.2 meters. Service data rates of up to 150 Mbps will be provided using the 1.2 meter antenna and up to 500 Mbps using the 2.2 meter antenna. Figure A6-1 shows these ESV terminals.

Figure A.6-1: O3b's 1.2 meter and 2.2 meter ESV terminals

The ESV antennas are fully stabilized to account for movement of the ship as well as the movement of the O3b satellite in its orbit. A typical ship installation will employ three such antennas, with two being required to accomplish handover between the setting and rising O3b

satellites, and the third in hot standby mode. Each antenna is enclosed within a radome to protect it from the marine environment.

The antennas and their associated control system will ensure that they maintain a stabilization tracking accuracy of better than 0.2 degrees under specified ship motion conditions. The internal controller software continuously monitors the instantaneous antenna tracking error and will cease transmissions within 100ms if an unexpected event occurs that causes the tracking error to exceed 0.5 degrees. Transmissions will not restart until the tracking error, relative to the target O3b satellite, is less than 0.2 degrees.

The ESV antennas are no smaller in antenna size than the range of antenna sizes that O3b has previously described to the Commission as its "Tier 2" service.[4] Therefore these ESV antennas present no new technical issues in terms of interference with respect to GSO or other non-GSO satellite networks.

Recognizing that there are no existing FCC rules relating to the uplink off-axis EIRP density levels for non-GSO FSS networks, O3b nevertheless believes it is useful to compare the off-axis EIRP density levels from the O3b transmitting ESV terminals with the levels in §25.138(a) which relate to blanket licensing of GSO FSS transmitting earth stations. The §25.138(a) levels are intended to ensure interference compatible operations between co-frequency, co-coverage GSO satellites spaced two degrees apart in the GSO orbit. O3b confirms here that its ESV transmitting terminals will actually comply with the off-axis EIRP density levels of §25.138(a)(1) to (4).

The off-axis EIRP density radiation patterns for both types of ESV antenna are given in Annex 1. These patterns are based on computer simulations of the antenna, as actual measurements are not yet available. O3b will provide measured data when it becomes available.

The ESV receive antenna radiation patterns comply with §25.209(a) and (b).

---

[4] See O3b's Hawaii application, FCC File No. SES-LIC-20100723-00952, technical narrative at Section A.5.

Annex 2 provides a manufacturer's declaration concerning compliance of the ESV terminal with the FCC's off-axis EIRP density requirements in §25.138 provided the input power spectral density ("PSD") does not exceed stated values. O3b will not exceed these stated PSD values, as given in the accompanying FCC Form 312 Schedule B that is part of this application.

Additional technical characteristics of the ESV terminals are also provided in the accompanying FCC Form 312 Schedule B.

A radiation hazard study report for each of the two ESV antennas is provided as Annex 3.

A.7 Interference with Respect to GSO Networks

The proposed transmitting ESV terminals will not cause unacceptable interference into any GSO satellite network by virtue of the fact that the ESV terminals requested in this application will not transmit from latitudes south of 7°N. Operation at these latitudes ensures a certain separation angle between the GSO and O3b orbits as viewed from the earth stations. This fact, coupled with the compliance with the off-axis EIRP density limits of §25.138(a)(1) to (4) as described in Section A.6 above, will not result in unacceptable uplink interference to GSO satellites. This assertion is justified based on the following:

(a) At latitudes of least 7°N and higher the minimum angular separation between the O3b orbit and the GSO orbit, as seen from the transmitting ESV terminal, will be greater than 2.6°, based purely on the geometry of the orbits. This worst-case value is for the situation where the ESV terminal is pointing at the lowest operational elevation angle of 10° and the victim GSO satellite is also providing service to the same geographic location as the ESV, also at a low elevation angle of approximately 10°. Such a situation would be very unlikely to occur in practice and more realistic scenarios, with higher elevation angles to the GSO, would result in a larger minimum separation angle than 2.6°.

(b) The minimum topocentric separation angle between adjacent GSO satellites spaced nominally 2° apart is approximately 2.1°, allowing for ±0.05° station-keeping accuracy.

(c) Thus the worst-case interference from a transmitting O3b ESV terminal at 7°N latitude into a co-frequency, co-coverage GSO satellite is less than such a satellite would receive

from another GSO satellite network spaced 2° apart in the GSO and operating according to the FCC's blanket licensing rules for Ka-band (§25.138(a)). In practice the O3b interference would be time varying with only the short-term peak interference corresponding to the 2.6° separation case and only for the low latitude extremes of the ESV service area. For example, when the ESV terminal is at 10°N latitude the minimum angular separation would increase to at least 3.8°, based on the same assumptions as above.

The downlink transmissions from the O3b satellites were fully described in the Schedule S that was filed with the Commission as part of the license application for the Hawaii earth station. The most southerly US territory or protectorate that might be affected by O3b's ESV service would be Puerto Rico, which is at a latitude of approximately 18°N. For this latitude the minimum separation angle between the O3b and GSO orbits is approximately 7°, even for 10° elevation operation, which would result in interference that is more than 13 dB lower than that permitted by the FCC blanket licensing rules assuming a 2° spaced neighboring GSO satellite, and assuming that the O3b satellite was transmitting a downlink PFD equal to the -118 dBW/m^2/MHz level of the FCC blanket licensing rules. In practice, for the ESV application, the maximum downlink PFD from the O3b satellites would likely be at least 7 dB below this, as explained in Section A.5 above.

The uplink and downlink interference situations described above are notional ones only. In practice there are no non-government US registered GSO Ka-band satellites licensed to operate in the bands used by the O3b ESV terminals with beams operating outside of CONUS. Within CONUS, where the minimum latitude is approximately 25°N, the minimum separation angle between the O3b and GSO orbits is always greater than 10°, even for 10° elevation operation. Such large off-axis angles provide approximately 17 dB more interference isolation than for the case of a 2° spaced neighboring satellite operating according to the FCC blanket licensing conditions of §25.138(a).

With respect to non-US registered Ka-band GSO satellites O3b will only operate its ESV service in a manner that is consistent with its ITU coordination obligations and agreements, and consistent with Ofcom's own rules between UK registered satellite operators.

A.8 Interference with Respect to Other Non-GSO Systems

The ESV service to be provided by O3b presents no different interference environment with respect to other non-GSO satellite systems than was addressed in O3b's Hawaii gateway earth station application.[5]

A.9 Interference to and from Existing Domestic US Terrestrial Licensees

28 GHz (ESV uplink frequencies). Interference from transmitting O3b ESV terminals into US terrestrial FS receivers in the 28 GHz band is a non-issue because there is no allocation in the FCC's Ka-band frequency plan for 28 GHz terrestrial FS stations.

18 GHz (ESV downlink frequencies). Based on O3b's analysis, which takes into account likely services and routes, O3b's ESV receivers should not be subject to unacceptable interference from any 18 GHz terrestrial FS licensees that are in the FCC's database. In any event, O3b agrees to accept any interference from these FS licensees in situations in which the O3b ESV terminal is operating on a non-conforming use basis because the ship on which it is installed is in motion. For situations in which the ship on which the O3b ESV terminal is installed stationary, O3b will operate on a primary basis consistent with the FCC's Ka-band frequency plan.

A.10 Interference with Respect to Foreign Terrestrial Services

When the ships that are using O3b's ESV terminals are in the proximity of foreign countries (e.g., the Caribbean, Central and South American nations, Mexico and Canada) there may be potential interference with respect to terrestrial FS operating in those countries. O3b has analyzed the potential separation distances that would apply in these cases to ensure there is no unacceptable interference either to or from the O3b ESV terminals, and the results are given in Annex 4.

In summary, the following can be concluded from this analysis:

---

[5] See O3b's Hawaii application, FCC File No. SES-LIC-20100723-00952, technical narrative at Section A.10.2.

(a) The ITU's conservative methodology given in Appendix 7 of the Radio Regulations leads to a coordination contour of approximately 100 km radius. This is the default minimum contour size for this frequency band regardless of the characteristics of the O3b terminal, and therefore is not representative of the likely distance at which potential interference may occur.

(b) Based on a more specific, but static worst-case, interference analysis in the 28 GHz band (where potential interference might occur from the ESV terminal into the foreign FS receivers) the actual separation distance that might be required to protect the FS is likely to be in the 25 to 50 km range, in order to meet the ITU short-term interference criteria for the FS.

(c) Further statistical (Monte Carlo) interference analysis indicates the required separation distance is in the range 10 to 20 km to meet the ITU interference criteria. This analysis takes into account the movement of the ship.

O3b therefore intends to operate its ESV terminals on a non-interference basis consistent with the ITU procedures that apply to ESVs in other frequency bands.[6] O3b will liaise with the regulatory authorities of countries whose territory is within 100 km of the ship on which an O3b ESV is operating, and will comply with all applicable laws and regulations in those countries.

A.11 Link Budgets for the ESV Service

New representative link budgets are provided in Annex 5 for the ESV service. These include various ship/ESV locations over a range of latitudes for both types of ESV terminal, different transmission rates and different weather conditions. Adaptive coding and modulation is used in all the links.

---

[6] ITU-R Recommendation 37 (WRC-03).

A.12 Coordination with US Government Satellite Networks and Earth Stations

O3b has completed all necessary coordination with US government satellite networks operating in Ka-band, including GSO and non-GSO, as well as their associated specific earth stations filed under 9.7A and 9.7B of the ITU Radio Regulations through other administrations. O3b has also completed coordination, according to US footnote 334 of the FCC table of frequency allocations, with the US government, and this US334 coordination agreement specifically caters for additional O3b earth stations operating in US territory. O3b believes this existing US334 coordination agreement covers the use of ESVs as requested in this application but acknowledges that it may need to confirm this with the US government coordination representatives once this application is filed.

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/_____

Richard J. Barnett, PhD, BSc
Telecomm Strategies Inc.
6404 Highland Drive
Chevy Chase, MD 20815
(301) 656-8969

May 26, 2013

Annex 1: ESV Antenna Radiation Patterns

This annex contains the off-axis EIRP density levels produced by the two types of O3b's ESV terminal (1.2 meter and 2.2 meter), based on the best available computer simulations of the antenna performance available at this time. Measured data will be provided to the Commission when it becomes available.

The FCC requirements for this data are stated in §25.138(d), which are as follows:

> The applicant shall provide for each earth station antenna type, a series of radiation patterns measured on a production antenna performed on a calibrated antenna range and, as a minimum, shall be made at the bottom, middle, and top frequencies of the 30 GHz band. The radiation patterns are:
>
> (1) Co-polarized patterns for each of two orthogonal senses of polarizations in two orthogonal planes of the antenna.
>
> (i) In the azimuth plane, plus and minus 10 degrees and plus and minus 180 degrees.
>
> (ii) In the elevation plane, zero to 30 degrees.
>
> (2) Cross-polarization patterns in the E- and H-planes, plus and minus 10 degrees.
>
> (3) Main beam gain.

The computer predicted performance data are provided for a frequency of 29.1 GHz and are applicable to both senses of circular polarization.

Figures A1-1 to A1-4 are for the 1.2 meter ESV terminal, and assume a maximum input PSD level of -11.7 dBW/40kHz. This is the maximum PSD level for this antenna to comply with the FCC masks, due to the cross-polar off-axis gain in the azimuth plane at approximately +7° off-axis (see Figure A1-4). The peak transmit gain of the 1.2 meter ESV antenna is 48.5 dBi.

Figures A1-5 to A1-8 are for the 2.2 meter ESV terminal, and assume a maximum input PSD level of -11.6 dBW/40kHz. This is the maximum PSD level for this antenna to comply with the FCC masks, due to the co-polar off-axis gain in the azimuth plane at approximately +35° off-axis (see Figure A1-5). The peak transmit gain of the 2.2 meter ESV antenna is 54.5 dBi.

Note that both the azimuth and elevation co-polar data are plotted alongside the more stringent of the two FCC co-polar masks which is the one that applies along the GSO arc (i.e., §25.138(a)(1)).

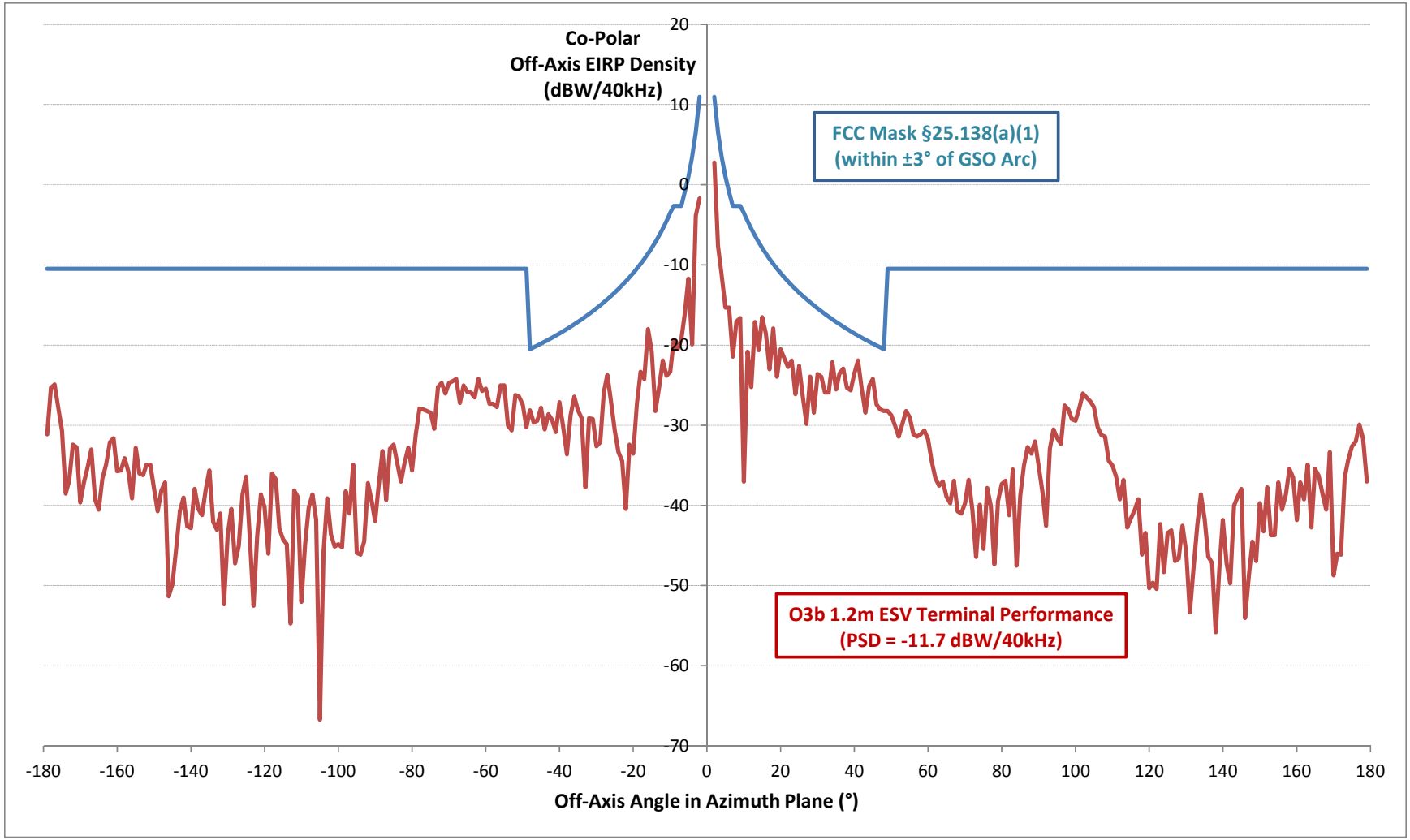


Figure A1-1: 1.2m ESV Terminal Off-Axis Co-Polar EIRP Density in Azimuth Plane

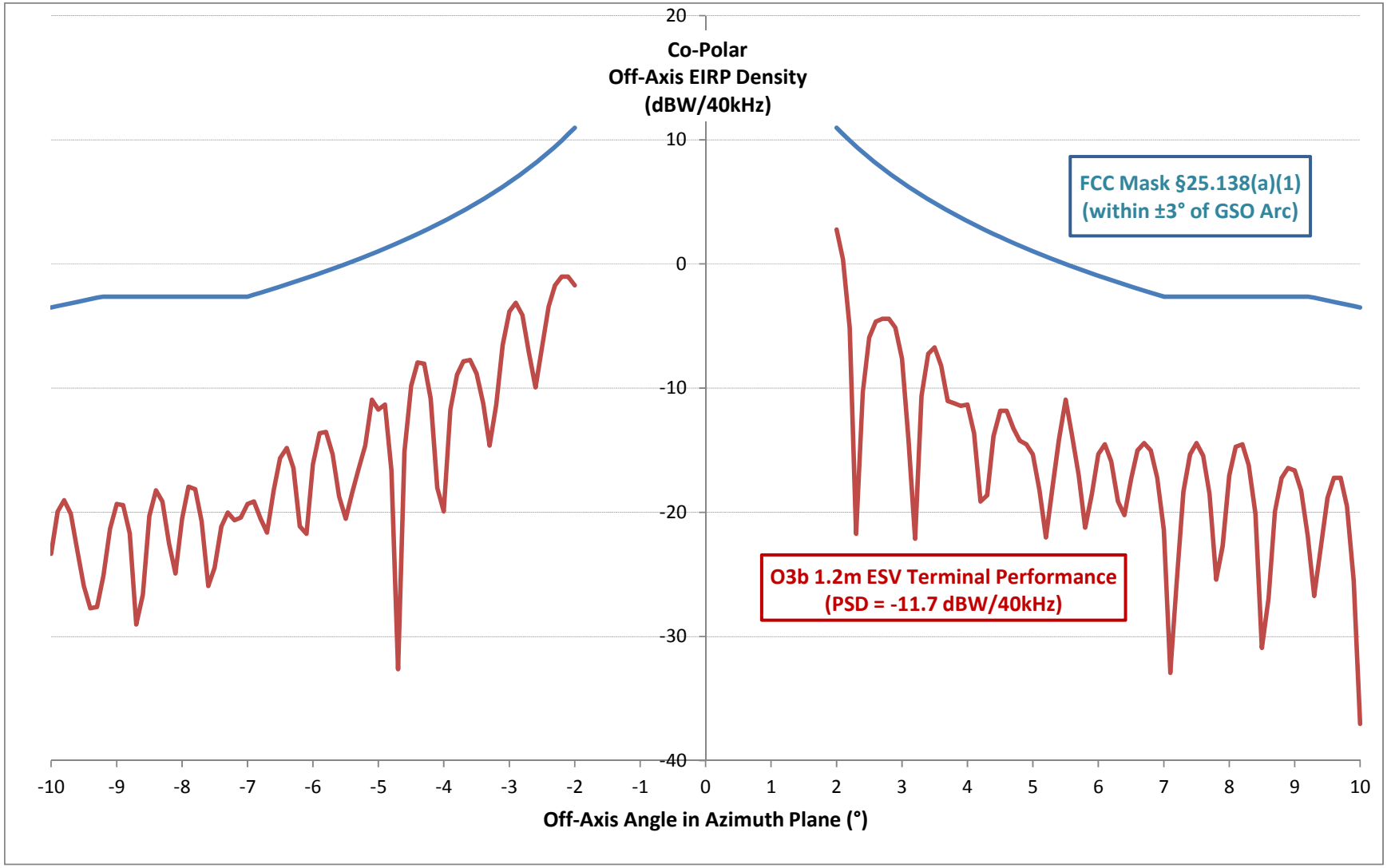


Figure A1-2: 1.2m ESV Terminal Off-Axis Co-Polar EIRP Density in Azimuth Plane

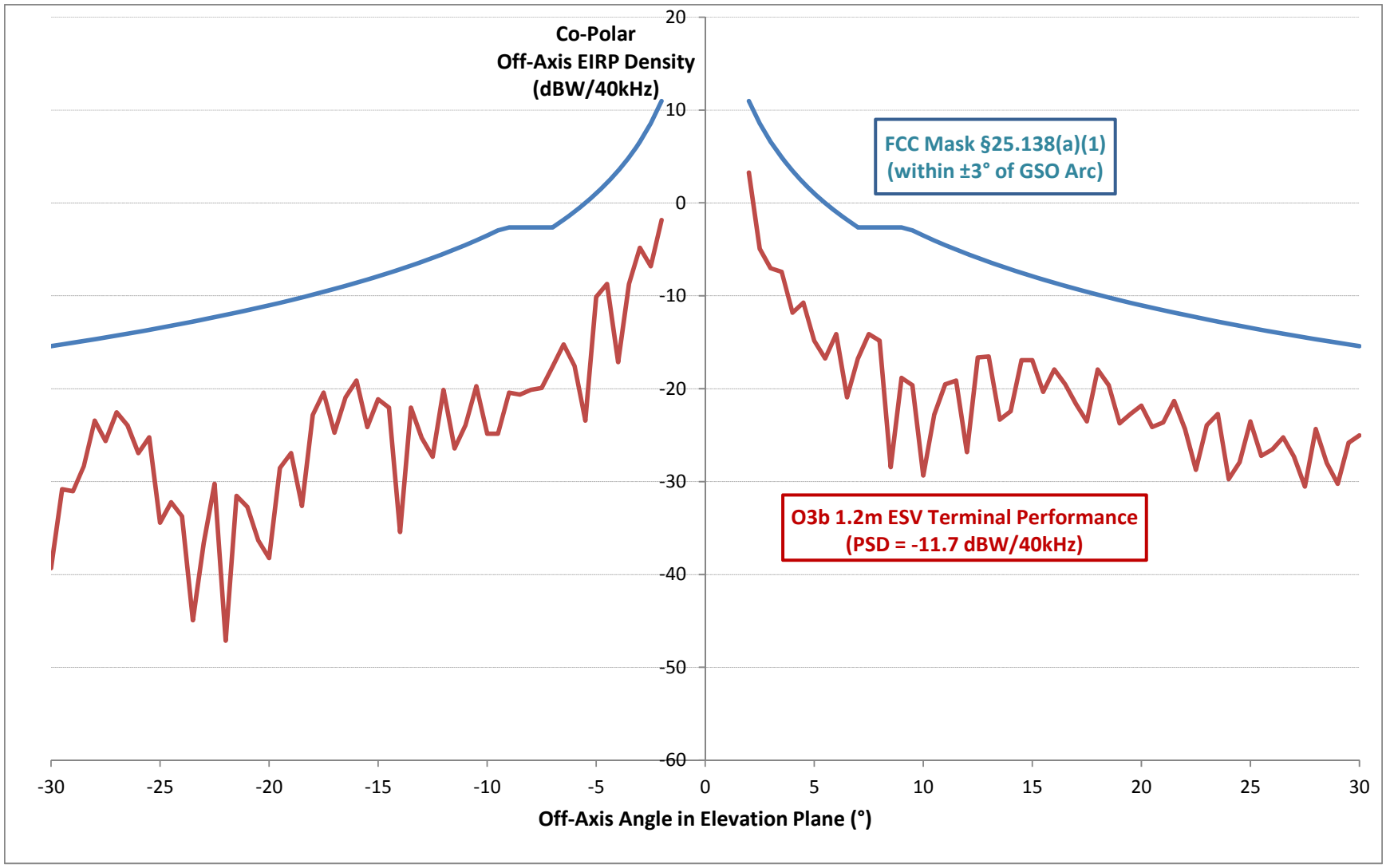


Figure A1-3: 1.2m ESV Terminal Off-Axis Co-Polar EIRP Density in Elevation Plane

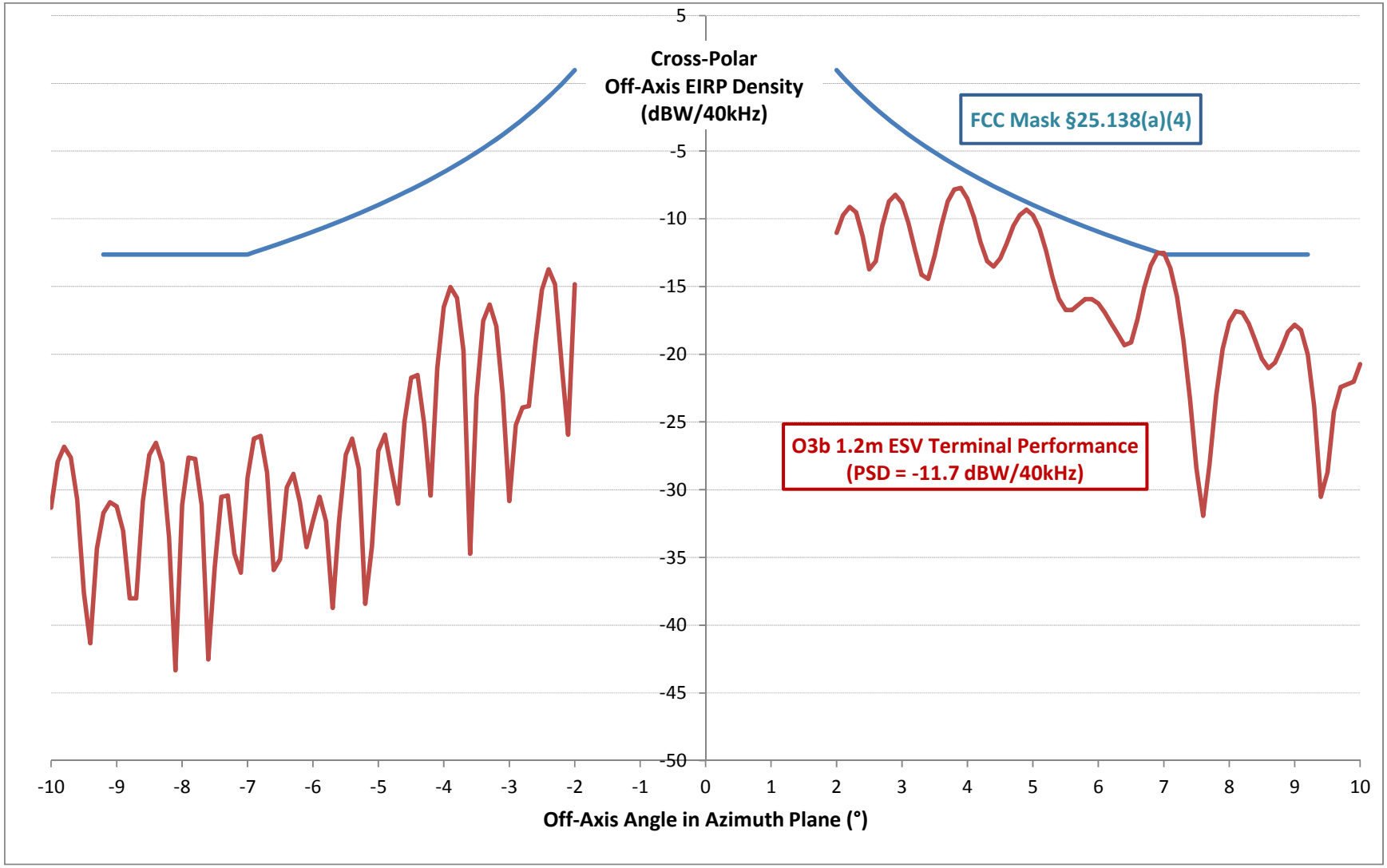


Figure A1-4: 1.2m ESV Terminal Off-Axis Cross-Polar EIRP Density in Azimuth Plane

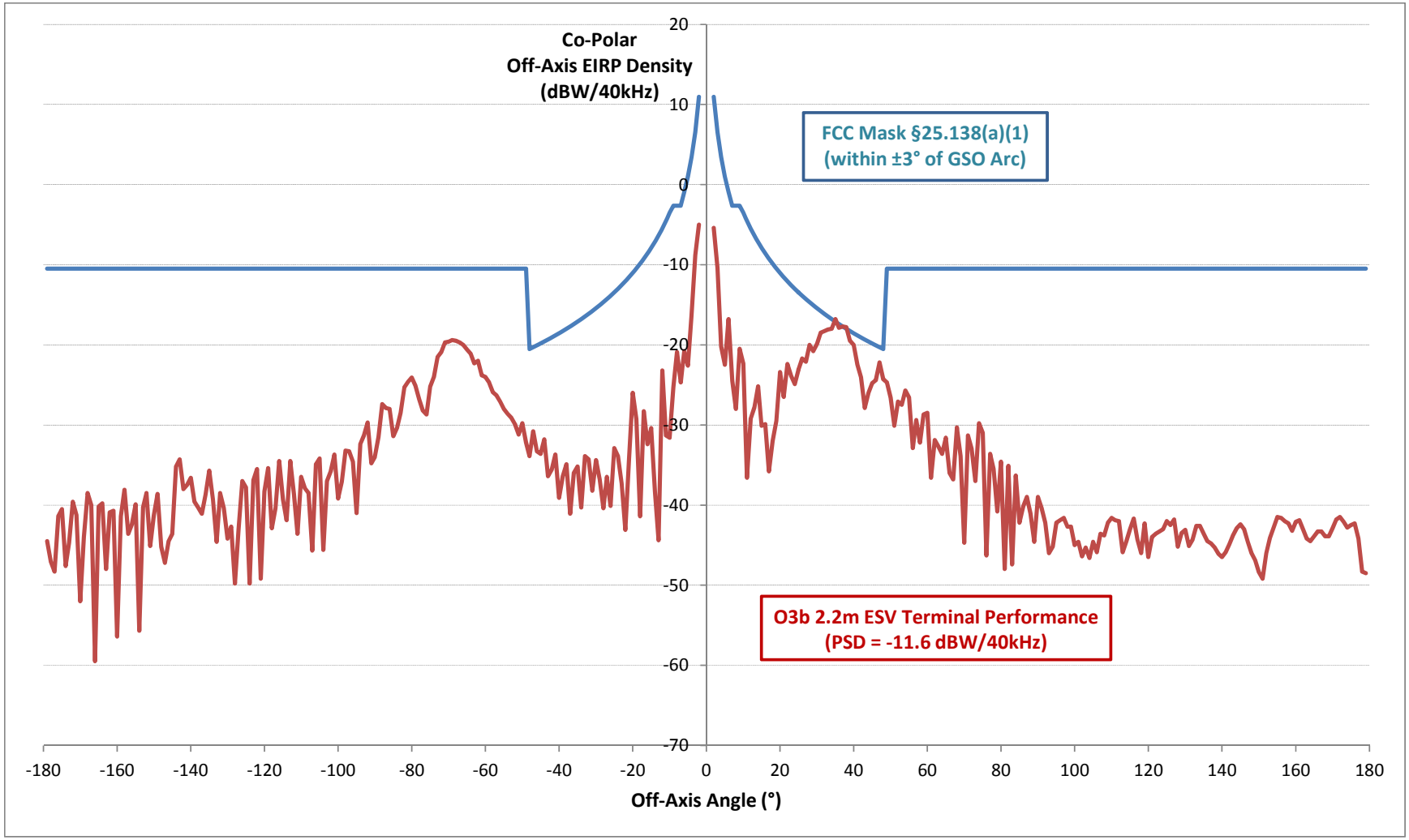


Figure A1-5: 2.2m ESV Terminal Off-Axis Co-Polar EIRP Density in Azimuth Plane

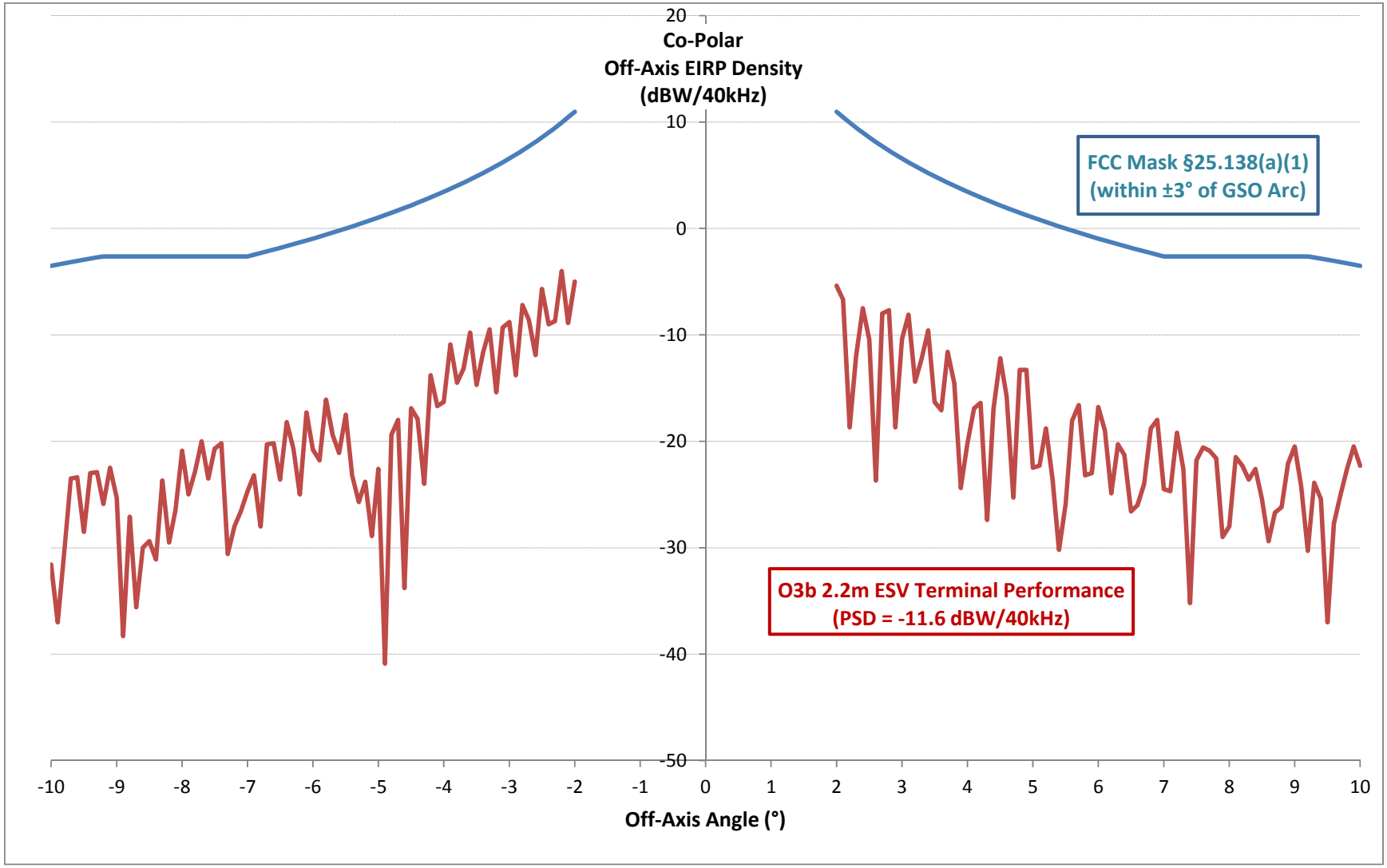


Figure A1-6: 2.2m ESV Terminal Off-Axis Co-Polar EIRP Density in Azimuth Plane

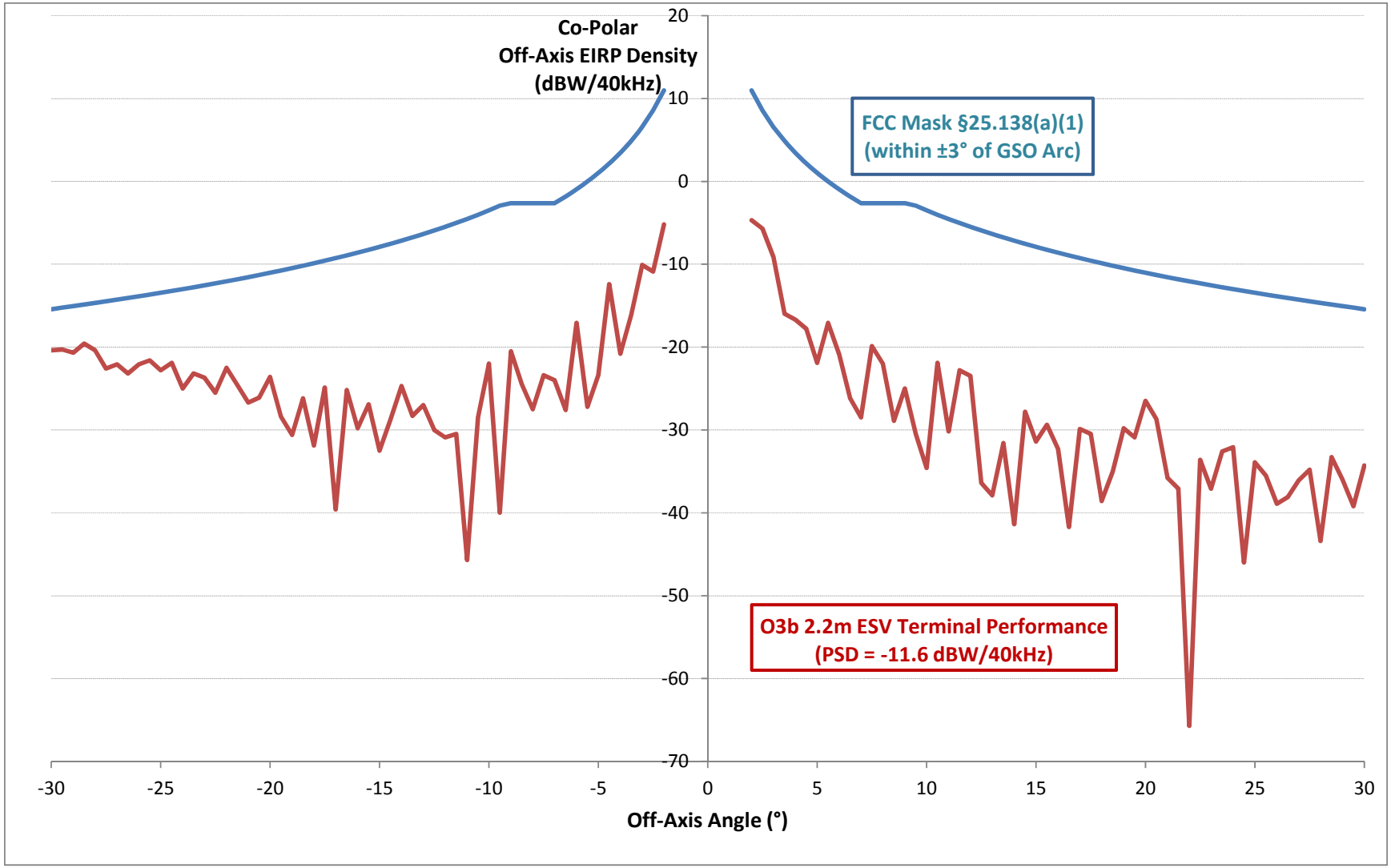


Figure A1-7: 2.2m ESV Terminal Off-Axis Co-Polar EIRP Density in Elevation Plane

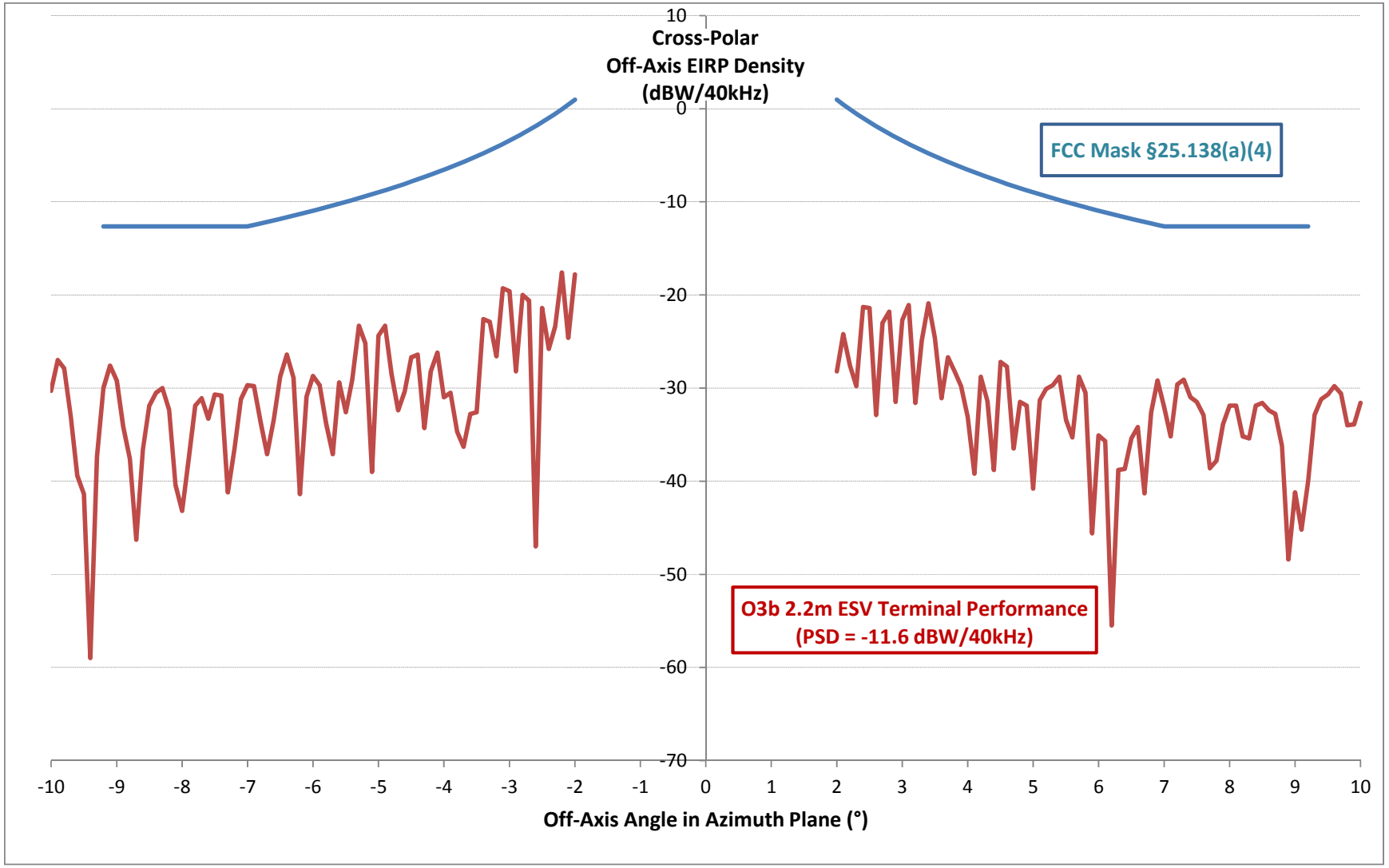


Figure A1-8: 2.2m ESV Terminal Off-Axis Cross-Polar EIRP Density in Azimuth Plane

Annex 2: ESV Terminal Manufacturer's Declaration

The following four pages provide the ESV terminal manufacturer's declaration concerning their compliance with the FCC's off-axis EIRP density levels in §25.138 for the stated PSD levels.

The first two pages (A3-2 and A3-3) apply to the 1.2 meter ESV terminal. The next two pages (A3-4 and A3-5) apply to the 2.2 meter ESV terminal.

DECLARATION OF ORBIT COMMUNICATION LTD

Model "AL-7103-Ka OrSat" (Ka-band)

At this stage, the analysis done is based on simulations/computations of the antenna

I, Guy Naym, Director R&D Satcom Systems, hereby declare, that the following statements are true and correct:

1. Orbit Communication Ltd. Designs, develops and manufactures marine stabilized antenna systems for satellite communications at sea.

2. The Model "AL-7103-Ka" (Ka-band) meets the shape of the off-axis EIRP spectral density mask provided for in 47 CFR Section 25.138.

3. Anyone using the Model "AL-7103-Ka" (Ka-band) antenna will comply with U.S. Federal Communications Commission (FCC) off-axis EIRP spectral density limits provided that, the transmit power density at the antenna input is kept below (-11.76 dBW/40KHz (0.067 Watts/40KHz) of occupied bandwidth (limited at 29.1 GHz by the Az. X-Pol).

4. Orbit Communication Ltd "AL-7103-Ka" (Ka-band) Marine Stabilized System will maintain a stabilization tracking accuracy of better than 0.2 degrees under specified ship motion conditions. The internal controller software continuously monitor the instantaneous antenna tracking error and will cease the Tx of the BUC within 100ms (using M&C of the BUC) if an unexpected even occurs that causes the tracking error to exceed 0.5 degrees. Transmissions will not restart until the tracking error is less than 0.2 degrees of the target satellite.

5. Orbit Communication Ltd maintains all relevant test & analyzed data, which is available upon request.

Executed on November 13, 2012

Guy Naym

Director R&D SatCom Systems

Orbit Communication Ltd

DECLARATION OF ORBIT COMMUNICATION LTD

Model "AL-7107-Ka OrBand" (Ka-band)

(At this stage, the analysis done is based on simulations / computations of the antenna)

I, Guy Naym, Director R&D Satcom Systems, hereby declare, that the following statements are true and correct:

1. Orbit Communication Ltd. Designs, develops and manufactures marine stabilized antenna systems for satellite communications at sea.

2. The Model "AL-7107-Ka" (Ka-band) meets the shape of the off-axis EIRP spectral density mask provided for in 47 CFR Section 25.138.

3. Anyone using the Model "AL-7107-Ka" (Ka-band) antenna will comply with U.S. Federal Communications Commission (FCC) off-axis EIRP spectral density limits provided that, the transmit power density at the antenna input is kept below -11.58 dBW/40KHz (0.07 Watts/40KHz) of occupied bandwidth (limited at 29.1 GHz by Az, Co-pol).

4. Orbit Communication Ltd "AL-7107-Ka" (Ka-band) Marine Stabilized System will maintain a stabilization tracking accuracy of better than 0.2 degrees under specified ship motion conditions. The internal controller software continuously monitor the instantaneous antenna tracking error and will cease the Tx of the BUC within 100ms (using M&C of the BUC) if an unexpected even occurs that causes the tracking error to exceed 0.5 degrees. Transmissions will not restart until the tracking error is less than 0.2 degrees of the target satellite.

5. Orbit Communication Ltd maintains all relevant test & analyzed data, which is available upon request.

Executed on December 13, 2012

Guy Naym

Director R&D SatCom Systems

Orbit Communication Ltd

Annex 3: Radiation Hazard Study

The following eight pages provide the radiation hazard study results for the two types of O3b's ESV terminal (1.2 meter and 2.2 meter).

Radiation Hazard Study

The study in this section analyzes the potential RF human exposure levels caused by the Electro Magnetic (EM) fields of an Orbit AL-7107-Ka 2.2m antenna operating with a maximum power at the flange of 40 Watts. The mathematical analysis performed below complies with the methods described in the FCC Office of Engineering and Technology (OET) Bulletin No. 65 (1985 rev. 1997) R&O 96-3 26 in "Evaluating Compliance with FCC Guideliness for Human Exposure to RF EM Fields, OET Bulletin 65 (Edition 97-01), Supplement B, FCC Office of Engineering & Technology, November 1997".

Maximum Permissible Exposure

There are two separate levels of exposure limits. The first applies to persons in the general population who are in an uncontrolled environment. The second applies to trained personnel in a controlled environment. According to 47 C.F.R. § 1.1310, the Maximum Permissible Exposure (MPE) limits for frequencies above 1.5 GHz are as follows:

* General Population / Uncontrolled Exposure: 1.0 mW/cm^2
* Occupational / Controlled Exposure: 5.0 mW/cm^2

The purpose of this study is to determine the power flux density levels for the earth station under study as compared with the MPE limits. This comparison is done in each of the following regions:

1. Far-field region
2. Near-field region
3. Transition region
4. The region between the feed and the antenna surface
5. The main reflector region
6. The region between the antenna edge and the ground

Input Parameters

The following input parameters were used in the calculations:

Input Parameter	Value	Unit	Symbol
Antenna Diameter	1.20	m	D
Antenna Transmit Gain	48.50	dBi	G
Transmit Frequency	29100.0	MHz	f
Antenna Feed Flange Diam.	6.00	cm	d
Power Input to the Antenna	40.00	Watts	P

Calculated Parameters

The following values were calculated using the above input parameters and the corresponding formula:

Calculated Parameter	Value	Unit	Symbol	Formula
Antenna Surface Area	1.13	m²	A	πD²/4
Area of Antenna Flange	28.3	cm²	a	πd²/4
Antenna Efficiency	0.53	real	η	gλ²/(π²D²)
Gain Factor	70795	real	g	10^(G/10)
Wavelength	0.010	m	λ	300/f

Behavior of EM Fields as a Function of Distance

The behavior of the characteristics of EM fields varies depending on the distance from the radiating antenna. These characteristics are analyzed in three primary regions: the near-field region, the far-field region and the transition region. Of interest also are the region between the antenna main reflector and the subreflector, the region of the main reflector area and the region between the main reflector and ground.

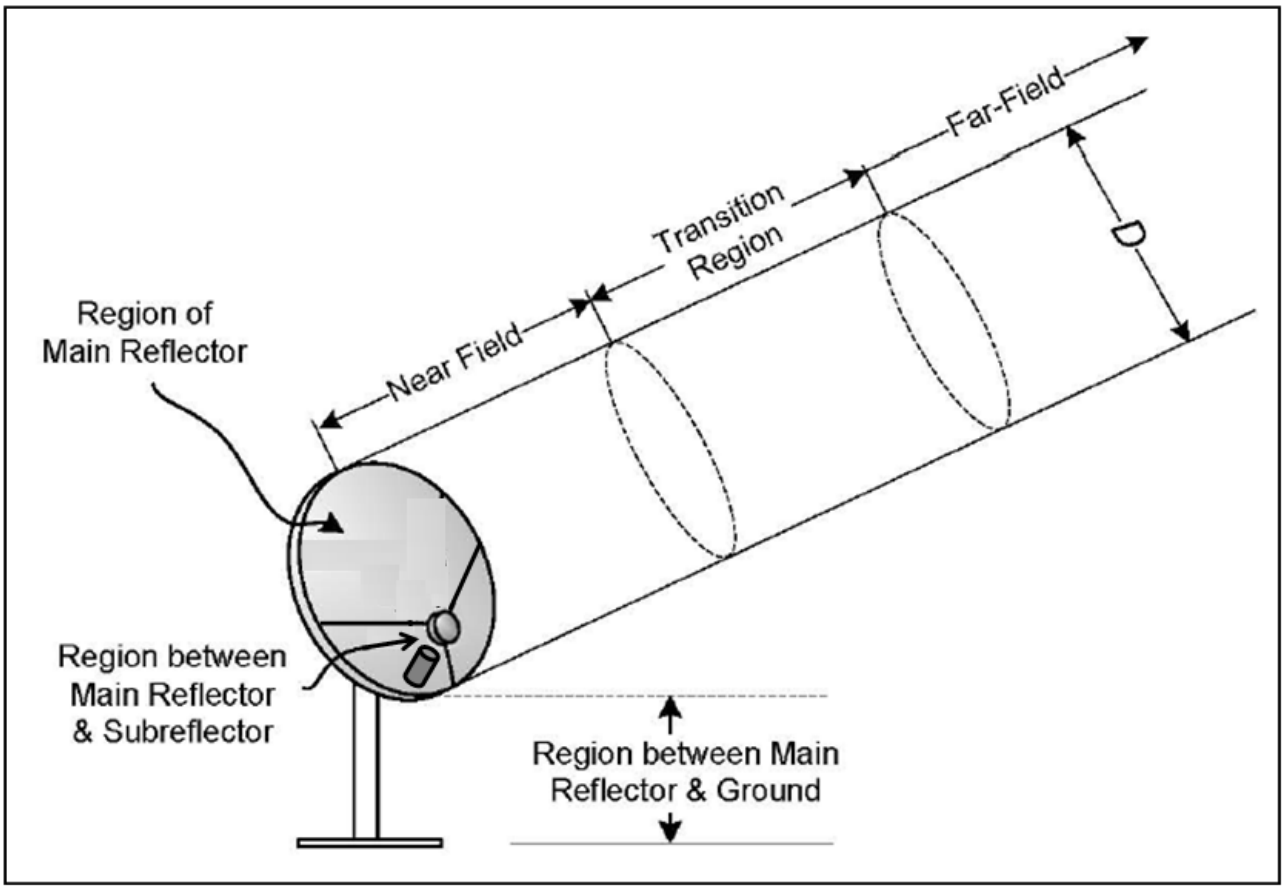


Figure 1. Electro-Magnetic Fields as a Function of Distance

For parabolic aperture antennas with circular cross sections, such as the antenna under study, the near-field, far-field and transition region distances are calculated as follows:

Calculated Parameter	Value	Unit	Symbol	Formula
Near-Field Distance	34.92	m	Rnf	$D^2/(4\lambda)$
Distance to Far-Field	83.81	m	Rff	$0.6D^2/\lambda$
Distance of Transition Region	34.92	m	Rt	Rt=Rnf

The distance in the transition region is between the near and far fields. Thus, Rnf ≤ Rt ≤ Rff . However, the power density in the transition region will not exceed the power density in the near-field. Therefore, for purposes of the present analysis, the distance of the transition region can equate the distance to the near-field.

Power Flux Density Calculations

The power flux density is considered to be at a maximum through the entire length of the near-field. This region is contained within a cylindrical volume with a diameter, *D*, equal to the diameter of the antenna. In the transition region and the far-field, the power density decreases inversely with the square of the distance. The following equations are used to calculate power density in these regions:

Calculated Parameter	Value	Unit	Symbol	Formula
Power Density in the Near-Field	7.49	mW/cm^2	Snf	$16\eta P/(\pi D^2)$
Power Density in the Far-Field	3.21	mW/cm^2	Sff	$gP/(4\pi Rff^2)$
Power Density in the Transition Region	7.49	mW/cm^2	St	Snf*Rnf/Rt

The region between the main reflector and the subreflector is confined to within a conical shape defined by the feed assembly. The most common feed assemblies are waveguide flanges. This energy is determined as follows:

Calculated Parameter	Value	Unit	Symbol	Formula
Power Density at the Feed Flange	5658.8	mW/cm^2	Sfa	4P/a

The power density in the main reflector is determined similarly to the power density at the feed flange; except that the area of the reflector is used.

Calculated Parameter	Value	Unit	Symbol	Formula
Power Density at Main Reflector	14.15	mW/cm^2	Ssurface	4P/A

The power density between the reflector and ground, assuming uniform illumination of the reflector surface, is calculated as follows:

Calculated Parameter	Value	Unit	Symbol	Formula
Power Density between Reflector & Gnd	3.54	mW/cm^2	Sg	P/A

Summary of Calculations

Table 1 below summarizes the calculated power flux density values for each region. In a controlled environment, the only regions that exceed FCC limitations are the regions between the main reflector and the sub-reflector as well as the main reflector region. These regions are only accessible by trained technicians who, as a matter of procedure, turn off transmit power before performing any work in these areas.

Table 1. Power Flux Density for Each Region:

Calculated Parameter	**Unit**	**Exposure Limit**	**Exposure Limit**
Power Densities	**mW/cm²**	**Uncontrolled Environment ≤ 1 mW/cm²**	**Controlled Environment ≤ 5 mW/cm²**
Far Field Calculation	3.21	Exceeds limitations	Satisfies FCC MPE
Near Field Calculation	7.49	Exceeds limitations	Exceeds limitations
Transition Region	7.49	Exceeds limitations	Exceeds limitations
Region between Main & Subreflector	5658.8	Exceeds limitations	Exceeds limitations
Main Reflector Region	14.15	Exceeds limitations	Exceeds limitations
Region between Main Reflector & Gnd	3.54	Exceeds limitations	Satisfies FCC MPE

In conclusion, the results show that the antenna, in a controlled environment, and under the proper mitigation procedures, meets the guidelines specified in § 1.1310 of the Regulations.

Radiation Hazard Study

The study in this section analyzes the potential RF human exposure levels caused by the Electro Magnetic (EM) fields of an Orbit AL-7107-Ka 2.2m antenna operating with a maximum power at the flange of 40 Watts. The mathematical analysis performed below complies with the methods described in the FCC Office of Engineering and Technology (OET) Bulletin No. 65 (1985 rev. 1997) R&O 96-3 26 in "Evaluating Compliance with FCC Guideliness for Human Exposure to RF EM Fields, OET Bulletin 65 (Edition 97-01), Supplement B, FCC Office of Engineering & Technology, November 1997".

Maximum Permissible Exposure

There are two separate levels of exposure limits. The first applies to persons in the general population who are in an uncontrolled environment. The second applies to trained personnel in a controlled environment. According to 47 C.F.R. § 1.1310, the Maximum Permissible Exposure (MPE) limits for frequencies above 1.5 GHz are as follows:

* General Population / Uncontrolled Exposure: 1.0 mW/cm^2
* Occupational / Controlled Exposure: 5.0 mW/cm^2

The purpose of this study is to determine the power flux density levels for the earth station under study as compared with the MPE limits. This comparison is done in each of the following regions:

1. Far-field region
2. Near-field region
3. Transition region
4. The region between the feed and the antenna surface
5. The main reflector region
6. The region between the antenna edge and the ground

Input Parameters

The following input parameters were used in the calculations:

Input Parameter	Value	Unit	Symbol
Antenna Diameter	2.20	m	D
Antenna Transmit Gain	54.50	dBi	G
Transmit Frequency	29100.0	MHz	f
Antenna Feed Flange Diam.	8.00	cm	d
Power Input to the Antenna	40.00	Watts	P

Calculated Parameters

The following values were calculated using the above input parameters and the corresponding formula:

Calculated Parameter	Value	Unit	Symbol	Formula
Antenna Surface Area	3.80	m²	A	πD²/4
Area of Antenna Flange	50.3	cm²	a	πd²/4
Antenna Efficiency	0.63	real	η	gλ²/(π²D²)
Gain Factor	281838	real	g	10^(G/10)
Wavelength	0.010	m	λ	300/f

Behavior of EM Fields as a Function of Distance

The behavior of the characteristics of EM fields varies depending on the distance from the radiating antenna. These characteristics are analyzed in three primary regions: the near-field region, the far-field region and the transition region. Of interest also are the region between the antenna main reflector and the subreflector, the region of the main reflector area and the region between the main reflector and ground.

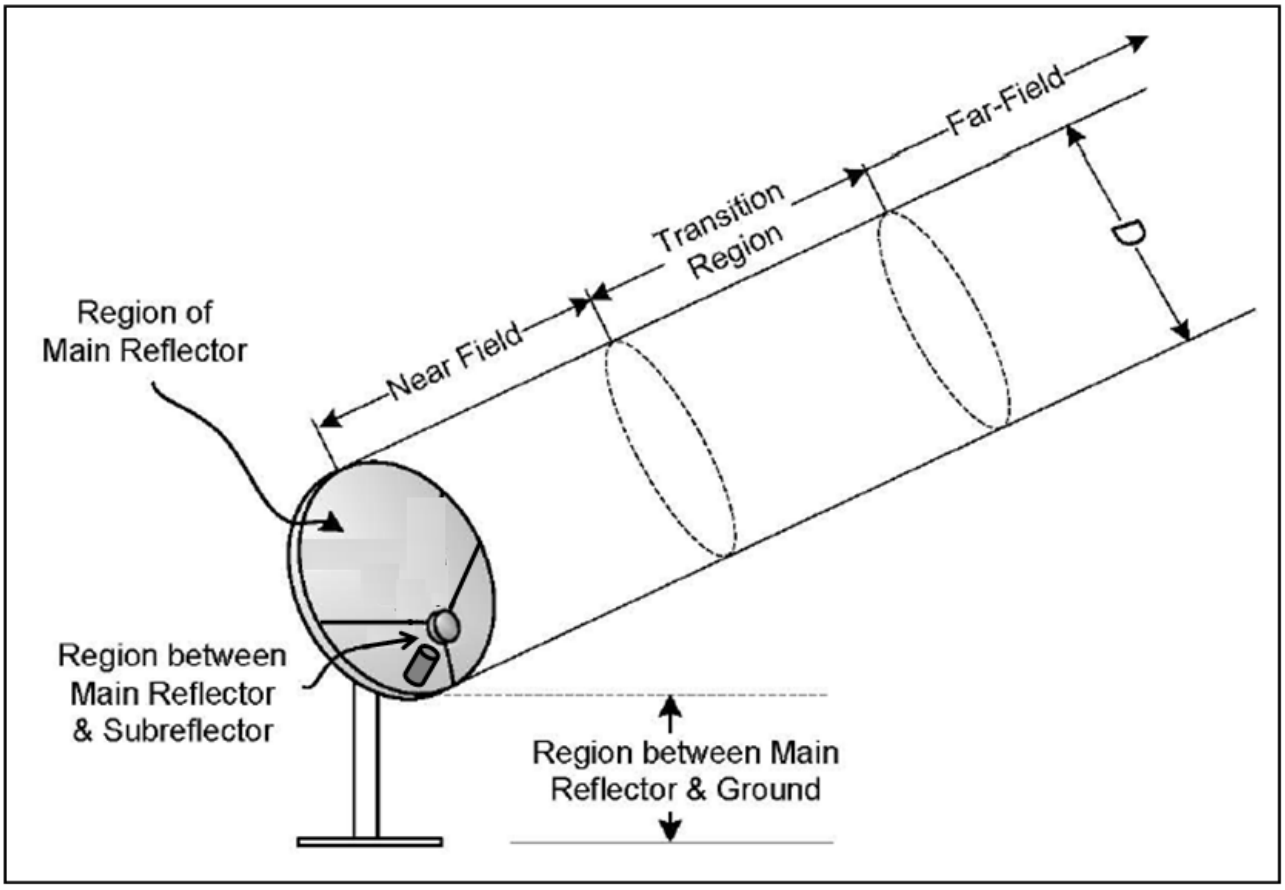


Figure 1. Electro-Magnetic Fields as a Function of Distance

For parabolic aperture antennas with circular cross sections, such as the antenna under study, the near-field, far-field and transition region distances are calculated as follows:

Calculated Parameter	Value	Unit	Symbol	Formula
Near-Field Distance	117.37	m	Rnf	$D^2/(4\lambda)$
Distance to Far-Field	281.69	m	Rff	$0.6D^2/\lambda$
Distance of Transition Region	117.37	m	Rt	Rt=Rnf

The distance in the transition region is between the near and far fields. Thus, Rnf ≤ Rt ≤ Rff . However, the power density in the transition region will not exceed the power density in the near-field. Therefore, for purposes of the present analysis, the distance of the transition region can equate the distance to the near-field.

Power Flux Density Calculations

The power flux density is considered to be at a maximum through the entire length of the near-field. This region is contained within a cylindrical volume with a diameter, *D*, equal to the diameter of the antenna. In the transition region and the far-field, the power density decreases inversely with the square of the distance. The following equations are used to calculate power density in these regions:

Calculated Parameter	Value	Unit	Symbol	Formula
Power Density in the Near-Field	2.64	mW/cm^2	Snf	$16\eta P/(\pi D^2)$
Power Density in the Far-Field	1.13	mW/cm^2	Sff	$gP/(4\pi Rff^2)$
Power Density in the Transition Region	2.64	mW/cm^2	St	Snf*Rnf/Rt

The region between the main reflector and the subreflector is confined to within a conical shape defined by the feed assembly. The most common feed assemblies are waveguide flanges. This energy is determined as follows:

Calculated Parameter	Value	Unit	Symbol	Formula
Power Density at the Feed Flange	3183.1	mW/cm^2	Sfa	4P/a

The power density in the main reflector is determined similarly to the power density at the feed flange; except that the area of the reflector is used.

Calculated Parameter	Value	Unit	Symbol	Formula
Power Density at Main Reflector	4.21	mW/cm^2	Ssurface	4P/A

The power density between the reflector and ground, assuming uniform illumination of the reflector surface, is calculated as follows:

Calculated Parameter	Value	Unit	Symbol	Formula
Power Density between Reflector & Gnd	1.05	mW/cm²	Sg	P/A

Summary of Calculations

Table 1 below summarizes the calculated power flux density values for each region. In a controlled environment, the only regions that exceed FCC limitations are the regions between the main reflector and the sub-reflector as well as the main reflector region. These regions are only accessible by trained technicians who, as a matter of procedure, turn off transmit power before performing any work in these areas.

Table 1. Power Flux Density for Each Region:

Calculated Parameter	Unit	Exposure Limit	Exposure Limit
Power Densities	**mW/cm²**	**Uncontrolled Environment ≤ 1 mW/cm²**	**Controlled Environment ≤ 5 mW/cm²**
Far Field Calculation	1.13	Exceeds limitations	Satisfies FCC MPE
Near Field Calculation	2.64	Exceeds limitations	Satisfies FCC MPE
Transition Region	2.64	Exceeds limitations	Satisfies FCC MPE
Region between Main & Subreflector	3183.1	Exceeds limitations	Exceeds limitations
Main Reflector Region	4.21	Exceeds limitations	Satisfies FCC MPE
Region between Main Reflector & Gnd	1.05	Exceeds limitations	Satisfies FCC MPE

In conclusion, the results show that the antenna, in a controlled environment, and under the proper mitigation procedures, meets the guidelines specified in § 1.1310 of the Regulations.

Annex 4: Interference Analysis related to Foreign Fixed Services ("FS")

This annex contains the results of interference studies related to the transmitting ESV terminal and potential FS receiving stations operating outside of the USA in the 28.6-29.1 GHz band.

Initially the ITU's Appendix 7 coordination contour software was used. This resulted in the coordination contours given in Figures A4-1 and A4-2 for a notional ship location of 75°W longitude and 25°N latitude. The full results from the ITU software in tabular form are given in Tables A4-1 and A4-2 at the end of this annex. A minimum ESV antenna elevation of 10° in all directions was used. Maximum PSD levels of -57.7 dBW/Hz (i.e., -11.7 dBW/40kHz) for the 1.2 meter ESV terminal and -57.6 dBW/Hz (i.e., -11.6 dBW/40kHz) for the 2.2 meter ESV terminal were assumed. The resulting coordination contours are identical for the two ESV terminal types and have a constant radius of 96 km. The reason for this is that the ITU Appendix 7 methodology defaults to a minimum coordination distance that is dependent only on the frequency and the latitude of the earth station and is completely independent of the power density levels or antenna characteristics of the earth station. This minimum coordination distance is therefore not meant to be representative of the distance over which actual unacceptable interference to the FS might occur.

Diagram 2: 2.2_TABLE7. TRANSMITTING NGSO ES in FIXED-SATELLITE SERVICE W.R.T. RECEIVING TERRESTRIAL STATIONS. TS in FS or MS

Notice ID: 1
Administration/Geographical area: USA/USA
Satellite orbital position: -
Frequency band: 28600.00-29100.00 MHz

Earth station name: O3B_ESV_1.2M
Earth station position: 075W000025N0000
Satellite name: O3B

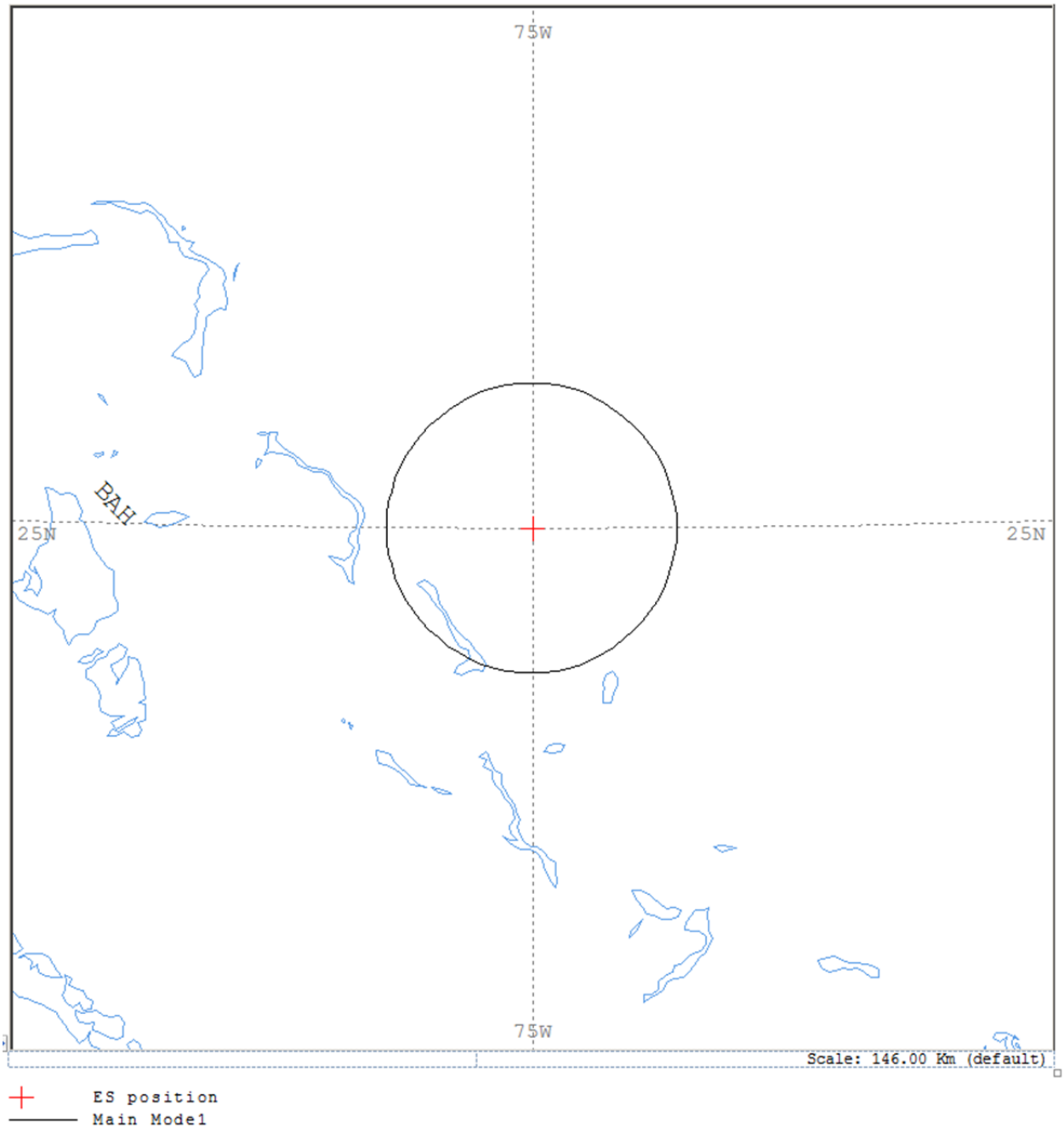


Figure A4-1:

Minimum Default Transmit Coordination Contour from ITU Appendix 7 for 1.2m ESV Terminal

Diagram 1: 2.2_TABLE7. TRANSMITTING NGSO ES in FIXED-SATELLITE SERVICE W.R.T. RECEIVING TERRESTRIAL STATIONS. TS in FS or MS

Notice ID: 3
Administration/Geographical area: USA/USA
Satellite orbital position: -
Frequency band: 28600.00-29100.00 MHz

Earth station name: O3B_ESV_2.2M
Earth station position: 075W000025N0000
Satellite name: O3B

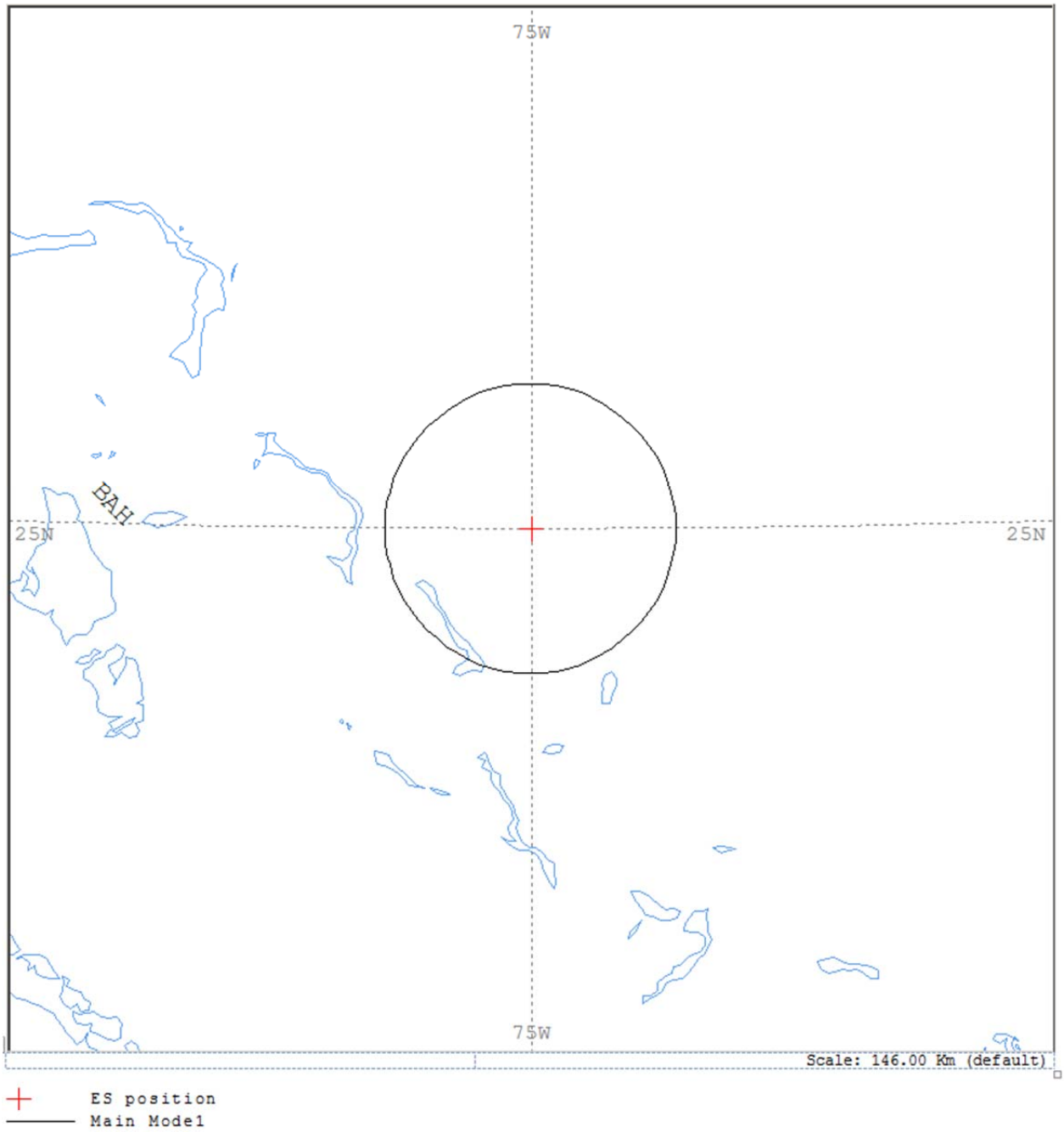


Figure A4-2:

Minimum Default Transmit Coordination Contour from ITU Appendix 7 for 2.2m ESV Terminal

The next analysis involved a static worst-case interference calculation using the likely characteristics of the victim FS receiver and the actual geometry of the interference path (i.e., correct height of the ESV terminal above sea level, representative FS receive antenna gain and height). The same Appendix 7 interference criterion was used for the FS which is the short-term limit requiring the received interference signal power not to exceed -111 dBW/MHz for more than 0.0025% of the time. The key parameters of this interference calculation are as follows:

- The worst case static geometry is assumed, whereby:
    - The azimuth pointing direction of the ESV terminal is assumed to be directly towards the victim FS receiver, and the ESV terminal elevation is assumed to be the minimum operational level of 10° at all times;
    - The victim FS receiver is assumed to be pointing directly towards the ship equipped with the transmitting ESV terminal;
    - The location of the ESV is fixed at the given location for 100% of time;
    - The interference path is entirely over water.
- The propagation model used was ITU-R Rec. P.452-14 in smooth Earth mode.
- The FS receive antenna is assumed to be the largest that is typically available for use in the 28 GHz FS band. This has a diameter of 0.6 meters and a corresponding peak gain of 43 dBi.[7]
- The antenna height of the ESV terminal above sea level is assumed to be 60 meters, which accurately represents the situation for the O3b ESV terminals to be deployed. The FS receiver is assumed to be 10 meters above the ground level.

The ESV terminal maximum off-axis EIRP density characteristics are provided elsewhere in this application. For negative elevation angles of greater than or equal to 10° (i.e., from -10° to -90°), which corresponds to the horizontal direction towards the victim FS receiver, the maximum EIRP density is less than -20 dBW/40 kHz (or -6 dBW/MHz) for both the 1.2

[7] Note that the latest version of ITU-R Recommendation F.758-3 proposes that a significantly lower antenna gain of 31.5 dBi be assumed for sharing studies involving point-to-point FS receivers operating in this band, and that such a small FS antenna would reduce the potential interference by 11.5 dB, corresponding to a reduction in the coordination distance of at least 50%.

meter and 2.2 meter ESV terminals. Using this value the interfering signal power at the victim FS receiver was calculated, as a function of the distance between the ESV terminal and the FS receiver, and is given in Figure A4-3.

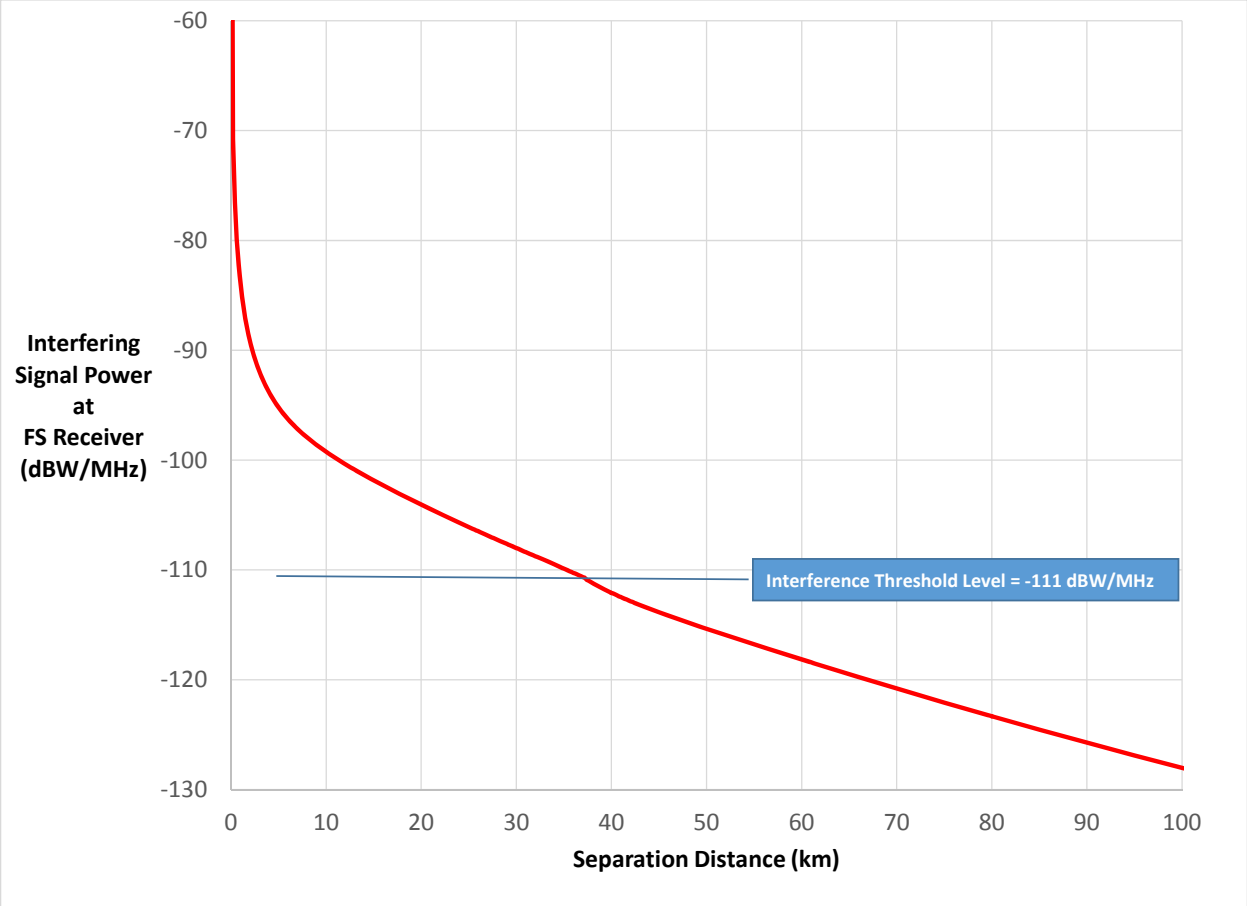


Figure A4-3:
Interfering Signal Power at the FS Receiver vs Distance

This result shows that the threshold interference level of -111 dBW/MHz is met for a separation distance of approximately 38 km, which is significantly less than the default minimum distance of approximately 100 km given by the ITU Appendix 7 methodology presented above. The slope of the curve in Figure A4-3 above is greater than 25 km for every 10 dB for distances less than approximately 40 km. Additional significant attenuation of the interfering signal would occur in practice for a several reasons, such as:

a) Off-axis discrimination from the FS receiver antenna boresight, which has a -3 dB half-cone beamwidth of approximately 0.6°;
b) Additional off-axis discrimination of the ESV antenna when it is tracking the O3b satellite at higher elevation angles than the minimum 10°.

Taking into account the motion of the ESV and the narrow antenna beam of the FS receiver, an initial Monte Carlo analysis has been performed that suggests that interference is likely to be below the Appendix 7 threshold level as long as the ESV does not transmit within 10 to 20 km of the coastline, depending upon the ESV maximum EIRP density.

Diagram 2: 2.2_TABLE7. TRANSMITTING NGSO ES in FIXED-SATELLITE SERVICE W.R.T. RECEIVING TERRESTRIAL STATIONS, TS in FS or MS

NOTICE ID: 1 EARTH STATION NAME: O3B_ESV_1.2M EARTH STATION POSITION: 075W000025N0000 PHASE: D
ADM/GEO_AREA: USA/USA RAIN CLIMATICAL ZONE: N
SATELLITE NAME: O3B SATELLITE ORBITAL POSITION: - DEG
ANTENNA AZIMUTH: - DEG ANTENNA ELEVATION: - DEG
FREQUENCY BAND: 28600.00-29100.00 MHZ ASSIGNED FREQUENCY: 28850.00 MHZ PERCENTAGE OF TIME: 0.0025 %
MAXIMUM ANTENNA GAIN: 49.4 DBI MAXIMUM POWER DENSITY: -57.7 DBW/HZ NOISE TEMPERATURE: - K
ANTENNA PATTERN: APENST806V01
2.2_TABLE7 Model: PLM_DUCTING

TRANSMISSION LOSS MODE 1: 163.3 DB (DOES NOT INCLUDE HOR. CORR. AND ANT. GAIN)
TRANSMISSION LOSS MODE 2:

AZIMUTH	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115
OFF-AXIS	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
HOR.ELEV.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HOR.CORR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ANT.GAIN	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
COORDINATION DISTANCE (KM)																								
MODE 1																								
0.0 DB	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96

AZIMUTH	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230	235
OFF-AXIS	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
HOR.ELEV.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HOR.CORR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ANT.GAIN	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
COORDINATION DISTANCE (KM)																								
MODE 1																								
0.0 DB	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96

AZIMUTH	240	245	250	255	260	265	270	275	280	285	290	295	300	305	310	315	320	325	330	335	340	345	350	355
OFF-AXIS	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
HOR.ELEV.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HOR.CORR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ANT.GAIN	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
COORDINATION DISTANCE (KM)																								
MODE 1																								
0.0 DB	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96

PROBABLY AFFECTED COUNTRIES: BAH

Table A4-1:

Transmit Coordination Contour Results from ITU Appendix 7 for 1.2m ESV Terminal

Diagram 1: 2.2_TABLE7. TRANSMITTING NGSO ES in FIXED-SATELLITE SERVICE W.R.T. RECEIVING TERRESTRIAL STATIONS, TS in FS or MS

NOTICE ID: 3 EARTH STATION NAME: O3B_ESV_2.2M EARTH STATION POSITION: 075W000025N0000 PHASE: D
ADM/GEO_AREA: USA/USA RAIN CLIMATICAL ZONE: N
SATELLITE NAME: O3B SATELLITE ORBITAL POSITION: - DEG
ANTENNA AZIMUTH: - DEG ANTENNA ELEVATION: - DEG
FREQUENCY BAND: 28600.00-29100.00 MHZ ASSIGNED FREQUENCY: 28850.00 MHZ PERCENTAGE OF TIME: 0.0025 %
MAXIMUM ANTENNA GAIN: 54.6 DBI MAXIMUM POWER DENSITY: -57.7 DBW/HZ NOISE TEMPERATURE: - K
ANTENNA PATTERN: APENST806V01
2.2_TABLE7 Model: PLM_DUCTING

TRANSMISSION LOSS MODE 1: 163.3 DB (DOES NOT INCLUDE HOR. CORR. AND ANT. GAIN)
TRANSMISSION LOSS MODE 2:

AZIMUTH	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115
OFF-AXIS	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
HOR.ELEV.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HOR.CORR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ANT.GAIN	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
COORDINATION DISTANCE (KM)																								
MODE 1																								
0.0 DB	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96

AZIMUTH	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230	235
OFF-AXIS	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
HOR.ELEV.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HOR.CORR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ANT.GAIN	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
COORDINATION DISTANCE (KM)																								
MODE 1																								
0.0 DB	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96

AZIMUTH	240	245	250	255	260	265	270	275	280	285	290	295	300	305	310	315	320	325	330	335	340	345	350	355
OFF-AXIS	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
HOR.ELEV.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HOR.CORR.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ANT.GAIN	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
COORDINATION DISTANCE (KM)																								
MODE 1																								
0.0 DB	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96

PROBABLY AFFECTED COUNTRIES: BAH

Table A4-2:

Transmit Coordination Contour Results from ITU Appendix 7 for 2.2m ESV Terminal

Annex 5: Representative Link Budgets for the O3b ESV Service

This annex contains example link budgets for various scenarios of the O3b ESV service. These are provided for the following:

- Three different ESV/ship locations:
  - San Juan, Puerto Rico;
  - 7°N latitude located just to the south-west of the Panama Canal;
  - 50°N latitude located just west of Newfoundland.
- Two different ESV antenna sizes: 1.2 meter and 2.2 meter.
- Various transmission data rates:
  - 180 MSymbols/s in both forward and return links between gateway and 2.2 meter ESV;
  - 30 MSymbols/s in the forward direction and 10 MSymbols/s in the return direction between gateway and 2.2 meter ESV;
  - 45 MSymbols/s in the forward direction and 4.1 MSymbols/s in the return direction between gateway and 1.2 meter ESV.
- Two different weather conditions.
- The use of adaptive coding and modulation is assumed throughout.

The link budgets are provided in the following 36 pages.

O3b Network Link Analysis - Tier 2 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: May 15, 2013		Tier 2	Tier 2
Ground Parameter		**Teleport**	**Telco**
Location		Vernon (LHCP), United States	San Juan-, United States
Latitude	(°)	34.2	18.5
Longitude (East)	(°)	260.7	293.9
E/S Maximum Range to SV	(km)	9986.9	9329.7
E/S Minimmum Elevation to SV	(°)	32.3	42.8
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)	25	
Minutes Into Pass (Sample #45)	(Min)	21:17	
Telco Spot Beam Off-Angle	(°)	0.20	
Telco Spot Beam Diameter	(km)	60.30	
Maximum Roundtrip Latency	(msec)	128.87	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	3.5%	
Number of Carriers per Channel	(#)	1	
Available Bandwidth	(Hz)	216,000,000	
Available Throughput	(bps)	**521,337,648**	
Channel Symbol Rate	(sps)	180,000,000	
Channel Modulation Type		16APSK	
Channel FEC Rate		0.75	
Channel Spectral Efficiency	(bits/Sym)	3.00	
Channel Throughput (100% / 100% of Full Rate)	(bps)	521,337,648.33	
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)	5	
E/S Tx Carrier Frequency	(MHz)	28,963	
E/S Tx HPA Power Level	(W)	500	
E/S Tx OBO	(dB)	-4.00	
E/S Tx Post-HPA Losses	(dB)	-2.24	
E/S Tx Antenna Gain (7.3 m / 2.2 m)	(dB)	65.11	
E/S Tx EIRP Per Channel	(dBW)	78.87	
E/S Tx Pointing Loss	(dB)	-0.50	
E/S Tx RF Link Availability	(%)	75.000	
E/S Tx Atmospheric Losses	(dB)	-1.20	
E/S Tx Spreading Loss	(dB)	-150.98	
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	5.24	
SV Rx Power Per Tier	(dBW)	-119.27	
SV Rx Flux Density Per Tier	(dBW/m^2)	-73.82	
SV Tx OBO (ALC / ALC)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	31.54	
SV Tx EIRP Per Channel/Carrier	(dBW)	44.37	
SV Tx Pointing Loss	(dB)	0.00	
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)	19,163	
E/S Rx Wavelength	(m)	0.015644	
E/S Rx RF Link Availability	(%)	75.000	
E/S Rx Atmospheric Losses	(dB)	-1.05	
E/S Rx Radome & Pointing Loss	(dB)	-1.00	
E/S Rx Antenna Gain (2.2 m / 7.3 m)	(dBi)	48.81	
E/S Rx Effective G/T	(dB/K)	24.72	
E/S Rx Power Per Channel	(dBW)	-106.36	
E/S Rx Flux Density Per Channel	(dBW/m^2)	-108.07	
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)	82.55	
Carrier / Noise Uplink	(dB)	26.77	
Carrier / Noise Downlink	(dB)	15.60	
Carrier / Intermodulation Im (C/Im)	(dB)	23.53	
(C/N) - Total Actual	(dB)	12.64	
(C/N) - Total Required	(dB)	12.30	
(E_b/N_o) - Total Actual	(dB)	7.87	
(E_b/N_o) - Total Required	(dB)	7.53	
Excess Margin	**(dB)**	**0.34**	
Fade Margin	**(dB)**	**14.84**	

O3b Network Link Analysis - Tier 2 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: May 15, 2013		Tier 2	Tier 2
Ground Parameter		**Teleport**	**Telco**
Location		Vernon (LHCP), United States	San Juan-, United States
Latitude	(°)	34.2	18.5
Longitude (East)	(°)	260.7	293.9
E/S Maximum Range to SV	(km)	9986.9	9329.7
E/S Minimmum Elevation to SV	(°)	32.3	42.8
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)	25	
Minutes Into Pass (Sample #45)	(Min)	21:17	
Telco Spot Beam Off-Angle	(°)	0.20	
Telco Spot Beam Diameter	(km)	60.30	
Maximum Roundtrip Latency	(msec)	128.87	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type		DVB-S2
Modem Overhead	(%)		3.1%
Number of Carriers per Channel	(#)		1
Available Bandwidth	(Hz)		216,000,000
Available Throughput	(bps)		**290,751,758**
Channel Symbol Rate	(sps)		180,000,000
Channel Modulation Type			QPSK
Channel FEC Rate			0.83
Channel Spectral Efficiency	(bits/Sym)		1.67
Channel Throughput (100% / 100% of Full Rate)	(bps)		290,751,757.71
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)		1
E/S Tx Carrier Frequency	(MHz)		28,963
E/S Tx HPA Power Level	(W)		40
E/S Tx OBO	(dB)		-6.00
E/S Tx Post-HPA Losses	(dB)		-0.69
E/S Tx Antenna Gain (7.3 m / 2.2 m)	(dB)		52.62
E/S Tx EIRP Per Channel	(dBW)		61.95
E/S Tx Radome & Pointing Loss	(dB)		-1.00
E/S Tx RF Link Availability	(%)		75.000
E/S Tx Atmospheric Losses	(dB)		-1.59
E/S Tx Spreading Loss	(dB)		-150.39
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)		5
SV Rx G/T	(dB/K)		4.34
SV Rx Power Per Tier	(dBW)		-137.39
SV Rx Flux Density Per Tier	(dBW/m^2)		-91.03
SV Tx OBO (ALC / ALC)	(dB)		-5.80
SV Tx Post-TWTA Losses	(dB)		-1.50
SV Tx Antenna Gain	(dBi)		31.77
SV Tx EIRP Per Channel/Carrier	(dBW)		35.61
SV Tx Pointing Loss	(dB)		0.00
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)		19,163
E/S Rx Spreading Loss	(dB)		-150.98
E/S Rx RF Link Availability	(%)		75.000
E/S Rx Atmospheric Losses	(dB)		-0.86
E/S Rx Pointing Loss	(dB)		-0.50
E/S Rx Antenna Gain (2.2 m / 7.3 m)	(dBi)		62.35
E/S Rx Effective G/T	(dB/K)		39.14
E/S Rx Power Per Channel	(dBW)		-101.48
E/S Rx Flux Density Per Channel	(dBW/m^2)		-116.73
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)		82.55
Carrier / Noise Uplink	(dB)		8.66
Carrier / Noise Downlink	(dB)		21.36
Carrier / Intermodulation Im (C/Im)	(dB)		23.28
(C/N) - Total Actual	(dB)		6.98
(C/N) - Total Required	(dB)		6.50
(E_b/N_o) - Total Actual	(dB)		4.77
(E_b/N_o) - Total Required	(dB)		4.28
Excess Margin	**(dB)**		**0.48**
Fade Margin	**(dB)**		**9.18**

O3b Network Link Analysis - Tier 2 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: May 15, 2013		Tier 2	Tier 2
Ground Parameter		**Teleport**	**Telco**
Location		Vernon (LHCP), United States	San Juan-, United States
Latitude	(°)	34.2	18.5
Longitude (East)	(°)	260.7	293.9
E/S Maximum Range to SV	(km)	9840.6	10014.2
E/S Minimmum Elevation to SV	(°)	34.5	31.9
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)	25	
Minutes Into Pass (Sample #25)	(Min)	11:37	
Telco Spot Beam Off-Angle	(°)	0.20	
Telco Spot Beam Diameter	(km)	60.30	
Maximum Roundtrip Latency	(msec)	132.46	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	3.1%	
Number of Carriers per Channel	(#)	1	
Available Bandwidth	(Hz)	216,000,000	
Available Throughput	(bps)	**290,751,758**	
Channel Symbol Rate	(sps)	180,000,000	
Channel Modulation Type		QPSK	
Channel FEC Rate		0.83	
Channel Spectral Efficiency	(bits/Sym)	1.67	
Channel Throughput (100% / 100% of Full Rate)	(bps)	290,751,757.71	
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)	5	
E/S Tx Carrier Frequency	(MHz)	28,963	
E/S Tx HPA Power Level	(W)	500	
E/S Tx OBO	(dB)	-4.00	
E/S Tx Post-HPA Losses	(dB)	-2.24	
E/S Tx Antenna Gain (7.3 m / 2.2 m)	(dB)	65.11	
E/S Tx EIRP Per Channel	(dBW)	78.87	
E/S Tx Pointing Loss	(dB)	-0.50	
E/S Tx RF Link Availability	(%)	75.000	
E/S Tx Atmospheric Losses	(dB)	-1.15	
E/S Tx Spreading Loss	(dB)	-150.85	
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	5.24	
SV Rx Power Per Tier	(dBW)	-119.09	
SV Rx Flux Density Per Tier	(dBW/m^2)	-73.63	
SV Tx OBO (ALC / ALC)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	31.60	
SV Tx EIRP Per Channel/Carrier	(dBW)	44.43	
SV Tx Pointing Loss	(dB)	0.00	
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)	19,163	
E/S Rx Wavelength	(m)	0.015644	
E/S Rx RF Link Availability	(%)	99.000	
E/S Rx Atmospheric Losses	(dB)	-6.77	
E/S Rx Radome & Pointing Loss	(dB)	-1.00	
E/S Rx Antenna Gain (2.2 m / 7.3 m)	(dBi)	48.81	
E/S Rx Effective G/T	(dB/K)	23.00	
E/S Rx Power Per Channel	(dBW)	-112.64	
E/S Rx Flux Density Per Channel	(dBW/m^2)	-114.35	
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)	82.55	
Carrier / Noise Uplink	(dB)	26.96	
Carrier / Noise Downlink	(dB)	7.60	
Carrier / Intermodulation Im (C/Im)	(dB)	23.53	
(C/N) - Total Actual	(dB)	6.97	
(C/N) - Total Required	(dB)	6.50	
(E_b/N_o) - Total Actual	(dB)	4.75	
(E_b/N_o) - Total Required	(dB)	4.28	
Excess Margin	**(dB)**	**0.47**	
Fade Margin	**(dB)**	**9.17**	

O3b Network Link Analysis - Tier 2 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: May 15, 2013		Tier 2	Tier 2
Ground Parameter		**Teleport**	**Telco**
Location		Vernon (LHCP), United States	San Juan-, United States
Latitude	(°)	34.2	18.5
Longitude (East)	(°)	260.7	293.9
E/S Maximum Range to SV	(km)	9840.6	10014.2
E/S Minimmum Elevation to SV	(°)	34.5	31.9
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)	25	
Minutes Into Pass (Sample #25)	(Min)	11:37	
Telco Spot Beam Off-Angle	(°)	0.20	
Telco Spot Beam Diameter	(km)	60.30	
Maximum Roundtrip Latency	(msec)	132.46	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type		DVB-S2
Modem Overhead	(%)		3.9%
Number of Carriers per Channel	(#)		1
Available Bandwidth	(Hz)		216,000,000
Available Throughput	(bps)		**115,348,837**
Channel Symbol Rate	(sps)		180,000,000
Channel Modulation Type			QPSK
Channel FEC Rate			0.33
Channel Spectral Efficiency	(bits/Sym)		0.67
Channel Throughput (100% / 100% of Full Rate)	(bps)		115,348,837.21
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)		1
E/S Tx Carrier Frequency	(MHz)		28,963
E/S Tx HPA Power Level	(W)		40
E/S Tx OBO	(dB)		-1.17
E/S Tx Post-HPA Losses	(dB)		-0.69
E/S Tx Antenna Gain (7.3 m / 2.2 m)	(dB)		52.62
E/S Tx EIRP Per Channel	(dBW)		66.78
E/S Tx Radome & Pointing Loss	(dB)		-1.00
E/S Tx RF Link Availability	(%)		99.000
E/S Tx Atmospheric Losses	(dB)		-13.11
E/S Tx Spreading Loss	(dB)		-151.00
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)		5
SV Rx G/T	(dB/K)		4.52
SV Rx Power Per Tier	(dBW)		-144.50
SV Rx Flux Density Per Tier	(dBW/m^2)		-98.34
SV Tx OBO (ALC / ALC)	(dB)		-5.80
SV Tx Post-TWTA Losses	(dB)		-1.50
SV Tx Antenna Gain	(dBi)		31.77
SV Tx EIRP Per Channel/Carrier	(dBW)		35.61
SV Tx Pointing Loss	(dB)		0.00
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)		19,163
E/S Rx Spreading Loss	(dB)		-150.85
E/S Rx RF Link Availability	(%)		75.000
E/S Rx Atmospheric Losses	(dB)		-0.82
E/S Rx Pointing Loss	(dB)		-0.50
E/S Rx Antenna Gain (2.2 m / 7.3 m)	(dBi)		62.35
E/S Rx Effective G/T	(dB/K)		39.15
E/S Rx Power Per Channel	(dBW)		-101.31
E/S Rx Flux Density Per Channel	(dBW/m^2)		-116.56
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)		82.55
Carrier / Noise Uplink	(dB)		1.54
Carrier / Noise Downlink	(dB)		21.53
Carrier / Intermodulation Im (C/Im)	(dB)		18.35
(C/N) - Total Actual	(dB)		1.21
(C/N) - Total Required	(dB)		0.30
(E_b/N_o) - Total Actual	(dB)		2.97
(E_b/N_o) - Total Required	(dB)		2.06
Excess Margin	**(dB)**		**0.91**
Fade Margin	**(dB)**		**3.41**

O3b Network Link Analysis - Tier 2 Service For ESOMPs 7 deg lat, ocean

Link Budget Creator - Rev 3.2.9: May 15, 2013		Tier 2	Tier 2
Ground Parameter		**Teleport**	**Telco**
Location		Vernon (LHCP), United States	ESOMPs 7 deg lat, ocean
Latitude	(°)	34.2	7.0
Longitude (East)	(°)	260.7	280.0
E/S Maximum Range to SV	(km)	9986.9	8254.9
E/S Minimmum Elevation to SV	(°)	32.3	71.3
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)	24	
Minutes Into Pass (Sample #45)	(Min)	21:17	
Telco Spot Beam Off-Angle	(°)	0.20	
Telco Spot Beam Diameter	(km)	56.90	
Maximum Roundtrip Latency	(msec)	121.70	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	3.5%	
Number of Carriers per Channel	(#)	1	
Available Bandwidth	(Hz)	216,000,000	
Available Throughput	(bps)	**521,337,648**	
Channel Symbol Rate	(sps)	180,000,000	
Channel Modulation Type		16APSK	
Channel FEC Rate		0.75	
Channel Spectral Efficiency	(bits/Sym)	3.00	
Channel Throughput (100% / 100% of Full Rate)	(bps)	521,337,648.33	
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)	5	
E/S Tx Carrier Frequency	(MHz)	28,709	
E/S Tx HPA Power Level	(W)	500	
E/S Tx OBO	(dB)	-4.00	
E/S Tx Post-HPA Losses	(dB)	-2.24	
E/S Tx Antenna Gain (7.3 m / 2.2 m)	(dB)	65.03	
E/S Tx EIRP Per Channel	(dBW)	78.79	
E/S Tx Pointing Loss	(dB)	-0.50	
E/S Tx RF Link Availability	(%)	75.000	
E/S Tx Atmospheric Losses	(dB)	-1.20	
E/S Tx Spreading Loss	(dB)	-150.98	
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	5.24	
SV Rx Power Per Tier	(dBW)	-119.27	
SV Rx Flux Density Per Tier	(dBW/m^2)	-73.89	
SV Tx OBO (ALC / ALC)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	31.31	
SV Tx EIRP Per Channel/Carrier	(dBW)	44.14	
SV Tx Pointing Loss	(dB)	0.00	
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)	18,909	
E/S Rx Wavelength	(m)	0.015854	
E/S Rx RF Link Availability	(%)	75.000	
E/S Rx Atmospheric Losses	(dB)	-1.41	
E/S Rx Radome & Pointing Loss	(dB)	-1.00	
E/S Rx Antenna Gain (2.2 m / 7.3 m)	(dBi)	48.70	
E/S Rx Effective G/T	(dB/K)	25.09	
E/S Rx Power Per Channel	(dBW)	-105.88	
E/S Rx Flux Density Per Channel	(dBW/m^2)	-107.59	
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)	82.55	
Carrier / Noise Uplink	(dB)	26.77	
Carrier / Noise Downlink	(dB)	16.55	
Carrier / Intermodulation Im (C/Im)	(dB)	23.53	
(C/N) - Total Actual	(dB)	12.73	
(C/N) - Total Required	(dB)	12.30	
(E_b/N_o) - Total Actual	(dB)	7.96	
(E_b/N_o) - Total Required	(dB)	7.53	
Excess Margin	**(dB)**	**0.43**	
Fade Margin	**(dB)**	**14.93**	

O3b Network Link Analysis - Tier 2 Service For ESOMPs 7 deg lat, ocean

Link Budget Creator - Rev 3.2.9: May 15, 2013		Tier 2	Tier 2
Ground Parameter		**Teleport**	**Telco**
Location		Vernon (LHCP), United States	ESOMPs 7 deg lat, ocean
Latitude	(°)	34.2	7.0
Longitude (East)	(°)	260.7	280.0
E/S Maximum Range to SV	(km)	9986.9	8254.9
E/S Minimmum Elevation to SV	(°)	32.3	71.3
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)	24	
Minutes Into Pass (Sample #45)	(Min)	21:17	
Telco Spot Beam Off-Angle	(°)	0.20	
Telco Spot Beam Diameter	(km)	56.90	
Maximum Roundtrip Latency	(msec)	121.70	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type		DVB-S2
Modem Overhead	(%)		3.1%
Number of Carriers per Channel	(#)		1
Available Bandwidth	(Hz)		216,000,000
Available Throughput	(bps)		**290,751,758**
Channel Symbol Rate	(sps)		180,000,000
Channel Modulation Type			QPSK
Channel FEC Rate			0.83
Channel Spectral Efficiency	(bits/Sym)		1.67
Channel Throughput (100% / 100% of Full Rate)	(bps)		290,751,757.71
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)		1
E/S Tx Carrier Frequency	(MHz)		28,709
E/S Tx HPA Power Level	(W)		40
E/S Tx OBO	(dB)		-6.00
E/S Tx Post-HPA Losses	(dB)		-0.69
E/S Tx Antenna Gain (7.3 m / 2.2 m)	(dB)		52.54
E/S Tx EIRP Per Channel	(dBW)		61.87
E/S Tx Radome & Pointing Loss	(dB)		-1.00
E/S Tx RF Link Availability	(%)		75.000
E/S Tx Atmospheric Losses	(dB)		-2.68
E/S Tx Spreading Loss	(dB)		-149.33
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)		5
SV Rx G/T	(dB/K)		3.82
SV Rx Power Per Tier	(dBW)		-137.92
SV Rx Flux Density Per Tier	(dBW/m^2)		-91.13
SV Tx OBO (ALC / ALC)	(dB)		-5.80
SV Tx Post-TWTA Losses	(dB)		-1.50
SV Tx Antenna Gain	(dBi)		31.77
SV Tx EIRP Per Channel/Carrier	(dBW)		35.61
SV Tx Pointing Loss	(dB)		0.00
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)		18,909
E/S Rx Spreading Loss	(dB)		-150.98
E/S Rx RF Link Availability	(%)		75.000
E/S Rx Atmospheric Losses	(dB)		-0.79
E/S Rx Pointing Loss	(dB)		-0.50
E/S Rx Antenna Gain (2.2 m / 7.3 m)	(dBi)		62.24
E/S Rx Effective G/T	(dB/K)		39.15
E/S Rx Power Per Channel	(dBW)		-101.42
E/S Rx Flux Density Per Channel	(dBW/m^2)		-116.66
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)		82.55
Carrier / Noise Uplink	(dB)		8.12
Carrier / Noise Downlink	(dB)		21.55
Carrier / Intermodulation Im (C/Im)	(dB)		23.28
(C/N) - Total Actual	(dB)		6.59
(C/N) - Total Required	(dB)		6.50
(E_b/N_o) - Total Actual	(dB)		4.37
(E_b/N_o) - Total Required	(dB)		4.28
Excess Margin	**(dB)**		**0.09**
Fade Margin	**(dB)**		**8.79**

O3b Network Link Analysis - Tier 2 Service For ESOMPs 7 deg lat, ocean

Link Budget Creator - Rev 3.2.9: May 15, 2013		Tier 2	Tier 2
Ground Parameter		**Teleport**	**Telco**
Location		Vernon (LHCP), United States	ESOMPs 7 deg lat, ocean
Latitude	(°)	34.2	7.0
Longitude (East)	(°)	260.7	280.0
E/S Maximum Range to SV	(km)	9840.6	8658.8
E/S Minimmum Elevation to SV	(°)	34.5	57.2
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)	24	
Minutes Into Pass (Sample #25)	(Min)	11:37	
Telco Spot Beam Off-Angle	(°)	0.20	
Telco Spot Beam Diameter	(km)	56.90	
Maximum Roundtrip Latency	(msec)	123.41	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	3.3%	
Number of Carriers per Channel	(#)	1	
Available Bandwidth	(Hz)	216,000,000	
Available Throughput	(bps)	**208,804,759**	
Channel Symbol Rate	(sps)	180,000,000	
Channel Modulation Type		QPSK	
Channel FEC Rate		0.60	
Channel Spectral Efficiency	(bits/Sym)	1.20	
Channel Throughput (100% / 100% of Full Rate)	(bps)	208,804,759.33	
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)	5	
E/S Tx Carrier Frequency	(MHz)	28,709	
E/S Tx HPA Power Level	(W)	500	
E/S Tx OBO	(dB)	-4.00	
E/S Tx Post-HPA Losses	(dB)	-2.24	
E/S Tx Antenna Gain (7.3 m / 2.2 m)	(dB)	65.03	
E/S Tx EIRP Per Channel	(dBW)	78.79	
E/S Tx Pointing Loss	(dB)	-0.50	
E/S Tx RF Link Availability	(%)	75.000	
E/S Tx Atmospheric Losses	(dB)	-1.15	
E/S Tx Spreading Loss	(dB)	-150.85	
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	5.24	
SV Rx Power Per Tier	(dBW)	-119.09	
SV Rx Flux Density Per Tier	(dBW/m^2)	-73.71	
SV Tx OBO (ALC / ALC)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	31.43	
SV Tx EIRP Per Channel/Carrier	(dBW)	44.26	
SV Tx Pointing Loss	(dB)	0.00	
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)	18,909	
E/S Rx Wavelength	(m)	0.015854	
E/S Rx RF Link Availability	(%)	99.500	
E/S Rx Atmospheric Losses	(dB)	-10.14	
E/S Rx Radome & Pointing Loss	(dB)	-1.00	
E/S Rx Antenna Gain (2.2 m / 7.3 m)	(dBi)	48.70	
E/S Rx Effective G/T	(dB/K)	22.36	
E/S Rx Power Per Channel	(dBW)	-114.91	
E/S Rx Flux Density Per Channel	(dBW/m^2)	-116.62	
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)	82.55	
Carrier / Noise Uplink	(dB)	26.96	
Carrier / Noise Downlink	(dB)	4.80	
Carrier / Intermodulation Im (C/Im)	(dB)	23.53	
(C/N) - Total Actual	(dB)	4.41	
(C/N) - Total Required	(dB)	4.20	
(E_b/N_o) - Total Actual	(dB)	3.62	
(E_b/N_o) - Total Required	(dB)	3.41	
Excess Margin	**(dB)**	**0.21**	
Fade Margin	**(dB)**	**6.61**	

O3b Network Link Analysis - Tier 2 Service For ESOMPs 7 deg lat, ocean

Link Budget Creator - Rev 3.2.9: May 15, 2013		Tier 2	Tier 2
Ground Parameter		**Teleport**	**Telco**
Location		Vernon (LHCP), United States	ESOMPs 7 deg lat, ocean
Latitude	(°)	34.2	7.0
Longitude (East)	(°)	260.7	280.0
E/S Maximum Range to SV	(km)	9840.6	8658.8
E/S Minimmum Elevation to SV	(°)	34.5	57.2
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)	24	
Minutes Into Pass (Sample #25)	(Min)	11:37	
Telco Spot Beam Off-Angle	(°)	0.20	
Telco Spot Beam Diameter	(km)	56.90	
Maximum Roundtrip Latency	(msec)	123.41	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type		DVB-S2
Modem Overhead	(%)		3.7%
Number of Carriers per Channel	(#)		1
Available Bandwidth	(Hz)		216,000,000
Available Throughput	(bps)		**138,712,818**
Channel Symbol Rate	(sps)		180,000,000
Channel Modulation Type			QPSK
Channel FEC Rate			0.40
Channel Spectral Efficiency	(bits/Sym)		0.80
Channel Throughput (100% / 100% of Full Rate)	(bps)		138,712,817.74
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)		1
E/S Tx Carrier Frequency	(MHz)		28,709
E/S Tx HPA Power Level	(W)		40
E/S Tx OBO	(dB)		-1.17
E/S Tx Post-HPA Losses	(dB)		-0.69
E/S Tx Antenna Gain (7.3 m / 2.2 m)	(dB)		52.54
E/S Tx EIRP Per Channel	(dBW)		66.70
E/S Tx Radome & Pointing Loss	(dB)		-1.00
E/S Tx RF Link Availability	(%)		99.000
E/S Tx Atmospheric Losses	(dB)		-13.14
E/S Tx Spreading Loss	(dB)		-149.74
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)		5
SV Rx G/T	(dB/K)		4.01
SV Rx Power Per Tier	(dBW)		-143.78
SV Rx Flux Density Per Tier	(dBW/m^2)		-97.18
SV Tx OBO (ALC / ALC)	(dB)		-5.80
SV Tx Post-TWTA Losses	(dB)		-1.50
SV Tx Antenna Gain	(dBi)		31.77
SV Tx EIRP Per Channel/Carrier	(dBW)		35.61
SV Tx Pointing Loss	(dB)		0.00
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)		18,909
E/S Rx Spreading Loss	(dB)		-150.85
E/S Rx RF Link Availability	(%)		75.000
E/S Rx Atmospheric Losses	(dB)		-0.75
E/S Rx Pointing Loss	(dB)		-0.50
E/S Rx Antenna Gain (2.2 m / 7.3 m)	(dBi)		62.24
E/S Rx Effective G/T	(dB/K)		39.16
E/S Rx Power Per Channel	(dBW)		-101.25
E/S Rx Flux Density Per Channel	(dBW/m^2)		-116.50
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)		82.55
Carrier / Noise Uplink	(dB)		2.26
Carrier / Noise Downlink	(dB)		21.72
Carrier / Intermodulation Im (C/Im)	(dB)		18.35
(C/N) - Total Actual	(dB)		1.90
(C/N) - Total Required	(dB)		1.40
(E_b/N_o) - Total Actual	(dB)		2.87
(E_b/N_o) - Total Required	(dB)		2.37
Excess Margin	**(dB)**		**0.50**
Fade Margin	**(dB)**		**4.10**

O3b Network Link Analysis - Tier 2 Service For ESOMPs 50 deg lat, Ocean

Link Budget Creator - Rev 3.2.9: May 15, 2013		Tier 2	Tier 2
Ground Parameter		**Teleport**	**Telco**
Location		Lima (east), Peru	ESOMPs 50 deg lat, Ocean
Latitude	(°)	-12.3	50.0
Longitude (East)	(°)	283.2	300.0
E/S Maximum Range to SV	(km)	8700.1	11439.0
E/S Minimmum Elevation to SV	(°)	56.2	14.7
E/S Altitude	(km)	2.0	0.0
SV Beam Identifier	(#)	15	
Minutes Into Pass (Sample #45)	(Min)	21:17	
Telco Spot Beam Off-Angle	(°)	0.20	
Telco Spot Beam Diameter	(km)	79.80	
Maximum Roundtrip Latency	(msec)	134.35	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	3.0%	
Number of Carriers per Channel	(#)	1	
Available Bandwidth	(Hz)	216,000,000	
Available Throughput	(bps)	**465,466,342**	
Channel Symbol Rate	(sps)	180,000,000	
Channel Modulation Type		16APSK	
Channel FEC Rate		0.67	
Channel Spectral Efficiency	(bits/Sym)	2.67	
Channel Throughput (100% / 100% of Full Rate)	(bps)	465,466,342.25	
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)	5	
E/S Tx Carrier Frequency	(MHz)	28,963	
E/S Tx HPA Power Level	(W)	500	
E/S Tx OBO	(dB)	-4.00	
E/S Tx Post-HPA Losses	(dB)	-2.24	
E/S Tx Antenna Gain (7.3 m / 2.2 m)	(dB)	65.11	
E/S Tx EIRP Per Channel	(dBW)	78.87	
E/S Tx Pointing Loss	(dB)	-0.50	
E/S Tx RF Link Availability	(%)	75.000	
E/S Tx Atmospheric Losses	(dB)	-0.50	
E/S Tx Spreading Loss	(dB)	-149.78	
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	4.69	
SV Rx Power Per Tier	(dBW)	-117.91	
SV Rx Flux Density Per Tier	(dBW/m^2)	-71.91	
SV Tx OBO (ALC / ALC)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	31.69	
SV Tx EIRP Per Channel/Carrier	(dBW)	44.52	
SV Tx Pointing Loss	(dB)	0.00	
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)	19,163	
E/S Rx Wavelength	(m)	0.015644	
E/S Rx RF Link Availability	(%)	75.000	
E/S Rx Atmospheric Losses	(dB)	-1.38	
E/S Rx Radome & Pointing Loss	(dB)	-1.00	
E/S Rx Antenna Gain (2.2 m / 7.3 m)	(dBi)	48.81	
E/S Rx Effective G/T	(dB/K)	23.67	
E/S Rx Power Per Channel	(dBW)	-108.31	
E/S Rx Flux Density Per Channel	(dBW/m^2)	-110.02	
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)	82.55	
Carrier / Noise Uplink	(dB)	28.13	
Carrier / Noise Downlink	(dB)	12.59	
Carrier / Intermodulation Im (C/Im)	(dB)	23.53	
(C/N) - Total Actual	(dB)	11.81	
(C/N) - Total Required	(dB)	11.10	
(E_b/N_o) - Total Actual	(dB)	7.56	
(E_b/N_o) - Total Required	(dB)	6.84	
Excess Margin	**(dB)**	**0.71**	
Fade Margin	**(dB)**	**14.01**	

O3b Network Link Analysis - Tier 2 Service For ESOMPs 50 deg lat, Ocean

Link Budget Creator - Rev 3.2.9: May 15, 2013		Tier 2	Tier 2
Ground Parameter		**Teleport**	**Telco**
Location		Lima (east), Peru	ESOMPs 50 deg lat, Ocean
Latitude	(°)	-12.3	50.0
Longitude (East)	(°)	283.2	300.0
E/S Maximum Range to SV	(km)	8700.1	11439.0
E/S Minimmum Elevation to SV	(°)	56.2	14.7
E/S Altitude	(km)	2.0	0.0
SV Beam Identifier	(#)	15	
Minutes Into Pass (Sample #45)	(Min)	21:17	
Telco Spot Beam Off-Angle	(°)	0.20	
Telco Spot Beam Diameter	(km)	79.80	
Maximum Roundtrip Latency	(msec)	134.35	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type		DVB-S2
Modem Overhead	(%)		3.2%
Number of Carriers per Channel	(#)		1
Available Bandwidth	(Hz)		216,000,000
Available Throughput	(bps)		**261,373,716**
Channel Symbol Rate	(sps)		180,000,000
Channel Modulation Type			QPSK
Channel FEC Rate			0.75
Channel Spectral Efficiency	(bits/Sym)		1.50
Channel Throughput (100% / 100% of Full Rate)	(bps)		261,373,715.52
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)		1
E/S Tx Carrier Frequency	(MHz)		28,963
E/S Tx HPA Power Level	(W)		40
E/S Tx OBO	(dB)		-6.00
E/S Tx Post-HPA Losses	(dB)		-0.69
E/S Tx Antenna Gain (7.3 m / 2.2 m)	(dB)		52.62
E/S Tx EIRP Per Channel	(dBW)		61.95
E/S Tx Radome & Pointing Loss	(dB)		-1.00
E/S Tx RF Link Availability	(%)		75.000
E/S Tx Atmospheric Losses	(dB)		-2.12
E/S Tx Spreading Loss	(dB)		-152.16
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)		5
SV Rx G/T	(dB/K)		4.79
SV Rx Power Per Tier	(dBW)		-139.24
SV Rx Flux Density Per Tier	(dBW/m^2)		-93.33
SV Tx OBO (ALC / ALC)	(dB)		-5.80
SV Tx Post-TWTA Losses	(dB)		-1.50
SV Tx Antenna Gain	(dBi)		31.60
SV Tx EIRP Per Channel/Carrier	(dBW)		35.44
SV Tx Pointing Loss	(dB)		0.00
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)		19,163
E/S Rx Spreading Loss	(dB)		-149.78
E/S Rx RF Link Availability	(%)		75.000
E/S Rx Atmospheric Losses	(dB)		-0.38
E/S Rx Pointing Loss	(dB)		-0.50
E/S Rx Antenna Gain (2.2 m / 7.3 m)	(dBi)		62.35
E/S Rx Effective G/T	(dB/K)		39.29
E/S Rx Power Per Channel	(dBW)		-99.98
E/S Rx Flux Density Per Channel	(dBW/m^2)		-115.22
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)		82.55
Carrier / Noise Uplink	(dB)		6.81
Carrier / Noise Downlink	(dB)		23.01
Carrier / Intermodulation Im (C/Im)	(dB)		23.28
(C/N) - Total Actual	(dB)		5.85
(C/N) - Total Required	(dB)		5.70
(E_b/N_o) - Total Actual	(dB)		4.09
(E_b/N_o) - Total Required	(dB)		3.94
Excess Margin	**(dB)**		**0.15**
Fade Margin	**(dB)**		**8.05**

O3b Network Link Analysis - Tier 2 Service For ESOMPs 50 deg lat, Ocean

Link Budget Creator - Rev 3.2.9: May 15, 2013		Tier 2	Tier 2
Ground Parameter		**Teleport**	**Telco**
Location		Lima (east), Peru	ESOMPs 50 deg lat, Ocean
Latitude	(°)	-12.3	50.0
Longitude (East)	(°)	283.2	300.0
E/S Maximum Range to SV	(km)	8700.1	11439.0
E/S Minimmum Elevation to SV	(°)	56.2	14.7
E/S Altitude	(km)	2.0	0.0
SV Beam Identifier	(#)	15	
Minutes Into Pass (Sample #45)	(Min)	21:17	
Telco Spot Beam Off-Angle	(°)	0.20	
Telco Spot Beam Diameter	(km)	79.80	
Maximum Roundtrip Latency	(msec)	134.35	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	3.2%	
Number of Carriers per Channel	(#)	1	
Available Bandwidth	(Hz)	216,000,000	
Available Throughput	(bps)	**278,896,701**	
Channel Symbol Rate	(sps)	180,000,000	
Channel Modulation Type		QPSK	
Channel FEC Rate		0.80	
Channel Spectral Efficiency	(bits/Sym)	1.60	
Channel Throughput (100% / 100% of Full Rate)	(bps)	278,896,700.92	
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)	5	
E/S Tx Carrier Frequency	(MHz)	28,963	
E/S Tx HPA Power Level	(W)	500	
E/S Tx OBO	(dB)	-4.00	
E/S Tx Post-HPA Losses	(dB)	-2.24	
E/S Tx Antenna Gain (7.3 m / 2.2 m)	(dB)	65.11	
E/S Tx EIRP Per Channel	(dBW)	78.87	
E/S Tx Pointing Loss	(dB)	-0.50	
E/S Tx RF Link Availability	(%)	75.000	
E/S Tx Atmospheric Losses	(dB)	-0.50	
E/S Tx Spreading Loss	(dB)	-149.78	
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	4.69	
SV Rx Power Per Tier	(dBW)	-117.91	
SV Rx Flux Density Per Tier	(dBW/m^2)	-71.91	
SV Tx OBO (ALC / ALC)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	31.69	
SV Tx EIRP Per Channel/Carrier	(dBW)	44.52	
SV Tx Pointing Loss	(dB)	0.00	
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)	19,163	
E/S Rx Wavelength	(m)	0.015644	
E/S Rx RF Link Availability	(%)	99.000	
E/S Rx Atmospheric Losses	(dB)	-6.59	
E/S Rx Radome & Pointing Loss	(dB)	-1.00	
E/S Rx Antenna Gain (2.2 m / 7.3 m)	(dBi)	48.81	
E/S Rx Effective G/T	(dB/K)	22.86	
E/S Rx Power Per Channel	(dBW)	-113.51	
E/S Rx Flux Density Per Channel	(dBW/m^2)	-115.22	
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)	82.55	
Carrier / Noise Uplink	(dB)	28.13	
Carrier / Noise Downlink	(dB)	6.58	
Carrier / Intermodulation Im (C/Im)	(dB)	23.53	
(C/N) - Total Actual	(dB)	6.37	
(C/N) - Total Required	(dB)	6.30	
(E_b/N_o) - Total Actual	(dB)	4.33	
(E_b/N_o) - Total Required	(dB)	4.26	
Excess Margin	**(dB)**	**0.07**	
Fade Margin	**(dB)**	**8.57**	

O3b Network Link Analysis - Tier 2 Service For ESOMPs 50 deg lat, Ocean

Link Budget Creator - Rev 3.2.9: May 15, 2013		Tier 2	Tier 2
Ground Parameter		**Teleport**	**Telco**
Location		Lima (east), Peru	ESOMPs 50 deg lat, Ocean
Latitude	(°)	-12.3	50.0
Longitude (East)	(°)	283.2	300.0
E/S Maximum Range to SV	(km)	8700.1	11439.0
E/S Minimmum Elevation to SV	(°)	56.2	14.7
E/S Altitude	(km)	2.0	0.0
SV Beam Identifier	(#)	15	
Minutes Into Pass (Sample #45)	(Min)	21:17	
Telco Spot Beam Off-Angle	(°)	0.20	
Telco Spot Beam Diameter	(km)	79.80	
Maximum Roundtrip Latency	(msec)	134.35	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type		DVB-S2
Modem Overhead	(%)		3.9%
Number of Carriers per Channel	(#)		1
Available Bandwidth	(Hz)		216,000,000
Available Throughput	(bps)		**115,348,837**
Channel Symbol Rate	(sps)		180,000,000
Channel Modulation Type			QPSK
Channel FEC Rate			0.33
Channel Spectral Efficiency	(bits/Sym)		0.67
Channel Throughput (100% / 100% of Full Rate)	(bps)		115,348,837.21
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)		1
E/S Tx Carrier Frequency	(MHz)		28,963
E/S Tx HPA Power Level	(W)		40
E/S Tx OBO	(dB)		-1.17
E/S Tx Post-HPA Losses	(dB)		-0.69
E/S Tx Antenna Gain (7.3 m / 2.2 m)	(dB)		52.62
E/S Tx EIRP Per Channel	(dBW)		66.78
E/S Tx Radome & Pointing Loss	(dB)		-1.00
E/S Tx RF Link Availability	(%)		99.000
E/S Tx Atmospheric Losses	(dB)		-12.35
E/S Tx Spreading Loss	(dB)		-152.16
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)		5
SV Rx G/T	(dB/K)		4.79
SV Rx Power Per Tier	(dBW)		-144.63
SV Rx Flux Density Per Tier	(dBW/m^2)		-98.73
SV Tx OBO (ALC / ALC)	(dB)		-5.80
SV Tx Post-TWTA Losses	(dB)		-1.50
SV Tx Antenna Gain	(dBi)		31.60
SV Tx EIRP Per Channel/Carrier	(dBW)		35.44
SV Tx Pointing Loss	(dB)		0.00
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)		19,163
E/S Rx Spreading Loss	(dB)		-149.78
E/S Rx RF Link Availability	(%)		75.000
E/S Rx Atmospheric Losses	(dB)		-0.38
E/S Rx Pointing Loss	(dB)		-0.50
E/S Rx Antenna Gain (2.2 m / 7.3 m)	(dBi)		62.35
E/S Rx Effective G/T	(dB/K)		39.29
E/S Rx Power Per Channel	(dBW)		-99.98
E/S Rx Flux Density Per Channel	(dBW/m^2)		-115.22
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)		82.55
Carrier / Noise Uplink	(dB)		1.42
Carrier / Noise Downlink	(dB)		23.01
Carrier / Intermodulation Im (C/Im)	(dB)		18.35
(C/N) - Total Actual	(dB)		1.19
(C/N) - Total Required	(dB)		0.30
(E_b/N_o) - Total Actual	(dB)		2.95
(E_b/N_o) - Total Required	(dB)		2.06
Excess Margin	**(dB)**		**0.89**
Fade Margin	**(dB)**		**3.39**

O3b Network Link Analysis - Tier 2 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: May 16, 2013		Tier 2	Tier 2
Ground Parameter		**Teleport**	**Telco**
Location		Vernon (LHCP), United States	San Juan-, United States
Latitude	(°)	34.2	18.5
Longitude (East)	(°)	260.7	293.9
E/S Maximum Range to SV	(km)	9886.7	9649.2
E/S Minimmum Elevation to SV	(°)	33.8	37.4
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)	25	
Minutes Into Pass (Sample #35)	(Min)	16:27	
Telco Spot Beam Off-Angle	(°)	1.30	
Telco Spot Beam Diameter	(km)	391.70	
Maximum Roundtrip Latency	(msec)	130.33	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	3.2%	
Number of Carriers per Channel	(#)	4	
Available Bandwidth	(Hz)	216,000,000	
Available Throughput	(bps)	**278,896,701**	
Channel Symbol Rate	(sps)	45,000,000	
Channel Modulation Type		QPSK	
Channel FEC Rate		0.80	
Channel Spectral Efficiency	(bits/Sym)	1.60	
Channel Throughput (100% / 100% of Full Rate)	(bps)	69,724,175.23	
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)	5	
E/S Tx Carrier Frequency	(MHz)	28,963	
E/S Tx HPA Power Level	(W)	500	
E/S Tx OBO	(dB)	-8.00	
E/S Tx Post-HPA Losses	(dB)	-2.24	
E/S Tx Antenna Gain (7.3 m / 1.2 m)	(dB)	65.11	
E/S Tx EIRP Per Channel	(dBW)	68.84	
E/S Tx Pointing Loss	(dB)	-0.50	
E/S Tx RF Link Availability	(%)	75.000	
E/S Tx Atmospheric Losses	(dB)	-1.16	
E/S Tx Spreading Loss	(dB)	-150.89	
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	5.24	
SV Rx Power Per Tier	(dBW)	-123.15	
SV Rx Flux Density Per Tier	(dBW/m^2)	-77.69	
SV Tx OBO (ALC / ALC)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	29.11	
SV Tx EIRP Per Channel/Carrier	(dBW)	35.91	
SV Tx Pointing Loss	(dB)	0.00	
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)	19,163	
E/S Rx Wavelength	(m)	0.015644	
E/S Rx RF Link Availability	(%)	70.000	
E/S Rx Atmospheric Losses	(dB)	-1.07	
E/S Rx Radome & Pointing Loss	(dB)	-1.00	
E/S Rx Antenna Gain (1.2 m / 7.3 m)	(dBi)	42.82	
E/S Rx Effective G/T	(dB/K)	19.07	
E/S Rx Power Per Channel	(dBW)	-121.11	
E/S Rx Flux Density Per Channel	(dBW/m^2)	-116.83	
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)	76.53	
Carrier / Noise Uplink	(dB)	22.90	
Carrier / Noise Downlink	(dB)	7.20	
Carrier / Intermodulation Im (C/Im)	(dB)	21.04	
(C/N) - Total Actual	(dB)	6.40	
(C/N) - Total Required	(dB)	6.30	
(E_b/N_o) - Total Actual	(dB)	4.36	
(E_b/N_o) - Total Required	(dB)	4.26	
Excess Margin	**(dB)**	**0.10**	
Fade Margin	**(dB)**	**8.60**	

O3b Network Link Analysis - Tier 2 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: May 16, 2013		Tier 2	Tier 2
Ground Parameter		**Teleport**	**Telco**
Location		Vernon (LHCP), United States	San Juan-, United States
Latitude	(°)	34.2	18.5
Longitude (East)	(°)	260.7	293.9
E/S Maximum Range to SV	(km)	9886.7	9649.2
E/S Minimmum Elevation to SV	(°)	33.8	37.4
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)	25	
Minutes Into Pass (Sample #35)	(Min)	16:27	
Telco Spot Beam Off-Angle	(°)	1.30	
Telco Spot Beam Diameter	(km)	391.70	
Maximum Roundtrip Latency	(msec)	130.33	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type		DVB-S2
Modem Overhead	(%)		3.0%
Number of Carriers per Channel	(#)		10
Available Bandwidth	(Hz)		49,200,000
Available Throughput	(bps)		**71,588,006**
Channel Symbol Rate	(sps)		4,100,000
Channel Modulation Type			8PSK
Channel FEC Rate			0.60
Channel Spectral Efficiency	(bits/Sym)		1.80
Channel Throughput (100% / 100% of Full Rate)	(bps)		7,158,800.62
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)		1
E/S Tx Carrier Frequency	(MHz)		28,963
E/S Tx HPA Power Level	(W)		10
E/S Tx OBO	(dB)		-6.00
E/S Tx Post-HPA Losses	(dB)		-0.28
E/S Tx Antenna Gain (7.3 m / 1.2 m)	(dB)		46.54
E/S Tx EIRP Per Channel	(dBW)		50.26
E/S Tx Radome & Pointing Loss	(dB)		-1.00
E/S Tx RF Link Availability	(%)		70.000
E/S Tx Atmospheric Losses	(dB)		-1.56
E/S Tx Spreading Loss	(dB)		-150.68
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)		5
SV Rx G/T	(dB/K)		0.79
SV Rx Power Per Tier	(dBW)		-142.88
SV Rx Flux Density Per Tier	(dBW/m^2)		-92.98
SV Tx OBO (ALC / ALC)	(dB)		-15.00
SV Tx Post-TWTA Losses	(dB)		-1.50
SV Tx Antenna Gain	(dBi)		31.77
SV Tx EIRP Per Channel/Carrier	(dBW)		16.41
SV Tx Pointing Loss	(dB)		0.00
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)		19,163
E/S Rx Spreading Loss	(dB)		-150.89
E/S Rx RF Link Availability	(%)		75.000
E/S Rx Atmospheric Losses	(dB)		-0.83
E/S Rx Pointing Loss	(dB)		-0.50
E/S Rx Antenna Gain (1.2 m / 7.3 m)	(dBi)		62.35
E/S Rx Effective G/T	(dB/K)		39.15
E/S Rx Power Per Channel	(dBW)		-120.56
E/S Rx Flux Density Per Channel	(dBW/m^2)		-135.81
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)		66.13
Carrier / Noise Uplink	(dB)		9.60
Carrier / Noise Downlink	(dB)		18.70
Carrier / Intermodulation Im (C/Im)	(dB)		26.64
(C/N) - Total Actual	(dB)		7.42
(C/N) - Total Required	(dB)		7.40
(E_b/N_o) - Total Actual	(dB)		4.87
(E_b/N_o) - Total Required	(dB)		4.85
Excess Margin	**(dB)**		**0.02**
Fade Margin	**(dB)**		**9.62**

O3b Network Link Analysis - Tier 2 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: May 16, 2013		Tier 2	Tier 2
Ground Parameter		**Teleport**	**Telco**
Location		Vernon (LHCP), United States	San Juan-, United States
Latitude	(°)	34.2	18.5
Longitude (East)	(°)	260.7	293.9
E/S Maximum Range to SV	(km)	9874.6	10631.3
E/S Minimmum Elevation to SV	(°)	34.0	23.9
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)	25	
Minutes Into Pass (Sample #10)	(Min)	4:21	
Telco Spot Beam Off-Angle	(°)	1.30	
Telco Spot Beam Diameter	(km)	391.70	
Maximum Roundtrip Latency	(msec)	136.80	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	4.3%	
Number of Carriers per Channel	(#)	4	
Available Bandwidth	(Hz)	216,000,000	
Available Throughput	(bps)	**86,143,862**	
Channel Symbol Rate	(sps)	45,000,000	
Channel Modulation Type		QPSK	
Channel FEC Rate		0.25	
Channel Spectral Efficiency	(bits/Sym)	0.50	
Channel Throughput (100% / 100% of Full Rate)	(bps)	21,535,965.39	
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)	5	
E/S Tx Carrier Frequency	(MHz)	28,963	
E/S Tx HPA Power Level	(W)	500	
E/S Tx OBO	(dB)	-8.00	
E/S Tx Post-HPA Losses	(dB)	-2.24	
E/S Tx Antenna Gain (7.3 m / 1.2 m)	(dB)	65.11	
E/S Tx EIRP Per Channel	(dBW)	68.84	
E/S Tx Pointing Loss	(dB)	-0.50	
E/S Tx RF Link Availability	(%)	75.000	
E/S Tx Atmospheric Losses	(dB)	-1.16	
E/S Tx Spreading Loss	(dB)	-150.88	
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	5.24	
SV Rx Power Per Tier	(dBW)	-123.13	
SV Rx Flux Density Per Tier	(dBW/m^2)	-77.68	
SV Tx OBO (ALC / ALC)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	29.21	
SV Tx EIRP Per Channel/Carrier	(dBW)	36.02	
SV Tx Pointing Loss	(dB)	0.00	
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)	19,163	
E/S Rx Wavelength	(m)	0.015644	
E/S Rx RF Link Availability	(%)	98.500	
E/S Rx Atmospheric Losses	(dB)	-6.86	
E/S Rx Radome & Pointing Loss	(dB)	-1.00	
E/S Rx Antenna Gain (1.2 m / 7.3 m)	(dBi)	42.82	
E/S Rx Effective G/T	(dB/K)	17.18	
E/S Rx Power Per Channel	(dBW)	-127.65	
E/S Rx Flux Density Per Channel	(dBW/m^2)	-123.37	
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)	76.53	
Carrier / Noise Uplink	(dB)	22.91	
Carrier / Noise Downlink	(dB)	-1.22	
Carrier / Intermodulation Im (C/Im)	(dB)	21.04	
(C/N) - Total Actual	(dB)	-1.34	
(C/N) - Total Required	(dB)	-2.20	
(E_b/N_o) - Total Actual	(dB)	1.67	
(E_b/N_o) - Total Required	(dB)	0.81	
Excess Margin	**(dB)**	**0.86**	
Fade Margin	**(dB)**	**0.86**	

O3b Network Link Analysis - Tier 2 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: May 16, 2013		Tier 2	Tier 2
Ground Parameter		**Teleport**	**Telco**
Location		Vernon (LHCP), United States	San Juan-, United States
Latitude	(°)	34.2	18.5
Longitude (East)	(°)	260.7	293.9
E/S Maximum Range to SV	(km)	9874.6	10631.3
E/S Minimmum Elevation to SV	(°)	34.0	23.9
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)	25	
Minutes Into Pass (Sample #10)	(Min)	4:21	
Telco Spot Beam Off-Angle	(°)	1.30	
Telco Spot Beam Diameter	(km)	391.70	
Maximum Roundtrip Latency	(msec)	136.80	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type		DVB-S2
Modem Overhead	(%)		3.7%
Number of Carriers per Channel	(#)		10
Available Bandwidth	(Hz)		49,200,000
Available Throughput	(bps)		**31,595,698**
Channel Symbol Rate	(sps)		4,100,000
Channel Modulation Type			QPSK
Channel FEC Rate			0.40
Channel Spectral Efficiency	(bits/Sym)		0.80
Channel Throughput (100% / 100% of Full Rate)	(bps)		3,159,569.77
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)		1
E/S Tx Carrier Frequency	(MHz)		28,963
E/S Tx HPA Power Level	(W)		10
E/S Tx OBO	(dB)		-0.50
E/S Tx Post-HPA Losses	(dB)		-0.28
E/S Tx Antenna Gain (7.3 m / 1.2 m)	(dB)		46.54
E/S Tx EIRP Per Channel	(dBW)		55.76
E/S Tx Radome & Pointing Loss	(dB)		-1.00
E/S Tx RF Link Availability	(%)		98.500
E/S Tx Atmospheric Losses	(dB)		-12.79
E/S Tx Spreading Loss	(dB)		-151.52
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)		5
SV Rx G/T	(dB/K)		0.94
SV Rx Power Per Tier	(dBW)		-149.30
SV Rx Flux Density Per Tier	(dBW/m^2)		-99.55
SV Tx OBO (ALC / ALC)	(dB)		-15.00
SV Tx Post-TWTA Losses	(dB)		-1.50
SV Tx Antenna Gain	(dBi)		31.77
SV Tx EIRP Per Channel/Carrier	(dBW)		16.41
SV Tx Pointing Loss	(dB)		0.00
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)		19,163
E/S Rx Spreading Loss	(dB)		-150.88
E/S Rx RF Link Availability	(%)		75.000
E/S Rx Atmospheric Losses	(dB)		-0.83
E/S Rx Pointing Loss	(dB)		-0.50
E/S Rx Antenna Gain (1.2 m / 7.3 m)	(dBi)		62.35
E/S Rx Effective G/T	(dB/K)		39.15
E/S Rx Power Per Channel	(dBW)		-120.55
E/S Rx Flux Density Per Channel	(dBW/m^2)		-135.80
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)		66.13
Carrier / Noise Uplink	(dB)		3.17
Carrier / Noise Downlink	(dB)		18.72
Carrier / Intermodulation Im (C/Im)	(dB)		19.18
(C/N) - Total Actual	(dB)		2.61
(C/N) - Total Required	(dB)		1.40
(E_b/N_o) - Total Actual	(dB)		3.58
(E_b/N_o) - Total Required	(dB)		2.37
Excess Margin	**(dB)**		**1.21**
Fade Margin	**(dB)**		**4.81**

O3b Network Link Analysis - Tier 2 Service For ESOMPs 7 deg lat, ocean

Link Budget Creator - Rev 3.2.9: May 16, 2013		Tier 2	Tier 2
Ground Parameter		**Teleport**	**Telco**
Location		Vernon (LHCP), United States	ESOMPs 7 deg lat, ocean
Latitude	(°)	34.2	7.0
Longitude (East)	(°)	260.7	280.0
E/S Maximum Range to SV	(km)	9886.7	8421.6
E/S Minimmum Elevation to SV	(°)	33.8	64.5
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)	24	
Minutes Into Pass (Sample #35)	(Min)	16:27	
Telco Spot Beam Off-Angle	(°)	1.30	
Telco Spot Beam Diameter	(km)	369.80	
Maximum Roundtrip Latency	(msec)	122.14	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	3.1%	
Number of Carriers per Channel	(#)	4	
Available Bandwidth	(Hz)	216,000,000	
Available Throughput	(bps)	**290,751,758**	
Channel Symbol Rate	(sps)	45,000,000	
Channel Modulation Type		QPSK	
Channel FEC Rate		0.83	
Channel Spectral Efficiency	(bits/Sym)	1.67	
Channel Throughput (100% / 100% of Full Rate)	(bps)	72,687,939.43	
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)	5	
E/S Tx Carrier Frequency	(MHz)	28,709	
E/S Tx HPA Power Level	(W)	500	
E/S Tx OBO	(dB)	-8.00	
E/S Tx Post-HPA Losses	(dB)	-2.24	
E/S Tx Antenna Gain (7.3 m / 1.2 m)	(dB)	65.03	
E/S Tx EIRP Per Channel	(dBW)	68.77	
E/S Tx Pointing Loss	(dB)	-0.50	
E/S Tx RF Link Availability	(%)	75.000	
E/S Tx Atmospheric Losses	(dB)	-1.16	
E/S Tx Spreading Loss	(dB)	-150.89	
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	5.24	
SV Rx Power Per Tier	(dBW)	-123.15	
SV Rx Flux Density Per Tier	(dBW/m^2)	-77.77	
SV Tx OBO (ALC / ALC)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	28.90	
SV Tx EIRP Per Channel/Carrier	(dBW)	35.71	
SV Tx Pointing Loss	(dB)	0.00	
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)	18,909	
E/S Rx Wavelength	(m)	0.015854	
E/S Rx RF Link Availability	(%)	70.000	
E/S Rx Atmospheric Losses	(dB)	-1.27	
E/S Rx Radome & Pointing Loss	(dB)	-1.00	
E/S Rx Antenna Gain (1.2 m / 7.3 m)	(dBi)	42.71	
E/S Rx Effective G/T	(dB/K)	19.52	
E/S Rx Power Per Channel	(dBW)	-120.34	
E/S Rx Flux Density Per Channel	(dBW/m^2)	-116.06	
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)	76.53	
Carrier / Noise Uplink	(dB)	22.90	
Carrier / Noise Downlink	(dB)	8.53	
Carrier / Intermodulation Im (C/Im)	(dB)	21.04	
(C/N) - Total Actual	(dB)	7.36	
(C/N) - Total Required	(dB)	6.50	
(E_b/N_o) - Total Actual	(dB)	5.15	
(E_b/N_o) - Total Required	(dB)	4.28	
Excess Margin	**(dB)**	**0.86**	
Fade Margin	**(dB)**	**9.56**	

O3b Network Link Analysis - Tier 2 Service For ESOMPs 7 deg lat, ocean

Link Budget Creator - Rev 3.2.9: May 16, 2013		Tier 2	Tier 2
Ground Parameter		**Teleport**	**Telco**
Location		Vernon (LHCP), United States	ESOMPs 7 deg lat, ocean
Latitude	(°)	34.2	7.0
Longitude (East)	(°)	260.7	280.0
E/S Maximum Range to SV	(km)	9886.7	8421.6
E/S Minimmum Elevation to SV	(°)	33.8	64.5
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)	24	
Minutes Into Pass (Sample #35)	(Min)	16:27	
Telco Spot Beam Off-Angle	(°)	1.30	
Telco Spot Beam Diameter	(km)	369.80	
Maximum Roundtrip Latency	(msec)	122.14	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type		DVB-S2
Modem Overhead	(%)		3.0%
Number of Carriers per Channel	(#)		10
Available Bandwidth	(Hz)		49,200,000
Available Throughput	(bps)		**71,588,006**
Channel Symbol Rate	(sps)		4,100,000
Channel Modulation Type			8PSK
Channel FEC Rate			0.60
Channel Spectral Efficiency	(bits/Sym)		1.80
Channel Throughput (100% / 100% of Full Rate)	(bps)		7,158,800.62
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)		1
E/S Tx Carrier Frequency	(MHz)		28,709
E/S Tx HPA Power Level	(W)		10
E/S Tx OBO	(dB)		-6.00
E/S Tx Post-HPA Losses	(dB)		-0.28
E/S Tx Antenna Gain (7.3 m / 1.2 m)	(dB)		46.47
E/S Tx EIRP Per Channel	(dBW)		50.19
E/S Tx Radome & Pointing Loss	(dB)		-1.00
E/S Tx RF Link Availability	(%)		70.000
E/S Tx Atmospheric Losses	(dB)		-2.33
E/S Tx Spreading Loss	(dB)		-149.50
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)		5
SV Rx G/T	(dB/K)		0.54
SV Rx Power Per Tier	(dBW)		-142.72
SV Rx Flux Density Per Tier	(dBW/m^2)		-92.64
SV Tx OBO (ALC / ALC)	(dB)		-15.00
SV Tx Post-TWTA Losses	(dB)		-1.50
SV Tx Antenna Gain	(dBi)		31.77
SV Tx EIRP Per Channel/Carrier	(dBW)		16.41
SV Tx Pointing Loss	(dB)		0.00
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)		18,909
E/S Rx Spreading Loss	(dB)		-150.89
E/S Rx RF Link Availability	(%)		75.000
E/S Rx Atmospheric Losses	(dB)		-0.77
E/S Rx Pointing Loss	(dB)		-0.50
E/S Rx Antenna Gain (1.2 m / 7.3 m)	(dBi)		62.24
E/S Rx Effective G/T	(dB/K)		39.16
E/S Rx Power Per Channel	(dBW)		-120.50
E/S Rx Flux Density Per Channel	(dBW/m^2)		-135.75
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)		66.13
Carrier / Noise Uplink	(dB)		9.76
Carrier / Noise Downlink	(dB)		18.89
Carrier / Intermodulation Im (C/Im)	(dB)		26.64
(C/N) - Total Actual	(dB)		7.53
(C/N) - Total Required	(dB)		7.40
(E_b/N_o) - Total Actual	(dB)		4.98
(E_b/N_o) - Total Required	(dB)		4.85
Excess Margin	**(dB)**		**0.13**
Fade Margin	**(dB)**		**9.73**

O3b Network Link Analysis - Tier 2 Service For ESOMPs 7 deg lat, ocean

Link Budget Creator - Rev 3.2.9: May 16, 2013		Tier 2	Tier 2
Ground Parameter		**Teleport**	**Telco**
Location		Vernon (LHCP), United States	ESOMPs 7 deg lat, ocean
Latitude	(°)	34.2	7.0
Longitude (East)	(°)	260.7	280.0
E/S Maximum Range to SV	(km)	9874.6	9130.8
E/S Minimmum Elevation to SV	(°)	34.0	46.5
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)	24	
Minutes Into Pass (Sample #10)	(Min)	4:21	
Telco Spot Beam Off-Angle	(°)	1.30	
Telco Spot Beam Diameter	(km)	369.80	
Maximum Roundtrip Latency	(msec)	126.79	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	3.9%	
Number of Carriers per Channel	(#)	4	
Available Bandwidth	(Hz)	216,000,000	
Available Throughput	(bps)	**115,348,837**	
Channel Symbol Rate	(sps)	45,000,000	
Channel Modulation Type		QPSK	
Channel FEC Rate		0.33	
Channel Spectral Efficiency	(bits/Sym)	0.67	
Channel Throughput (100% / 100% of Full Rate)	(bps)	28,837,209.30	
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)	5	
E/S Tx Carrier Frequency	(MHz)	28,709	
E/S Tx HPA Power Level	(W)	500	
E/S Tx OBO	(dB)	-8.00	
E/S Tx Post-HPA Losses	(dB)	-2.24	
E/S Tx Antenna Gain (7.3 m / 1.2 m)	(dB)	65.03	
E/S Tx EIRP Per Channel	(dBW)	68.77	
E/S Tx Pointing Loss	(dB)	-0.50	
E/S Tx RF Link Availability	(%)	75.000	
E/S Tx Atmospheric Losses	(dB)	-1.16	
E/S Tx Spreading Loss	(dB)	-150.88	
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	5.24	
SV Rx Power Per Tier	(dBW)	-123.13	
SV Rx Flux Density Per Tier	(dBW/m^2)	-77.75	
SV Tx OBO (ALC / ALC)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	29.02	
SV Tx EIRP Per Channel/Carrier	(dBW)	35.83	
SV Tx Pointing Loss	(dB)	0.00	
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)	18,909	
E/S Rx Wavelength	(m)	0.015854	
E/S Rx RF Link Availability	(%)	98.500	
E/S Rx Atmospheric Losses	(dB)	-5.81	
E/S Rx Radome & Pointing Loss	(dB)	-1.00	
E/S Rx Antenna Gain (1.2 m / 7.3 m)	(dBi)	42.71	
E/S Rx Effective G/T	(dB/K)	17.46	
E/S Rx Power Per Channel	(dBW)	-125.46	
E/S Rx Flux Density Per Channel	(dBW/m^2)	-121.18	
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)	76.53	
Carrier / Noise Uplink	(dB)	22.92	
Carrier / Noise Downlink	(dB)	1.36	
Carrier / Intermodulation Im (C/Im)	(dB)	21.04	
(C/N) - Total Actual	(dB)	1.10	
(C/N) - Total Required	(dB)	0.30	
(E_b/N_o) - Total Actual	(dB)	2.86	
(E_b/N_o) - Total Required	(dB)	2.06	
Excess Margin	**(dB)**	**0.80**	
Fade Margin	**(dB)**	**3.30**	

O3b Network Link Analysis - Tier 2 Service For ESOMPs 7 deg lat, ocean			
Link Budget Creator - Rev 3.2.9: May 16, 2013		**Tier 2**	**Tier 2**
Ground Parameter		**Teleport**	**Telco**
Location		Vernon (LHCP), United States	ESOMPs 7 deg lat, ocean
Latitude	(°)	34.2	7.0
Longitude (East)	(°)	260.7	280.0
E/S Maximum Range to SV	(km)	9874.6	9130.8
E/S Minimmum Elevation to SV	(°)	34.0	46.5
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)	24	
Minutes Into Pass (Sample #10)	(Min)	4:21	
Telco Spot Beam Off-Angle	(°)	1.30	
Telco Spot Beam Diameter	(km)	369.80	
Maximum Roundtrip Latency	(msec)	126.79	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type		DVB-S2
Modem Overhead	(%)		3.3%
Number of Carriers per Channel	(#)		10
Available Bandwidth	(Hz)		49,200,000
Available Throughput	(bps)		**47,561,085**
Channel Symbol Rate	(sps)		4,100,000
Channel Modulation Type			QPSK
Channel FEC Rate			0.60
Channel Spectral Efficiency	(bits/Sym)		1.20
Channel Throughput (100% / 100% of Full Rate)	(bps)		4,756,108.45
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)		1
E/S Tx Carrier Frequency	(MHz)		28,709
E/S Tx HPA Power Level	(W)		10
E/S Tx OBO	(dB)		-0.50
E/S Tx Post-HPA Losses	(dB)		-0.28
E/S Tx Antenna Gain (7.3 m / 1.2 m)	(dB)		46.47
E/S Tx EIRP Per Channel	(dBW)		55.69
E/S Tx Radome & Pointing Loss	(dB)		-1.00
E/S Tx RF Link Availability	(%)		98.500
E/S Tx Atmospheric Losses	(dB)		-11.91
E/S Tx Spreading Loss	(dB)		-150.20
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)		5
SV Rx G/T	(dB/K)		0.68
SV Rx Power Per Tier	(dBW)		-147.36
SV Rx Flux Density Per Tier	(dBW/m^2)		-97.42
SV Tx OBO (ALC / ALC)	(dB)		-15.00
SV Tx Post-TWTA Losses	(dB)		-1.50
SV Tx Antenna Gain	(dBi)		31.77
SV Tx EIRP Per Channel/Carrier	(dBW)		16.41
SV Tx Pointing Loss	(dB)		0.00
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)		18,909
E/S Rx Spreading Loss	(dB)		-150.88
E/S Rx RF Link Availability	(%)		75.000
E/S Rx Atmospheric Losses	(dB)		-0.76
E/S Rx Pointing Loss	(dB)		-0.50
E/S Rx Antenna Gain (1.2 m / 7.3 m)	(dBi)		62.24
E/S Rx Effective G/T	(dB/K)		39.16
E/S Rx Power Per Channel	(dBW)		-120.49
E/S Rx Flux Density Per Channel	(dBW/m^2)		-135.74
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)		66.13
Carrier / Noise Uplink	(dB)		5.11
Carrier / Noise Downlink	(dB)		18.91
Carrier / Intermodulation Im (C/Im)	(dB)		19.18
(C/N) - Total Actual	(dB)		4.36
(C/N) - Total Required	(dB)		4.20
(E_b/N_o) - Total Actual	(dB)		3.57
(E_b/N_o) - Total Required	(dB)		3.41
Excess Margin	**(dB)**		**0.16**
Fade Margin	**(dB)**		**6.56**

O3b Network Link Analysis - Tier 2 Service For ESOMPs 50 deg lat, Ocean			
Link Budget Creator - Rev 3.2.9: May 16, 2013		**Tier 2**	**Tier 2**
Ground Parameter		**Teleport**	**Telco**
Location		Lima (east), Peru	ESOMPs 50 deg lat, Ocean
Latitude	(°)	-12.3	50.0
Longitude (East)	(°)	283.2	300.0
E/S Maximum Range to SV	(km)	8501.6	11468.5
E/S Minimmum Elevation to SV	(°)	61.8	14.4
E/S Altitude	(km)	2.0	0.0
SV Beam Identifier	(#)	15	
Minutes Into Pass (Sample #35)	(Min)	16:27	
Telco Spot Beam Off-Angle	(°)	1.30	
Telco Spot Beam Diameter	(km)	519.10	
Maximum Roundtrip Latency	(msec)	133.23	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	3.3%	
Number of Carriers per Channel	(#)	4	
Available Bandwidth	(Hz)	216,000,000	
Available Throughput	(bps)	**208,804,759**	
Channel Symbol Rate	(sps)	45,000,000	
Channel Modulation Type		QPSK	
Channel FEC Rate		0.60	
Channel Spectral Efficiency	(bits/Sym)	1.20	
Channel Throughput (100% / 100% of Full Rate)	(bps)	52,201,189.83	
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)	5	
E/S Tx Carrier Frequency	(MHz)	28,963	
E/S Tx HPA Power Level	(W)	500	
E/S Tx OBO	(dB)	-4.00	
E/S Tx Post-HPA Losses	(dB)	-2.24	
E/S Tx Antenna Gain (7.3 m / 1.2 m)	(dB)	65.11	
E/S Tx EIRP Per Channel	(dBW)	72.84	
E/S Tx Pointing Loss	(dB)	-0.50	
E/S Tx RF Link Availability	(%)	75.000	
E/S Tx Atmospheric Losses	(dB)	-0.47	
E/S Tx Spreading Loss	(dB)	-149.58	
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	4.62	
SV Rx Power Per Tier	(dBW)	-117.76	
SV Rx Flux Density Per Tier	(dBW/m^2)	-71.69	
SV Tx OBO (ALC / ALC)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	29.26	
SV Tx EIRP Per Channel/Carrier	(dBW)	36.07	
SV Tx Pointing Loss	(dB)	0.00	
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)	19,163	
E/S Rx Wavelength	(m)	0.015644	
E/S Rx RF Link Availability	(%)	70.000	
E/S Rx Atmospheric Losses	(dB)	-1.22	
E/S Rx Radome & Pointing Loss	(dB)	-1.00	
E/S Rx Antenna Gain (1.2 m / 7.3 m)	(dBi)	42.82	
E/S Rx Effective G/T	(dB/K)	17.94	
E/S Rx Power Per Channel	(dBW)	-122.62	
E/S Rx Flux Density Per Channel	(dBW/m^2)	-118.34	
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)	76.53	
Carrier / Noise Uplink	(dB)	28.29	
Carrier / Noise Downlink	(dB)	4.57	
Carrier / Intermodulation Im (C/Im)	(dB)	18.44	
(C/N) - Total Actual	(dB)	4.31	
(C/N) - Total Required	(dB)	4.20	
(E_b/N_o) - Total Actual	(dB)	3.52	
(E_b/N_o) - Total Required	(dB)	3.41	
Excess Margin	**(dB)**	**0.11**	
Fade Margin	**(dB)**	**6.51**	

O3b Network Link Analysis - Tier 2 Service For ESOMPs 50 deg lat, Ocean			
Link Budget Creator - Rev 3.2.9: May 16, 2013		**Tier 2**	**Tier 2**
Ground Parameter		**Teleport**	**Telco**
Location		Lima (east), Peru	ESOMPs 50 deg lat, Ocean
Latitude	(°)	-12.3	50.0
Longitude (East)	(°)	283.2	300.0
E/S Maximum Range to SV	(km)	8501.6	11468.5
E/S Minimmum Elevation to SV	(°)	61.8	14.4
E/S Altitude	(km)	2.0	0.0
SV Beam Identifier	(#)	15	
Minutes Into Pass (Sample #35)	(Min)	16:27	
Telco Spot Beam Off-Angle	(°)	1.30	
Telco Spot Beam Diameter	(km)	519.10	
Maximum Roundtrip Latency	(msec)	133.23	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type		DVB-S2
Modem Overhead	(%)		3.1%
Number of Carriers per Channel	(#)		10
Available Bandwidth	(Hz)		49,200,000
Available Throughput	(bps)		**66,226,790**
Channel Symbol Rate	(sps)		4,100,000
Channel Modulation Type			QPSK
Channel FEC Rate			0.83
Channel Spectral Efficiency	(bits/Sym)		1.67
Channel Throughput (100% / 100% of Full Rate)	(bps)		6,622,678.99
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)		1
E/S Tx Carrier Frequency	(MHz)		28,963
E/S Tx HPA Power Level	(W)		10
E/S Tx OBO	(dB)		-6.00
E/S Tx Post-HPA Losses	(dB)		-0.28
E/S Tx Antenna Gain (7.3 m / 1.2 m)	(dB)		46.54
E/S Tx EIRP Per Channel	(dBW)		50.26
E/S Tx Radome & Pointing Loss	(dB)		-1.00
E/S Tx RF Link Availability	(%)		70.000
E/S Tx Atmospheric Losses	(dB)		-1.82
E/S Tx Spreading Loss	(dB)		-152.18
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)		5
SV Rx G/T	(dB/K)		1.01
SV Rx Power Per Tier	(dBW)		-144.43
SV Rx Flux Density Per Tier	(dBW/m^2)		-94.74
SV Tx OBO (ALC / ALC)	(dB)		-15.00
SV Tx Post-TWTA Losses	(dB)		-1.50
SV Tx Antenna Gain	(dBi)		31.56
SV Tx EIRP Per Channel/Carrier	(dBW)		16.20
SV Tx Pointing Loss	(dB)		0.00
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)		19,163
E/S Rx Spreading Loss	(dB)		-149.58
E/S Rx RF Link Availability	(%)		75.000
E/S Rx Atmospheric Losses	(dB)		-0.36
E/S Rx Pointing Loss	(dB)		-0.50
E/S Rx Antenna Gain (1.2 m / 7.3 m)	(dBi)		62.35
E/S Rx Effective G/T	(dB/K)		39.91
E/S Rx Power Per Channel	(dBW)		-118.99
E/S Rx Flux Density Per Channel	(dBW/m^2)		-134.24
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)		66.13
Carrier / Noise Uplink	(dB)		8.05
Carrier / Noise Downlink	(dB)		21.04
Carrier / Intermodulation Im (C/Im)	(dB)		26.64
(C/N) - Total Actual	(dB)		7.02
(C/N) - Total Required	(dB)		6.50
(E_b/N_o) - Total Actual	(dB)		4.80
(E_b/N_o) - Total Required	(dB)		4.28
Excess Margin	**(dB)**		**0.52**
Fade Margin	**(dB)**		**9.22**

O3b Network Link Analysis - Tier 2 Service For ESOMPs 50 deg lat, Ocean

Link Budget Creator - Rev 3.2.9: May 16, 2013		Tier 2	Tier 2
Ground Parameter		**Teleport**	**Telco**
Location		Lima (east), Peru	ESOMPs 50 deg lat, Ocean
Latitude	(°)	-12.3	50.0
Longitude (East)	(°)	283.2	300.0
E/S Maximum Range to SV	(km)	8324.6	11698.8
E/S Minimmum Elevation to SV	(°)	68.2	12.0
E/S Altitude	(km)	2.0	0.0
SV Beam Identifier	(#)	15	
Minutes Into Pass (Sample #10)	(Min)	4:21	
Telco Spot Beam Off-Angle	(°)	1.30	
Telco Spot Beam Diameter	(km)	519.10	
Maximum Roundtrip Latency	(msec)	133.58	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	4.3%	
Number of Carriers per Channel	(#)	4	
Available Bandwidth	(Hz)	216,000,000	
Available Throughput	(bps)	**86,143,862**	
Channel Symbol Rate	(sps)	45,000,000	
Channel Modulation Type		QPSK	
Channel FEC Rate		0.25	
Channel Spectral Efficiency	(bits/Sym)	0.50	
Channel Throughput (100% / 100% of Full Rate)	(bps)	21,535,965.39	
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)	5	
E/S Tx Carrier Frequency	(MHz)	28,963	
E/S Tx HPA Power Level	(W)	500	
E/S Tx OBO	(dB)	-4.00	
E/S Tx Post-HPA Losses	(dB)	-2.24	
E/S Tx Antenna Gain (7.3 m / 1.2 m)	(dB)	65.11	
E/S Tx EIRP Per Channel	(dBW)	72.84	
E/S Tx Pointing Loss	(dB)	-0.50	
E/S Tx RF Link Availability	(%)	75.000	
E/S Tx Atmospheric Losses	(dB)	-0.44	
E/S Tx Spreading Loss	(dB)	-149.40	
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	4.56	
SV Rx Power Per Tier	(dBW)	-117.61	
SV Rx Flux Density Per Tier	(dBW/m^2)	-71.48	
SV Tx OBO (ALC / ALC)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	29.26	
SV Tx EIRP Per Channel/Carrier	(dBW)	36.07	
SV Tx Pointing Loss	(dB)	0.00	
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)	19,163	
E/S Rx Wavelength	(m)	0.015644	
E/S Rx RF Link Availability	(%)	98.500	
E/S Rx Atmospheric Losses	(dB)	-6.81	
E/S Rx Radome & Pointing Loss	(dB)	-1.00	
E/S Rx Antenna Gain (1.2 m / 7.3 m)	(dBi)	42.82	
E/S Rx Effective G/T	(dB/K)	17.16	
E/S Rx Power Per Channel	(dBW)	-128.38	
E/S Rx Flux Density Per Channel	(dBW/m^2)	-124.10	
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)	76.53	
Carrier / Noise Uplink	(dB)	28.43	
Carrier / Noise Downlink	(dB)	-1.97	
Carrier / Intermodulation Im (C/Im)	(dB)	18.44	
(C/N) - Total Actual	(dB)	-2.03	
(C/N) - Total Required	(dB)	-2.20	
(E_b/N_o) - Total Actual	(dB)	0.98	
(E_b/N_o) - Total Required	(dB)	0.81	
Excess Margin	**(dB)**	**0.17**	
Fade Margin	**(dB)**	**0.17**	

O3b Network Link Analysis - Tier 2 Service For ESOMPs 50 deg lat, Ocean			
Link Budget Creator - Rev 3.2.9: May 16, 2013		**Tier 2**	**Tier 2**
Ground Parameter		**Teleport**	**Telco**
Location		Lima (east), Peru	ESOMPs 50 deg lat, Ocean
Latitude	(°)	-12.3	50.0
Longitude (East)	(°)	283.2	300.0
E/S Maximum Range to SV	(km)	8324.6	11698.8
E/S Minimmum Elevation to SV	(°)	68.2	12.0
E/S Altitude	(km)	2.0	0.0
SV Beam Identifier	(#)	15	
Minutes Into Pass (Sample #10)	(Min)	4:21	
Telco Spot Beam Off-Angle	(°)	1.30	
Telco Spot Beam Diameter	(km)	519.10	
Maximum Roundtrip Latency	(msec)	133.58	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type		DVB-S2
Modem Overhead	(%)		3.7%
Number of Carriers per Channel	(#)		10
Available Bandwidth	(Hz)		49,200,000
Available Throughput	(bps)		**31,595,698**
Channel Symbol Rate	(sps)		4,100,000
Channel Modulation Type			QPSK
Channel FEC Rate			0.40
Channel Spectral Efficiency	(bits/Sym)		0.80
Channel Throughput (100% / 100% of Full Rate)	(bps)		3,159,569.77
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)		1
E/S Tx Carrier Frequency	(MHz)		28,963
E/S Tx HPA Power Level	(W)		10
E/S Tx OBO	(dB)		-0.50
E/S Tx Post-HPA Losses	(dB)		-0.28
E/S Tx Antenna Gain (7.3 m / 1.2 m)	(dB)		46.54
E/S Tx EIRP Per Channel	(dBW)		55.76
E/S Tx Radome & Pointing Loss	(dB)		-1.00
E/S Tx RF Link Availability	(%)		98.500
E/S Tx Atmospheric Losses	(dB)		-12.57
E/S Tx Spreading Loss	(dB)		-152.35
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)		5
SV Rx G/T	(dB/K)		1.01
SV Rx Power Per Tier	(dBW)		-149.85
SV Rx Flux Density Per Tier	(dBW/m^2)		-100.16
SV Tx OBO (ALC / ALC)	(dB)		-15.00
SV Tx Post-TWTA Losses	(dB)		-1.50
SV Tx Antenna Gain	(dBi)		31.52
SV Tx EIRP Per Channel/Carrier	(dBW)		16.16
SV Tx Pointing Loss	(dB)		0.00
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)		19,163
E/S Rx Spreading Loss	(dB)		-149.40
E/S Rx RF Link Availability	(%)		75.000
E/S Rx Atmospheric Losses	(dB)		-0.34
E/S Rx Pointing Loss	(dB)		-0.50
E/S Rx Antenna Gain (1.2 m / 7.3 m)	(dBi)		62.35
E/S Rx Effective G/T	(dB/K)		39.91
E/S Rx Power Per Channel	(dBW)		-118.83
E/S Rx Flux Density Per Channel	(dBW/m^2)		-134.08
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)		66.13
Carrier / Noise Uplink	(dB)		2.62
Carrier / Noise Downlink	(dB)		21.20
Carrier / Intermodulation Im (C/Im)	(dB)		19.18
(C/N) - Total Actual	(dB)		2.28
(C/N) - Total Required	(dB)		1.40
(E_b/N_o) - Total Actual	(dB)		3.25
(E_b/N_o) - Total Required	(dB)		2.37
Excess Margin	**(dB)**		**0.88**
Fade Margin	**(dB)**		**4.48**

O3b Network Link Analysis - Tier 2 Service For San Juan-, United States			
Link Budget Creator - Rev 3.2.9: May 16, 2013		**Tier 2**	**Tier 2**
Ground Parameter		**Teleport**	**Telco**
Location		Vernon (LHCP), United States	San Juan-, United States
Latitude	(°)	34.2	18.5
Longitude (East)	(°)	260.7	293.9
E/S Maximum Range to SV	(km)	10138.9	9062.9
E/S Minimmum Elevation to SV	(°)	30.2	47.9
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)	25	
Minutes Into Pass (Sample #55)	(Min)	26:8	
Telco Spot Beam Off-Angle	(°)	1.30	
Telco Spot Beam Diameter	(km)	391.70	
Maximum Roundtrip Latency	(msec)	128.10	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	3.2%	
Number of Carriers per Channel	(#)	6	
Available Bandwidth	(Hz)	216,000,000	
Available Throughput	(bps)	**391,954,582**	
Channel Symbol Rate	(sps)	30,000,000	
Channel Modulation Type		8PSK	
Channel FEC Rate		0.75	
Channel Spectral Efficiency	(bits/Sym)	2.25	
Channel Throughput (100% / 100% of Full Rate)	(bps)	65,325,763.72	
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)	5	
E/S Tx Carrier Frequency	(MHz)	28,963	
E/S Tx HPA Power Level	(W)	500	
E/S Tx OBO	(dB)	-8.00	
E/S Tx Post-HPA Losses	(dB)	-2.24	
E/S Tx Antenna Gain (7.3 m / 2.2 m)	(dB)	65.11	
E/S Tx EIRP Per Channel	(dBW)	67.08	
E/S Tx Pointing Loss	(dB)	-0.50	
E/S Tx RF Link Availability	(%)	75.000	
E/S Tx Atmospheric Losses	(dB)	-1.26	
E/S Tx Spreading Loss	(dB)	-151.11	
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	5.24	
SV Rx Power Per Tier	(dBW)	-123.47	
SV Rx Flux Density Per Tier	(dBW/m^2)	-78.01	
SV Tx OBO (ALC / ALC)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	29.02	
SV Tx EIRP Per Channel/Carrier	(dBW)	34.07	
SV Tx Pointing Loss	(dB)	0.00	
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)	19,163	
E/S Rx Wavelength	(m)	0.015644	
E/S Rx RF Link Availability	(%)	50.000	
E/S Rx Atmospheric Losses	(dB)	-0.71	
E/S Rx Radome & Pointing Loss	(dB)	-1.00	
E/S Rx Antenna Gain (2.2 m / 7.3 m)	(dBi)	48.81	
E/S Rx Effective G/T	(dB/K)	24.85	
E/S Rx Power Per Channel	(dBW)	-116.07	
E/S Rx Flux Density Per Channel	(dBW/m^2)	-117.78	
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)	74.77	
Carrier / Noise Uplink	(dB)	22.58	
Carrier / Noise Downlink	(dB)	13.79	
Carrier / Intermodulation Im (C/Im)	(dB)	14.98	
(C/N) - Total Actual	(dB)	10.85	
(C/N) - Total Required	(dB)	9.50	
(E_b/N_o) - Total Actual	(dB)	7.33	
(E_b/N_o) - Total Required	(dB)	5.98	
Excess Margin	**(dB)**	**1.35**	
Fade Margin	**(dB)**	**13.05**	

O3b Network Link Analysis - Tier 2 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: May 16, 2013		Tier 2	Tier 2
Ground Parameter		**Teleport**	**Telco**
Location		Vernon (LHCP), United States	San Juan-, United States
Latitude	(°)	34.2	18.5
Longitude (East)	(°)	260.7	293.9
E/S Maximum Range to SV	(km)	9874.6	10631.3
E/S Minimmum Elevation to SV	(°)	34.0	23.9
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)	25	
Minutes Into Pass (Sample #10)	(Min)	4:21	
Telco Spot Beam Off-Angle	(°)	1.30	
Telco Spot Beam Diameter	(km)	391.70	
Maximum Roundtrip Latency	(msec)	136.80	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type		DVB-S2
Modem Overhead	(%)		3.1%
Number of Carriers per Channel	(#)		18
Available Bandwidth	(Hz)		216,000,000
Available Throughput	(bps)		**290,751,758**
Channel Symbol Rate	(sps)		10,000,000
Channel Modulation Type			QPSK
Channel FEC Rate			0.83
Channel Spectral Efficiency	(bits/Sym)		1.67
Channel Throughput (100% / 100% of Full Rate)	(bps)		16,152,875.43
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)		1
E/S Tx Carrier Frequency	(MHz)		28,963
E/S Tx HPA Power Level	(W)		40
E/S Tx OBO	(dB)		-5.00
E/S Tx Post-HPA Losses	(dB)		-0.69
E/S Tx Antenna Gain (7.3 m / 2.2 m)	(dB)		52.62
E/S Tx EIRP Per Channel	(dBW)		62.95
E/S Tx Radome & Pointing Loss	(dB)		-1.00
E/S Tx RF Link Availability	(%)		50.000
E/S Tx Atmospheric Losses	(dB)		-1.68
E/S Tx Spreading Loss	(dB)		-151.52
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)		5
SV Rx G/T	(dB/K)		0.94
SV Rx Power Per Tier	(dBW)		-128.45
SV Rx Flux Density Per Tier	(dBW/m^2)		-78.70
SV Tx OBO (ALC / ALC)	(dB)		-15.00
SV Tx Post-TWTA Losses	(dB)		-1.50
SV Tx Antenna Gain	(dBi)		31.77
SV Tx EIRP Per Channel/Carrier	(dBW)		13.86
SV Tx Pointing Loss	(dB)		0.00
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)		19,163
E/S Rx Spreading Loss	(dB)		-150.88
E/S Rx RF Link Availability	(%)		75.000
E/S Rx Atmospheric Losses	(dB)		-0.83
E/S Rx Pointing Loss	(dB)		-0.50
E/S Rx Antenna Gain (2.2 m / 7.3 m)	(dBi)		62.35
E/S Rx Effective G/T	(dB/K)		39.15
E/S Rx Power Per Channel	(dBW)		-123.10
E/S Rx Flux Density Per Channel	(dBW/m^2)		-138.35
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)		70.00
Carrier / Noise Uplink	(dB)		17.59
Carrier / Noise Downlink	(dB)		12.29
Carrier / Intermodulation Im (C/Im)	(dB)		26.64
(C/N) - Total Actual	(dB)		7.37
(C/N) - Total Required	(dB)		6.50
(E_b/N_o) - Total Actual	(dB)		5.15
(E_b/N_o) - Total Required	(dB)		4.28
Excess Margin	**(dB)**		**0.87**
Fade Margin	**(dB)**		**9.57**

O3b Network Link Analysis - Tier 2 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: May 16, 2013		Tier 2	Tier 2
Ground Parameter		**Teleport**	**Telco**
Location		Vernon (LHCP), United States	San Juan-, United States
Latitude	(°)	34.2	18.5
Longitude (East)	(°)	260.7	293.9
E/S Maximum Range to SV	(km)	9838.1	10211.5
E/S Minimmum Elevation to SV	(°)	34.5	29.2
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)	25	
Minutes Into Pass (Sample #20)	(Min)	9:11	
Telco Spot Beam Off-Angle	(°)	1.30	
Telco Spot Beam Diameter	(km)	391.70	
Maximum Roundtrip Latency	(msec)	133.76	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	4.3%	
Number of Carriers per Channel	(#)	6	
Available Bandwidth	(Hz)	216,000,000	
Available Throughput	(bps)	**86,143,862**	
Channel Symbol Rate	(sps)	30,000,000	
Channel Modulation Type		QPSK	
Channel FEC Rate		0.25	
Channel Spectral Efficiency	(bits/Sym)	0.50	
Channel Throughput (100% / 100% of Full Rate)	(bps)	14,357,310.26	
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)	5	
E/S Tx Carrier Frequency	(MHz)	28,963	
E/S Tx HPA Power Level	(W)	500	
E/S Tx OBO	(dB)	-8.00	
E/S Tx Post-HPA Losses	(dB)	-2.24	
E/S Tx Antenna Gain (7.3 m / 2.2 m)	(dB)	65.11	
E/S Tx EIRP Per Channel	(dBW)	67.08	
E/S Tx Pointing Loss	(dB)	-0.50	
E/S Tx RF Link Availability	(%)	75.000	
E/S Tx Atmospheric Losses	(dB)	-1.15	
E/S Tx Spreading Loss	(dB)	-150.85	
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	5.24	
SV Rx Power Per Tier	(dBW)	-123.09	
SV Rx Flux Density Per Tier	(dBW/m^2)	-77.63	
SV Tx OBO (ALC / ALC)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	29.18	
SV Tx EIRP Per Channel/Carrier	(dBW)	34.23	
SV Tx Pointing Loss	(dB)	0.00	
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)	19,163	
E/S Rx Wavelength	(m)	0.015644	
E/S Rx RF Link Availability	(%)	99.500	
E/S Rx Atmospheric Losses	(dB)	-10.78	
E/S Rx Radome & Pointing Loss	(dB)	-1.00	
E/S Rx Antenna Gain (2.2 m / 7.3 m)	(dBi)	48.81	
E/S Rx Effective G/T	(dB/K)	22.39	
E/S Rx Power Per Channel	(dBW)	-127.01	
E/S Rx Flux Density Per Channel	(dBW/m^2)	-128.72	
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)	74.77	
Carrier / Noise Uplink	(dB)	22.96	
Carrier / Noise Downlink	(dB)	0.39	
Carrier / Intermodulation Im (C/Im)	(dB)	14.98	
(C/N) - Total Actual	(dB)	0.12	
(C/N) - Total Required	(dB)	-2.20	
(E_b/N_o) - Total Actual	(dB)	3.13	
(E_b/N_o) - Total Required	(dB)	0.81	
Excess Margin	**(dB)**	**2.32**	
Fade Margin	**(dB)**	**2.32**	

O3b Network Link Analysis - Tier 2 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: May 16, 2013		Tier 2	Tier 2
Ground Parameter		**Teleport**	**Telco**
Location		Vernon (LHCP), United States	San Juan-, United States
Latitude	(°)	34.2	18.5
Longitude (East)	(°)	260.7	293.9
E/S Maximum Range to SV	(km)	9838.1	10211.5
E/S Minimmum Elevation to SV	(°)	34.5	29.2
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)	25	
Minutes Into Pass (Sample #20)	(Min)	9:11	
Telco Spot Beam Off-Angle	(°)	1.30	
Telco Spot Beam Diameter	(km)	391.70	
Maximum Roundtrip Latency	(msec)	133.76	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type		DVB-S2
Modem Overhead	(%)		3.9%
Number of Carriers per Channel	(#)		18
Available Bandwidth	(Hz)		216,000,000
Available Throughput	(bps)		**115,348,837**
Channel Symbol Rate	(sps)		10,000,000
Channel Modulation Type			QPSK
Channel FEC Rate			0.33
Channel Spectral Efficiency	(bits/Sym)		0.67
Channel Throughput (100% / 100% of Full Rate)	(bps)		6,408,268.73
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)		1
E/S Tx Carrier Frequency	(MHz)		28,963
E/S Tx HPA Power Level	(W)		40
E/S Tx OBO	(dB)		-1.17
E/S Tx Post-HPA Losses	(dB)		-0.69
E/S Tx Antenna Gain (7.3 m / 2.2 m)	(dB)		52.62
E/S Tx EIRP Per Channel	(dBW)		66.78
E/S Tx Radome & Pointing Loss	(dB)		-1.00
E/S Tx RF Link Availability	(%)		99.500
E/S Tx Atmospheric Losses	(dB)		-20.90
E/S Tx Spreading Loss	(dB)		-151.17
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)		5
SV Rx G/T	(dB/K)		0.90
SV Rx Power Per Tier	(dBW)		-143.54
SV Rx Flux Density Per Tier	(dBW/m^2)		-93.74
SV Tx OBO (ALC / ALC)	(dB)		-15.00
SV Tx Post-TWTA Losses	(dB)		-1.50
SV Tx Antenna Gain	(dBi)		31.77
SV Tx EIRP Per Channel/Carrier	(dBW)		13.86
SV Tx Pointing Loss	(dB)		0.00
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)		19,163
E/S Rx Spreading Loss	(dB)		-150.85
E/S Rx RF Link Availability	(%)		75.000
E/S Rx Atmospheric Losses	(dB)		-0.81
E/S Rx Pointing Loss	(dB)		-0.50
E/S Rx Antenna Gain (2.2 m / 7.3 m)	(dBi)		62.35
E/S Rx Effective G/T	(dB/K)		39.15
E/S Rx Power Per Channel	(dBW)		-123.06
E/S Rx Flux Density Per Channel	(dBW/m^2)		-138.31
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)		70.00
Carrier / Noise Uplink	(dB)		2.51
Carrier / Noise Downlink	(dB)		12.34
Carrier / Intermodulation Im (C/Im)	(dB)		19.18
(C/N) - Total Actual	(dB)		1.35
(C/N) - Total Required	(dB)		0.30
(E_b/N_o) - Total Actual	(dB)		3.11
(E_b/N_o) - Total Required	(dB)		2.06
Excess Margin	**(dB)**		**1.05**
Fade Margin	**(dB)**		**3.55**

O3b Network Link Analysis - Tier 2 Service For ESOMPs 7 deg lat, ocean

Link Budget Creator - Rev 3.2.9: May 16, 2013		Tier 2	Tier 2
Ground Parameter		**Teleport**	**Telco**
Location		Vernon (LHCP), United States	ESOMPs 7 deg lat, ocean
Latitude	(°)	34.2	7.0
Longitude (East)	(°)	260.7	280.0
E/S Maximum Range to SV	(km)	9874.6	9130.8
E/S Minimmum Elevation to SV	(°)	34.0	46.5
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)	24	
Minutes Into Pass (Sample #10)	(Min)	4:21	
Telco Spot Beam Off-Angle	(°)	1.30	
Telco Spot Beam Diameter	(km)	369.80	
Maximum Roundtrip Latency	(msec)	126.79	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	3.2%	
Number of Carriers per Channel	(#)	6	
Available Bandwidth	(Hz)	216,000,000	
Available Throughput	(bps)	**348,418,491**	
Channel Symbol Rate	(sps)	30,000,000	
Channel Modulation Type		8PSK	
Channel FEC Rate		0.67	
Channel Spectral Efficiency	(bits/Sym)	2.00	
Channel Throughput (100% / 100% of Full Rate)	(bps)	58,069,748.58	
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)	5	
E/S Tx Carrier Frequency	(MHz)	28,709	
E/S Tx HPA Power Level	(W)	500	
E/S Tx OBO	(dB)	-8.00	
E/S Tx Post-HPA Losses	(dB)	-2.24	
E/S Tx Antenna Gain (7.3 m / 2.2 m)	(dB)	65.03	
E/S Tx EIRP Per Channel	(dBW)	67.01	
E/S Tx Pointing Loss	(dB)	-0.50	
E/S Tx RF Link Availability	(%)	75.000	
E/S Tx Atmospheric Losses	(dB)	-1.16	
E/S Tx Spreading Loss	(dB)	-150.88	
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	5.24	
SV Rx Power Per Tier	(dBW)	-123.13	
SV Rx Flux Density Per Tier	(dBW/m^2)	-77.75	
SV Tx OBO (ALC / ALC)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	29.02	
SV Tx EIRP Per Channel/Carrier	(dBW)	34.07	
SV Tx Pointing Loss	(dB)	0.00	
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)	18,909	
E/S Rx Wavelength	(m)	0.015854	
E/S Rx RF Link Availability	(%)	50.000	
E/S Rx Atmospheric Losses	(dB)	-1.04	
E/S Rx Radome & Pointing Loss	(dB)	-1.00	
E/S Rx Antenna Gain (2.2 m / 7.3 m)	(dBi)	48.70	
E/S Rx Effective G/T	(dB/K)	24.80	
E/S Rx Power Per Channel	(dBW)	-116.46	
E/S Rx Flux Density Per Channel	(dBW/m^2)	-118.17	
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)	74.77	
Carrier / Noise Uplink	(dB)	22.92	
Carrier / Noise Downlink	(dB)	13.47	
Carrier / Intermodulation Im (C/Im)	(dB)	14.98	
(C/N) - Total Actual	(dB)	9.45	
(C/N) - Total Required	(dB)	8.20	
(E_b/N_o) - Total Actual	(dB)	6.44	
(E_b/N_o) - Total Required	(dB)	5.19	
Excess Margin	**(dB)**	**1.25**	
Fade Margin	**(dB)**	**11.65**	

O3b Network Link Analysis - Tier 2 Service For ESOMPs 7 deg lat, ocean			
Link Budget Creator - Rev 3.2.9: May 16, 2013		**Tier 2**	**Tier 2**
Ground Parameter		**Teleport**	**Telco**
Location		Vernon (LHCP), United States	ESOMPs 7 deg lat, ocean
Latitude	(°)	34.2	7.0
Longitude (East)	(°)	260.7	280.0
E/S Maximum Range to SV	(km)	9874.6	9130.8
E/S Minimmum Elevation to SV	(°)	34.0	46.5
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)	24	
Minutes Into Pass (Sample #10)	(Min)	4:21	
Telco Spot Beam Off-Angle	(°)	1.30	
Telco Spot Beam Diameter	(km)	369.80	
Maximum Roundtrip Latency	(msec)	126.79	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type		DVB-S2
Modem Overhead	(%)		3.2%
Number of Carriers per Channel	(#)		18
Available Bandwidth	(Hz)		216,000,000
Available Throughput	(bps)		**348,418,491**
Channel Symbol Rate	(sps)		10,000,000
Channel Modulation Type			8PSK
Channel FEC Rate			0.67
Channel Spectral Efficiency	(bits/Sym)		2.00
Channel Throughput (100% / 100% of Full Rate)	(bps)		19,356,582.86
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)		1
E/S Tx Carrier Frequency	(MHz)		28,709
E/S Tx HPA Power Level	(W)		40
E/S Tx OBO	(dB)		-5.00
E/S Tx Post-HPA Losses	(dB)		-0.69
E/S Tx Antenna Gain (7.3 m / 2.2 m)	(dB)		52.54
E/S Tx EIRP Per Channel	(dBW)		62.87
E/S Tx Radome & Pointing Loss	(dB)		-1.00
E/S Tx RF Link Availability	(%)		50.000
E/S Tx Atmospheric Losses	(dB)		-1.66
E/S Tx Spreading Loss	(dB)		-150.20
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)		5
SV Rx G/T	(dB/K)		0.68
SV Rx Power Per Tier	(dBW)		-127.37
SV Rx Flux Density Per Tier	(dBW/m^2)		-77.43
SV Tx OBO (ALC / ALC)	(dB)		-15.00
SV Tx Post-TWTA Losses	(dB)		-1.50
SV Tx Antenna Gain	(dBi)		31.77
SV Tx EIRP Per Channel/Carrier	(dBW)		13.86
SV Tx Pointing Loss	(dB)		0.00
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)		18,909
E/S Rx Spreading Loss	(dB)		-150.88
E/S Rx RF Link Availability	(%)		75.000
E/S Rx Atmospheric Losses	(dB)		-0.76
E/S Rx Pointing Loss	(dB)		-0.50
E/S Rx Antenna Gain (2.2 m / 7.3 m)	(dBi)		62.24
E/S Rx Effective G/T	(dB/K)		39.16
E/S Rx Power Per Channel	(dBW)		-123.04
E/S Rx Flux Density Per Channel	(dBW/m^2)		-138.29
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)		70.00
Carrier / Noise Uplink	(dB)		18.68
Carrier / Noise Downlink	(dB)		12.48
Carrier / Intermodulation Im (C/Im)	(dB)		26.64
(C/N) - Total Actual	(dB)		8.71
(C/N) - Total Required	(dB)		8.20
(E_b/N_o) - Total Actual	(dB)		5.70
(E_b/N_o) - Total Required	(dB)		5.19
Excess Margin	**(dB)**		**0.51**
Fade Margin	**(dB)**		**10.91**

O3b Network Link Analysis - Tier 2 Service For ESOMPs 7 deg lat, ocean			
Link Budget Creator - Rev 3.2.9: May 16, 2013		**Tier 2**	**Tier 2**
Ground Parameter		**Teleport**	**Telco**
Location		Vernon (LHCP), United States	ESOMPs 7 deg lat, ocean
Latitude	(°)	34.2	7.0
Longitude (East)	(°)	260.7	280.0
E/S Maximum Range to SV	(km)	9874.6	9130.8
E/S Minimmum Elevation to SV	(°)	34.0	46.5
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)	24	
Minutes Into Pass (Sample #10)	(Min)	4:21	
Telco Spot Beam Off-Angle	(°)	1.30	
Telco Spot Beam Diameter	(km)	369.80	
Maximum Roundtrip Latency	(msec)	126.79	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	3.9%	
Number of Carriers per Channel	(#)	6	
Available Bandwidth	(Hz)	216,000,000	
Available Throughput	(bps)	**115,348,837**	
Channel Symbol Rate	(sps)	30,000,000	
Channel Modulation Type		QPSK	
Channel FEC Rate		0.33	
Channel Spectral Efficiency	(bits/Sym)	0.67	
Channel Throughput (100% / 100% of Full Rate)	(bps)	19,224,806.20	
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)	5	
E/S Tx Carrier Frequency	(MHz)	28,709	
E/S Tx HPA Power Level	(W)	500	
E/S Tx OBO	(dB)	-8.00	
E/S Tx Post-HPA Losses	(dB)	-2.24	
E/S Tx Antenna Gain (7.3 m / 2.2 m)	(dB)	65.03	
E/S Tx EIRP Per Channel	(dBW)	67.01	
E/S Tx Pointing Loss	(dB)	-0.50	
E/S Tx RF Link Availability	(%)	75.000	
E/S Tx Atmospheric Losses	(dB)	-1.16	
E/S Tx Spreading Loss	(dB)	-150.88	
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	5.24	
SV Rx Power Per Tier	(dBW)	-123.13	
SV Rx Flux Density Per Tier	(dBW/m^2)	-77.75	
SV Tx OBO (ALC / ALC)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	29.02	
SV Tx EIRP Per Channel/Carrier	(dBW)	34.07	
SV Tx Pointing Loss	(dB)	0.00	
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)	18,909	
E/S Rx Wavelength	(m)	0.015854	
E/S Rx RF Link Availability	(%)	99.500	
E/S Rx Atmospheric Losses	(dB)	-10.70	
E/S Rx Radome & Pointing Loss	(dB)	-1.00	
E/S Rx Antenna Gain (2.2 m / 7.3 m)	(dBi)	48.70	
E/S Rx Effective G/T	(dB/K)	22.34	
E/S Rx Power Per Channel	(dBW)	-126.12	
E/S Rx Flux Density Per Channel	(dBW/m^2)	-127.83	
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)	74.77	
Carrier / Noise Uplink	(dB)	22.92	
Carrier / Noise Downlink	(dB)	1.35	
Carrier / Intermodulation Im (C/Im)	(dB)	14.98	
(C/N) - Total Actual	(dB)	0.96	
(C/N) - Total Required	(dB)	0.30	
(E_b/N_o) - Total Actual	(dB)	2.72	
(E_b/N_o) - Total Required	(dB)	2.06	
Excess Margin	**(dB)**	**0.66**	
Fade Margin	**(dB)**	**3.16**	

O3b Network Link Analysis - Tier 2 Service For ESOMPs 7 deg lat, ocean

Link Budget Creator - Rev 3.2.9: May 16, 2013		Tier 2	Tier 2
Ground Parameter		**Teleport**	**Telco**
Location		Vernon (LHCP), United States	ESOMPs 7 deg lat, ocean
Latitude	(°)	34.2	7.0
Longitude (East)	(°)	260.7	280.0
E/S Maximum Range to SV	(km)	9874.6	9130.8
E/S Minimmum Elevation to SV	(°)	34.0	46.5
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)	24	
Minutes Into Pass (Sample #10)	(Min)	4:21	
Telco Spot Beam Off-Angle	(°)	1.30	
Telco Spot Beam Diameter	(km)	369.80	
Maximum Roundtrip Latency	(msec)	126.79	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	3.9%	
Number of Carriers per Channel	(#)	6	
Available Bandwidth	(Hz)	216,000,000	
Available Throughput	(bps)	**115,348,837**	
Channel Symbol Rate	(sps)	30,000,000	
Channel Modulation Type		QPSK	
Channel FEC Rate		0.33	
Channel Spectral Efficiency	(bits/Sym)	0.67	
Channel Throughput (100% / 100% of Full Rate)	(bps)	19,224,806.20	
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)	5	
E/S Tx Carrier Frequency	(MHz)	28,709	
E/S Tx HPA Power Level	(W)	500	
E/S Tx OBO	(dB)	-8.00	
E/S Tx Post-HPA Losses	(dB)	-2.24	
E/S Tx Antenna Gain (7.3 m / 2.2 m)	(dB)	65.03	
E/S Tx EIRP Per Channel	(dBW)	67.01	
E/S Tx Pointing Loss	(dB)	-0.50	
E/S Tx RF Link Availability	(%)	75.000	
E/S Tx Atmospheric Losses	(dB)	-1.16	
E/S Tx Spreading Loss	(dB)	-150.88	
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	5.24	
SV Rx Power Per Tier	(dBW)	-123.13	
SV Rx Flux Density Per Tier	(dBW/m^2)	-77.75	
SV Tx OBO (ALC / ALC)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	29.02	
SV Tx EIRP Per Channel/Carrier	(dBW)	34.07	
SV Tx Pointing Loss	(dB)	0.00	
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)	18,909	
E/S Rx Wavelength	(m)	0.015854	
E/S Rx RF Link Availability	(%)	99.500	
E/S Rx Atmospheric Losses	(dB)	-10.70	
E/S Rx Radome & Pointing Loss	(dB)	-1.00	
E/S Rx Antenna Gain (2.2 m / 7.3 m)	(dBi)	48.70	
E/S Rx Effective G/T	(dB/K)	22.34	
E/S Rx Power Per Channel	(dBW)	-126.12	
E/S Rx Flux Density Per Channel	(dBW/m^2)	-127.83	
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)	74.77	
Carrier / Noise Uplink	(dB)	22.92	
Carrier / Noise Downlink	(dB)	1.35	
Carrier / Intermodulation Im (C/Im)	(dB)	14.98	
(C/N) - Total Actual	(dB)	0.96	
(C/N) - Total Required	(dB)	0.30	
(E_b/N_o) - Total Actual	(dB)	2.72	
(E_b/N_o) - Total Required	(dB)	2.06	
Excess Margin	**(dB)**	**0.66**	
Fade Margin	**(dB)**	**3.16**	

O3b Network Link Analysis - Tier 2 Service For ESOMPs 50 deg lat, Ocean			
Link Budget Creator - Rev 3.2.9: May 16, 2013		**Tier 2**	**Tier 2**
Ground Parameter		**Teleport**	**Telco**
Location		Lima (east), Peru	ESOMPs 50 deg lat, Ocean
Latitude	(°)	-12.3	50.0
Longitude (East)	(°)	283.2	300.0
E/S Maximum Range to SV	(km)	8324.6	11698.8
E/S Minimmum Elevation to SV	(°)	68.2	12.0
E/S Altitude	(km)	2.0	0.0
SV Beam Identifier	(#)	15	
Minutes Into Pass (Sample #10)	(Min)	4:21	
Telco Spot Beam Off-Angle	(°)	1.30	
Telco Spot Beam Diameter	(km)	519.10	
Maximum Roundtrip Latency	(msec)	133.58	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	3.2%	
Number of Carriers per Channel	(#)	6	
Available Bandwidth	(Hz)	216,000,000	
Available Throughput	(bps)	**348,418,491**	
Channel Symbol Rate	(sps)	30,000,000	
Channel Modulation Type		8PSK	
Channel FEC Rate		0.67	
Channel Spectral Efficiency	(bits/Sym)	2.00	
Channel Throughput (100% / 100% of Full Rate)	(bps)	58,069,748.58	
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)	5	
E/S Tx Carrier Frequency	(MHz)	28,963	
E/S Tx HPA Power Level	(W)	500	
E/S Tx OBO	(dB)	-4.00	
E/S Tx Post-HPA Losses	(dB)	-2.24	
E/S Tx Antenna Gain (7.3 m / 2.2 m)	(dB)	65.11	
E/S Tx EIRP Per Channel	(dBW)	71.08	
E/S Tx Pointing Loss	(dB)	-0.50	
E/S Tx RF Link Availability	(%)	75.000	
E/S Tx Atmospheric Losses	(dB)	-0.44	
E/S Tx Spreading Loss	(dB)	-149.40	
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	4.56	
SV Rx Power Per Tier	(dBW)	-117.61	
SV Rx Flux Density Per Tier	(dBW/m^2)	-71.48	
SV Tx OBO (ALC / ALC)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	29.26	
SV Tx EIRP Per Channel/Carrier	(dBW)	34.31	
SV Tx Pointing Loss	(dB)	0.00	
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)	19,163	
E/S Rx Wavelength	(m)	0.015644	
E/S Rx RF Link Availability	(%)	50.000	
E/S Rx Atmospheric Losses	(dB)	-0.94	
E/S Rx Radome & Pointing Loss	(dB)	-1.00	
E/S Rx Antenna Gain (2.2 m / 7.3 m)	(dBi)	48.81	
E/S Rx Effective G/T	(dB/K)	23.71	
E/S Rx Power Per Channel	(dBW)	-118.28	
E/S Rx Flux Density Per Channel	(dBW/m^2)	-119.99	
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)	74.77	
Carrier / Noise Uplink	(dB)	28.43	
Carrier / Noise Downlink	(dB)	10.44	
Carrier / Intermodulation Im (C/Im)	(dB)	14.17	
(C/N) - Total Actual	(dB)	8.68	
(C/N) - Total Required	(dB)	8.20	
(E_b/N_o) - Total Actual	(dB)	5.67	
(E_b/N_o) - Total Required	(dB)	5.19	
Excess Margin	**(dB)**	**0.48**	
Fade Margin	**(dB)**	**10.88**	

O3b Network Link Analysis - Tier 2 Service For ESOMPs 50 deg lat, Ocean

Link Budget Creator - Rev 3.2.9: May 16, 2013		Tier 2	Tier 2
Ground Parameter		**Teleport**	**Telco**
Location		Lima (east), Peru	ESOMPs 50 deg lat, Ocean
Latitude	(°)	-12.3	50.0
Longitude (East)	(°)	283.2	300.0
E/S Maximum Range to SV	(km)	8324.6	11698.8
E/S Minimmum Elevation to SV	(°)	68.2	12.0
E/S Altitude	(km)	2.0	0.0
SV Beam Identifier	(#)	15	
Minutes Into Pass (Sample #10)	(Min)	4:21	
Telco Spot Beam Off-Angle	(°)	1.30	
Telco Spot Beam Diameter	(km)	519.10	
Maximum Roundtrip Latency	(msec)	133.58	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type		DVB-S2
Modem Overhead	(%)		3.2%
Number of Carriers per Channel	(#)		18
Available Bandwidth	(Hz)		216,000,000
Available Throughput	(bps)		**348,418,491**
Channel Symbol Rate	(sps)		10,000,000
Channel Modulation Type			8PSK
Channel FEC Rate			0.67
Channel Spectral Efficiency	(bits/Sym)		2.00
Channel Throughput (100% / 100% of Full Rate)	(bps)		19,356,582.86
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)		1
E/S Tx Carrier Frequency	(MHz)		28,963
E/S Tx HPA Power Level	(W)		40
E/S Tx OBO	(dB)		-5.00
E/S Tx Post-HPA Losses	(dB)		-0.69
E/S Tx Antenna Gain (7.3 m / 2.2 m)	(dB)		52.62
E/S Tx EIRP Per Channel	(dBW)		62.95
E/S Tx Radome & Pointing Loss	(dB)		-1.00
E/S Tx RF Link Availability	(%)		50.000
E/S Tx Atmospheric Losses	(dB)		-1.36
E/S Tx Spreading Loss	(dB)		-152.35
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)		5
SV Rx G/T	(dB/K)		1.01
SV Rx Power Per Tier	(dBW)		-128.90
SV Rx Flux Density Per Tier	(dBW/m^2)		-79.21
SV Tx OBO (ALC / ALC)	(dB)		-15.00
SV Tx Post-TWTA Losses	(dB)		-1.50
SV Tx Antenna Gain	(dBi)		31.52
SV Tx EIRP Per Channel/Carrier	(dBW)		13.61
SV Tx Pointing Loss	(dB)		0.00
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)		19,163
E/S Rx Spreading Loss	(dB)		-149.40
E/S Rx RF Link Availability	(%)		75.000
E/S Rx Atmospheric Losses	(dB)		-0.34
E/S Rx Pointing Loss	(dB)		-0.50
E/S Rx Antenna Gain (2.2 m / 7.3 m)	(dBi)		62.35
E/S Rx Effective G/T	(dB/K)		39.91
E/S Rx Power Per Channel	(dBW)		-121.38
E/S Rx Flux Density Per Channel	(dBW/m^2)		-136.63
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)		70.00
Carrier / Noise Uplink	(dB)		17.15
Carrier / Noise Downlink	(dB)		14.78
Carrier / Intermodulation Im (C/Im)	(dB)		26.64
(C/N) - Total Actual	(dB)		8.41
(C/N) - Total Required	(dB)		8.20
(E_b/N_o) - Total Actual	(dB)		5.40
(E_b/N_o) - Total Required	(dB)		5.19
Excess Margin	**(dB)**		**0.21**
Fade Margin	**(dB)**		**10.61**

O3b Network Link Analysis - Tier 2 Service For ESOMPs 50 deg lat, Ocean			
Link Budget Creator - Rev 3.2.9: May 16, 2013		**Tier 2**	**Tier 2**
Ground Parameter		**Teleport**	**Telco**
Location		Lima (east), Peru	ESOMPs 50 deg lat, Ocean
Latitude	(°)	-12.3	50.0
Longitude (East)	(°)	283.2	300.0
E/S Maximum Range to SV	(km)	8324.6	11698.8
E/S Minimmum Elevation to SV	(°)	68.2	12.0
E/S Altitude	(km)	2.0	0.0
SV Beam Identifier	(#)	15	
Minutes Into Pass (Sample #10)	(Min)	4:21	
Telco Spot Beam Off-Angle	(°)	1.30	
Telco Spot Beam Diameter	(km)	519.10	
Maximum Roundtrip Latency	(msec)	133.58	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	3.7%	
Number of Carriers per Channel	(#)	6	
Available Bandwidth	(Hz)	216,000,000	
Available Throughput	(bps)	**138,712,818**	
Channel Symbol Rate	(sps)	30,000,000	
Channel Modulation Type		QPSK	
Channel FEC Rate		0.40	
Channel Spectral Efficiency	(bits/Sym)	0.80	
Channel Throughput (100% / 100% of Full Rate)	(bps)	23,118,802.96	
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)	5	
E/S Tx Carrier Frequency	(MHz)	28,963	
E/S Tx HPA Power Level	(W)	500	
E/S Tx OBO	(dB)	-4.00	
E/S Tx Post-HPA Losses	(dB)	-2.24	
E/S Tx Antenna Gain (7.3 m / 2.2 m)	(dB)	65.11	
E/S Tx EIRP Per Channel	(dBW)	71.08	
E/S Tx Pointing Loss	(dB)	-0.50	
E/S Tx RF Link Availability	(%)	75.000	
E/S Tx Atmospheric Losses	(dB)	-0.44	
E/S Tx Spreading Loss	(dB)	-149.40	
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	4.56	
SV Rx Power Per Tier	(dBW)	-117.61	
SV Rx Flux Density Per Tier	(dBW/m^2)	-71.48	
SV Tx OBO (ALC / ALC)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	29.26	
SV Tx EIRP Per Channel/Carrier	(dBW)	34.31	
SV Tx Pointing Loss	(dB)	0.00	
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)	19,163	
E/S Rx Wavelength	(m)	0.015644	
E/S Rx RF Link Availability	(%)	99.000	
E/S Rx Atmospheric Losses	(dB)	-7.87	
E/S Rx Radome & Pointing Loss	(dB)	-1.00	
E/S Rx Antenna Gain (2.2 m / 7.3 m)	(dBi)	48.81	
E/S Rx Effective G/T	(dB/K)	22.77	
E/S Rx Power Per Channel	(dBW)	-125.21	
E/S Rx Flux Density Per Channel	(dBW/m^2)	-126.92	
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)	74.77	
Carrier / Noise Uplink	(dB)	28.43	
Carrier / Noise Downlink	(dB)	2.57	
Carrier / Intermodulation Im (C/Im)	(dB)	14.17	
(C/N) - Total Actual	(dB)	2.23	
(C/N) - Total Required	(dB)	1.40	
(E_b/N_o) - Total Actual	(dB)	3.20	
(E_b/N_o) - Total Required	(dB)	2.37	
Excess Margin	**(dB)**	**0.83**	
Fade Margin	**(dB)**	**4.43**	

O3b Network Link Analysis - Tier 2 Service For ESOMPs 50 deg lat, Ocean			
Link Budget Creator - Rev 3.2.9: May 16, 2013		**Tier 2**	**Tier 2**
Ground Parameter		**Teleport**	**Telco**
Location		Lima (east), Peru	ESOMPs 50 deg lat, Ocean
Latitude	(°)	-12.3	50.0
Longitude (East)	(°)	283.2	300.0
E/S Maximum Range to SV	(km)	8324.6	11698.8
E/S Minimmum Elevation to SV	(°)	68.2	12.0
E/S Altitude	(km)	2.0	0.0
SV Beam Identifier	(#)	15	
Minutes Into Pass (Sample #10)	(Min)	4:21	
Telco Spot Beam Off-Angle	(°)	1.30	
Telco Spot Beam Diameter	(km)	519.10	
Maximum Roundtrip Latency	(msec)	133.58	
Modulation Parameters		**Forward**	**Return**
Enter Receiver	Type		DVB-S2
Modem Overhead	(%)		3.2%
Number of Carriers per Channel	(#)		18
Available Bandwidth	(Hz)		216,000,000
Available Throughput	(bps)		**232,341,806**
Channel Symbol Rate	(sps)		10,000,000
Channel Modulation Type			QPSK
Channel FEC Rate			0.67
Channel Spectral Efficiency	(bits/Sym)		1.33
Channel Throughput (100% / 100% of Full Rate)	(bps)		12,907,878.13
Uplink		**Forward**	**Return**
E/S Tx Channels per HPA	(#)		1
E/S Tx Carrier Frequency	(MHz)		28,963
E/S Tx HPA Power Level	(W)		40
E/S Tx OBO	(dB)		-1.17
E/S Tx Post-HPA Losses	(dB)		-0.69
E/S Tx Antenna Gain (7.3 m / 2.2 m)	(dB)		52.62
E/S Tx EIRP Per Channel	(dBW)		66.78
E/S Tx Radome & Pointing Loss	(dB)		-1.00
E/S Tx RF Link Availability	(%)		99.000
E/S Tx Atmospheric Losses	(dB)		-14.67
E/S Tx Spreading Loss	(dB)		-152.35
Satellite		**Forward**	**Return**
SV Number of Channels per HPA	(#)		5
SV Rx G/T	(dB/K)		1.01
SV Rx Power Per Tier	(dBW)		-138.38
SV Rx Flux Density Per Tier	(dBW/m^2)		-88.69
SV Tx OBO (ALC / ALC)	(dB)		-15.00
SV Tx Post-TWTA Losses	(dB)		-1.50
SV Tx Antenna Gain	(dBi)		31.52
SV Tx EIRP Per Channel/Carrier	(dBW)		13.61
SV Tx Pointing Loss	(dB)		0.00
Downlink		**Forward**	**Return**
E/S Rx Carrier Frequency	(MHz)		19,163
E/S Rx Spreading Loss	(dB)		-149.40
E/S Rx RF Link Availability	(%)		75.000
E/S Rx Atmospheric Losses	(dB)		-0.34
E/S Rx Pointing Loss	(dB)		-0.50
E/S Rx Antenna Gain (2.2 m / 7.3 m)	(dBi)		62.35
E/S Rx Effective G/T	(dB/K)		39.91
E/S Rx Power Per Channel	(dBW)		-121.38
E/S Rx Flux Density Per Channel	(dBW/m^2)		-136.63
Total Link		**Forward**	**Return**
Carrier / Noise Bandwidth	(dB)		70.00
Carrier / Noise Uplink	(dB)		7.67
Carrier / Noise Downlink	(dB)		14.78
Carrier / Intermodulation Im (C/Im)	(dB)		19.18
(C/N) - Total Actual	(dB)		5.15
(C/N) - Total Required	(dB)		4.80
(E_b/N_o) - Total Actual	(dB)		3.90
(E_b/N_o) - Total Required	(dB)		3.55
Excess Margin	**(dB)**		**0.35**
Fade Margin	**(dB)**		**7.35**