

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

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Technical Statement

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

**I. INTRODUCTION AND SUMMARY**

O3b Limited (“O3b”) operates a U.K.-authorized, non-geostationary orbit (“NGSO”) Fixed-Satellite Service (“FSS”) system in the Ka-band.<sup>1</sup> O3b’s first four satellites were launched in June 2013, and an additional four satellites were launched on July 10, 2014.

In this application, O3b seeks a blanket license permitting it to operate up to one thousand 1.2m, one thousand 2.2m, one thousand 1.8m, and one thousand 2.4m fixed earth stations (collectively, the “Blanket-Licensed Earth Stations”) that will communicate with O3b’s system.<sup>2</sup> The essential terms of O3b’s application are as follows:

**Frequencies.** O3b seeks authority for its Blanket-Licensed Earth Stations 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.

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<sup>1</sup> 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 Sept. 25, 2012) (the “Hawaii License”). In June 2013, the Commission granted O3b a license to operate a second gateway in the United States, located in Vernon, Texas (the “Texas License”). *See* FCC File No. SES-LIC-20130124-00089 (granted June 20, 2013).

<sup>2</sup> The Blanket-Licensed Earth Stations will all be land based. O3b is not seeking authority in this application to operate maritime or aeronautical terminals.

**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 FSS systems on a primary basis.<sup>3</sup>

**Service area.** O3b seeks authority to operate the Blanket-Licensed Earth Stations in the contiguous United States, Hawaii, Puerto Rico, and the U.S. Virgin Islands.

**Operation in border areas.** Although there is no allocation in the FCC's U.S. band plan for terrestrial Fixed Service ("FS") stations in the frequency ranges to be used by O3b's Blanket-Licensed Earth Stations, under the international Table of Frequency Allocations terrestrial FS stations have co-primary status in these frequency bands. For this reason, O3b addresses in this application the potential for harmful interference from its Blanket-Licensed Earth Stations to terrestrial FS stations in Canada and Mexico.

O3b demonstrates in the attached Technical Statement (Section A.10) that even under the very conservative methodology contained in the ITU's Appendix 7 methodology there is no risk of harmful interference when O3b's Blanket-Licensed Earth Stations are located at least 100 km from the Canadian and Mexican borders. O3b also shows in the Technical Statement, based on additional analysis, that O3b's Blanket-Licensed Earth Stations should be able to operate closer than 100 km from foreign borders without posing a risk of harmful interference to terrestrial FS stations on the other side of the Canadian and Mexican borders.

**Waiver requests.** O3b seeks a waiver of 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 Blanket-Licensed Earth Station operations certain waivers that it granted previously.

**Timetable.** O3b respectfully requests that its blanket license application be granted on or before January 2, 2015.

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<sup>3</sup> *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). 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").

## **II. DISCUSSION**

### **A. Description of Service**

#### **1. Overview**

O3b's service represents a major advance in the state of the art. Using fully steerable beams, O3b's Medium Earth Orbit ("MEO") satellites can provide high-quality, broadband Internet access that is comparable to fiber-based broadband services. O3b's system offers scalable bandwidth options from 100 MB up to 1.6 GB. In addition, because the O3b satellites are 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.

O3b's unique architecture makes it ideal for government and business applications that require high data throughput and low latency. For example, it is expected that O3b's system will be used in the United States for 3G and 4G backhaul services; for data trunking in industries with high data requirements (like the energy sector); for local networks on business campuses; for specialized communications requirements of government agencies, the military, and first responders; and for network monitoring. O3b's system supports numerous real-time broadband applications, including cloud-based services, very large file transfers, interactive video and voice conferencing, interactive web content, video streaming, and real-time multiplayer video games.

#### **2. Service area**

The service area for the Blanket-Licensed Earth Stations consists of the contiguous United States, Hawaii, Puerto Rico, and the U.S. Virgin Islands.

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

O3b's target customer base includes telecommunications services providers, internet service providers, mobile services providers, large enterprises, and federal, state, and local governments. O3b will provide these customers with lower prices and better service.

O3b's advanced technology enables it to use satellites that are smaller and less expensive to build than traditional satellites. This cost structure enhances competition and lowers prices. O3b combines its lower prices with a throughput that is many times the throughput of traditional satellites. And because O3b's satellites orbit closer to the earth, latency is minimized. These factors – lower

costs, better throughput, and reduced latency – ensure that O3b’s system will advance 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.<sup>4</sup> 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.<sup>5</sup> In September 2012, the Commission, by granting the Hawaii License and associated waivers, determined that O3b meets the criteria for U.S. market access.<sup>6</sup>

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.<sup>7</sup> 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.<sup>8</sup> 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.

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<sup>4</sup> See *Amendment of the Commission's Regulatory Policies to Allow Non-U.S. Licensed Space Stations to Provide Domestic and International Satellite Service in the United States (“DISCO II”)*, 15 FCC Rcd 7207, ¶ 5 (1999).

<sup>5</sup> See O3b’s application for a Hawaii gateway license (“O3b Hawaii Application”), FCC File No. SES-LIC-20100723-00952, narrative at Section V.

<sup>6</sup> See Hawaii License. The Commission subsequently issued the Texas License (*see* n.1) and a blanket license for O3b’s earth stations on maritime vessels (*see* FCC File No. SES-LIC-20130528-00455 (granted May 13, 2014) (the “Blanket Maritime License”).

<sup>7</sup> *DISCO II*, 15 FCC Rcd 7207 at ¶ 192.

<sup>8</sup> *Id.*

**D. 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 fixed earth stations, some of which may operate on a temporary basis, that will communicate with O3b's system in the 18.8-19.3 and 28.6-29.1 GHz bands. Under the Commission's frequency plan for the Ka-band, NGSO FSS systems have primary status in the 18.8-19.3 and 28.6-29.1 GHz bands.<sup>9</sup> 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.<sup>10</sup>

**E. Waivers Sought by O3b**

*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.<sup>11</sup> The Commission has waived Section 25.145(c) for O3b's Hawaii and Texas gateway earth stations and its maritime terminals but has reserved judgment on granting a waiver of Section 25.145(c) for any other O3b applications.<sup>12</sup>

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."<sup>13</sup> 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."<sup>14</sup> The Commission granted a similar waiver for O3b's Texas earth station<sup>15</sup> and granted a waiver in connection with the grant of O3b's blanket maritime earth station application because O3b's maritime service area is "less extensive than the

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<sup>9</sup> See note 3, above.

<sup>10</sup> 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); *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).

<sup>11</sup> 47 C.F.R. § 25.145(c).

<sup>12</sup> See Hawaii License, Condition 90044; Texas License, Condition 90044; and Blanket Maritime License, Condition 6597.

<sup>13</sup> *Id.*

<sup>14</sup> *Id.*

<sup>15</sup> See Texas License, Condition 90044.

geographic coverage areas required in Section 25.145(c).<sup>16</sup> These grants also were without prejudice to action on future waiver requests.

O3b requests a waiver of Section 25.145(c) for its Blanket-Licensed Earth Stations. The architecture of O3b's system furnishes good cause for waiving this provision. Because of where O3b's target customers are located, O3b chose an equatorial orbit for its constellation of satellites. Due to look-angle constraints, this orbit carries with it a limitation on the northernmost and southernmost latitudes that can be served by O3b's system. A waiver is needed to take this unique system architecture into account.

A waiver, moreover, would not undercut the underlying purpose of Section 25.145(c); it would promote it. The rule is intended to foster a seamless global communications network.<sup>17</sup> O3b's system, which has ten 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 service.

Accordingly, there is good cause for waiving 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).<sup>18</sup> For the reasons stated therein, which apply with equal force here, those waivers, if needed again, should be granted in this case as well.

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<sup>16</sup> See Blanket Maritime License, Condition 6597

<sup>17</sup> *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, ¶ 34 (1997).

<sup>18</sup> See Application for Hawaii License, Legal Narrative, Section D(2)(ii) at 22-23 and Section D(2)(iii) at 24; see also Attachment A (Technical Information) thereto, Section A.14 at 40-42 and Section A.13.2 at 34-36.



*Bond Requirement.* O3b respectfully requests that it not be required, in connection with a grant of its Blanket-Licensed Earth Station 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.<sup>19</sup> 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.<sup>20</sup> The same result should obtain here.

### Conclusion

O3b has demonstrated that its Blanket-Licensed Earth Stations will enhance competition and improve service. Grant of O3b's application, therefore, is in the public interest, and O3b ask that the Commission act in accordance with O3b's timetable as outlined above.<sup>21</sup>

Respectfully submitted,

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<sup>19</sup> See [http://licensing.fcc.gov/myibfs/download.do?attachment\\_key=972913](http://licensing.fcc.gov/myibfs/download.do?attachment_key=972913).

<sup>20</sup> See *Telesat Canada*, DA 07-118, *Order*, 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.”).

<sup>21</sup> O3b is submitting with this application the \$10,430.00 initial application filing fee for Fixed Satellite Very Small Aperture Terminal Systems (fee code BGV).

# **O3B NON-GEOSTATIONARY SATELLITE SYSTEM**

## **Technical Information to Supplement the Existing Schedule S for the Blanket Licensed Earth Station Application**

### **A.1 Scope**

There are several elements to the technical showing associated with O3b's Blanket-Licensed Earth Station application. The Schedule B that is filed with the application provides the technical parameters for O3b's Blanket-Licensed Earth Stations that are the subject of this application. The Schedule S that O3b filed previously, which is hereby incorporated by reference, provides the technical parameters for O3b's space stations.<sup>1</sup> This Attachment A provides additional technical information concerning the proposed operations of the Blanket-Licensed Earth Stations.

### **A.2 General Description of Earth Stations and Network Configuration**

The Blanket-Licensed Earth Stations will be connected via the O3b satellites to O3b's gateway earth stations. The Blanket-Licensed Earth Stations, some of which may operate on a temporary basis, will be used by telecommunications operators (wireless and wireline), internet service providers, large enterprises, and government agencies. The Blanket-Licensed Earth Stations are not intended to be used directly for mass consumer service, but rather for specialized government and business applications that make use of the O3b system's very high data throughput and low latency. The operational characteristics of these earth stations are within all aspects of the envelope defined for user terminals in O3b's Schedule S, including both fixed and temporary fixed terminals.

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<sup>1</sup> A Schedule S for the O3b non-geostationary satellite system originally was filed with the Commission as part of the license application for the Hawaii earth station. See O3b's Hawaii application, FCC File No. SES-LIC-20100723-00952. A modified version of the Schedule S, which contains all necessary information concerning the O3b satellite system, was provided to the Commission as part of O3b's response to FCC questions concerning O3b's Blanket ESV Application, FCC File No. SES-LIC-20130528-00455. See O3b's Response to FCC Questions, October 25, 2013. References in this filing to "Schedule S" are to this modified Schedule S.

### A.3 Frequencies of Operation

These earth stations will operate in the following frequency ranges:

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

O3b operates a non-geostationary orbit (“NGSO”) fixed-satellite service (“FSS”) system. Under the FCC’s detailed band plan relating to Ka-band services in the United States, the frequency ranges shown above are allocated to the non-geostationary satellite orbit (“NGSO”) FSS on a primary basis and to the GSO FSS on a secondary basis.<sup>2</sup> There is no allocation for terrestrial services in these frequency ranges in the FCC’s band plan.

### A.4 Service Area

The service area requested for the Blanket-Licensed Earth Stations consists of the contiguous United States, Hawaii, Puerto Rico, and the U.S. Virgin Islands. These territories are all at Earth latitudes greater than 17.9°N. The active O3b satellites with which these earth stations will communicate will be selected so that the minimum elevation angle from the earth station to the O3b satellite does not fall below 10°.

The service area designated as “U” in the original Schedule S for the O3b non-geostationary satellite system covers all Earth locations with elevation angles to the operational O3b satellites of greater than 3 degrees. Therefore the operation of the Blanket-Licensed Earth Stations within

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<sup>2</sup> *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). 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).

the service area stated above falls within the “U” service area as defined in the existing Schedule S.

#### **A.5 Predicted Space Station Antenna Gain Contours**

In its Schedule S, which is incorporated by reference in this filing, O3b has provided satellite antenna relative gain information, as requested by the Commission, in the form of mathematical equations that bound the gain as a function of the off-axis angle from the boresight of the antenna.

#### **A.6 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 Blanket-Licensed Earth Stations that are the subject of this application.

§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:<sup>3</sup>

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

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<sup>3</sup> 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.

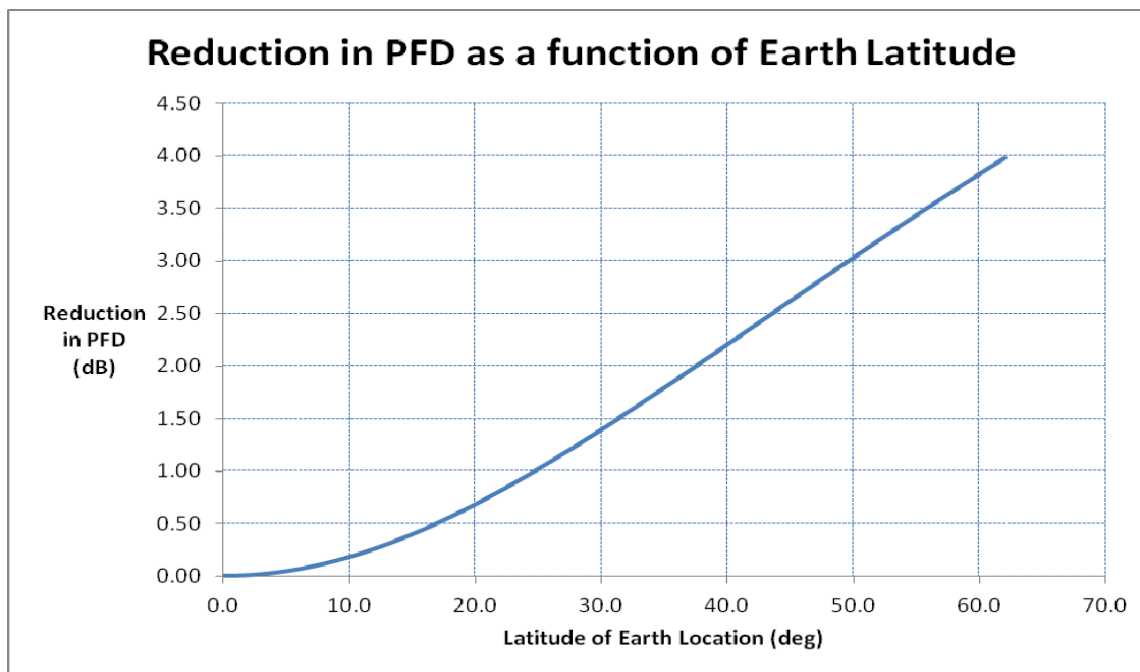
- -105 dB(W/m<sup>2</sup>) in any 1 MHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.

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) 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 links to the Blanket-Licensed Earth Stations, 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<sup>2</sup>/MHz, which is less than the most stringent -115 dBW/m<sup>2</sup>/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<sup>2</sup>/MHz, based on the worst-case assessment described in the preceding paragraph. In practice the maximum downlink PFD for O3b's Blanket-Licensed Earth Station service will likely not exceed -125 dBW/m<sup>2</sup>/MHz.

In addition, for Earth latitudes away from the equator the minimum path length from the O3b satellites to the Earth is higher than the 8,062 km assumed in the worst-case calculation given above. This is demonstrated in the diagram below which gives the resulting reduction in PFD arising from the increased minimum path length at latitudes away from the equator. For example, at 38°N, the approximate latitude of the Blanket-Licensed Earth Stations, the reduction in PFD would be an additional 2 dB.



The PFD analysis presented above is specific to one of the downlink beams of an O3b satellite. There is no significant aggregation of the downlink PFD due to multiple beams from the O3b satellites, as explained previously to the Commission in the context of an earlier O3b earth station application.<sup>4</sup>

#### **A.7 Interference Analysis with respect to GSO Satellite Networks**

According to the Commission’s Ka-band plan NGSO satellite systems are primary in the frequency bands that are the subject of this application and GSO satellite networks are secondary, and are obliged to protect NGSO systems from harmful interference. In the case of this application O3b does not anticipate any harmful interference from NGSO systems because of the inherent orbit geometry as explained further below.

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<sup>4</sup> See O3b “Responses to FCC Questions,” dated October 25, 2013, FCC File Nos. SES-LIC-20130528-00455 and SES-AMD-20131025-01138, response to Question 12; letter, dated November 19, 2013, from Joslyn Read, O3b’s Vice-President, Regulatory Affairs, to Marlene H. Dortch, Secretary, FCC, FCC File Nos. SES-LIC-20130528-00455 and SES-AMD-20131025-01138.

At the minimum latitude in the requested service area for the Blanket-Licensed Earth Stations (i.e. 17.9°) the minimum angular separation between the O3b satellite orbit and the GSO is always greater than 7.2°, as viewed from the surface of the Earth.<sup>5</sup> This minimum separation angle is large enough that GSO satellite networks should be able to protect the O3b links to the Blanket-Licensed Earth Stations from harmful interference without undue constraint, as demonstrated below.

For the downlink, a reasonable assumption is that the GSO satellite downlink PFD is consistent with the Commission's blanket licensing requirements for GSO Ka-band earth stations and so does not exceed the value given in §25.138(a)(6) which is -118 dBW/m<sup>2</sup>/MHz towards the O3b receiving earth stations. Consistent with Section A.6 above this means the GSO interfering PFD is comparable to, or somewhat higher than, the wanted O3b PFD level. In this case the resulting C/I ratio is equal to or greater than the off-axis gain of the receiving O3b earth station at the off-axis angle of 7.2°, which is in excess of 35 dB, which would adequately protect the O3b downlink.

For the uplink, a reasonable assumption is that the GSO satellite uplink transmission is consistent with the Commission's blanket licensing requirements and so complies with the requirements of §25.138(a)(1). This would result in an off-axis EIRP density towards the O3b satellite of -2.63 dBW/40kHz, resulting in a  $\Delta T/T$  at the O3b satellite receiver of approximately 5% (or an  $I_o/N_o$  of -13 dB), which would be acceptable. This calculation pessimistically assumes the path length from the interfering earth station to the O3b satellite is equal to the minimum possible distance, which is the O3b orbit altitude of 8,062 km.

The uplink and downlink interference situations described above are notional ones only. In practice there are no non-government U.S. licensed GSO Ka-band satellites operating or planning to operate in the bands used by the O3b ESV terminals with beams operating outside of

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<sup>5</sup> This pessimistic calculation is based on an assumed minimum elevation angle of 20° from the GSO earth station located at 17.9° latitude to the corresponding GSO satellite. This implies a GSO satellite that is very far to the east or west of the GSO earth station which would not enable reliable service to be provided from this satellite to more northerly latitudes such as CONUS.

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. In this case there would be an additional 3.5 dB of additional interference protection between the O3b and GSO systems.

With respect to non-U.S. licensed Ka-band GSO satellites O3b will only operate its Blanket-Licensed Earth Stations 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 Analysis with respect to NGSO Satellite Systems**

The Blanket-Licensed Earth Station service to be provided by O3b presents no significantly different interference environment with respect to other NGSO satellite systems than was addressed in O3b's Hawaii gateway earth station application.<sup>6</sup> The use of Blanket-Licensed Earth Stations over the range of latitudes consistent with the stated service area will still permit O3b to employ satellite diversity and/or band segmentation as measures to enable the sharing of spectrum with other NGSO systems. Alternatively, for other NGSO systems employing Highly Elliptical Orbit ("HEO") type orbits there will be very large angular separation at all times between the O3b and the HEO links.

#### **A.9 Interference to and from Existing Domestic U.S. Terrestrial Licensees**

In the uplink band (28.6-29.1 GHz) there is no allocation in the Commission's Ka-band Band Plan for terrestrial services.

In the downlink band (18.8-19.3 GHz) 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. However, according to Sections 101.85-101.97 of the FCC's rules there are some legacy Fixed Service links in this band which are obliged to protect, and not claim protection from, Fixed-Satellite

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<sup>6</sup> See O3b's Hawaii application, FCC File No. SES-LIC-20100723-00952, Attachment A, Section A.10.2, pp. 28-30.



Services such as O3b. These rules establish procedures for relocating FS stations that raise interference issues.

#### **A.10 Interference in the 28.6-29.1 GHz Uplink Band with Respect to Foreign Terrestrial Services<sup>7</sup>**

For FSS earth stations in the United States that are located close to the border of foreign countries, there is a potential in the 28.6-29.1 GHz uplink band for interference to terrestrial FS stations operating in those foreign countries.<sup>8</sup> O3b has carefully assessed this matter and proposes the following approaches to ensure that no harmful interference is experienced.<sup>9</sup>

First, whenever the O3b Blanket-Licensed Earth Station is located *more than* 100 km from the territory of a foreign country that is adjacent to or nearby the service area of the Blanket-Licensed Earth Stations (e.g., Canada, Mexico), it can safely be assumed there is no risk of harmful interference, even using the very conservative methodology contained in the ITU's Appendix 7 methodology.<sup>10</sup>

Furthermore, in practice, for the following reasons O3b's Blanket-Licensed Earth Stations should be able to operate *closer than* 100 km from foreign borders without posing a risk of harmful interference to terrestrial FS stations on the other side of the border:

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<sup>7</sup> As discussed in Section A.6, O3b will protect terrestrial FS stations using O3b's 18.8-19.3 GHz downlink band by complying with FCC and ITU power flux density limits.

<sup>8</sup> Although (as stated above) there is no allocation in the FCC's band plan for terrestrial FS stations in the frequency ranges to be used by O3b's Blanket-Licensed Earth Stations, under the international Table of Frequency Allocations terrestrial FS stations have co-primary status in these frequency bands.

<sup>9</sup> Out of an abundance of caution, O3b has responded "yes" to question E19 of FCC Form 312, Schedule B, which asks whether coordination with another country is required. Coordination with other countries may be unnecessary, however, in light of the showing O3b is making in this Section A.10.

<sup>10</sup> See Annex 2 for the derivation of the 100 km separation distance based on ITU Appendix 7.

## Canada

- Under the Canadian allocation plan,” the fixed-satellite service has priority over ... the fixed service” in the frequencies to be used by O3b’s Blanket-Licensed Earth Stations, and fixed service operations on those frequencies must “be limited to applications that pose minimal constraints on the deployment of fixed-satellite services.”<sup>11</sup>
- For O3b Blanket-Licensed Earth Stations located near the U.S. border with Canada, the cases where the minimum elevation angle exists will correspond to azimuth pointing directions that are generally in a southerly direction, including pointing to the south-east and south-west. For these geometries, the minimum off-axis angle from directions towards Canadian territory will be significantly higher than simply the minimum elevation angle, because of the azimuth component. Therefore, a Blanket-Licensed Earth Station should be able to operate closer to the Canadian border than the 100 km distance that is predicted using the ITU Appendix 7 methodology in Annex 2.
- O3b has reviewed the online listing of Industry Canada’s FS licensees in the frequencies requested for the Blanket-Licensed Earth Stations. There are currently no FS operators licensed by Canada to use the uplink frequencies proposed by O3b in this application.

## Mexico

- For O3b Blanket-Licensed Earth Stations located near the U.S. border with Mexico, the minimum elevation angle of the O3b earth station will be significantly higher than the 10° minimum used in the ITU Appendix 7 analysis in Annex 2, because of the geometry of the O3b orbit in relation to the relatively low latitudes of the U.S.-Mexican border. Higher elevation angles mean less interference on the path between the O3b earth station and the FS station, because of the increased off-axis gain of the O3b earth station. For example, an increase in the elevation angle from 10° to 25°

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<sup>11</sup> Canadian table of frequency allocations, footnotes C16E and C16F.

reduces the off-axis gain of the O3b earth station antenna in the horizontal direction by approximately 10 dB, which would correspond to a 3.3 fold reduction in the separation distance assuming a simple square law propagation characteristic. Therefore, an O3b Blanket-Licensed Earth Station should be able to operate closer to the Mexican border than the 100 km distance that is predicted using the ITU Appendix 7 methodology in Annex 2.

- O3b is not aware of any terrestrial FS licensees that are operating in Mexico in the U.S. border region, or are planning to operate in Mexico in the U.S. border region, in the 28.6-29.1 GHz band. O3b is also not aware of any licensing procedures or policies that the Mexican regulator has put in place with regard to licensing FS operators in this band.

Nevertheless, if the Commission remains concerned about the possibility of harmful interference being caused by O3b's transmitting earth stations located less than 100 km from the border, O3b proposes the following alternative.

O3b earth stations located less than 100 km from the border will be operated either on a non-interference basis with respect to foreign terrestrial services (*see* items i-iv below) or will be coordinated with the foreign terrestrial services (*see* item v below). This will be implemented as follows:

- (i) For the specific O3b earth station and its geographic location O3b will analyze potential cross-border interference paths for typical Ka-band FS terminals located in the other country. This analysis will take account of the actual terrain data which impacts the interference path and the actual pointing directions of the O3b earth station antenna. From this it will be determined whether there is any realistic likelihood of harmful interference occurring with respect to the foreign FS terminals for the particular location of the O3b earth station.
- (ii) O3b will take operational measures with the O3b earth station such that, upon receiving any indication that it might be causing harmful interference to a foreign FS receiver, its transmissions will be modified or ceased in order to prevent harmful interference from occurring.

- (iii) O3b will accept any harmful interference received by its earth station from FS transmitters in foreign countries.
- (iv) In the event of harmful interference occurring according to (ii) or (iii) above, O3b will initiate coordination discussions, via the FCC and its foreign counterpart, or if directed, with the operator responsible for the foreign FS service in question in order to agree mutually acceptable operating conditions.
- (v) In the event that O3b requires full operational rights and full interference protection for a particular O3b earth station that is located within 100 km of the border of a foreign country, O3b will coordinate that earth station with the responsible authorities in the foreign country.

The alternative approach described above might be an interim one if superseded by bilateral agreements or arrangements between the U.S. and its neighboring countries concerning the coordination of terrestrial and satellite services in the Ka-band operating near common borders.

#### **A.11 Link Budgets for the Blanket Licensed Earth Stations**

A number of representative link budgets are provided in Annex 1 for the Blanket-Licensed Earth Stations. These address a range of technical and operational parameters as explained in the Annex.

#### **A.12 TT&C Characteristics**

O3b is not seeking TT&C authority for the Blanket-Licensed Earth Stations.

#### **A.13 Coordination with U.S. Government Satellite Networks and Earth Stations**

O3b has completed all necessary coordination with U.S. 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 U.S. government, and this US334 coordination agreement specifically takes into account O3b earth stations such as the blanket licensed ones requested herein.



## **Annex 1 - Representative Link Budgets for the Blanket-Licensed Earth Stations**

This annex contains example link budgets for communications transmissions to and from the Blanket-Licensed Earth Stations. These are provided for the following:

- Two extreme geographic locations for the blanket-licensed earth stations, in terms of their latitudes: San Juan, Puerto Rico and Seattle, Washington.
- The gateway earth station location is assumed to be Vernon, Texas for all the link budgets.
- Blanket-licensed earth station antenna diameters of 2.4m, 2.2m, 1.8m and 1.2m.
- Transmission data rates varying from 2.3 Mbps to 594 Mbps.
- Various modulation/coding rates and emission bandwidths.
- The use of adaptive coding and modulation is assumed throughout.

The link budgets are provided in the following 48 pages.

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

Link Budget Creator - Rev 3.2.9: July 18, 2014			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 Range to SV	(km)		9953.9	11033.2
E/S Elevation to SV	(°)		32.8	19.1
E/S Altitude	(km)		0.3	0.0
SV Beam Identifier	(#)			25
Minutes Into Pass (Sample #1)	(Min)			0:0
Telco Spot Beam Off-Angle	(°)			0.20
Telco Spot Beam Diameter	(km)			60.30
Maximum Roundtrip Latency	(msec)			140.01
Modulation Parameters			Forward	Return
Enter Receiver	Type		DVB-S2	
Modem Overhead	(%)		3.3%	
Number of Carriers per Channel	(#)		1	
Available Bandwidth	(Hz)		54,000,000	
Channel Symbol Rate	(sps)		45,000,000	
Channel Modulation Type			16APSK	
Channel FEC Rate			0.90	
Channel Spectral Efficiency	(bits/Sym)		3.60	
Channel Throughput (100% / 100% of Full Rate)	(bps)		156,720,604	
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)		125	
E/S Tx OBO	(dB)		-8.00	
E/S Tx Post-HPA Losses	(dB)		-2.24	
E/S Tx Antenna Gain (7.3 m / 2.4 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)		-1.19	
E/S Tx Spreading Loss	(dB)		-150.95	
Satellite			Forward	Return
SV Number of Channels per HPA	(#)		1	
SV Rx G/T	(dB/K)		5.41	
SV Rx Power Per Tier	(dBW)		-129.08	
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )		-83.80	
SV Tx OBO (ALC / FGM)	(dB)		-3.80	
SV Tx Post-TWTA Losses	(dB)		-1.50	
SV Tx Antenna Gain	(dBi)		31.94	
SV Tx EIRP Per Channel/Carrier	(dBW)		44.77	
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	
E/S Rx Atmospheric Losses	(dB)		-1.54	
E/S Rx Pointing Loss	(dB)		-0.50	
E/S Rx Antenna Gain (2.4 m / 7.3 m)	(dBi)		51.5	
E/S Rx Effective G/T	(dB/K)		26.6	
E/S Rx Power Per Channel	(dBW)		-104.7	
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )		-109.1	
Total Link			Forward	Return
Carrier / Noise Bandwidth	(dB)		76.53	
Carrier / Noise Uplink	(dB)		22.99	
Carrier / Noise Downlink	(dB)		22.42	
Carrier / Intermodulation Im (C/Im)	(dB)		29.35	
(C/N) - Total Actual	(dB)		15.25	
(C/N) - Total Required	(dB)		15.20	
(E <sub>v</sub> /N <sub>0</sub> ) - Total Actual	(dB)		9.69	
(E <sub>v</sub> /N <sub>0</sub> ) - Total Required	(dB)		9.64	
<b>Excess Margin</b>	<b>(dB)</b>		<b>0.05</b>	
<b>Fade Margin</b>	<b>(dB)</b>		<b>17.45</b>	

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

Link Budget Creator - Rev 3.2.9: July 18, 2014			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 Range to SV	(km)		9953.9	11033.2
E/S Elevation to SV	(°)		32.8	19.1
E/S Altitude	(km)		0.3	0.0
SV Beam Identifier	(#)		25	
Minutes Into Pass (Sample #1)	(Min)		0:0	
Telco Spot Beam Off-Angle	(°)		0.20	
Telco Spot Beam Diameter	(km)		60.30	
Maximum Roundtrip Latency	(msec)		140.01	
Modulation Parameters			Forward	Return
Enter Receiver	Type			DVB-S2
Modem Overhead	(%)			3.2%
Number of Carriers per Channel	(#)			1
Available Bandwidth	(Hz)			54,000,000
Channel Symbol Rate	(sps)			45,000,000
Channel Modulation Type				8PSK
Channel FEC Rate				0.75
Channel Spectral Efficiency	(bits/Sym)			2.25
Channel Throughput (100% / 100% of Full Rate)	(bps)			<b>97,988,646</b>
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)			-0.77
E/S Tx Antenna Gain (7.3 m / 2.4 m)	(dB)			55.3
E/S Tx EIRP Per Channel	(dBW)			65.56
E/S Tx Pointing Loss	(dB)			-0.50
E/S Tx RF Link Availability	(%)			50.000
E/S Tx Atmospheric Losses	(dB)			-2.03
E/S Tx Spreading Loss	(dB)			-151.85
Satellite			Forward	Return
SV Number of Channels per HPA	(#)			5
SV Rx G/T	(dB/K)			5.10
SV Rx Power Per Tier	(dBW)			-134.41
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )			-88.82
SV Tx OBO (ALC / FGM)	(dB)			-11.84
SV Tx Post-TWTA Losses	(dB)			-1.50
SV Tx Antenna Gain	(dBi)			31.90
SV Tx EIRP Per Channel/Carrier	(dBW)			29.70
SV Tx Pointing Loss	(dB)			0.00
Downlink			Forward	Return
E/S Rx Carrier Frequency	(MHz)			19,163
E/S Rx Spreading Loss	(dB)			-150.95
E/S Rx RF Link Availability	(%)			75.000
E/S Rx Atmospheric Losses	(dB)			-0.85
E/S Rx Pointing Loss	(dB)			-0.50
E/S Rx Antenna Gain (2.4 m / 7.3 m)	(dBi)			62.35
E/S Rx Effective G/T	(dB/K)			39.14
E/S Rx Power Per Channel	(dBW)			-107.35
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )			-122.60
Total Link			Forward	Return
Carrier / Noise Bandwidth	(dB)			76.53
Carrier / Noise Uplink	(dB)			17.65
Carrier / Noise Downlink	(dB)			21.51
(C/N) - Total Actual	(dB)			10.74
(C/N) - Total Required	(dB)			9.50
(E <sub>b</sub> /N <sub>0</sub> ) - Total Actual	(dB)			7.22
(E <sub>b</sub> /N <sub>0</sub> ) - Total Required	(dB)			5.98
<b>Excess Margin</b>	<b>(dB)</b>			<b>1.24</b>
<b>Fade Margin</b>	<b>(dB)</b>			<b>12.94</b>



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

Link Budget Creator - Rev 3.2.9: July 18, 2014			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 Range to SV	(km)		9953.9	11033.2
E/S Elevation to SV	(°)		32.8	19.1
E/S Altitude	(km)		0.3	0.0
SV Beam Identifier	(#)			25
Minutes Into Pass (Sample #1)	(Min)			0:0
Telco Spot Beam Off-Angle	(°)			0.20
Telco Spot Beam Diameter	(km)			60.30
Maximum Roundtrip Latency	(msec)			140.01
Modulation Parameters			Forward	Return
Enter Receiver	Type		DVB-S2	
Modem Overhead	(%)		3.3%	
Number of Carriers per Channel	(#)		1	
Available Bandwidth	(Hz)		54,000,000	
Channel Symbol Rate	(sps)		45,000,000	
Channel Modulation Type			16APSK	
Channel FEC Rate			0.83	
Channel Spectral Efficiency	(bits/Sym)		3.33	
Channel Throughput (100% / 100% of Full Rate)	(bps)		144,983,819	
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)		125	
E/S Tx OBO	(dB)		-8.00	
E/S Tx Post-HPA Losses	(dB)		-2.24	
E/S Tx Antenna Gain (7.3 m / 1.8 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)		-1.19	
E/S Tx Spreading Loss	(dB)		-150.95	
Satellite			Forward	Return
SV Number of Channels per HPA	(#)		1	
SV Rx G/T	(dB/K)		5.41	
SV Rx Power Per Tier	(dBW)		-129.08	
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )		-83.80	
SV Tx OBO (ALC / FGM)	(dB)		-3.80	
SV Tx Post-TWTA Losses	(dB)		-1.50	
SV Tx Antenna Gain	(dBi)		31.94	
SV Tx EIRP Per Channel/Carrier	(dBW)		44.77	
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	
E/S Rx Atmospheric Losses	(dB)		-1.54	
E/S Rx Pointing Loss	(dB)		-0.50	
E/S Rx Antenna Gain (1.8 m / 7.3 m)	(dBi)		49.0	
E/S Rx Effective G/T	(dB/K)		24.1	
E/S Rx Power Per Channel	(dBW)		-107.2	
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )		-109.1	
Total Link			Forward	Return
Carrier / Noise Bandwidth	(dB)		76.53	
Carrier / Noise Uplink	(dB)		22.99	
Carrier / Noise Downlink	(dB)		19.92	
Carrier / Intermodulation Im (C/Im)	(dB)		29.35	
(C/N) - Total Actual	(dB)		14.65	
(C/N) - Total Required	(dB)		13.70	
(E <sub>v</sub> /N <sub>0</sub> ) - Total Actual	(dB)		9.42	
(E <sub>v</sub> /N <sub>0</sub> ) - Total Required	(dB)		8.47	
<b>Excess Margin</b>	<b>(dB)</b>		<b>0.95</b>	
<b>Fade Margin</b>	<b>(dB)</b>		<b>16.85</b>	

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

Link Budget Creator - Rev 3.2.9: July 18, 2014		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 Range to SV	(km)	9953.9	11033.2
E/S Elevation to SV	(°)	32.8	19.1
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)		25
Minutes Into Pass (Sample #1)	(Min)		0:0
Telco Spot Beam Off-Angle	(°)		0.20
Telco Spot Beam Diameter	(km)		60.30
Maximum Roundtrip Latency	(msec)		140.01
Modulation Parameters		Forward	Return
Enter Receiver	Type		DVB-S2
Modem Overhead	(%)		3.2%
Number of Carriers per Channel	(#)		1
Available Bandwidth	(Hz)		54,000,000
Channel Symbol Rate	(sps)		45,000,000
Channel Modulation Type			8PSK
Channel FEC Rate			0.67
Channel Spectral Efficiency	(bits/Sym)		2.00
Channel Throughput (100% / 100% of Full Rate)	(bps)		<b>87,104,623</b>
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)		-0.77
E/S Tx Antenna Gain (7.3 m / 1.8 m)	(dB)		52.8
E/S Tx EIRP Per Channel	(dBW)		63.06
E/S Tx Pointing Loss	(dB)		-0.50
E/S Tx RF Link Availability	(%)		50.000
E/S Tx Atmospheric Losses	(dB)		-2.03
E/S Tx Spreading Loss	(dB)		-151.85
Satellite		Forward	Return
SV Number of Channels per HPA	(#)		5
SV Rx G/T	(dB/K)		5.10
SV Rx Power Per Tier	(dBW)		-136.91
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )		-91.32
SV Tx OBO (ALC / FGM)	(dB)		-13.67
SV Tx Post-TWTA Losses	(dB)		-1.50
SV Tx Antenna Gain	(dBi)		31.90
SV Tx EIRP Per Channel/Carrier	(dBW)		27.87
SV Tx Pointing Loss	(dB)		0.00
Downlink		Forward	Return
E/S Rx Carrier Frequency	(MHz)		19,163
E/S Rx Spreading Loss	(dB)		-150.95
E/S Rx RF Link Availability	(%)		75.000
E/S Rx Atmospheric Losses	(dB)		-0.85
E/S Rx Pointing Loss	(dB)		-0.50
E/S Rx Antenna Gain (1.8 m / 7.3 m)	(dBi)		62.35
E/S Rx Effective G/T	(dB/K)		39.14
E/S Rx Power Per Channel	(dBW)		-109.18
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )		-124.43
Total Link		Forward	Return
Carrier / Noise Bandwidth	(dB)		76.53
Carrier / Noise Uplink	(dB)		15.15
Carrier / Noise Downlink	(dB)		19.67
(C/N) - Total Actual	(dB)		9.00
(C/N) - Total Required	(dB)		8.20
(E <sub>v</sub> /N <sub>0</sub> ) - Total Actual	(dB)		5.99
(E <sub>v</sub> /N <sub>0</sub> ) - Total Required	(dB)		5.19
<b>Excess Margin</b>	<b>(dB)</b>		<b>0.80</b>
<b>Fade Margin</b>	<b>(dB)</b>		<b>11.20</b>

## O3b Network Link Analysis - Tier 1 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014			Tier 1	Tier 1
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 Range to SV	(km)		9953.9	11033.2
E/S Elevation to SV	(°)		32.8	19.1
E/S Altitude	(km)		0.3	0.0
SV Beam Identifier	(#)			25
Minutes Into Pass (Sample #1)	(Min)			0:0
Telco Spot Beam Off-Angle	(°)			0.20
Telco Spot Beam Diameter	(km)			60.30
Maximum Roundtrip Latency	(msec)			140.01
Modulation Parameters			Forward	Return
Enter Receiver	Type		DVB-S2	
Modem Overhead	(%)		1.0%	
Number of Carriers per Channel	(#)		1	
Available Bandwidth	(Hz)		54,000,000	
Channel Symbol Rate	(sps)		45,000,000	
Channel Modulation Type			32APSK	
Channel FEC Rate			0.75	
Channel Spectral Efficiency	(bits/Sym)		3.75	
Channel Throughput (100% / 100% of Full Rate)	(bps)		167,062,500	
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)		125	
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)		68.84	
E/S Tx Pointing Loss	(dB)		-0.50	
E/S Tx RF Link Availability	(%)		75.000	
E/S Tx Atmospheric Losses	(dB)		-1.19	
E/S Tx Spreading Loss	(dB)		-150.95	
Satellite			Forward	Return
SV Number of Channels per HPA	(#)		1	
SV Rx G/T	(dB/K)		5.41	
SV Rx Power Per Tier	(dBW)		-129.08	
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )		-83.80	
SV Tx OBO (ALC / FGM)	(dB)		-3.80	
SV Tx Post-TWTA Losses	(dB)		-1.50	
SV Tx Antenna Gain	(dBi)		31.94	
SV Tx EIRP Per Channel/Carrier	(dBW)		44.77	
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	
E/S Rx Atmospheric Losses	(dB)		-1.54	
E/S Rx Pointing Loss	(dB)		-1.00	
E/S Rx Antenna Gain (2.2 m / 7.3 m)	(dBi)		48.8	
E/S Rx Effective G/T	(dB/K)		23.6	
E/S Rx Power Per Channel	(dBW)		-107.9	
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )		-109.6	
Total Link			Forward	Return
Carrier / Noise Bandwidth	(dB)		76.53	
Carrier / Noise Uplink	(dB)		22.99	
Carrier / Noise Downlink	(dB)		18.96	
Carrier / Intermodulation Im (C/Im)	(dB)		29.35	
(C/N) - Total Actual	(dB)		14.34	
(C/N) - Total Required	(dB)		14.30	
(E <sub>b</sub> /N <sub>0</sub> ) - Total Actual	(dB)		8.60	
(E <sub>b</sub> /N <sub>0</sub> ) - Total Required	(dB)		8.56	
<b>Excess Margin</b>	<b>(dB)</b>		<b>0.04</b>	
<b>Fade Margin</b>	<b>(dB)</b>		<b>16.94</b>	

## O3b Network Link Analysis - Tier 1 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014		Tier 1	Tier 1
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 Range to SV	(km)	9953.9	11033.2
E/S Elevation to SV	(°)	32.8	19.1
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)		25
Minutes Into Pass (Sample #1)	(Min)		0:0
Telco Spot Beam Off-Angle	(°)		0.20
Telco Spot Beam Diameter	(km)		60.30
Maximum Roundtrip Latency	(msec)		140.01
Modulation Parameters		Forward	Return
Enter Receiver	Type		DVB-S2
Modem Overhead	(%)		1.0%
Number of Carriers per Channel	(#)		1
Available Bandwidth	(Hz)		54,000,000
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)		<b>71,280,000</b>
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)		-7.20
E/S Tx Post-HPA Losses	(dB)		-0.69
E/S Tx Antenna Gain (7.3 m / 2.2 m)	(dB)		52.6
E/S Tx EIRP Per Channel	(dBW)		60.75
E/S Tx Pointing Loss	(dB)		-1.00
E/S Tx RF Link Availability	(%)		50.000
E/S Tx Atmospheric Losses	(dB)		-2.03
E/S Tx Spreading Loss	(dB)		-151.85
Satellite		Forward	Return
SV Number of Channels per HPA	(#)		5
SV Rx G/T	(dB/K)		5.10
SV Rx Power Per Tier	(dBW)		-139.72
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )		-94.13
SV Tx OBO (ALC / FGM)	(dB)		-16.71
SV Tx Post-TWTA Losses	(dB)		-1.50
SV Tx Antenna Gain	(dBi)		31.90
SV Tx EIRP Per Channel/Carrier	(dBW)		24.84
SV Tx Pointing Loss	(dB)		0.00
Downlink		Forward	Return
E/S Rx Carrier Frequency	(MHz)		19,163
E/S Rx Spreading Loss	(dB)		-150.95
E/S Rx RF Link Availability	(%)		75.000
E/S Rx Atmospheric Losses	(dB)		-0.85
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)		-112.22
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )		-127.47
Total Link		Forward	Return
Carrier / Noise Bandwidth	(dB)		76.53
Carrier / Noise Uplink	(dB)		12.34
Carrier / Noise Downlink	(dB)		16.64
(C/N) - Total Actual	(dB)		6.28
(C/N) - Total Required	(dB)		5.90
(E <sub>b</sub> /N <sub>0</sub> ) - Total Actual	(dB)		4.24
(E <sub>b</sub> /N <sub>0</sub> ) - Total Required	(dB)		3.86
<b>Excess Margin</b>	<b>(dB)</b>		<b>0.38</b>
<b>Fade Margin</b>	<b>(dB)</b>		<b>8.88</b>

## O3b Network Link Analysis - Tier 1 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014		Tier 1	
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 Range to SV	(km)	9953.9	11033.2
E/S Elevation to SV	(°)	32.8	19.1
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)		25
Minutes Into Pass (Sample #1)	(Min)		0:0
Telco Spot Beam Off-Angle	(°)		0.20
Telco Spot Beam Diameter	(km)		60.30
Maximum Roundtrip Latency	(msec)		140.01
Modulation Parameters		Forward	Return
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	1.0%	
Number of Carriers per Channel	(#)	1	
Available Bandwidth	(Hz)	54,000,000	
Channel Symbol Rate	(sps)	45,000,000	
Channel Modulation Type		16APSK	
Channel FEC Rate		0.75	
Channel Spectral Efficiency	(bits/Sym)	3.00	
Channel Throughput (100% / 100% of Full Rate)	(bps)	133,650,000	
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)	125	
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)	-1.19	
E/S Tx Spreading Loss	(dB)	-150.95	
Satellite		Forward	Return
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	5.41	
SV Rx Power Per Tier	(dBW)	-129.08	
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )	-83.80	
SV Tx OBO (ALC / FGM)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	31.94	
SV Tx EIRP Per Channel/Carrier	(dBW)	44.77	
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	
E/S Rx Atmospheric Losses	(dB)	-1.54	
E/S Rx Pointing Loss	(dB)	-1.00	
E/S Rx Antenna Gain (1.2 m / 7.3 m)	(dBi)	42.8	
E/S Rx Effective G/T	(dB/K)	17.9	
E/S Rx Power Per Channel	(dBW)	-113.9	
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )	-109.6	
Total Link		Forward	Return
Carrier / Noise Bandwidth	(dB)	76.53	
Carrier / Noise Uplink	(dB)	22.99	
Carrier / Noise Downlink	(dB)	13.23	
Carrier / Intermodulation Im (C/Im)	(dB)	29.35	
(C/N) - Total Actual	(dB)	11.45	
(C/N) - Total Required	(dB)	11.40	
(E <sub>b</sub> /N <sub>0</sub> ) - Total Actual	(dB)	6.68	
(E <sub>b</sub> /N <sub>0</sub> ) - Total Required	(dB)	6.63	
<b>Excess Margin</b>	<b>(dB)</b>	<b>0.05</b>	
<b>Fade Margin</b>	<b>(dB)</b>	<b>14.05</b>	

## O3b Network Link Analysis - Tier 1 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014			Tier 1	Tier 1
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 Range to SV	(km)		9953.9	11033.2
E/S Elevation to SV	(°)		32.8	19.1
E/S Altitude	(km)		0.3	0.0
SV Beam Identifier	(#)		25	
Minutes Into Pass (Sample #1)	(Min)		0:0	
Telco Spot Beam Off-Angle	(°)		0.20	
Telco Spot Beam Diameter	(km)		60.30	
Maximum Roundtrip Latency	(msec)		140.01	
Modulation Parameters			Forward	Return
Enter Receiver	Type			DVB-S2
Modem Overhead	(%)			1.0%
Number of Carriers per Channel	(#)			1
Available Bandwidth	(Hz)			54,000,000
Channel Symbol Rate	(sps)			45,000,000
Channel Modulation Type				QPSK
Channel FEC Rate				0.40
Channel Spectral Efficiency	(bits/Sym)			0.80
Channel Throughput (100% / 100% of Full Rate)	(bps)			<b>35,640,000</b>
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)			20
E/S Tx OBO	(dB)			-3.00
E/S Tx Post-HPA Losses	(dB)			-0.28
E/S Tx Antenna Gain (7.3 m / 1.2 m)	(dB)			46.5
E/S Tx EIRP Per Channel	(dBW)			56.27
E/S Tx Pointing Loss	(dB)			-1.00
E/S Tx RF Link Availability	(%)			50.000
E/S Tx Atmospheric Losses	(dB)			-2.03
E/S Tx Spreading Loss	(dB)			-151.85
Satellite			Forward	Return
SV Number of Channels per HPA	(#)			5
SV Rx G/T	(dB/K)			5.10
SV Rx Power Per Tier	(dBW)			-144.20
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )			-98.61
SV Tx OBO (ALC / FGM)	(dB)			-22.23
SV Tx Post-TWTA Losses	(dB)			-1.50
SV Tx Antenna Gain	(dBi)			31.90
SV Tx EIRP Per Channel/Carrier	(dBW)			19.31
SV Tx Pointing Loss	(dB)			0.00
Downlink			Forward	Return
E/S Rx Carrier Frequency	(MHz)			19,163
E/S Rx Spreading Loss	(dB)			-150.95
E/S Rx RF Link Availability	(%)			75.000
E/S Rx Atmospheric Losses	(dB)			-0.85
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)			39.14
E/S Rx Power Per Channel	(dBW)			-117.74
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )			-132.99
Total Link			Forward	Return
Carrier / Noise Bandwidth	(dB)			76.53
Carrier / Noise Uplink	(dB)			7.87
Carrier / Noise Downlink	(dB)			11.12
(C/N) - Total Actual	(dB)			1.18
(C/N) - Total Required	(dB)			0.90
(E <sub>v</sub> /N <sub>0</sub> ) - Total Actual	(dB)			2.15
(E <sub>v</sub> /N <sub>0</sub> ) - Total Required	(dB)			1.87
<b>Excess Margin</b>	<b>(dB)</b>			<b>0.28</b>
<b>Fade Margin</b>	<b>(dB)</b>			<b>3.78</b>

## O3b Network Link Analysis - Tier 2 Service For Seattle, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014			Tier 2	Tier 2
Ground Parameter			Teleport	Telco
Location			Vernon (LHCP), United States	Seattle, United States
Latitude	(°)		34.2	47.6
Longitude (East)	(°)		260.7	237.7
E/S Range to SV	(km)		9953.9	11324.9
E/S Elevation to SV	(°)		32.8	15.9
E/S Altitude	(km)		0.3	0.3
SV Beam Identifier	(#)		24	
Minutes Into Pass (Sample #1)	(Min)		0:0	
Telco Spot Beam Off-Angle	(°)		0.20	
Telco Spot Beam Diameter	(km)		79.10	
Maximum Roundtrip Latency	(msec)		141.96	
Modulation Parameters			Forward	Return
Enter Receiver	Type		DVB-S2	
Modem Overhead	(%)		3.3%	
Number of Carriers per Channel	(#)		1	
Available Bandwidth	(Hz)		54,000,000	
Channel Symbol Rate	(sps)		45,000,000	
Channel Modulation Type			16APSK	
Channel FEC Rate			0.90	
Channel Spectral Efficiency	(bits/Sym)		3.60	
Channel Throughput (100% / 100% of Full Rate)	(bps)		156,720,604	
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)		125	
E/S Tx OBO	(dB)		-8.00	
E/S Tx Post-HPA Losses	(dB)		-2.24	
E/S Tx Antenna Gain (7.3 m / 2.4 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)		-1.19	
E/S Tx Spreading Loss	(dB)		-150.95	
Satellite			Forward	Return
SV Number of Channels per HPA	(#)		1	
SV Rx G/T	(dB/K)		5.41	
SV Rx Power Per Tier	(dBW)		-129.08	
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )		-83.87	
SV Tx OBO (ALC / FGM)	(dB)		-3.80	
SV Tx Post-TWTA Losses	(dB)		-1.50	
SV Tx Antenna Gain	(dBi)		31.94	
SV Tx EIRP Per Channel/Carrier	(dBW)		44.77	
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	
E/S Rx Atmospheric Losses	(dB)		-0.67	
E/S Rx Pointing Loss	(dB)		-0.50	
E/S Rx Antenna Gain (2.4 m / 7.3 m)	(dBi)		51.4	
E/S Rx Effective G/T	(dB/K)		26.8	
E/S Rx Power Per Channel	(dBW)		-104.1	
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )		-108.5	
Total Link			Forward	Return
Carrier / Noise Bandwidth	(dB)		76.53	
Carrier / Noise Uplink	(dB)		22.99	
Carrier / Noise Downlink	(dB)		23.40	
Carrier / Intermodulation Im (C/Im)	(dB)		29.35	
(C/N) - Total Actual	(dB)		15.44	
(C/N) - Total Required	(dB)		15.20	
(E <sub>v</sub> /N <sub>o</sub> ) - Total Actual	(dB)		9.87	
(E <sub>v</sub> /N <sub>o</sub> ) - Total Required	(dB)		9.64	
<b>Excess Margin</b>	<b>(dB)</b>		<b>0.24</b>	
<b>Fade Margin</b>	<b>(dB)</b>		<b>17.64</b>	

## O3b Network Link Analysis - Tier 2 Service For Seattle, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014			Tier 2	Tier 2
Ground Parameter			Teleport	Telco
Location			Vernon (LHCP), United States	Seattle, United States
Latitude	(°)		34.2	47.6
Longitude (East)	(°)		260.7	237.7
E/S Range to SV	(km)		9953.9	11324.9
E/S Elevation to SV	(°)		32.8	15.9
E/S Altitude	(km)		0.3	0.3
SV Beam Identifier	(#)		24	
Minutes Into Pass (Sample #1)	(Min)		0:0	
Telco Spot Beam Off-Angle	(°)		0.20	
Telco Spot Beam Diameter	(km)		79.10	
Maximum Roundtrip Latency	(msec)		141.96	
Modulation Parameters			Forward	Return
Enter Receiver	Type			DVB-S2
Modem Overhead	(%)			3.3%
Number of Carriers per Channel	(#)			1
Available Bandwidth	(Hz)			54,000,000
Channel Symbol Rate	(sps)			45,000,000
Channel Modulation Type				16APSK
Channel FEC Rate				0.83
Channel Spectral Efficiency	(bits/Sym)			3.33
Channel Throughput (100% / 100% of Full Rate)	(bps)			<b>144,983,819</b>
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)			-0.77
E/S Tx Antenna Gain (7.3 m / 2.4 m)	(dB)			55.2
E/S Tx EIRP Per Channel	(dBW)			65.48
E/S Tx Pointing Loss	(dB)			-0.50
E/S Tx RF Link Availability	(%)			50.000
E/S Tx Atmospheric Losses	(dB)			-0.99
E/S Tx Spreading Loss	(dB)			-152.07
Satellite			Forward	Return
SV Number of Channels per HPA	(#)			5
SV Rx G/T	(dB/K)			5.10
SV Rx Power Per Tier	(dBW)			-133.60
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )			-88.08
SV Tx OBO (ALC / FGM)	(dB)			-10.96
SV Tx Post-TWTA Losses	(dB)			-1.50
SV Tx Antenna Gain	(dBi)			31.90
SV Tx EIRP Per Channel/Carrier	(dBW)			30.58
SV Tx Pointing Loss	(dB)			0.00
Downlink			Forward	Return
E/S Rx Carrier Frequency	(MHz)			18,909
E/S Rx Spreading Loss	(dB)			-150.95
E/S Rx RF Link Availability	(%)			75.000
E/S Rx Atmospheric Losses	(dB)			-0.78
E/S Rx Pointing Loss	(dB)			-0.50
E/S Rx Antenna Gain (2.4 m / 7.3 m)	(dBi)			62.24
E/S Rx Effective G/T	(dB/K)			39.16
E/S Rx Power Per Channel	(dBW)			-106.41
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )			-121.66
Total Link			Forward	Return
Carrier / Noise Bandwidth	(dB)			76.53
Carrier / Noise Uplink	(dB)			18.47
Carrier / Noise Downlink	(dB)			22.57
(C/N) - Total Actual	(dB)			14.17
(C/N) - Total Required	(dB)			13.70
(E <sub>b</sub> /N <sub>0</sub> ) - Total Actual	(dB)			8.94
(E <sub>b</sub> /N <sub>0</sub> ) - Total Required	(dB)			8.47
<b>Excess Margin</b>	<b>(dB)</b>			<b>0.47</b>
<b>Fade Margin</b>	<b>(dB)</b>			<b>16.37</b>



## O3b Network Link Analysis - Tier 2 Service For Seattle, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014		Tier 2	Tier 2
Ground Parameter		Teleport	Telco
Location		Vernon (LHCP), United States	Seattle, United States
Latitude	(°)	34.2	47.6
Longitude (East)	(°)	260.7	237.7
E/S Range to SV	(km)	9953.9	11324.9
E/S Elevation to SV	(°)	32.8	15.9
E/S Altitude	(km)	0.3	0.3
SV Beam Identifier	(#)		24
Minutes Into Pass (Sample #1)	(Min)		0:0
Telco Spot Beam Off-Angle	(°)		0.20
Telco Spot Beam Diameter	(km)		79.10
Maximum Roundtrip Latency	(msec)		141.96
Modulation Parameters		Forward	Return
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	3.3%	
Number of Carriers per Channel	(#)	1	
Available Bandwidth	(Hz)	54,000,000	
Channel Symbol Rate	(sps)	45,000,000	
Channel Modulation Type		16APSK	
Channel FEC Rate		0.83	
Channel Spectral Efficiency	(bits/Sym)	3.33	
Channel Throughput (100% / 100% of Full Rate)	(bps)	144,983,819	
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)	125	
E/S Tx OBO	(dB)	-8.00	
E/S Tx Post-HPA Losses	(dB)	-2.24	
E/S Tx Antenna Gain (7.3 m / 1.8 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)	-1.19	
E/S Tx Spreading Loss	(dB)	-150.95	
Satellite		Forward	Return
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	5.41	
SV Rx Power Per Tier	(dBW)	-129.08	
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )	-83.87	
SV Tx OBO (ALC / FGM)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	31.94	
SV Tx EIRP Per Channel/Carrier	(dBW)	44.77	
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	
E/S Rx Atmospheric Losses	(dB)	-0.67	
E/S Rx Pointing Loss	(dB)	-0.50	
E/S Rx Antenna Gain (1.8 m / 7.3 m)	(dBi)	48.9	
E/S Rx Effective G/T	(dB/K)	24.3	
E/S Rx Power Per Channel	(dBW)	-106.6	
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )	-108.5	
Total Link		Forward	Return
Carrier / Noise Bandwidth	(dB)	76.53	
Carrier / Noise Uplink	(dB)	22.99	
Carrier / Noise Downlink	(dB)	20.90	
Carrier / Intermodulation Im (C/Im)	(dB)	29.35	
(C/N) - Total Actual	(dB)	14.93	
(C/N) - Total Required	(dB)	13.70	
(E <sub>v</sub> /N <sub>o</sub> ) - Total Actual	(dB)	9.70	
(E <sub>v</sub> /N <sub>o</sub> ) - Total Required	(dB)	8.47	
<b>Excess Margin</b>	<b>(dB)</b>	<b>1.23</b>	
<b>Fade Margin</b>	<b>(dB)</b>	<b>17.13</b>	

## O3b Network Link Analysis - Tier 2 Service For Seattle, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014			Tier 2	Tier 2
Ground Parameter			Teleport	Telco
Location			Vernon (LHCP), United States	Seattle, United States
Latitude	(°)		34.2	47.6
Longitude (East)	(°)		260.7	237.7
E/S Range to SV	(km)		9953.9	11324.9
E/S Elevation to SV	(°)		32.8	15.9
E/S Altitude	(km)		0.3	0.3
SV Beam Identifier	(#)		24	
Minutes Into Pass (Sample #1)	(Min)		0:0	
Telco Spot Beam Off-Angle	(°)		0.20	
Telco Spot Beam Diameter	(km)		79.10	
Maximum Roundtrip Latency	(msec)		141.96	
Modulation Parameters			Forward	Return
Enter Receiver	Type			DVB-S2
Modem Overhead	(%)			3.5%
Number of Carriers per Channel	(#)			1
Available Bandwidth	(Hz)			54,000,000
Channel Symbol Rate	(sps)			45,000,000
Channel Modulation Type				16APSK
Channel FEC Rate				0.75
Channel Spectral Efficiency	(bits/Sym)			3.00
Channel Throughput (100% / 100% of Full Rate)	(bps)			<b>130,334,412</b>
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)			-0.77
E/S Tx Antenna Gain (7.3 m / 1.8 m)	(dB)			52.7
E/S Tx EIRP Per Channel	(dBW)			62.98
E/S Tx Pointing Loss	(dB)			-0.50
E/S Tx RF Link Availability	(%)			50.000
E/S Tx Atmospheric Losses	(dB)			-0.99
E/S Tx Spreading Loss	(dB)			-152.07
Satellite			Forward	Return
SV Number of Channels per HPA	(#)			5
SV Rx G/T	(dB/K)			5.10
SV Rx Power Per Tier	(dBW)			-136.09
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )			-90.58
SV Tx OBO (ALC / FGM)	(dB)			-13.67
SV Tx Post-TWTA Losses	(dB)			-1.50
SV Tx Antenna Gain	(dBi)			31.90
SV Tx EIRP Per Channel/Carrier	(dBW)			27.87
SV Tx Pointing Loss	(dB)			0.00
Downlink			Forward	Return
E/S Rx Carrier Frequency	(MHz)			18,909
E/S Rx Spreading Loss	(dB)			-150.95
E/S Rx RF Link Availability	(%)			75.000
E/S Rx Atmospheric Losses	(dB)			-0.78
E/S Rx Pointing Loss	(dB)			-0.50
E/S Rx Antenna Gain (1.8 m / 7.3 m)	(dBi)			62.24
E/S Rx Effective G/T	(dB/K)			39.16
E/S Rx Power Per Channel	(dBW)			-109.12
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )			-124.37
Total Link			Forward	Return
Carrier / Noise Bandwidth	(dB)			76.53
Carrier / Noise Uplink	(dB)			15.97
Carrier / Noise Downlink	(dB)			19.87
(C/N) - Total Actual	(dB)			12.35
(C/N) - Total Required	(dB)			12.30
(E <sub>b</sub> /N <sub>0</sub> ) - Total Actual	(dB)			7.58
(E <sub>b</sub> /N <sub>0</sub> ) - Total Required	(dB)			7.53
<b>Excess Margin</b>	<b>(dB)</b>			<b>0.05</b>
<b>Fade Margin</b>	<b>(dB)</b>			<b>14.55</b>

## O3b Network Link Analysis - Tier 1 Service For Seattle, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014			Tier 1	Tier 1
Ground Parameter			Teleport	Telco
Location			Vernon (LHCP), United States	Seattle, United States
Latitude	(°)		34.2	47.6
Longitude (East)	(°)		260.7	237.7
E/S Range to SV	(km)		9953.9	11324.9
E/S Elevation to SV	(°)		32.8	15.9
E/S Altitude	(km)		0.3	0.3
SV Beam Identifier	(#)			24
Minutes Into Pass (Sample #1)	(Min)			0:0
Telco Spot Beam Off-Angle	(°)			0.20
Telco Spot Beam Diameter	(km)			79.10
Maximum Roundtrip Latency	(msec)			141.96
Modulation Parameters			Forward	Return
Enter Receiver	Type		DVB-S2	
Modem Overhead	(%)		1.0%	
Number of Carriers per Channel	(#)		1	
Available Bandwidth	(Hz)		54,000,000	
Channel Symbol Rate	(sps)		45,000,000	
Channel Modulation Type			32APSK	
Channel FEC Rate			0.75	
Channel Spectral Efficiency	(bits/Sym)		3.75	
Channel Throughput (100% / 100% of Full Rate)	(bps)		167,062,500	
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)		125	
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)		68.77	
E/S Tx Pointing Loss	(dB)		-0.50	
E/S Tx RF Link Availability	(%)		75.000	
E/S Tx Atmospheric Losses	(dB)		-1.19	
E/S Tx Spreading Loss	(dB)		-150.95	
Satellite			Forward	Return
SV Number of Channels per HPA	(#)		1	
SV Rx G/T	(dB/K)		5.41	
SV Rx Power Per Tier	(dBW)		-129.08	
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )		-83.87	
SV Tx OBO (ALC / FGM)	(dB)		-3.80	
SV Tx Post-TWTA Losses	(dB)		-1.50	
SV Tx Antenna Gain	(dBi)		31.94	
SV Tx EIRP Per Channel/Carrier	(dBW)		44.77	
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	
E/S Rx Atmospheric Losses	(dB)		-0.67	
E/S Rx Pointing Loss	(dB)		-1.00	
E/S Rx Antenna Gain (2.2 m / 7.3 m)	(dBi)		48.7	
E/S Rx Effective G/T	(dB/K)		23.8	
E/S Rx Power Per Channel	(dBW)		-107.3	
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )		-109.0	
Total Link			Forward	Return
Carrier / Noise Bandwidth	(dB)		76.53	
Carrier / Noise Uplink	(dB)		22.99	
Carrier / Noise Downlink	(dB)		19.92	
Carrier / Intermodulation Im (C/Im)	(dB)		29.35	
(C/N) - Total Actual	(dB)		14.66	
(C/N) - Total Required	(dB)		14.30	
(E <sub>b</sub> /N <sub>0</sub> ) - Total Actual	(dB)		8.91	
(E <sub>b</sub> /N <sub>0</sub> ) - Total Required	(dB)		8.56	
<b>Excess Margin</b>	<b>(dB)</b>		<b>0.36</b>	
<b>Fade Margin</b>	<b>(dB)</b>		<b>17.26</b>	

## O3b Network Link Analysis - Tier 1 Service For Seattle, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014			Tier 1	Tier 1
Ground Parameter			Teleport	Telco
Location			Vernon (LHCP), United States	Seattle, United States
Latitude	(°)		34.2	47.6
Longitude (East)	(°)		260.7	237.7
E/S Range to SV	(km)		9953.9	11324.9
E/S Elevation to SV	(°)		32.8	15.9
E/S Altitude	(km)		0.3	0.3
SV Beam Identifier	(#)		24	
Minutes Into Pass (Sample #1)	(Min)		0:0	
Telco Spot Beam Off-Angle	(°)		0.20	
Telco Spot Beam Diameter	(km)		79.10	
Maximum Roundtrip Latency	(msec)		141.96	
Modulation Parameters			Forward	Return
Enter Receiver	Type			DVB-S2
Modem Overhead	(%)			1.0%
Number of Carriers per Channel	(#)			1
Available Bandwidth	(Hz)			54,000,000
Channel Symbol Rate	(sps)			45,000,000
Channel Modulation Type				16APSK
Channel FEC Rate				0.67
Channel Spectral Efficiency	(bits/Sym)			2.67
Channel Throughput (100% / 100% of Full Rate)	(bps)			<b>118,800,000</b>
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)			-7.20
E/S Tx Post-HPA Losses	(dB)			-0.69
E/S Tx Antenna Gain (7.3 m / 2.2 m)	(dB)			52.5
E/S Tx EIRP Per Channel	(dBW)			60.67
E/S Tx Pointing Loss	(dB)			-1.00
E/S Tx RF Link Availability	(%)			50.000
E/S Tx Atmospheric Losses	(dB)			-0.99
E/S Tx Spreading Loss	(dB)			-152.07
Satellite			Forward	Return
SV Number of Channels per HPA	(#)			5
SV Rx G/T	(dB/K)			5.10
SV Rx Power Per Tier	(dBW)			-138.91
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )			-93.39
SV Tx OBO (ALC / FGM)	(dB)			-15.67
SV Tx Post-TWTA Losses	(dB)			-1.50
SV Tx Antenna Gain	(dBi)			31.90
SV Tx EIRP Per Channel/Carrier	(dBW)			25.87
SV Tx Pointing Loss	(dB)			0.00
Downlink			Forward	Return
E/S Rx Carrier Frequency	(MHz)			18,909
E/S Rx Spreading Loss	(dB)			-150.95
E/S Rx RF Link Availability	(%)			75.000
E/S Rx Atmospheric Losses	(dB)			-0.78
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)			-111.12
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )			-126.37
Total Link			Forward	Return
Carrier / Noise Bandwidth	(dB)			76.53
Carrier / Noise Uplink	(dB)			13.16
Carrier / Noise Downlink	(dB)			17.87
(C/N) - Total Actual	(dB)			10.33
(C/N) - Total Required	(dB)			10.10
(E <sub>v</sub> /N <sub>0</sub> ) - Total Actual	(dB)			6.07
(E <sub>v</sub> /N <sub>0</sub> ) - Total Required	(dB)			5.84
<b>Excess Margin</b>	<b>(dB)</b>			<b>0.23</b>
<b>Fade Margin</b>	<b>(dB)</b>			<b>12.93</b>

## O3b Network Link Analysis - Tier 1 Service For Seattle, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014		Tier 1	
Ground Parameter		Teleport	Telco
Location		Vernon (LHCP), United States	Seattle, United States
Latitude	(°)	34.2	47.6
Longitude (East)	(°)	260.7	237.7
E/S Range to SV	(km)	9953.9	11324.9
E/S Elevation to SV	(°)	32.8	15.9
E/S Altitude	(km)	0.3	0.3
SV Beam Identifier	(#)		24
Minutes Into Pass (Sample #1)	(Min)		0:0
Telco Spot Beam Off-Angle	(°)		0.20
Telco Spot Beam Diameter	(km)		79.10
Maximum Roundtrip Latency	(msec)		141.96
Modulation Parameters		Forward	Return
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	1.0%	
Number of Carriers per Channel	(#)	1	
Available Bandwidth	(Hz)	54,000,000	
Channel Symbol Rate	(sps)	45,000,000	
Channel Modulation Type		16APSK	
Channel FEC Rate		0.75	
Channel Spectral Efficiency	(bits/Sym)	3.00	
Channel Throughput (100% / 100% of Full Rate)	(bps)	133,650,000	
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)	125	
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)	-1.19	
E/S Tx Spreading Loss	(dB)	-150.95	
Satellite		Forward	Return
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	5.41	
SV Rx Power Per Tier	(dBW)	-129.08	
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )	-83.87	
SV Tx OBO (ALC / FGM)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	31.94	
SV Tx EIRP Per Channel/Carrier	(dBW)	44.77	
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	
E/S Rx Atmospheric Losses	(dB)	-0.67	
E/S Rx Pointing Loss	(dB)	-1.00	
E/S Rx Antenna Gain (1.2 m / 7.3 m)	(dBi)	42.7	
E/S Rx Effective G/T	(dB/K)	18.1	
E/S Rx Power Per Channel	(dBW)	-113.3	
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )	-109.0	
Total Link		Forward	Return
Carrier / Noise Bandwidth	(dB)	76.53	
Carrier / Noise Uplink	(dB)	22.99	
Carrier / Noise Downlink	(dB)	14.21	
Carrier / Intermodulation Im (C/Im)	(dB)	29.35	
(C/N) - Total Actual	(dB)	12.08	
(C/N) - Total Required	(dB)	11.40	
(E <sub>v</sub> /N <sub>0</sub> ) - Total Actual	(dB)	7.31	
(E <sub>v</sub> /N <sub>0</sub> ) - Total Required	(dB)	6.63	
<b>Excess Margin</b>	<b>(dB)</b>	<b>0.68</b>	
<b>Fade Margin</b>	<b>(dB)</b>	<b>14.68</b>	

## O3b Network Link Analysis - Tier 1 Service For Seattle, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014			Tier 1	Tier 1
Ground Parameter			Teleport	Telco
Location			Vernon (LHCP), United States	Seattle, United States
Latitude	(°)		34.2	47.6
Longitude (East)	(°)		260.7	237.7
E/S Range to SV	(km)		9953.9	11324.9
E/S Elevation to SV	(°)		32.8	15.9
E/S Altitude	(km)		0.3	0.3
SV Beam Identifier	(#)			24
Minutes Into Pass (Sample #1)	(Min)			0:0
Telco Spot Beam Off-Angle	(°)			0.20
Telco Spot Beam Diameter	(km)			79.10
Maximum Roundtrip Latency	(msec)			141.96
Modulation Parameters			Forward	Return
Enter Receiver	Type			DVB-S2
Modem Overhead	(%)			1.0%
Number of Carriers per Channel	(#)			1
Available Bandwidth	(Hz)			54,000,000
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)			<b>71,280,000</b>
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)			20
E/S Tx OBO	(dB)			-3.00
E/S Tx Post-HPA Losses	(dB)			-0.28
E/S Tx Antenna Gain (7.3 m / 1.2 m)	(dB)			46.5
E/S Tx EIRP Per Channel	(dBW)			56.20
E/S Tx Pointing Loss	(dB)			-1.00
E/S Tx RF Link Availability	(%)			50.000
E/S Tx Atmospheric Losses	(dB)			-0.99
E/S Tx Spreading Loss	(dB)			-152.07
Satellite			Forward	Return
SV Number of Channels per HPA	(#)			5
SV Rx G/T	(dB/K)			5.10
SV Rx Power Per Tier	(dBW)			-143.38
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )			-97.87
SV Tx OBO (ALC / FGM)	(dB)			-21.10
SV Tx Post-TWTA Losses	(dB)			-1.50
SV Tx Antenna Gain	(dBi)			31.90
SV Tx EIRP Per Channel/Carrier	(dBW)			20.44
SV Tx Pointing Loss	(dB)			0.00
Downlink			Forward	Return
E/S Rx Carrier Frequency	(MHz)			18,909
E/S Rx Spreading Loss	(dB)			-150.95
E/S Rx RF Link Availability	(%)			75.000
E/S Rx Atmospheric Losses	(dB)			-0.78
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)			-116.55
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )			-131.80
Total Link			Forward	Return
Carrier / Noise Bandwidth	(dB)			76.53
Carrier / Noise Uplink	(dB)			8.68
Carrier / Noise Downlink	(dB)			12.44
(C/N) - Total Actual	(dB)			5.93
(C/N) - Total Required	(dB)			5.90
(E <sub>v</sub> /N <sub>0</sub> ) - Total Actual	(dB)			3.89
(E <sub>v</sub> /N <sub>0</sub> ) - Total Required	(dB)			3.86
<b>Excess Margin</b>	<b>(dB)</b>			<b>0.03</b>
<b>Fade Margin</b>	<b>(dB)</b>			<b>8.53</b>

## O3b Network Link Analysis - Tier 1 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014			Tier 1	
Ground Parameter			Teleport	Telco
Location			Vernon (LHCP), United States	
Latitude	(°)		34.2	18.5
Longitude (East)	(°)		260.7	293.9
E/S Range to SV	(km)		9953.9	11033.2
E/S Elevation to SV	(°)		32.8	19.1
E/S Altitude	(km)		0.3	0.0
SV Beam Identifier	(#)			25
Minutes Into Pass (Sample #1)	(Min)			0:0
Telco Spot Beam Off-Angle	(°)			0.20
Telco Spot Beam Diameter	(km)			60.30
Maximum Roundtrip Latency	(msec)			140.01
Modulation Parameters			Forward	Return
Enter Receiver	Type		DVB-S2	
Modem Overhead	(%)		1.0%	
Number of Carriers per Channel	(#)		1	
Available Bandwidth	(Hz)		216,000,000	
Channel Symbol Rate	(sps)		180,000,000	
Channel Modulation Type			16APSK	
Channel FEC Rate			0.83	
Channel Spectral Efficiency	(bits/Sym)		3.33	
Channel Throughput (100% / 100% of Full Rate)	(bps)		594,000,000	
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 / 2.4 m)	(dB)		65.11	
E/S Tx EIRP Per Channel	(dBW)		74.87	
E/S Tx Pointing Loss	(dB)		-0.50	
E/S Tx RF Link Availability	(%)		75.000	
E/S Tx Atmospheric Losses	(dB)		-1.19	
E/S Tx Spreading Loss	(dB)		-150.95	
Satellite			Forward	Return
SV Number of Channels per HPA	(#)		1	
SV Rx G/T	(dB/K)		5.41	
SV Rx Power Per Tier	(dBW)		-123.06	
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )		-77.77	
SV Tx OBO (ALC / FGM)	(dB)		-3.80	
SV Tx Post-TWTA Losses	(dB)		-1.50	
SV Tx Antenna Gain	(dBi)		31.94	
SV Tx EIRP Per Channel/Carrier	(dBW)		44.77	
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	
E/S Rx Atmospheric Losses	(dB)		-1.54	
E/S Rx Pointing Loss	(dB)		-0.50	
E/S Rx Antenna Gain (2.4 m / 7.3 m)	(dBi)		51.5	
E/S Rx Effective G/T	(dB/K)		26.6	
E/S Rx Power Per Channel	(dBW)		-104.7	
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )		-109.1	
Total Link			Forward	Return
Carrier / Noise Bandwidth	(dB)		82.55	
Carrier / Noise Uplink	(dB)		22.99	
Carrier / Noise Downlink	(dB)		16.40	
Carrier / Intermodulation Im (C/Im)	(dB)		29.35	
(C/N) - Total Actual	(dB)		13.28	
(C/N) - Total Required	(dB)		12.90	
(E <sub>b</sub> /N <sub>0</sub> ) - Total Actual	(dB)		8.05	
(E <sub>b</sub> /N <sub>0</sub> ) - Total Required	(dB)		7.67	
<b>Excess Margin</b>	<b>(dB)</b>		<b>0.38</b>	
<b>Fade Margin</b>	<b>(dB)</b>		<b>15.88</b>	

## O3b Network Link Analysis - Tier 1 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014			Tier 1	Tier 1
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 Range to SV	(km)		9953.9	11033.2
E/S Elevation to SV	(°)		32.8	19.1
E/S Altitude	(km)		0.3	0.0
SV Beam Identifier	(#)		25	
Minutes Into Pass (Sample #1)	(Min)		0:0	
Telco Spot Beam Off-Angle	(°)		0.20	
Telco Spot Beam Diameter	(km)		60.30	
Maximum Roundtrip Latency	(msec)		140.01	
Modulation Parameters			Forward	Return
Enter Receiver	Type			DVB-S2
Modem Overhead	(%)			1.0%
Number of Carriers per Channel	(#)			1
Available Bandwidth	(Hz)			216,000,000
Channel Symbol Rate	(sps)			180,000,000
Channel Modulation Type				8PSK
Channel FEC Rate				0.75
Channel Spectral Efficiency	(bits/Sym)			2.25
Channel Throughput (100% / 100% of Full Rate)	(bps)			<b>400,950,000</b>
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)			-0.77
E/S Tx Antenna Gain (7.3 m / 2.4 m)	(dB)			55.3
E/S Tx EIRP Per Channel	(dBW)			65.56
E/S Tx Pointing Loss	(dB)			-0.50
E/S Tx RF Link Availability	(%)			50.000
E/S Tx Atmospheric Losses	(dB)			-2.03
E/S Tx Spreading Loss	(dB)			-151.85
Satellite			Forward	Return
SV Number of Channels per HPA	(#)			5
SV Rx G/T	(dB/K)			5.10
SV Rx Power Per Tier	(dBW)			-134.41
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )			-88.82
SV Tx OBO (ALC / FGM)	(dB)			-11.84
SV Tx Post-TWTA Losses	(dB)			-1.50
SV Tx Antenna Gain	(dBi)			31.90
SV Tx EIRP Per Channel/Carrier	(dBW)			29.70
SV Tx Pointing Loss	(dB)			0.00
Downlink			Forward	Return
E/S Rx Carrier Frequency	(MHz)			19,163
E/S Rx Spreading Loss	(dB)			-150.95
E/S Rx RF Link Availability	(%)			75.000
E/S Rx Atmospheric Losses	(dB)			-0.85
E/S Rx Pointing Loss	(dB)			-0.50
E/S Rx Antenna Gain (2.4 m / 7.3 m)	(dBi)			62.35
E/S Rx Effective G/T	(dB/K)			39.14
E/S Rx Power Per Channel	(dBW)			-107.35
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )			-122.60
Total Link			Forward	Return
Carrier / Noise Bandwidth	(dB)			82.55
Carrier / Noise Uplink	(dB)			11.63
Carrier / Noise Downlink	(dB)			15.49
(C/N) - Total Actual	(dB)			9.56
(C/N) - Total Required	(dB)			9.00
(E <sub>b</sub> /N <sub>0</sub> ) - Total Actual	(dB)			6.04
(E <sub>b</sub> /N <sub>0</sub> ) - Total Required	(dB)			5.48
<b>Excess Margin</b>	<b>(dB)</b>			<b>0.56</b>
<b>Fade Margin</b>	<b>(dB)</b>			<b>12.16</b>



## O3b Network Link Analysis - Tier 1 Service For Seattle, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014			Tier 1	Tier 1
Ground Parameter			Teleport	Telco
Location			Vernon (LHCP), United States	
Latitude	(°)		34.2	47.6
Longitude (East)	(°)		260.7	237.7
E/S Range to SV	(km)		9953.9	11324.9
E/S Elevation to SV	(°)		32.8	15.9
E/S Altitude	(km)		0.3	0.3
SV Beam Identifier	(#)		24	
Minutes Into Pass (Sample #1)	(Min)		0:0	
Telco Spot Beam Off-Angle	(°)		0.20	
Telco Spot Beam Diameter	(km)		79.10	
Maximum Roundtrip Latency	(msec)		141.96	
Modulation Parameters			Forward	Return
Enter Receiver	Type		DVB-S2	
Modem Overhead	(%)		1.0%	
Number of Carriers per Channel	(#)		1	
Available Bandwidth	(Hz)		216,000,000	
Channel Symbol Rate	(sps)		180,000,000	
Channel Modulation Type			16APSK	
Channel FEC Rate			0.83	
Channel Spectral Efficiency	(bits/Sym)		3.33	
Channel Throughput (100% / 100% of Full Rate)	(bps)		594,000,000	
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 / 2.4 m)	(dB)		65.03	
E/S Tx EIRP Per Channel	(dBW)		74.79	
E/S Tx Pointing Loss	(dB)		-0.50	
E/S Tx RF Link Availability	(%)		75.000	
E/S Tx Atmospheric Losses	(dB)		-1.19	
E/S Tx Spreading Loss	(dB)		-150.95	
Satellite			Forward	Return
SV Number of Channels per HPA	(#)		1	
SV Rx G/T	(dB/K)		5.41	
SV Rx Power Per Tier	(dBW)		-123.06	
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )		-77.85	
SV Tx OBO (ALC / FGM)	(dB)		-3.80	
SV Tx Post-TWTA Losses	(dB)		-1.50	
SV Tx Antenna Gain	(dBi)		31.94	
SV Tx EIRP Per Channel/Carrier	(dBW)		44.77	
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	
E/S Rx Atmospheric Losses	(dB)		-0.67	
E/S Rx Pointing Loss	(dB)		-0.50	
E/S Rx Antenna Gain (2.4 m / 7.3 m)	(dBi)		51.4	
E/S Rx Effective G/T	(dB/K)		26.8	
E/S Rx Power Per Channel	(dBW)		-104.1	
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )		-108.5	
Total Link			Forward	Return
Carrier / Noise Bandwidth	(dB)		82.55	
Carrier / Noise Uplink	(dB)		22.99	
Carrier / Noise Downlink	(dB)		17.38	
Carrier / Intermodulation Im (C/Im)	(dB)		29.35	
(C/N) - Total Actual	(dB)		13.68	
(C/N) - Total Required	(dB)		12.90	
(E <sub>b</sub> /N <sub>0</sub> ) - Total Actual	(dB)		8.45	
(E <sub>b</sub> /N <sub>0</sub> ) - Total Required	(dB)		7.67	
<b>Excess Margin</b>	<b>(dB)</b>		<b>0.78</b>	
<b>Fade Margin</b>	<b>(dB)</b>		<b>16.28</b>	

## O3b Network Link Analysis - Tier 1 Service For Seattle, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014			Tier 1	Tier 1
Ground Parameter			Teleport	Telco
Location			Vernon (LHCP), United States	Seattle, United States
Latitude	(°)		34.2	47.6
Longitude (East)	(°)		260.7	237.7
E/S Range to SV	(km)		9953.9	11324.9
E/S Elevation to SV	(°)		32.8	15.9
E/S Altitude	(km)		0.3	0.3
SV Beam Identifier	(#)		24	
Minutes Into Pass (Sample #1)	(Min)		0:0	
Telco Spot Beam Off-Angle	(°)		0.20	
Telco Spot Beam Diameter	(km)		79.10	
Maximum Roundtrip Latency	(msec)		141.96	
Modulation Parameters			Forward	Return
Enter Receiver	Type			DVB-S2
Modem Overhead	(%)			1.0%
Number of Carriers per Channel	(#)			1
Available Bandwidth	(Hz)			216,000,000
Channel Symbol Rate	(sps)			180,000,000
Channel Modulation Type				8PSK
Channel FEC Rate				0.75
Channel Spectral Efficiency	(bits/Sym)			2.25
Channel Throughput (100% / 100% of Full Rate)	(bps)			<b>400,950,000</b>
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)			-0.77
E/S Tx Antenna Gain (7.3 m / 2.4 m)	(dB)			55.2
E/S Tx EIRP Per Channel	(dBW)			65.48
E/S Tx Pointing Loss	(dB)			-0.50
E/S Tx RF Link Availability	(%)			50.000
E/S Tx Atmospheric Losses	(dB)			-0.99
E/S Tx Spreading Loss	(dB)			-152.07
Satellite			Forward	Return
SV Number of Channels per HPA	(#)			5
SV Rx G/T	(dB/K)			5.10
SV Rx Power Per Tier	(dBW)			-133.60
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )			-88.08
SV Tx OBO (ALC / FGM)	(dB)			-10.96
SV Tx Post-TWTA Losses	(dB)			-1.50
SV Tx Antenna Gain	(dBi)			31.90
SV Tx EIRP Per Channel/Carrier	(dBW)			30.58
SV Tx Pointing Loss	(dB)			0.00
Downlink			Forward	Return
E/S Rx Carrier Frequency	(MHz)			18,909
E/S Rx Spreading Loss	(dB)			-150.95
E/S Rx RF Link Availability	(%)			75.000
E/S Rx Atmospheric Losses	(dB)			-0.78
E/S Rx Pointing Loss	(dB)			-0.50
E/S Rx Antenna Gain (2.4 m / 7.3 m)	(dBi)			62.24
E/S Rx Effective G/T	(dB/K)			39.16
E/S Rx Power Per Channel	(dBW)			-106.41
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )			-121.66
Total Link			Forward	Return
Carrier / Noise Bandwidth	(dB)			82.55
Carrier / Noise Uplink	(dB)			12.45
Carrier / Noise Downlink	(dB)			16.55
(C/N) - Total Actual	(dB)			9.51
(C/N) - Total Required	(dB)			9.00
(E <sub>p</sub> /N <sub>0</sub> ) - Total Actual	(dB)			5.99
(E <sub>p</sub> /N <sub>0</sub> ) - Total Required	(dB)			5.48
<b>Excess Margin</b>	<b>(dB)</b>			<b>0.51</b>
<b>Fade Margin</b>	<b>(dB)</b>			<b>12.11</b>

## O3b Network Link Analysis - Tier 1 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014		Tier 1	Tier 1
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 Range to SV	(km)	9953.9	11033.2
E/S Elevation to SV	(°)	32.8	19.1
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)		25
Minutes Into Pass (Sample #1)	(Min)		0:0
Telco Spot Beam Off-Angle	(°)		0.20
Telco Spot Beam Diameter	(km)		60.30
Maximum Roundtrip Latency	(msec)		140.01
Modulation Parameters		Forward	Return
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	1.0%	
Number of Carriers per Channel	(#)	1	
Available Bandwidth	(Hz)	216,000,000	
Channel Symbol Rate	(sps)	180,000,000	
Channel Modulation Type		8PSK	
Channel FEC Rate		0.60	
Channel Spectral Efficiency	(bits/Sym)	1.80	
Channel Throughput (100% / 100% of Full Rate)	(bps)	320,760,000	
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)	74.87	
E/S Tx Pointing Loss	(dB)	-0.50	
E/S Tx RF Link Availability	(%)	75.000	
E/S Tx Atmospheric Losses	(dB)	-1.19	
E/S Tx Spreading Loss	(dB)	-150.95	
Satellite		Forward	Return
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	5.41	
SV Rx Power Per Tier	(dBW)	-123.06	
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )	-77.77	
SV Tx OBO (ALC / FGM)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	31.94	
SV Tx EIRP Per Channel/Carrier	(dBW)	44.77	
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	
E/S Rx Atmospheric Losses	(dB)	-1.54	
E/S Rx Pointing Loss	(dB)	-1.00	
E/S Rx Antenna Gain (1.2 m / 7.3 m)	(dBi)	42.8	
E/S Rx Effective G/T	(dB/K)	17.9	
E/S Rx Power Per Channel	(dBW)	-113.9	
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )	-109.6	
Total Link		Forward	Return
Carrier / Noise Bandwidth	(dB)	82.55	
Carrier / Noise Uplink	(dB)	22.99	
Carrier / Noise Downlink	(dB)	7.21	
Carrier / Intermodulation Im (C/Im)	(dB)	29.35	
(C/N) - Total Actual	(dB)	6.70	
(C/N) - Total Required	(dB)	6.60	
(E <sub>b</sub> /N <sub>0</sub> ) - Total Actual	(dB)	4.15	
(E <sub>b</sub> /N <sub>0</sub> ) - Total Required	(dB)	4.05	
<b>Excess Margin</b>	<b>(dB)</b>	<b>0.10</b>	
<b>Fade Margin</b>	<b>(dB)</b>	<b>9.30</b>	

## O3b Network Link Analysis - Tier 1 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014		Tier 1	Tier 1
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 Range to SV	(km)	9953.9	11033.2
E/S Elevation to SV	(°)	32.8	19.1
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)	25	
Minutes Into Pass (Sample #1)	(Min)	0:0	
Telco Spot Beam Off-Angle	(°)	0.20	
Telco Spot Beam Diameter	(km)	60.30	
Maximum Roundtrip Latency	(msec)	140.01	
Modulation Parameters		Forward	Return
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	1.0%	
Number of Carriers per Channel	(#)	1	
Available Bandwidth	(Hz)	216,000,000	
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)	<b>118,800,000</b>	
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)	20	
E/S Tx OBO	(dB)	-3.00	
E/S Tx Post-HPA Losses	(dB)	-0.28	
E/S Tx Antenna Gain (7.3 m / 1.2 m)	(dB)	46.5	
E/S Tx EIRP Per Channel	(dBW)	56.27	
E/S Tx Pointing Loss	(dB)	-1.00	
E/S Tx RF Link Availability	(%)	50.000	
E/S Tx Atmospheric Losses	(dB)	-2.03	
E/S Tx Spreading Loss	(dB)	-151.85	
Satellite		Forward	Return
SV Number of Channels per HPA	(#)	5	
SV Rx G/T	(dB/K)	5.10	
SV Rx Power Per Tier	(dBW)	-144.20	
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )	-98.61	
SV Tx OBO (ALC / FGM)	(dB)	-22.23	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	31.90	
SV Tx EIRP Per Channel/Carrier	(dBW)	19.31	
SV Tx Pointing Loss	(dB)	0.00	
Downlink		Forward	Return
E/S Rx Carrier Frequency	(MHz)	19,163	
E/S Rx Spreading Loss	(dB)	-150.95	
E/S Rx RF Link Availability	(%)	75.000	
E/S Rx Atmospheric Losses	(dB)	-0.85	
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)	39.14	
E/S Rx Power Per Channel	(dBW)	-117.74	
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )	-132.99	
Total Link		Forward	Return
Carrier / Noise Bandwidth	(dB)	82.55	
Carrier / Noise Uplink	(dB)	1.85	
Carrier / Noise Downlink	(dB)	5.10	
(C/N) - Total Actual	(dB)	0.10	
(C/N) - Total Required	(dB)	-0.30	
(E <sub>v</sub> /N <sub>0</sub> ) - Total Actual	(dB)	1.86	
(E <sub>v</sub> /N <sub>0</sub> ) - Total Required	(dB)	1.46	
<b>Excess Margin</b>	<b>(dB)</b>	<b>0.40</b>	
<b>Fade Margin</b>	<b>(dB)</b>	<b>2.70</b>	

## O3b Network Link Analysis - Tier 1 Service For Seattle, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014			Tier 1	Tier 1
Ground Parameter			Teleport	Telco
Location			Vernon (LHCP), United States	Seattle, United States
Latitude	(°)		34.2	47.6
Longitude (East)	(°)		260.7	237.7
E/S Range to SV	(km)		9953.9	11324.9
E/S Elevation to SV	(°)		32.8	15.9
E/S Altitude	(km)		0.3	0.3
SV Beam Identifier	(#)			24
Minutes Into Pass (Sample #1)	(Min)			0:0
Telco Spot Beam Off-Angle	(°)			0.20
Telco Spot Beam Diameter	(km)			79.10
Maximum Roundtrip Latency	(msec)			141.96
Modulation Parameters			Forward	Return
Enter Receiver	Type		DVB-S2	
Modem Overhead	(%)		1.0%	
Number of Carriers per Channel	(#)		1	
Available Bandwidth	(Hz)		216,000,000	
Channel Symbol Rate	(sps)		180,000,000	
Channel Modulation Type			8PSK	
Channel FEC Rate			0.60	
Channel Spectral Efficiency	(bits/Sym)		1.80	
Channel Throughput (100% / 100% of Full Rate)	(bps)		320,760,000	
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)		74.79	
E/S Tx Pointing Loss	(dB)		-0.50	
E/S Tx RF Link Availability	(%)		75.000	
E/S Tx Atmospheric Losses	(dB)		-1.19	
E/S Tx Spreading Loss	(dB)		-150.95	
Satellite			Forward	Return
SV Number of Channels per HPA	(#)		1	
SV Rx G/T	(dB/K)		5.41	
SV Rx Power Per Tier	(dBW)		-123.06	
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )		-77.85	
SV Tx OBO (ALC / FGM)	(dB)		-3.80	
SV Tx Post-TWTA Losses	(dB)		-1.50	
SV Tx Antenna Gain	(dBi)		31.94	
SV Tx EIRP Per Channel/Carrier	(dBW)		44.77	
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	
E/S Rx Atmospheric Losses	(dB)		-0.67	
E/S Rx Pointing Loss	(dB)		-1.00	
E/S Rx Antenna Gain (1.2 m / 7.3 m)	(dBi)		42.7	
E/S Rx Effective G/T	(dB/K)		18.1	
E/S Rx Power Per Channel	(dBW)		-113.3	
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )		-109.0	
Total Link			Forward	Return
Carrier / Noise Bandwidth	(dB)		82.55	
Carrier / Noise Uplink	(dB)		22.99	
Carrier / Noise Downlink	(dB)		8.19	
Carrier / Intermodulation Im (C/Im)	(dB)		29.35	
(C/N) - Total Actual	(dB)		7.56	
(C/N) - Total Required	(dB)		6.60	
(E <sub>b</sub> /N <sub>0</sub> ) - Total Actual	(dB)		5.00	
(E <sub>b</sub> /N <sub>0</sub> ) - Total Required	(dB)		4.05	
<b>Excess Margin</b>	<b>(dB)</b>		<b>0.96</b>	
<b>Fade Margin</b>	<b>(dB)</b>		<b>10.16</b>	

## O3b Network Link Analysis - Tier 1 Service For Seattle, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014			Tier 1	Tier 1
Ground Parameter			Teleport	Telco
Location			Vernon (LHCP), United States	Seattle, United States
Latitude	(°)		34.2	47.6
Longitude (East)	(°)		260.7	237.7
E/S Range to SV	(km)		9953.9	11324.9
E/S Elevation to SV	(°)		32.8	15.9
E/S Altitude	(km)		0.3	0.3
SV Beam Identifier	(#)		24	
Minutes Into Pass (Sample #1)	(Min)		0:0	
Telco Spot Beam Off-Angle	(°)		0.20	
Telco Spot Beam Diameter	(km)		79.10	
Maximum Roundtrip Latency	(msec)		141.96	
Modulation Parameters			Forward	Return
Enter Receiver	Type			DVB-S2
Modem Overhead	(%)			1.0%
Number of Carriers per Channel	(#)			1
Available Bandwidth	(Hz)			216,000,000
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)			<b>142,560,000</b>
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)			20
E/S Tx OBO	(dB)			-3.00
E/S Tx Post-HPA Losses	(dB)			-0.28
E/S Tx Antenna Gain (7.3 m / 1.2 m)	(dB)			46.5
E/S Tx EIRP Per Channel	(dBW)			56.20
E/S Tx Pointing Loss	(dB)			-1.00
E/S Tx RF Link Availability	(%)			50.000
E/S Tx Atmospheric Losses	(dB)			-0.99
E/S Tx Spreading Loss	(dB)			-152.07
Satellite			Forward	Return
SV Number of Channels per HPA	(#)			5
SV Rx G/T	(dB/K)			5.10
SV Rx Power Per Tier	(dBW)			-143.38
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )			-97.87
SV Tx OBO (ALC / FGM)	(dB)			-21.10
SV Tx Post-TWTA Losses	(dB)			-1.50
SV Tx Antenna Gain	(dBi)			31.90
SV Tx EIRP Per Channel/Carrier	(dBW)			20.44
SV Tx Pointing Loss	(dB)			0.00
Downlink			Forward	Return
E/S Rx Carrier Frequency	(MHz)			18,909
E/S Rx Spreading Loss	(dB)			-150.95
E/S Rx RF Link Availability	(%)			75.000
E/S Rx Atmospheric Losses	(dB)			-0.78
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)			-116.55
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )			-131.80
Total Link			Forward	Return
Carrier / Noise Bandwidth	(dB)			82.55
Carrier / Noise Uplink	(dB)			2.66
Carrier / Noise Downlink	(dB)			6.42
(C/N) - Total Actual	(dB)			1.05
(C/N) - Total Required	(dB)			0.90
(E <sub>b</sub> /N <sub>0</sub> ) - Total Actual	(dB)			2.02
(E <sub>b</sub> /N <sub>0</sub> ) - Total Required	(dB)			1.87
<b>Excess Margin</b>	<b>(dB)</b>			<b>0.15</b>
<b>Fade Margin</b>	<b>(dB)</b>			<b>3.65</b>

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

Link Budget Creator - Rev 3.2.9: July 18, 2014			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 Range to SV	(km)		9953.9	11033.2
E/S Elevation to SV	(°)		32.8	19.1
E/S Altitude	(km)		0.3	0.0
SV Beam Identifier	(#)		25	
Minutes Into Pass (Sample #1)	(Min)		0:0	
Telco Spot Beam Off-Angle	(°)		0.20	
Telco Spot Beam Diameter	(km)		60.30	
Maximum Roundtrip Latency	(msec)		140.01	
Modulation Parameters			Forward	
Enter Receiver	Type		DVB-S2	
Modem Overhead	(%)		3.3%	
Number of Carriers per Channel	(#)		1	
Available Bandwidth	(Hz)		21,600,000	
Channel Symbol Rate	(sps)		18,000,000	
Channel Modulation Type			16APSK	
Channel FEC Rate			0.90	
Channel Spectral Efficiency	(bits/Sym)		3.60	
Channel Throughput (100% / 100% of Full Rate)	(bps)		62,688,242	
Uplink			Forward	
E/S Tx Channels per HPA	(#)		5	
E/S Tx Carrier Frequency	(MHz)		28,963	
E/S Tx HPA Power Level	(W)		50	
E/S Tx OBO	(dB)		-8.00	
E/S Tx Post-HPA Losses	(dB)		-2.24	
E/S Tx Antenna Gain (7.3 m / 2.4 m)	(dB)		65.11	
E/S Tx EIRP Per Channel	(dBW)		64.87	
E/S Tx Pointing Loss	(dB)		-0.50	
E/S Tx RF Link Availability	(%)		75.000	
E/S Tx Atmospheric Losses	(dB)		-1.19	
E/S Tx Spreading Loss	(dB)		-150.95	
Satellite			Forward	
SV Number of Channels per HPA	(#)		1	
SV Rx G/T	(dB/K)		5.41	
SV Rx Power Per Tier	(dBW)		-133.06	
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )		-87.77	
SV Tx OBO (ALC / FGM)	(dB)		-3.80	
SV Tx Post-TWTA Losses	(dB)		-1.50	
SV Tx Antenna Gain	(dBi)		31.94	
SV Tx EIRP Per Channel/Carrier	(dBW)		44.77	
SV Tx Pointing Loss	(dB)		0.00	
Downlink			Forward	
E/S Rx Carrier Frequency	(MHz)		19,163	
E/S Rx Wavelength	(m)		0.015644	
E/S Rx RF Link Availability	(%)		50	
E/S Rx Atmospheric Losses	(dB)		-1.54	
E/S Rx Pointing Loss	(dB)		-0.50	
E/S Rx Antenna Gain (2.4 m / 7.3 m)	(dBi)		51.5	
E/S Rx Effective G/T	(dB/K)		26.6	
E/S Rx Power Per Channel	(dBW)		-104.7	
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )		-109.1	
Total Link			Forward	
Carrier / Noise Bandwidth	(dB)		72.55	
Carrier / Noise Uplink	(dB)		22.99	
Carrier / Noise Downlink	(dB)		26.40	
Carrier / Intermodulation Im (C/Im)	(dB)		29.35	
(C/N) - Total Actual	(dB)		15.82	
(C/N) - Total Required	(dB)		15.20	
(E <sub>b</sub> /N <sub>0</sub> ) - Total Actual	(dB)		10.26	
(E <sub>b</sub> /N <sub>0</sub> ) - Total Required	(dB)		9.64	
<b>Excess Margin</b>	<b>(dB)</b>		<b>0.62</b>	
<b>Fade Margin</b>	<b>(dB)</b>		<b>18.02</b>	

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

Link Budget Creator - Rev 3.2.9: July 18, 2014		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 Range to SV	(km)	9953.9	11033.2
E/S Elevation to SV	(°)	32.8	19.1
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)		25
Minutes Into Pass (Sample #1)	(Min)		0:0
Telco Spot Beam Off-Angle	(°)		0.20
Telco Spot Beam Diameter	(km)		60.30
Maximum Roundtrip Latency	(msec)		140.01
Modulation Parameters		Forward	Return
Enter Receiver	Type		DVB-S2
Modem Overhead	(%)		3.4%
Number of Carriers per Channel	(#)		1
Available Bandwidth	(Hz)		21,600,000
Channel Symbol Rate	(sps)		18,000,000
Channel Modulation Type			16APSK
Channel FEC Rate			0.80
Channel Spectral Efficiency	(bits/Sym)		3.20
Channel Throughput (100% / 100% of Full Rate)	(bps)		<b>55,628,910</b>
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)		-10.00
E/S Tx Post-HPA Losses	(dB)		-0.77
E/S Tx Antenna Gain (7.3 m / 2.4 m)	(dB)		55.3
E/S Tx EIRP Per Channel	(dBW)		60.56
E/S Tx Pointing Loss	(dB)		-0.50
E/S Tx RF Link Availability	(%)		50.000
E/S Tx Atmospheric Losses	(dB)		-2.03
E/S Tx Spreading Loss	(dB)		-151.85
Satellite		Forward	Return
SV Number of Channels per HPA	(#)		5
SV Rx G/T	(dB/K)		5.10
SV Rx Power Per Tier	(dBW)		-139.41
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )		-93.82
SV Tx OBO (ALC / FGM)	(dB)		-16.71
SV Tx Post-TWTA Losses	(dB)		-1.50
SV Tx Antenna Gain	(dBi)		31.90
SV Tx EIRP Per Channel/Carrier	(dBW)		24.84
SV Tx Pointing Loss	(dB)		0.00
Downlink		Forward	Return
E/S Rx Carrier Frequency	(MHz)		19,163
E/S Rx Spreading Loss	(dB)		-150.95
E/S Rx RF Link Availability	(%)		75.000
E/S Rx Atmospheric Losses	(dB)		-0.85
E/S Rx Pointing Loss	(dB)		-0.50
E/S Rx Antenna Gain (2.4 m / 7.3 m)	(dBi)		62.35
E/S Rx Effective G/T	(dB/K)		39.14
E/S Rx Power Per Channel	(dBW)		-112.22
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )		-127.47
Total Link		Forward	Return
Carrier / Noise Bandwidth	(dB)		72.55
Carrier / Noise Uplink	(dB)		16.63
Carrier / Noise Downlink	(dB)		20.62
(C/N) - Total Actual	(dB)		13.55
(C/N) - Total Required	(dB)		13.30
(E <sub>b</sub> /N <sub>0</sub> ) - Total Actual	(dB)		8.50
(E <sub>b</sub> /N <sub>0</sub> ) - Total Required	(dB)		8.25
<b>Excess Margin</b>	<b>(dB)</b>		<b>0.25</b>
<b>Fade Margin</b>	<b>(dB)</b>		<b>15.75</b>



## O3b Network Link Analysis - Tier 2 Service For Seattle, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014		Tier 2	Tier 2
Ground Parameter		Teleport	Telco
Location		Vernon (LHCP), United States	Seattle, United States
Latitude	(°)	34.2	47.6
Longitude (East)	(°)	260.7	237.7
E/S Range to SV	(km)	9953.9	11324.9
E/S Elevation to SV	(°)	32.8	15.9
E/S Altitude	(km)	0.3	0.3
SV Beam Identifier	(#)		24
Minutes Into Pass (Sample #1)	(Min)		0.0
Telco Spot Beam Off-Angle	(°)		0.20
Telco Spot Beam Diameter	(km)		79.10
Maximum Roundtrip Latency	(msec)		141.96
Modulation Parameters		Forward	Return
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	3.3%	
Number of Carriers per Channel	(#)	1	
Available Bandwidth	(Hz)	21,600,000	
Channel Symbol Rate	(sps)	18,000,000	
Channel Modulation Type		16APSK	
Channel FEC Rate		0.90	
Channel Spectral Efficiency	(bits/Sym)	3.60	
Channel Throughput (100% / 100% of Full Rate)	(bps)	62,688,242	
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)	50	
E/S Tx OBO	(dB)	-8.00	
E/S Tx Post-HPA Losses	(dB)	-2.24	
E/S Tx Antenna Gain (7.3 m / 2.4 m)	(dB)	65.03	
E/S Tx EIRP Per Channel	(dBW)	64.79	
E/S Tx Pointing Loss	(dB)	-0.50	
E/S Tx RF Link Availability	(%)	75.000	
E/S Tx Atmospheric Losses	(dB)	-1.19	
E/S Tx Spreading Loss	(dB)	-150.95	
Satellite		Forward	Return
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	5.41	
SV Rx Power Per Tier	(dBW)	-133.06	
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )	-87.85	
SV Tx OBO (ALC / FGM)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	31.94	
SV Tx EIRP Per Channel/Carrier	(dBW)	44.77	
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	
E/S Rx Atmospheric Losses	(dB)	-0.67	
E/S Rx Pointing Loss	(dB)	-0.50	
E/S Rx Antenna Gain (2.4 m / 7.3 m)	(dBi)	51.4	
E/S Rx Effective G/T	(dB/K)	26.8	
E/S Rx Power Per Channel	(dBW)	-104.1	
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )	-108.5	
Total Link		Forward	Return
Carrier / Noise Bandwidth	(dB)	72.55	
Carrier / Noise Uplink	(dB)	22.99	
Carrier / Noise Downlink	(dB)	27.38	
Carrier / Intermodulation Im (C/Im)	(dB)	29.35	
(C/N) - Total Actual	(dB)	15.91	
(C/N) - Total Required	(dB)	15.20	
(E <sub>v</sub> /N <sub>0</sub> ) - Total Actual	(dB)	10.34	
(E <sub>v</sub> /N <sub>0</sub> ) - Total Required	(dB)	9.64	
<b>Excess Margin</b>	<b>(dB)</b>	<b>0.71</b>	
<b>Fade Margin</b>	<b>(dB)</b>	<b>18.11</b>	

## O3b Network Link Analysis - Tier 2 Service For Seattle, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014		Tier 2	Tier 2
Ground Parameter		Teleport	Telco
Location		Vernon (LHCP), United States	Seattle, United States
Latitude	(°)	34.2	47.6
Longitude (East)	(°)	260.7	237.7
E/S Range to SV	(km)	9953.9	11324.9
E/S Elevation to SV	(°)	32.8	15.9
E/S Altitude	(km)	0.3	0.3
SV Beam Identifier	(#)		24
Minutes Into Pass (Sample #1)	(Min)		0:0
Telco Spot Beam Off-Angle	(°)		0.20
Telco Spot Beam Diameter	(km)		79.10
Maximum Roundtrip Latency	(msec)		141.96
Modulation Parameters		Forward	Return
Enter Receiver	Type		DVB-S2
Modem Overhead	(%)		3.3%
Number of Carriers per Channel	(#)		1
Available Bandwidth	(Hz)		21,600,000
Channel Symbol Rate	(sps)		18,000,000
Channel Modulation Type			16APSK
Channel FEC Rate			0.83
Channel Spectral Efficiency	(bits/Sym)		3.33
Channel Throughput (100% / 100% of Full Rate)	(bps)		<b>57,993,528</b>
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)		-10.00
E/S Tx Post-HPA Losses	(dB)		-0.77
E/S Tx Antenna Gain (7.3 m / 2.4 m)	(dB)		55.2
E/S Tx EIRP Per Channel	(dBW)		60.48
E/S Tx Pointing Loss	(dB)		-0.50
E/S Tx RF Link Availability	(%)		50.000
E/S Tx Atmospheric Losses	(dB)		-0.99
E/S Tx Spreading Loss	(dB)		-152.07
Satellite		Forward	Return
SV Number of Channels per HPA	(#)		5
SV Rx G/T	(dB/K)		5.10
SV Rx Power Per Tier	(dBW)		-138.60
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )		-93.08
SV Tx OBO (ALC / FGM)	(dB)		-15.67
SV Tx Post-TWTA Losses	(dB)		-1.50
SV Tx Antenna Gain	(dBi)		31.90
SV Tx EIRP Per Channel/Carrier	(dBW)		25.87
SV Tx Pointing Loss	(dB)		0.00
Downlink		Forward	Return
E/S Rx Carrier Frequency	(MHz)		18,909
E/S Rx Spreading Loss	(dB)		-150.95
E/S Rx RF Link Availability	(%)		75.000
E/S Rx Atmospheric Losses	(dB)		-0.78
E/S Rx Pointing Loss	(dB)		-0.50
E/S Rx Antenna Gain (2.4 m / 7.3 m)	(dBi)		62.24
E/S Rx Effective G/T	(dB/K)		39.16
E/S Rx Power Per Channel	(dBW)		-111.12
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )		-126.37
Total Link		Forward	Return
Carrier / Noise Bandwidth	(dB)		72.55
Carrier / Noise Uplink	(dB)		17.45
Carrier / Noise Downlink	(dB)		21.85
(C/N) - Total Actual	(dB)		14.18
(C/N) - Total Required	(dB)		13.70
(E <sub>b</sub> /N <sub>0</sub> ) - Total Actual	(dB)		8.95
(E <sub>b</sub> /N <sub>0</sub> ) - Total Required	(dB)		8.47
<b>Excess Margin</b>	<b>(dB)</b>		<b>0.48</b>
<b>Fade Margin</b>	<b>(dB)</b>		<b>16.38</b>

## O3b Network Link Analysis - Tier 1 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014			Tier 1	Tier 1
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 Range to SV	(km)		9953.9	11033.2
E/S Elevation to SV	(°)		32.8	19.1
E/S Altitude	(km)		0.3	0.0
SV Beam Identifier	(#)			25
Minutes Into Pass (Sample #1)	(Min)			0:0
Telco Spot Beam Off-Angle	(°)			0.20
Telco Spot Beam Diameter	(km)			60.30
Maximum Roundtrip Latency	(msec)			140.01
Modulation Parameters			Forward	Return
Enter Receiver	Type		DVB-S2	
Modem Overhead	(%)		1.0%	
Number of Carriers per Channel	(#)		1	
Available Bandwidth	(Hz)		21,600,000	
Channel Symbol Rate	(sps)		18,000,000	
Channel Modulation Type			16APSK	
Channel FEC Rate			0.83	
Channel Spectral Efficiency	(bits/Sym)		3.33	
Channel Throughput (100% / 100% of Full Rate)	(bps)		59,400,000	
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)		50	
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)		64.87	
E/S Tx Pointing Loss	(dB)		-0.50	
E/S Tx RF Link Availability	(%)		75.000	
E/S Tx Atmospheric Losses	(dB)		-1.19	
E/S Tx Spreading Loss	(dB)		-150.95	
Satellite			Forward	Return
SV Number of Channels per HPA	(#)		1	
SV Rx G/T	(dB/K)		5.41	
SV Rx Power Per Tier	(dBW)		-133.06	
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )		-87.77	
SV Tx OBO (ALC / FGM)	(dB)		-3.80	
SV Tx Post-TWTA Losses	(dB)		-1.50	
SV Tx Antenna Gain	(dBi)		31.94	
SV Tx EIRP Per Channel/Carrier	(dBW)		44.77	
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	
E/S Rx Atmospheric Losses	(dB)		-1.54	
E/S Rx Pointing Loss	(dB)		-1.00	
E/S Rx Antenna Gain (1.2 m / 7.3 m)	(dBi)		42.8	
E/S Rx Effective G/T	(dB/K)		17.9	
E/S Rx Power Per Channel	(dBW)		-113.9	
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )		-109.6	
Total Link			Forward	Return
Carrier / Noise Bandwidth	(dB)		72.55	
Carrier / Noise Uplink	(dB)		22.99	
Carrier / Noise Downlink	(dB)		17.21	
Carrier / Intermodulation Im (C/Im)	(dB)		29.35	
(C/N) - Total Actual	(dB)		13.68	
(C/N) - Total Required	(dB)		12.90	
(E <sub>v</sub> /N <sub>0</sub> ) - Total Actual	(dB)		8.45	
(E <sub>v</sub> /N <sub>0</sub> ) - Total Required	(dB)		7.67	
<b>Excess Margin</b>	<b>(dB)</b>		<b>0.78</b>	
<b>Fade Margin</b>	<b>(dB)</b>		<b>16.28</b>	

## O3b Network Link Analysis - Tier 1 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014		Tier 1	Tier 1
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 Range to SV	(km)	9953.9	11033.2
E/S Elevation to SV	(°)	32.8	19.1
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)		25
Minutes Into Pass (Sample #1)	(Min)		0:0
Telco Spot Beam Off-Angle	(°)		0.20
Telco Spot Beam Diameter	(km)		60.30
Maximum Roundtrip Latency	(msec)		140.01
Modulation Parameters		Forward	Return
Enter Receiver	Type		DVB-S2
Modem Overhead	(%)		1.0%
Number of Carriers per Channel	(#)		1
Available Bandwidth	(Hz)		21,600,000
Channel Symbol Rate	(sps)		18,000,000
Channel Modulation Type			QPSK
Channel FEC Rate			0.60
Channel Spectral Efficiency	(bits/Sym)		1.20
Channel Throughput (100% / 100% of Full Rate)	(bps)		<b>21,384,000</b>
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)		20
E/S Tx OBO	(dB)		-10.00
E/S Tx Post-HPA Losses	(dB)		-0.28
E/S Tx Antenna Gain (7.3 m / 1.2 m)	(dB)		46.5
E/S Tx EIRP Per Channel	(dBW)		49.27
E/S Tx Pointing Loss	(dB)		-1.00
E/S Tx RF Link Availability	(%)		50.000
E/S Tx Atmospheric Losses	(dB)		-2.03
E/S Tx Spreading Loss	(dB)		-151.85
Satellite		Forward	Return
SV Number of Channels per HPA	(#)		5
SV Rx G/T	(dB/K)		5.10
SV Rx Power Per Tier	(dBW)		-151.20
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )		-105.61
SV Tx OBO (ALC / FGM)	(dB)		-25.63
SV Tx Post-TWTA Losses	(dB)		-1.50
SV Tx Antenna Gain	(dBi)		31.90
SV Tx EIRP Per Channel/Carrier	(dBW)		15.92
SV Tx Pointing Loss	(dB)		0.00
Downlink		Forward	Return
E/S Rx Carrier Frequency	(MHz)		19,163
E/S Rx Spreading Loss	(dB)		-150.95
E/S Rx RF Link Availability	(%)		75.000
E/S Rx Atmospheric Losses	(dB)		-0.85
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)		39.14
E/S Rx Power Per Channel	(dBW)		-121.14
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )		-136.38
Total Link		Forward	Return
Carrier / Noise Bandwidth	(dB)		72.55
Carrier / Noise Uplink	(dB)		4.85
Carrier / Noise Downlink	(dB)		11.70
(C/N) - Total Actual	(dB)		3.88
(C/N) - Total Required	(dB)		3.60
(E <sub>v</sub> /N <sub>0</sub> ) - Total Actual	(dB)		3.09
(E <sub>v</sub> /N <sub>0</sub> ) - Total Required	(dB)		2.81
<b>Excess Margin</b>	<b>(dB)</b>		<b>0.28</b>
<b>Fade Margin</b>	<b>(dB)</b>		<b>6.48</b>

## O3b Network Link Analysis - Tier 1 Service For Seattle, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014		Tier 1	Tier 1
Ground Parameter		Teleport	Telco
Location		Vernon (LHCP), United States	Seattle, United States
Latitude	(°)	34.2	47.6
Longitude (East)	(°)	260.7	237.7
E/S Range to SV	(km)	9953.9	11324.9
E/S Elevation to SV	(°)	32.8	15.9
E/S Altitude	(km)	0.3	0.3
SV Beam Identifier	(#)		24
Minutes Into Pass (Sample #1)	(Min)		0:0
Telco Spot Beam Off-Angle	(°)		0.20
Telco Spot Beam Diameter	(km)		79.10
Maximum Roundtrip Latency	(msec)		141.96
Modulation Parameters		Forward	Return
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	1.0%	
Number of Carriers per Channel	(#)	1	
Available Bandwidth	(Hz)	21,600,000	
Channel Symbol Rate	(sps)	18,000,000	
Channel Modulation Type		16APSK	
Channel FEC Rate		0.83	
Channel Spectral Efficiency	(bits/Sym)	3.33	
Channel Throughput (100% / 100% of Full Rate)	(bps)	59,400,000	
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)	50	
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)	64.79	
E/S Tx Pointing Loss	(dB)	-0.50	
E/S Tx RF Link Availability	(%)	75.000	
E/S Tx Atmospheric Losses	(dB)	-1.19	
E/S Tx Spreading Loss	(dB)	-150.95	
Satellite		Forward	Return
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	5.41	
SV Rx Power Per Tier	(dBW)	-133.06	
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )	-87.85	
SV Tx OBO (ALC / FGM)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	31.94	
SV Tx EIRP Per Channel/Carrier	(dBW)	44.77	
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	
E/S Rx Atmospheric Losses	(dB)	-0.67	
E/S Rx Pointing Loss	(dB)	-1.00	
E/S Rx Antenna Gain (1.2 m / 7.3 m)	(dBi)	42.7	
E/S Rx Effective G/T	(dB/K)	18.1	
E/S Rx Power Per Channel	(dBW)	-113.3	
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )	-109.0	
Total Link		Forward	Return
Carrier / Noise Bandwidth	(dB)	72.55	
Carrier / Noise Uplink	(dB)	22.99	
Carrier / Noise Downlink	(dB)	18.19	
Carrier / Intermodulation Im (C/Im)	(dB)	29.35	
(C/N) - Total Actual	(dB)	14.09	
(C/N) - Total Required	(dB)	12.90	
(E <sub>v</sub> /N <sub>0</sub> ) - Total Actual	(dB)	8.86	
(E <sub>v</sub> /N <sub>0</sub> ) - Total Required	(dB)	7.67	
<b>Excess Margin</b>	<b>(dB)</b>	<b>1.19</b>	
<b>Fade Margin</b>	<b>(dB)</b>	<b>16.69</b>	

## O3b Network Link Analysis - Tier 1 Service For Seattle, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014			Tier 1	Tier 1
Ground Parameter			Teleport	Telco
Location			Vernon (LHCP), United States	Seattle, United States
Latitude	(°)		34.2	47.6
Longitude (East)	(°)		260.7	237.7
E/S Range to SV	(km)		9953.9	11324.9
E/S Elevation to SV	(°)		32.8	15.9
E/S Altitude	(km)		0.3	0.3
SV Beam Identifier	(#)		24	
Minutes Into Pass (Sample #1)	(Min)		0:0	
Telco Spot Beam Off-Angle	(°)		0.20	
Telco Spot Beam Diameter	(km)		79.10	
Maximum Roundtrip Latency	(msec)		141.96	
Modulation Parameters			Forward	Return
Enter Receiver	Type			DVB-S2
Modem Overhead	(%)			1.0%
Number of Carriers per Channel	(#)			1
Available Bandwidth	(Hz)			21,600,000
Channel Symbol Rate	(sps)			18,000,000
Channel Modulation Type				QPSK
Channel FEC Rate				0.67
Channel Spectral Efficiency	(bits/Sym)			1.33
Channel Throughput (100% / 100% of Full Rate)	(bps)			<b>23,760,000</b>
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)			20
E/S Tx OBO	(dB)			-10.00
E/S Tx Post-HPA Losses	(dB)			-0.28
E/S Tx Antenna Gain (7.3 m / 1.2 m)	(dB)			46.5
E/S Tx EIRP Per Channel	(dBW)			49.20
E/S Tx Pointing Loss	(dB)			-1.00
E/S Tx RF Link Availability	(%)			50.000
E/S Tx Atmospheric Losses	(dB)			-0.99
E/S Tx Spreading Loss	(dB)			-152.07
Satellite			Forward	Return
SV Number of Channels per HPA	(#)			5
SV Rx G/T	(dB/K)			5.10
SV Rx Power Per Tier	(dBW)			-150.38
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )			-104.87
SV Tx OBO (ALC / FGM)	(dB)			-25.63
SV Tx Post-TWTA Losses	(dB)			-1.50
SV Tx Antenna Gain	(dBi)			31.90
SV Tx EIRP Per Channel/Carrier	(dBW)			15.92
SV Tx Pointing Loss	(dB)			0.00
Downlink			Forward	Return
E/S Rx Carrier Frequency	(MHz)			18,909
E/S Rx Spreading Loss	(dB)			-150.95
E/S Rx RF Link Availability	(%)			75.000
E/S Rx Atmospheric Losses	(dB)			-0.78
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)			-121.07
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )			-136.32
Total Link			Forward	Return
Carrier / Noise Bandwidth	(dB)			72.55
Carrier / Noise Uplink	(dB)			5.66
Carrier / Noise Downlink	(dB)			11.89
(C/N) - Total Actual	(dB)			4.56
(C/N) - Total Required	(dB)			4.20
(E <sub>p</sub> /N <sub>0</sub> ) - Total Actual	(dB)			3.31
(E <sub>p</sub> /N <sub>0</sub> ) - Total Required	(dB)			2.95
<b>Excess Margin</b>	<b>(dB)</b>			<b>0.36</b>
<b>Fade Margin</b>	<b>(dB)</b>			<b>7.16</b>

## O3b Network Link Analysis - Tier 1 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014			Tier 1	
Ground Parameter			Tier 1	
			Teleport	Telco
Location			Vernon (LHCP), United States	San Juan-, United States
Latitude	(°)		34.2	18.5
Longitude (East)	(°)		260.7	293.9
E/S Range to SV	(km)		9953.9	11033.2
E/S Elevation to SV	(°)		32.8	19.1
E/S Altitude	(km)		0.3	0.0
SV Beam Identifier	(#)			25
Minutes Into Pass (Sample #1)	(Min)			0:0
Telco Spot Beam Off-Angle	(°)			1.70
Telco Spot Beam Diameter	(km)			512.30
Maximum Roundtrip Latency	(msec)			140.01
Modulation Parameters			Forward	Return
Enter Receiver	Type		DVB-S2	
Modem Overhead	(%)		1.0%	
Number of Carriers per Channel	(#)		50	
Available Bandwidth	(Hz)		216,000,000	
Channel Symbol Rate	(sps)		3,600,000	
Channel Modulation Type			16APSK	
Channel FEC Rate			0.75	
Channel Spectral Efficiency	(bits/Sym)		3.00	
Channel Throughput (100% / 100% of Full Rate)	(bps)		10,692,000	
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 / 2.4 m)	(dB)		65.11	
E/S Tx EIRP Per Channel	(dBW)		57.88	
E/S Tx Pointing Loss	(dB)		-0.50	
E/S Tx RF Link Availability	(%)		75.000	
E/S Tx Atmospheric Losses	(dB)		-1.19	
E/S Tx Spreading Loss	(dB)		-150.95	
Satellite			Forward	Return
SV Number of Channels per HPA	(#)		1	
SV Rx G/T	(dB/K)		5.41	
SV Rx Power Per Tier	(dBW)		-123.06	
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )		-77.77	
SV Tx OBO (ALC / FGM)	(dB)		-3.80	
SV Tx Post-TWTA Losses	(dB)		-1.50	
SV Tx Antenna Gain	(dBi)		29.24	
SV Tx EIRP Per Channel/Carrier	(dBW)		25.08	
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	
E/S Rx Atmospheric Losses	(dB)		-1.54	
E/S Rx Pointing Loss	(dB)		-0.50	
E/S Rx Antenna Gain (2.4 m / 7.3 m)	(dBi)		51.5	
E/S Rx Effective G/T	(dB/K)		26.6	
E/S Rx Power Per Channel	(dBW)		-124.4	
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )		-128.8	
Total Link			Forward	Return
Carrier / Noise Bandwidth	(dB)		65.56	
Carrier / Noise Uplink	(dB)		22.99	
Carrier / Noise Downlink	(dB)		13.70	
Carrier / Intermodulation Im (C/Im)	(dB)		28.61	
(C/N) - Total Actual	(dB)		11.74	
(C/N) - Total Required	(dB)		11.40	
(E <sub>b</sub> /N <sub>0</sub> ) - Total Actual	(dB)		6.97	
(E <sub>b</sub> /N <sub>0</sub> ) - Total Required	(dB)		6.63	
<b>Excess Margin</b>	<b>(dB)</b>		<b>0.34</b>	
<b>Fade Margin</b>	<b>(dB)</b>		<b>14.34</b>	

## O3b Network Link Analysis - Tier 1 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014			Tier 1	Tier 1
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 Range to SV	(km)		9953.9	11033.2
E/S Elevation to SV	(°)		32.8	19.1
E/S Altitude	(km)		0.3	0.0
SV Beam Identifier	(#)		25	
Minutes Into Pass (Sample #1)	(Min)		0:0	
Telco Spot Beam Off-Angle	(°)		1.70	
Telco Spot Beam Diameter	(km)		512.30	
Maximum Roundtrip Latency	(msec)		140.01	
Modulation Parameters			Forward	Return
Enter Receiver	Type			DVB-S2
Modem Overhead	(%)			1.0%
Number of Carriers per Channel	(#)			50
Available Bandwidth	(Hz)			216,000,000
Channel Symbol Rate	(sps)			3,600,000
Channel Modulation Type				8PSK
Channel FEC Rate				0.75
Channel Spectral Efficiency	(bits/Sym)			2.25
Channel Throughput (100% / 100% of Full Rate)	(bps)			<b>8,019,000</b>
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)			20
E/S Tx OBO	(dB)			-15.00
E/S Tx Post-HPA Losses	(dB)			-0.77
E/S Tx Antenna Gain (7.3 m / 2.4 m)	(dB)			55.3
E/S Tx EIRP Per Channel	(dBW)			52.55
E/S Tx Pointing Loss	(dB)			-0.50
E/S Tx RF Link Availability	(%)			50.000
E/S Tx Atmospheric Losses	(dB)			-2.03
E/S Tx Spreading Loss	(dB)			-151.85
Satellite			Forward	Return
SV Number of Channels per HPA	(#)			5
SV Rx G/T	(dB/K)			0.98
SV Rx Power Per Tier	(dBW)			-134.55
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )			-84.84
SV Tx OBO (ALC / FGM)	(dB)			-11.84
SV Tx Post-TWTA Losses	(dB)			-1.50
SV Tx Antenna Gain	(dBi)			31.90
SV Tx EIRP Per Channel/Carrier	(dBW)			12.71
SV Tx Pointing Loss	(dB)			0.00
Downlink			Forward	Return
E/S Rx Carrier Frequency	(MHz)			19,163
E/S Rx Spreading Loss	(dB)			-150.95
E/S Rx RF Link Availability	(%)			75.000
E/S Rx Atmospheric Losses	(dB)			-0.85
E/S Rx Pointing Loss	(dB)			-0.50
E/S Rx Antenna Gain (2.4 m / 7.3 m)	(dBi)			62.35
E/S Rx Effective G/T	(dB/K)			39.14
E/S Rx Power Per Channel	(dBW)			-124.34
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )			-139.59
Total Link			Forward	Return
Carrier / Noise Bandwidth	(dB)			65.56
Carrier / Noise Uplink	(dB)			11.49
Carrier / Noise Downlink	(dB)			15.49
(C/N) - Total Actual	(dB)			9.46
(C/N) - Total Required	(dB)			9.00
(E <sub>v</sub> /N <sub>0</sub> ) - Total Actual	(dB)			5.94
(E <sub>v</sub> /N <sub>0</sub> ) - Total Required	(dB)			5.48
<b>Excess Margin</b>	<b>(dB)</b>			<b>0.46</b>
<b>Fade Margin</b>	<b>(dB)</b>			<b>12.06</b>



## O3b Network Link Analysis - Tier 1 Service For Seattle, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014			Tier 1	
Ground Parameter			Tier 1	
			Teleport	Telco
Location			Vernon (LHCP), United States	Seattle, United States
Latitude	(°)		34.2	47.6
Longitude (East)	(°)		260.7	237.7
E/S Range to SV	(km)		9953.9	11324.9
E/S Elevation to SV	(°)		32.8	15.9
E/S Altitude	(km)		0.3	0.3
SV Beam Identifier	(#)			24
Minutes Into Pass (Sample #1)	(Min)			0:0
Telco Spot Beam Off-Angle	(°)			1.70
Telco Spot Beam Diameter	(km)			672.20
Maximum Roundtrip Latency	(msec)			141.96
Modulation Parameters			Forward	Return
Enter Receiver	Type		DVB-S2	
Modem Overhead	(%)		1.0%	
Number of Carriers per Channel	(#)		50	
Available Bandwidth	(Hz)		216,000,000	
Channel Symbol Rate	(sps)		3,600,000	
Channel Modulation Type			16APSK	
Channel FEC Rate			0.75	
Channel Spectral Efficiency	(bits/Sym)		3.00	
Channel Throughput (100% / 100% of Full Rate)	(bps)		10,692,000	
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 / 2.4 m)	(dB)		65.03	
E/S Tx EIRP Per Channel	(dBW)		57.80	
E/S Tx Pointing Loss	(dB)		-0.50	
E/S Tx RF Link Availability	(%)		75.000	
E/S Tx Atmospheric Losses	(dB)		-1.19	
E/S Tx Spreading Loss	(dB)		-150.95	
Satellite			Forward	Return
SV Number of Channels per HPA	(#)		1	
SV Rx G/T	(dB/K)		5.41	
SV Rx Power Per Tier	(dBW)		-123.06	
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )		-77.85	
SV Tx OBO (ALC / FGM)	(dB)		-3.80	
SV Tx Post-TWTA Losses	(dB)		-1.50	
SV Tx Antenna Gain	(dBi)		29.24	
SV Tx EIRP Per Channel/Carrier	(dBW)		25.08	
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	
E/S Rx Atmospheric Losses	(dB)		-0.67	
E/S Rx Pointing Loss	(dB)		-0.50	
E/S Rx Antenna Gain (2.4 m / 7.3 m)	(dBi)		51.4	
E/S Rx Effective G/T	(dB/K)		26.8	
E/S Rx Power Per Channel	(dBW)		-123.8	
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )		-128.2	
Total Link			Forward	Return
Carrier / Noise Bandwidth	(dB)		65.56	
Carrier / Noise Uplink	(dB)		22.99	
Carrier / Noise Downlink	(dB)		14.67	
Carrier / Intermodulation Im (C/Im)	(dB)		28.61	
(C/N) - Total Actual	(dB)		12.35	
(C/N) - Total Required	(dB)		11.40	
(E <sub>b</sub> /N <sub>0</sub> ) - Total Actual	(dB)		7.58	
(E <sub>b</sub> /N <sub>0</sub> ) - Total Required	(dB)		6.63	
<b>Excess Margin</b>	<b>(dB)</b>		<b>0.95</b>	
<b>Fade Margin</b>	<b>(dB)</b>		<b>14.95</b>	

## O3b Network Link Analysis - Tier 1 Service For Seattle, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014			Tier 1	Tier 1
Ground Parameter			Teleport	Telco
Location			Vernon (LHCP), United States	Seattle, United States
Latitude	(°)		34.2	47.6
Longitude (East)	(°)		260.7	237.7
E/S Range to SV	(km)		9953.9	11324.9
E/S Elevation to SV	(°)		32.8	15.9
E/S Altitude	(km)		0.3	0.3
SV Beam Identifier	(#)		24	
Minutes Into Pass (Sample #1)	(Min)		0:0	
Telco Spot Beam Off-Angle	(°)		1.70	
Telco Spot Beam Diameter	(km)		672.20	
Maximum Roundtrip Latency	(msec)		141.96	
Modulation Parameters			Forward	Return
Enter Receiver	Type			DVB-S2
Modem Overhead	(%)			1.0%
Number of Carriers per Channel	(#)			50
Available Bandwidth	(Hz)			216,000,000
Channel Symbol Rate	(sps)			3,600,000
Channel Modulation Type				16APSK
Channel FEC Rate				0.67
Channel Spectral Efficiency	(bits/Sym)			2.67
Channel Throughput (100% / 100% of Full Rate)	(bps)			<b>9,504,000</b>
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)			20
E/S Tx OBO	(dB)			-15.00
E/S Tx Post-HPA Losses	(dB)			-0.77
E/S Tx Antenna Gain (7.3 m / 2.4 m)	(dB)			55.2
E/S Tx EIRP Per Channel	(dBW)			52.47
E/S Tx Pointing Loss	(dB)			-0.50
E/S Tx RF Link Availability	(%)			50.000
E/S Tx Atmospheric Losses	(dB)			-0.99
E/S Tx Spreading Loss	(dB)			-152.07
Satellite			Forward	Return
SV Number of Channels per HPA	(#)			5
SV Rx G/T	(dB/K)			0.98
SV Rx Power Per Tier	(dBW)			-133.74
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )			-84.10
SV Tx OBO (ALC / FGM)	(dB)			-10.96
SV Tx Post-TWTA Losses	(dB)			-1.50
SV Tx Antenna Gain	(dBi)			31.90
SV Tx EIRP Per Channel/Carrier	(dBW)			13.59
SV Tx Pointing Loss	(dB)			0.00
Downlink			Forward	Return
E/S Rx Carrier Frequency	(MHz)			18,909
E/S Rx Spreading Loss	(dB)			-150.95
E/S Rx RF Link Availability	(%)			75.000
E/S Rx Atmospheric Losses	(dB)			-0.78
E/S Rx Pointing Loss	(dB)			-0.50
E/S Rx Antenna Gain (2.4 m / 7.3 m)	(dBi)			62.24
E/S Rx Effective G/T	(dB/K)			39.16
E/S Rx Power Per Channel	(dBW)			-123.40
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )			-138.65
Total Link			Forward	Return
Carrier / Noise Bandwidth	(dB)			65.56
Carrier / Noise Uplink	(dB)			12.31
Carrier / Noise Downlink	(dB)			16.55
(C/N) - Total Actual	(dB)			10.24
(C/N) - Total Required	(dB)			10.10
(E <sub>b</sub> /N <sub>0</sub> ) - Total Actual	(dB)			5.98
(E <sub>b</sub> /N <sub>0</sub> ) - Total Required	(dB)			5.84
<b>Excess Margin</b>	<b>(dB)</b>			<b>0.14</b>
<b>Fade Margin</b>	<b>(dB)</b>			<b>12.84</b>

## O3b Network Link Analysis - Tier 1 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014			Tier 1	Tier 1
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 Range to SV	(km)		9953.9	11033.2
E/S Elevation to SV	(°)		32.8	19.1
E/S Altitude	(km)		0.3	0.0
SV Beam Identifier	(#)		25	
Minutes Into Pass (Sample #1)	(Min)		0:0	
Telco Spot Beam Off-Angle	(°)		1.70	
Telco Spot Beam Diameter	(km)		512.30	
Maximum Roundtrip Latency	(msec)		140.01	
Modulation Parameters			Forward	Return
Enter Receiver	Type		DVB-S2	
Modem Overhead	(%)		1.0%	
Number of Carriers per Channel	(#)		50	
Available Bandwidth	(Hz)		216,000,000	
Channel Symbol Rate	(sps)		3,600,000	
Channel Modulation Type			QPSK	
Channel FEC Rate			0.67	
Channel Spectral Efficiency	(bits/Sym)		1.33	
Channel Throughput (100% / 100% of Full Rate)	(bps)		4,752,000	
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)		57.88	
E/S Tx Pointing Loss	(dB)		-0.50	
E/S Tx RF Link Availability	(%)		75.000	
E/S Tx Atmospheric Losses	(dB)		-1.19	
E/S Tx Spreading Loss	(dB)		-150.95	
Satellite			Forward	Return
SV Number of Channels per HPA	(#)		1	
SV Rx G/T	(dB/K)		5.41	
SV Rx Power Per Tier	(dBW)		-123.06	
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )		-77.77	
SV Tx OBO (ALC / FGM)	(dB)		-3.80	
SV Tx Post-TWTA Losses	(dB)		-1.50	
SV Tx Antenna Gain	(dBi)		29.24	
SV Tx EIRP Per Channel/Carrier	(dBW)		25.08	
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	
E/S Rx Atmospheric Losses	(dB)		-1.54	
E/S Rx Pointing Loss	(dB)		-1.00	
E/S Rx Antenna Gain (1.2 m / 7.3 m)	(dBi)		42.8	
E/S Rx Effective G/T	(dB/K)		17.9	
E/S Rx Power Per Channel	(dBW)		-133.6	
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )		-129.3	
Total Link			Forward	Return
Carrier / Noise Bandwidth	(dB)		65.56	
Carrier / Noise Uplink	(dB)		22.99	
Carrier / Noise Downlink	(dB)		4.51	
Carrier / Intermodulation Im (C/Im)	(dB)		28.61	
(C/N) - Total Actual	(dB)		4.22	
(C/N) - Total Required	(dB)		4.20	
(E <sub>v</sub> /N <sub>0</sub> ) - Total Actual	(dB)		2.97	
(E <sub>v</sub> /N <sub>0</sub> ) - Total Required	(dB)		2.95	
<b>Excess Margin</b>	<b>(dB)</b>		<b>0.02</b>	
<b>Fade Margin</b>	<b>(dB)</b>		<b>6.82</b>	

## O3b Network Link Analysis - Tier 1 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014			Tier 1	Tier 1
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 Range to SV	(km)		9953.9	11033.2
E/S Elevation to SV	(°)		32.8	19.1
E/S Altitude	(km)		0.3	0.0
SV Beam Identifier	(#)		25	
Minutes Into Pass (Sample #1)	(Min)		0:0	
Telco Spot Beam Off-Angle	(°)		1.70	
Telco Spot Beam Diameter	(km)		512.30	
Maximum Roundtrip Latency	(msec)		140.01	
Modulation Parameters			Forward	Return
Enter Receiver	Type			DVB-S2
Modem Overhead	(%)			1.0%
Number of Carriers per Channel	(#)			50
Available Bandwidth	(Hz)			216,000,000
Channel Symbol Rate	(sps)			3,600,000
Channel Modulation Type				QPSK
Channel FEC Rate				0.40
Channel Spectral Efficiency	(bits/Sym)			0.80
Channel Throughput (100% / 100% of Full Rate)	(bps)			<b>2,851,200</b>
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)			20
E/S Tx OBO	(dB)			-15.00
E/S Tx Post-HPA Losses	(dB)			-0.28
E/S Tx Antenna Gain (7.3 m / 1.2 m)	(dB)			46.5
E/S Tx EIRP Per Channel	(dBW)			44.27
E/S Tx Pointing Loss	(dB)			-1.00
E/S Tx RF Link Availability	(%)			50.000
E/S Tx Atmospheric Losses	(dB)			-2.03
E/S Tx Spreading Loss	(dB)			-151.85
Satellite			Forward	Return
SV Number of Channels per HPA	(#)			5
SV Rx G/T	(dB/K)			0.98
SV Rx Power Per Tier	(dBW)			-143.33
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )			-93.62
SV Tx OBO (ALC / FGM)	(dB)			-21.10
SV Tx Post-TWTA Losses	(dB)			-1.50
SV Tx Antenna Gain	(dBi)			31.90
SV Tx EIRP Per Channel/Carrier	(dBW)			3.45
SV Tx Pointing Loss	(dB)			0.00
Downlink			Forward	Return
E/S Rx Carrier Frequency	(MHz)			19,163
E/S Rx Spreading Loss	(dB)			-150.95
E/S Rx RF Link Availability	(%)			75.000
E/S Rx Atmospheric Losses	(dB)			-0.85
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)			39.14
E/S Rx Power Per Channel	(dBW)			-133.60
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )			-148.85
Total Link			Forward	Return
Carrier / Noise Bandwidth	(dB)			65.56
Carrier / Noise Uplink	(dB)			2.71
Carrier / Noise Downlink	(dB)			6.23
(C/N) - Total Actual	(dB)			1.04
(C/N) - Total Required	(dB)			0.90
(E <sub>b</sub> /N <sub>0</sub> ) - Total Actual	(dB)			2.00
(E <sub>b</sub> /N <sub>0</sub> ) - Total Required	(dB)			1.87
<b>Excess Margin</b>	<b>(dB)</b>			<b>0.14</b>
<b>Fade Margin</b>	<b>(dB)</b>			<b>3.64</b>

## O3b Network Link Analysis - Tier 1 Service For Seattle, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014		Tier 1	Tier 1
Ground Parameter		Teleport	Telco
Location		Vernon (LHCP), United States	Seattle, United States
Latitude	(°)	34.2	47.6
Longitude (East)	(°)	260.7	237.7
E/S Range to SV	(km)	9953.9	11324.9
E/S Elevation to SV	(°)	32.8	15.9
E/S Altitude	(km)	0.3	0.3
SV Beam Identifier	(#)		24
Minutes Into Pass (Sample #1)	(Min)		0:0
Telco Spot Beam Off-Angle	(°)		1.70
Telco Spot Beam Diameter	(km)		672.20
Maximum Roundtrip Latency	(msec)		141.96
Modulation Parameters		Forward	Return
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	1.0%	
Number of Carriers per Channel	(#)	50	
Available Bandwidth	(Hz)	216,000,000	
Channel Symbol Rate	(sps)	3,600,000	
Channel Modulation Type		QPSK	
Channel FEC Rate		0.67	
Channel Spectral Efficiency	(bits/Sym)	1.33	
Channel Throughput (100% / 100% of Full Rate)	(bps)	4,752,000	
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)	57.80	
E/S Tx Pointing Loss	(dB)	-0.50	
E/S Tx RF Link Availability	(%)	75.000	
E/S Tx Atmospheric Losses	(dB)	-1.19	
E/S Tx Spreading Loss	(dB)	-150.95	
Satellite		Forward	Return
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	5.41	
SV Rx Power Per Tier	(dBW)	-123.06	
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )	-77.85	
SV Tx OBO (ALC / FGM)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	29.24	
SV Tx EIRP Per Channel/Carrier	(dBW)	25.08	
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	
E/S Rx Atmospheric Losses	(dB)	-0.67	
E/S Rx Pointing Loss	(dB)	-1.00	
E/S Rx Antenna Gain (1.2 m / 7.3 m)	(dBi)	42.7	
E/S Rx Effective G/T	(dB/K)	18.1	
E/S Rx Power Per Channel	(dBW)	-132.9	
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )	-128.7	
Total Link		Forward	Return
Carrier / Noise Bandwidth	(dB)	65.56	
Carrier / Noise Uplink	(dB)	22.99	
Carrier / Noise Downlink	(dB)	5.48	
Carrier / Intermodulation Im (C/Im)	(dB)	28.61	
(C/N) - Total Actual	(dB)	5.13	
(C/N) - Total Required	(dB)	4.20	
(E <sub>b</sub> /N <sub>0</sub> ) - Total Actual	(dB)	3.88	
(E <sub>b</sub> /N <sub>0</sub> ) - Total Required	(dB)	2.95	
<b>Excess Margin</b>	<b>(dB)</b>	<b>0.93</b>	
<b>Fade Margin</b>	<b>(dB)</b>	<b>7.73</b>	

## O3b Network Link Analysis - Tier 1 Service For Seattle, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014		Tier 1	Tier 1
Ground Parameter		Teleport	Telco
Location		Vernon (LHCP), United States	Seattle, United States
Latitude	(°)	34.2	47.6
Longitude (East)	(°)	260.7	237.7
E/S Range to SV	(km)	9953.9	11324.9
E/S Elevation to SV	(°)	32.8	15.9
E/S Altitude	(km)	0.3	0.3
SV Beam Identifier	(#)		24
Minutes Into Pass (Sample #1)	(Min)		0:0
Telco Spot Beam Off-Angle	(°)		1.70
Telco Spot Beam Diameter	(km)		672.20
Maximum Roundtrip Latency	(msec)		141.96
Modulation Parameters		Forward	Return
Enter Receiver	Type		DVB-S2
Modem Overhead	(%)		1.0%
Number of Carriers per Channel	(#)		50
Available Bandwidth	(Hz)		216,000,000
Channel Symbol Rate	(sps)		3,600,000
Channel Modulation Type			QPSK
Channel FEC Rate			0.40
Channel Spectral Efficiency	(bits/Sym)		0.80
Channel Throughput (100% / 100% of Full Rate)	(bps)		<b>2,851,200</b>
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)		20
E/S Tx OBO	(dB)		-15.00
E/S Tx Post-HPA Losses	(dB)		-0.28
E/S Tx Antenna Gain (7.3 m / 1.2 m)	(dB)		46.5
E/S Tx EIRP Per Channel	(dBW)		44.20
E/S Tx Pointing Loss	(dB)		-1.00
E/S Tx RF Link Availability	(%)		50.000
E/S Tx Atmospheric Losses	(dB)		-0.99
E/S Tx Spreading Loss	(dB)		-152.07
Satellite		Forward	Return
SV Number of Channels per HPA	(#)		5
SV Rx G/T	(dB/K)		0.98
SV Rx Power Per Tier	(dBW)		-142.51
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )		-92.88
SV Tx OBO (ALC / FGM)	(dB)		-19.99
SV Tx Post-TWTA Losses	(dB)		-1.50
SV Tx Antenna Gain	(dBi)		31.90
SV Tx EIRP Per Channel/Carrier	(dBW)		4.56
SV Tx Pointing Loss	(dB)		0.00
Downlink		Forward	Return
E/S Rx Carrier Frequency	(MHz)		18,909
E/S Rx Spreading Loss	(dB)		-150.95
E/S Rx RF Link Availability	(%)		75.000
E/S Rx Atmospheric Losses	(dB)		-0.78
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)		-132.42
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )		-147.67
Total Link		Forward	Return
Carrier / Noise Bandwidth	(dB)		65.56
Carrier / Noise Uplink	(dB)		3.53
Carrier / Noise Downlink	(dB)		7.53
(C/N) - Total Actual	(dB)		1.98
(C/N) - Total Required	(dB)		0.90
(E <sub>v</sub> /N <sub>0</sub> ) - Total Actual	(dB)		2.95
(E <sub>v</sub> /N <sub>0</sub> ) - Total Required	(dB)		1.87
<b>Excess Margin</b>	<b>(dB)</b>		<b>1.08</b>
<b>Fade Margin</b>	<b>(dB)</b>		<b>4.58</b>

## O3b Network Link Analysis - Tier 1 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014		Tier 1	
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 Range to SV	(km)	9953.9	11033.2
E/S Elevation to SV	(°)	32.8	19.1
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)		25
Minutes Into Pass (Sample #1)	(Min)		0:0
Telco Spot Beam Off-Angle	(°)		1.70
Telco Spot Beam Diameter	(km)		512.30
Maximum Roundtrip Latency	(msec)		140.01
Modulation Parameters		Forward	Return
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	1.0%	
Number of Carriers per Channel	(#)	50	
Available Bandwidth	(Hz)	216,000,000	
Channel Symbol Rate	(sps)	3,600,000	
Channel Modulation Type		QPSK	
Channel FEC Rate		0.50	
Channel Spectral Efficiency	(bits/Sym)	1.00	
Channel Throughput (100% / 100% of Full Rate)	(bps)	3,564,000	
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 / 2.4 m)	(dB)	65.11	
E/S Tx EIRP Per Channel	(dBW)	57.88	
E/S Tx Pointing Loss	(dB)	-0.50	
E/S Tx RF Link Availability	(%)	75.000	
E/S Tx Atmospheric Losses	(dB)	-1.19	
E/S Tx Spreading Loss	(dB)	-150.95	
Satellite		Forward	Return
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	5.41	
SV Rx Power Per Tier	(dBW)	-123.06	
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )	-77.77	
SV Tx OBO (ALC / FGM)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	29.24	
SV Tx EIRP Per Channel/Carrier	(dBW)	25.08	
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	
E/S Rx Atmospheric Losses	(dB)	-10.07	
E/S Rx Pointing Loss	(dB)	-0.50	
E/S Rx Antenna Gain (2.4 m / 7.3 m)	(dBi)	51.5	
E/S Rx Effective G/T	(dB/K)	25.1	
E/S Rx Power Per Channel	(dBW)	-132.9	
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )	-137.3	
Total Link		Forward	Return
Carrier / Noise Bandwidth	(dB)	65.56	
Carrier / Noise Uplink	(dB)	22.99	
Carrier / Noise Downlink	(dB)	3.72	
Carrier / Intermodulation Im (C/Im)	(dB)	28.61	
(C/N) - Total Actual	(dB)	3.48	
(C/N) - Total Required	(dB)	2.10	
(E <sub>b</sub> /N <sub>0</sub> ) - Total Actual	(dB)	3.48	
(E <sub>b</sub> /N <sub>0</sub> ) - Total Required	(dB)	2.10	
<b>Excess Margin</b>	<b>(dB)</b>	<b>1.38</b>	
<b>Fade Margin</b>	<b>(dB)</b>	<b>6.08</b>	

## O3b Network Link Analysis - Tier 1 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014		Tier 1	Tier 1
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 Range to SV	(km)	9953.9	11033.2
E/S Elevation to SV	(°)	32.8	19.1
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)		25
Minutes Into Pass (Sample #1)	(Min)		0:0
Telco Spot Beam Off-Angle	(°)		1.70
Telco Spot Beam Diameter	(km)		512.30
Maximum Roundtrip Latency	(msec)		140.01
Modulation Parameters		Forward	Return
Enter Receiver	Type		DVB-S2
Modem Overhead	(%)		1.0%
Number of Carriers per Channel	(#)		50
Available Bandwidth	(Hz)		216,000,000
Channel Symbol Rate	(sps)		3,600,000
Channel Modulation Type			QPSK
Channel FEC Rate			0.80
Channel Spectral Efficiency	(bits/Sym)		1.60
Channel Throughput (100% / 100% of Full Rate)	(bps)		<b>5,702,400</b>
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)		20
E/S Tx OBO	(dB)		-2.00
E/S Tx Post-HPA Losses	(dB)		-0.77
E/S Tx Antenna Gain (7.3 m / 2.4 m)	(dB)		55.3
E/S Tx EIRP Per Channel	(dBW)		65.55
E/S Tx Pointing Loss	(dB)		-0.50
E/S Tx RF Link Availability	(%)		99.000
E/S Tx Atmospheric Losses	(dB)		-18.65
E/S Tx Spreading Loss	(dB)		-151.85
Satellite		Forward	Return
SV Number of Channels per HPA	(#)		5
SV Rx G/T	(dB/K)		0.98
SV Rx Power Per Tier	(dBW)		-138.17
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )		-88.46
SV Tx OBO (ALC / FGM)	(dB)		-15.67
SV Tx Post-TWTA Losses	(dB)		-1.50
SV Tx Antenna Gain	(dBi)		31.90
SV Tx EIRP Per Channel/Carrier	(dBW)		8.88
SV Tx Pointing Loss	(dB)		0.00
Downlink		Forward	Return
E/S Rx Carrier Frequency	(MHz)		19,163
E/S Rx Spreading Loss	(dB)		-150.95
E/S Rx RF Link Availability	(%)		75.000
E/S Rx Atmospheric Losses	(dB)		-0.85
E/S Rx Pointing Loss	(dB)		-0.50
E/S Rx Antenna Gain (2.4 m / 7.3 m)	(dBi)		62.35
E/S Rx Effective G/T	(dB/K)		39.14
E/S Rx Power Per Channel	(dBW)		-128.17
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )		-143.42
Total Link		Forward	Return
Carrier / Noise Bandwidth	(dB)		65.56
Carrier / Noise Uplink	(dB)		7.87
Carrier / Noise Downlink	(dB)		11.66
(C/N) - Total Actual	(dB)		6.00
(C/N) - Total Required	(dB)		5.90
(E <sub>b</sub> /N <sub>0</sub> ) - Total Actual	(dB)		3.96
(E <sub>b</sub> /N <sub>0</sub> ) - Total Required	(dB)		3.86
<b>Excess Margin</b>	<b>(dB)</b>		<b>0.10</b>
<b>Fade Margin</b>	<b>(dB)</b>		<b>8.60</b>



## O3b Network Link Analysis - Tier 1 Service For Seattle, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014			Tier 1	Tier 1
Ground Parameter			Teleport	Telco
Location			Vernon (LHCP), United States	Seattle, United States
Latitude	(°)		34.2	47.6
Longitude (East)	(°)		260.7	237.7
E/S Range to SV	(km)		9953.9	11324.9
E/S Elevation to SV	(°)		32.8	15.9
E/S Altitude	(km)		0.3	0.3
SV Beam Identifier	(#)		24	
Minutes Into Pass (Sample #1)	(Min)		0:0	
Telco Spot Beam Off-Angle	(°)		1.70	
Telco Spot Beam Diameter	(km)		672.20	
Maximum Roundtrip Latency	(msec)		141.96	
Modulation Parameters			Forward	Return
Enter Receiver	Type		DVB-S2	
Modem Overhead	(%)		1.0%	
Number of Carriers per Channel	(#)		50	
Available Bandwidth	(Hz)		216,000,000	
Channel Symbol Rate	(sps)		3,600,000	
Channel Modulation Type			8PSK	
Channel FEC Rate			0.75	
Channel Spectral Efficiency	(bits/Sym)		2.25	
Channel Throughput (100% / 100% of Full Rate)	(bps)		8,019,000	
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 / 2.4 m)	(dB)		65.03	
E/S Tx EIRP Per Channel	(dBW)		57.80	
E/S Tx Pointing Loss	(dB)		-0.50	
E/S Tx RF Link Availability	(%)		75.000	
E/S Tx Atmospheric Losses	(dB)		-1.19	
E/S Tx Spreading Loss	(dB)		-150.95	
Satellite			Forward	Return
SV Number of Channels per HPA	(#)		1	
SV Rx G/T	(dB/K)		5.41	
SV Rx Power Per Tier	(dBW)		-123.06	
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )		-77.85	
SV Tx OBO (ALC / FGM)	(dB)		-3.80	
SV Tx Post-TWTA Losses	(dB)		-1.50	
SV Tx Antenna Gain	(dBi)		29.24	
SV Tx EIRP Per Channel/Carrier	(dBW)		25.08	
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	
E/S Rx Atmospheric Losses	(dB)		-4.29	
E/S Rx Pointing Loss	(dB)		-0.50	
E/S Rx Antenna Gain (2.4 m / 7.3 m)	(dBi)		51.4	
E/S Rx Effective G/T	(dB/K)		25.9	
E/S Rx Power Per Channel	(dBW)		-127.4	
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )		-131.8	
Total Link			Forward	Return
Carrier / Noise Bandwidth	(dB)		65.56	
Carrier / Noise Uplink	(dB)		22.99	
Carrier / Noise Downlink	(dB)		10.16	
Carrier / Intermodulation Im (C/Im)	(dB)		28.61	
(C/N) - Total Actual	(dB)		9.19	
(C/N) - Total Required	(dB)		9.00	
(E <sub>b</sub> /N <sub>0</sub> ) - Total Actual	(dB)		5.67	
(E <sub>b</sub> /N <sub>0</sub> ) - Total Required	(dB)		5.48	
<b>Excess Margin</b>	<b>(dB)</b>		<b>0.19</b>	
<b>Fade Margin</b>	<b>(dB)</b>		<b>11.79</b>	

## O3b Network Link Analysis - Tier 1 Service For Seattle, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014		Tier 1	Tier 1
Ground Parameter		Teleport	Telco
Location		Vernon (LHCP), United States	Seattle, United States
Latitude	(°)	34.2	47.6
Longitude (East)	(°)	260.7	237.7
E/S Range to SV	(km)	9953.9	11324.9
E/S Elevation to SV	(°)	32.8	15.9
E/S Altitude	(km)	0.3	0.3
SV Beam Identifier	(#)		24
Minutes Into Pass (Sample #1)	(Min)		0:0
Telco Spot Beam Off-Angle	(°)		1.70
Telco Spot Beam Diameter	(km)		672.20
Maximum Roundtrip Latency	(msec)		141.96
Modulation Parameters		Forward	Return
Enter Receiver	Type		DVB-S2
Modem Overhead	(%)		1.0%
Number of Carriers per Channel	(#)		50
Available Bandwidth	(Hz)		216,000,000
Channel Symbol Rate	(sps)		3,600,000
Channel Modulation Type			16APSK
Channel FEC Rate			0.80
Channel Spectral Efficiency	(bits/Sym)		3.20
Channel Throughput (100% / 100% of Full Rate)	(bps)		<b>11,404,800</b>
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)		20
E/S Tx OBO	(dB)		-5.00
E/S Tx Post-HPA Losses	(dB)		-0.77
E/S Tx Antenna Gain (7.3 m / 2.4 m)	(dB)		55.2
E/S Tx EIRP Per Channel	(dBW)		62.47
E/S Tx Pointing Loss	(dB)		-0.50
E/S Tx RF Link Availability	(%)		99.000
E/S Tx Atmospheric Losses	(dB)		-8.20
E/S Tx Spreading Loss	(dB)		-152.07
Satellite		Forward	Return
SV Number of Channels per HPA	(#)		5
SV Rx G/T	(dB/K)		0.98
SV Rx Power Per Tier	(dBW)		-130.95
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )		-81.31
SV Tx OBO (ALC / FGM)	(dB)		-7.99
SV Tx Post-TWTA Losses	(dB)		-1.50
SV Tx Antenna Gain	(dBi)		31.90
SV Tx EIRP Per Channel/Carrier	(dBW)		16.57
SV Tx Pointing Loss	(dB)		0.00
Downlink		Forward	Return
E/S Rx Carrier Frequency	(MHz)		18,909
E/S Rx Spreading Loss	(dB)		-150.95
E/S Rx RF Link Availability	(%)		75.000
E/S Rx Atmospheric Losses	(dB)		-0.78
E/S Rx Pointing Loss	(dB)		-0.50
E/S Rx Antenna Gain (2.4 m / 7.3 m)	(dBi)		62.24
E/S Rx Effective G/T	(dB/K)		39.16
E/S Rx Power Per Channel	(dBW)		-120.42
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )		-135.67
Total Link		Forward	Return
Carrier / Noise Bandwidth	(dB)		65.56
Carrier / Noise Uplink	(dB)		15.10
Carrier / Noise Downlink	(dB)		19.53
(C/N) - Total Actual	(dB)		12.47
(C/N) - Total Required	(dB)		12.40
(E <sub>b</sub> /N <sub>0</sub> ) - Total Actual	(dB)		7.42
(E <sub>b</sub> /N <sub>0</sub> ) - Total Required	(dB)		7.35
<b>Excess Margin</b>	<b>(dB)</b>		<b>0.07</b>
<b>Fade Margin</b>	<b>(dB)</b>		<b>15.07</b>

## O3b Network Link Analysis - Tier 1 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014		Tier 1	Tier 1
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 Range to SV	(km)	9953.9	11033.2
E/S Elevation to SV	(°)	32.8	19.1
E/S Altitude	(km)	0.3	0.0
SV Beam Identifier	(#)	25	
Minutes Into Pass (Sample #1)	(Min)	0:0	
Telco Spot Beam Off-Angle	(°)	1.70	
Telco Spot Beam Diameter	(km)	512.30	
Maximum Roundtrip Latency	(msec)	140.01	
Modulation Parameters		Forward	Return
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	0.0%	
Number of Carriers per Channel	(#)	50	
Available Bandwidth	(Hz)	216,000,000	
Channel Symbol Rate	(sps)	3,600,000	
Channel Modulation Type		0.00	
Channel FEC Rate		0.00	
Channel Spectral Efficiency	(bits/Sym)	0.00	
Channel Throughput (100% / 100% of Full Rate)	(bps)	0	
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)	57.88	
E/S Tx Pointing Loss	(dB)	-0.50	
E/S Tx RF Link Availability	(%)	75.000	
E/S Tx Atmospheric Losses	(dB)	-1.19	
E/S Tx Spreading Loss	(dB)	-150.95	
Satellite		Forward	Return
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	5.41	
SV Rx Power Per Tier	(dBW)	-123.06	
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )	-77.77	
SV Tx OBO (ALC / FGM)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	29.24	
SV Tx EIRP Per Channel/Carrier	(dBW)	25.08	
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	
E/S Rx Atmospheric Losses	(dB)	-10.08	
E/S Rx Pointing Loss	(dB)	-1.00	
E/S Rx Antenna Gain (1.2 m / 7.3 m)	(dBi)	42.8	
E/S Rx Effective G/T	(dB/K)	16.4	
E/S Rx Power Per Channel	(dBW)	-142.1	
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )	-137.8	
Total Link		Forward	Return
Carrier / Noise Bandwidth	(dB)	65.56	
Carrier / Noise Uplink	(dB)	22.99	
Carrier / Noise Downlink	(dB)	-5.48	
Carrier / Intermodulation Im (C/Im)	(dB)	28.61	
(C/N) - Total Actual	(dB)	-5.51	
(C/N) - Total Required	(dB)	-2.60	
(E <sub>v</sub> /N <sub>0</sub> ) - Total Actual	(dB)	#NUM!	
(E <sub>v</sub> /N <sub>0</sub> ) - Total Required	(dB)	#NUM!	
<b>Excess Margin</b>	<b>(dB)</b>	<b>-2.91</b>	
<b>Fade Margin</b>	<b>(dB)</b>	<b>-2.91</b>	

## O3b Network Link Analysis - Tier 1 Service For San Juan-, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014			Tier 1	Tier 1
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 Range to SV	(km)		9953.9	11033.2
E/S Elevation to SV	(°)		32.8	19.1
E/S Altitude	(km)		0.3	0.0
SV Beam Identifier	(#)		25	
Minutes Into Pass (Sample #1)	(Min)		0:0	
Telco Spot Beam Off-Angle	(°)		1.70	
Telco Spot Beam Diameter	(km)		512.30	
Maximum Roundtrip Latency	(msec)		140.01	
Modulation Parameters			Forward	Return
Enter Receiver	Type			DVB-S2
Modem Overhead	(%)			1.0%
Number of Carriers per Channel	(#)			50
Available Bandwidth	(Hz)			216,000,000
Channel Symbol Rate	(sps)			3,600,000
Channel Modulation Type				QPSK
Channel FEC Rate				0.25
Channel Spectral Efficiency	(bits/Sym)			0.50
Channel Throughput (100% / 100% of Full Rate)	(bps)			<b>1,782,000</b>
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)			20
E/S Tx OBO	(dB)			-2.00
E/S Tx Post-HPA Losses	(dB)			-0.28
E/S Tx Antenna Gain (7.3 m / 1.2 m)	(dB)			46.5
E/S Tx EIRP Per Channel	(dBW)			57.27
E/S Tx Pointing Loss	(dB)			-1.00
E/S Tx RF Link Availability	(%)			99.000
E/S Tx Atmospheric Losses	(dB)			-18.66
E/S Tx Spreading Loss	(dB)			-151.85
Satellite			Forward	Return
SV Number of Channels per HPA	(#)			5
SV Rx G/T	(dB/K)			0.98
SV Rx Power Per Tier	(dBW)			-146.96
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )			-97.24
SV Tx OBO (ALC / FGM)	(dB)			-24.49
SV Tx Post-TWTA Losses	(dB)			-1.50
SV Tx Antenna Gain	(dBi)			31.90
SV Tx EIRP Per Channel/Carrier	(dBW)			0.06
SV Tx Pointing Loss	(dB)			0.00
Downlink			Forward	Return
E/S Rx Carrier Frequency	(MHz)			19,163
E/S Rx Spreading Loss	(dB)			-150.95
E/S Rx RF Link Availability	(%)			75.000
E/S Rx Atmospheric Losses	(dB)			-0.85
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)			39.14
E/S Rx Power Per Channel	(dBW)			-136.99
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )			-152.24
Total Link			Forward	Return
Carrier / Noise Bandwidth	(dB)			65.56
Carrier / Noise Uplink	(dB)			-0.91
Carrier / Noise Downlink	(dB)			2.83
(C/N) - Total Actual	(dB)			-2.49
(C/N) - Total Required	(dB)			-2.60
(E <sub>r</sub> /N <sub>0</sub> ) - Total Actual	(dB)			0.52
(E <sub>r</sub> /N <sub>0</sub> ) - Total Required	(dB)			0.41
<b>Excess Margin</b>	<b>(dB)</b>			<b>0.11</b>
<b>Fade Margin</b>	<b>(dB)</b>			<b>0.11</b>

## O3b Network Link Analysis - Tier 1 Service For Seattle, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014		Tier 1	Tier 1
Ground Parameter		Teleport	Telco
Location		Vernon (LHCP), United States	Seattle, United States
Latitude	(°)	34.2	47.6
Longitude (East)	(°)	260.7	237.7
E/S Range to SV	(km)	9953.9	11324.9
E/S Elevation to SV	(°)	32.8	15.9
E/S Altitude	(km)	0.3	0.3
SV Beam Identifier	(#)		24
Minutes Into Pass (Sample #1)	(Min)		0:0
Telco Spot Beam Off-Angle	(°)		1.70
Telco Spot Beam Diameter	(km)		672.20
Maximum Roundtrip Latency	(msec)		141.96
Modulation Parameters		Forward	Return
Enter Receiver	Type	DVB-S2	
Modem Overhead	(%)	1.0%	
Number of Carriers per Channel	(#)	50	
Available Bandwidth	(Hz)	216,000,000	
Channel Symbol Rate	(sps)	3,600,000	
Channel Modulation Type		QPSK	
Channel FEC Rate		0.33	
Channel Spectral Efficiency	(bits/Sym)	0.67	
Channel Throughput (100% / 100% of Full Rate)	(bps)	2,376,000	
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)	57.80	
E/S Tx Pointing Loss	(dB)	-0.50	
E/S Tx RF Link Availability	(%)	75.000	
E/S Tx Atmospheric Losses	(dB)	-1.19	
E/S Tx Spreading Loss	(dB)	-150.95	
Satellite		Forward	Return
SV Number of Channels per HPA	(#)	1	
SV Rx G/T	(dB/K)	5.41	
SV Rx Power Per Tier	(dBW)	-123.06	
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )	-77.85	
SV Tx OBO (ALC / FGM)	(dB)	-3.80	
SV Tx Post-TWTA Losses	(dB)	-1.50	
SV Tx Antenna Gain	(dBi)	29.24	
SV Tx EIRP Per Channel/Carrier	(dBW)	25.08	
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	
E/S Rx Atmospheric Losses	(dB)	-4.29	
E/S Rx Pointing Loss	(dB)	-1.00	
E/S Rx Antenna Gain (1.2 m / 7.3 m)	(dBi)	42.7	
E/S Rx Effective G/T	(dB/K)	17.2	
E/S Rx Power Per Channel	(dBW)	-136.6	
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )	-132.3	
Total Link		Forward	Return
Carrier / Noise Bandwidth	(dB)	65.56	
Carrier / Noise Uplink	(dB)	22.99	
Carrier / Noise Downlink	(dB)	0.96	
Carrier / Intermodulation Im (C/Im)	(dB)	28.61	
(C/N) - Total Actual	(dB)	0.83	
(C/N) - Total Required	(dB)	-0.30	
(E <sub>b</sub> /N <sub>0</sub> ) - Total Actual	(dB)	2.60	
(E <sub>b</sub> /N <sub>0</sub> ) - Total Required	(dB)	1.46	
<b>Excess Margin</b>	<b>(dB)</b>	<b>1.13</b>	
<b>Fade Margin</b>	<b>(dB)</b>	<b>3.43</b>	

## O3b Network Link Analysis - Tier 1 Service For Seattle, United States

Link Budget Creator - Rev 3.2.9: July 18, 2014			Tier 1	Tier 1
Ground Parameter			Teleport	Telco
Location			Vernon (LHCP), United States	Seattle, United States
Latitude	(°)		34.2	47.6
Longitude (East)	(°)		260.7	237.7
E/S Range to SV	(km)		9953.9	11324.9
E/S Elevation to SV	(°)		32.8	15.9
E/S Altitude	(km)		0.3	0.3
SV Beam Identifier	(#)		24	
Minutes Into Pass (Sample #1)	(Min)		0:0	
Telco Spot Beam Off-Angle	(°)		1.70	
Telco Spot Beam Diameter	(km)		672.20	
Maximum Roundtrip Latency	(msec)		141.96	
Modulation Parameters			Forward	Return
Enter Receiver	Type			DVB-S2
Modem Overhead	(%)			1.0%
Number of Carriers per Channel	(#)			50
Available Bandwidth	(Hz)			216,000,000
Channel Symbol Rate	(sps)			3,600,000
Channel Modulation Type				8PSK
Channel FEC Rate				0.60
Channel Spectral Efficiency	(bits/Sym)			1.80
Channel Throughput (100% / 100% of Full Rate)	(bps)			<b>6,415,200</b>
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)			20
E/S Tx OBO	(dB)			-2.00
E/S Tx Post-HPA Losses	(dB)			-0.28
E/S Tx Antenna Gain (7.3 m / 1.2 m)	(dB)			46.5
E/S Tx EIRP Per Channel	(dBW)			57.20
E/S Tx Pointing Loss	(dB)			-1.00
E/S Tx RF Link Availability	(%)			99.000
E/S Tx Atmospheric Losses	(dB)			-8.20
E/S Tx Spreading Loss	(dB)			-152.07
Satellite			Forward	Return
SV Number of Channels per HPA	(#)			5
SV Rx G/T	(dB/K)			0.98
SV Rx Power Per Tier	(dBW)			-136.73
SV Rx Flux Density Per Tier	(dBW/m <sup>2</sup> )			-87.09
SV Tx OBO (ALC / FGM)	(dB)			-13.67
SV Tx Post-TWTA Losses	(dB)			-1.50
SV Tx Antenna Gain	(dBi)			31.90
SV Tx EIRP Per Channel/Carrier	(dBW)			10.88
SV Tx Pointing Loss	(dB)			0.00
Downlink			Forward	Return
E/S Rx Carrier Frequency	(MHz)			18,909
E/S Rx Spreading Loss	(dB)			-150.95
E/S Rx RF Link Availability	(%)			75.000
E/S Rx Atmospheric Losses	(dB)			-0.78
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)			-126.11
E/S Rx Flux Density Per Channel	(dBW/m <sup>2</sup> )			-141.36
Total Link			Forward	Return
Carrier / Noise Bandwidth	(dB)			65.56
Carrier / Noise Uplink	(dB)			9.32
Carrier / Noise Downlink	(dB)			13.85
(C/N) - Total Actual	(dB)			7.51
(C/N) - Total Required	(dB)			6.60
(E <sub>v</sub> /N <sub>0</sub> ) - Total Actual	(dB)			4.95
(E <sub>v</sub> /N <sub>0</sub> ) - Total Required	(dB)			4.05
<b>Excess Margin</b>	<b>(dB)</b>			<b>0.91</b>
<b>Fade Margin</b>	<b>(dB)</b>			<b>10.11</b>

## **Annex 2 - ITU Appendix 7 Coordination Contour Analysis**

This annex uses the ITU Appendix 7 calculation methodology as incorporated in the ITU software to determine the most conservative separation distance required between a transmitting O3b Blanket-Licensed Earth Station and a foreign terrestrial FS receiver operating in the 28.6-29.1 GHz bands.

The key technical parameters used to obtain the results presented here are as follows:

- 1.2 meter O3b earth station antenna;<sup>12</sup>
- O3b earth station arbitrarily located in Houston (95°25'W, 29°45'N);
- Transmit frequency range 28.6-29.1 GHz;
- Maximum PSD into transmit earth station antenna is -58 dBW/Hz;
- Minimum O3b earth station elevation angle is simplistically assumed to be 10° in all directions.

The results are shown in the following two pages where the calculated coordination distance values have been highlighted in yellow. They give a coordination distance of between 96 and 101 km.

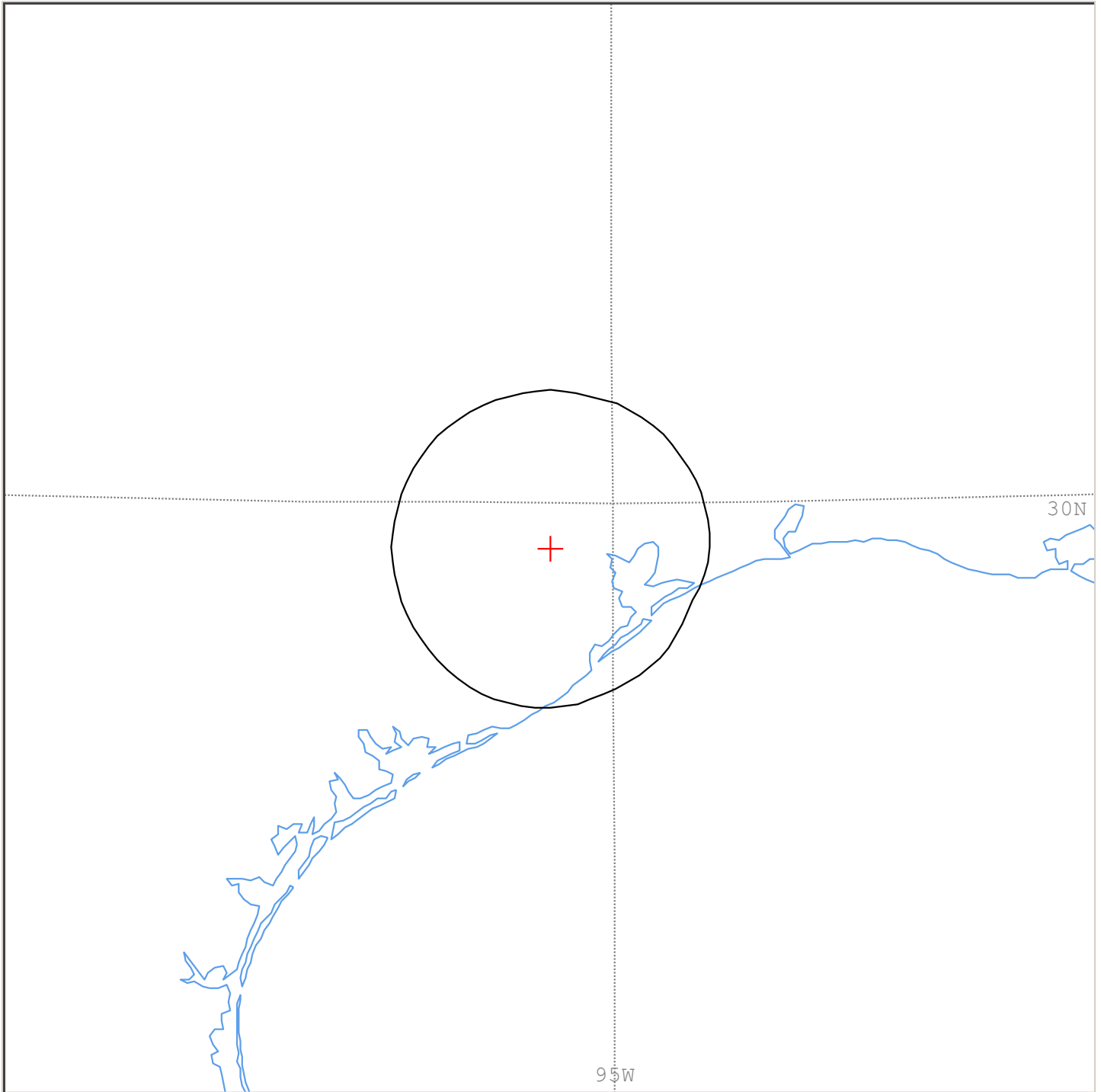
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<sup>12</sup> The results will be the same for other O3b earth station antenna diameters that are the subject of this application because they have the same off-axis gain at the off-axis angles germane to this analysis.

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\_1.2M  
Earth station position: 095W250029N4500  
Satellite name: O3B





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\_1.2M EARTH STATION POSITION: 095W250029N4500 PHASE: D  
 ADM/GEO\_AREA: USA/USA RAIN CLIMATICAL\_ZONE: M  
 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: 48.5 DBI MAXIMUM\_POWER\_DENSITY: -58.0 DBW/HZ NOISE\_TEMPERATURE: - K  
 ANTENNA\_PATTERN: APENST806V01  
 2.2\_TABLE7 Model: PLM\_DUCTING

TRANSMISSION LOSS MODE 1: 163.0 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	99	99	99	99	99	100	100	100	101	101	101	101	101	101	101	101	101	100	100	99	97	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	98	98	98	98	98	98	99	100	100	101	101	101	101	101	101	101	100	100	99	99

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	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99

PROBABLY AFFECTED COUNTRIES: None

**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 supplement, 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 supplement and that it is complete and accurate to the best of my knowledge and belief.

\_\_\_\_\_/s/\_\_\_\_\_  
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