SHEPPARD MULLIN
SHEPPARD MULLIN RICHTER & HAMPTON LLP
ATTORNEYS AT LAW

11th Floor East | 1300 I Street, N.W. | Washington, DC 20005-3314
202-218-0000 *office* | 202-218-0020 *fax* | ***www.sheppardmullin.com***

Brian D. Weimer
Writer's Direct Line: 202-469-4904
bweimer@sheppardmullin.com

April 22, 2011

VIA ELECTRONIC FILING

Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, SW
Room TW-A325
Washington, DC 20554

Attn: Satellite Division, International Bureau

Re: O3b Limited
IBFS File No. SES-LIC-20100723-00952
(Call Sign E100088)

Dear Ms. Dortch:

By letter dated March 23, 2011, the International Bureau, Satellite Division, requested additional information from O3b Limited ("O3b") concerning the above-referenced application for authority to construct and operate a Ka-band fixed-satellite service telemetry, tracking, telecommand, and gateway earth station in Haleiwa, Hawaii. By undersigned counsel, O3b hereby responds to the March 23 information request. O3b's responses are set forth in *italics* beneath each information request from the Commission (which have been reprinted below for ease of reference):

1. O3b seeks a waiver of the space station cross-polarization isolation requirement set forth in Section 25.210(i)(1) of the Commission's rules to operate with a cross-polarization isolation of 18.5 dB, rather than the required 30 dB. In this regard, O3b states "the co-polar transmissions . . . will dictate the interference levels to and from other networks and systems, and not the level of cross-polar radiation in the O3b system." The link budget and interference analysis submitted by O3b lacks support for this claim. Accordingly, we request O3b to further substantiate its claim.

   <u>O3b Response to Item 1</u>:

   The representative link budgets included in the O3b earth station application are intended to show examples of the level of performance achieved in the O3b system and *not specifically the level of inter-system interference. The calculations within these link budgets did in fact include an allowance for intra-system degradation of the O3b links due to a variety of effects, including the typical cross-polar isolation ("XPI") between co-frequency beams of the O3b satellites. This calculation is included as applicable in the "(C/N) - Total Actual" line of the link budgets. In this regard, note that a XPI value of -18.5 dB (worst case value for O3b) corresponds to only a 0.06 dB degradation of the O3b link due to self-interference from a cross-polar beam, which is negligible. Such a situation would only occur extremely rarely in the O3b system when co-frequency, opposite polarization beams are pointed near to each other and the low level of XPI happens to be in the direction of the receiving earth station.*

The instantaneous XPI on any O3b link will be time varying as the satellite moves and the geometry of the link changes. For very large percentages of the time the instantaneous XPI will be much better than the minimum performance level of 18.5 dB. The use of adaptive coding and modulation in the O3b system can exploit this time varying nature of the XPI as the link dynamically adapts to the actual instantaneous C/(N+I) level. Allowance has been made for this as the degradation due to XPI effects has been included in the link budgets already submitted by O3b as follows. For scenarios where lower order modulation and higher coding rates are applied, a cross-polar degradation term has been included. In scenarios where higher throughput is being demonstrated through the use of the adaptive modulation and coding scheme, then the cross-polar degradation is assumed to be negligible. This is consistent with the purpose of the representative link budgets, which are intended to show a range of operating scenarios, of which the more favorable ones will have negligible cross-polar degradation.

The interference analysis section of the O3b earth station application addresses all the relevant interference scenarios, including (a) interference with GSO networks, both within and outside of the frequency bands subject to EPFD limits, (b) interference with non-GSO networks, and (c) interference with terrestrial systems.[1] *All these cases implicitly assume the interfering transmission from O3b is the co-polar signal. The corresponding levels of interference from any cross-polar transmissions in the O3b system would be at least 18.5 dB below this, and therefore of no significance, given the fact that no XPI is assumed in the interference interaction between O3b and other systems.*

In addition to the above explanations, in the case of O3b's Hawaii beam the angular discrimination between the GSO and the O3b orbit is never less than 7 degrees, as explained in the O3b earth station application. For any GSO earth

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[1] *See* Attachment A to Legal Narrative in support of the O3b earth station application, at A.10 (the "Technical Information to Supplement Schedule S").

station located in Hawaii, 7 degrees off-boresight is well outside of the main beam of the earth station antenna, even for small earth station antennas. At such large off-axis angles, the XPI of the earth station antenna will be very small, typically of the order of 6 dB or less (see ITU-R Rec. S.731, "Reference earth-station cross-polarized radiation pattern for use in frequency coordination and interference assessment in the frequency range from 2 to about 30 GHz"). Therefore, the levels of cross-polar signal received by such a station will be dominated by the earth station XPI and not by the space station XPI.

2. Article 22.5I of the ITU Radio Regulations requires NGSO networks to meet the effective power flux density (EPFD) limits specified in Articles 22.5C (EPFD ↓), 22.5D (EPFD ↑), and 22.5F ($EPFD_{is}$) in order for an NGSO system to be fully coordinated with geostationary satellite orbit (GSO) systems under Article 22.2. O3b provides, in its interference analysis, a showing that it complies with Articles 22.5C (for the 17.8-18.6 GHz frequency band), 22.5D (for the 27.5-28.6 GHz frequency band) and 22.5I. However, O3b has not provided a showing relating to compliance with Article 22.5F (for the 17.8-18.4 GHz frequency band). Consequently, we request O3b to provide the Article 22.5F $EPFD_{is}$ analysis.

<u>O3b Response to Item 2</u>:

Annex A to this letter supplement contains an analysis of the EPFD(is) levels caused by the O3b system for two extreme interference geometries. This demonstrates that the O3b system will comply with the EPFD(is) limits in the Radio Regulations for the 17.8-18.4 GHz frequency band for these two worst-case scenarios and all interference geometries in between.

3. To demonstrate that the EPFD limits calculated for its NGSO system satisfy the requirements of Article 22 of the ITU Radio Regulations, O3b performed a time-domain simulation of the O3b system to determine whether the satellites conform to relevant Article 22 EPFD limits/masks. O3b provides a narrative summary of the results of its software simulation, but did not provide a copy of the software or the software's supporting documentation. Pursuant to ITU Radio Regulations, this information must be filed by O3b's notifying administration with the ITU. We request O3b to submit to the Commission a copy of the simulation software developed in accordance with ITU-R Recommendations S.1503-1 (04/05) and supporting documentation.

<u>Response to Item 3</u>:

O3b used the commercially available Visualyse software from Transfinite Systems to perform the time-domain simulation of the EPFD levels produced by the EPFD system. This software has been developed over many years as the ITU work on

EPFD limits was progressed, and the software is virtually "industry-standard" for this kind of simulation and has been designed to be compatible with the ITU-R Recommendation S.1503-1. For commercial software licensing reasons it is not possible for O3b to provide this software to the Commission, and we understand the Commission already has its own copy of this software. Therefore, we are providing to the Commission an electronic copy of the Visualyse data file used to produce the EPFD results shown in Figure A.10-3 of the Technical Information to Supplement Schedule S of the O3b earth station application so that the Commission can replicate this simulation and the results obtained.[2]

The current ITU Radio Regulations and associated procedures (and the ones in force at the time O3b ITU filings were made through Ofcom to the ITU) do not require the submission to the ITU of any software related to demonstrating EPFD compliance when a filing for a non-GSO system subject to EPFD limits is made. Therefore, neither O3b nor Ofcom has made any filing to the ITU of any software related to EPFD compliance for the O3b system. The ITU-BR has published the coordination request filings for the O3b-A system with a "qualified favourable" finding, thereby confirming the correctness of the O3b filings to the ITU.

4. O3b requests a waiver of the requirement in Section 25.283(c) of the Commission's rules that all stored energy sources on board the satellite be discharged at the end of life by venting excess propellant, discharging batteries, relieving pressure vessels, and other appropriate measures. O3b notes that a small amount of pressurant will remain (about 100 psia) that cannot be vented. We request that O3b provide the following information:

O3b Responses to Item 4 included inline:

a. The type of pressurant;

Nitrogen (1.4 kg)

b. The type of propellant to be used;

Hydrazine N2H4 (154 kg max)

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[2] This Visualyse data file cannot be uploaded to IBFS. Thus, we are submitting a copy by email to the International Bureau staff members copied on this letter supplement.

c. The mass and volume of remaining propellant at end-of-life (if any);

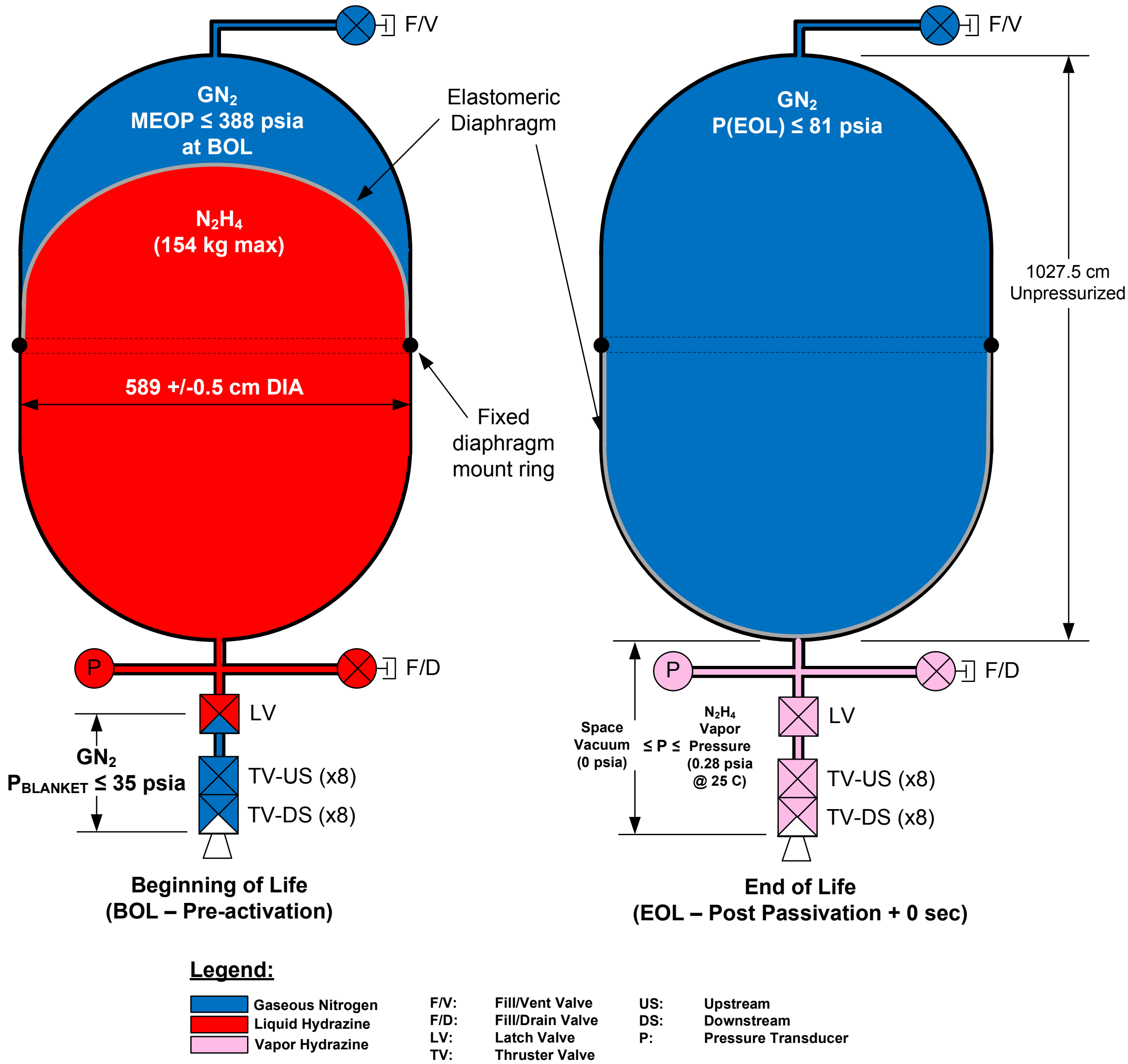
Per the specification, the expulsion efficiency of the tank is greater than 99%, and therefore, the maximum propellant remaining assuming a maximum propellant load of 154 kg is 1.5 kg. This is approximately 1.5 litres.[3]

d. The volume of the tank;

204.6 litres

e. A diagram of the tank with dimensions, indicating the location of the diaphragm in the tank at end-of-life;

[3] In the O3b earth station application, O3b indicated that all the propellant in the tank will be expelled. O3b hereby updates this statement with the information set forth in this letter supplement.



As shown in the above figure (left), at beginning of life (BOL), the propellant tank contains both propellant (N2H4) and pressurant (GN2). The two commodities are separated by an elastomeric diaphragm. This is how the system works:

- *The pressurant pressure exerts a force against the diaphragm*
- *The force on the diaphragms pushes the liquid propellant through the system plumbing;*

- *The propellant moves through the open latch valves and the normally closed thruster valves (if energized);*
- *Upon exit of the thruster valves, the liquid propellant enters the catalyst bed (cat-bed);*
- *In the "cat-bed" the liquid flows across granules of catalyst of various diameters and surface areas to ensure maximum decomposition;*
- *The resulting gases from the decomposition process are elevated in temperature and velocity;*
- *The resulting gases pass through an orifice and expand into the thruster nozzle creating thrust.*

As the mission elapses, the propellant is utilized for various maneuvers. The volume of propellant is decreased, while the volume of the pressurant gas is increased. Due to conservation of mass and Boyles law, the pressurant pressure decreases as the volume expands. This process continues until the diaphragm rests against the propellant side of the tank (as shown in the above figure on the right).

Due to the tank and diaphragm design and construction, there is always a minor amount of propellant remaining in the tank. Interior crevices and diaphragm ridges are the primary reason for the residual propellant. In addition, in any system containing seat/seal interfaces, there are "soft" goods such as Teflon. Over time the interior soft goods will become permeated with hydrazine. At the end of life, the system will be evacuated and passivated to the maximum extent possible. However, the seals will slowly release the hydrazine due to the delta pressure. Therefore, immediately after the passivation, the propellant system pressure will be equivalent to the hydrazine vapor pressure (0.28 psia) (see pink in left diagram).

f. The worst-case change in satellite velocity that could result from perforation of the propellant tank at end-of-life and the method used to calculate this;

First, the probability of the propellant tank rupturing at end of life is zero. This is not considered a credible failure mode. The maximum expected operating pressure (MEOP) is 26.4 bar (388 psig, 403 psia). The burst pressure is greater than 2.0 × MEOP. At end of life, the pressurant pressure is 5.5 bar (81 psig, 96 psia) or nearly 1/5th the MEOP or 1/10th of the burst pressure. Although this is not a credible failure mode, the response has been provided below:

In the impossible event of the tank being perforated by a micrometeorite, the resulting puncture would be a relatively symmetric circular hole. For a well designed nozzle application, the specific impulse of a cold gas nitrogen thruster is 80 N-sec/kg maximum. Using this conservative specific impulse, the total impulse would be 112 N-sec.

$$\Delta V = g_0 I_{sp} ln\left(\frac{m_i}{m_f}\right)$$

Where:

g0 = 9.8 m/s2

Isp = maximum specific impulse of gaseous nitrogen (80 seconds)

mi = space vehicle initial mass prior to tank perforation (589 kg)

mf = space vehicle final mass after tank perforation (587.6 kg)

The calculated maximum delta V is 1.95 m/sec.

If the less than 1.5 kg of residual propellant is somehow released from the tank via another micro-meteor perforation in the tank, it will release as a liquid, not a decomposed heated gas as described above. Therefore, the specific impulse is on the order of 55 seconds maximum (think miniature high school water rocket project). Using the above equation for ΔV,

Where:

g0 = 9.8 m/s2

Isp = maximum specific impulse of gaseous nitrogen (55 seconds)

mi = space vehicle initial mass prior to tank perforation (589 kg)

mf = space vehicle final mass after tank perforation (587.5 kg)

The calculated maximum delta V is 1.37 m/sec.

Therefore, the total theoretical maximum delta V from the system after passivation is 3.32 m/sec.

It should be noted that the tank is nested inside the structure and any gas or liquid escaping the tank via a perforation would impinge upon the satellite interior before gently diffusing from the satellite control volume. Therefore, it is virtually impossible for the 3.32 m/sec (or 195 N-sec) to be applied in a specific direction. In addition, such a leak – even if the direction was known – would have minimal *effect given that the space vehicle orbital velocity is >5200 m/sec in its disposal orbit.*

g. Analysis of whether post-mission rupture of the diaphragm following normal completion of mission could under any circumstances result in repressurization of some part of the propulsion system;

If the elastomer diaphragm is perforated, then the remaining pressurant will pressurize the remaining downstream system expanding to a pressure slightly below the final pressure of 5.5 bar (81 psig, 96 psia). However, the immediate circumstances are inconsequential because the downstream hardware, specifically the thruster valves have redundant seals and have proof pressure of 2 × MEOP.

Note: it is possible the gas will slowly leak across the redundant valve seat/seal interfaces and evacuate to space. Again as noted in response (f), the maximum pressurant theoretical delta V is 1.95 m/sec. However, the leak rate will be on the order of 1.0×10-4 scc/sec for the valve seat/seal interface. Therefore, the minimum amount of time to vent 1.4 kg would be on the order of 350 years. The resultant leak through the thruster valves may result in the space vehicle having a very slow angular rotation rate like a spinning top while maintaining its orbit speed and altitude.

h. Your technical exhibit states, at p. 35, that all of the remaining propellant will be vented from the tank at end-of-life. Please explain how this will be accomplished, and indicate whether the interior of the tank will effectively be open to space once the satellite is retired.

*First "**all** of the remaining propellant" cannot physically be removed from the propellant tank in a **finite** time period. As discussed above, hydrazine vapor will slowly diffuse from soft goods for at least 10 years. In addition, removal of all of the liquid is not achievable on a finite timeline.*

Once the final end of life orbit is achieved, O3b will keep the propulsion valves open for an extended period of time allowing propellant to vent to space until a stabilized final pressure is reached. After such time, power will be removed from the valves (in order to open, the valve must be energized) prior to configuring the solar arrays away from the sun and draining the battery capacity accordingly. As stated above, the diaphragm device provides expulsion efficiency greater than 99% which may result in a maximum residual propellant amount of 1.5 kg.

A grant of a waiver of Section 25.283(c) of the Commission's rules in this case would not pose a material risk or otherwise undermine the purpose of the rule based on the O3b earth station application and given the additional information supplied above. Moreover, a waiver would be consistent with Commission precedent approving the second generation Globalstar satellites which use the same heritage propulsion system as O3b's space vehicles. Accordingly, O3b respectfully requests that the Commission recognizes O3b's intent to meet the purpose of the rule which is to minimize the risk of accidental explosions after completion of mission operations at end of life, and waive the requirement to vent all excess propellant and relieve all pressure vessels to the extent necessary.

5. Although O3b provides predicted space station antenna beam contours, in accordance with Section 25.114(d)(3) of the Commission's rules, the antenna beam contour diagrams provided in Schedule S contain confusing labels. O3b did not include a title block with its beam information (*i.e.* beam ID, polarization, antenna gain, *etc.*) or latitude/longitude information on the contour diagrams. In addition, the antenna beam contour diagrams provided in the narrative of the application differ slightly from the contour diagrams provided in Schedule S. We ask O3b to review the predicted space station antenna beam contour information provided in both its narrative and Schedule S for consistency. We further request O3b to provide improved labels for antenna beam contour diagrams in Schedule S.

<u>O3b Response to Item 5</u>:

The apparent discrepancy between the antenna beam contours diagram contained in the Technical Information to Supplement Schedule S and those in the Schedule S was due to the fact that the former were shown on a flat Earth projection (equidistant latitude and longitude lines) and the latter were (inadvertently) shown in terms of a satellite centered "theta space" projection (i.e., as viewed from the satellite). The actual antenna beam contour information was identical other than this. As requested, O3b has re-plotted on a flat-Earth projection the antenna beam contour diagrams that were embedded in Schedule S for the beams in question and has labeled them clearly. The filenames have been appended with "(REV)" to indicate they are the revised ones. They apply to beams GT1, GT2, GR1, GR2, UR1 to UR10 and UT1 to UT10. The revised beam plots are being provided as four separate PDF files. See Annex B.

6. In response to question E16 on Schedule B, O3b indicates that the proposed 7.3 meter antenna complies with the antenna gain patterns specified in Section 25.209(a)(2) and (b), as demonstrated by the manufacturer's qualification measurements. We ask O3b to provide manufacturer's qualification measurements and/or certified measurements of the antenna's performance. In doing so, O3b should ensure that the submissions establish

that the antenna gain patterns demonstrate performance within the off axis limits of Section 25.209(a)(2) and (b) and Article 22.5D (EPFD ↑) as O3b's NGSO space stations pass from horizon to horizon when communicating with the proposed earth station location.

O3b Response to Item 6:

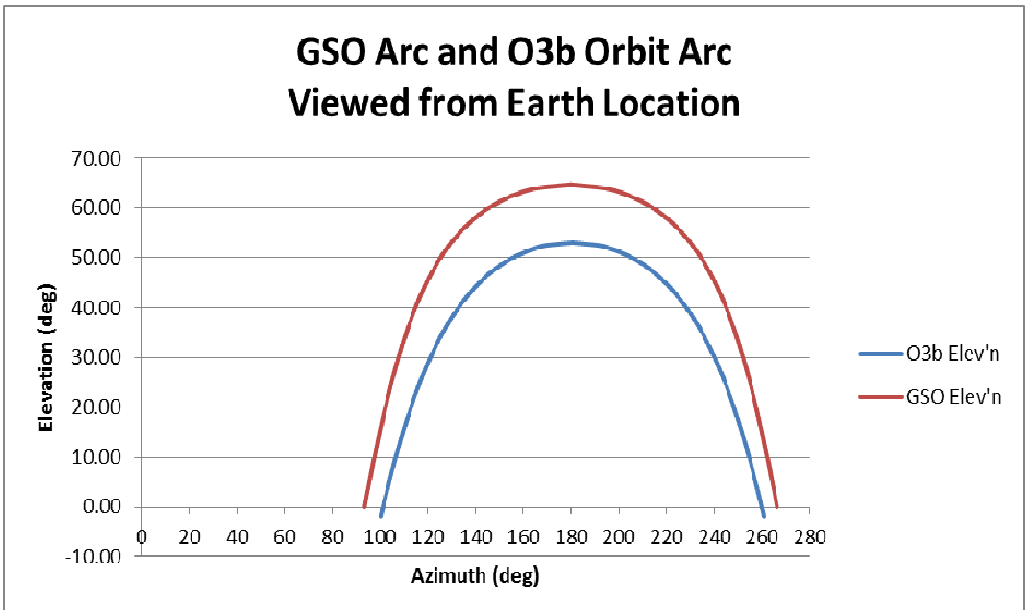
Annex C to this letter supplement provides all of the ViaSat-measured data for the O3b Hawaii gateway earth station antennas. The measured data that is available and that is supplied in Annex C demonstrates that the antennas meet the requirements of Section 25.209(a)(2) and (b) in terms of their off-axis gain performance.

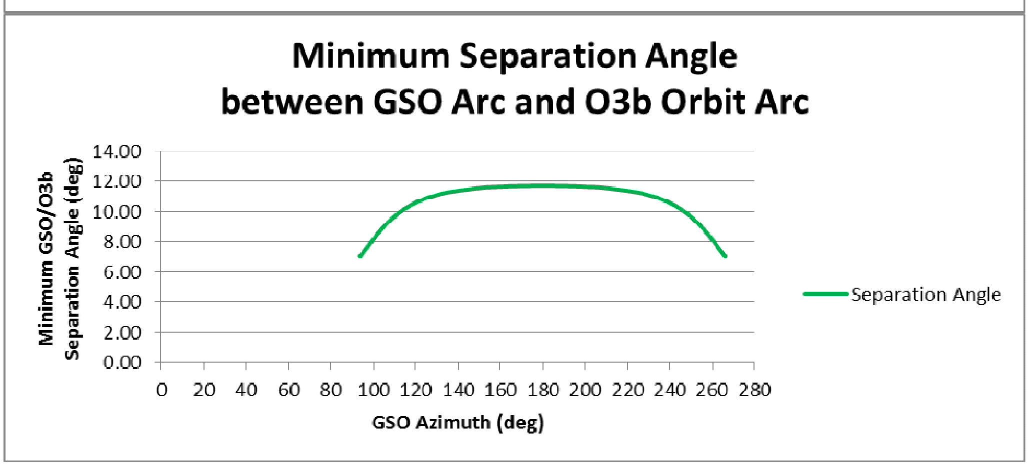
These antennas, and their associated emissions, meet the Article 22.5(D) limits for EPFD↑ as explained in Section A.10.1 (pages 26 and 27) of the Technical Information to Supplement Schedule S of the O3b earth station application. In the Technical Information to Supplement Schedule S, O3b demonstrated using a simple worst-case methodology that the proposed Hawaii transmitting earth stations meet the EPFD↑ limits of the ITU Radio Regulations. Such a methodology is appropriate because the EPFD↑ limits are defined in the Radio Regulations as "never to be exceeded" limits (i.e., worst-case). Using this methodology it was shown that an O3b earth station antenna in Hawaii with a maximum boresight EIRP spectral density level of 40 dBW/4kHz, meets the EPFD↑ limit with 5.5 dB of margin, even if the antenna only meets an off-axis gain mask of 32-25log(θ). As the antenna data in Annex C shows, however, the ViaSat antennas that O3b proposes to use will perform better than that at certain off-axis angles as they meet the mask in Section 25.209(a)(2) in both the azimuth and elevation directions. Note that the maximum filed EIRP spectral density for this earth station, in the bands where EPFD↑ limits apply, is actually 39.97 dBW/4kHz.

The demonstration of EPFD↑ compliance described in the preceding paragraph is based on the angular separation that inherently exists between the O3b orbit and the GSO which, as explained in the O3b application, is dependent on the earth location latitude. In the case of Hawaii (21°40' North latitude) the analysis described above uses a minimum separation angle of 7.1° which corresponds to the worst case situation where the O3b satellite is at zero elevation as viewed from Hawaii. In order to be able to demonstrate the validity of this assertion concerning the minimum separation angle, O3b has prepared an Excel tool that computes the azimuth and elevation of both the GSO and O3b orbits as viewed from the required earth latitude, and is providing this tool to the Commission with this letter supplement.[4] Using this tool the charts below were

[4] This Excel file is being submitted by email to the International Bureau staff members copied on this letter supplement.

generated. The top chart is essentially the "view" of the two orbits from the surface of the earth at the latitude selected. So, for an azimuth direction of 180° (i.e., due south), both orbits are at their highest elevation, with the GSO being higher in the sky than the O3b orbit. The separation between the orbits at this point is just under 12° as shown in the lower chart. As the parts of the orbits to the east or to the west of due south are viewed, their elevation reduces and they become somewhat closer together in angle viewed from the earth location. In the extreme, where the O3b satellite is just visible at 0° elevation (either to the east or to the west) the minimum separation of the O3b satellite from the GSO is 7.1°, which is the value used in the analyses described above. Therefore, the EPFD↑ analysis described above fully takes into account the movement of the O3b satellites as they pass from horizon to horizon and communicate with the Hawaii earth station throughout that period.





The EPFD↑ analysis described above takes account of a single co-frequency transmitting earth station only, despite the fact that EPFD↑, as defined in the ITU Radio Regulations, takes account of all the co-frequency transmitting earth stations in a non-GSO system. This is perfectly correct for the case of the O3b system for the following reasons:

(a) *Only one of the three antennas at O3b's proposed earth station in Hawaii will be communicating with a particular O3b satellite at any time. The second active antenna will be tracking a different O3b satellite, spaced many tens of degrees apart, and therefore the off-axis angle between the second O3b satellite and the point on the GSO orbit where the EPFD↑ level is being assessed is so high as to make the contribution of the second earth station to the EPFD↑ level insignificant. The third antenna is a spare and will not be transmitting unless there is a problem with one of the other antennas.*

(b) *Two-fold co-polar frequency re-use in a single O3b satellite does occur between the gateway and the traffic beams of the O3b satellite. In practice the O3b gateway and traffic beams must be geographically separated from each other, typically between 500 and 1,000 km depending on the specific situation, otherwise unacceptable self-interference would occur in the O3b system. This separation is large enough that the contribution of a traffic earth station to the EPFD↑ level caused by the Hawaii gateway earth station will be negligible because the ITU definition of EPFD↑ assumes that the victim GSO satellite has a relatively narrow spot beam (1.55° beamwidth, according to Table 22.2 of the Radio Regulations) pointing towards the non-GSO transmitting earth station. However, ignoring this factor and assuming the hypothetical worst case, the EPFD↑ level caused by the combination of two O3b co-frequency transmitting earth stations (gateway and traffic) would be 3 dB higher than the -167.5 dBW/m2/40kHz value calculated as the worst case in Section A.10.1 of the Technical Information to Supplement Schedule S of the O3b earth station application. Even with these grossly pessimistic assumptions there is still a 2.5 dB margin relative to the EPFD↑ limits in the Radio Regulations.*

7. We ask O3b to provide the following earth station information for all uplink bands requested in its application:

a. A set of NGSO FSS earth station maximum equivalent isotropically radiated power (EIRP) masks as a function of the off-axis angle generated by O3b's proposed NGSO FSS earth station antennas. In particular, the calculations should encompass what would be radiated regardless of the earth station transmitter power resource allocation and traffic/beam switching strategy that are used at different periods of the NGSO FSS system life. The EIRP masks must be in an electronic form that can be accessed by the computer program referenced in subparagraph (c) below;

b. A detailed description of the assumptions and conditions used in generating the maximum earth station EIRP mask;

c. The single-entry EPFD ↑ validation limits derived using software developed in accordance with ITU-R Recommendation S.1503-1 (04/05). Please provide the program name and version used if publicly available, or the executable file for the software program if not publicly available;

d. The input parameters necessary to run for the execution of the computer program identified in paragraph (c) above;

e. The result of the computer program described above.

O3b Response to Item 7:

In response to items 7(a) and 7(b) above the off-axis EIRP masks for the Hawaii earth station have been prepared and are included as requested in electronic form as an Excel spreadsheet that is being provided to the Commission with this letter supplement.[5] *These masks collectively cover all uplink bands requested in O3b's application, including the bands that are subject to EPFD↑ limits (i.e., 27.6-28.4 GHz). The masks are based on the following:*

(a) *Separate masks for:*

(i) *Traffic emissions in the 27.6-28.4 GHz band where EPFD↑ limits apply;*

(ii) *Traffic emissions in the 28.6-29.1 GHz band where EPFD↑ limits do not apply;*

(iii) *TT&C transmissions in the restricted frequency range 29.0878-29.0891 GHz where EPFD↑ limits do not apply.*

(b) *The maximum power spectral density into the antenna has been determined consistent with the stated antenna gain and maximum (boresight) EIRP density for the emissions, as contained in the FCC Form 312 submitted with the original O3b earth station application;*

[5] This Excel file is being submitted by email to the International Bureau staff members copied on this letter supplement.

(c) *The off-axis gain of the antennas in both the azimuth and elevation planes comply with Section 25.209(a)(3), as this is the worst case gain mask in any direction and is consistent with the assumptions used in demonstrating compliance with the EPFD↑ limits as shown in the response to item 6 above.*

Note the masks provided are the highest ones that apply to any possible traffic scenario.

In response to items 7(c), 7(d) and 7(e) above, and as explained in response to item 6 above, compliance with the EPFD↑ limits in the ITU Radio Regulations was demonstrated using a worst-case methodology in the O3b application, which has been further elaborated upon in the response to item 6 above. The only software necessary to replicate and validate these results is an Excel tool which is being provided by O3b to the Commission with this letter supplement, as explained above. See response to Question 6. This software computes the minimum angular separation angle between the GSO and the O3b orbit (which is the off-axis angle for the purpose of calculating the worst-case EPFD↑) for various azimuth directions.

8. Sections 25.203(g)(1) of the Commission's rules states that applicants proposing to operate new transmitting facilities are advised to consider the effect of the operations on Commission monitoring stations. The Commission's monitoring station at Waipahu, Hawaii (21°22'33.6" N. Latitude, 157°59'44.1" W. Longitude) is 33 kilometers from O3b's proposed site. Please submit a field strength analysis that demonstrates the earth station will operate within the limits defined by Section 25.203(g)(1).

<u>O3b Response to Item 8</u>:

The Comsearch Field Strength Analysis (attached as Annex D) concludes that there is ample protection to the Waipahu Field Station with a margin which exceeds 100 dB.

9. We ask O3b to correct minor discrepancies in the coordination data sent to terrestrial stations and the data contained in the Form 312. In particular, in item E36 of Schedule B (antenna height above sea level), O3b lists 147.97 meters. In its Technical Information Supplement (Exhibit 1 to Appendix B of Attachment A to the Technical Information Supplement at 2), O3b lists 137.77 meters. In addition, on page 2 of Exhibit 1 to Appendix B of Attachment A to the Technical Information Supplement Schedules, O3b indicates it has coordinated emission bandwidths of up to 720 MHz in frequency bands that only contain 216 MHz of bandwidth. Please correct any discrepancies and indicate whether these corrections will have any impact to the coordination report.

<u>O3b Response to Item 9</u>:

O3b and the owner of the Sunset Beach facility have recently agreed upon final antenna locations that are slightly different from the ones previously provided. Additionally, the vendor of the antenna has modified the height of the system in a manner which raises slightly the Antenna Centerline (center of radiation).

As a result of these changes, O3b takes this opportunity to update the geographic coordinates and antenna height data provided in Schedule B of the Form 312 of its earth station application. In addition, O3b's frequency coordinator, Comsearch, has sent updated coordination data to co-frequency terrestrial stations and has indicated that this small change does not affect its interference analysis. Please see the Comsearch letter at Annex E.

Original Form 312, Schedule B data:

E11. Latitude: 21° 40' 15.8" N
E12. Longitude: 158° 1' 56.1" W
E14. Site Elevation (AMSL): 137.77m
E35. Antenna Height (AGL): 10.2m
E36. Antenna Height (AMSL): 147.97m

Updated Form 312, Schedule B data:

E11. Latitude: 21° 40' 17.8" N
E12. Longitude: 158° 1' 54.9" W
E14. Site Elevation: 140m
E35. Antenna Height (AGL): 9.87m
E36. Antenna Height (AMSL): 149.87m

This change represents a movement of 70.53 meters (2.28 arc seconds) north and east of the original location and an elevation change of 2.23m.

Original Spectrum Coordination Data:

Latitude (DMS) (NAD83) 21 40 15.8 N
Longitude (DMS) (NAD83) 158 1 56.1 W
Ground Elevation (Ft/m) 452.00 / 137.77 AMSL
Antenna Centerline (Ft/m) 12.01 / 3.66 AGL

Updated Spectrum Coordination Data:

Latitude (DMS) (NAD83) 21 40 17.8 N

Longitude (DMS) (NAD83) 158 1 54.9 W
Ground Elevation (Ft/m) 459.2 / 140.00 AMSL
Antenna Centerline (Ft/m) 13.74 / 4.19 AGL

With respect to the difference between the 720 MHz emission bandwidth coordinated by Comsearch and the 216 MHz emission bandwidth mentioned by O3b, please see the Comsearch letter attached as Annex E. That letter explains that the different bandwidths of emission do not affect the integrity of Comsearch's frequency coordination study. As explained in that letter, the critical elements in that study were the maximum EIRP density and RF transmit power.

O3b also takes this opportunity to correct a data entry error in its Schedule B. The entry under E50. relating to the 29087.8-29089.1 MHz band incorrectly indicates that this is a receive band when it is in fact a transmit frequency. This is indicated by the emission designator and power levels associated with the telecommand carrier that will be in this band. All other information in that entry is correct.

Please do not hesitate to contact me if you need any additional information.

Sincerely,

/s/ Brian D. Weimer

Brian D. Weimer

for SHEPPARD, MULLIN, RICHTER & HAMPTON LLP

cc: (by electronic mail)

Marlene Dortch
Mindel De La Torre
Roderick Porter
Robert Nelson
Cassandra Thomas
Fern Jarmulneck
Stephen Duall
Kathyrn Medley
Kal Krautkramer
Chip Fleming
Karl Kensinger
Paul Blais

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

_________/s/_________

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

Dated: April 22, 2011

ANNEX A

(EPFD(is) Analysis for O3b)

EPFD(is) Analysis for O3b

In this annex we demonstrate that the O3b system will comply with the EPFD(is) limits in the ITU Radio Regulations. These limits are contained in Article 22.5F, Table 22-3 of the Radio Regulations, which has been copied below:

22.5F 4) The equivalent power flux-density[18], $epfd_{is}$, produced at any point in the geostationary-satellite orbit by emissions from all the space stations in a non-geostationary-satellite system in the fixed-satellite service in the frequency bands listed in Table **22-3**, including emissions from a reflecting satellite, for all conditions and for all methods of modulation, shall not exceed the limits given in Table **22-3** for the specified percentages of time. These limits relate to the equivalent power flux-density which would be obtained under free-space propagation conditions into a reference antenna and in the reference bandwidth specified in Table **22-3**, for all pointing directions towards the Earth's surface visible from any given location in the geostationary-satellite orbit. (WRC-2000)

TABLE **22-3** (WRC-2000)

Limits to the $epfd_{is}$ radiated by non-geostationary-satellite systems in the fixed-satellite service in certain frequency bands[19]

Frequency band (GHz)	$epfd_{is}$ (dB(W/m^2))	Percentage of time during which $epfd_{is}$ level may not be exceeded	Reference bandwidth (kHz)	Reference antenna beamwidth and reference radiation pattern[20]
10.7-11.7 (Region 1) 12.5-12.75 (Region 1) 12.7-12.75 (Region 2)	–160	100	40	4° Recommendation ITU-R S.672-4, $Ls = –20$
17.8-18.4	–160	100	40	4° Recommendation ITU-R S.672-4, $Ls = –20$

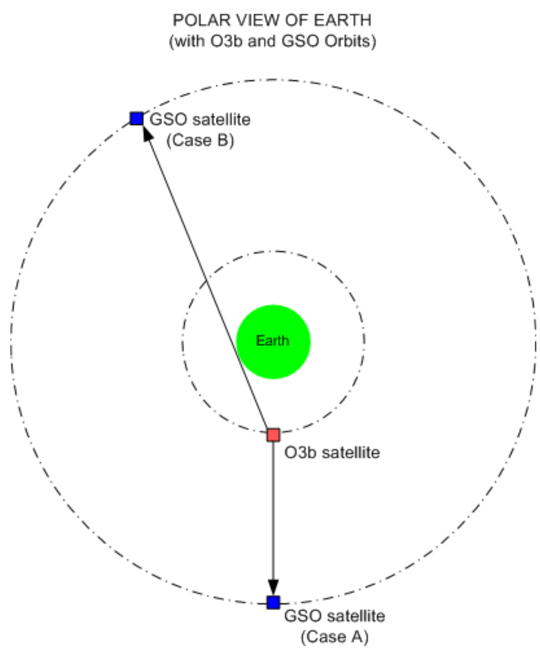
These limits apply to the O3b system in the 17.8-18.4 GHz band which is the band where the EPFD(down) limits also apply.

There are two limiting geometrical cases to consider when analyzing compliance with the EPFD(is) limits, as follows:

Case A: This is where the O3b satellite is the closest to the point on the GSO orbit where the EPFD(is) is being evaluated (i.e., the O3b satellite is immediately below the GSO satellite). In this case the emissions from the O3b satellite are due to backlobe radiation from the O3b satellite transmit antennas.

Case B: This is where the O3b satellite is furthest from the point on the GSO orbit where the EPFD(is) is being evaluated, and the interfering signal path just skims the surface of the Earth at the equator (the so-called "Earth limb" case). In this case the emission levels from the O3b satellite would be at their highest when the steerable transmit antenna of an O3b satellite is pointed close to the equator at the Earth limb.

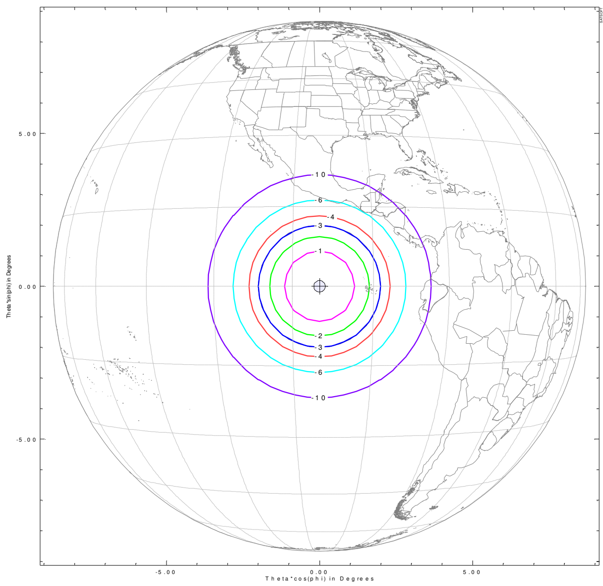
These two cases are shown on the diagram below.



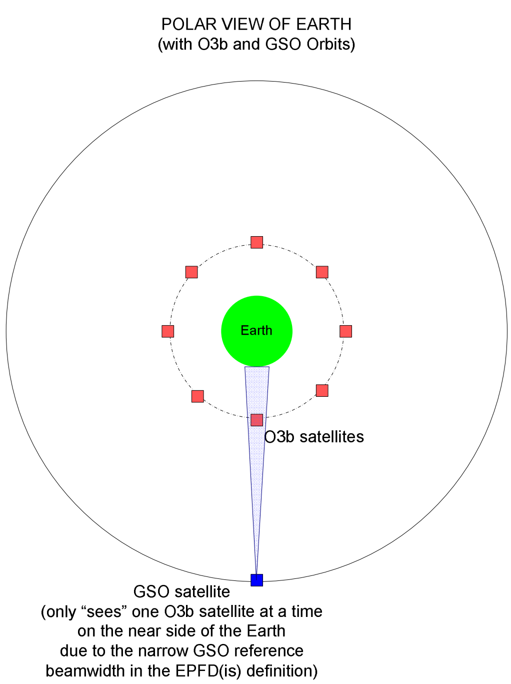
EPFD(is) analysis for Case A

For this case the path length between the O3b satellite and the GSO satellite is the difference in altitude of the two orbits, which is 27,724 km, corresponding to a free space spreading loss of 159.85 dB. The peak O3b satellite transmit EIRP is 49.7 dBW (consistent with the Schedule S data and Section A.9 of Attachment A of the O3b application) and the smallest bandwidth over which this EIRP is spread is 40 MHz (ditto). This results in a maximum beam peak EIRP density from the O3b satellite of 19.7 dBW/40kHz. The backlobe radiation from the O3b satellite is expected to be at least 50 dB below beam peak in the worst case, and much lower than that in most cases. Taking the conservative backlobe radiation level of -50 dB, the transmit EIRP density in the direction of the GSO satellite would be -30.3 dBW/40kHz resulting in a PFD at the GSO satellite of -190.15 dBW/m^2/40kHz (i.e., –30.3 – 159.85).

To convert from PFD to EPFD(is) we have to determine the maximum number of co-frequency interferers from the O3b constellation. The definition of EPFD(is) involves an assumed GSO satellite receive antenna with a beamwidth of 4° pointed towards any part of the Earth's surface visible from any given location in the GSO. The relative gain contours of this GSO reference antenna are shown in the diagram below, illustrating that such a small antenna beamwidth illuminates only a small proportion of the visible Earth's surface.



This means that such a reference GSO antenna only "sees" at most one O3b satellite at a time on the near side of the Earth (i.e., Case A) as shown in the diagram below.



Each O3b satellite has four-fold frequency re-use (two-fold by polarization discrimination and two-fold by spatial separation), so for Case A a further margin of 6 dB would be required to account for the absolute worst-case of four simultaneous interference entries from the same O3b satellite. Taking this into account, the worst case EPFD(is) from a single O3b satellite, as computed above, would be -184.15 dBW/m^2/40kHz (i.e., –190.15 + 6 dB). This is more than 24 dB below the EPFD(is) limit in the Radio Regulations, which is a value of -160 dBW/m^2/40kHz, so compliance with the EPFD(is) limits is assured.

<u>EPFD(is) analysis for Case B</u>

For this case the path length between the O3b satellite and the GSO satellite is 54,634.16 km, corresponding to a free space spreading loss of 165.74 dB which is approximately 6 dB more loss than for Case A above. Using the same assumptions for the peak O3b satellite transmit EIRP (49.7 dBW) and the smallest bandwidth over which this EIRP is spread (40 MHz), the beam peak EIRP density from the O3b satellite is no greater than 19.7 dBW/40kHz.

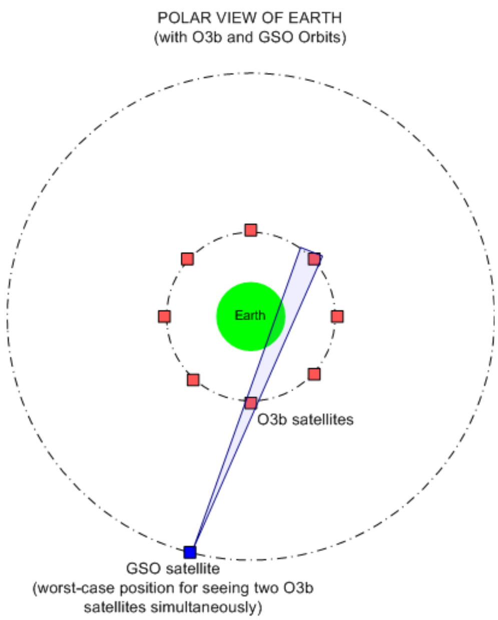
For this analysis we are assuming that the O3b satellite transmit antenna is directed close to the equator and close to the Earth limb. However, because the frequency range where EPFD(is) limits apply is also a range where EPFD(down) limits apply, O3b is not able to direct its steerable beams close to the equator and operate at the highest power densities in this frequency range otherwise it would violate the EPFD(down) limits. As explained in Section A.10.1 of Attachment A of the O3b application, the downlink EIRP density from the O3b satellites must be reduced significantly below the level used in the calculation above for latitudes typically less than 10°, and this would require a reduction in the maximum downlink EIRP density of at least 6 dB relative to the 19.7 dBW/40kHz value referred to in the previous paragraph, equal to a value of less than 13.7 dBW/40kHz.

For the purpose of this EPFD(is) analysis we will conservatively assume that the O3b satellite transmit antenna gain has dropped to only 15 dB below peak in directions corresponding to the Earth's limb at the equator if the beam peak EIRP density was 13.7 dBW/40kHz. In practice the O3b antenna gain in this direction must be lower than this, assuming this beam peak EIRP density, in order to comply with EPFD(down) limits. This would result in an EIRP density from the O3b satellite towards the Earth's limb at the equator of less than -1.3 dBW/40kHz (i.e., 13.7 – 15). Taking account of the spreading loss (165.74 dB) to the victim satellite, as referred to above, the resulting PFD level at the victim GSO satellite, due to the transmitting O3b satellite, would not exceed -167.04 dBW/m^2/40kHz.

In order to calculate the correct aggregate of the EPFD(is) for Case B due to frequency re-use by the O3b satellite, we can ignore the spatial frequency re-use as this requires the second beam to be pointed well away from the beam shown in the diagram above, and so it would contribute negligibly to the aggregate EPFD(is) level. However, the two-fold frequency re-use due to the dual polarization should be factored in to account for the worst case. This would effectively increase the EPFD(is) by 3 dB relative to the value calculated above, but the resulting worst case aggregate EPFD(is) for Case B is still 4.04 dB less than the -160 $dBW/m^2/40kHz$ limit value in the Radio Regulations.

Combination of Cases A and B

There is a particular geometry where the effects of Case A and Case B, as analyzed above, can add together. This is illustrated in the diagram below which shows that in a particular pointing direction of the GSO satellite reference receive beam, where it is towards the Earth's limb, it will simultaneously see both the Case A and the Case B O3b satellites. As the analysis results above for both Case A and Case B produce EPFD(is) levels that are more than 3 dB below the EPFD(is) limit (in the case of Case A, with a 24 dB margin), then the aggregation of both Case A and Case B cannot exceed the EPFD(is) limit.



Intermediate geometries between Case A and Case B

For intermediate interference geometries between Case A and Case B, involving the GSO satellite further around the GSO towards the O3b satellite, the reduction in interference level resulting from the roll-off of the O3b satellite transmit antenna is much greater than the slight increase in interference due to the reduced path length between the O3b and GSO satellites. Therefore those other cases will always result in less interference than Case B as analyzed above.

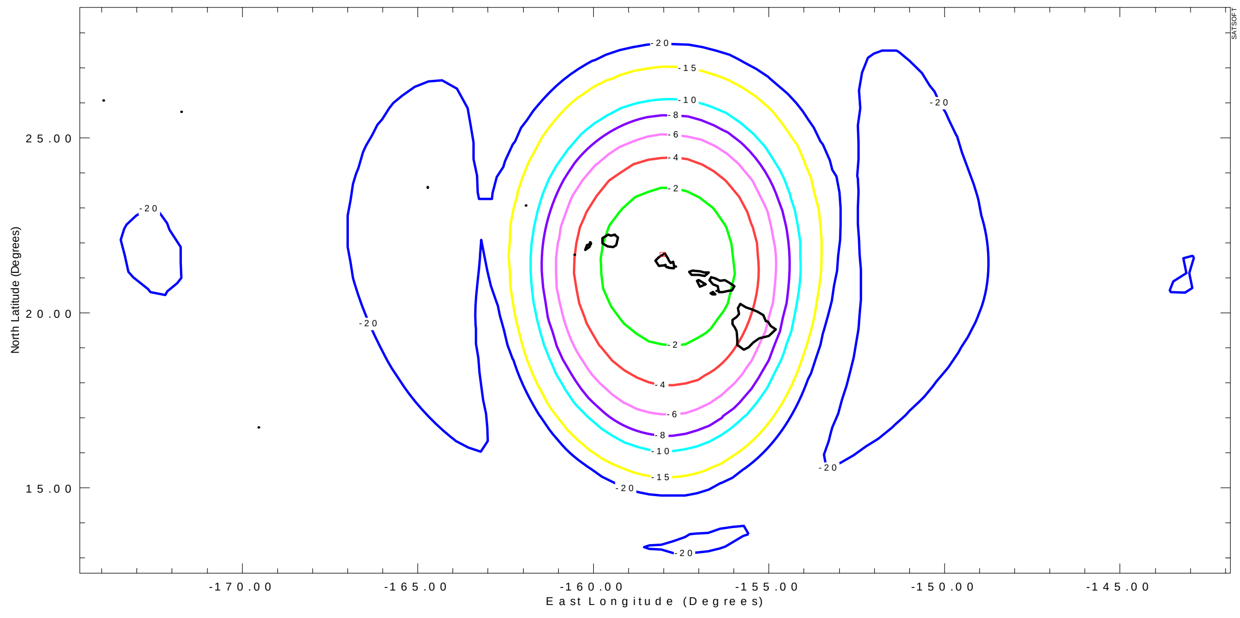
ANNEX B

(Revised Antenna Beam Contour Diagrams)

Filename: Rx_Gateway_Hawaii_158E.pdf

Receive Copolar Antenna Beam Contours for Beams GR1 and GR2

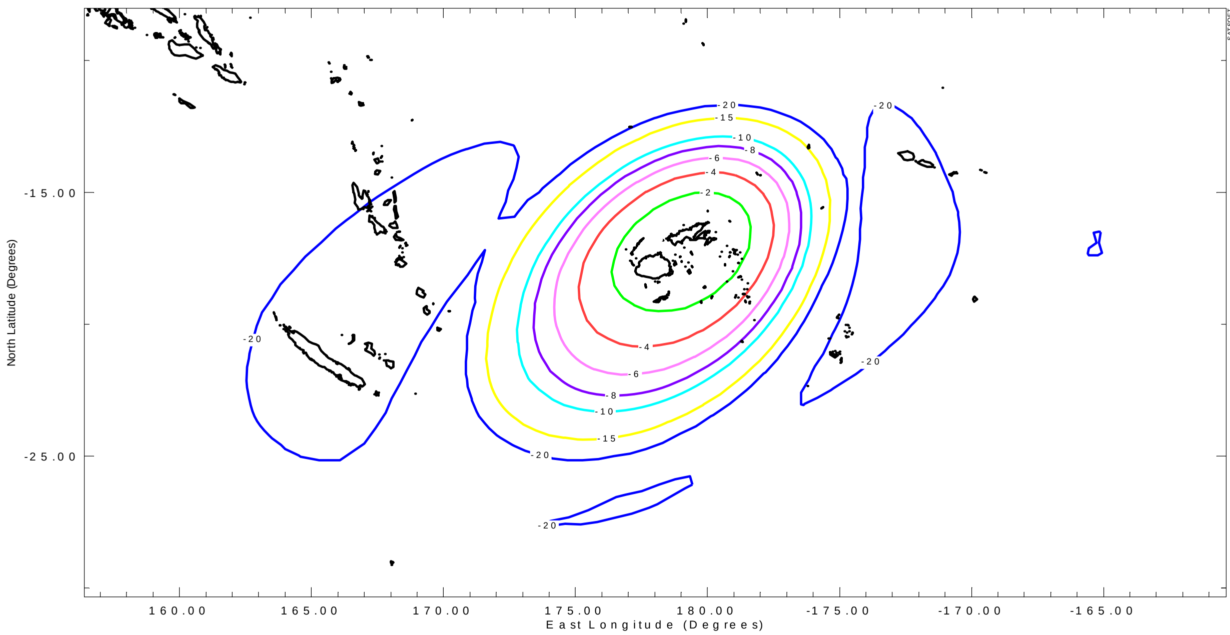
Peak Gain = 34.5 dBi



Filename: Rx_User_Suva_158E.pdf

Receive Copolar Antenna Beam Contours for Beams UR1 to UR10

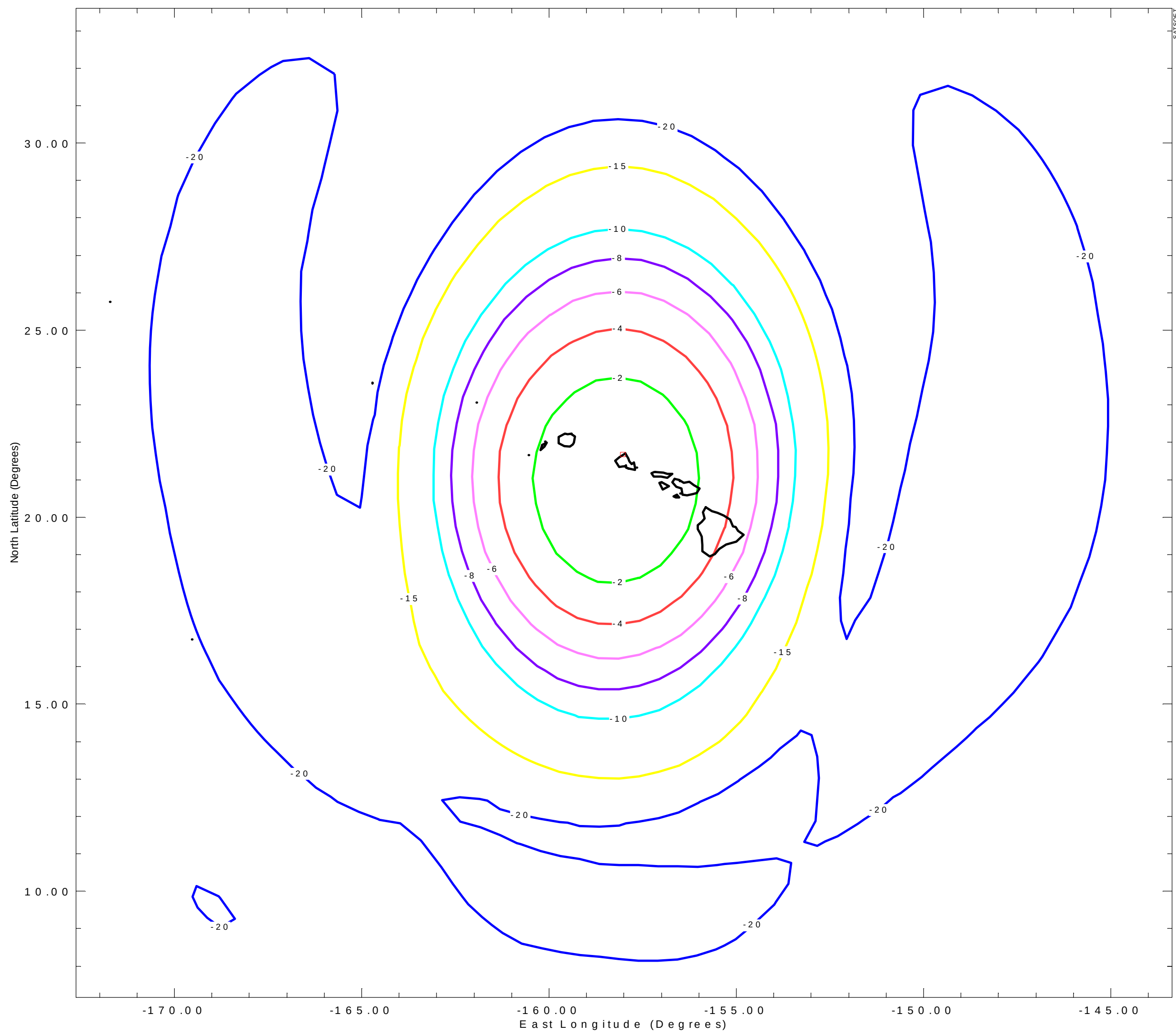
Peak Gain = 34.5 dBi



Filename: Tx_Gateway_Hawaii_158E.pdf

Transmit Copolar Antenna Beam Contours for Beams GT1 and GT2

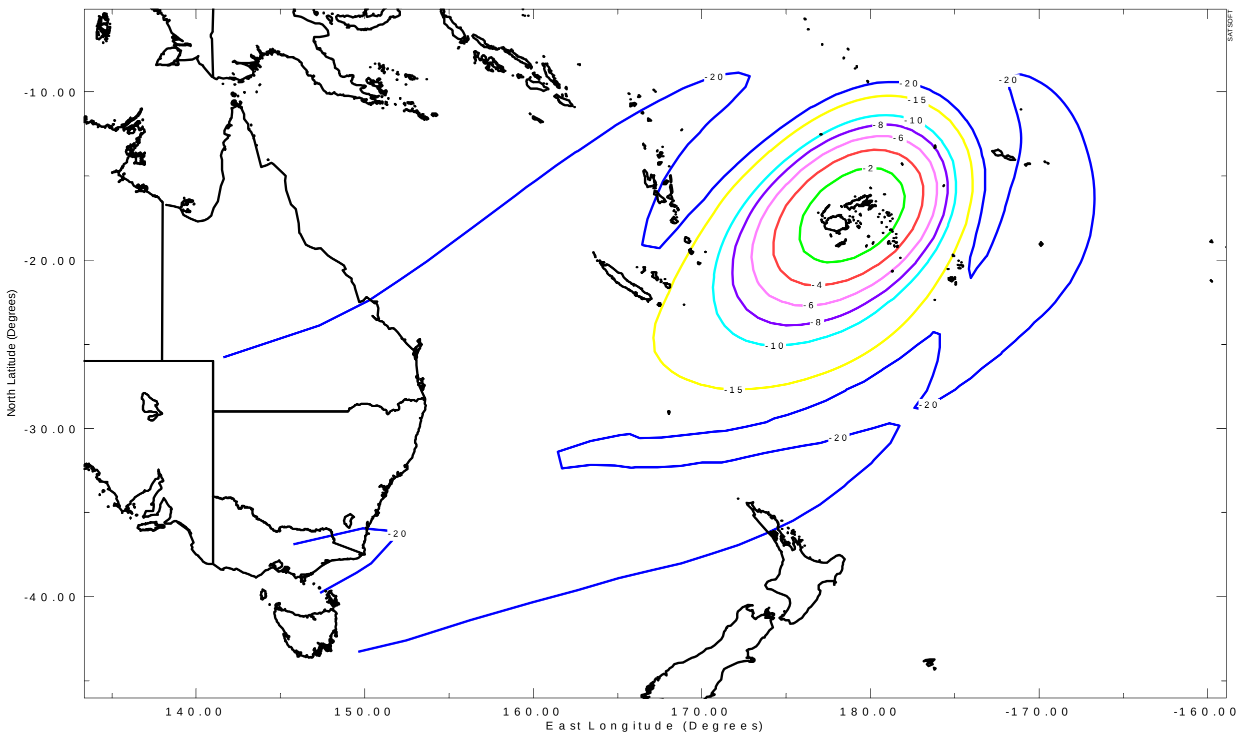
Peak Gain = 33.1 dBi



Filename: Tx_User_Suva_158E.pdf

Transmit Copolar Antenna Beam Contours for Beams UT1 to UT10

Peak Gain = 33.1 dBi



ANNEX C

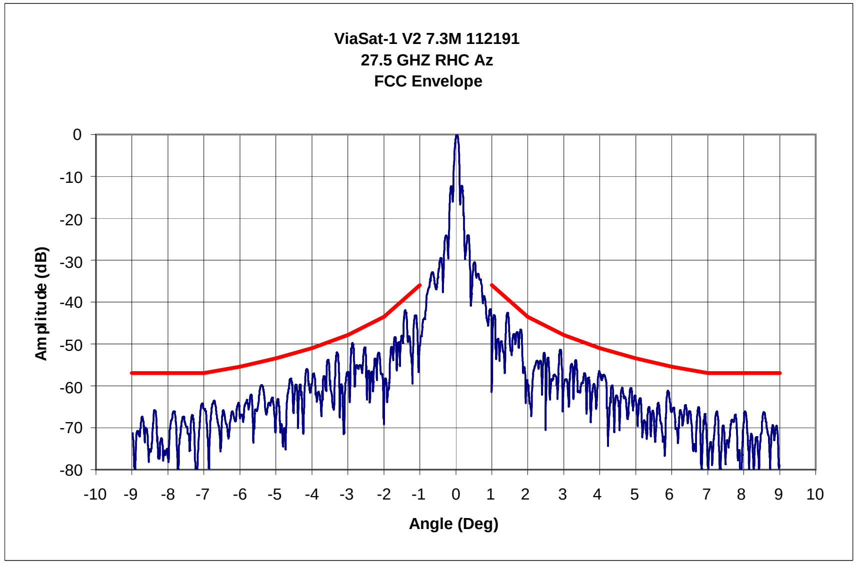
(ViaSat Measured Data)

		Freq	AUT Plane	AUT Pol	Range TX Pol	Span (25.138)	Span (measured)	Pattern #	Page		Notes
AZ, co-pol, RX		17.7	AZ	RHC	RHC	±10°	±9°	112548	11		
		18.6	AZ	RHC	RHC	±10°	±9°	112551	11		
		19.3	AZ	RHC	RHC	±10°	±9°	112557	12		
		17.7	AZ	RHC	RHC	±180°	+/- 45°	112547	11		±180° data exceeds measurement dynamic range
		18.6	AZ	RHC	RHC	±180°	+/- 45°	112552	11		
		19.3	AZ	RHC	RHC	±180°	+/- 45°	112556	12		
		17.7	AZ	LHC	LHC	±10°	±9°	112511	15		
		18.6	AZ	LHC	LHC	±10°	±9°	112515	15		
		19.3	AZ	LHC	LHC	±10°	±9°	112520	16		
		17.7	AZ	LHC	LHC	±180°	+/- 45°	112510	15		±180° data exceeds measurement dynamic range
		18.6	AZ	LHC	LHC	±180°	+/- 45°	112514	15		
		19.3	AZ	LHC	LHC	±180°	+/- 45°	112519	16		
EL, co-pol, RX		17.7	EL	RHC	RHC		±9°	112576	13		narrow cuts not required in 25.138
		18.6	EL	RHC	RHC		±9°	112579	13		
		19.3	EL	RHC	RHC		±9°	112586	14		
		17.7	EL	RHC	RHC	0-30°	+/- 45°	112575	13		
		18.6	EL	RHC	RHC	0-30°	+/- 45°	112580	13		
		19.3	EL	RHC	RHC	0-30°	+/- 45°	112585	14		
		17.7	EL	LHC	LHC		±9°	112529	17		narrow cuts not required in 25.138
		18.6	EL	LHC	LHC		±9°	112534	17		
		19.3	EL	LHC	LHC		±9°	112540	18		
		17.7	EL	LHC	LHC	0-30°	+/- 45°	112527	17		
		18.6	EL	LHC	LHC	0-30°	+/- 45°	112533	17		
		19.3	EL	LHC	LHC	0-30°	+/- 45°	112539	18		

Note:
Peak Gain @ 27.5 GHz = 64.95 dBi
Peak Gain @ 28.4 GHz = 65.29 dBi
Peak Gain @ 29.1 GHz = 65.39 dBi

	Freq	AUT Plane	AUT Pol	Range TX Pol	Span (25.138)	Span (measured)	Pattern #	Page	Notes
AZ, co-pol, TX	27.5	AZ	RHC	RHC	±10°	±9°	112191	3	
	28.4	AZ	RHC	RHC	±10°	±9°	112199	3	
	29.1	AZ	RHC	RHC	±10°	±9°	112203	4	
	27.5	AZ	RHC	RHC	±180°	+/- 45°	112192	3	±180° data exceeds measurement dynamic range
	28.4	AZ	RHC	RHC	±180°	+/- 45°	112198	3	
	29.1	AZ	RHC	RHC	±180°	+/- 45°	112202	4	
	27.5	AZ	LHC	LHC	±10°	±9°	112602	7	
	28.4	AZ	LHC	LHC	±10°	±9°	112608	7	
	29.1	AZ	LHC	LHC	±10°	±9°	112613	8	
	27.5	AZ	LHC	LHC	±180°	+/- 45°	112601	7	±180° data exceeds measurement dynamic range
	28.4	AZ	LHC	LHC	±180°	+/- 45°	112607	7	
	29.1	AZ	LHC	LHC	±180°	+/- 45°	112611	19	
EL, co-pol, TX	27.5	EL	RHC	RHC		±9°	112207	5	narrow cuts not required in 25.138
	28.4	EL	RHC	RHC		±9°	112222	5	
	29.1	EL	RHC	RHC		±9°	112226	6	
	27.5	EL	RHC	RHC	0-30°	+/- 45°	112206	5	
	28.4	EL	RHC	RHC	0-30°	+/- 45°	112211	5	
	29.1	EL	RHC	RHC	0-30°	+/- 45°	112225	6	
	27.5	EL	LHC	LHC		±9°	112621	9	narrow cuts not required in 25.138
	28.4	EL	LHC	LHC		±9°	112625	9	
	29.1	EL	LHC	LHC		±9°	112629	10	
	27.5	EL	LHC	LHC	0-30°	+/- 45°	112620	9	
	28.4	EL	LHC	LHC	0-30°	+/- 45°	112624	9	
	29.1	EL	LHC	LHC	0-30°	+/- 45°	112628	10	
AZ, co-pol, TX	27.5	AZ	RHC	RHC	±180°	±180°	112193	20	±180° dynamic range limitation example
AZ, cross-pol, TX	29.1	AZ	RH & LH	LHC	±10°	+/- 4.5°	112646	21	

Note:
Peak gain @ 27.5 GHz = 64.95 dBi
Peak gain @ 28.4 GHz = 65.29 dBi
Peak gain @ 29.1 GHz = 65.39 dBi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27.5 GHZ RHC Az
FCC Envelope
Amplitude (dB)
Angle (Deg)
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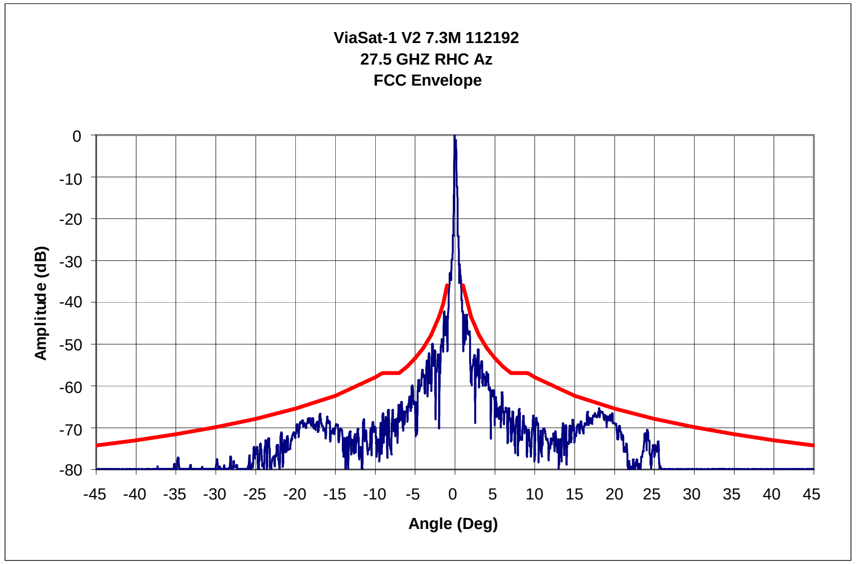
-30
-40
-50
-60
-70
-80
-10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10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FCC Envelope
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Angle (Deg)
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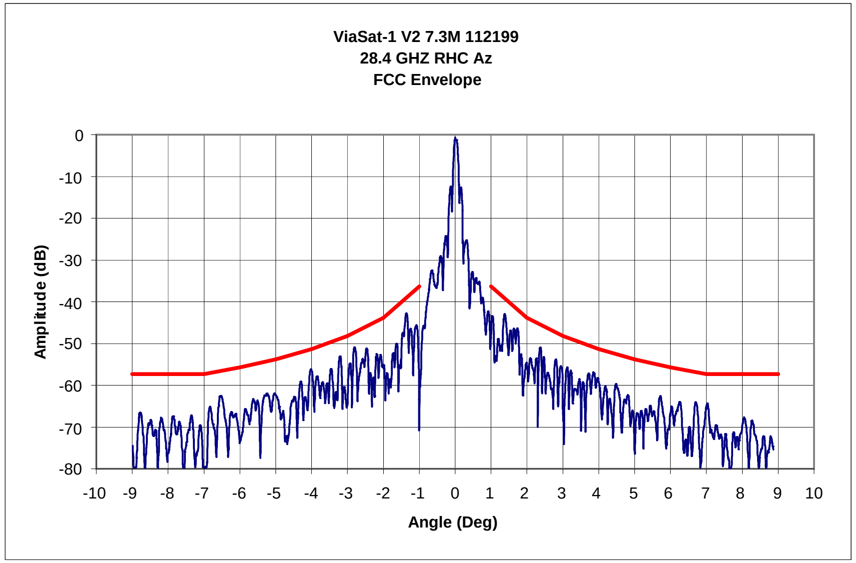
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28.4 GHZ RHC Az
FCC Envelope
Amplitude (dB)
Angle (Deg)
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-10
-20
-30
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-50
-60
-70
-80
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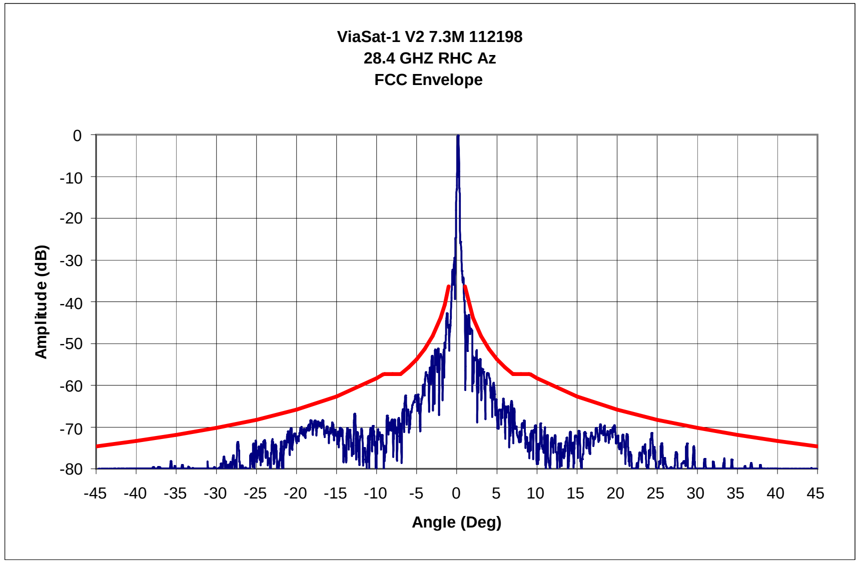
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28.4 GHZ RHC Az
FCC Envelope
Amplitude (dB)
Angle (Deg)
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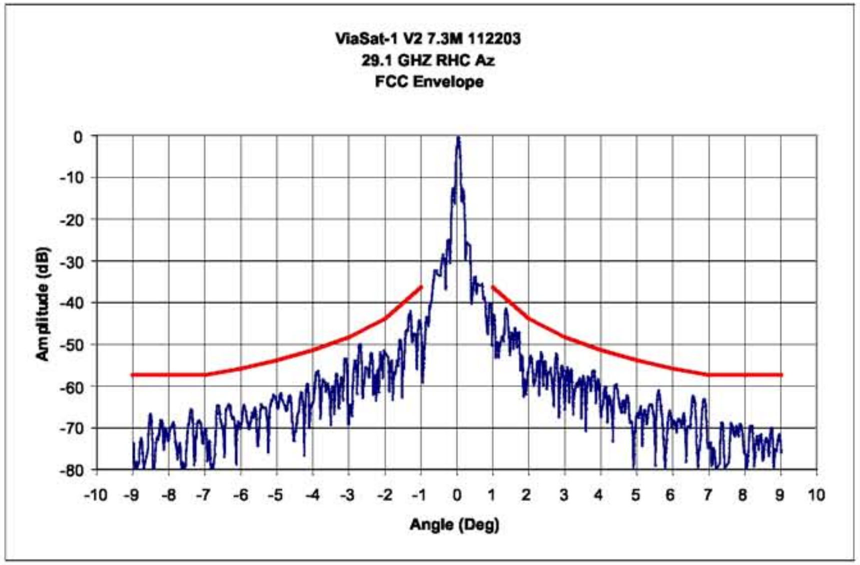
ViaSat-1 V2 7.3M 112203
29.1 GHZ RHC Az
FCC Envelope
Amplitude (dB)
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-20
-30
-40
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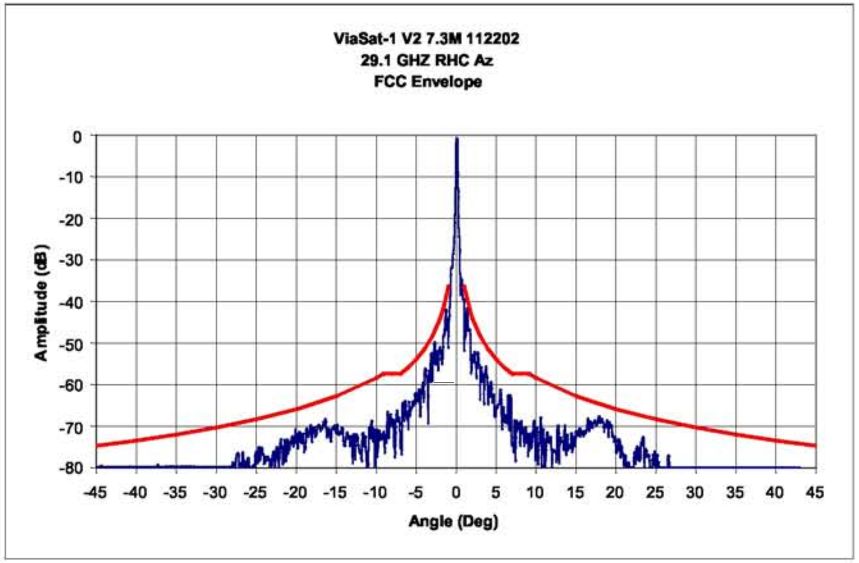
Angle (Deg)


ViaSat-1 V2 7.3M 112202
29.1 GHZ RHC Az
FCC Envelope
Amplitude (dB)
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-20
-30
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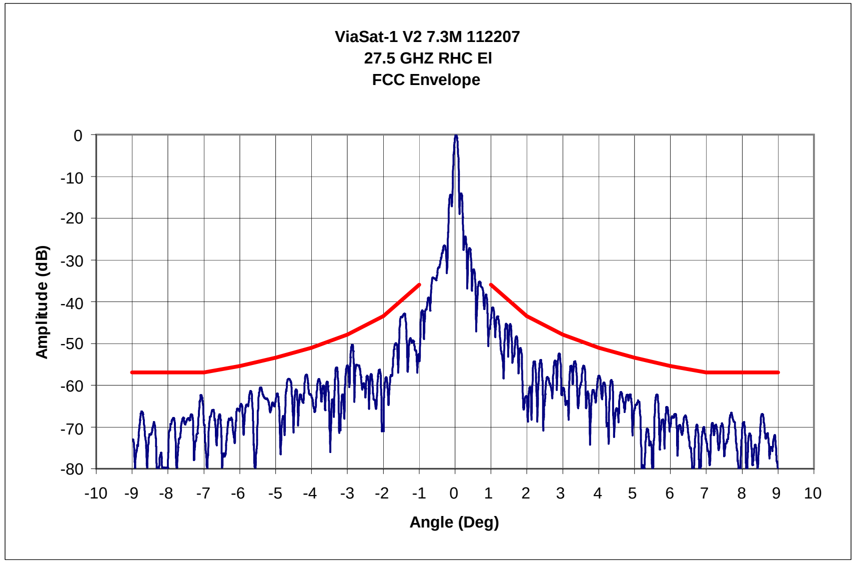
Angle (Deg)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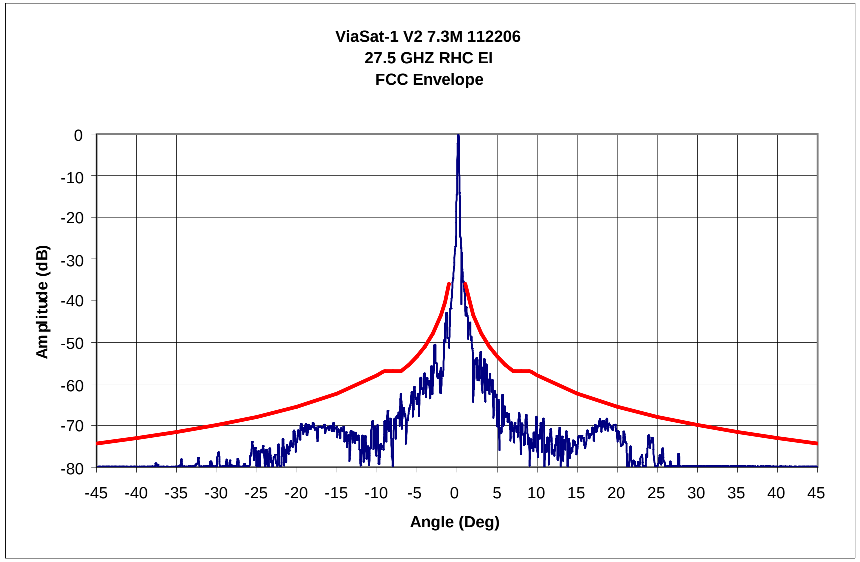
27.5 GHZ RHC El
FCC Envelope
Amplitude (dB)
Angle (Deg)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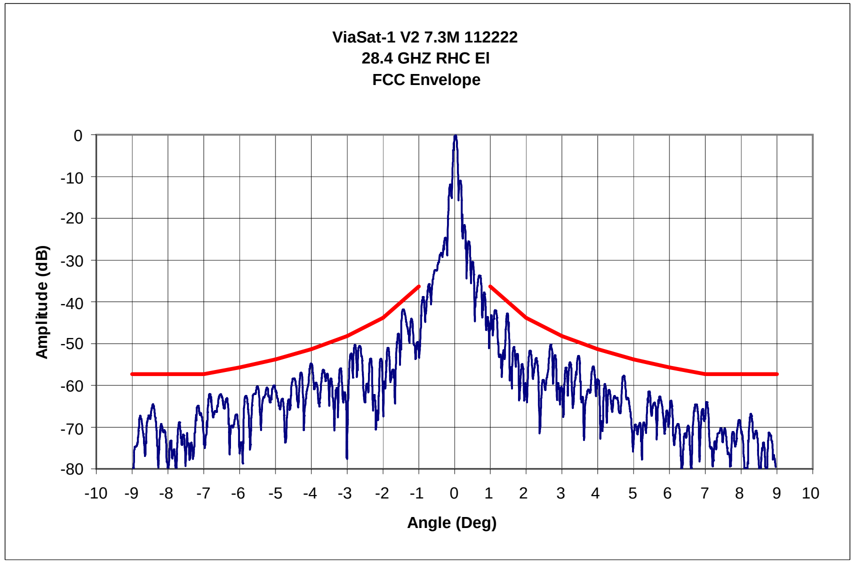
FCC Envelope
Amplitude (dB)
Angle (Deg)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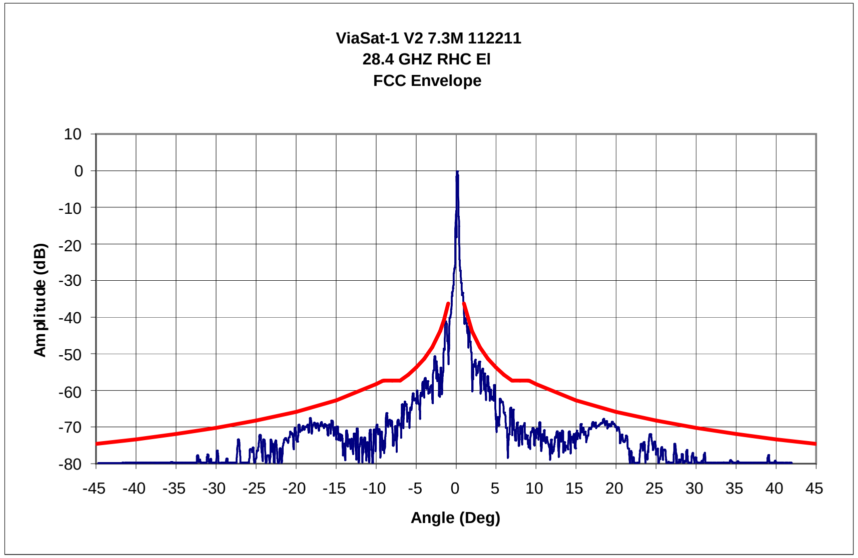
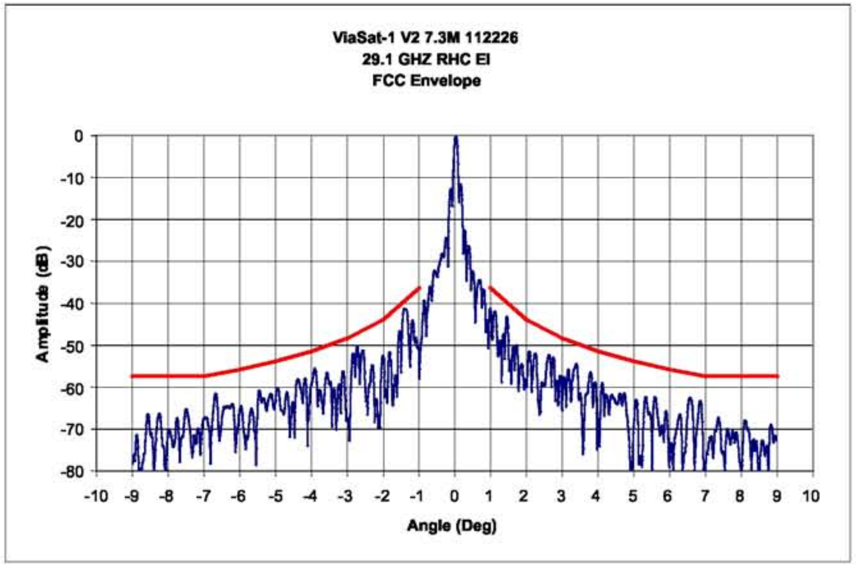
28.4 GHZ RHC El
FCC Envelope
Amplitude (dB)
Angle (Deg)


ViaSat-1 V2 7.3M 112211
28.4 GHZ RHC El
FCC Envelope
Amplitude (dB)
Angle (Deg)


ViaSat-1 V2 7.3M 112226
29.1 GHZ RHC El
FCC Envelope
Amplitude (dB)
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-20
-30
-40
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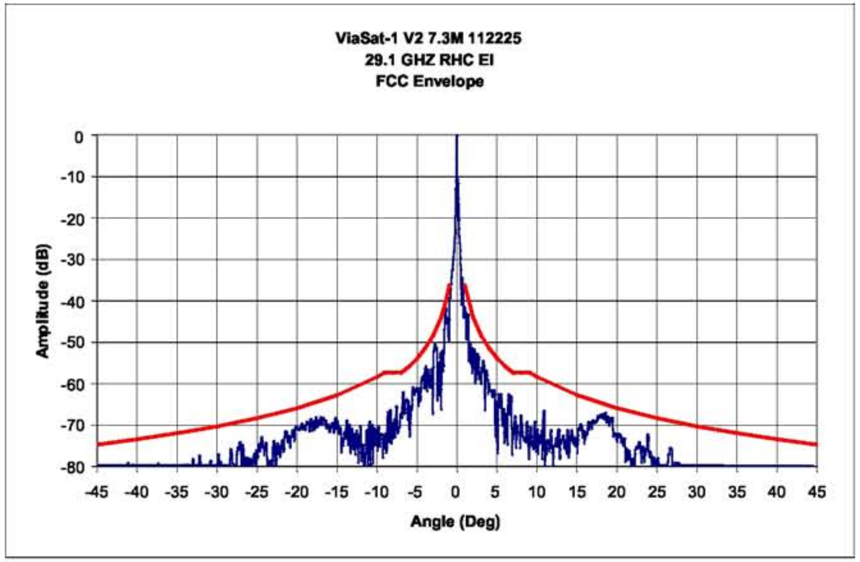
Angle (Deg)


ViaSat-1 V2 7.3M 112225
29.1 GHZ RHC El
FCC Envelope
Amplitude (dB)
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-20
-30
-40
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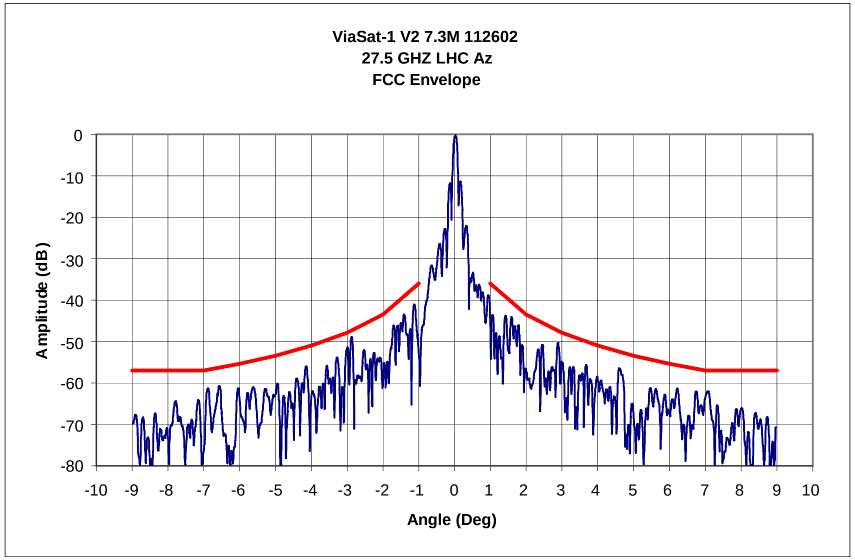
Angle (Deg)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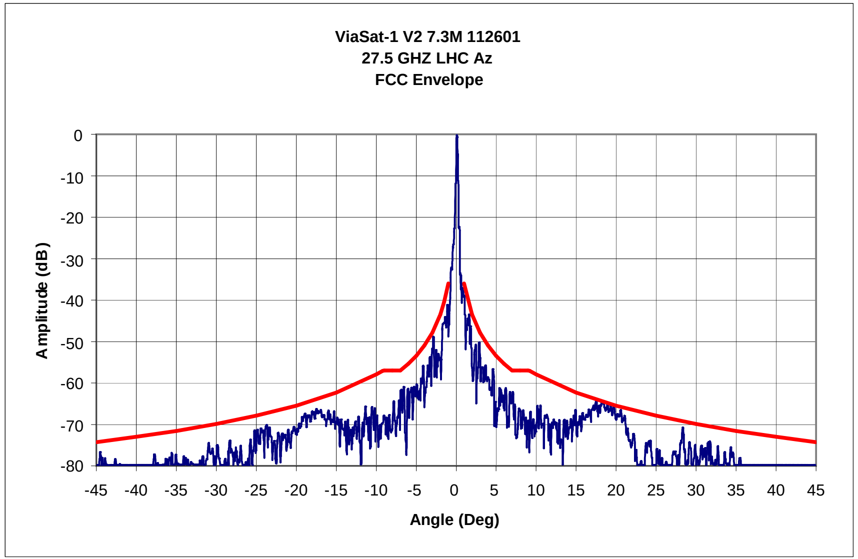
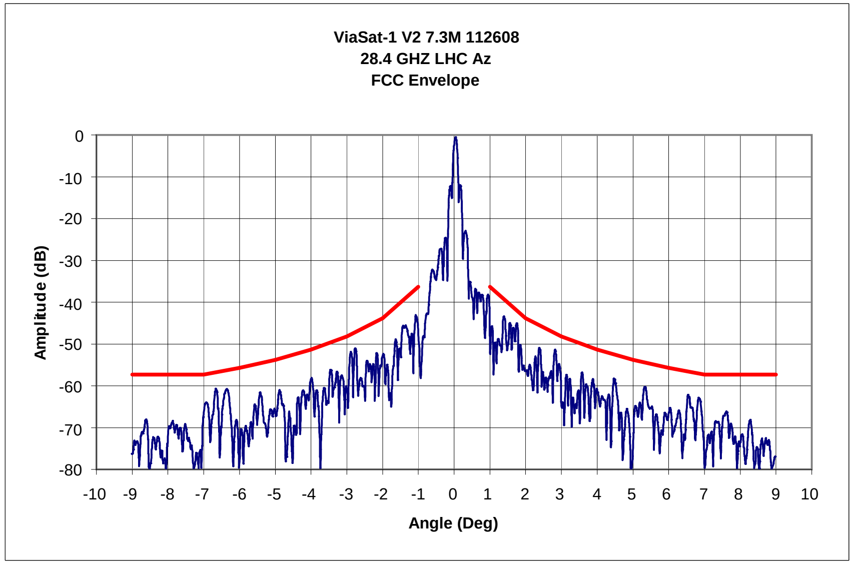
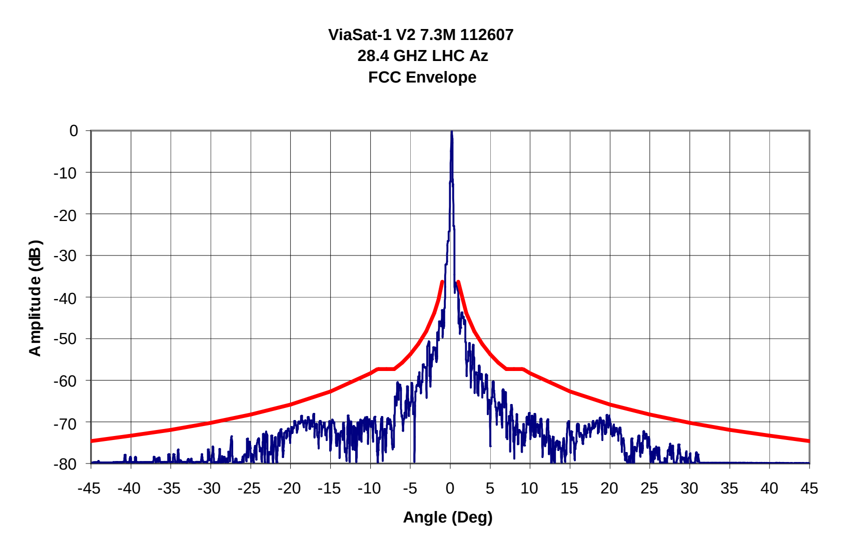
27.5 GHZ LHC Az
FCC Envelope
Amplitude (dB)
Angle (Deg)


ViaSat-1 V2 7.3M 112601
27.5 GHZ LHC Az
FCC Envelope
Amplitude (dB)
Angle (Deg)


ViaSat-1 V2 7.3M 112608
28.4 GHZ LHC Az
FCC Envelope
Amplitude (dB)
Angle (Deg)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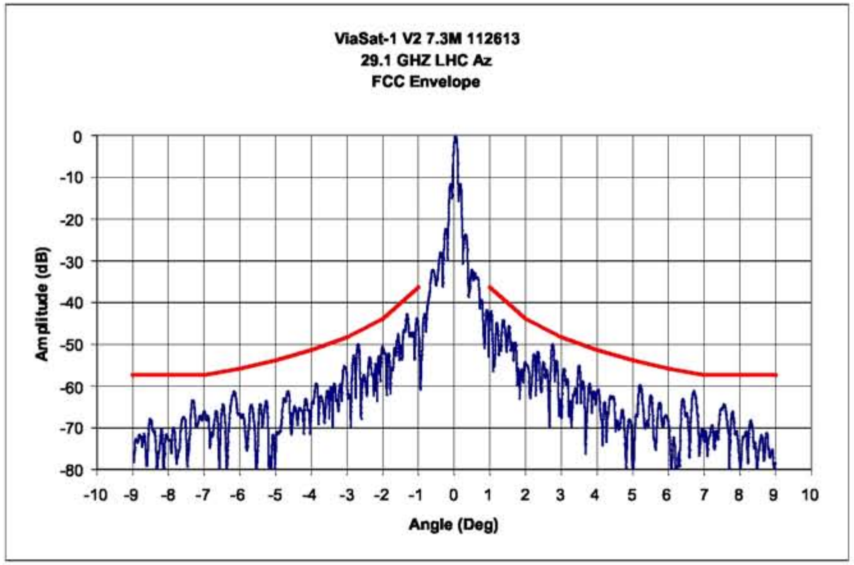
Angle (Deg)


ViaSat-1 V2 7.3M 112613
29.1 GHZ LHC Az
FCC Envelope
Amplitude (dB)
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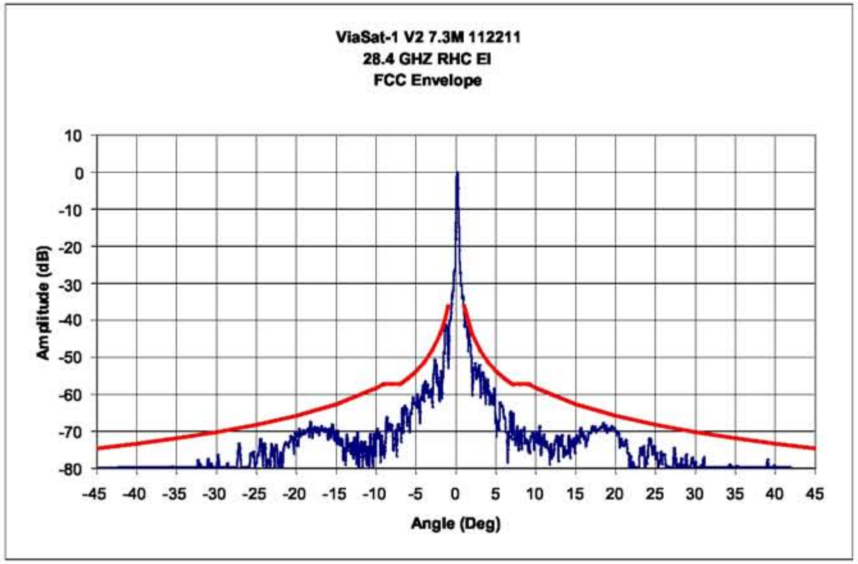
Angle (Deg)


ViaSat-1 V2 7.3M 112211
28.4 GHZ RHC El
FCC Envelope
Amplitude (dB)
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-20
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-70
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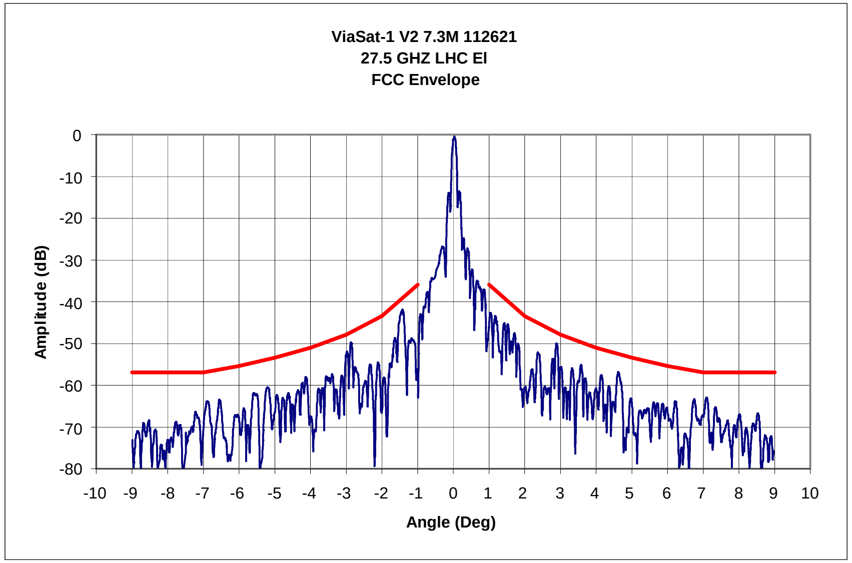
Angle (Deg)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Angle (Deg)
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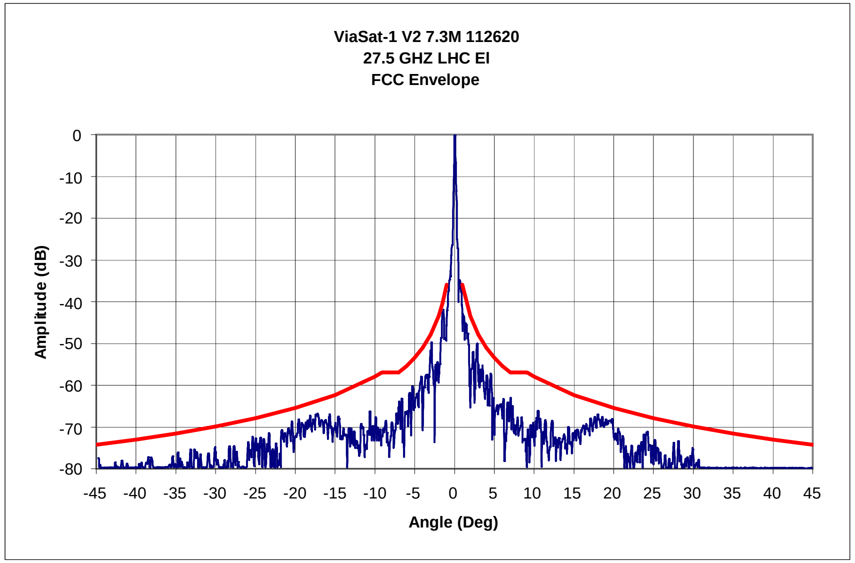
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FCC Envelope
Amplitude (dB)
Angle (Deg)
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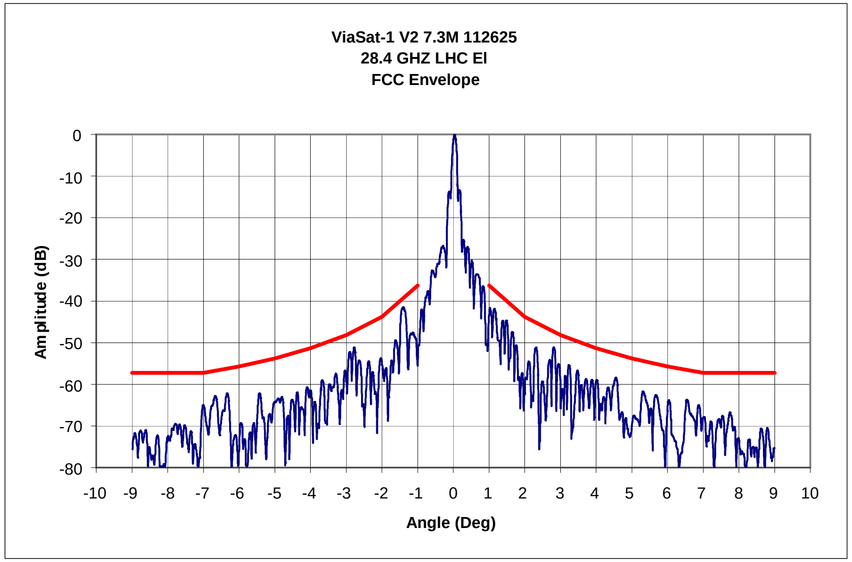
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FCC Envelope
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Angle (Deg)
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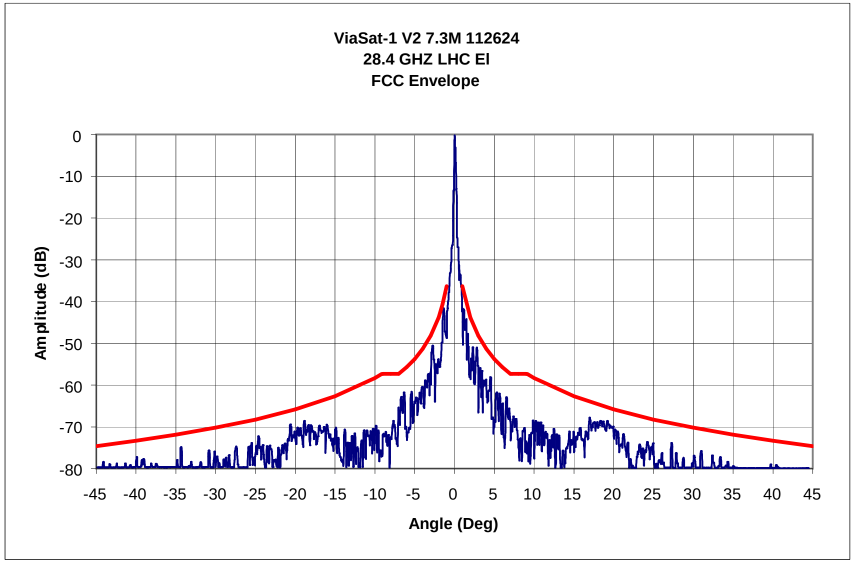
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28.4 GHZ LHC El
FCC Envelope
Amplitude (dB)
Angle (Deg)
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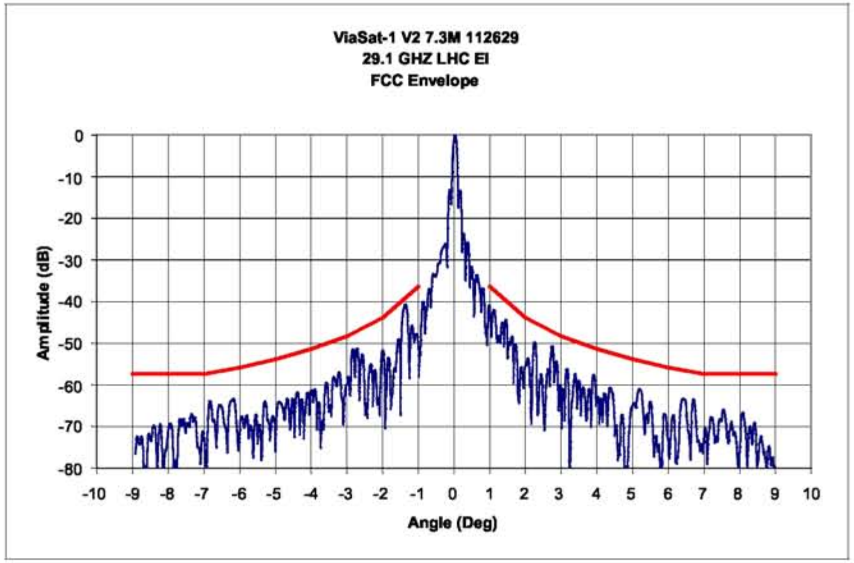
ViaSat-1 V2 7.3M 112629
29.1 GHZ LHC El
FCC Envelope
Amplitude (dB)
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-70
-80
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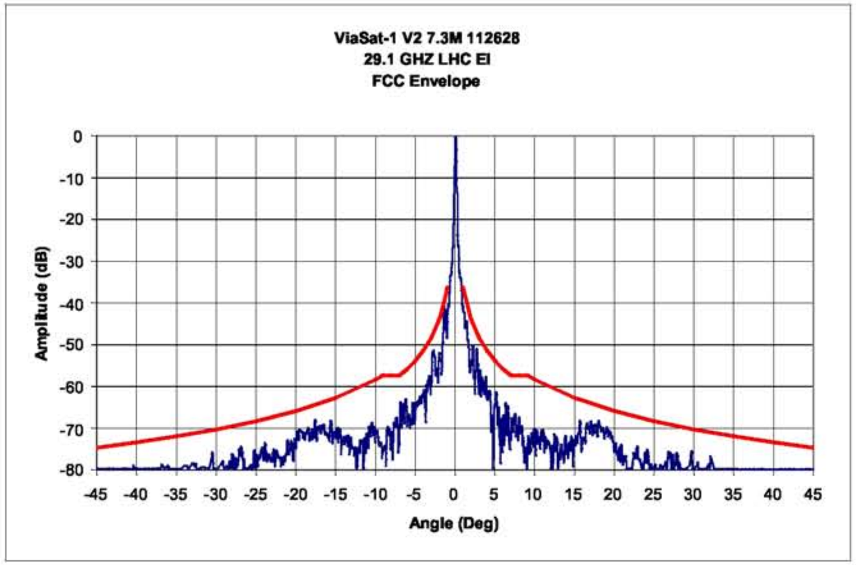
Angle (Deg)


ViaSat-1 V2 7.3M 112628
29.1 GHZ LHC El
FCC Envelope
Amplitude (dB)
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-80
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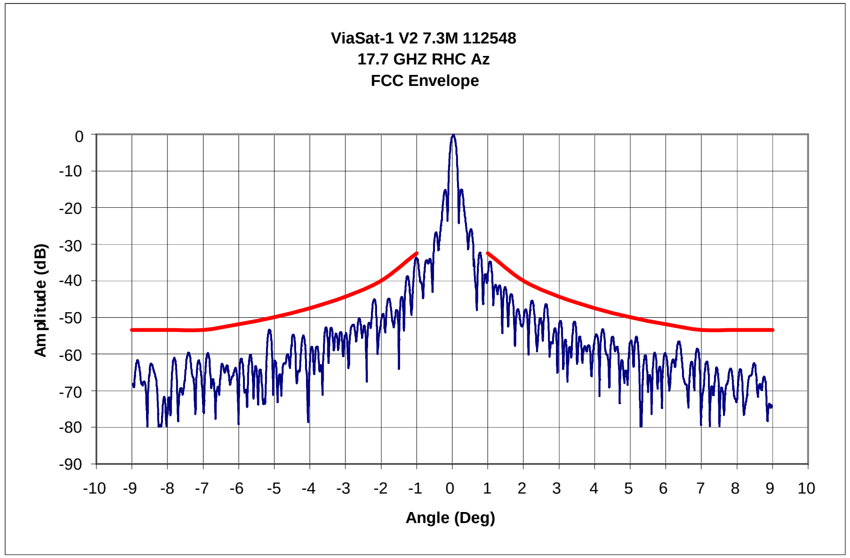
Angle (Deg)


ViaSat-1 V2 7.3M 112548
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FCC Envelope
Amplitude (dB)
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-20
-30
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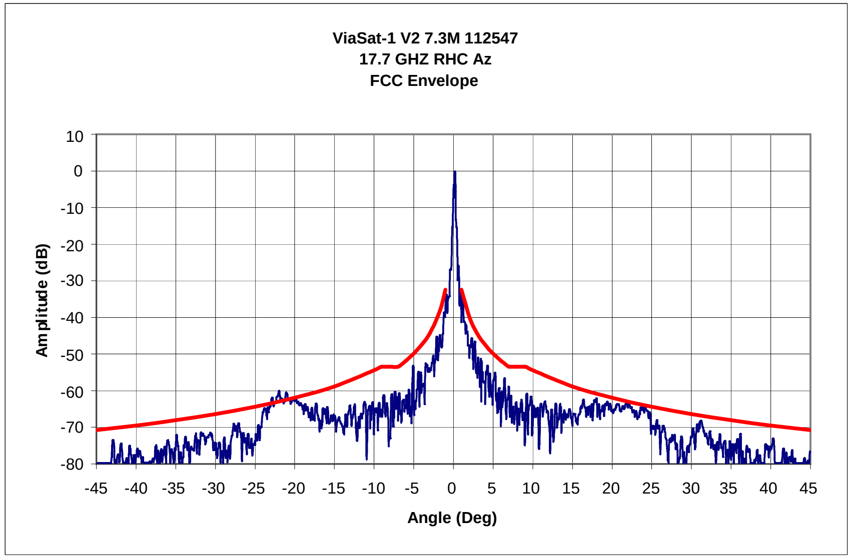
-80
-90
-10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10
Angle (Deg)


ViaSat-1 V2 7.3M 112547
17.7 GHZ RHC Az
FCC Envelope
Amplitude (dB)
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0
-10
-20
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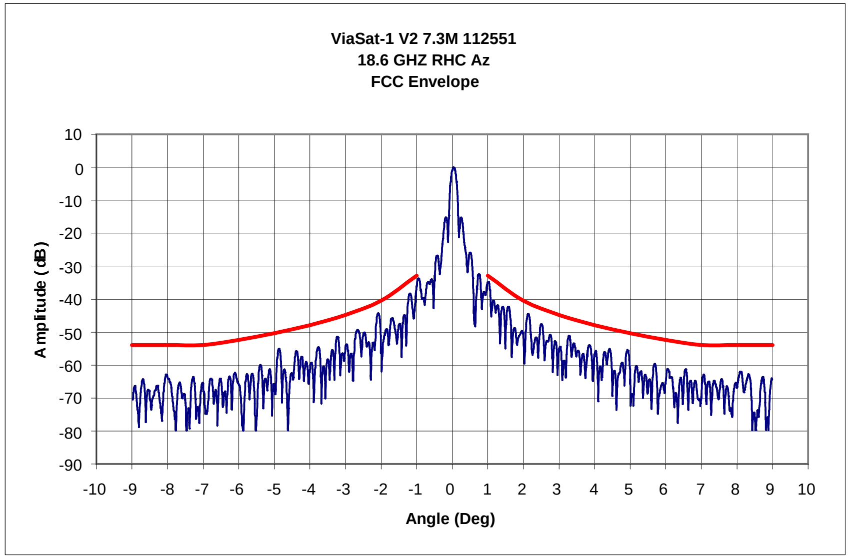
-40
-50
-60
-70
-80
-45 -40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40 45
Angle (Deg)


ViaSat-1 V2 7.3M 112551
18.6 GHZ RHC Az
FCC Envelope
Amplitude (dB)
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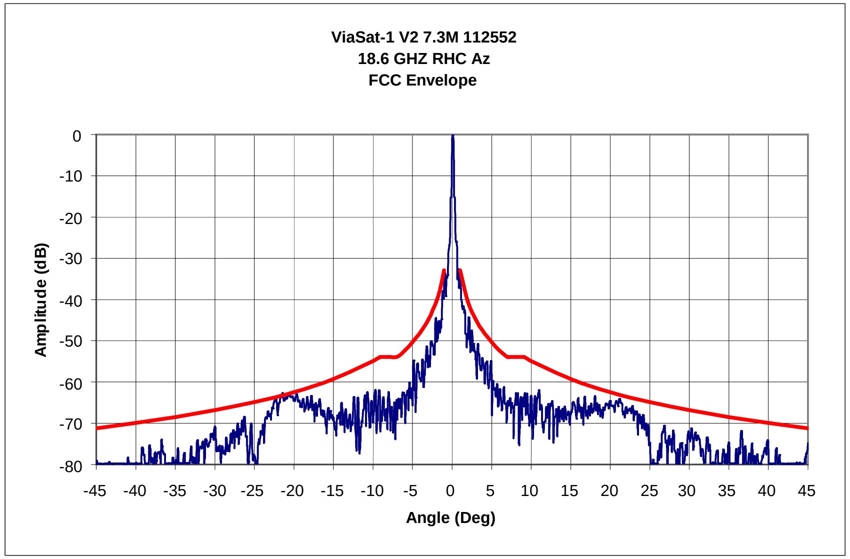
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10
Angle (Deg)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18.6 GHZ RHC Az
FCC Envelope
Amplitude (dB)
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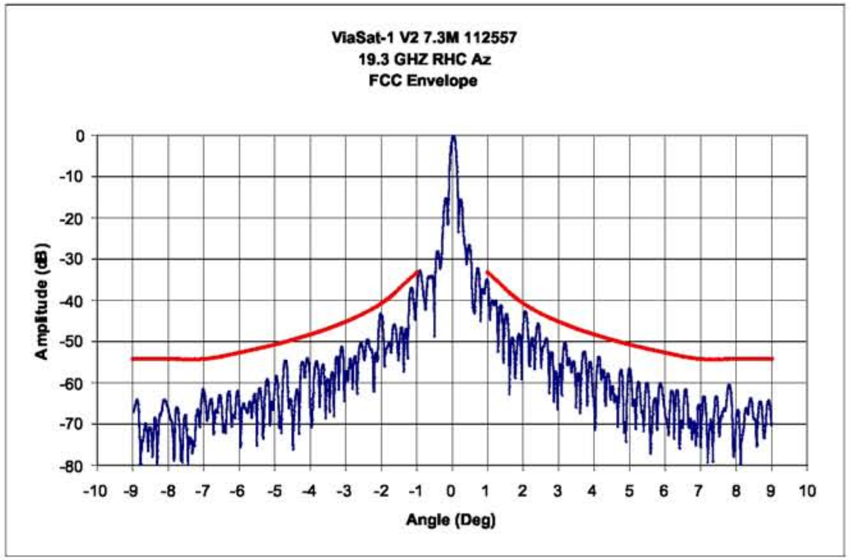
-60
-70
-80
-45 -40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40 45
Angle (Deg)


ViaSat-1 V2 7.3M 112557
19.3 GHZ RHC Az
FCC Envelope
Amplitude (dB)
0
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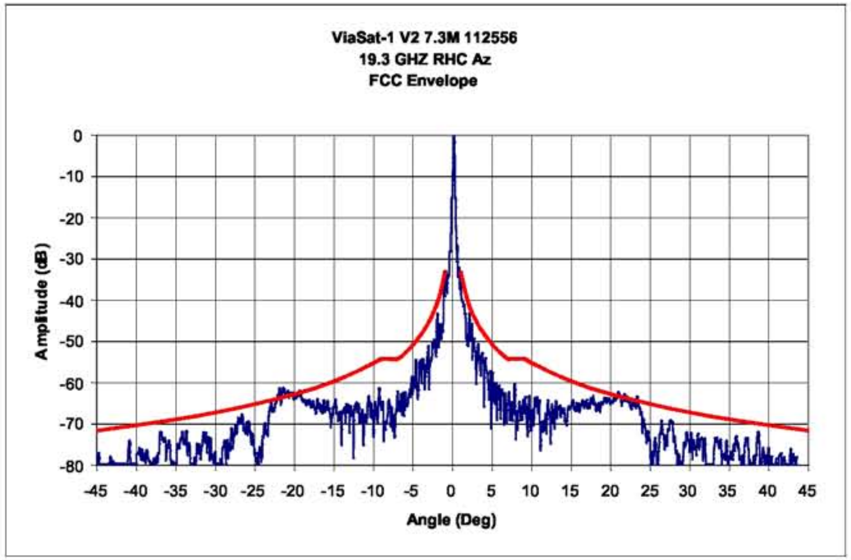
Angle (Deg)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19.3 GHZ RHC Az
FCC Envelope
Amplitude (dB)
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-20
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-60
-70
-80
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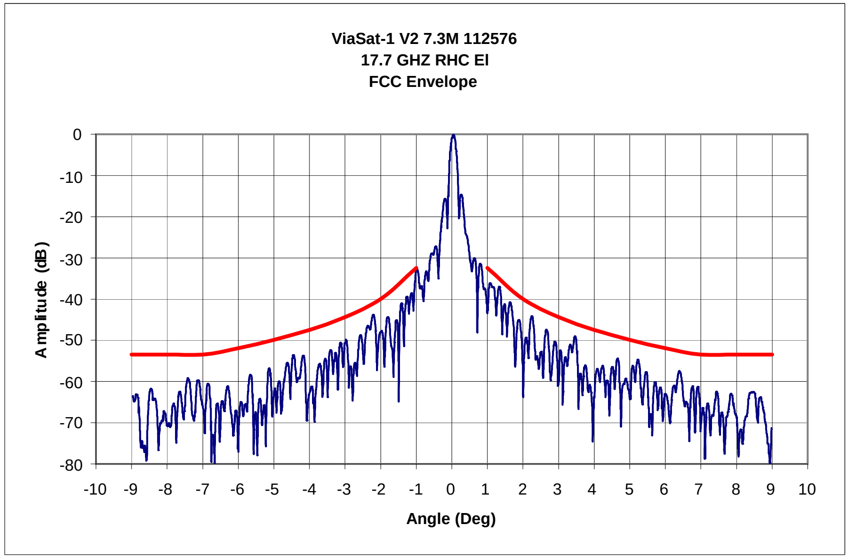
Angle (Deg)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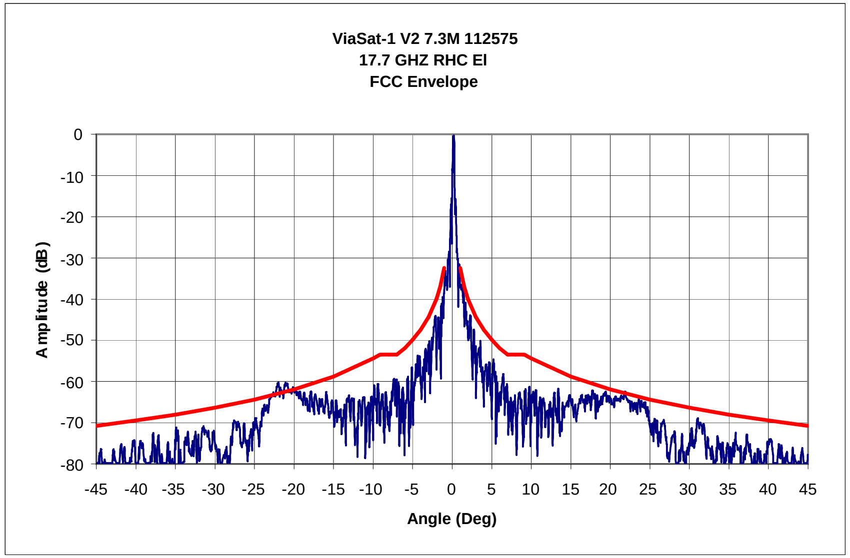
17.7 GHZ RHC El
FCC Envelope
Amplitude (dB)
Angle (Deg)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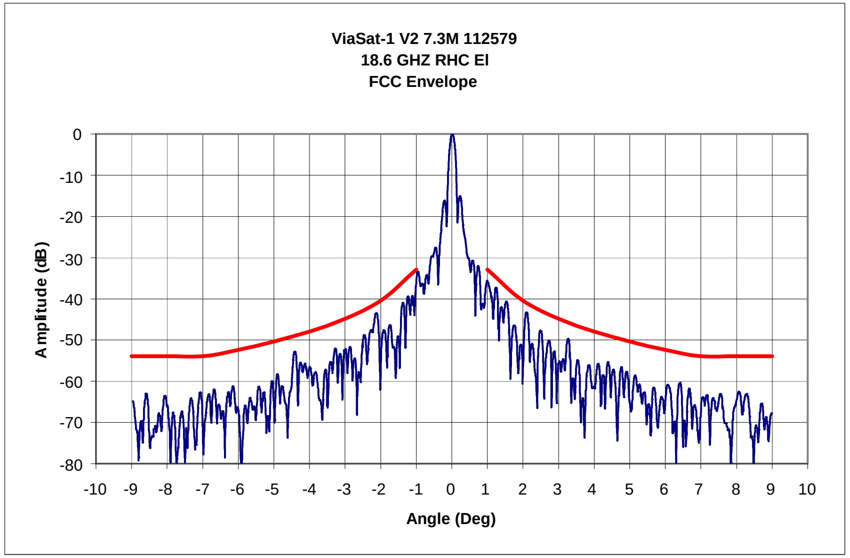
17.7 GHZ RHC El
FCC Envelope
Amplitude (dB)
Angle (Deg)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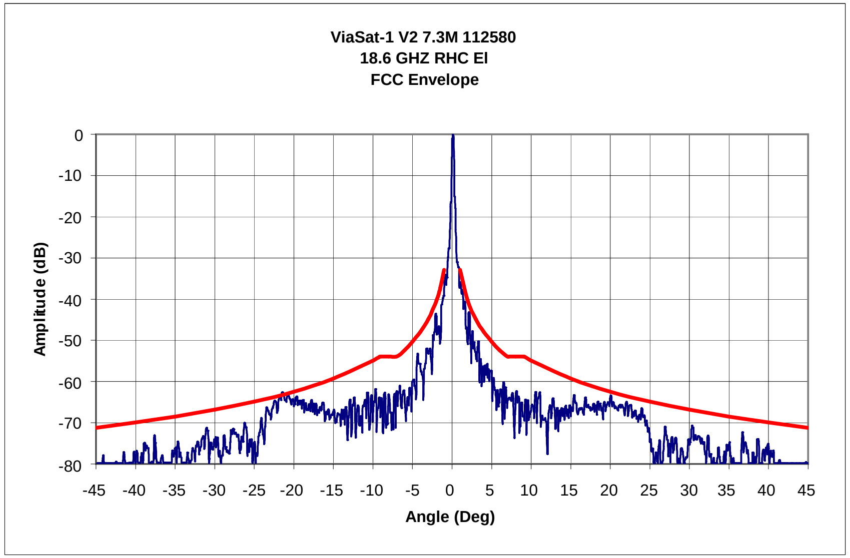
18.6 GHZ RHC El
FCC Envelope
Amplitude (dB)
Angle (Deg)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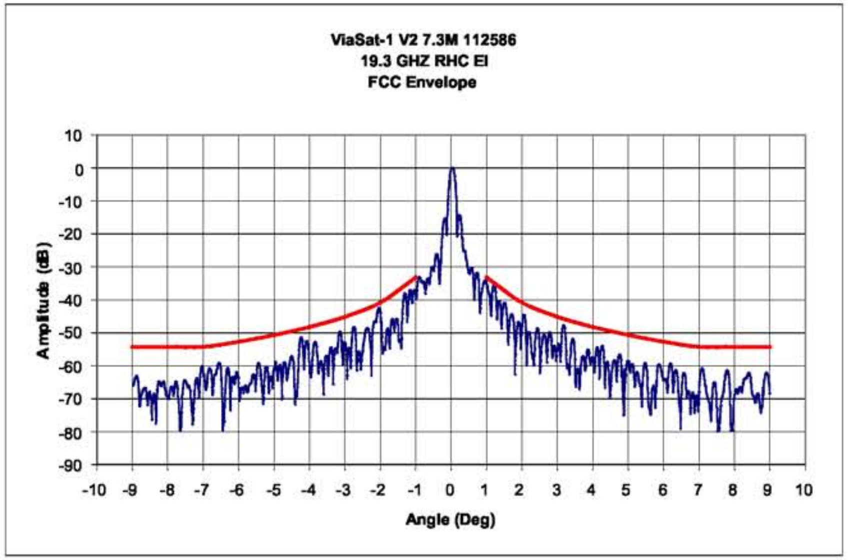
18.6 GHZ RHC El
FCC Envelope
Amplitude (dB)
Angle (Deg)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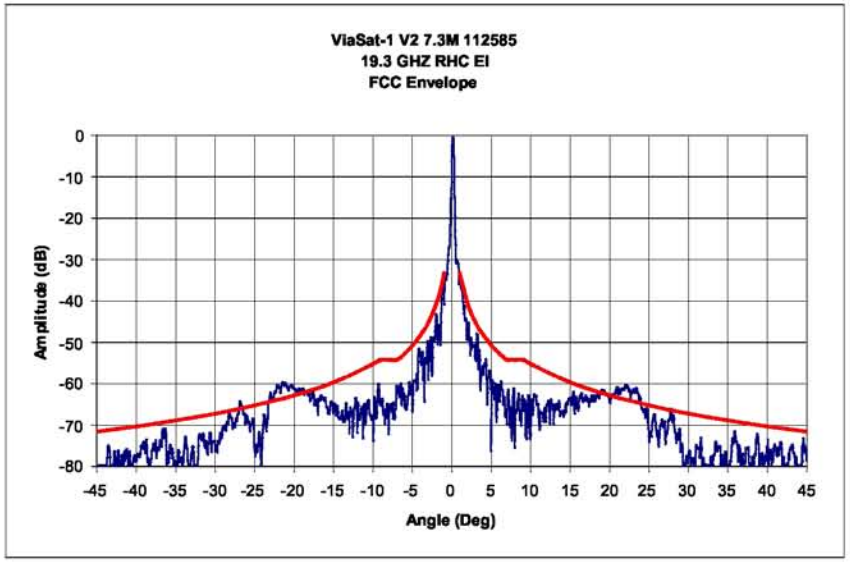
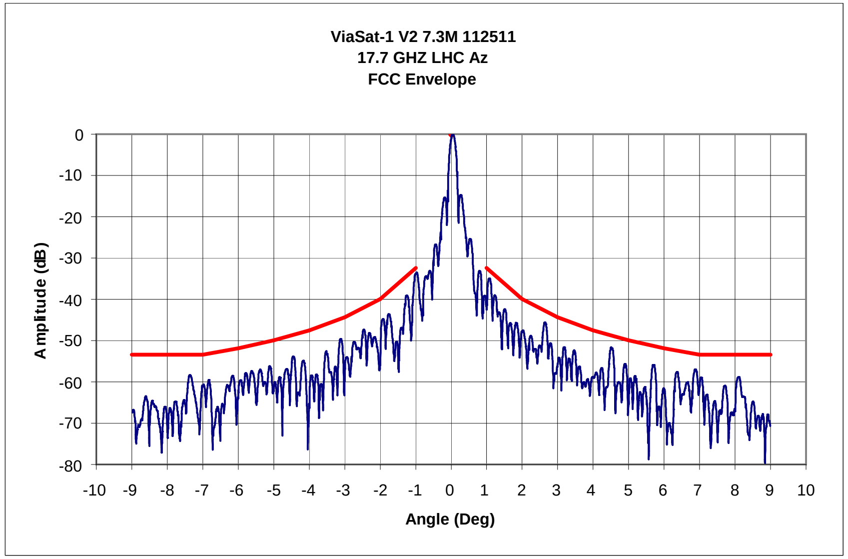
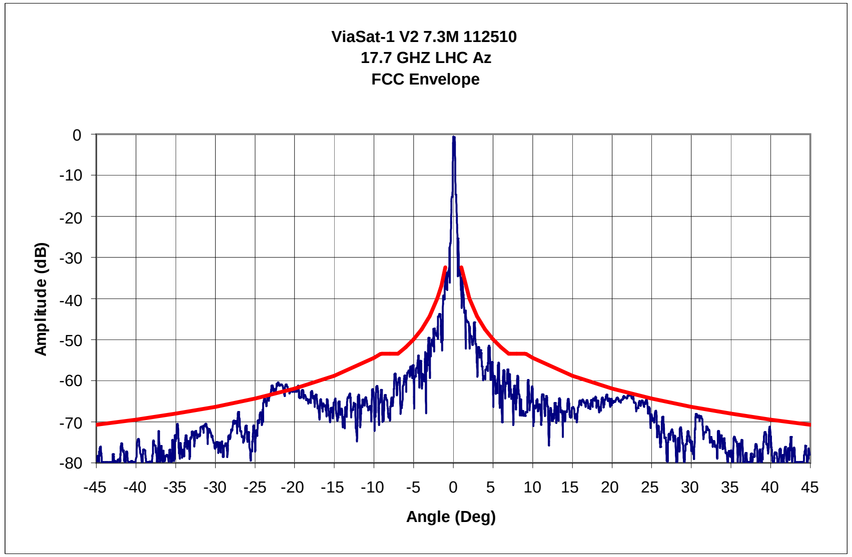
19.3 GHZ RHC El
FCC Envelope
Amplitude (dB)
Angle (Deg)


ViaSat-1 V2 7.3M 112585
19.3 GHZ RHC El
FCC Envelope
Amplitude (dB)
Angle (Deg)


ViaSat-1 V2 7.3M 112511
17.7 GHZ LHC Az
FCC Envelope
Amplitude (dB)
Angle (Deg)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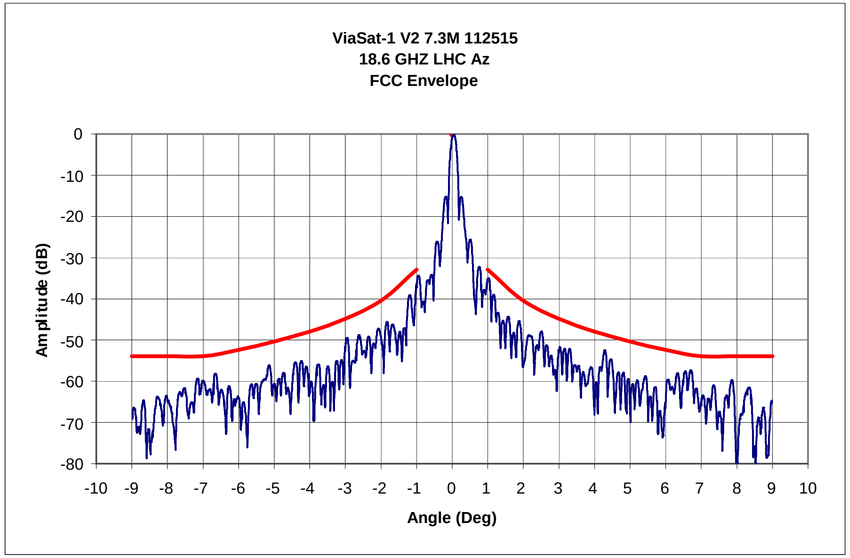
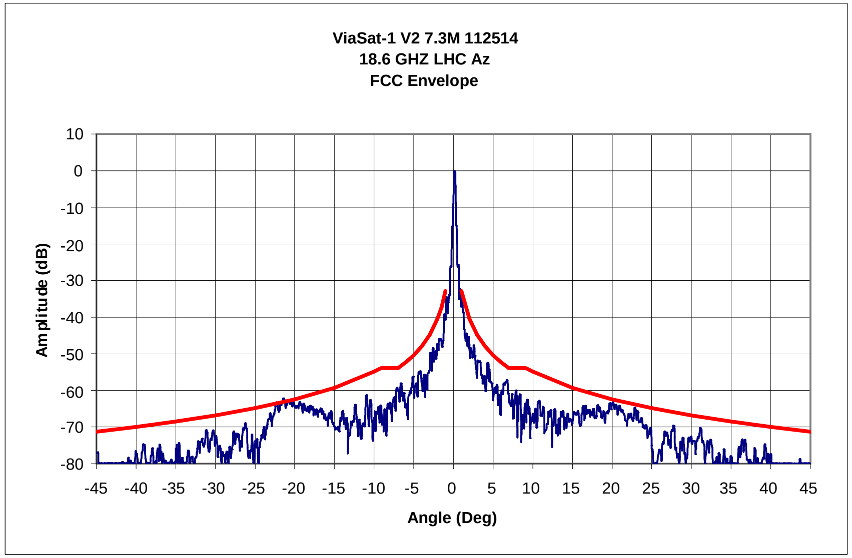
17.7 GHZ LHC Az
FCC Envelope
Amplitude (dB)
Angle (Deg)


ViaSat-1 V2 7.3M 112515
18.6 GHZ LHC Az
FCC Envelope
Amplitude (dB)
Angle (Deg)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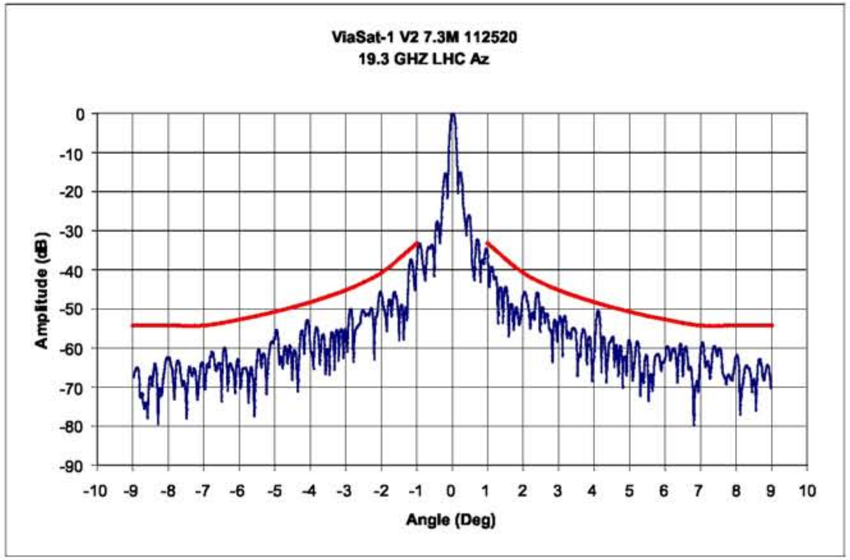
FCC Envelope
Amplitude (dB)
Angle (Deg)


ViaSat-1 V2 7.3M 112520
19.3 GHZ LHC Az
Amplitude (dB)
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-20
-30
-40
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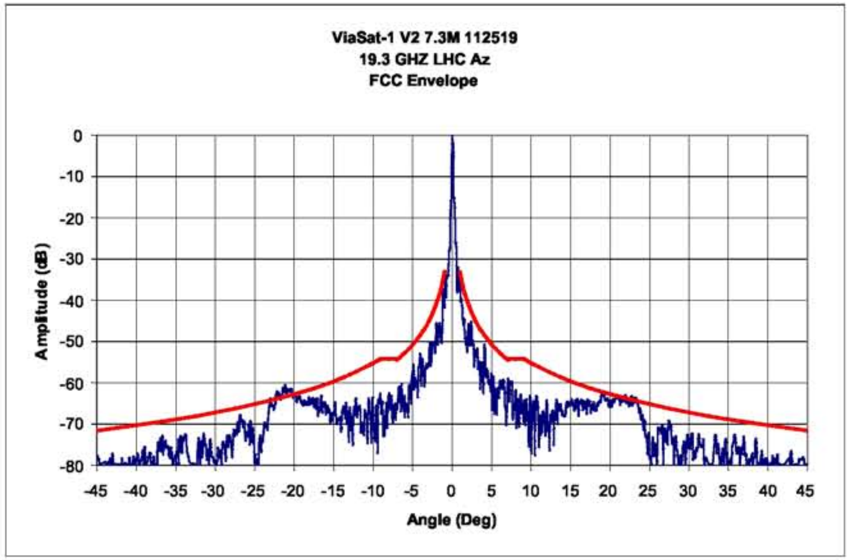
-60
-70
-80
-90
-10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10
Angle (Deg)


ViaSat-1 V2 7.3M 112519
19.3 GHZ LHC Az
FCC Envelope
Amplitude (dB)
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-20
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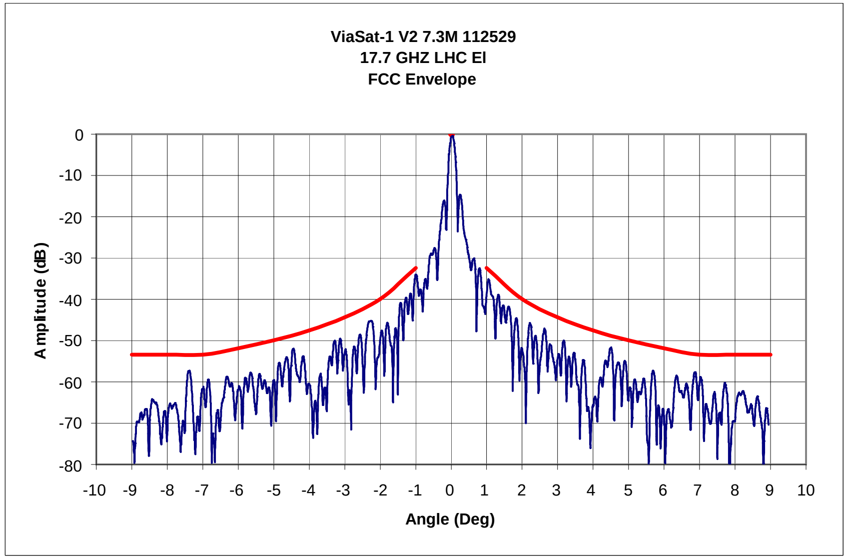
-60
-70
-80
-45 -40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40 45
Angle (Deg)


ViaSat-1 V2 7.3M 112529
17.7 GHZ LHC El
FCC Envelope
Amplitude (dB)
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-70
-80
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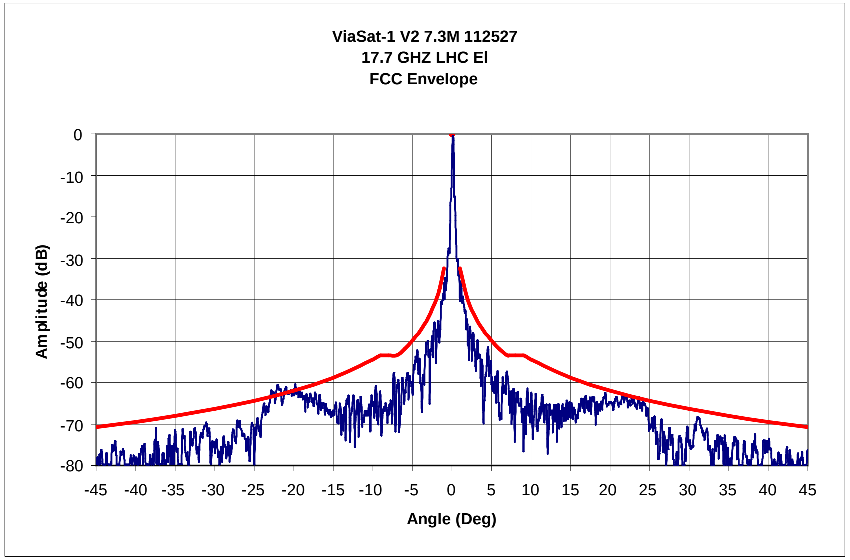
Angle (Deg)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17.7 GHZ LHC El
FCC Envelope
Amplitude (dB)
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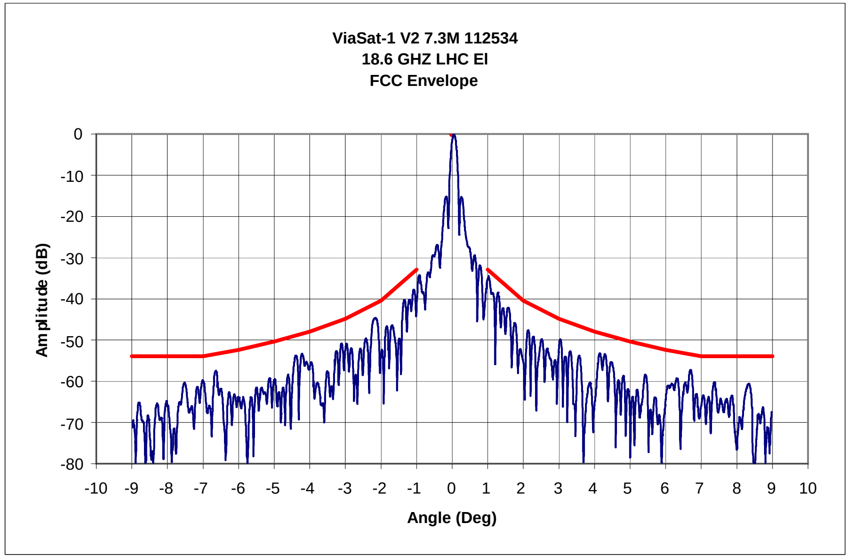
-60
-70
-80
-45 -40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40 45
Angle (Deg)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18.6 GHZ LHC El
FCC Envelope
Amplitude (dB)
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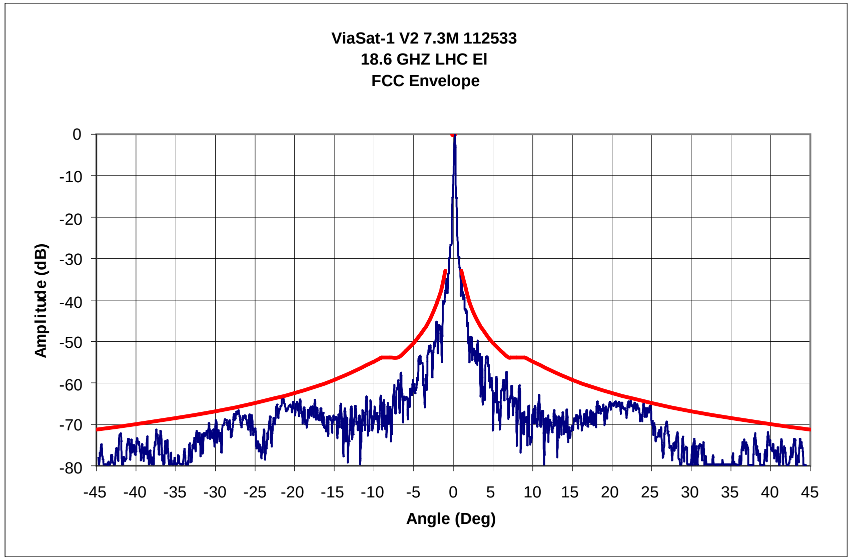
-20
-30
-40
-50
-60
-70
-80
-10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10
Angle (Deg)


ViaSat-1 V2 7.3M 112533
18.6 GHZ LHC El
FCC Envelope
Amplitude (dB)
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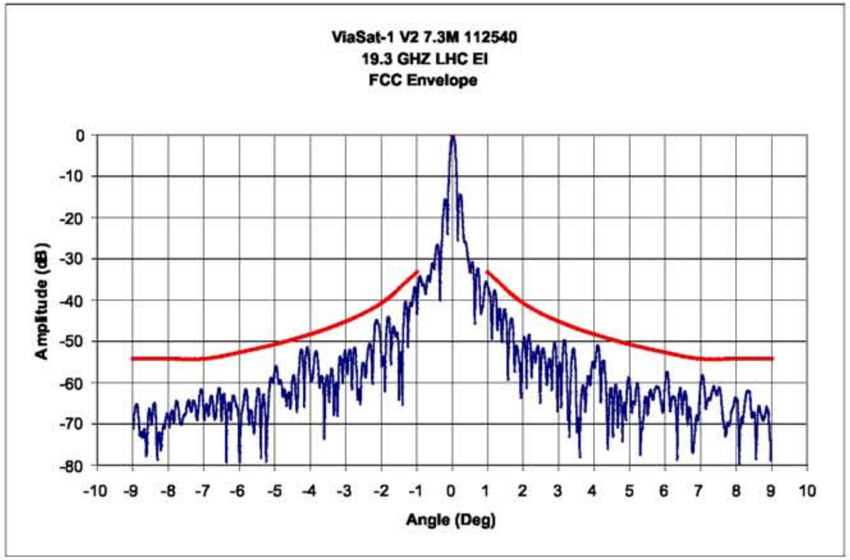
-10
-20
-30
-40
-50
-60
-70
-80
-45 -40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40 45
Angle (Deg)


ViaSat-1 V2 7.3M 112540
19.3 GHZ LHC El
FCC Envelope
Amplitude (dB)
0
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-20
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-50
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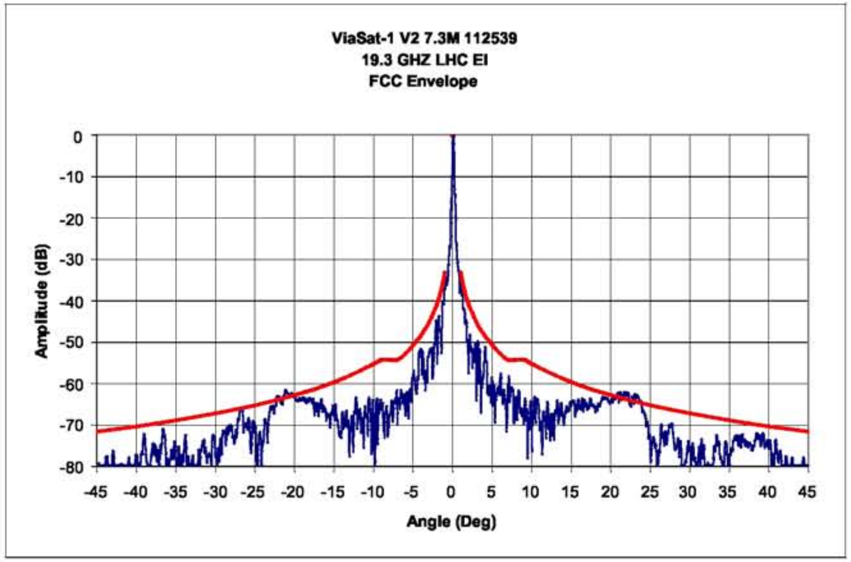
-70
-80
-10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10
Angle (Deg)


ViaSat-1 V2 7.3M 112539
19.3 GHZ LHC El
FCC Envelope
Amplitude (dB)
0
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-20
-30
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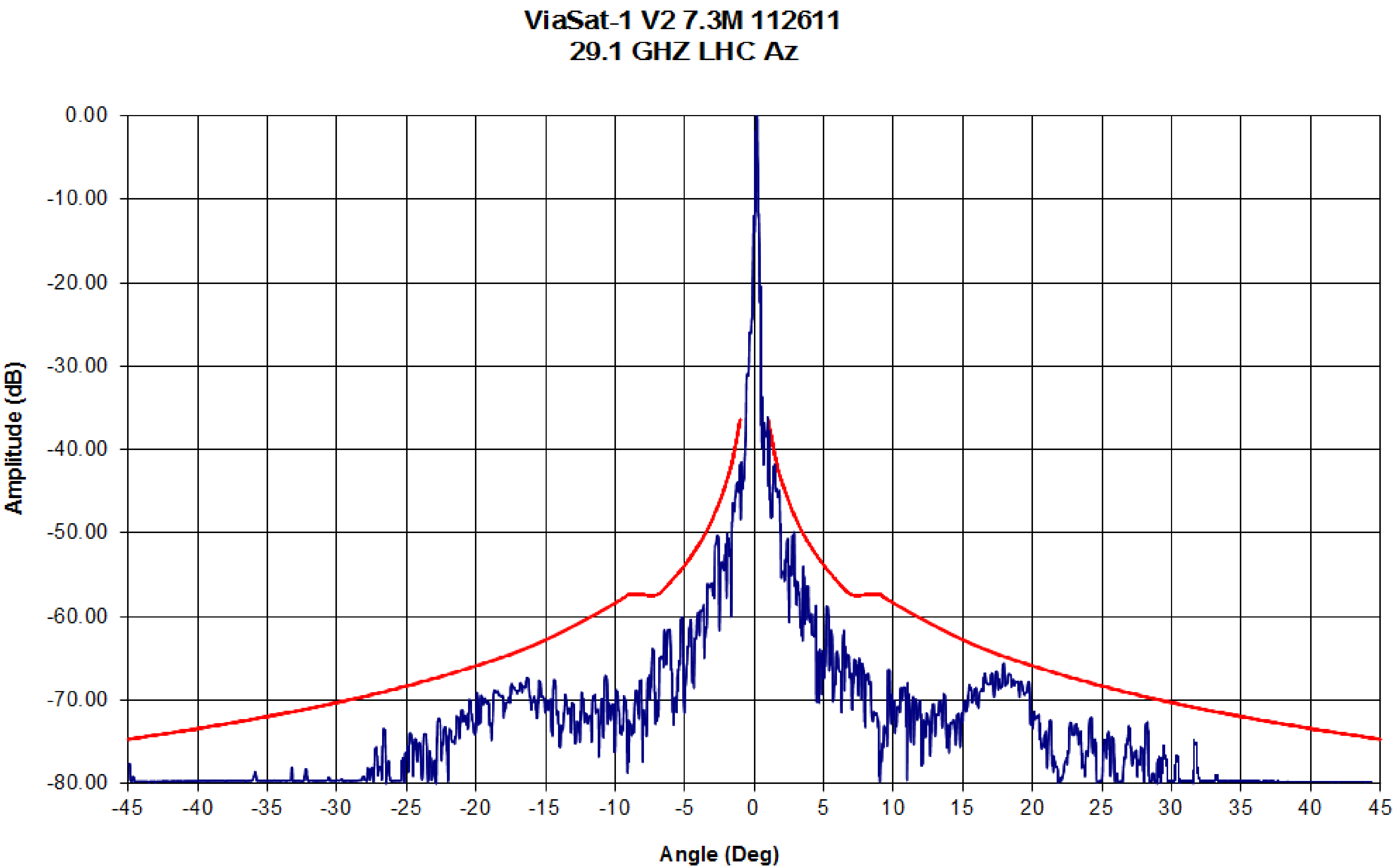
-60
-70
-80
-45 -40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40 45
Angle (Deg)



ViaSat-1 V2 7.3M 112611
29.1 GHZ LHC Az
Amplitude (dB)
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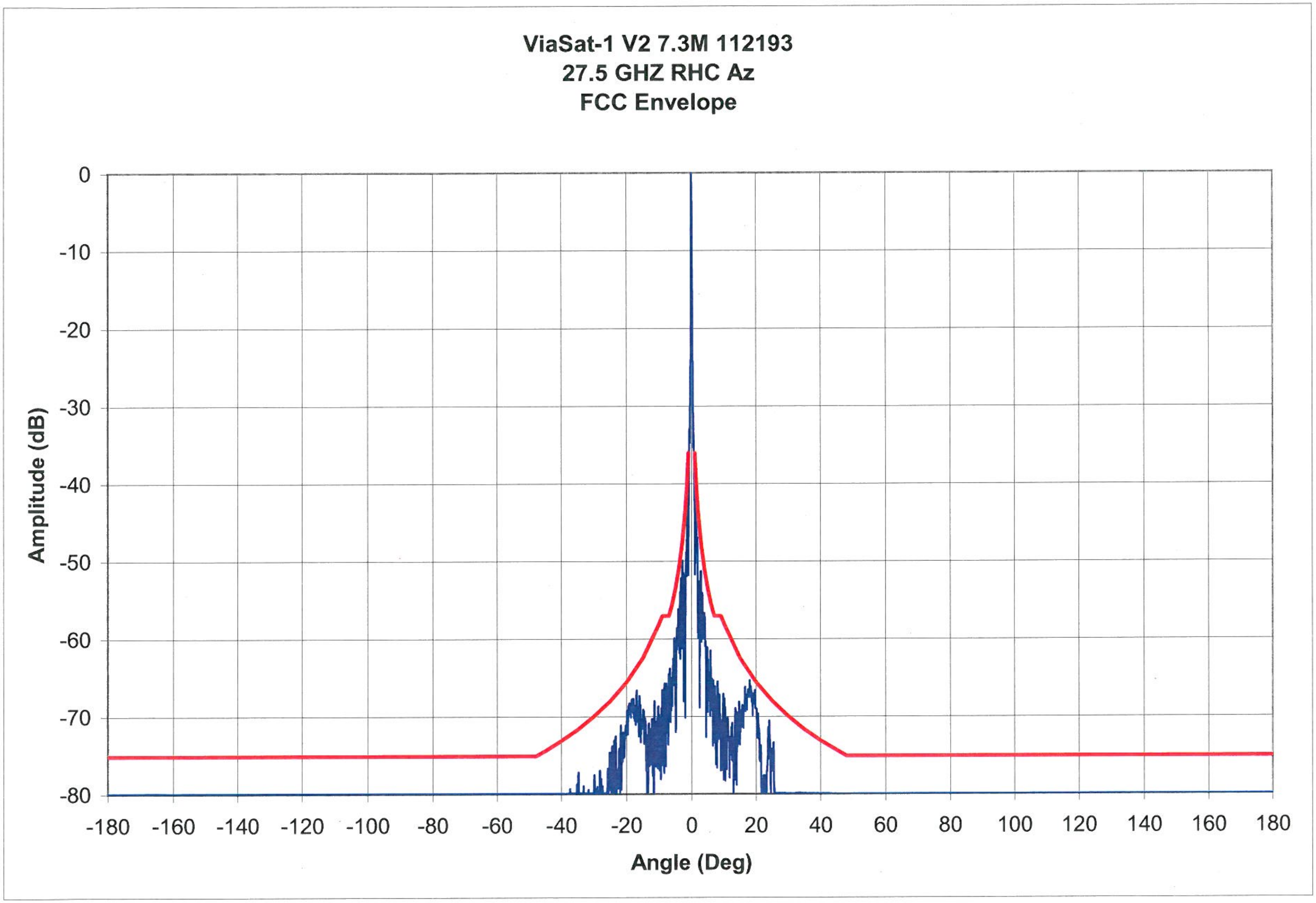
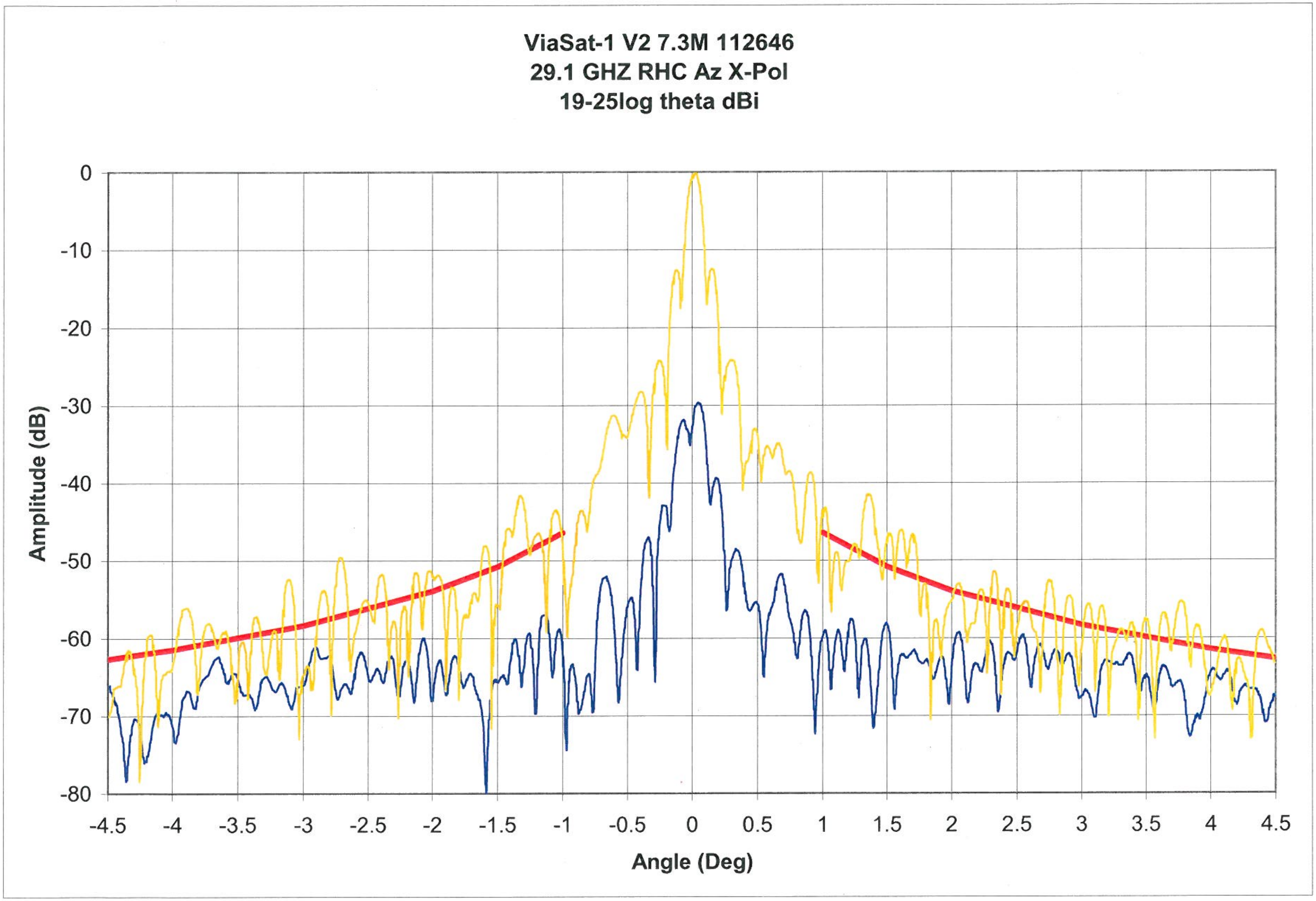
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
-70.00
-80.00
-45 -40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40 45
Angle (Deg)


ViaSat-1 V2 7.3M 112193
27.5 GHZ RHC Az
FCC Envelope
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-70
-80
-180
-160
-140
-120
-100
-80
-60
-40
-20
0
20
40
60
80
100
120
140
160
180
Angle (Deg)


ViaSat-1 V2 7.3M 112646
29.1 GHZ RHC Az X-Pol
19-25log theta dBi
Amplitude (dB)
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-20
-30
-40
-50
-60
-70
-80
-4.5
-4
-3.5
-3
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
Angle (Deg)

ANNEX D

(Comsearch Field Strength Analysis)

19700 Janelia Farm Boulevard
Ashburn, VA 20147 USA
(703) 726-5500
Fax (703) 726-5600
http://www.comsearch.com

COMSEARCH®

April 22, 2011

RE: O3b Limited
Haleiwa, HI Gateway Earth Station Application
IBFS File Number: SES-LIC-20100723-00952
Call Sign: E100088
Protection of FCC Monitoring Station at Waipahu, HI
Power Flux Density Calculation With Respect to 47 C.F.R. §25.203(g)(1) Limit

This analysis demonstrates that the proposed Haleiwa, HI earth station will protect the FCC Monitoring Station at Waipahu, HI by satisfying the limits stated in §25.203(g)(1).

The FCC Monitoring Station at Waipahu is 32.9 km at an azimuth of 173.4º from the location of the proposed earth station. Each of the two antennas that would transmit simultaneously at the earth station facility has a total input power of 447 W and the maximum antenna gain towards the horizon in the direction of Waipahu is -10 dBi. Thus the total EIRP of the earth station antennas towards Waipahu is 89.5 W (19.5 dBW).

Power flux density (*PFD*) is calculated for free-space propagation from:

$$PFD(dBW/m^2) = 10\log_{10}\left[\frac{EIRP}{4\pi D^2}\right]$$

where *EIRP* is in Watts and *D* is the distance in meters. Using this relationship the free-space power flux density of -81.8 dBW/m^2 is below the §25.203(g)(1) limit of -65.8 dBW/m^2. In addition the path from Haleiwa to Waipahu is significantly blocked by terrain and at 28 GHz there are appreciable losses due to absorption by atmospheric gases. The attached path profile shows additional long-term over-the-horizon loss of 80.9 dB and atmospheric absorption loss of 3.4 dB.

Based on this discussion the power flux density calculations are listed in the following table:

Earth Station Name	**Haleiwa, HI**
ES Latitude (D-M-S) North	21-40-17.8
ES Longitude (D-M-S) West	158-01-54.9
ES Transmit Frequency Band (MHz)	27,600 to 29,100
ES Transmitter Power (W)	447.23
Number of Transmitting Antennas	2
Total ES Transmitter Power (W)	894.46
Total ES Transmitter Power (dBW)	29.5
FCC Monitoring Station Name	**Waipahu, HI**
FCC Monitoring Station Latitude (D-M-S) North	21-22-33.6
FCC Monitoring Station Longitude (D-M-S) West	157-59-44.1
ES Antenna to FCC Monitoring Station Distance (km)	32.95
ES Antenna Azimuth towards FCC Monitoring Station (deg)	173.44
ES Antenna Horizon Gain @ 173.37 deg Az (dBi)	-10.0
ES EIRP towards the Horizon @173.37 deg Az (dBW)	19.5
ES EIRP towards the Horizon @173.37 deg Az (W)	89.45
Free Space Power Flux Density at FCC Monitoring Station (W/m^2))	6.56E-09
Free Space Power Flux Density at FCC Monitoring Station (dBW/m^2)	**-81.8**
§25.203(g)(1) Power Flux Density Objective (dBW/m^2)	**-65.8**
Margin - Free Space (dB)	**16.0**
Over-the-Horizon Loss (dB)	80.9
Atmospheric Absorption Loss (dB)	3.4
Power Flux Density at FCC Monitoring Station (dBW/m^2)	**-166.1**
Margin - With OH and Absorption Losses (dB)	**100.3**

The proposed O3b Limited earth station facility at Haleiwa, HI satisfies the §25.203(g)(1) limits with respect to the FCC Monitoring Station at Waipahu, HI.

Respectfully Submitted,

Comsearch

William W. Perkins
Principal Engineer
(703) 726-5681
wperkins@comsearch.com

Pathloss Calculation (NSMA Tropo)

Path data for case # 1	HALEIWA		WAIPAHU	
Latitude	21 40 17.8		21 22 33.6	
Longitude	158 1 54.9		157 59 44.1	
Antenna Center Agl	13.75 ft.	4.19 m.	20.01 ft.	6.10 m.
Site Elevation Amsl	459.34 ft.	140.00 m.	6.50 ft.	1.98 m.
Antenna Center Amsl	473.09 ft.	144.19 m.	26.51 ft.	8.08 m.
Effective Antenna Ht ...	13.75 ft.	4.19 m.	20.01 ft.	6.10 m.
Horizon Distance	1.95 mi.	3.14 km.	5.14 mi.	8.27 km.
Horizon Elevation Amsl .	917.86 ft.	279.75 m.	718.54 ft.	219.00 m.
Ray Crossover Angle	71.92 mr.			
Terrain Delta Ht	366.96 ft.	111.84 m.		
Effective Distance	83.60 mi.	134.51 km.		
Pathlength	20.48 mi.	32.95 km.		
Azimuth	173.43 deg.		353.45 deg.	
Frequency	28350 MHz			
K Factor	1.33 (K)			

Radio Climate Phrase ... Maritime Temperate Climate Over Land
Type of Path .... Irregular Terrain
Free Space Path Loss ... 151.8 dB   Atmospheric Loss ... 3.406 dB
Diff. Loss .... 544.0 dB (695.8 dB) Tropo. Loss ... 90.7 dB (242.5 dB)
Terrain data type ...... 1.0 ARC Second

Losses	L-Fspl	Sigma	Controlling	Propagation Mode
232.7 dB	80.9 dB	4.1 dB	20. %	Tropospheric Scatter
212.5 dB	60.7 dB	7.8 dB	1. %	Tropospheric Scatter
199.0 dB	47.2 dB	10.7 dB	0.1 %	Tropospheric Scatter
182.1 dB	30.3 dB	14.3 dB	0.01 %	Tropospheric Scatter
163.9 dB	12.1 dB	18.2 dB	0.0025%	Tropospheric Scatter

The OH loss calculations considered a terrain profile of 232 points.
The list below shows the highest point in each fiftieth of the path length.

Dist. (km.)	Elev. (m.)	Obstr. (m.)	K=Inf. Clrnce. (m.)	K= 1.33 Clrnce. (m.)	Dist. (km.)	Elev. (m.)	Obstr. (m.)	K=Inf. Clrnce. (m.)	K= 1.33 Clrnce. (m.)
0.00	140.0	4.2	0.0	0.0	16.69	343.7	0.0	-268.5	-284.5
0.57	155.0	0.0	-13.1	-14.2	17.54	335.0	0.0	-263.3	-279.2
0.71	145.2	0.0	-3.9	-5.3	17.83	326.9	0.0	-256.4	-272.3
1.43	154.2	0.0	-15.9	-18.6	18.54	313.8	0.0	-246.2	-262.0
2.42	216.7	0.0	-82.5	-86.9	19.11	308.4	0.0	-243.2	-258.8
3.14	279.8	0.2	-148.8	-154.3	19.97	287.6	0.0	-225.9	-241.2
3.28	282.0	0.0	-151.3	-157.1	20.54	281.3	0.0	-222.0	-237.0
3.42	257.9	0.0	-127.9	-133.8	21.11	270.8	0.0	-213.8	-228.6
4.56	240.5	0.0	-115.2	-122.8	21.82	249.1	0.0	-195.0	-209.3
5.13	220.6	0.0	-97.6	-106.0	22.68	227.0	0.0	-176.5	-190.2
5.42	247.3	0.0	-125.5	-134.3	23.39	226.0	0.0	-178.4	-191.6
6.42	279.3	0.0	-161.6	-171.7	24.25	221.0	0.0	-177.0	-189.4
6.99	318.0	0.0	-202.6	-213.3	24.39	220.0	0.0	-176.6	-188.9
7.84	334.1	0.0	-222.4	-234.0	25.10	198.1	0.0	-157.6	-169.2
8.41	355.3	0.0	-245.9	-258.0	26.10	158.0	0.0	-121.6	-132.2
8.70	356.8	0.0	-248.5	-260.9	26.53	153.0	0.0	-118.4	-128.4
9.41	332.1	0.0	-226.8	-239.8	27.24	141.1	0.0	-109.5	-118.7
10.13	278.5	0.0	-176.1	-189.8	27.81	129.0	0.0	-99.7	-108.1
11.12	356.4	0.0	-258.2	-272.5	28.38	113.3	0.0	-86.3	-94.0
11.69	375.1	0.0	-279.2	-293.9	29.09	91.0	0.0	-67.0	-73.6
12.12	371.2	0.0	-277.1	-292.0	29.67	74.0	0.0	-52.4	-58.1
12.55	368.4	0.0	-276.0	-291.1	30.38	41.0	0.0	-22.3	-26.9
13.41	369.8	0.0	-281.0	-296.5	31.09	15.9	0.0	-0.2	-3.5
13.98	372.0	0.0	-285.6	-301.2	31.95	14.0	0.0	-1.8	-3.7
14.83	345.8	0.0	-262.9	-278.7	32.66	4.0	0.0	5.3	4.7
15.26	343.0	0.0	-261.9	-277.8	32.95	2.0	6.1	0.0	0.0
16.12	323.3	0.0	-245.7	-261.7					

ANNEX E

(Comsearch Confirmation Letter)

COMSEARCH
A CommScope Company

April 22, 2011

Mr. Gary Mattie
O3B
Gary.mattie@o3bnetworks.com

Re: Coordinate Update
Haleiwa, Hawaii
Ka-band Transmit/Receive earth Station

Dear Mr. Mattie,

This letter is confirmation that the proposed change in geographic coordinates from 21° 40' 15.8" North 158° 1' 56.1" West to 21° 40' 17.8" North 158°1' 54.9" West, and the slight increase in antenna ground elevation (from 137.77m to 140.00m AMSL) and antenna centerlines (from 3.66m AGL to 4.19m AGL) for your 7.3 Meter earth station at Haleiwa, Hawaii will have a minimal impact on the previous studies completed for O3B and that those studies will be sufficient to cover the new coordination effort.

This letter constitutes further confirmation that your 7.3 Meter earth station at Haleiwa, Hawaii was coordinated per the requirements of FCC 25.251(a) and (b). The critical parameters used were a 'Maximum EIRP Density' of 80.7 dBW/4 kHz and an 'RF Transmit Power' of 15.7 dBW/4 kHz.

The Maximum EIRP Density and RF Transmit Power used for coordination purposes was the maximum per carrier transmit power for this earth station considering all potentially licensed Emission Bandwidths; as long as the *power density per carrier* is not exceeded, the *bandwidth range of emissions* will not affect the integrity of our frequency coordination study. The emission designators declared in the report are generically applied fields which do not affect the interference potential of the earth station.

The updated Coordination Notice will be issued shortly and we will forward the Coordination Final Report as soon as possible. Please let us know if you have any questions, or require additional information on this earth station.

Sincerely,

Comsearch

Gary Edwards
Manager Satellite Services
(703) 726-5662
gedwards@comsearch.com