ATTACHMENT
Technical Information to Supplement Schedule S

A.1 SCOPE AND PURPOSE

The purpose of this Attachment is to provide the Commission with the updated technical characteristics and related information for the Jupiter 97W satellite as required by 47 C.F.R. §25.114 and other sections of the FCC's Part 25 rules that cannot be entered into the Schedule S submission.

A.2 GENERAL DESCRIPTION

The Jupiter 97W satellite will operate at the nominal 97.1° W.L. orbital location and provide Ka broadband communications services to both user earth stations ("UES") and gateway earth stations ("GES") located in United States, Canada, Columbia, Costa Rica, Cuba, Mexico, Panama and Venezuela.

The satellite will operate its gateway links in the 27.85-29.1 GHz and 29.25-30.0 GHz bands (Earth-to-space) and the 18.3-19.3 GHz and 19.7-20.2 GHz bands (space-to-Earth) bands. The UES links operate in the 29.25-30.0 GHz (Earth-to-space) and the 18.3-19.3 GHz and 19.7-20.2 GHz (space-to-Earth) bands. It uses both left and right hand circular polarization (LHCP and RHCP) together with spatial frequency re-use between geographically separated beams to achieve full frequency re-use at acceptable levels of co- and cross-polarized intra-system interference.

There are a total of 22 gateway beams, 17 of which are in CONUS, two in Canada and three in Mexico. There are 139 UES beams, with 90 of these being in CONUS, two in Alaska, 16 in

Canada, 24 in Mexico, five in Central/South America, one in Puerto Rico and one in Cuba.[1] The exact locations of the GES beams are given in Annex A. The figure in Annex C displays by means of a contour, the region on the Earth encompassing the boresight of all the UES beams.

The U.S. gateway beams will provide gateway services for both the U.S. UES beams as well as UES beams outside the U.S. The gateway beams in Canada and Mexico will provide gateway services to the UES beams in these respective countries. There are three UES beams in the Canadian/U.S. border area which are interconnected with two separate gateways (one in Canada and one in the United States). Through this technical configuration on the satellite, Hughes will ensure that all U.S. subscribers, including those on the U.S./Canada border, will be serviced by a gateway that is located in the United States.

The planned locations of the U.S. gateway earth stations are given in Annex A and are used in Annex B to complete an analysis of the coordination issues with respect to terrestrial services in the 27.85-28.35 GHz frequency band.

The satellite utilizes a bent-pipe architecture with asymmetric forward (gateway-to-user) and return (user-to-gateway) links. Forward links consist of a single wideband TDM carrier, typically of 250 MHz bandwidth but with the ability to also operate down to reduced bandwidths. The return links use MF-TDMA with a variety of bandwidths/data rates employed. The networks will use adaptive coding and modulation to combat rain fades. This allows the modulation type, amount of coding and/or subscriber data rate to be dynamically varied to meet the link requirements during rain events.

Information concerning additional satellite antenna beams used for telemetry, tracking and control ("TT&C"), beacons, RF auto-tracking ("RFAT") and in orbit testing ("IOT") is given in Section A6 below.

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[1] The beam directed towards Cuba will not be used until appropriately licensed.

As explained in Section A.11.3, the Jupiter 97W satellite is proposed to be offset by 0.1° from 97º W.L. with the center of the station-keeping box at 97.1° W.L. in order to avoid an overlap of the station-keeping volume with a satellite that operates nominally at 97.0° W.L.

The Jupiter 97W satellite will be operated by Hughes Network Systems, LLC ("Hughes") under the International Telecommunications Union ("ITU") network RAGGIANA-5 registered at the ITU by Papua New Guinea. Hughes will ensure that the transmissions between the U.S. earth stations and the Jupiter 97W satellite comply with the coordination agreements obtained by Papua New Guinea.

A.3 PREDICTED SPACE STATION ANTENNA GAIN CONTOURS

Consistent with §25.114(c)(4)(vii) the Schedule S contains representative gain contours for some fixed beams that are essentially identical except for their pointing directions. These beams are as follows:

- One transmit and one receive beam that represent all the UES spot beams (with the exception of the shaped Cuba beam);
- One transmit and one receive beam that represent all the gateway beams;
- One receive beam that represents the four beams used for Radio Frequency Auto Tracking ("RFAT").

The map of the isoline encompassing the boresight of all the US spot beams is shown in Annex C.[2] The GXT file capturing this contour is included with the application.

In addition the following unique beams are included in the Schedule S:

- A shaped fixed receive and transmit beam providing coverage of Cuba;
- A transmit beam used for beacon downlink transmissions;
- A transmit beam used for IOT downlink transmissions.

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[2] See Section 25.114 (c)(4)(vii) of the Commission's rules.

Two additional satellite beams that are included in the Schedule S, but for which no GXT contour data is provided, are the emergency-mode telecommand receive and telemetry transmit beams. These are both near-omnidirectional and therefore do not require gain contour information, consistent with §25.114(c)(4)(vi)(A).

A.4 FREQUENCY PLAN AND TRANSPONDER CONNECTIVITY

The frequency plan is provided in Sections S2, S9 and S10 of the Schedule S. S2 provides the broad frequency ranges while S9 defines the detailed uplink and downlink channels. S10 defines the interconnection between uplink channels and downlink channels, including the flexible interconnection capability of the communications payload and the type of beam to which the channels can be connected.

A.5 TT&C, BEACON, RF TRACKING AND IOT OPERATIONS

TT&C for the Jupiter 97W satellite will take place from the existing Hughes satellite control center in Cheyenne, WY, with backup from Gilbert AZ. Details of the TT&C technical characteristics and transmissions are given in the Schedule S.

During the launch and early operations phase ("LEOP"), as well as during spacecraft emergencies, TT&C is performed using near-omnidirectional satellite antenna beams. In normal on-station mode, the TT&C is performed using two of the gateway beams that are pointed towards Cheyenne and Gilbert.

The satellite also transmits a downlink beacon that is used for measuring rain fades. The data from this is used for the uplink power control system of the transmitting gateway earth stations.

The accuracy of the pointing of the satellite antennas is enhanced by means of an RFAT system. This involves transmissions from four dedicated earth stations in North America (two in the USA and two in Canada) which are received by four separate RFAT antenna beams on the Jupiter 97W satellite.

In addition there is an IOT transmit antenna on the Jupiter 97W satellite that is used for uniquely for the in orbit testing of the satellite. Since all UES and GES beams are narrow, dedicated hardware is need to isolate the uplink from the downlink during testing. This is done through the use of a small horn antenna that is oriented towards Earth and has a very wide beam width. The IOT antenna simplifies testing by allowing the re-transmission any receive beam. Through the use of this beam, the performance each receive beam can be characterized through the use of a single testing earth station.[3]

A.6 CESSATION OF EMISSIONS

All downlink transmissions can be turned on and off by ground telecommand, thereby causing cessation of emissions from the satellite, as required.

Hughes has the capability of reducing or terminating transmissions to and from the U.S. beams of the Jupiter 97W satellite should a directive to do so be received from the FCC.

A.7 POWER FLUX DENSITY AT THE EARTH'S SURFACE

The Jupiter 97W satellite uses the 18.3-19.3 GHz and 19.7-20.2 GHz downlink bands. The FCC rules contain PFD limits pertaining to these bands, as follows:

- §25.208(c) contains PFD limits that apply in the 18.3-18.8 GHz band;
- §25.208(d) contains additional PFD limits aggregated across the 18.6-18.8 GHz band;

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[3] The satellite attitude will adjusted such that the receive beam under test will point towards the in orbit testing earth station. (This station has a high gain antenna in order to have the lowest noise floor.) As the IOT antenna beam has a large beam width, the signal from this antenna can be received at the test gateway. Minor variations in the satellite attitude are needed to test the receive antenna pattern but will have little impact on the signal received from the IOT antenna. No transmission will occur from this antenna once the in orbit testing has been completed.

- §25.208(e) contains PFD limits that apply in the 18.8-19.3 GHz band;[4]
- (There are no PFD limits in the 19.7-20.2 GHz band).

The PFD limits of §25.208(c), which apply in the 18.3-18.8 GHz band, as well as the PFD limits of §25.208(e), which apply in the 18.8-19.3 GHz band, are as follows:[5]

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

Compliance of the downlink transmissions with the above mentioned FCC PFD limits is demonstrated below using a simple worst-case methodology. The maximum downlink EIRP that the Jupiter 97W satellite can generate by any one of its TWTAs operating with the UES downlink beams is 71 dBW. Every one of these TWTAs supports carriers in four 250 MHz user downlink channels, and therefore the 71 dBW EIRP is effectively spread over a 1,000 MHz bandwidth, resulting in a maximum EIRP density of 41 dBW/MHz (i.e., 71-10log(1000). The shortest distance from the satellite to the Earth is 35,786 km, corresponding to a spreading loss of 162.1 dB. Therefore the maximum possible PFD at the Earth's surface in the UES downlink beams cannot exceed -121.1 dBW/m^2/MHz (i.e., 41 - 162.1). This level meets the -115 dBW/m^2/MHz PFD limit value that applies at elevation angles of 5° and below, with at least 6 dB margin.

For the Jupiter 97W *gateway* downlink beams the maximum EIRP density will also not exceed 41 dBW/MHz, and so the PFD at the Earth's surface will similarly not exceed -121.1 dBW/m^2/MHz.

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[4] The wording of rule §25.208(e) makes reference to non-GSO constellations but this PFD limit is assumed to apply equally to GSO space stations and mirrors the identical PFD limits in this band in the ITU Radio Regulations which apply to GSO space stations.

[5] These PFD limit values are based on the formulae given in §25.208(e) but with the value of X equal to one for a GSO satellite.

In addition, §25.208(d) of the FCC rules contains PFD limits that apply in the aggregate across the 18.6-18.8 GHz band produced by emissions from a space station under assumed free-space propagation conditions as follows:

- -95 dB(W/m^2) for all angles of arrival. This limit may be exceeded by up to 3 dB for no more than 5% of the time.

This would correspond to a PFD limit of -118 dBW/m^2/MHz (i.e., -95-10*log(200)) averaged over the 200 MHz bandwidth. As demonstrated above, no downlink transmissions from the Jupiter 97W satellite in any of its downlink beams will exceed -121.1 dBW/m^2/MHz at any angle of arrival and therefore, compliance with §25.208(d) is also assured.

Therefore, compliance with all the Commission's PFD limits for all of the downlink beams of the Jupiter 97W satellite is assured.

A.8 KA-BAND TWO DEGREE COMPATIBILITY AT 97.1° W.L.

No transmissions of the Jupiter 97W satellite network will exceed the uplink off-axis EIRP density and downlink PFD levels of §25.138, regardless of whether the frequency band used is subject to §25.138.

A.8.1 Frequency Bands Subject to §25.138

Some of the frequency bands used by the Jupiter 97W satellite are included in §25.138. Those bands are 18.3-18.8 GHz, 19.7-20.2 GHz, 28.35-28.6 GHz and 29.25-30.0 GHz. Compliance with the Commission's two-degree spacing policy is assured in these bands provided:

- The uplink off-axis EIRP density levels of §25.138(a) of the rules for blanket licensing are not exceeded;
- The maximum downlink PFD levels are lower than the PFD value of -118 dBW/m^2/MHz given in §25.138(a)(6) of the rules.

The clear sky uplink off-axis EIRP density limits of §25.138(a)(1) are equivalent to a maximum uplink input power spectral density ("PSD") of -56.5 dBW/Hz, assuming the antenna gain meets the off-axis gain mask of §25.209. Below we will demonstrate that the maximum PSD level from any of the transmitting earth stations to be located in U.S. territory is below this value of -56.5 dBW/Hz:

- For the transmitting gateway earth stations, the maximum EIRP level is 72 dBW in 250 MHz bandwidth. This corresponds to a PSD level into the antenna of approximately -75 dBW/Hz, which is 18.5 dB below the above mentioned limit value.

- All the UES will meet the off-axis EIRP density limits of §25.138(a). An example of this would be terminals whose antennas meet the off-axis gain mask of §25.209 and have a 2 Watt power amplifier operating over a 1 MHz bandwidth. This results in a maximum PSD level of -56 dBW/Hz.

No authorized uplink transmissions toward the Jupiter 97W satellite from earth stations located in the United States will exceed the clear sky uplink off-axis EIRP density limits of §25.138(a).

Section A.7 above demonstrates that the maximum downlink PFD that could be transmitted by the Jupiter 97W satellite, at an elevation angle of 90 degrees, is -121.1 dBW/m^2/MHz and, therefore, the PFD levels at all other elevation angles will necessarily be lower. Accordingly, all downlink Ka band transmissions from the Jupiter 97W satellite will be compliant with §25.138(a)(6) of the rules.

A.8.2 Frequency Bands Not Subject to §25.138

The only frequencies to be used by the Jupiter 97W satellite, which are not covered by §25.138, are as follows:

- For the gateway links: the 27.85-28.35 GHz and 28.6-29.1 GHz uplink bands and the 18.8-19.3 GHz downlink band;
- For the UES links: the 18.8-19.3 GHz downlink band.

This section demonstrates that the transmissions in these bands are two-degree compatible.[6]

Currently there are no operational GSO Ka-band satellites that use the above listed bands within two degrees of the 97.1º W.L. location, nor are there any pending applications before the Commission for use of these bands by a GSO satellite within two degrees.

Therefore, in order to demonstrate two-degree compatibility in these frequency ranges, the transmission parameters of the Jupiter 97W satellite have been assumed as both the wanted and victim carriers. The link budgets given in Table 8-1 below are representative ones for the forward (gateway-to-user) and return (user-to-gateway) links. Included in these link budgets is an assessment of the effects of an adjacent interfering satellite spaced 2 degrees away operating with identical parameters to the Jupiter 97W satellite network. The results are given as an overall C/(N+I) degradation due to the interference, and values of 1 dB degradation in both forward and return direction are derived. This simple approach of assessing the overall C/(N+I) degradation is considered to be an appropriate way to represent the effects of the interference in a system employing adaptive coding and modulation, as used in the Jupiter 97W satellite and most Ka-band satellite networks these days.

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[6] Even in the frequency bands not covered by §25.138, the uplink transmissions from the gateway earth stations of the Jupiter 97W network are still compliant with the uplink off-axis EIRP density levels that are given in §25.138.

Table 8-1. Link Budgets to Demonstrate 2 Degree Compatibility in Frequency Bands Not Subject to §25.138

Link Parameters		FORWARD LINK (clear-sky)	RETURN LINK (clear-sky)
Link Geometry:			
Path length (assumed, typical)	(km)	38,000	38,000
Uplink (per carrier):			
Carrier Frequency	(MHz)	29,000	29,250
HPA Power Level	(W)	6.60	2.00
HPA Power in dBW	(dBW)	8.2	3.0
PSD into Tx E/S Antenna	(dBW/Hz)	-75.8	-57.0
Tx E/S Antenna Diameter	(m)	6.3	0.74
Tx E/S Antenna Gain	(dB)	63.8	45.6
Tx E/S EIRP per Carrier	(dBW)	72.0	48.6
Atmospheric & Rain Losses	(dB)	1.00	1.00
Free Space Loss	(dB)	213.3	213.4
Satellite:			
G/T towards Tx E/S	(dB/K)	22.3	15.3
EIRP per Carrier towards Rx E/S	(dBW)	62.0	38.0
Downlink:			
Carrier Frequency	(MHz)	18,300	18,300
Atmospheric & Rain Losses	(dB)	1.00	1.00
Free Space Loss	(dB)	209.3	209.3
Rx E/S Antenna Diameter	(m)	0.74	6.30
Rx E/S Antenna Gain	(dB)	42.2	59.8
Rx E/S G/T (clear-sky)	(dB/K)	18.2	35.8
System (LNA+Sky) Noise Temp.	(K)	250	250
Total Link:			
Carrier Noise Bandwidth	(kHz)	250,000	1,000
(C/N) - Thermal Uplink	(dB)	24.6	18.1
(C/N) - Thermal Downlink	(dB)	14.5	32.1
(C/I) - Intra-System Interference	(dB)	16.0	18.0
(C/N) - Overall Link without ASI	(dB)	11.9	15.0
Adjacent Satellite Interference :			
(C/I) - ASI Uplink	(dB)	39.3	21.1
(C/N+I) - Uplink	(dB)	24.5	16.3
(C/I) - ASI Downlink	(dB)	17.7	35.3
(C/N+I) - Downlink	(dB)	12.8	30.4
(C/N+I) - Overall Link with ASI	(dB)	10.9	14.0
ASI Degradation to Overall Link (C/N+I)	(dB)	1.0	1.0

The analysis presented above is based on the clear-sky situation. Under rain-fade conditions at a gateway earth station site the transmit power density would be increased, in proportion to the uplink rain fade, by up to 20 dB. However, under such conditions the rain would equally attenuate the interfering signal path to the adjacent satellite, and so the resulting interference level would remain the same, or very close to, the clear-sky values.

A.9 SHARING WITH NON-GSO FSS IN THE 28.6-29.1 GHZ BANDS

The 28.6-29.1 GHz uplink and 18.8-19.3 GHz downlink bands are allocated to non-geostationary orbit (non-GSO) FSS on a primary basis and allocated to GSO FSS on a secondary basis according to the FCC Ka band plan. Stations operating in a secondary service cannot cause harmful interference to or claim protection from harmful interference from stations of a primary service. The gateway transmissions in the Jupiter 97W network overlap with these non-GSO primary bands in both the 28.6-29.1 GHz uplink band and the 18.8-19.3 GHz downlink band. The user terminal transmissions in the Jupiter 97W network overlap with these non-GSO primary bands only in the 18.8-19.3 GHz downlink band.

In order to prevent the Jupiter 97W satellite network from causing harmful interference into non-GSO satellite networks using the 28.6-29.1 GHz uplink or 18.8-19.3 GHz downlink bands, the Jupiter 97W satellite and its associated earth stations will cease transmissions in these bands during all potential interference conditions. The highest interference levels that could occur into non-GSO networks from the Jupiter 97W network are when there is an “in-line” event. On the uplink an in-line event occurs when the non-GSO satellite, the GSO satellite and the interfering GSO earth station are all in a line. As the non-GSO satellite continues to move within its orbit, an angle between the non-GSO satellite and the GSO satellite, subtended at the GSO earth station, is created. As long as the GSO earth station does not transmit when the non-GSO satellite is within a certain angle, no harmful interference to the non-GSO satellite will occur. A similar situation exists on the downlink. The amount of angular separation required will be dependent on the parameters of the non-GSO FSS networks, their earth station locations, and their interference criteria.

Currently there is only the O3b Limited ("O3b") non-GSO satellite system authorized for U.S. market access by the Commission, and which overlaps with the Jupiter 97W network in the 28.6-29.1 GHz uplink and 18.8-19.3 GHz downlink bands.[7] The interference analysis provided below demonstrates that no harmful interference between O3b's non-GSO system, as proposed, and the Jupiter 97W satellite network will occur with respect to the links between the U.S. earth stations and the Jupiter 97W satellite.

Northrop Grumman Space and Mission Systems Corp. ("Northrop Grumman") had previously received Commission authorization for its Global EHF Satellite Network ("GESN") and ATCONTACT Communications, LLC ("ATCONTACT") had previously received Commission authorization for its non-GSO network. Both networks were to utilize highly elliptical orbits ("HEO"). The interference analysis contained herein demonstrates that the operations of the Jupiter 97W satellite network would protect the HEO satellite systems previously licensed to AtContact and NGST from harmful interference.

A.9.1 Sharing with the O3b System

Frequency overlap between the Jupiter 97W network and the O3b system occurs in the 28.6-29.1 GHz band for the gateway uplinks in the Jupiter network, and the 18.8-19.3 GHz band for both the GES and UES downlinks in the Jupiter network.

For the gateway uplinks the minimum latitude to be considered in this analysis is 33°N as this corresponds to the most southerly of the U.S. gateway earth stations (see Annex A). For the user downlinks the minimum latitude used is 17.9°N which corresponds to Puerto Rico, the most southerly U.S. territory where the FCC has jurisdiction and which falls within the service area of the Jupiter 97W network. The analyses below are based on these minimum latitudes.

Table 9-1 below gives the calculation of the potential uplink interference from a Jupiter 97W gateway earth station located in Puerto Rico which is at a latitude of 17.9°N and longitude of

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[7] *See* SES-LIC-20100723-00952

117.1°W. From this location the minimum angular separation between the Jupiter 97W satellite and the O3b orbit is 15.0°, as viewed from the surface of the Earth.

Table 9-1. Calculation of Uplink Interference from the Most Southerly Jupiter 97W Transmitting Gateway Earth Station into the O3b Satellite Receiver

Tx ES EIRP per carrier (clear-sky)	dBW	72
Tx carrier bandwidth	MHz	250
Tx ES antenna diameter	m	6.3
Tx ES antenna Tx gain (at 29.0 GHz)	dBi	63.80
Tx power (at antenna flange)(clear-sky)	dBW	8.20
Power Spectral Density (at antenna flange)(clear-sky)	dBW/Hz	-75.78
Minimum off-axis angle between GSO and O3b orbits	°	15.0
Off-axis gain of Tx ES Tx antenna (32-25log(θ))	dBi	2.60
EIRP density towards O3b orbit (clear-sky)	dBW/Hz	-73.18
Minimum Space Loss to O3b orbit (8,062 km)(29.0 GHz)	dB	199.82
Rx interfering signal power density at O3b satellite (34.5 dBi Rx gain)	dBW/Hz	-238.50
Noise power density at O3b satellite receiver (1000K)	dBW/Hz	-198.60
Resulting ΔT/T at O3b satellite receiver	%	0.0102%
Resulting I_o/N_o at O3b satellite receiver	dB	-39.90

The analysis in Table 9-1 above is based on the clear-sky situation. Under rain-fade conditions at the gateway earth station site the transmit power density would be increased, in proportion to the uplink rain fade, by up to 20 dB. However, under such conditions the rain would equally attenuate the interfering signal path to the O3b satellite, and so the resulting interference level would remain the same, or very close to, the clear-sky values. Any slight discrepancy in the uplink power control would be more than covered by the very large interference margin that exists.

From Table 9-1 the potential degradation of the O3b satellite receive system noise temperature is approximately 0.01% in the worst case, corresponding to an interference-to-noise density ratio of close to -40 dB. This level of interference is exceedingly low and therefore the potential uplink interference from the transmitting U.S. gateway earth stations of the Jupiter 97W network into the O3b satellites is considered to be acceptable.

Table 9-2 below gives the calculation of the potential downlink interference from the Jupiter 97W satellite into a potential O3b receiving earth station located in the lowest latitude territory where the FCC has jurisdiction, and which is also within the service area of the Jupiter 97W satellite (i.e., Puerto Rico). From this location the minimum angular separation between the Jupiter 97W satellite and the O3b orbit is 9.1°, as viewed from the surface of the Earth

Table 9-2. Calculation of Downlink Interference from the Jupiter 97W Transmitting Satellite into the O3b Receiving Earth Stations

Satellite EIRP per carrier (clear-sky)	dBW	65
Carrier bandwidth	MHz	250
Maximum PFD at Earth's surface	$dBW/m^2/MHz$	-121.0
Minimum off-axis angle between GSO and O3b orbits	°	9.1
Off-axis gain of O3b ES Rx antenna ($32-25\log(\theta)$)	dBi	8.02
Minimum Space Loss from GSO orbit (35,786 km)(19.0 GHz)	dB	209.09
Rx interfering signal power density at O3b ES receiver	dBW/Hz	-220.05
Noise power density at O3b ES receiver (300K)	dBW/Hz	-203.83
Resulting $\Delta T/T$ at O3b ES receiver	%	2.3890%
Resulting I_o/N_o at O3b ES receiver	dB	-16.22
Worst-case increase in noise floor due to interference	dB	0.1025

From Table 9-2 the potential degradation of the O3b earth station receive system noise temperature is approximately 2.4% in the worst case, corresponding to an interference-to-noise density ratio of -16.2 dB. This level of interference would only raise the noise floor of the O3b earth station receiver by 0.10 dB during the periods of time when the O3b satellite is closest to the GSO orbit as viewed from the O3b earth station. Such a low level of interference from the transmitting Jupiter 97W satellite into the O3b receiving earth stations should be considered to be acceptable. Note that for O3b earth stations located at higher latitudes (e.g., CONUS) the minimum separation angle will be greater and hence the interference will be even less.

A.9.2 Sharing with the NGST and AtContact HEO Systems

Table 9-3 summarizes the salient parameters of the GESN and ATCONTACT HEO satellite networks. These parameters are identical to those used by Northrop Grumman and ATCONTACT to demonstrate independently that their GSO operations in the 28.6-29.1 GHz band were compatible with the other's proposed non-GSO operations.[8] It can be seen that the two networks' orbital and transmission parameters are identical, which allows a single interference analysis to be performed.

Table 9-3. GESN and ATCONTACT HEO Satellite Characteristics.

	GESN	ATCONTACT
Orbital parameters		
- # of satellites	3	3
- # of planes	3	3
- # of satellites per plane	1	1
- Inclination	63.4°	63.4°
- Apogee	39352 km	39352 km
- Perigee	1111 km	1111 km
- Minimum Tx altitude	16000 km	16000 km
Satellite Rx gain	46.5 dBi	46.5 dBi
Satellite Rx system noise temp.	504 K	504 K
Earth station uplink input power density	-63.45 dBW/Hz	-63.45 dBW/Hz
Satellite downlink EIRP density	-18 dBW/Hz	-18 dBW/Hz
E/S Rx system noise temperature	315 K	315 K

In order to demonstrate compatibility with these two non-GSO networks, a worst case, static interference analysis is performed. The smallest possible angle will occur when the GSO satellite, the non-GSO satellite and the relevant earth station are all on the same longitude and the earth station is at a high latitude. Assuming a minimum 10° elevation angle for the GSO earth station, this sets the latitude to 71.4°N. The GESN and ATCONTACT satellites do not transmit when they are at an altitude below 16000 km, which translates to a latitude of 31.9°N. With this information, the smallest possible angular separation is then calculated to be 27.4 degrees. Both the transmitting GSO earth station (uplink calculation) and the victim non-GSO earth station (downlink calculation) have been assumed to be at a latitude of 71.4°N.

Table 9-4 shows the results of interference calculations from the Jupiter 97W network into the GESN and ATCONTACT networks and vice versa. For the uplink the maximum PSD of the

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[8] *See* SAT-AMD-20040719-00138 and SAT-AMD-20040719-00141.

Jupiter transmitting *gateway* earth station is used because only gateways are used in the uplink frequency band considered here. For the downlink the maximum downlink EIRP density for either gateway or user beams is used for the Jupiter network. The calculated ΔT/T values in all cases are very small, indicating the technical compatibility of the Jupiter 97W satellite network with the GESN, ATCONTACT and similar HEO non-GSO systems.

The compatibility of a GSO network such as Jupiter 97W with these types of non-GSO systems is largely due to the fact that the non-GSO satellites do not communicate with earth stations when they cross the equatorial plane, thus in-line events with a GSO network do not occur. For other types of non-GSO constellations that do communicate with earth stations when the satellites pass through the equatorial plane, it is possible that an in-line interference event could occur. In order to protect such systems, Hughes will cease transmissions from the Jupiter 97W satellite and its associated earth stations such that the required amount of angular separation with the non-GSO system is always maintained.

Table 9-4. Worst-Case Interference Calculations with respect to GESN / ATCONTACT

Victim network		GESN / ATCONTACT	JUPITER 97W
Interfering network		JUPITER 97W	GESN / ATCONTACT
Uplink:			
Frequency band	GHz	29	29
Interfering uplink input power density	dBW/Hz	-75.78	-63.45
Angular separation	degrees	27.4	27.4
Slant range (Interfering path)	km	21,046	40,586
Space loss (Interfering path)	dB	208.2	213.9
Atmospheric & scintillation losses	dB	1.2	1.2
Victim satellite receive antenna gain	dBi	46.5	56.9
Victim satellite Rx system noise temperature	K	504	1951
No	dBW/Hz	-201.6	-195.7
Io	dBW/Hz	-245.6	-228.6
Io/No	dB	-44.0	-32.9
ΔT/T	%	0.0039	0.0513
Downlink:			
Frequency band	GHz	19	19
Interfering satellite downlink EIRP density	dBW/Hz	-19.0	-18.0
Slant range (Interfering path)	dB	40,586	21,046
Space loss (Interfering path)	dB	210.2	204.5
Atmospheric & scintillation losses	dB	1	1
Angular separation	degrees	27.4	27.4
Victim Rx earth station system noise temperature	K	315	250
No	dBW/Hz	-203.6	-204.6
Io	dBW/Hz	-237.2	-230.5
Io/No	dB	-33.6	-25.9
ΔT/T	%	0.0440	0.2592

A.10 SHARING WITH TERRESTRIAL SERVICES

In the 27.5-28.35 GHz band the Commission has designated that the Local Multipoint Distribution Service (“LMDS”) must be protected by the FSS and that the FSS must not claim any protection from the LMDS.[9] The proposed gateway earth stations of the Jupiter 97W network will be capable of operating in this frequency band, and are proposed to do so on a non-interference basis with respect to existing or future LMDS systems. The detailed technical analysis of the potential interference between the proposed U.S. gateway earth stations and the LMDS service is given in Annex B of this document.

A.11 ORBITAL DEBRIS MITIGATION PLAN

The spacecraft manufacturer for the Jupiter 97W satellite is Space Systems/Loral. Hughes has ensured that the material objectives of §25.114(d)(14) are incorporated into its satellite Technical Specifications, Statement of Work and Test Plans of the Jupiter 97W satellite. This includes provisions to review orbital debris mitigation as part of the ongoing design reviews for the Jupiter 97W satellite and to incorporate any related requirements, as appropriate, into its Test Plan, including a formal Failure Mode Verification Analysis ("FMVA") for orbital debris mitigation involving particularly the TT&C, propulsion and energy systems. During this process, some changes to the Orbital Debris Mitigation Plan may occur and Hughes will provide the Commission with updated information, as appropriate.

A.11.1 Spacecraft Hardware Design

Hughes confirms that the satellite will not undergo any planned release of debris during its operation. Furthermore, all separation and deployment mechanisms, and any other potential source of debris will be retained by the spacecraft or launch vehicle.

Furthermore, Hughes confirms that they will assess and limit the probability of the satellite becoming a source of debris by collisions with small debris or meteoroids of less than one gram that could cause loss of control and prevent post-mission disposal. Hughes, in conjunction with

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[9] See the FCC's 28 GHz band plan established in CC Docket No. 92-297, including *In the Matter of Rulemaking to Amend Parts 1, 2, 21, and 25 of the Commission's Rules to Redesignate the 27.5-29.5 GHz Frequency Band, to Reallocate the 29.5-30.0 GHz Frequency Band, to Establish Rules and Policies for Local Multipoint Distribution Service and for Fixed Satellite Services*, 11 FCC Rcd 19005, ¶ 42 (1996) and related decisions.

Space System / Loral, has taken steps to limit the effects of such collisions through shielding, the placement of components, and the use of redundant systems.

The Jupiter 97W satellite incorporates a rugged TT&C system with regard to meteoroids smaller than one gram through redundancy, shielding, and appropriate physical separation of components. The TT&C subsystem has no single points of failure and is equipped with near omni-directional antennas mounted on opposite sides of the spacecraft. These antennas are extremely rugged and capable of providing adequate coverage even if struck, bent or otherwise damaged by a small or medium sized particle. The omni-directional antennas, for both command and telemetry, are sufficient to enable orbit raising. The command receivers and decoders and telemetry encoders and transmitters are located within the satellite's Faraday cage which provides shielding and is totally redundant and physically separated.

The propulsion subsystem is designed such that it will not be separated from the spacecraft after de-orbit maneuvers. It is protected from the effects of collisions with small debris through shielding. Moreover, propulsion subsystem components critical to disposal (e.g., propellant tanks) are located deep inside the satellite, while other components, such as the thrusters, externally placed, are redundant to allow for de-orbit despite a collision with debris.

A.11.2 Minimizing Accidental Explosions

Hughes, in conjunction with Space System / Loral, has assessed and limited the probability of accidental explosions during and after completion of mission operations. The satellite is designed to ensure that debris generation will not result from the conversion of energy sources on board the satellite into energy that fragments the satellite. The propulsion subsystem pressure vessel is designed with high safety margins. Bipropellant mixing is prevented by the use of valves that prevent backwards flow in propellant lines and pressurization lines. All tank pressures will be monitored by telemetry. At end-of-life and once the satellite has been placed into its final disposal orbit, Hughes, will ensure the removal of all stored energy from the spacecraft by depleting any residual fuel, leaving all fuel line valves open, venting the pressure vessels and the batteries will be left in a permanent state of discharge.

A.11.3 Safe Flight Profiles

In considering current and planned satellites that may have a station-keeping volume that overlaps the Jupiter 97W satellite, Hughes has reviewed the lists of FCC licensed satellite networks, as well as those that are currently under consideration by the FCC. In addition, networks for which a request for coordination has been published by the ITU within ±0.15° of 97.1° W.L. have also been reviewed.

Intelsat operates the C-/Ku-band GALAXY-19 satellite at 97° W.L. with an east-west station-keeping tolerance of ±0.05°. There are no pending applications before the Commission to use an orbital location within ±0.15° of 97° W.L.

With respect to non-USA ITU filings, the ITU has published the following networks:

- The UK's INMARSAT-KA 97W at 97.0° W.L.;
- Malaysia's MEASAT-ROUTE-4B at 97.2° W.L.;

We can find no concrete evidence that any of these satellite networks are progressing towards launch.

Based on the preceding, Hughes seeks to locate the Jupiter 97W satellite at 97.1° W.L. in order to eliminate the possibility of any station-keeping volume overlap with the GALAXY-19 satellite that operates nominally at 97° W.L. Hughes concludes that physical coordination of the Jupiter 97W satellite with another satellite operator is not required at the present time.

A.11.4 Post-Mission Disposal

At the end of the operational life of the Jupiter 97W satellite, it will be maneuvered to a disposal orbit with a minimum perigee of 300 km above the normal GSO operational orbit. The post-mission disposal orbit altitude is based on the following calculation, according to §25.283:

Total Solar Pressure Area “A” = 98.3 m^2

“M” = Dry Mass of Satellite = 3642 kg

“C_R” = Solar Pressure Radiation Coefficient = 1.33

Therefore the Minimum Disposal Orbit Perigee Altitude is calculated as:

= 36,021 km + 1000 x C_R x A/m

= 36,021 km + 1000 x 1.24 x 100/3642

= 36,055.7 km

= 269 km above GSO (35,786 km)

To provide adequate margin, the disposal orbit will be increased to 300 km. This will require approximately 8.5 kg of propellant, taking account of all fuel measurement uncertainties, which will be allocated and reserved in order to perform the final orbit raising maneuver.

A.12 CROSS-POLAR ISOLATION OF THE SATELLITE ANTENNAS

The gateway beams are designed to have a minimum polarization isolation of 30 dB as the gateways fully reuse the entire spectrum in both polarizations. The user beams are designed to have a lower cross-polarization isolation as beams using the opposite polarization do not overlap.[10] As a consequence, user beams have a cross polarization of 22.5 dB or better. The use of a polarization of less than 30 dBi impacts no other licensee except for Hughes which has taken this factor into account in its link budget calculations.

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[10] The UES beams on Jupiter 97 make use of a four color frequency re-use scheme.

Annexes

Annex A – Peak of RFAT Beams

Annex B – LMDS Analysis

Annex C – Isoflux Diagram

Annex A: Peak of RFAT Beams

RFAT Receive Beams:

Beam Center	Polarization	Longitude	Lattitude
Yellowknife, NT, Canada	RHCP	114.4281° W	62.4331° N
Iqaluit, NU, Canada	RHCP	68.5560° W	63.7392° N
Eugene, OR	LHCP	123.061° W	44.0917° N
Monee, IL	LHCP	87.7761° W	41.4685° N

Gateway Locations

Gateway Receive and Transmit Beams:

City	**Longitude°E**	**Latitude°N**
Albuquerque, NM	-106.653	35.0923
Amarillo	-101.832	35.2046
Billings, MT	-108.541	45.7686
Bismark, ND	-100.7802	46.8516
Boise, ID	-116.31	43.6077
Cheyenne, WY	-104.736	41.132
Duluth, MN	-92.132913	46.826789
Gilbert, AZ	-111.814	33.3655
Roseburg, OR	-123.346070	43.211561
Missoula, MT	-114.117	46.9361
North Las Vegas, NV	-115.118	36.2361
North Platte, NE	-100.753	41.0908
Omaha, NE	-96.0591	41.2643
San Diego, CA	-117.0735	32.9888

Seattle, WA	-122.295	47.4942
San Jose, CA	-121.961	37.3652
Salt Lake City, UT	-111.728	40.3325
Edmonton, Canada	-113.286	53.5124
Regina, Canada	-104.478	50.4461
Chihuahua, Mexico	-106.120933	28.718325
Hermosillo, Mexico	-111.004444	29.095833
Monterrey, Mexico	-100.193522	25.764230

Annex B: LMDS Interference Analysis for the U.S. Gateway Earth Stations

In the 27.5-28.35 GHz band the Commission has designated that the Local Multipoint Distribution Service ("LMDS") must be protected by the FSS and that the FSS must not claim any protection from the LMDS.[1] The proposed U.S. gateway earth stations operating in the conjunction with the JUPITER 97W satellite will be capable of operating in the 27.85 - 28.35 GHz band on a non-interference basis with existing or future LMDS systems. The following technical analyses evaluate the interference into LMDS systems from the gateway uplinks under several worst-case scenarios.[2]

The initial worst-case analysis is based on the following assumptions:

a. The LMDS terminals have a gain of 31 dBi and a receiver noise figure of 6 dB;[3]
b. An LMDS interference threshold of I/N of -12.2 dB;
c. The LMDS hub is collocated with the gateway;[4]
d. Free space propagation;
e. The transmitting earth station is pointing at the JUPITER 97W satellite and in an azimuth direction that aligns with the LMDS user terminal.

This analysis determines the maximum required separation distance between an LMDS user terminal and a Hughes gateway earth station under these conditions. This scenario results in the

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[1] See the FCC's 28 GHz band plan established in CC Docket No. 92-297, including *In the Matter of Rulemaking to Amend Parts 1, 2, 21, and 25 of the Commission's Rules to Redesignate the 27.5-29.5 GHz Frequency Band, to Reallocate the 29.5-30.0 GHz Frequency Band, to Establish Rules and Policies for Local Multipoint Distribution Service and for Fixed Satellite Services*, 11 FCC Rcd 19005, ¶ 42 (1996) and related decisions.

[2] In addition to the technical analysis provided below, Hughes has also commissioned Comsearch to calculate the coordination contour around each GES. A Prior Coordination Notice ("PCN") was sent to each LMDS licensee withing the coordination contour. The report from Comsearch is attached to this application.

[3] Robert Duhamel, Telcordia Technologies, "Local Multipoint Distribution Service (LMDS) Cell Sizing and Availability," IEEE P802.16 Broadband Wireless Access Working Group, 9 June 1999.

[4] The higher antenna gain for the user terminal compared to the hub station make the user terminals more susceptible to interference and results in larger separation distances. Therefore, only the results of the analysis for interference into the LMDS user terminals are presented here.

lowest elevation angle and smallest off-axis angle toward the LMDS user terminal and, thus, will result in the highest level of interference into the LMDS receive antenna main beam. The calculation of the worst-case interference for four of the gateway earth station locations is shown in Table A2-1.

Table A2-1. Calculation of Uplink Interference from U.S. Gateway Earth Stations of the JUPITER 97W Network into an LMDS user terminal

Gateway Earth Station	Missoula	Duluth	Cheyenne	Omaha
Frequency (GHz)	27.85	27.85	27.85	27.85
GSO ES On-Axis EIRP (dBW)(clear-sky)[5]	72	72	72	72
Bandwidth (MHz)	250	250	250	250
GSO ES On-Axis EIRP Density (dBW/MHz)	48.02	48.02	48.02	48.02
GSO ES antenna diameter (m)	5.6	8.1	9.2	13.2
GSO ES On-Axis Transmit Antenna Gain (dBi)	62.4	65.6	66.7	69.8
GSO ES On-Axis PSD (dBW/MHz)	-14.37	-17.58	-18.68	-21.82
Minimum off-axis angle (°)	33.5	35.9	41.8	42.3
Maximum off-Axis Transmit Antenna Gain toward horizon (dBi) using 25.209 mask	-9.13	-9.89	-10.00	-10.00
Maximum Off-Axis EIRP Density toward horizon (dBW/MHz)	-23.50	-27.47	-28.68	-31.82
Polarization Discrimination (dB)	0	0	0	0
LMDS Thermal Noise Density (dBW/MHz)	-138	-138	-138	-138
LMDS Required I/N (dB)	-12.2	-12.2	-12.2	-12.2
Interfering Power Density to meet required I/N (dBW/MHz)	-150.2	-150.2	-150.2	-150.2
LMDS user-terminal Receive Antenna Gain (dBi)	31	31	31	31
Distance (km) (free space loss)	65.71	41.64	36.19	25.22

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[5] Under rain-fade conditions when the transmitting gateway earth station may increase its power to help overcome the rain attenuation, the resulting interference to an LMDS receiver is expected to be less than under clear-sky conditions. This is because the rain attenuation on the path between the gateway earth station and the LMDS receiver terminal will likely be greater than on the path between the gateway earth station and the JUPITER 97W satellite.

While all sites beyond the separation distances calculated using the above worst-case methodology will not suffer from interference, a more detailed consideration is required for terminals located within this geographic circle for each of the JUPITER 97W gateway earth stations. This subsequent analysis was performed using Visualyse software to identify areas where the interference threshold may be exceeded using a more realistic propagation model[6] and actual terrain features found around the specific gateway locations. As before, the LMDS hub station is assumed to be collocated with the gateway earth station. The LMDS user terminals were then located in a grid around the gateway with 0.1 km between LMDS terminals. At each of these grid locations, the I/N was calculated and compared to the -12.2 dB criterion. Contours are displayed to show areas where the interference threshold is exceeded.

Figure A2-1 shows the worst-case scenario in which the LMDS hub station is collocated with the Albuquerque gateway earth station. The results show that the maximum required separation distance in this scenario is about 26 km. However, the overall area where the I/N into the LMDS user terminal may exceed -12.2 dB in this worst-case scenario is a small portion of the area surrounding the gateway earth station. Figures A2-2 through A2-19 show the worst-case scenarios in which the LMDS hub station is collocated for the other 16 gateway earth station locations listed in Annex A (note that both Cheyenne and Gilbert have two gateway antenna sizes).

In summary, the area in which the harmful interference threshold may be exceeded in proximity to the gateway is small, and would become even smaller when a realistic location of the LMDS hub is selected. These contours stand to further reduce or disappear altogether when the measured gateway antenna performance is taken into account. As 5.6 meter to 13.2 meter antennas have an off-axis performance that is typically 10 to 20 dB below the performance mask used in this study, the interference levels that will be measured will be well below those identified in this worst case analysis.

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[6] Recommendation ITU-R P.452-13 “Predictions procedure for the evaluation of microwave interference between stations on the surface of the Earth at frequencies above about 0.7 GHz.”

However, in the highly unlikely event that an LMDS link were to receive unacceptable interference from one of the three gateways earth stations, Hughes undertakes to correct the situation by either reducing the transmitted power in the affected channel(s) or installing RF shielding in the direction of the impacted receiver.

Figure A2-1. Worst-Case Scenario for Albuquerque Gateway Earth Station

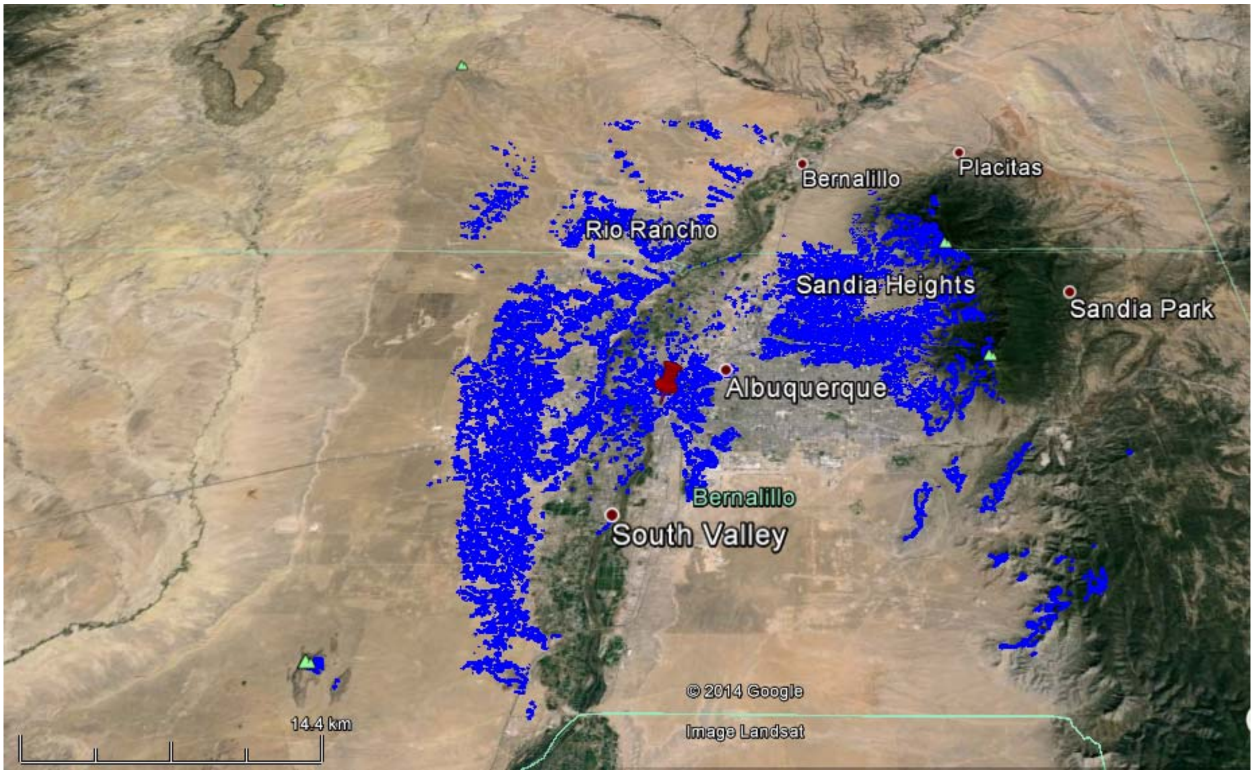


Figure A2-2. Worst-Case Scenario for Amarillo Gateway Earth Station

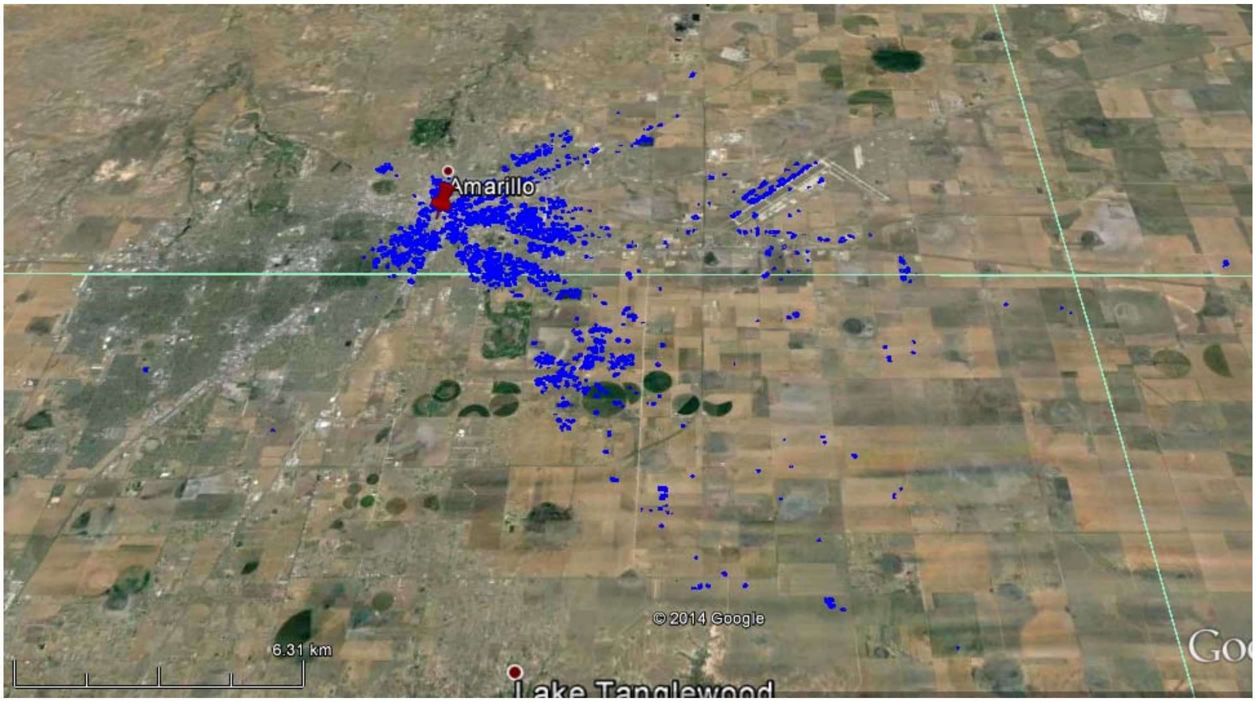


Figure A2-3. Worst-Case Scenario for Billings Gateway Earth Station

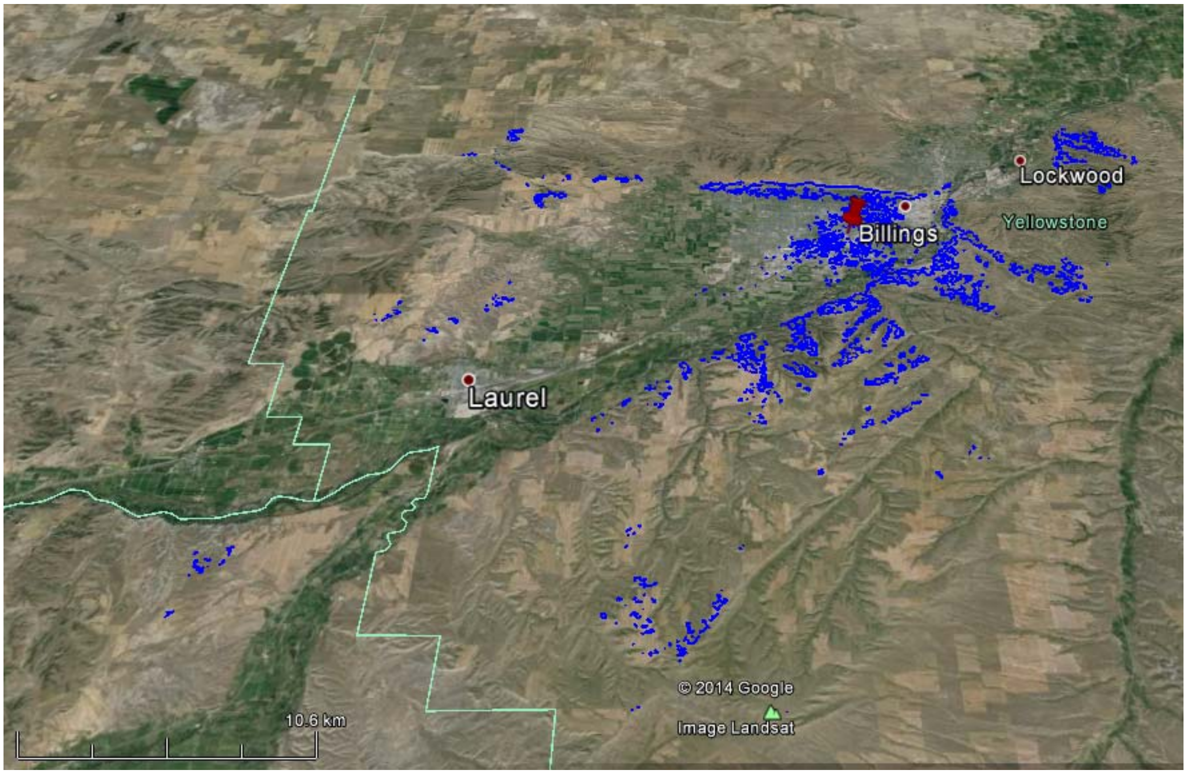


Figure A2-4. Worst-Case Scenario for Bismarck Gateway Earth Station

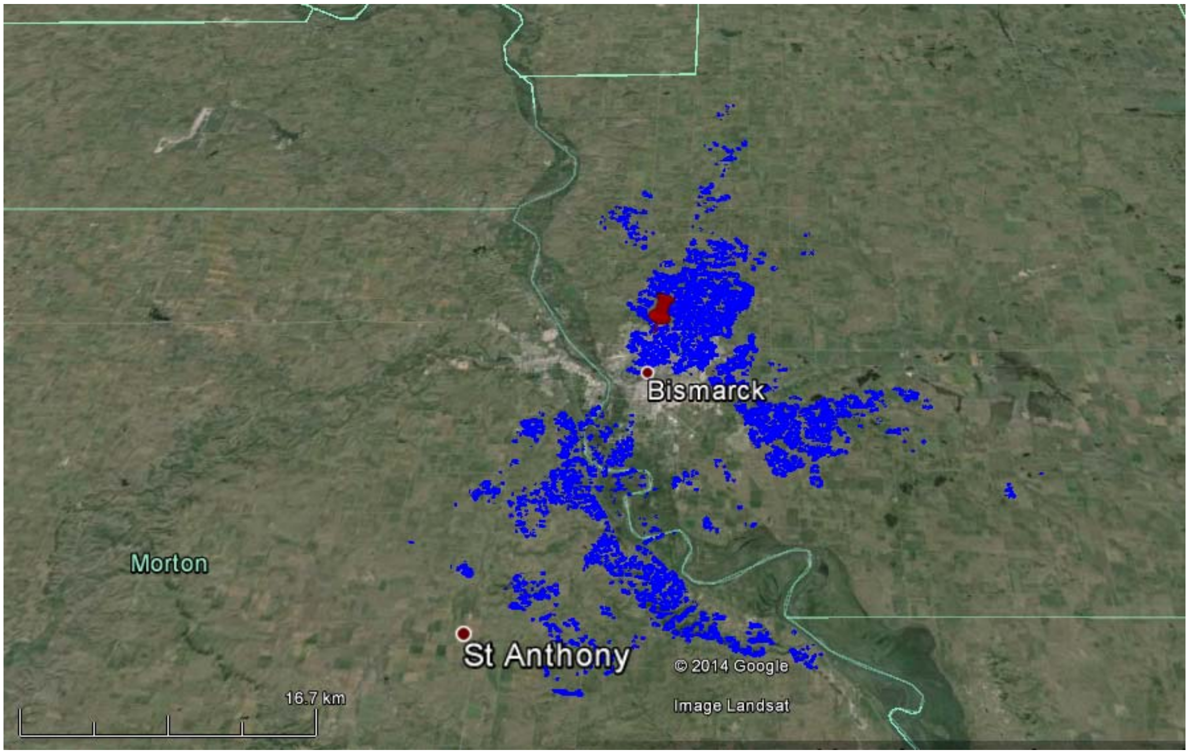


Figure A2-5. Worst-Case Scenario for Boise Gateway Earth Station

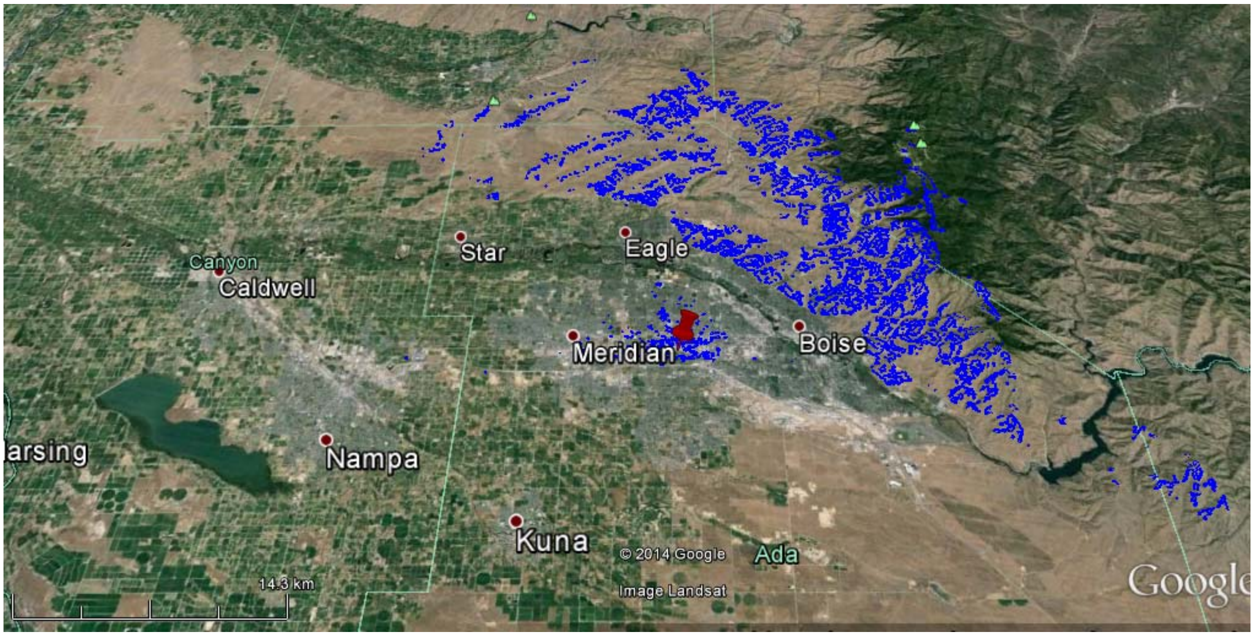


Figure A2-6. Worst-Case Scenario for Cheyenne (8.1 meter) Gateway Earth Station

Figure A2-7. Worst-Case Scenario for Cheyenne (9.2 meter) Gateway Earth Station

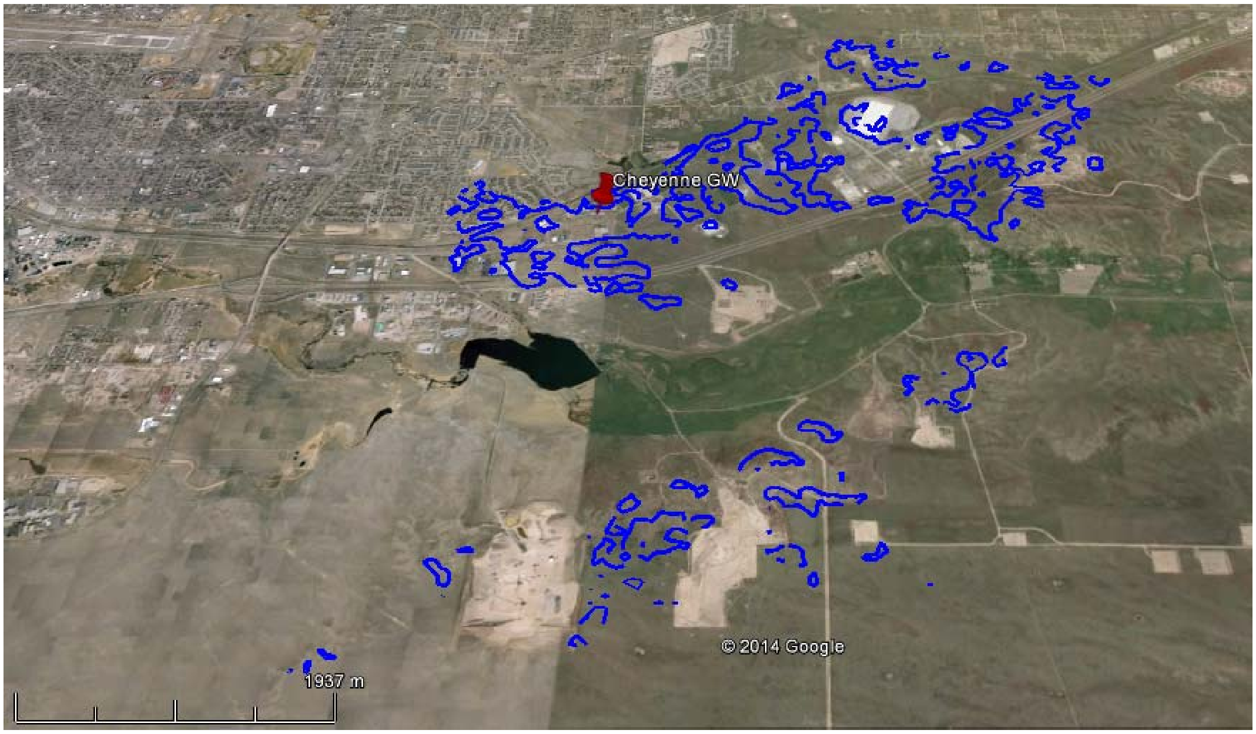


Figure A2-8. Worst-Case Scenario for Duluth Gateway Earth Station

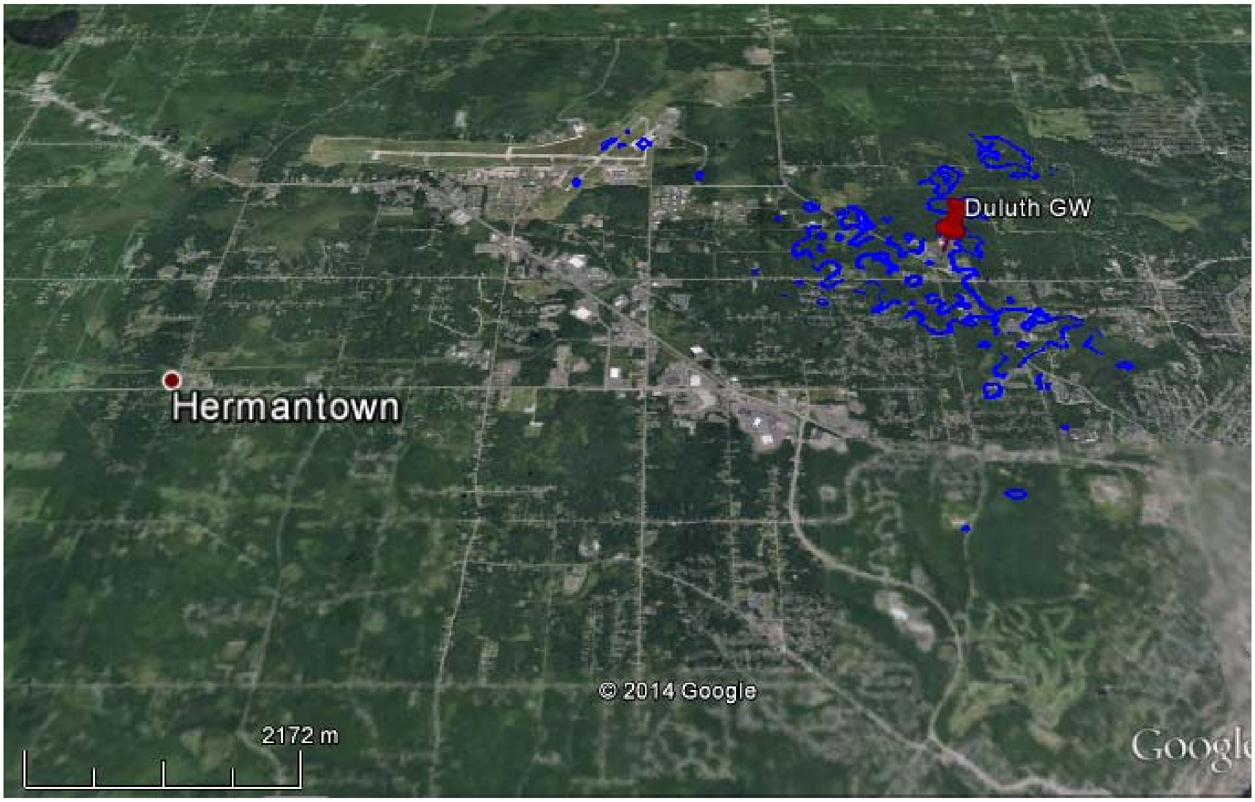


Figure A2-9. Worst-Case Scenario for Gilbert (8.1 meter) Gateway Earth Station

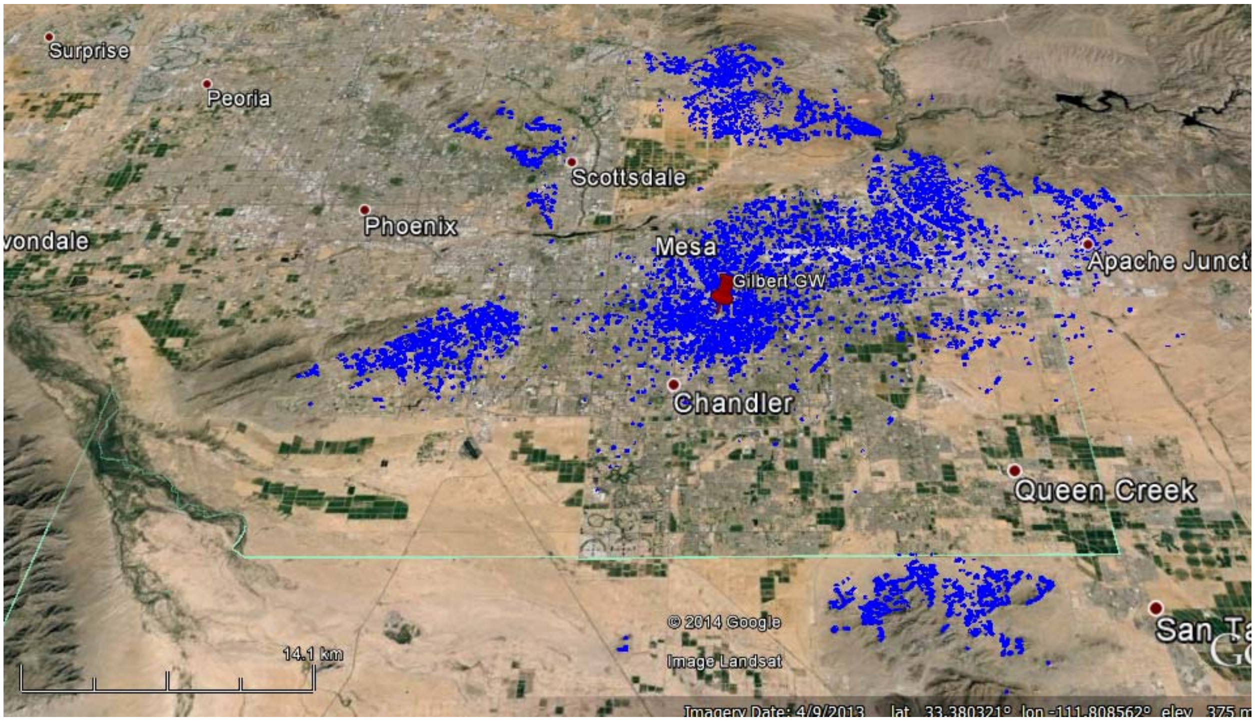


Figure A2-10. Worst-Case Scenario for Gilbert (9.2 meter) Gateway Earth Station

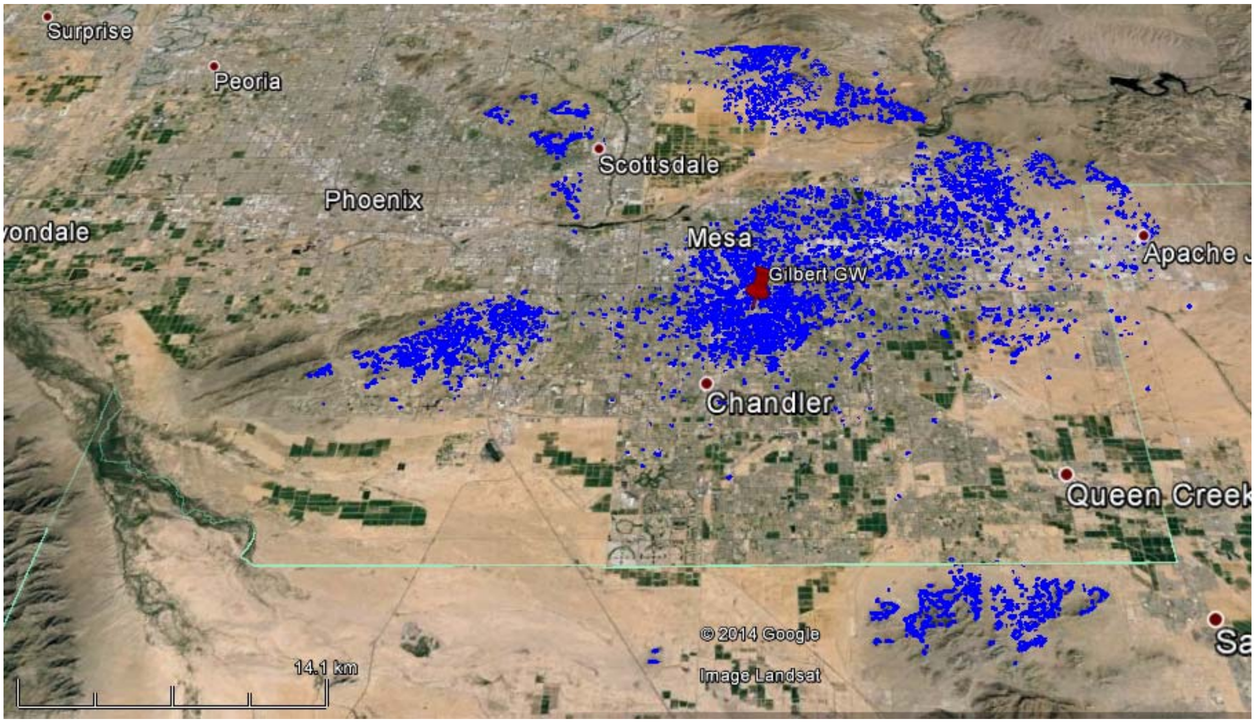


Figure A2-11. Worst-Case Scenario for Roseburg Gateway Earth Station

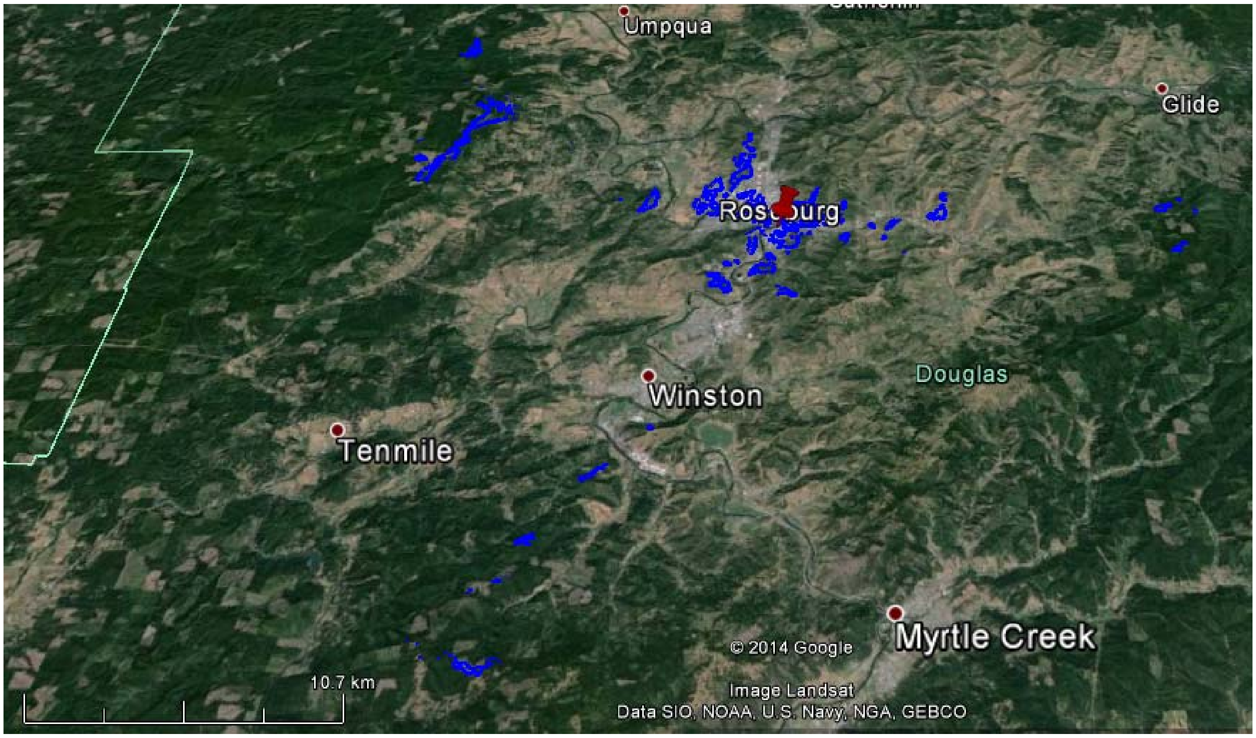


Figure A2-12. Worst-Case Scenario for Missoula Gateway Earth Station

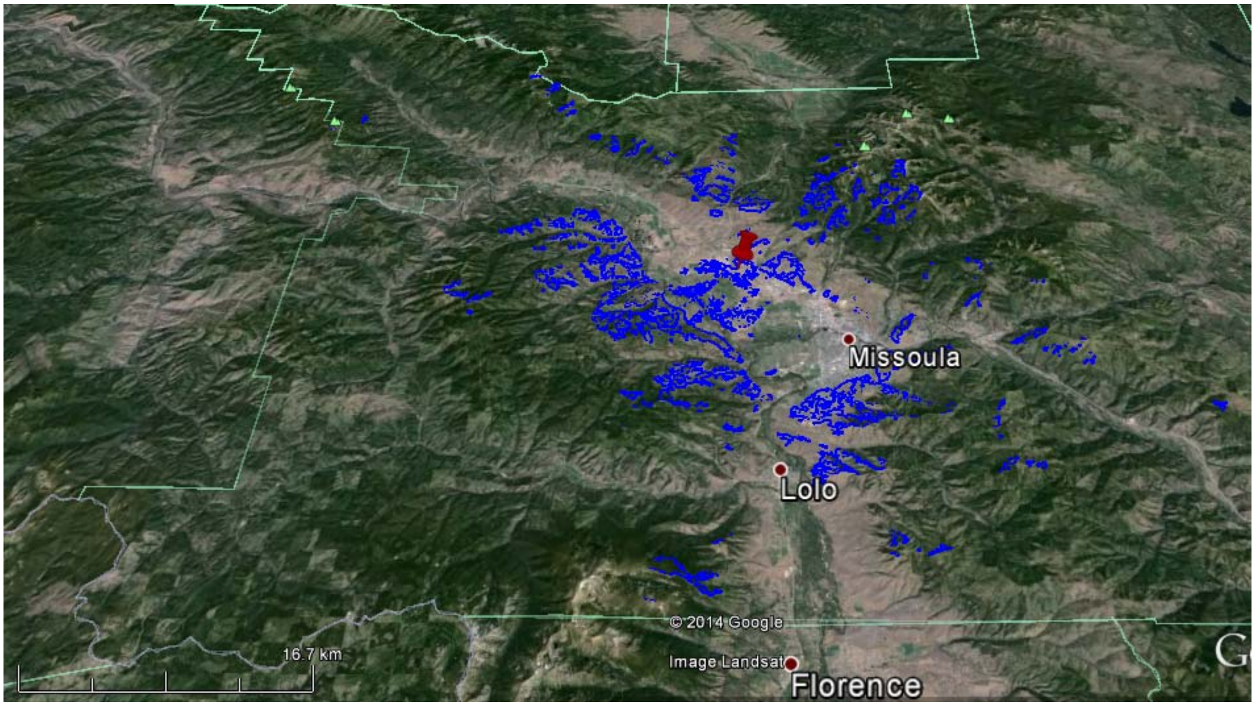


Figure A2-13. Worst-Case Scenario for North Las Vegas Gateway Earth Station

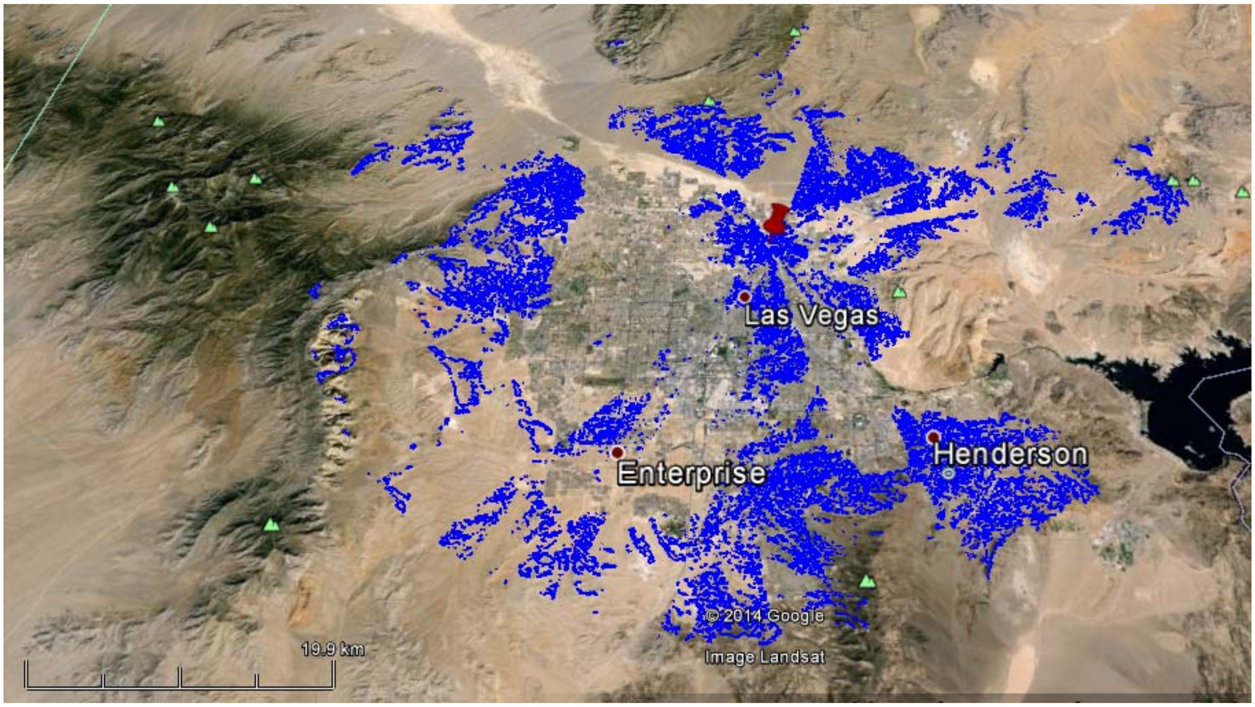


Figure A2-14. Worst-Case Scenario for North Platte Gateway Earth Station

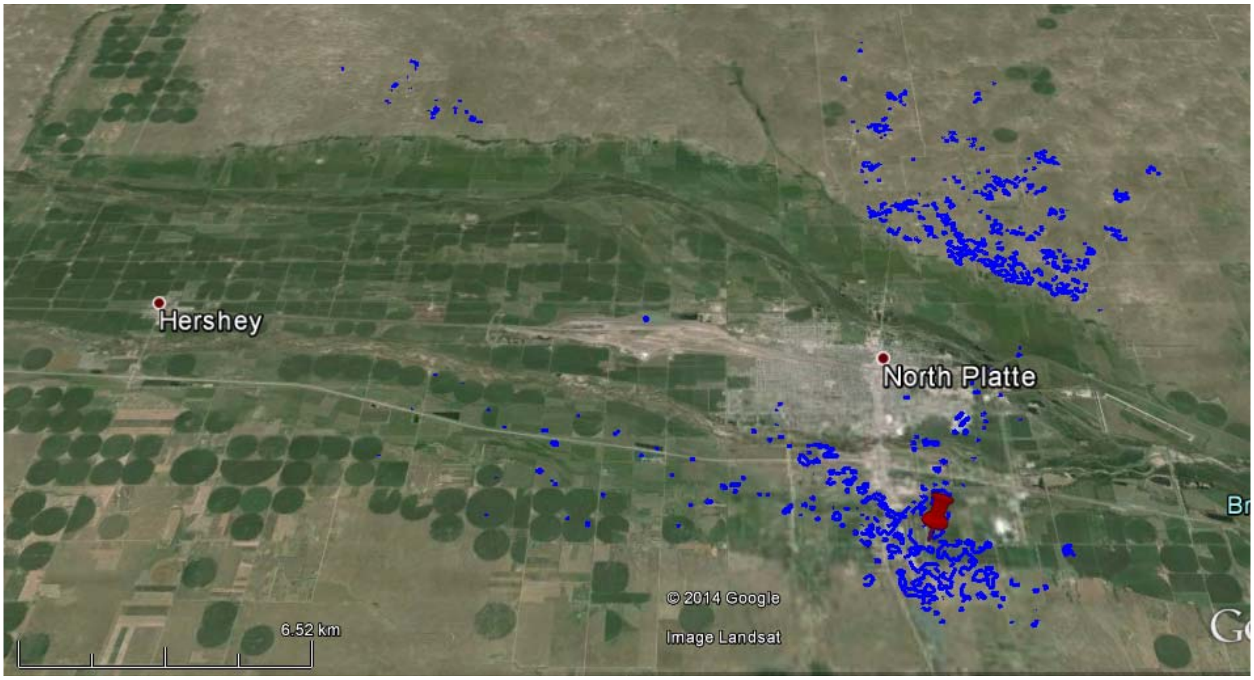


Figure A2-15. Worst-Case Scenario for Omaha Gateway Earth Station

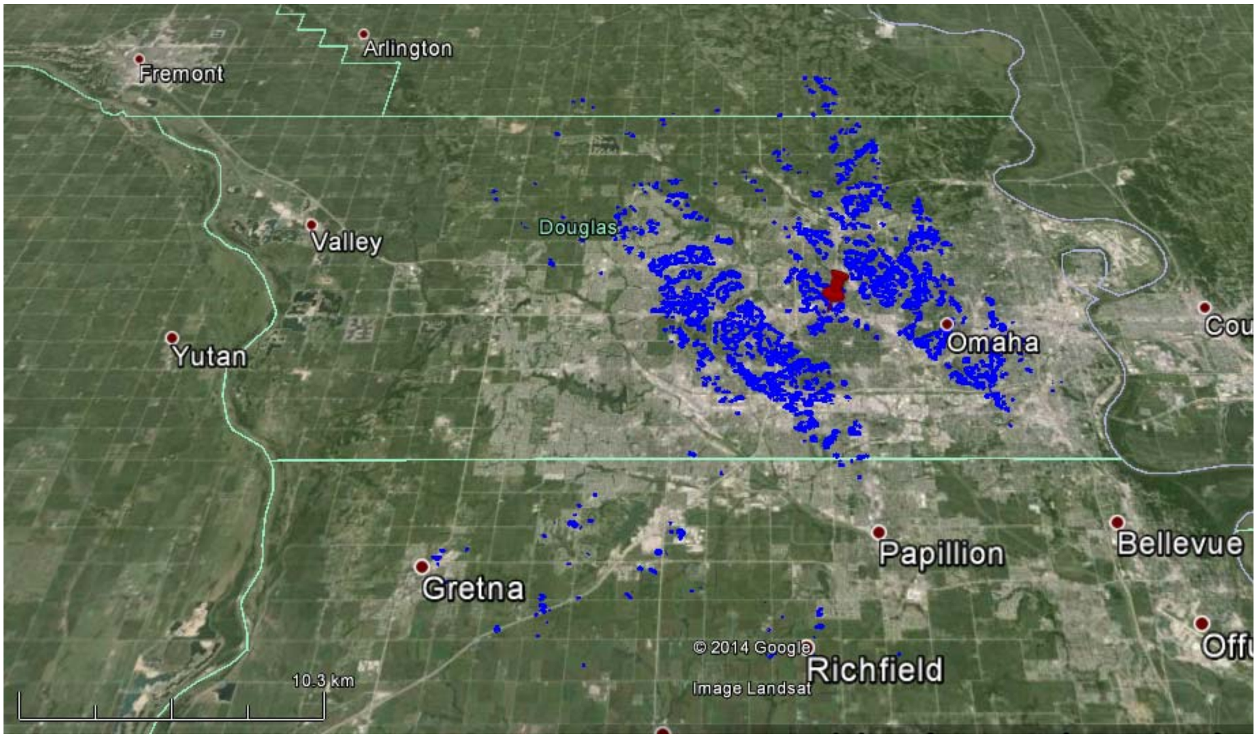


Figure A2-16. Worst-Case Scenario for San Diego Gateway Earth Station

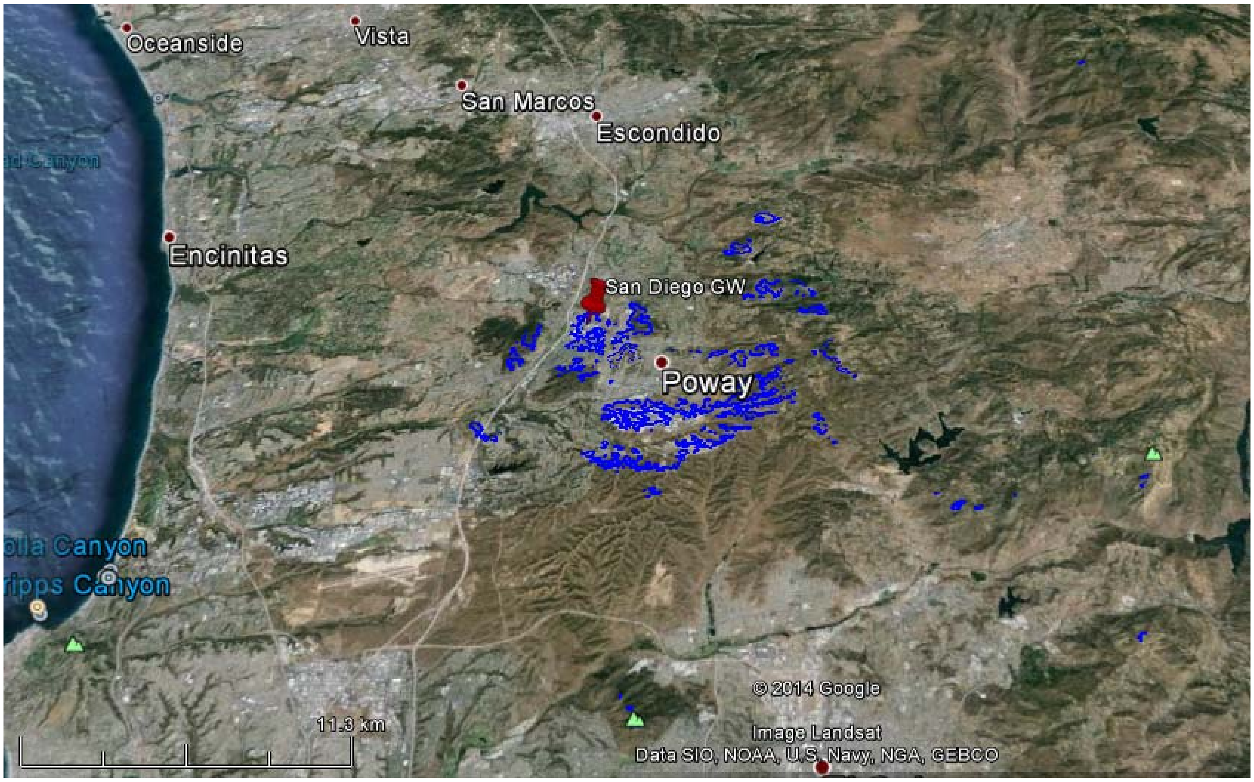


Figure A2-17. Worst-Case Scenario for Seattle Gateway Earth Station

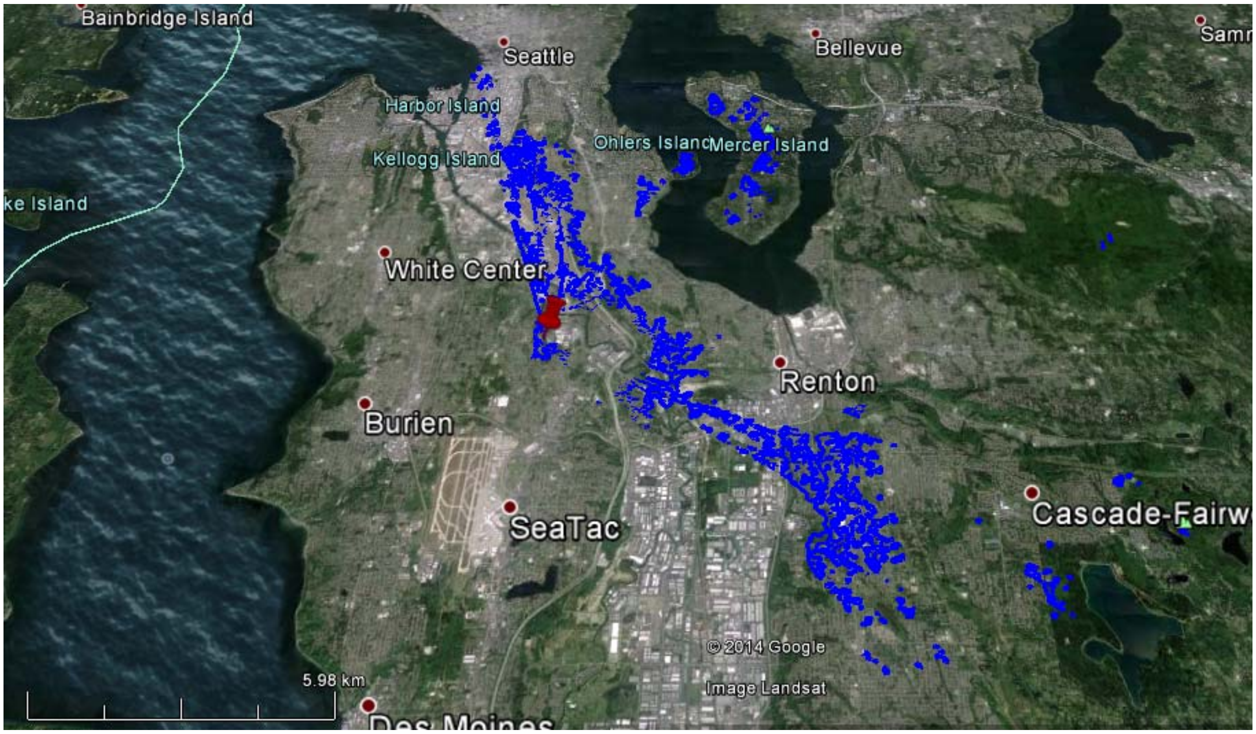


Figure A2-18. Worst-Case Scenario for San Jose Gateway Earth Station

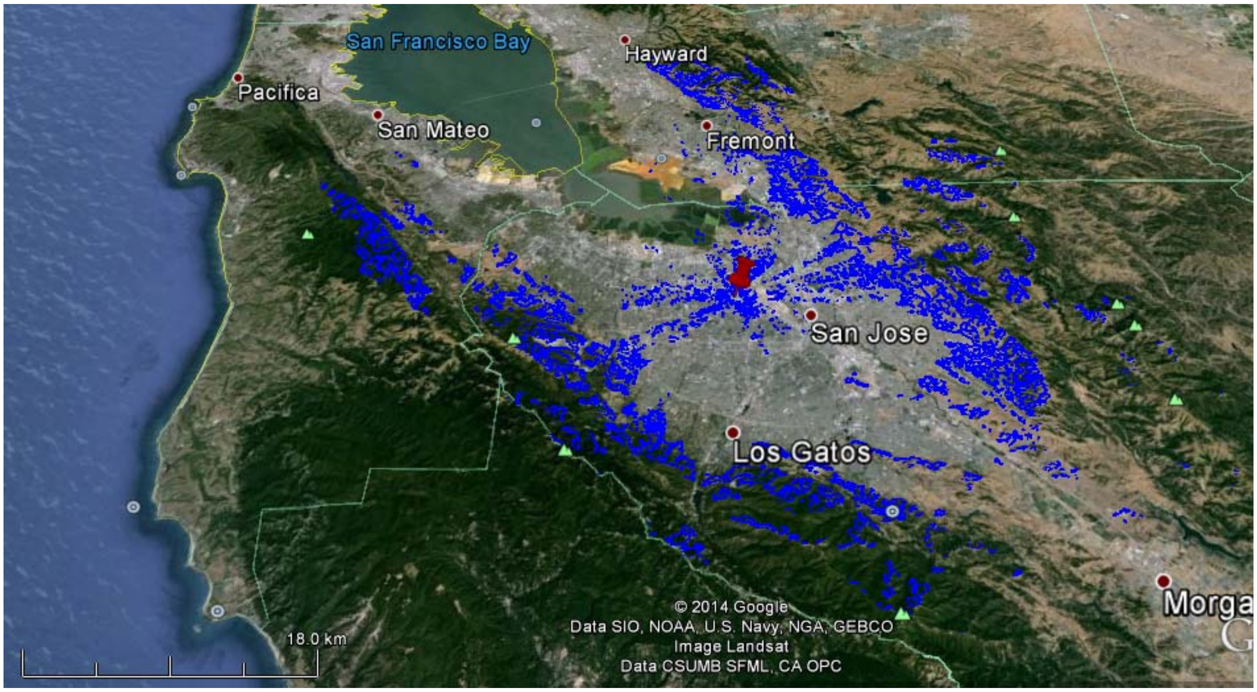
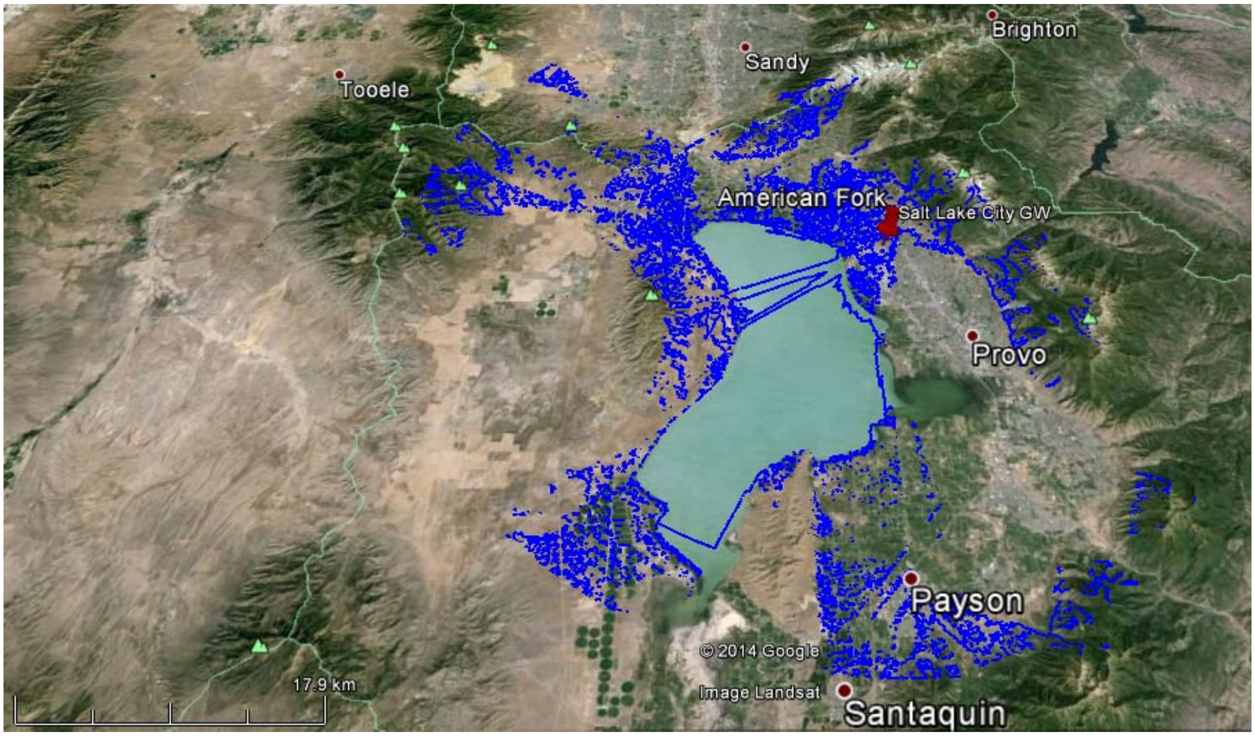


Figure A2-19. Worst-Case Scenario for Salt Lake City Gateway Earth Station



Annex C- Isoflux Diagram