ATTACHMENT

Technical Information to Supplement Schedule S

A.1 SCOPE AND PURPOSE

The purpose of this Attachment is to provide the Commission with the technical characteristics of the Ka band gateway beams on the EUTELSAT 65 West A ("E65WA") satellite for earth stations located within the United States. This attachment contains the information 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 E65WA satellite will operate at the nominal 65.2° W.L. orbital location and will include several different communications payloads.[1] Of relevance to this filing is the Ka band broadband payload which consists of sixteen (16) small subscriber spot beams covering parts of Brazil that are connected to three gateway beams that are located in CONUS.[2] This payload will provide high-speed broadband services to small subscriber terminals located in Brazil using fixed-satellite service ("FSS") bands. Connections from these small subscriber terminals to the global internet will be accomplished using three U.S. gateway earth stations.

The Ka band payload will operate its gateway links in the 27.5-29.0 GHz and 29.5-30.0 GHz bands (Earth-to-space) and the 18.3-18.8 GHz and 19.7-20.2 GHz bands (space-to-Earth). The

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[1] The E65WA satellite will carry several different communications payloads including C-band, Ku-band and Ka band. This application only addresses the Ka band payload to be operated by Hughes which will operate with the three gateway earth stations located in CONUS. The remaining communications payloads will provide service to countries other than the United States.

[2] The other Ka-band payload on the E65WA satellite employs both user beams and gateway beams that are outside of any U.S. territory and therefore not under the jurisdiction of the FCC.

subscriber links, which only provide service in the subscriber beams in Brazil, operate in the 29.5-30.0 GHz (Earth-to-space) and 17.8-18.8 GHz (space-to-Earth) bands.

The detailed information provided in the Schedule S includes only those beams operating in the United States, which are gateway beams.

Uplink and downlink transmissions from and to earth stations to be located in the United States will only involve gateway earth stations; no blanket-licensed subscriber antennas will operate in the United States.

The three U.S. gateway earth stations will be located in Riverside, CA, Cheyenne, WY and Germantown, MD. These locations are sufficiently far apart from each other to permit full spatial frequency re-use between them. In addition the gateway beams operate simultaneously in both left and right hand circular polarization (LHCP and RHCP). The resulting frequency re-use is therefore six-fold, taking account of both spatial and polarization re-use.

The antenna diameters of the gateway earth stations are as follows:

- Riverside, CA: 13.2 meters
- Cheyenne, WY: 8.1 meters
- Germantown, MD: 13.2 meters

The satellite utilizes a bent-pipe architecture with asymmetric forward (gateway-to-subscriber) and return (subscriber-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 network uses 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.

As explained in Section A.10.3, the E65WA satellite is proposed to be offset by 0.2° from 65º W.L. with the center of the station-keeping box at 65.2° W.L.

The E65WA satellite will be operated by Eutelsat under the International Telecommunications Union ("ITU") network RAGGIANA-2 registered at the ITU by Papua New Guinea. Hughes Network Systems, LLC ("Hughes") will ensure that the transmissions between the U.S. gateway earth stations and the E65WA satellite comply with the coordination agreements obtained by Papua New Guinea for the RAGGIANA-2 satellite networks. Papua New Guinea will also be the nation registering the space object at the United Nations.

A.3 PREDICTED SPACE STATION ANTENNA GAIN CONTOURS

The E65WA satellite's antenna gain contours for the receive and transmit beams of the three separate gateways that are located in the United States, as required by §25.114(c)(4)(vi)(A), are given in GXT format and embedded in the Schedule S.

A.4 TT&C

TT&C for the E65WA satellite will take place from a satellite control center and TT&C earth stations that are located in Brazil. Therefore no additional information is being provided related to these TT&C links.

A.5 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 under Section 25.207 of the Commission's Rules.

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

A.6 POWER FLUX DENSITY AT THE EARTH'S SURFACE

§25.208(c) contains PFD limits that apply in the 18.3-18.8 GHz band. The PFD limits of §25.208(c) are as follows:

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

In addition, §25.208(d) contains PFD limits that apply in 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.

Compliance of the gateway downlink transmissions with the applicable FCC PFD limits is demonstrated below using a simple worst-case methodology. The maximum downlink EIRP that the E65WA satellite can transmit in any of its three gateway beams is 71 dBW in 1000 MHz. 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 cannot exceed -91.1 dBW/m^2 in the 1000 MHz usable bandwidth (i.e., 71 - 162.1). Allowing for the use of digital modulation with an almost flat spectrum, the corresponding maximum PFD at an elevation angle of 90° measured in a 1 MHz band will not exceed -121.1 dBW/m^2. This level is less than the -115 dBW/m^2/MHz PFD limit value that applies at elevation angles of 5° and below. Therefore compliance with the Commission's PFD limits is assured.

In addition, §25.208(d) provides an additional aggregate PFD limit in the 200 MHz wide band 18.6-18.8 GHz of -95 dBW/m^2. In the worst case, this would correspond to a PFD limit of -118 dBW/m^2/MHz (i.e., -95-10*log(200)). As demonstrated in the previous paragraph, downlink transmissions from the E65WA satellite in its U.S. gateway downlink beams cannot exceed -121.1 dBW/m^2/MHz at any angle of arrival and therefore, compliance with §25.208(d) is also assured.

A.7 KA-BAND TWO DEGREE COMPATIBILITY

A.7.1 Frequency Bands Subject to §25.138

For those frequency bands subject to §25.138, which 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 provided:

1) The uplink off-axis EIRP density levels of §25.138(a) of the rules for blanket licensing are not exceeded;

2) 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. Table 7-1 compares the uplink input PSD derived from the uplink budgets that are contained in the Schedule S with the clear sky limits of §25.138 (a)(1). In all cases the clear sky uplink power limits are met with considerable margin. No authorized uplink transmissions toward the E65WA satellite will exceed the clear sky uplink off-axis EIRP density limits of §25.138(a)(1). In addition, authorized transmitting earth station antennas will meet the requirements of §25.209(a) and (b).

Table 7-1. Demonstration of Compliance with the Uplink Power limits of §25.138 (a)(1).

Uplink Antenna Size	Emission	Maximum Clear Sky Uplink Input Power Density (dBW/Hz)	Clear Sky Uplink Input Power Density Limit of §25.138 (a)(1) (dBW/Hz)	Excess Margin (dB)
13.2 m	250MG7W	-80.7	-56.5	24.2
13.2 m	40M0G7W	-80.7	-56.5	24.2
8.1 m	250MG7W	-77.3	-56.5	20.8
8.1 m	40M0G7W	-77.3	-56.5	20.8

Section A.6 above demonstrates that the maximum PFD that could be transmitted by the E65WA satellite, at an elevation angle of 90 degrees, is -121. 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 E65WA satellite will be compliant with §25.138(a)(6) of the rules.

A.7.2 Frequency Bands Not Subject to §25.138

The only frequencies to be used by the U.S. gateways with the E65WA satellite, which are not covered by §25.138, are the 27.5-28.35 GHz and 28.6-29.0 GHz bands. This section demonstrates that uplink transmissions in these bands are two-degree compatible.[3]

Currently there are no operators authorized by the Commission to use any of these frequency bands within two degrees of the 65º W.L. orbital location, although there is a pending application before the Commission for the INMARSAT-KA 63W satellite at 62.85º W.L . (i.e., 2.35º nominal separation from the proposed E65WA satellite at 65.2º W.L.) using some of these frequencies (28.1-28.35 GHz and 28.6-29.0 GHz). Therefore, in order to demonstrate two-degree compatibility with this potential neighboring satellite, the clear-sky uplink interference from the U.S. gateways of the E65WA network into the INMARSAT-KA 63W satellite receiver is calculated, as shown in Table 7-2 below. This is a worst-case analysis in that it assumes the Inmarsat satellite gateway receive beam peaks are directed towards the Hughes gateway earth stations. It can be seen that the ΔT/T is less than 0.06% in all cases and therefore the interference level would be acceptable with significant margin.

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[3] Even in the frequency bands not covered by §25.138, the uplink transmissions from the U.S. gateways of the E65WA network are still compliant with the uplink off-axis EIRP density levels that are given in §25.138.

Table 7-2. Calculation of Uplink Interference from the U.S. Gateway Earth Stations of the E65WA Satellite Network into the INMARSAT-KA 63W Satellite Receiver

		Gateway ES Location		
		Riverside	Cheyenne	Germantown
Gateway ES EIRP per carrier (clear-sky)	dBW	72	72	72
Gateway carrier bandwidth	MHz	250	250	250
Gateway ES antenna diameter	m	13.2	8.1	13.2
Gateway ES antenna Tx gain (at 29.0 GHz)	dBi	68.81	65.3	68.81
Transmit power (at antenna flange)(clear-sky)	dBW	3.19	6.70	3.19
Power Spectral Density (at antenna flange)(clear-sky)	dBW/Hz	-80.78	-77.28	-80.78
Minimum off-axis angle to INMARSAT-KA 63W satellite	°	2.42	2.42	2.42
Off-axis gain of Gateway ES Tx antenna	dBi	19.40	19.40	19.40
EIRP density towards INMARSAT-KA 63W satellite (clear-sky)	dBW/Hz	-61.38	-57.87	-61.38
Space Loss to INMARSAT-KA 63W satellite	dB	213.58	213.47	213.02
Rx interfering signal power density at INMARSAT-KA 63W satellite (40 dBi Rx gain)	dBW/Hz	-234.96	-231.35	-234.40
Noise power density at INMARSAT-KA 63W satellite receiver (1000K)	dBW/Hz	-198.60	-198.60	-198.60
Resulting $\Delta T/T$ at INMARSAT-KA 63W satellite receiver	%	0.0231%	0.0531%	0.0263%
Resulting I_o/N_o at INMARSAT-KA 63W satellite receiver	dB	-36.36	-32.75	-35.80

The analysis presented in Table 7-2 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 Inmarsat 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.

A.8 SHARING WITH NGSO FSS IN THE 28.6-29.0 GHZ BANDS

In the United States, the 28.6-29.1 GHz uplink and 18.8-19.3 GHz downlink bands are allocated to non-geostationary orbit (NGSO) FSS on a primary basis and allocated to GSO FSS on a secondary basis. Stations operating in a secondary service cannot cause harmful interference to or claim protection from harmful interference from stations of a primary service. The U.S. gateways of the E65WA network overlap with these NGSO primary bands only in the 28.6-29.0 GHz band.

The highest interference levels that could occur into NGSO networks from the E65WA network are when there is an "in-line" event. On the uplink an in-line event occurs when the NGSO satellite, the GSO satellite and the interfering GSO earth station are all in a line. As the NGSO satellite continues to move within its orbit, an angle between the NGSO satellite and the GSO satellite, subtended at the GSO earth station, is created. In order to prevent the E65WA satellite network from causing harmful interference into NGSO satellite networks using the 28.6-29.0 GHz band, the E65WA satellite and its associated earth stations will not operate the system in the NGSO primary spectrum if there is any possibility that there will be insufficient angular separation between an NGSO satellite or its associated earth stations and E65WA or its associated earth stations.

Currently there is only the O3b Limited ("O3b") NGSO satellite system authorized for U.S. market access by the Commission, and which overlaps with the U.S. gateways of the E65WA network in the 28.6-29.0 GHz band.[4] The interference analysis provided herein demonstrates that no harmful interference between O3b's NGSO system, as proposed, and the E65WA satellite network will occur with respect to the links between the U.S. gateways and the E65WA 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 NGSO network. Both networks were to utilize highly elliptical orbits ("HEO"). The interference analysis contained herein demonstrates that the operations of the E65WA satellite network would protect the HEO satellite systems previously licensed to AtContact and NGST from harmful interference.

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

A.8.1 Sharing with the O3b System

Frequency overlap between the U.S. gateways of the E65WA network and the O3b system occurs in the 28.6-29.0 GHz band. This sharing analysis will therefore be limited to that frequency range.

The three U.S. gateways in the E65WA satellite network are located at relatively high latitudes, with the minimum being 33°N in the case of Riverside, CA. At these latitudes there is relatively high minimum angular separation, as viewed from the surface of the Earth, between the O3b orbit and the E65WA satellite, as given in Table 8-1 below.

Table 8-1. Minimum Angular Separation between the E65WA Satellite and the O3b Orbit for the Three U.S. Gateways in the E65WA Network

Minimum Angular Separation from the O3b Orbit		
Riverside, CA	Cheyenne, WY	Germantown, MD
12.7°	15.3°	16.6°

The calculation of potential interference from the three U.S. gateways of the E65WA network into the O3b satellite is therefore based on these minimum elevation angles. The results are given in Table 8-2 below. This shows that the potential degradation of the O3b satellite receive system noise temperature is less than 0.007% for all cases, corresponding to an interference-to-noise density ratio of better than -41 dB.

Table 8-2. Calculation of Uplink Interference from the U.S. Gateway Earth Stations of the E65WA Network into the O3b Satellite Receiver

		Gateway ES Location		
		Riverside	Cheyenne	Germantown
Gateway ES EIRP per carrier (clear-sky)	dBW	72	72	72
Gateway carrier bandwidth	MHz	250	250	250
Gateway ES antenna diameter	m	13.2	8.1	13.2
Gateway ES antenna Tx gain (at 29.0 GHz)	dBi	68.81	65.3	68.81
Transmit power (at antenna flange)(clear-sky)	dBW	3.19	6.70	3.19
Power Spectral Density (at antenna flange)(clear-sky)	dBW/Hz	-80.78	-77.28	-80.78
Minimum off-axis angle to O3b orbit	°	12.7	15.3	16.6
Off-axis gain of Gateway ES Tx antenna	dBi	4.40	2.38	1.50
EIRP density towards O3b orbit (clear-sky)	dBW/Hz	-76.38	-74.90	-79.29
Minimum Space Loss to O3b orbit (8,062 km)(29.0 GHz)	dB	199.82	199.82	199.82
Rx interfering signal power density at O3b satellite (34.5 dBi Rx gain)	dBW/Hz	-241.70	-240.22	-244.61
Noise power density at O3b satellite receiver (1000K)	dBW/Hz	-198.60	-198.60	-198.60
Resulting ΔT/T at O3b satellite receiver	%	0.0049%	0.0069%	0.0025%
Resulting I_o/N_o at O3b satellite receiver	dB	-43.10	-41.62	-46.01

The analysis presented in Table 8-2 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.

Accordingly, there will be no potential uplink interference from the transmitting U.S. gateway earth stations of the E65WA network into the O3b satellites.

A.8.2 Sharing with the NGST and AtContact HEO Systems

Table 8-3 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 28.6-29.0 GHz band were compatible with the other's proposed NGSO operations.[5] It can be seen that the two networks' orbital and transmission parameters are identical, which allows a single interference analysis to be performed.

Table 8-3. GESN and ATCONTACT HEO Satellite Characteristics.

	GESN	ATCONTACT
Orbital parameters • # of satellites • # of planes • # of satellites per plane • Inclination • Apogee • Perigee • Minimum Tx altitude	 3 3 1 63.4° 39352 km 1111 km 16000 km	 3 3 1 63.4° 39352 km 1111 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 NGSO networks, a worst case, static interference analysis is performed. The smallest possible angle will occur when the GSO satellite, the NGSO 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 NGSO earth station (downlink calculation) have been assumed to be at a latitude of 71.4°N.

Table 8-4 shows the results of interference calculations from the E65WA network into the GESN and ATCONTACT networks and vice versa. The calculated ΔT/T values in all cases are very

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5 *See* SAT-AMD-20040719-00138 and SAT-AMD-20040719-00141.

small, indicating the technical compatibility of the E65WA satellite network with the GESN and ATCONTACT networks.

The compatibility of these networks is largely due to the fact that the two NGSO networks do not communicate with earth stations when their satellites cross the equatorial plane, thus in-line events with a GSO network do not occur. For other types of NGSO 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 E65WA satellite and its associated earth stations such that the required amount of angular separation with the NGSO network is always maintained.

Table 8-4. Worst-Case Interference Calculations with respect to GESN / ATCONTACT

Victim network Interfering network		GESN / ATCONTACT E65WA	E65WA GESN / ATCONTACT
Uplink:			
Frequency band	GHz	29	29
Interfering uplink input power density	dBW/Hz	-60	-63.45
Angular separation	degrees	27.4	27.4
Slant range (Interfering path)	km	21046	40586
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	52.7
Victim satellite Rx system noise temperature	K	504	1951
No	dBW/Hz	-201.6	-195.7
Io	dBW/Hz	-229.8	-232.8
Io/No	dB	-28.3	-37.1
ΔT/T	%	0.1490	0.0195
Downlink:			
Frequency band	GHz	19	19
Interfering satellite downlink EIRP density	dBW/Hz	-17.3	-18
Slant range (Interfering path)	dB	40586	21046
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	-235.5	-230.5
Io/No	dB	-31.9	-25.9
ΔT/T	%	0.0651	0.2592

A.9 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.[6] The three proposed U.S. gateway earth stations operating in conjunction with the E65WA satellite will be capable of operating in this frequency 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.

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;[7]
b. An interference threshold of I/N of -12.2 dB;
c. The LMDS hub is collocated with the gateway;[8]
d. Free space propagation;
e. The transmitting earth station is pointing at the E65WA 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 the Hughes gateway earth station under these conditions. This scenario results in the 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

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6 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.

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

8 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.

calculation of the worst-case interference for each of the gateway earth station locations is shown in Table 9-1.

Table 9-1. Calculation of Uplink Interference from the U.S. Gateway Earth Stations of the E65WA Network into an LMDS user terminal

Gateway Earth Station	Riverside	Cheyenne	Germantown
Frequency (GHz)	27.5	27.5	27.5
GSO ES On-Axis EIRP (dBW)(clear-sky)[9]	72	72	72
Bandwidth (MHz)	250	250	250
GSO ES On-Axis EIRP Density (dBW/MHz)	48.02	48.02	48.02
GSO ES antenna diameter (m)	13.2	8.1	13.2
GSO ES On-Axis Transmit Antenna Gain (dBi)	68.80	65.30	68.80
GSO ES On-Axis PSD (dBW/MHz)	-20.78	-17.28	-20.78
Minimum off-axis angle (°)	22.84	27.82	42.94
Maximum off-Axis Transmit Antenna Gain toward horizon (dBi) using 25.209 mask	-4.97	-7.11	-10.00
Maximum Off-Axis EIRP Density toward horizon (dBW/MHz)	-25.75	-24.39	-30.78
Polarization Discrimination (dB)	0	0	0
LMDS Thermal Noise Density (dBW/MHz)	-138	-138	-138
LMDS Required I/N (dB)	-12.2	-12.2	-12.2
Interfering Power Density to meet required I/N (dBW/MHz)	-150.2	-150.2	-150.2
LMDS user-terminal Receive Antenna Gain (dBi)	31	31	31
Distance (km) (free space loss)	51.38	60.08	28.79

[9] 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 E65WA satellite.

While all sites beyond the separation distances above will not suffer from interference, a more detailed consideration is required for terminals located within this circle. This subsequent analysis was performed using Visualyse software to identify areas where the interference threshold may be exceeded using a more realistic propagation model[10] 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.

In addition to this worst case scenario, the analysis was performed with the LMDS hub station offset by 1 km east, 1 km north, 1 km west and 1 km south of the gateway earth station. The results of this analysis are shown in the additional figures for each gateway. The purpose of this step is to demonstrate the sensitivity of these interference contours to a movement of the LMDS hub away from the gateway. Since each gateway earth station is located on a large, privately owned antenna farm it is reasonable to expect that any LMDS hub will be at least 1 km away from the E65WA gateway.

Figure 9-1 shows the worst-case scenario in which the LMDS hub station is collocated with the Riverside gateway earth station. The results show that the maximum required separation distance in this scenario is about 23 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 very small portion of the area surrounding the gateway earth station. Figures 9-1a, 9-1b, 9-1c and 9-1d show the results when the hub station is not collocated with the gateway earth station. These results show that the geographic area where the I/N may exceed -12.2 dB is smaller than in the worst case scenario.[11]

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[10] 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."

[11] In order to facilitate review of these and all other maps relating to the LMDS interference showing, Figure series 9-1 through 9-3 are also being provided as .kml files compatible with Google Earth.

Figure 9-2 shows the worst-case scenario in which the LMDS hub station is collocated with the Cheyenne gateway earth station. The results show that the maximum required separation distance in this scenario is about 8.5 km. Figures 9-2a, 9-2b, 9-2c and 9-2d show the results when the hub station is not collocated with the gateway earth station.

Figure 9-3 shows the worst-case scenario in which the LMDS hub station is collocated with the Germantown gateway earth station. The results show that the maximum required separation distance in this scenario is about 4.5 km. Figures 9-3a, 9-3b, 9-3c and 9-3d show the results when the hub station is not collocated with the gateway earth station.

In summary, the area in which the harmful interference threshold may be exceeded in proximity to the gateway is small, and becomes 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 8 and 13 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.

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 LMDS channel(s) or installing RF shielding in the direction of the impacted receiver.

Figure 9-1. Worst-Case Scenario for Riverside Gateway Earth Station

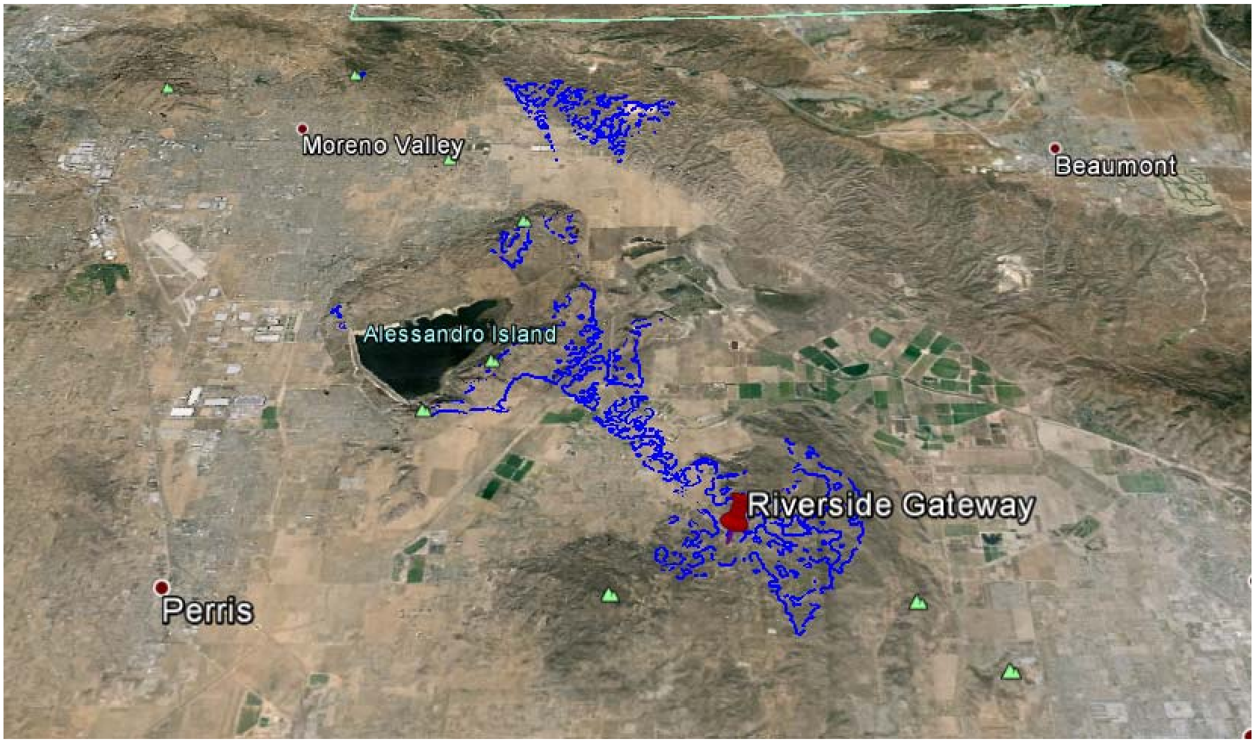


Figure 9-1a. LMDS Hub Station 1 km East of Riverside Gateway Station

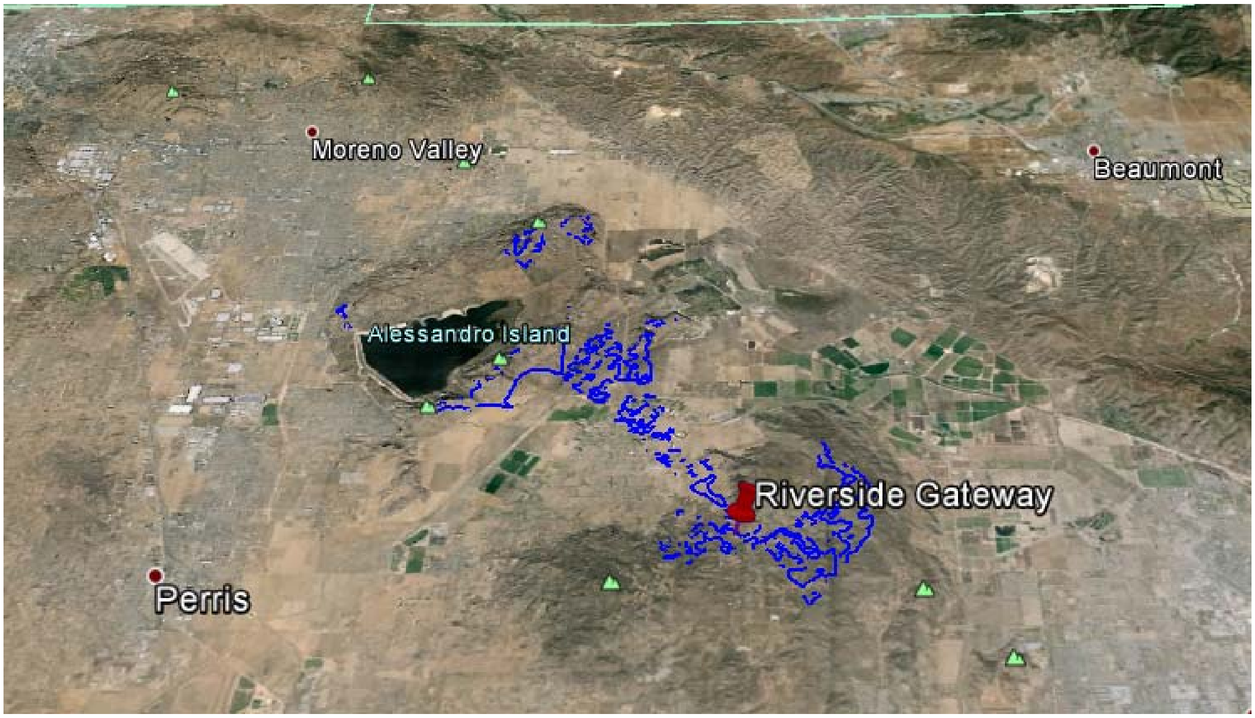


Figure 9-1b. LMDS Hub Station 1 km South of Riverside Gateway Station

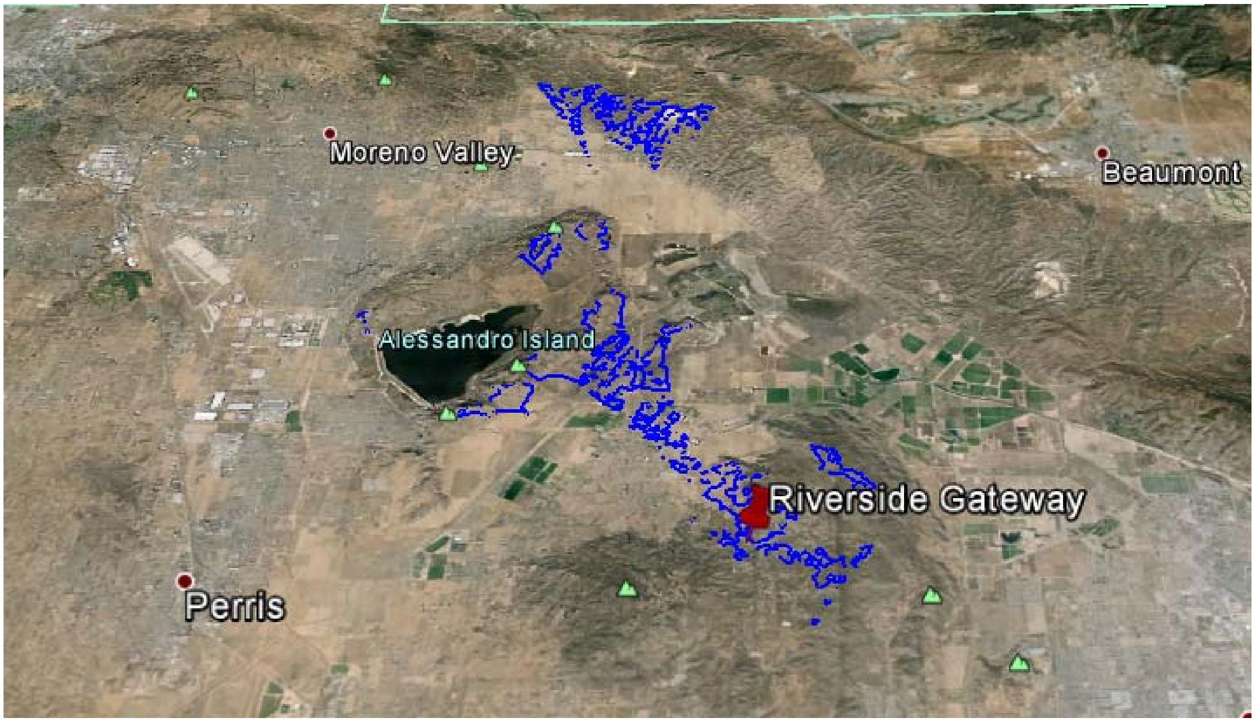


Figure 9-1c. LMDS Hub Station 1 km West of Riverside Gateway Station

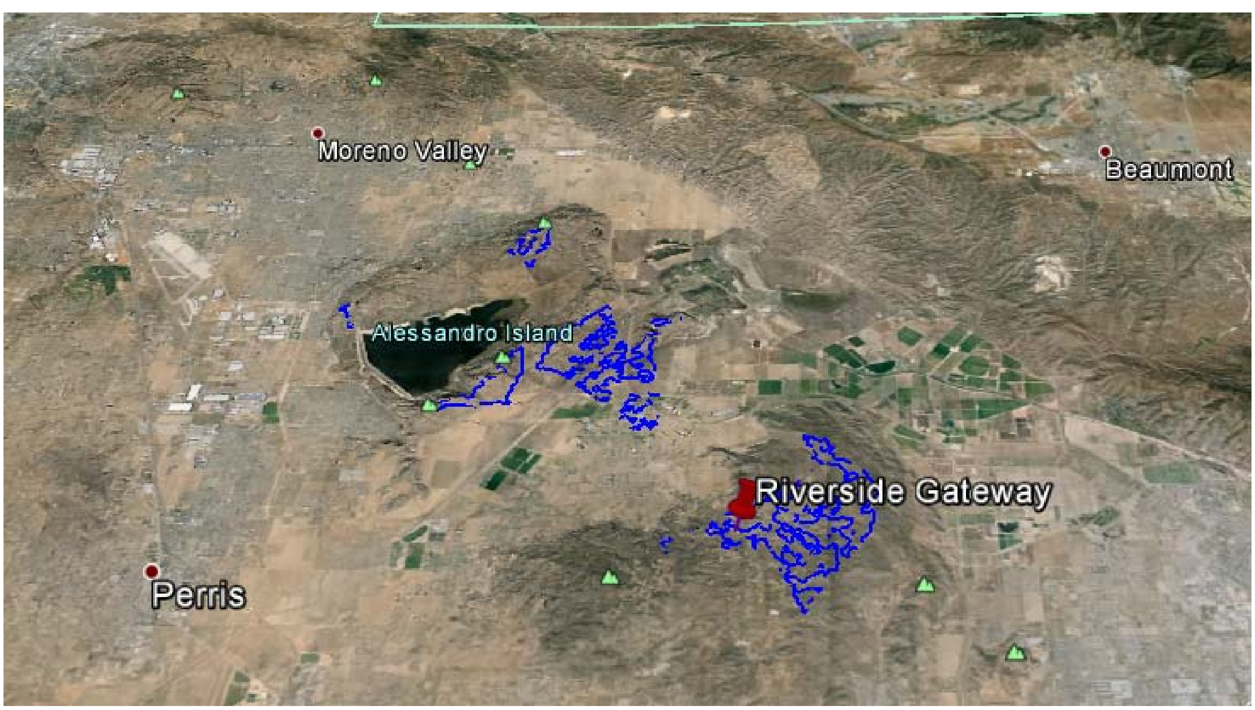


Figure 9-1d. LMDS Hub Station 1 km North of Riverside Gateway Station

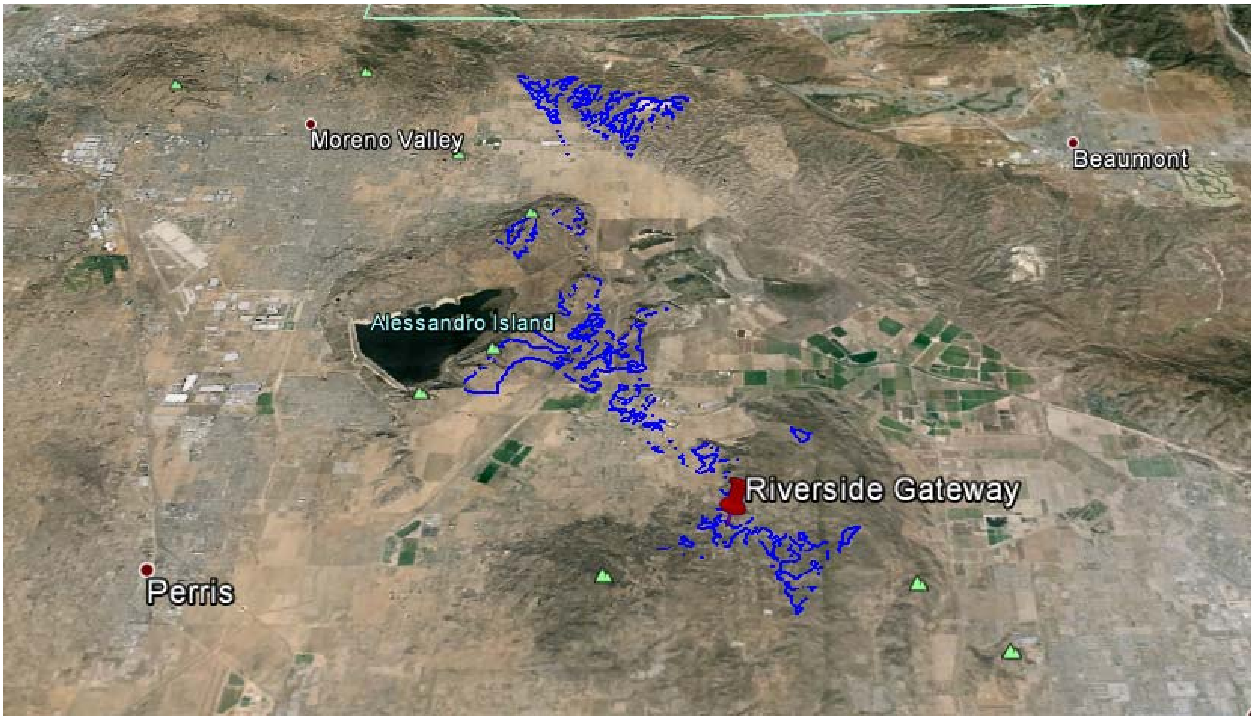


Figure 9-2. Worst-Case Scenario for Cheyenne Gateway Earth Station

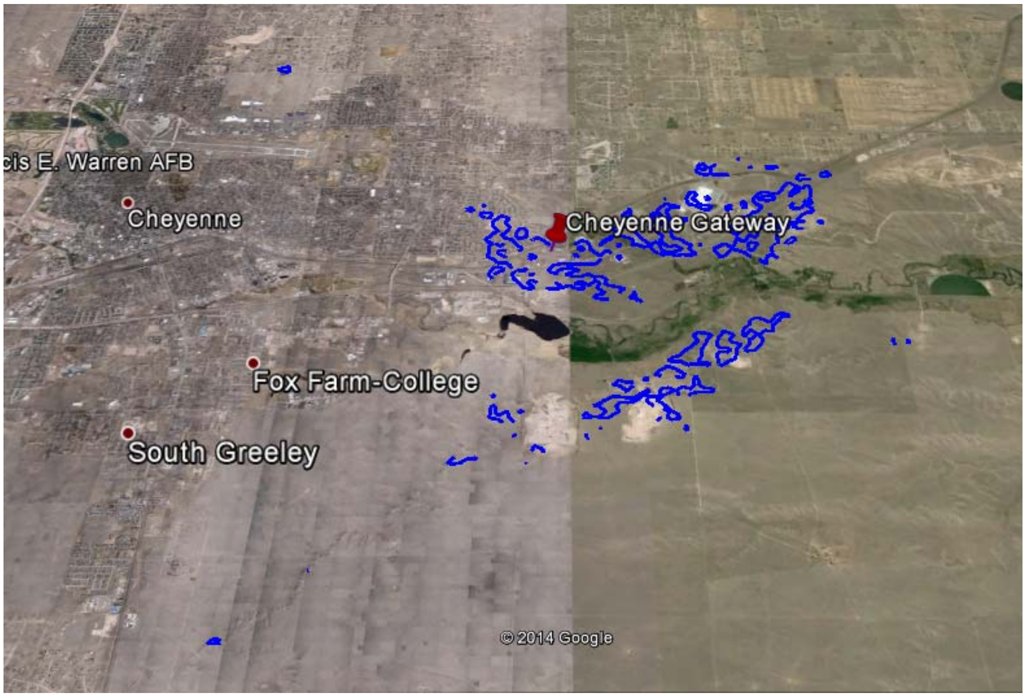


Figure 9-2a. LMDS Hub Station 1 km East of Cheyenne Gateway Station

Figure 9-2b. LMDS Hub Station 1 km South of Cheyenne Gateway Station

Figure 9-2c. LMDS Hub Station 1 km West of Cheyenne Gateway Station

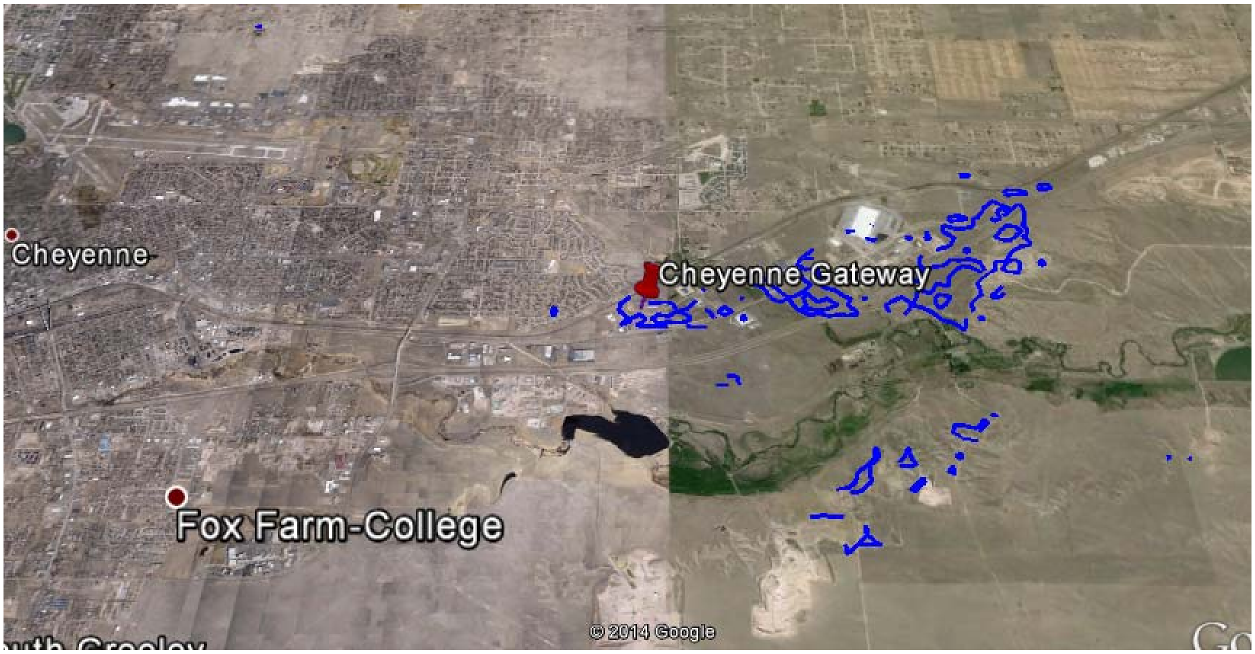


Figure 9-2d. LMDS Hub Station 1 km North of Cheyenne Gateway Station

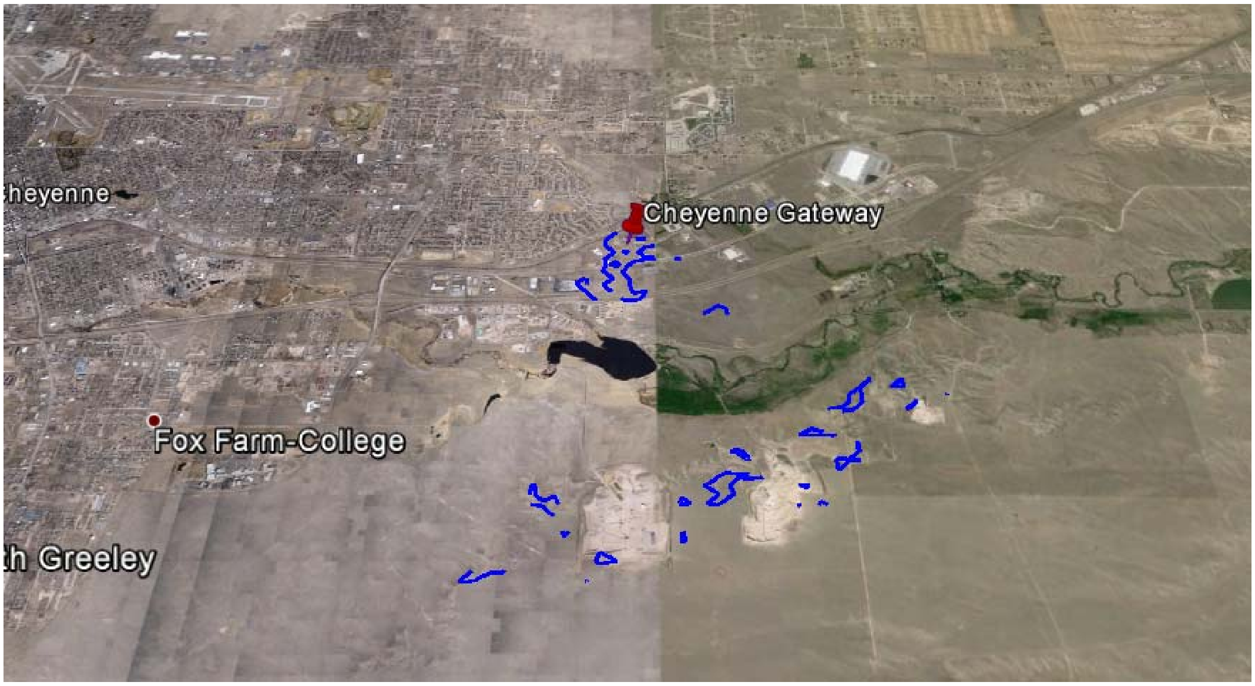


Figure 9-3. Worst-Case Scenario for Germantown Gateway Earth Station

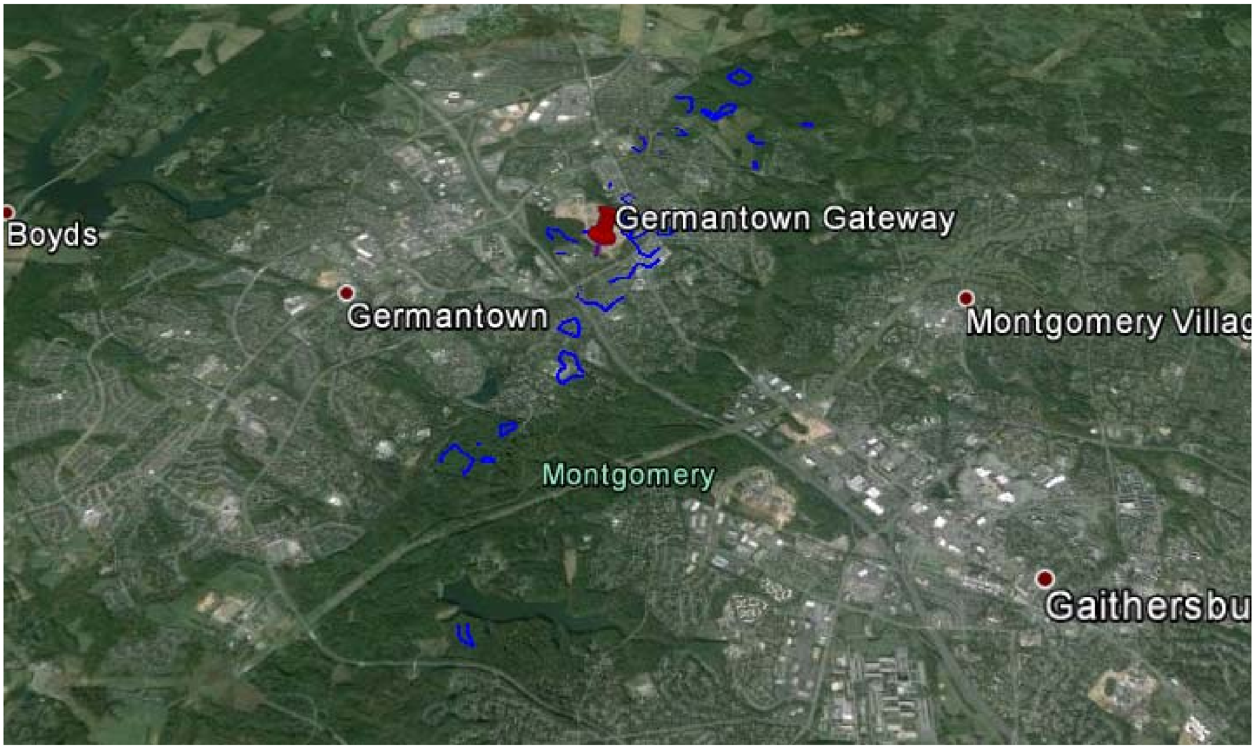


Figure 9-3a. LMDS Hub Station 1 km East of Germantown Gateway Station

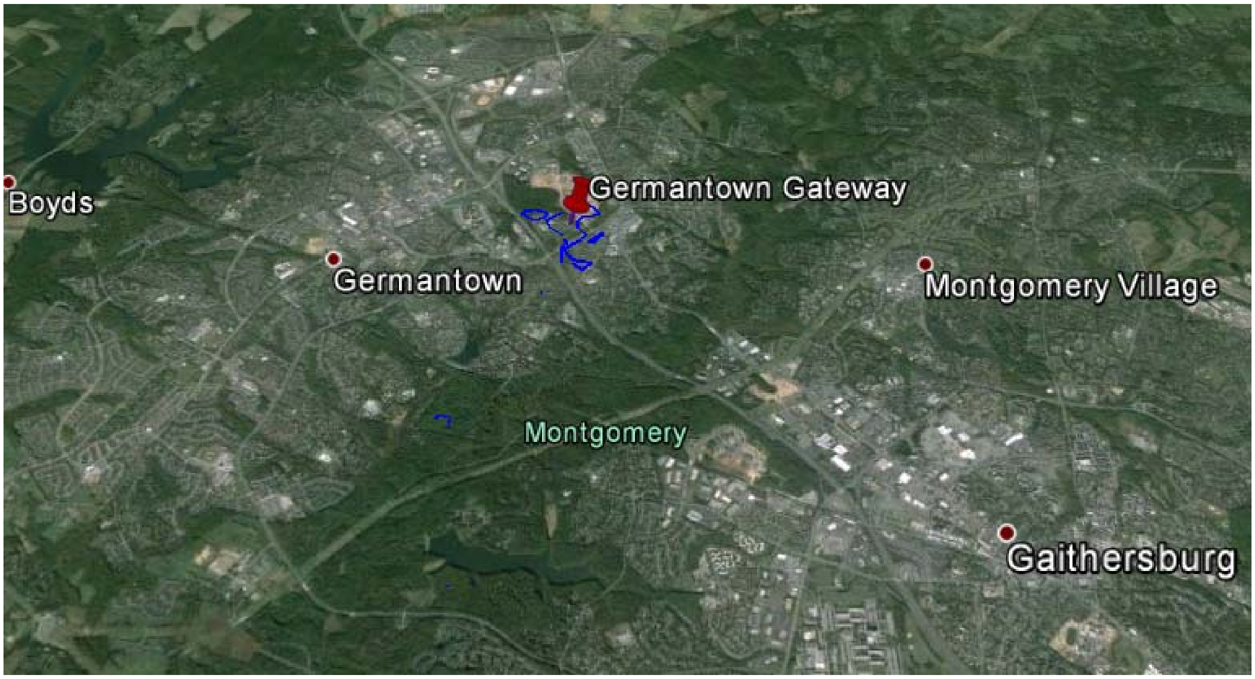


Figure 9-3b. LMDS Hub Station 1 km South of Germantown Gateway Station

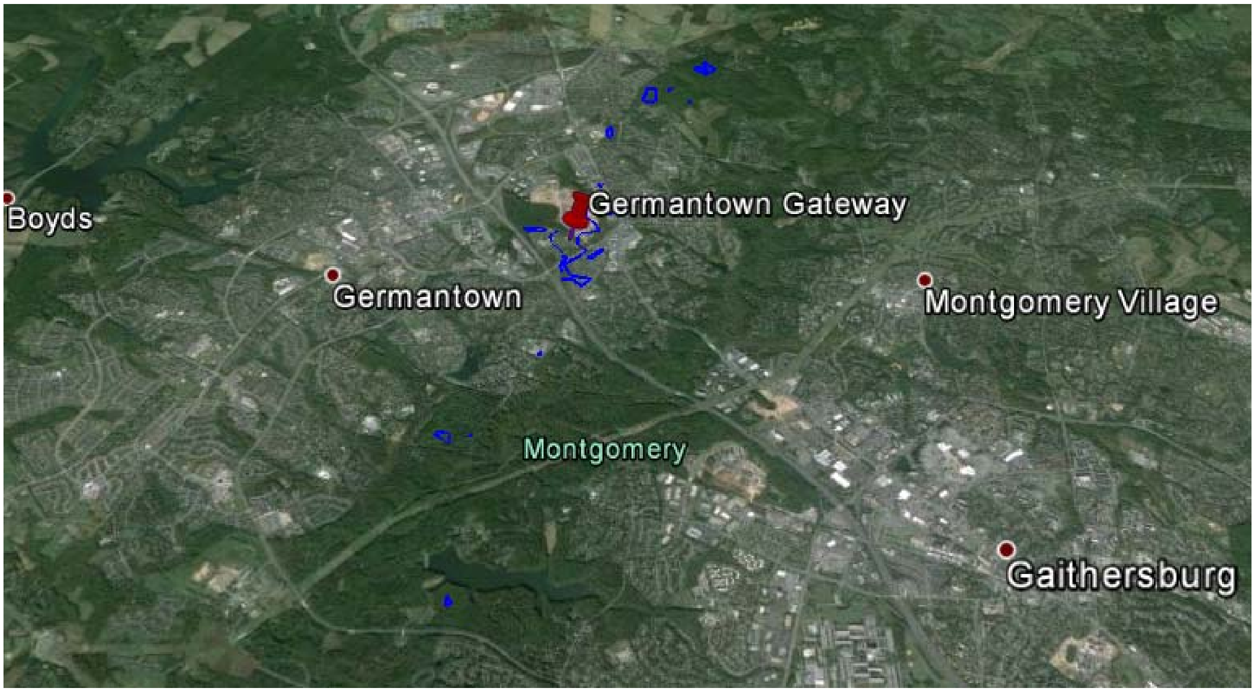


Figure 9-3c. LMDS Hub Station 1 km West of Germantown Gateway Station

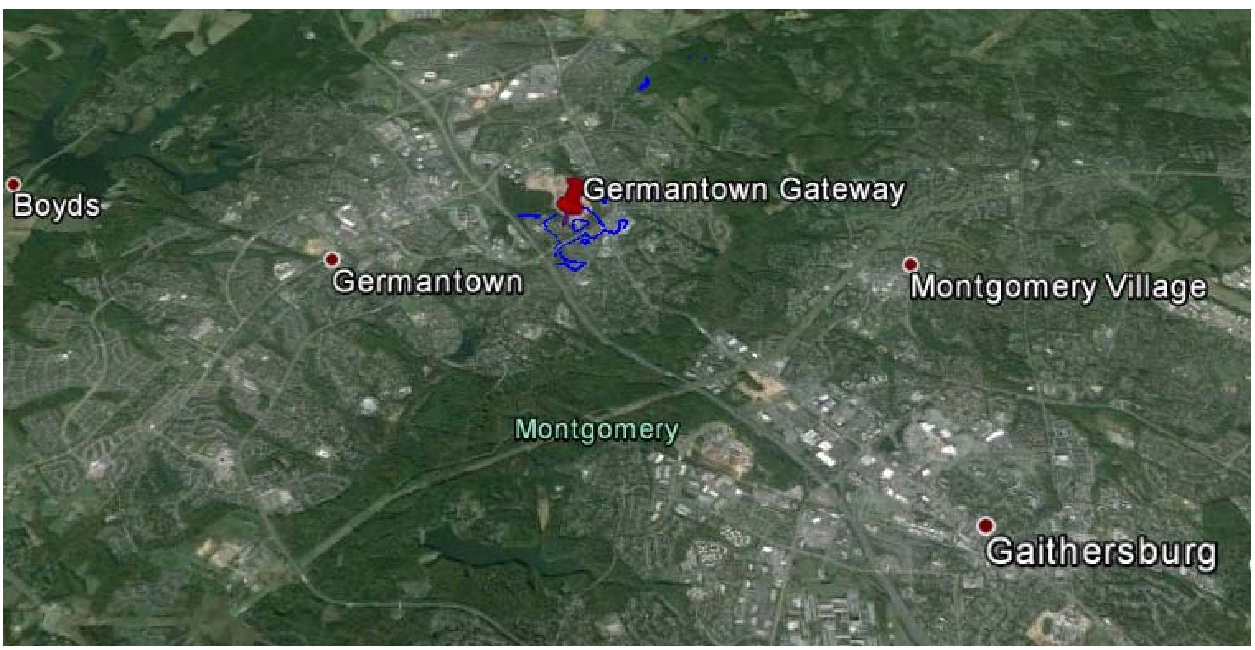
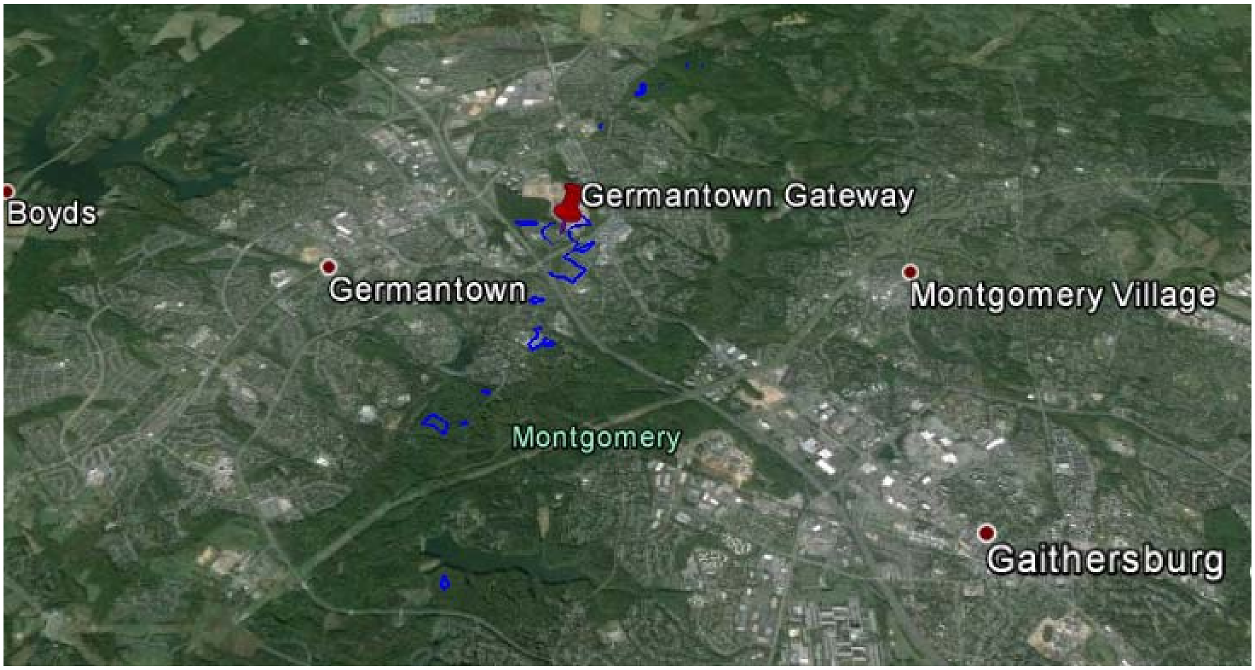


Figure 9-3d. LMDS Hub Station 1 km North of Germantown Gateway Station



A.10 ORBITAL DEBRIS MITIGATION PLAN

The spacecraft manufacturer for the E65WA satellite is Space Systems/Loral. Hughes will ensure that Eutelsat, the operator of the E65WA satellite, incorporates the material objectives of §25.114(d)(14) into its satellite Technical Specifications, Statement of Work and Test Plans. This will include provisions to review orbital debris mitigation as part of the ongoing design reviews for the E65WA 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, in conjunction with Eutelsat, will provide the Commission with updated information, as appropriate.

A.10.1 Spacecraft Hardware Design

Hughes can confirm 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.

In conjunction with the spacecraft operator and manufacturer, Hughes, in conjunction with Eutelsat, 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 and Eutelsat will take steps to limit the effects of such collisions through shielding, the placement of components, and the use of redundant systems.

The E65WA satellite will incorporate 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 will have no single points of failure. The TT&C system will be 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, will be sufficient to enable orbit raising. The command receivers and decoders and telemetry encoders and transmitters will be located within the satellite's Faraday cage which provides shielding and will be totally redundant and physically separated.

The propulsion subsystem will be designed such that it will not be separated from the spacecraft after de-orbit maneuvers. It will be protected from the effects of collisions with small debris through shielding. Moreover, propulsion subsystem components critical to disposal (e.g., propellant tanks) will be 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.10.2 Minimizing Accidental Explosions

Hughes, in conjunction with Eutelsat, will assess and limit the probability of accidental explosions during and after completion of mission operations. The satellite will be 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 vessels will be 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, in conjunction with Eutelsat, 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.10.3 Safe Flight Profiles

In considering current and planned satellites that may have a station-keeping volume that overlaps the E65WA 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 ±0.4° of 65° W.L. have also been reviewed. The findings are summarized below.

- Star One currently operates the Star One C1 satellite at 65.0 W.L.
- There are no pending applications before the Commission to use an orbital location within ±0.4° from 65° W.L.
- Hughes is not aware of any other satellite that is either in orbit or progressing towards launch, based on the existing ITU filing situation in the vicinity of 65° W.L.

Based on the preceding, the E65WA satellite will be located at 65.2° W.L. in order to eliminate the possibility of any station-keeping volume overlap with the Star One C1 satellite. Accordingly, physical coordination of the E65WA satellite with another party is not required at the present time.

A.10.4 Post-Mission Disposal

At the end of the operational life of the E65WA 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" = 101 m^2
"M" = Dry Mass of Satellite = 2817 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 1.33 x 100/2817
= 36,068.7 km
= 283 km above GSO (35,786 km)

To provide adequate margin, the disposal orbit will be increased to 300 km. This will require approximately 12.1 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.11 CROSS-POLAR ISOLATION OF THE SATELLITE ANTENNAS

Section S7 of the associated Schedule S submission states that the specified minimum cross-polar isolation ("XPI") of the E65WA satellite transmit antennas is 24 dB and of the receive antennas is 21 dB[12]. This is less than the 30 dB requirement stated in §25.210(i)(1). The shortfall in the XPI relative to §25.210(i)(1) will not be a problem for the U.S. gateway links of the E65WA network or other users of the spectrum for the following reasons:

(i) For the gateway-satellite links this level of XPI performance has been taken into account and there will be negligible degradation to service quality. The degradation

[12] The satellite as built is expected to exceed these minimum performance specifications.

due to XPI will be so small as to still allow for a very efficient 16APSK modulation scheme to be used.

(ii) The XPI performance will not prevent full frequency re-use of the spectrum from being achieved, as required by §25.210(d).

(iii) As the E65WA network uses both senses of circular polarization (RHCP and LHCP) then there is no scenario where the XPI performance would achieve interference isolation between the E65WA satellite network and any other space or terrestrial system. It is the co-polar transmissions that will dictate the interference levels to and from other systems, not the level of cross-polar radiation.

The only situation where the XPI performance of a satellite antenna could impact the interference between satellite networks, or between satellite and terrestrial systems, is when the associated earth station (or terrestrial terminal) has its antenna pointed directly at the interfering or interfered-with satellite. Only then is the polarization purity of the earth station high enough for the XPI of the satellite antenna to be a significant factor on the interference level. In all interference situations where the satellite is located at some angle away from the boresight of the earth station (or terrestrial terminal) the very poor XPI of the earth station (or terrestrial terminal) dominates the interference calculation. This latter situation is the case for all interference interaction between the E65WA network and other GSO networks or terrestrial systems. Therefore the shortfall in XPI for the E65WA satellite antenna will have no impact on the interference to or from other networks and systems.

A.12 ADDITIONAL EXPLANATION CONCERNING DATA ENTERED INTO SCHEDULE S

The following notes provide additional explanation concerning the link budgets that have been embedded in the Schedule S and the associated entries in Section S13 of the Schedule S:

1. Each link budget shows the link performance from the transmitting to the receiving earth station. This is to demonstrate the viability of the overall link. The link budget information relating to the half link between the non-U.S. earth stations and the E65WA satellite is for information only and does not form part of the Schedule S.

2. For the same reason certain information is missing from Section S13 of the Schedule S, where it relates to the half link between the non-U.S. earth stations and the E65WA satellite.

Similarly, in Sections S2, S7, S8, S9 and S10 of the Schedule S the operating frequency bands, space station beam characteristics and space station transponders are defined only in relation to the links between the U.S. gateway earth stations and the E65WA satellite.