Technical Analysis

ViaSat submits the following showing to demonstrate that the operation of the aeronautical earth station under Call Sign E120075 in the 28.1-28.35 GHz band segment will not cause harmful interference to existing or future LMDS stations.

The antenna of the earth station is installed on a fuselage mount on top of an aircraft using an approved mounting method that includes a faring adaptor ring and a radome to protect the antenna from the high wind forces in flight.

Locating the antenna on the top of the aircraft fuselage provides blockage of the signal toward the ground from the fuselage of the aircraft, the wings and horizontal stabilizers, and the faring mounting ring for the radome. The attenuation from blockage varies with respect to the downward angle to the LMDS station on the ground and in this analysis is conservatively estimated as 20 dB, even though the blockage value would increase to higher values as the downward angle toward the LMDS user station increases when the aircraft gets closer to the LMDS site.

ViaSat conducted a technical analysis to determine the potential level of an interfering signal received from an aircraft earth station at a LMDS station, assuming operation at both 10,000 ft and at 35,000 ft. Because no sharing criteria exist, ViaSat relied on research available in technical papers discussing LMDS systems and link budgets,[1] and also obtained LMDS equipment specifications from a major LMDS equipment manufacturer.[2]

Based on the available research, ViaSat selected a ΔT/T of 6% as the basis for calculating the threshold I/N ratio of -12.2 dB, which corresponds to an effective increase to the LMDS receiver's noise floor of 0.27 dB. As detailed below, even under a worst-case analysis (direct azimuth alignment), the resulting ΔT/T would be well under 1%.[3]

Notably, the potential interference case presented in this analysis is based on the same assumptions for LMDS operational parameters and interference thresholds that ViaSat utilized in its applications for sixteen earth stations at fixed locations that operate in the 28.1-28.35 GHz frequencies, all of which were approved by the Commission,[4] and all of which have been

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1 Robert Duhamel, "Local Multipoint Distribution Service (LMDS) Cell Sizing and Availability," IEEE P802.16 Broadband Wireless Access Working Group (June 9, 1999), *available at* http://wirelessman.org/sysreq/contributions/80216sc-99_17.pdf.

2 DragonWave Packet Microwave Systems, Product Link: http://www.dragonwaveinc.com/products-wireless-ethernet.asp.

3 These levels are used to illustrate are the lack of any impact on LMDS from the proposed aeronautical earth stations; they are not assumed to be, and should not be construed as, an admission about what level of unwanted emissions would conceivably constitute "harmful interference" into an LMDS facility.

4 The following secondary earth station authorizations were granted October 21, 2011 based on showings on compatibility with LMDS operations in the 28.1-28.35 GHz band

operating for almost four years without any reports of interference with respect to LMDS operations.

The analysis considered both hub-type and user-type LMDS stations. The higher antenna gain and better receiving performance of the user-type LMDS stations make these stations more sensitive than the hub-type stations, and thus, more susceptible to potential interference.

Table 1 and Table 2 consider the worst-case scenario, which results when the earth station and the LMDS station are directly aligned in the azimuth. This occurs when the LMDS hub-type station is located directly between the aircraft and the LMDS user-type station and when the aircraft is north east of the two LMDS stations as depicted in Figure 1 and Figure 5. In this case, the LMDS user-type station's antenna is pointing directly towards the antenna on the aircraft in the horizontal, or azimuth, plane. However, due to the difference in elevation between the stations, there is always some misalignment of the LMDS user-type station's antenna with the earth station antenna on the aircraft in the elevation plane. In other words, the earth station antenna points up toward the satellite while the LMDS user-type station antenna points along the ground toward the LMDS hub-type station, which results in less unwanted energy being received by the LMDS station than if they were on the same elevation plane.

Because the worst-case analysis (direct azimuth alignment) does not present a problem for the LMDS user-type station, it also does not present a problem for the LMDS-hub-type stations; only the results of the analysis of the LMDS user stations are presented here.

The analysis assumes the LMDS user terminal has the characteristics listed in the technical specifications provided for sample LMDS equipment.

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segment: ViaSat, Inc., File Nos. SES-LIC-20110211-00150 (E110015); SES-LIC-20110228-00212 (Call Sign E110026); File Nos. SES-LIC-20110318-00318 (Call Sign E110033); SES-LIC-20110318-00323 (Call Sign E110036); SES-LIC-20110328-00373 (Call Sign E110043); SES-LIC-20110328-00374 (Call Sign E110044); SES-LIC-20110328-00375 (Call Sign E110045); SES-LIC-20110328-00376 (Call Sign E110046); SES-LIC-20110328-00378 (Call Sign E110047); SES-LIC-20110328-00379 (Call Sign E110048); SES-LIC-20110328-00380 (Call Sign E110049); SES-LIC-20110328-00381 (Call Sign E110050); SES-LIC-20110328-00382 (Call Sign E110051); SES-LIC-20110328-00383 (Call Sign E110052); SES-LIC-20110418-00474 (Call Sign E110064); SES-LIC-20110419-00488 (Call Sign E110065).

Parameters	ViaSat	LMDS	
Frequency (GHz)	28.3	28.3	GHz
On-axis EIRP Density	44.5		dBW/MHz
On-axis Transmit Antenna Gain	37.0		dBi
Off-axis Angle (toward other system)	27.9	5.7	deg
Off-axis Transmit Antenna Gain Reduction	46.1		dB
Airframe Attenuation	20.0		dB
Off-Axis EIRP density	-21.6		dBW/MHz
Distance between sites		100.0	km
Path Loss		161.5	dB
ITU-R P.676 Atmospheric Attenuation		7.0	dB
On-axis Receive Antenna Gain		31.0	dBi
Off-axis Receive Antenna Gain Reduction		21.0	dB
Antenna Feed Loss		3.0	dB
System Noise Figure		6.0	dB
Thermal Noise Density		-138.0	dBW/MHz
Interference Noise Density		-183.1	dBW/MHz
I/N		-45.1	dB
Noise Floor Degradation		0.00	dB
ΔT/T		0.00	%
Received Carrier Level		-117.0	dBW/MHz
Received Noise Plus Interference		-138.0	dBW/MHz
C/(N+I)		20.96	dB
Reduction due to Interference Noise		0.00	dB

Table 1 System Parameters and Results for Direct Azimuth Alignment at 35,000 ft

The results in Table 1 for an aeronautical earth station operating at 35,000 ft indicate that, in a direct azimuth alignment case, the undesired signal from the aeronautical station would be received at 45 dB below the thermal noise floor of the LMDS user terminal and thus, well below the I/N threshold of -12.2 dB. In the case of operation at 10,000 ft, in a direct azimuth alignment case, the undesired signal would be received 24 dB below the thermal noise floor of the LMDS user terminal and still well below the I/N threshold. A direct azimuth alignment case represents the worst-case interference scenario, and even that worst-case scenario is likely to occur only on a fleeting basis, given the speed at which aircraft typically operate at these altitudes. Given the large margin under the thermal noise floor in each of these scenarios, ViaSat's proposed operations would not cause harmful interference to any LMDS users.

Parameters	ViaSat	LMDS	
Frequency (GHz)	28.3	28.3	GHz
On-axis EIRP Density	44.5		dBW/MHz
On-axis Transmit Antenna Gain	37.0		dBi
Off-axis Angle (toward other system)	23.7	1.3	deg
Off-axis Transmit Antenna Gain Reduction	45.5		dB
Airframe Attenuation	20.0		dB
Off-Axis EIRP density	-21.0		dBW/MHz
Distance between sites		100.0	km
Path Loss		161.5	dB
ITU-R P.676 Atmospheric Attenuation		7.0	dB
On-axis Receive Antenna Gain		31.0	dBi
Off-axis Receive Antenna Gain Reduction		1.1	dB
Antenna Feed Loss		3.0	dB
System Noise Figure		6.0	dB
Thermal Noise Density		-138.0	dBW/MHz
Interference Noise Density		-162.6	dBW/MHz
I/N		-24.6	dB
Noise Floor Degradation		0.01	dB
ΔT/T		0.35	%
Received Carrier Level		-117.0	dBW/MHz
Received Noise Plus Interference		-138.0	dBW/MHz
C/(N+I)		20.94	dB
Reduction due to Interference Noise		0.01	dB

Table 2 System Parameters and Results for Direct Azimuth Alignment at 10,000 ft

ViaSat conducted simulations using Visualyse software to perform an area analysis to verify the analytical results in the tables above. The Visualyse simulations determine the level of unwanted energy received by an LMDS user terminal at all locations surrounding the user terminal given the LMDS hub location. The location of the LMDS hub terminal with respect to the LMDS user terminal drives the pointing direction of the user terminal.

The Visualyse software does not have a parameter to enter airframe blockage toward the ground. To simulate airframe blockage during the area analysis, the input power to the antenna was adjusted downward by static value of 20 dB, even though the blockage value would increase to higher values as the downward angle toward the LMDS user station increases when the aircraft gets closer to the LMDS site. However, even without the full blockage effect included in the area analysis, the results still indicate an acceptable I/N at areas near the LMDS user terminal.

In the area analysis, the aeronautical earth station is moved in small steps to each location within the area, and the analysis is performed in successive iterations with the results recorded internally within Visualyse. Using these recorded results, Visualyse generates the figures shown below to illustrate the contour boundaries for various I/N levels for the LMDS system. The results compare well with the value in Table 1 and indicate a worst case I/N of -45 dB within the area analysis region during operation at 35,000 ft. When operating at 10,000 ft, a worst case I/N of -22 dB was observed.

These results are consistent with the values in Table 1 and Table 2 above and indicate an acceptable I/N at areas near the LMDS user terminal in all cases.

The following figures represent various alignments of the aeronautical earth station to the LMDS hub and user terminal that were evaluated. In most cases, there will be no alignment at all that needs to be considered as a potential interference case. For instance, (i) Figure 1 depicts the case where the LMDS hub terminal is North East of the LMDS user terminal and the user terminal pointing most directly towards the aeronautical earth station is more likely to receive unwanted energy than when facing other directions, (ii) Figures 2, 3 and 4 depict cases where the LMDS user terminal and the aeronautical earth station simply are not aligned in the azimuth plane.

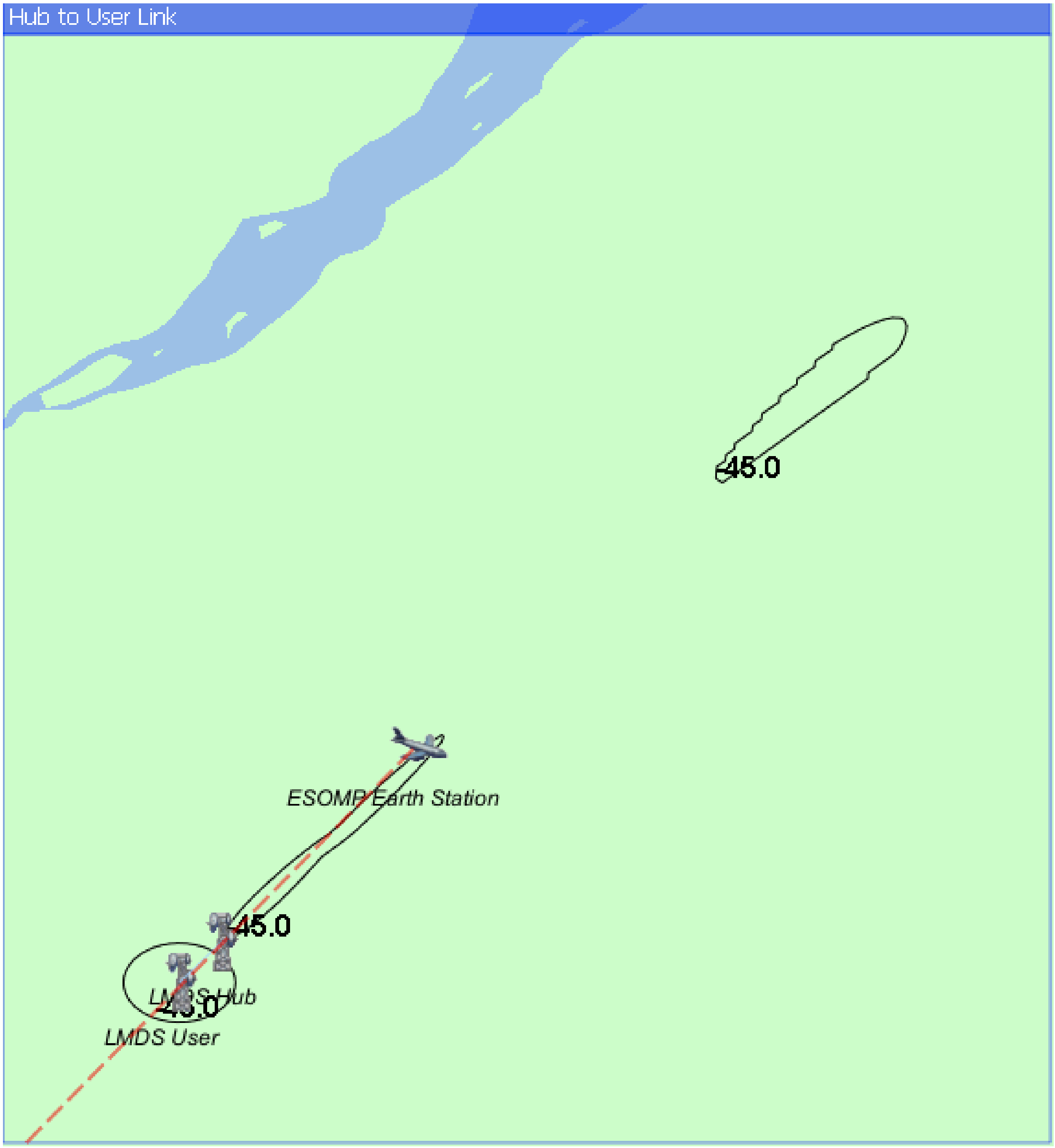

Figure 1: Aeronautical Earth Station at 35,000 ft - LMDS Hub NE of UT

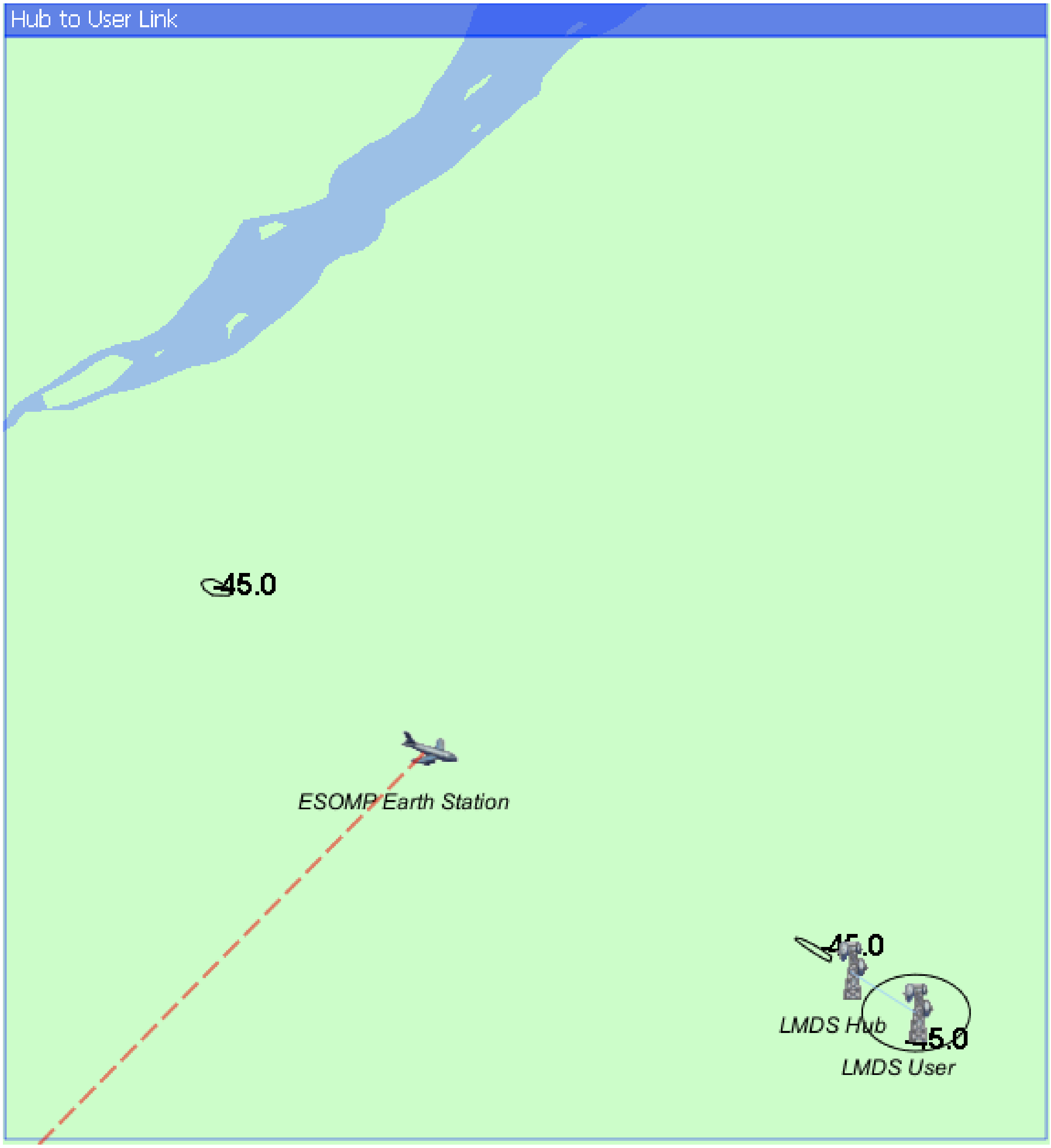

Figure 2: Aeronautical Earth Station at 35,000 ft - LMDS Hub NE of UT

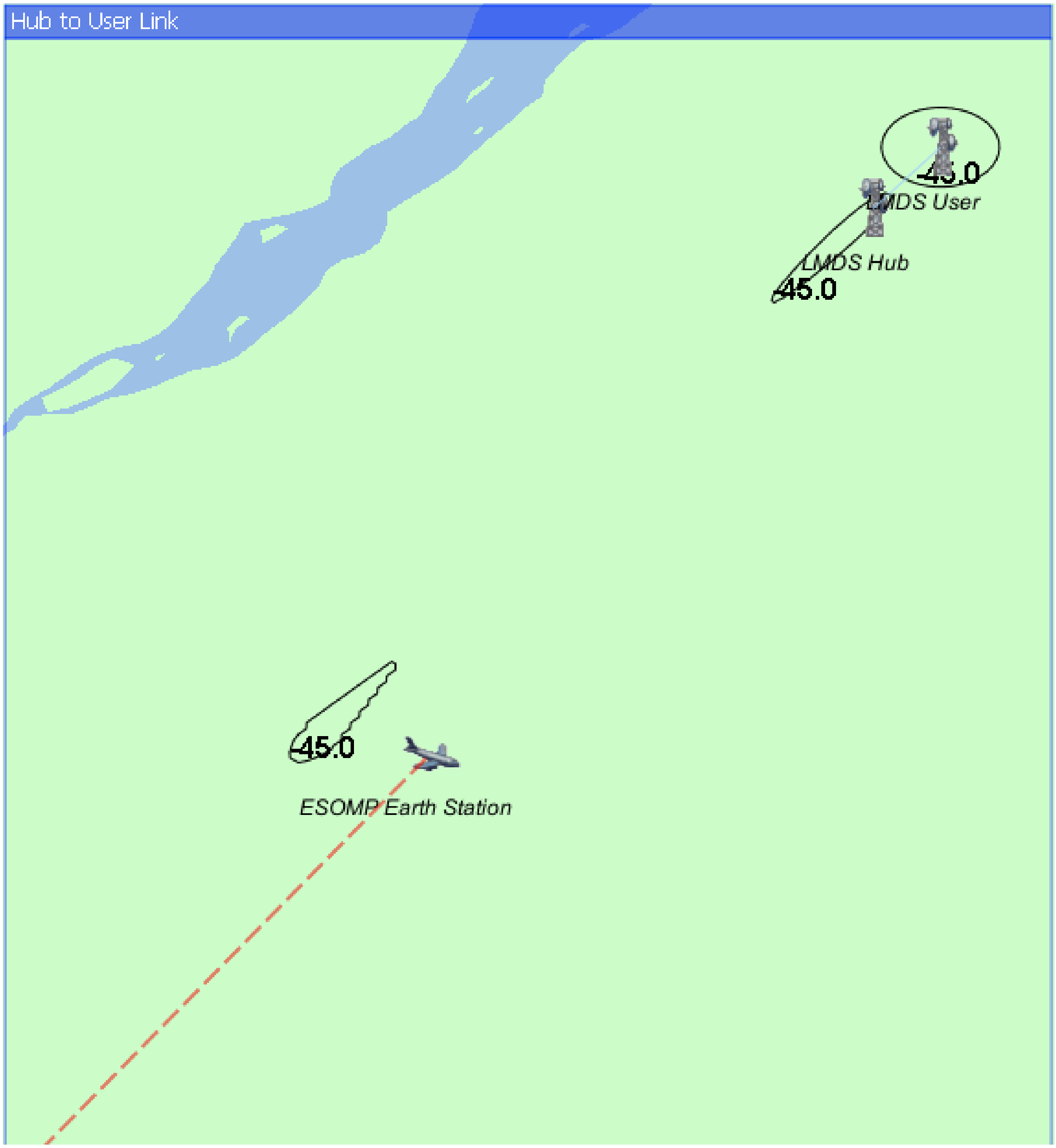

Figure 3 Aeronautical Earth Station at 35,000 ft – LMDS Hub SW of UT

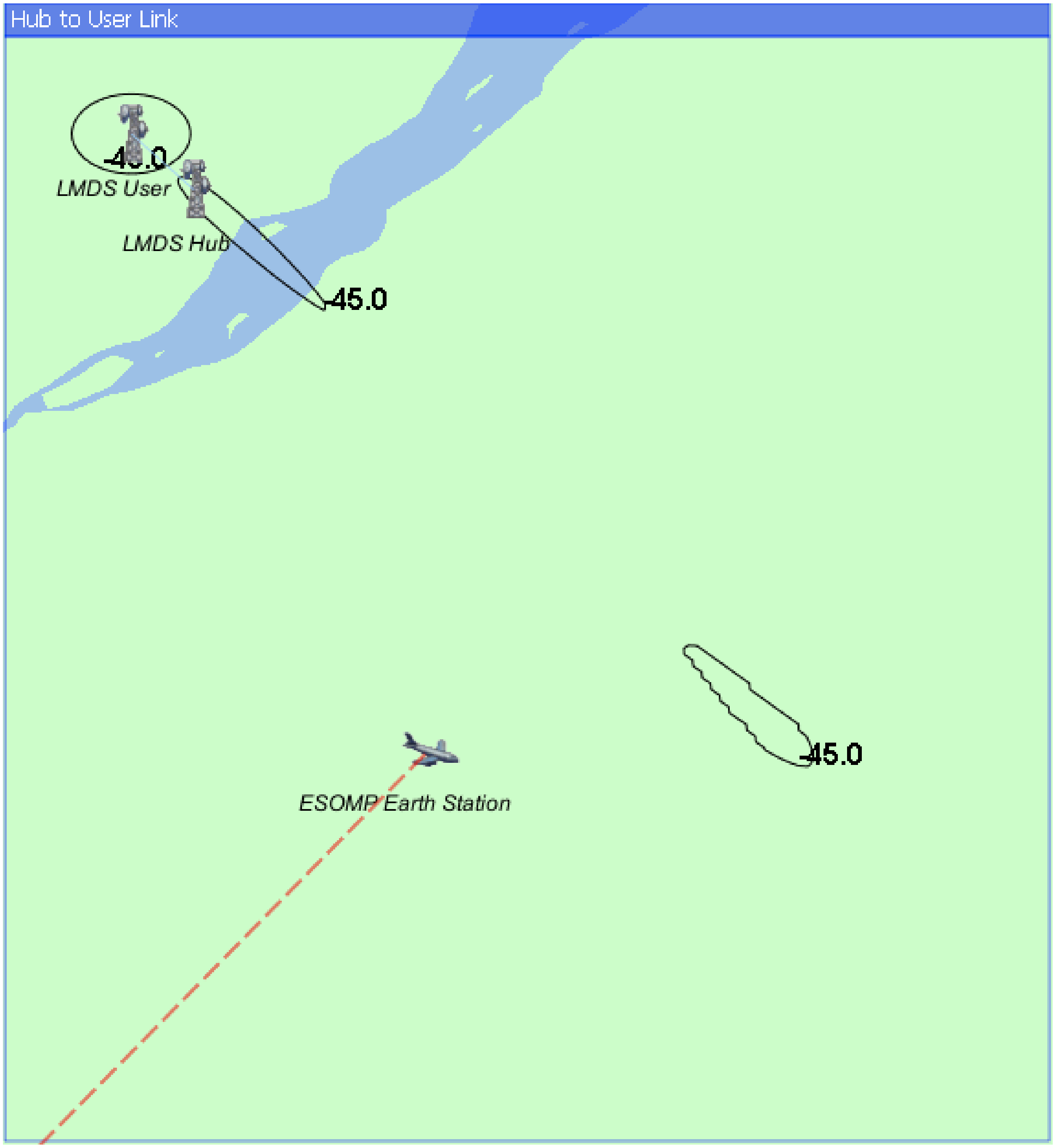

Figure 4 Aeronautical Earth Station at 35,000 ft – LMDS Hub SE of UT

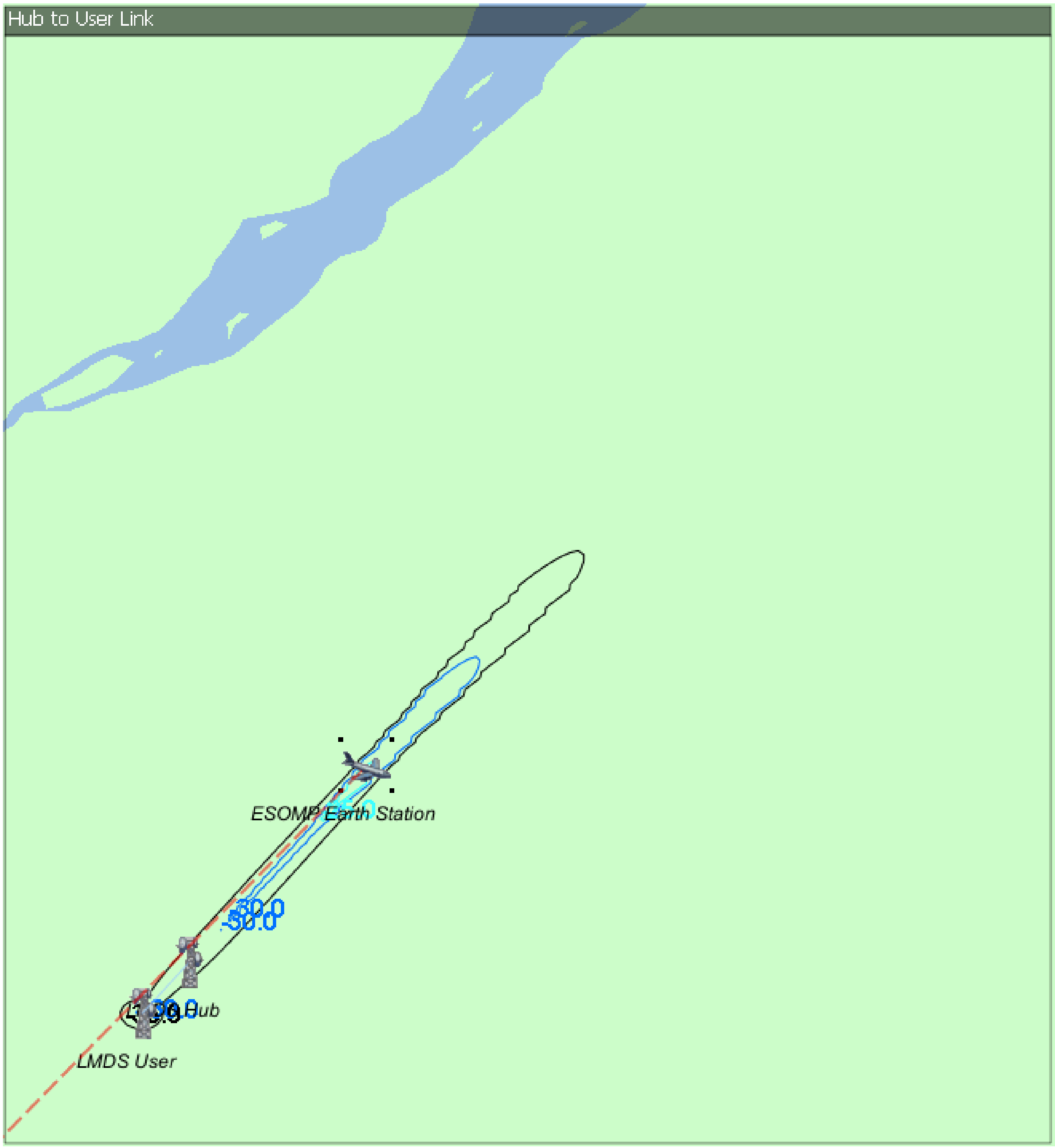

Figure 5 Aeronautical Earth Station at 10,000 ft – LMDS Hub NE of UT

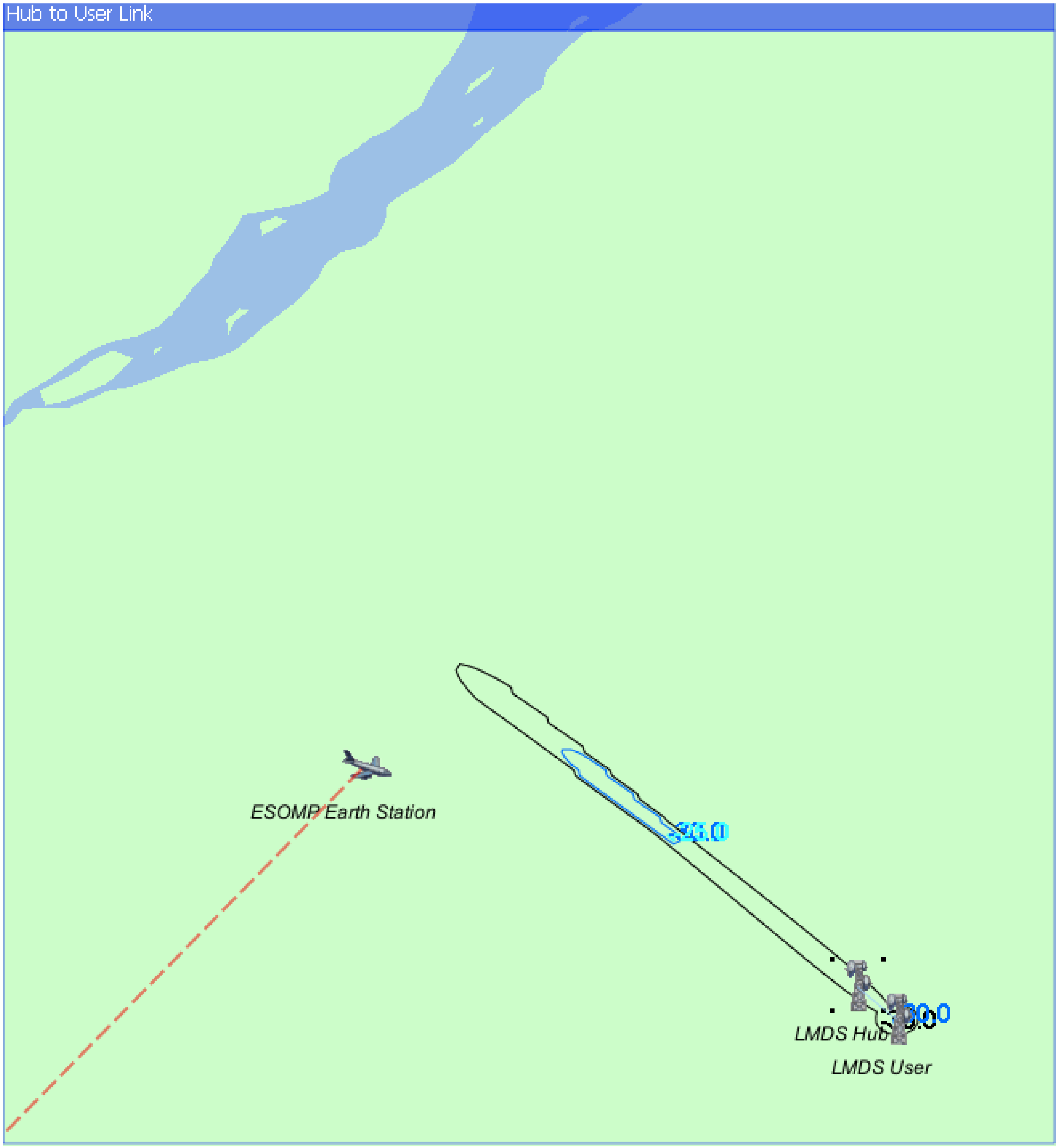

Figure 6 Aeronautical Earth Station at 10,000 ft – LMDS Hub NW of UT

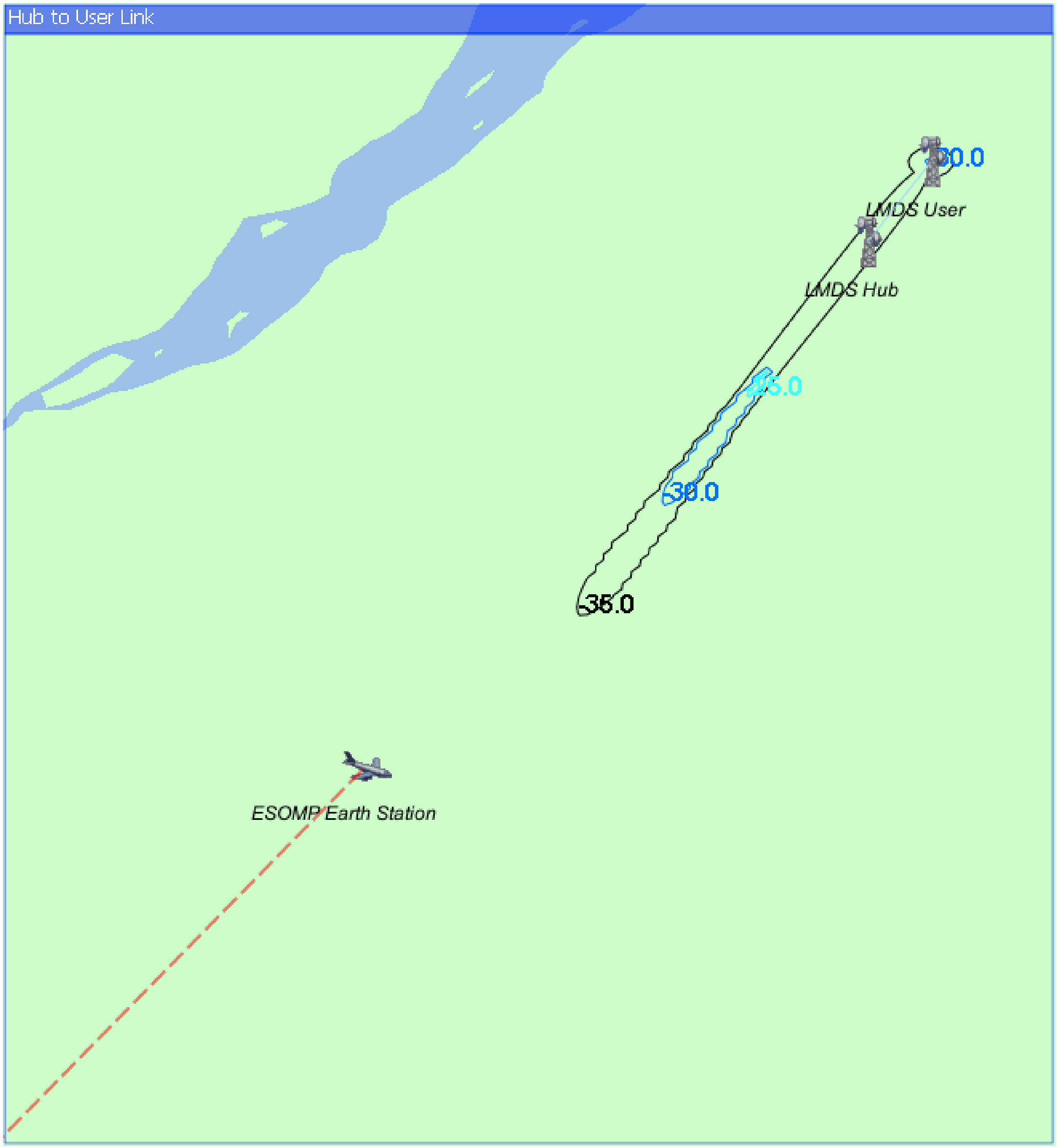

Figure 7 Aeronautical Earth Station at 10,000 ft – LMDS Hub SW of UT

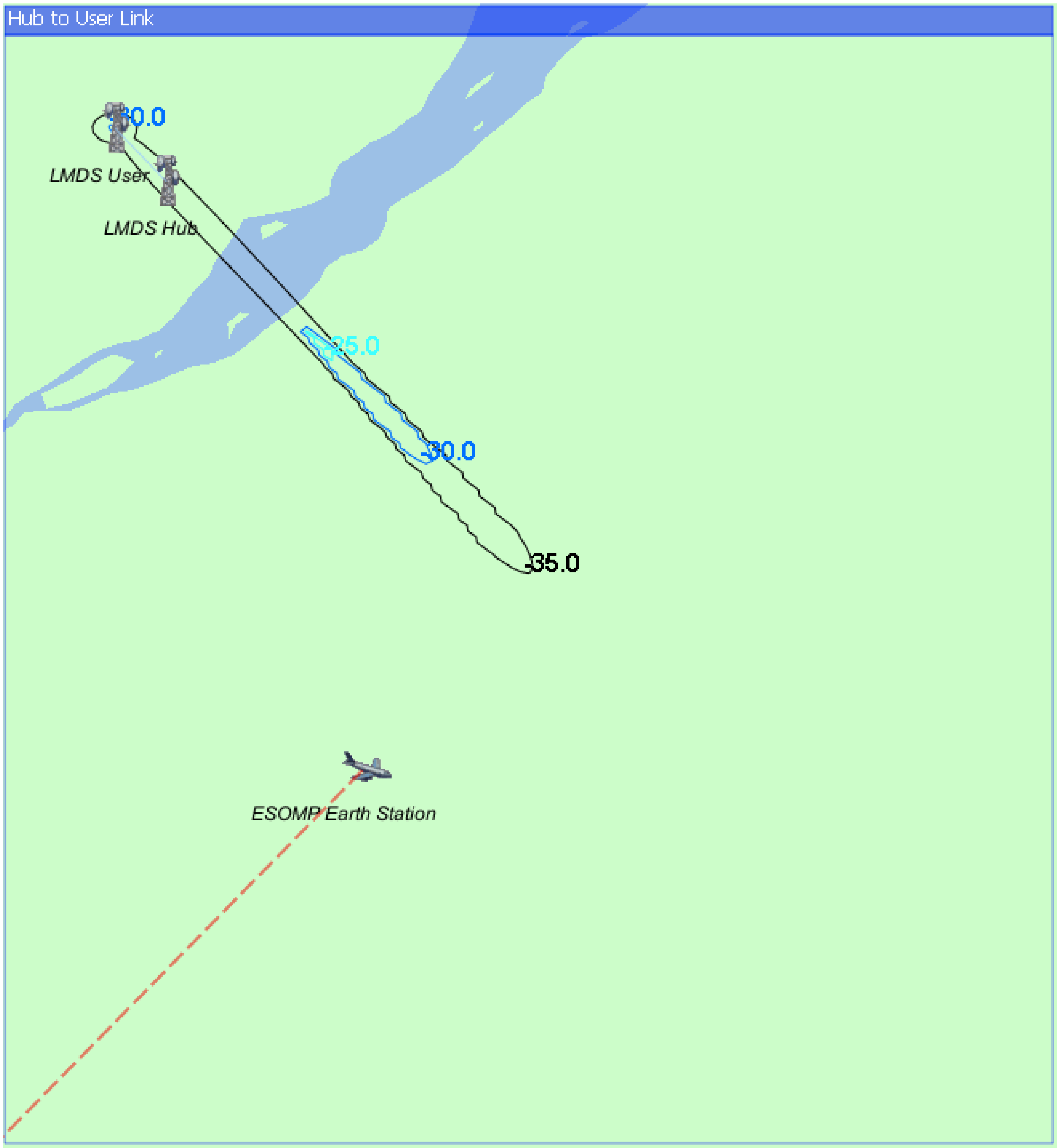

Figure 8 Aeronautical Earth Station at 10,000 ft – LMDS Hub SE of UT