Technical Exhibit In Support Of General Atomics Aeronautical Systems' Earth Station In Motion License Application

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Technical Exhibit In Support Of General Atomics Aeronautical Systems' Earth Station In Motion License Application

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Revision History

Revision	Date	Description
Rev A	4/30/2020	Initial Release

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1.1.1 Standards

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Document Number	Reference Document Title	Date
N/A	N/A	N/A

1.1.2 Other Publications

Table 1-2 Other Government Documents

Document Number	Reference Document Title	Date
N/A	N/A	N/A

1.2 NON-GOVERNMENT DOCUMENTS

1.2.1 Standards

Table 1-3 Non-Government Standards Documents

Document Number	Reference Document Title	Date	Source
N/A	N/A	N/A	N/A

1.2.2 Other Documents

Table 1-4 Other Non-Government Documents

Document Number	Reference Document Title	Date	Source
N/A	N/A	N/A	N/A

2. INTRODUCTION

General Atomics Aeronautical Systems Inc. (GA-ASI), pursuant to 47 CFR §25.228 of the Rules and Regulations of the Federal Communications Commission, respectfully requests the issuance of a new license to operate the Ku-band Earth Station in Motion (ESIM) in the United States. The proposed ESIM terminals will receive in the 11.7-12.2 GHz (Space-to-Earth) Ku-band frequencies and transmit in the 14.0-14.5 GHz (Earth-to-Space) conventional Ku-band frequencies with Geostationary Satellites in the Fixed-Satellite Service. The proposed ESIM terminals will be installed on GA-ASI Unmanned Aircraft (UA) and communicate with licensed Ku-band Ground Control Stations (GCS) in the United States.

The proposed ESIM terminal utilizes the General Dynamics M17-27A antenna with a circular aperture and is 27 inches in diameter. This terminal transmits three data rates, when paired with its partner Single Channel Per Carrier (SCPC) modem: 3072 kbps, 6144 kbps, and 9600 kbps.

2.1 SYSTEM OVERVIEW

The ESIM will be installed on a GA-ASI Remotely Piloted Aircraft (RPA). An RPA is controlled and communicates with a Ground Control Station (GCS), via a SATCOM Ground Data Terminal (SGDT). The end-to-end system is illustrated in Figure 2-1.

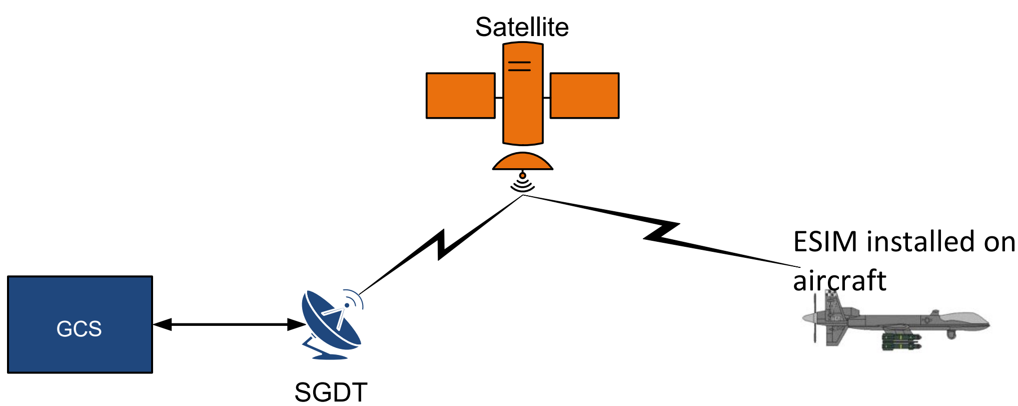

Figure 2-1 GA-ASI Ku-band ESIM OV-1

3. §25.218(A) EIRP SPECTRAL DENSITIES

From §25.228(a), *(a) ESIM transmissions must comport with the applicable EIRP density limits in §25.218, unless coordinated pursuant to the requirements in §25.220.*

From §25.218(f), *(f) Digital earth station operation in the conventional Ku-band. (1) For co-polarized transmissions in the plane tangent to the GSO arc:*

$15-25\log_{10}\theta$	dBW/4 kHz	for $1.5° \leq \theta \leq 7°$.
-6	dBW/4 kHz	for $7° < \theta \leq 9.2°$.
$18-25\log_{10}\theta$	dBW/4 kHz	for $9.2° < \theta \leq 19.1°$.
-14	dBW/4 kHz	for $19.1° < \theta \leq 180°$.

Where θ is as defined in paragraph (c)(1) of this section. The EIRP density levels specified for θ > 7° may be exceeded by up to 3 dB in up to 10% of the range of theta (θ) angles from ±7-180°, and by up to 6 dB in the region of main reflector spillover energy.

(2) For co-polarized transmissions in the plane perpendicular to the GSO arc:

$18-25\log_{10}\theta$	dBW/4 kHz	for $3° \leq \theta \leq 19.1°$.
-14	dBW/4 kHz	for $19.1° < \theta \leq 180°$.

Where θ is as defined in paragraph (c)(1) of this section. These EIRP density levels may be exceeded by up to 6 dB in the region of main reflector spillover energy and in up to 10% of the range of θ angles not included in that region, on each side of the line from the earth station to the target satellite.

(3) For cross-polarized transmissions in the plane tangent to the GSO arc and in the plane perpendicular to the GSO arc:

$5-25\log_{10}\theta$	dBW/4 kHz	for $1.5° \leq \theta \leq 7°$.

Where θ is as defined in paragraph (c)(1) of this section.

From §25.115(g)(1), *Applications for earth stations that will transmit to GSO space stations in any portion of the 5850-6725 MHz, 13.75-14.5 GHz, 24.75-25.25 GHz, 28.35-28.6 GHz, or 29.25-30.0 GHz bands must include, in addition to the particulars of operation identified on FCC Form 312 and associated Schedule B, the information specified in either paragraph (g)(1) or (g)(2) of this section for each earth station antenna type.*

(1) Specification of off-axis EIRP density calculated from measurements made consistent with the requirements in §25.132(b)(1), in accordance with the following requirements. For purposes of this rule, the "off-axis angle" is the angle in degrees from a line between an earth station antenna and the target satellite.

(i) A plot of maximum co-polarized EIRP density in the plane tangent to the GSO arc at off-axis angles from minus 180° to plus 180°;

(ii) A plot of maximum co-polarized EIRP density in the plane tangent to the GSO arc at off-axis angles from minus 10° to plus 10°;

(iii) A plot of maximum co-polarized EIRP density in the plane perpendicular to the GSO arc at off-axis angles from 0° to plus 30°;

(iv) A plot of maximum cross-polarized EIRP density in the plane tangent to the GSO arc at off-axis angles from minus 7° to plus 7°;

(v) A plot of maximum cross-polarized EIRP density in the plane perpendicular to the GSO arc at off-axis angles from minus 7° to plus 7°;

(vi) For antennas for which gain measurements are made pursuant to §25.132(b)(1)(iv), the EIRP density plots specified in paragraphs (g)(1)(i) through (v) of this section must be provided over the specified angular ranges in two orthogonal planes, one of which is tangent to the GSO arc and with the antenna operating at its maximum skew angle, which the applicant must specify.

(vii) The relevant off-axis EIRP density envelopes in §25.218 or §25.223 must be superimposed on plots submitted pursuant to paragraphs (g)(1)(i) through (vi) of this section.

(viii) The showing must include a supplemental table for each off-axis angular range in which the relevant EIRP density envelope will be exceeded, specifying angular coordinates in degrees off-axis and corresponding calculated off-axis EIRP density at 0.2° increments over the angular range in which the routine envelope will be exceeded and one degree on each side of that range.

The proposed ESIM terminal complies with §25.218(f) for the three data rates. In accordance with the requirements specified in §25.115(g)(1), EIRP spectral density plots and supplemental tables are provided for the three data rates.

3.1 EIRP SPECTRAL DENSITY FOR 3072 KBPS DATA RATE

To ensure the EIRP spectral density limits specified in §25.218(f) are satisfied at the 3072 kbps data rate, the maximum EIRP spectral density is limited to 24.7 dBW/4 kHz. The EIRP spectral density performance for the 3072 kbps data rate is shown in the following:

Co-polarized off-axis EIRP density of the earth station antenna in the plane tangent to the GSO arc.

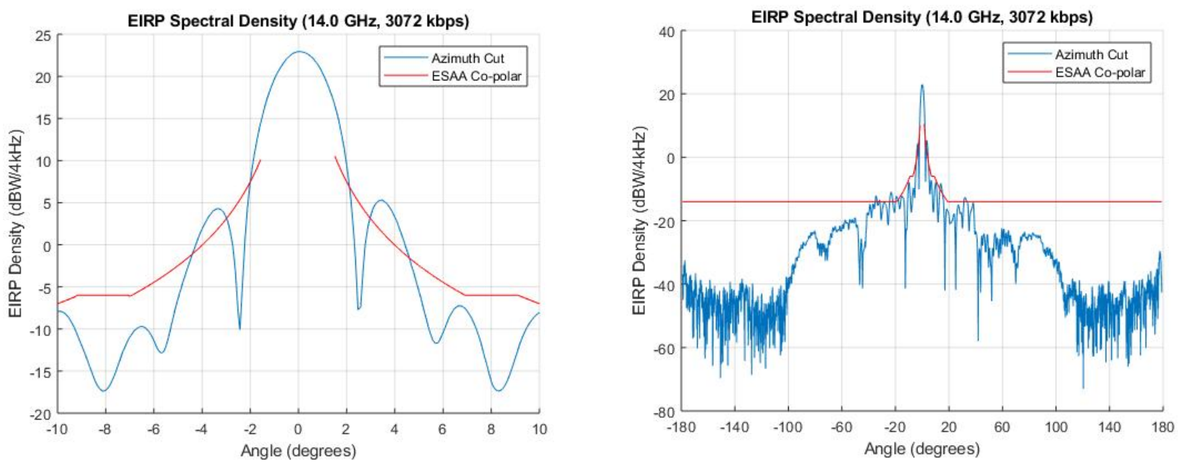

Figure 3-1 Off-Axis EIRP Density in the plane tangent to GSO Arc (14.0 GHz)

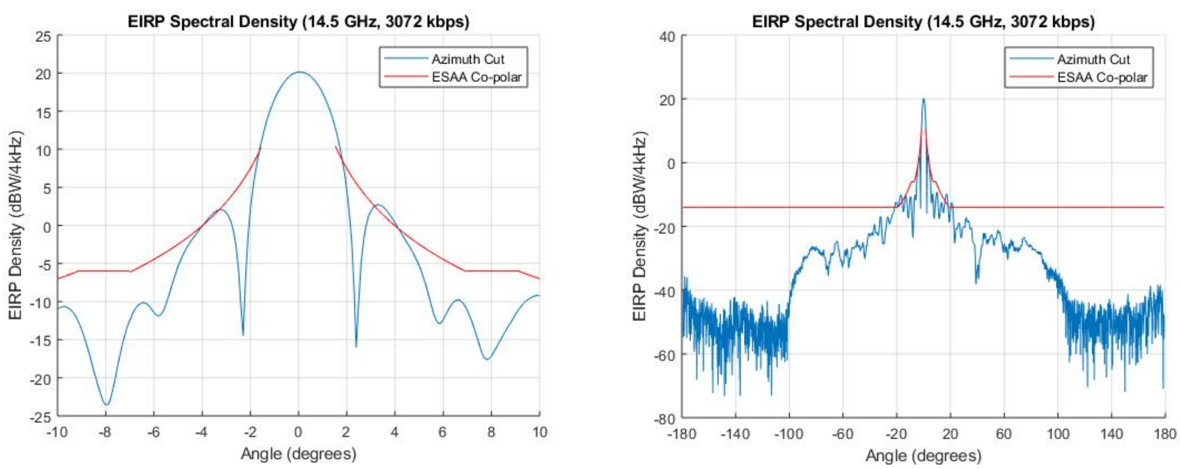

Figure 3-2 Off-Axis EIRP Density in the plane tangent to GSO Arc (14.5 GHz)

Co-polarized off-axis EIRP density in the plane perpendicular to the GSO arc

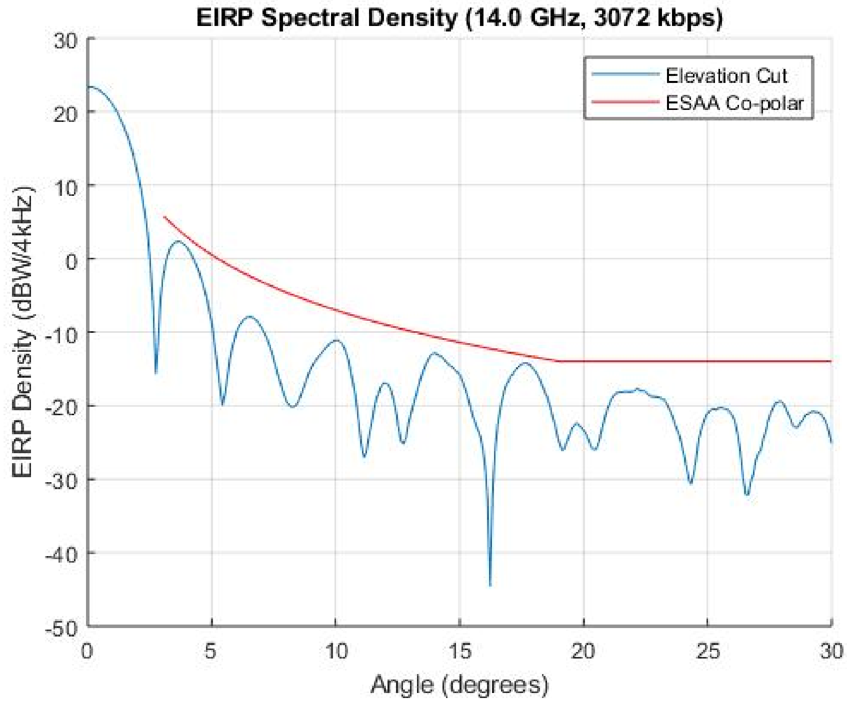

Figure 3-3 Off-Axis EIRP Density in the plane perpendicular to GSO Arc (14.0 GHz)

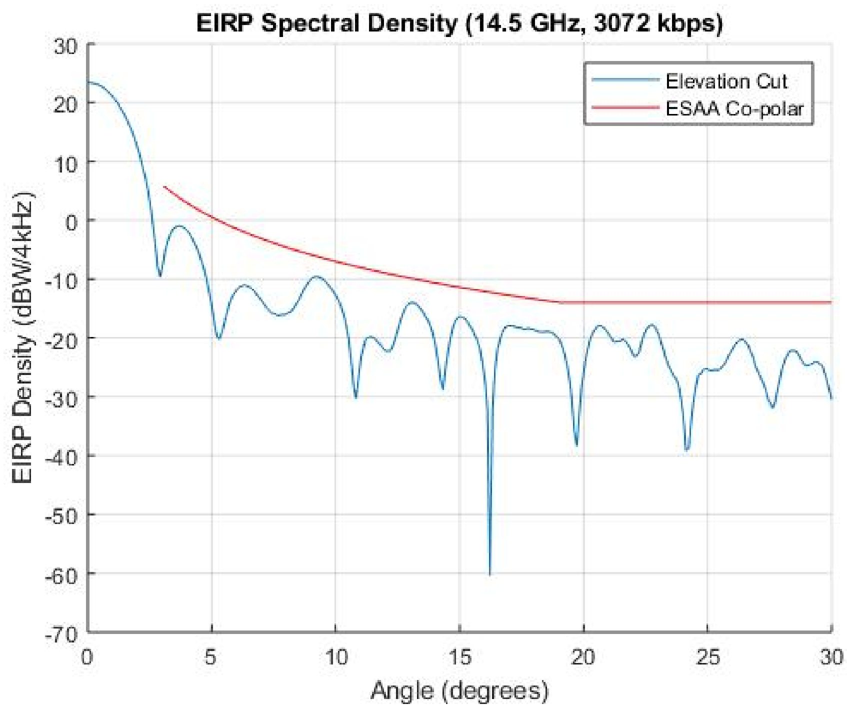

Figure 3-4 Off-Axis EIRP Density in the plane perpendicular to GSO Arc (14.5 GHz)

Cross-polarized off-axis EIRP density in the plane tangent to the GSO arc

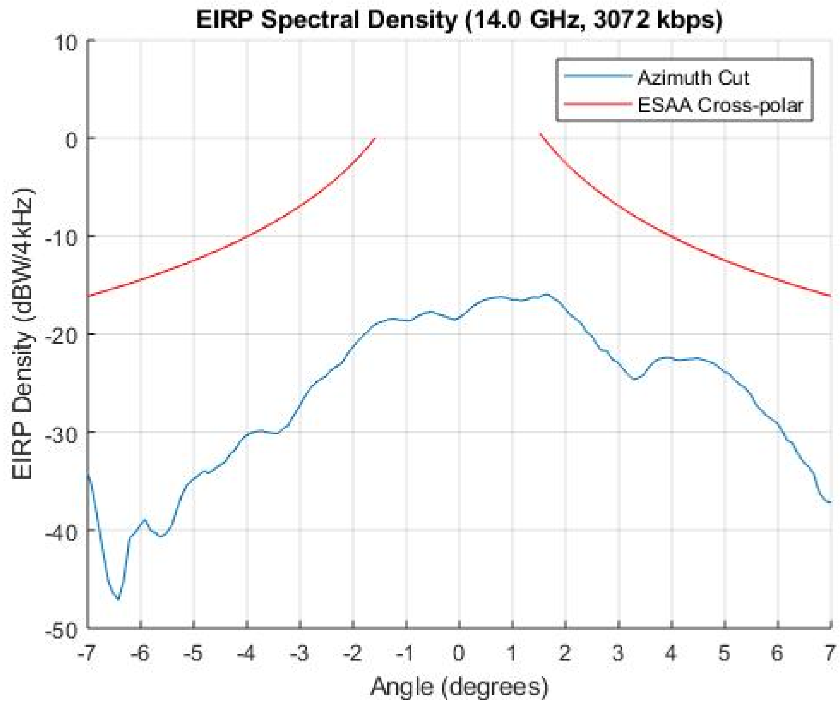

Figure 3-5 Cross-polarized Off-Axis EIRP Density in the plane of GSO Arc (14.0 GHz)

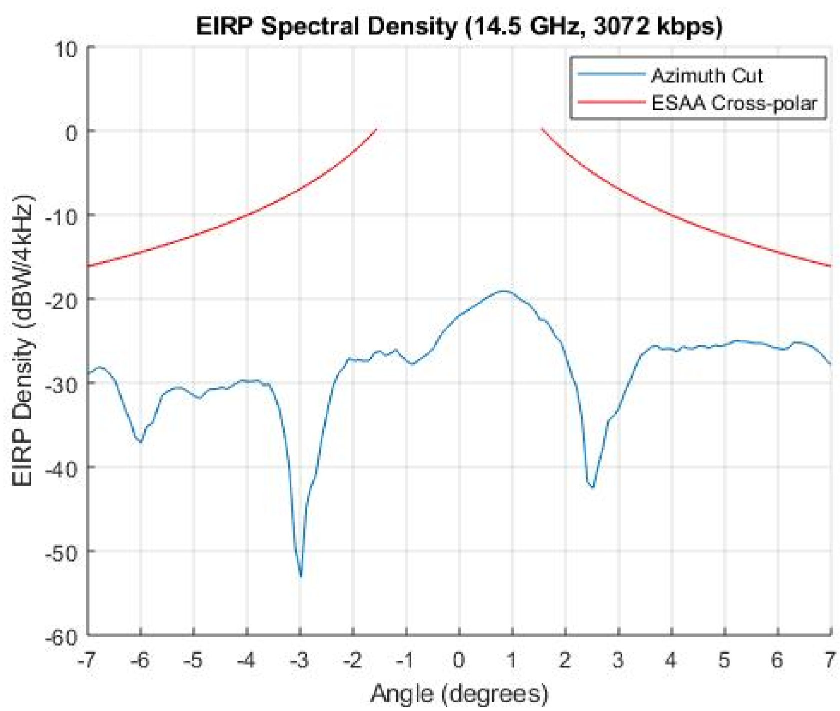

Figure 3-6 Cross-polarized Off-Axis EIRP Density in the plane of GSO Arc (14.5 GHz)

Cross-polarized off-axis EIRP density in the plane perpendicular to the GSO arc

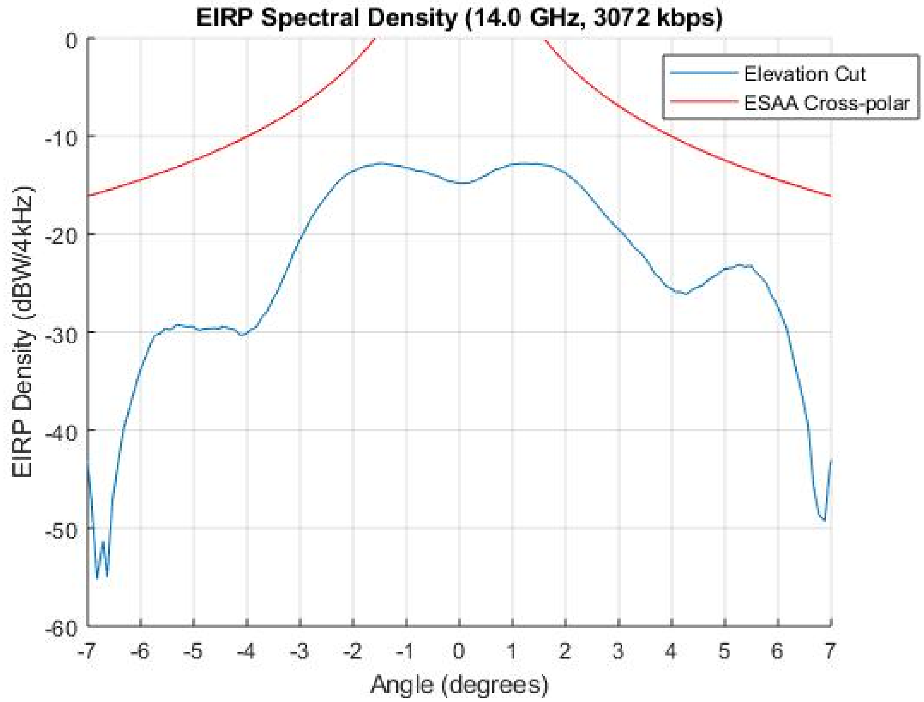

Figure 3-7 Cross-polarized Off-Axis EIRP Density in the plane perpendicular to GSO Arc (14.0 GHz)

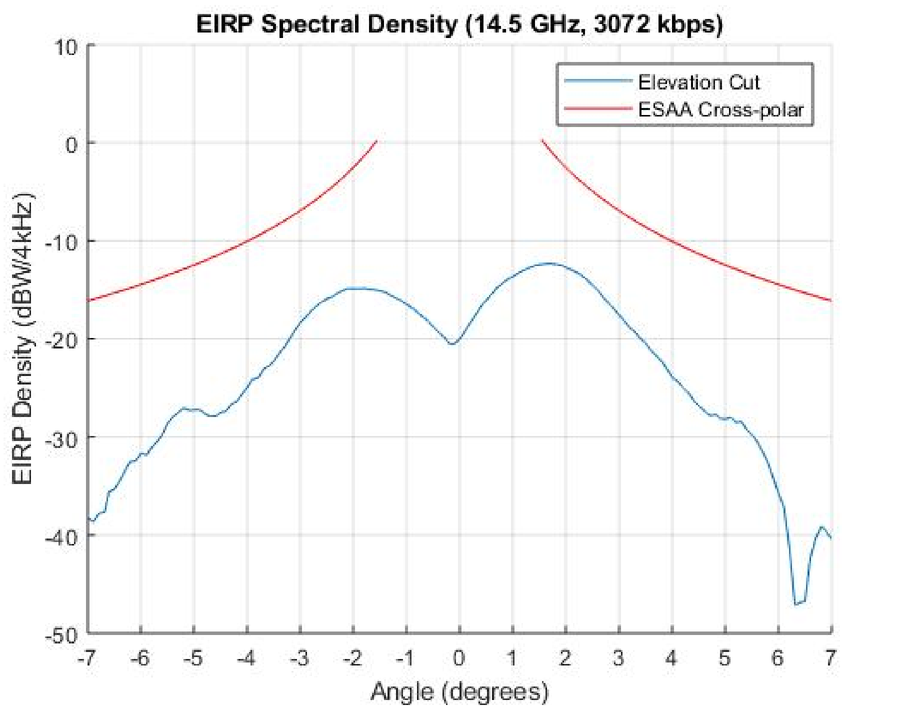

Figure 3-8 Cross-polarized Off-Axis EIRP Density in the plane perpendicular to GSO Arc (14.5 GHz)

3.2 EIRP SPECTRAL DENSITY FOR 6144 KBPS DATA RATE

To ensure the EIRP spectral density limits specified in §25.218(f) are satisfied, the maximum EIRP spectral density is limited to 21.5 dBW/4 kHz.

The EIRP spectral density performance for the 6144 kbps data rate is shown in the following:

Co-polarized off-axis EIRP density of the earth station antenna in the plane tangent to the GSO arc.

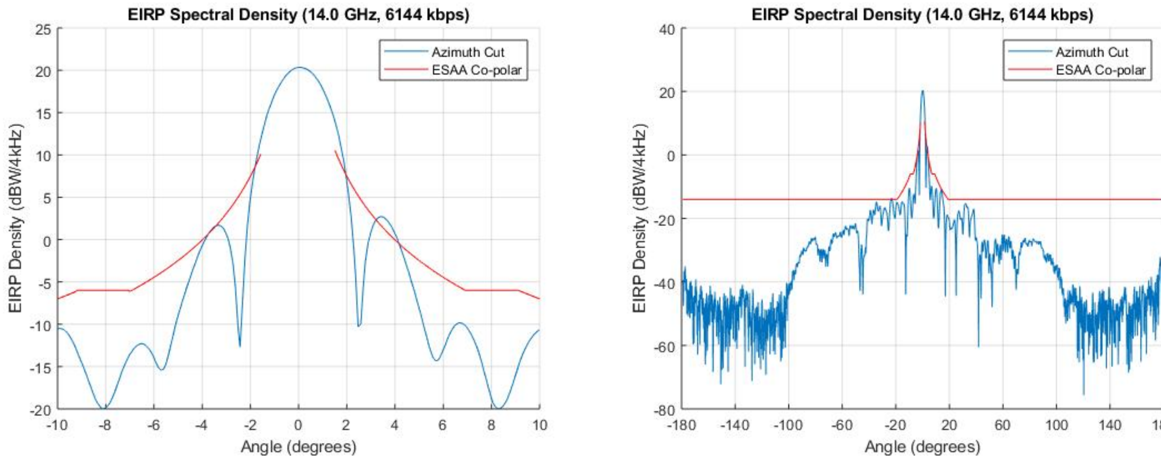

Figure 3-9 Off-Axis EIRP Density in the plane tangent to GSO Arc (14.0 GHz)

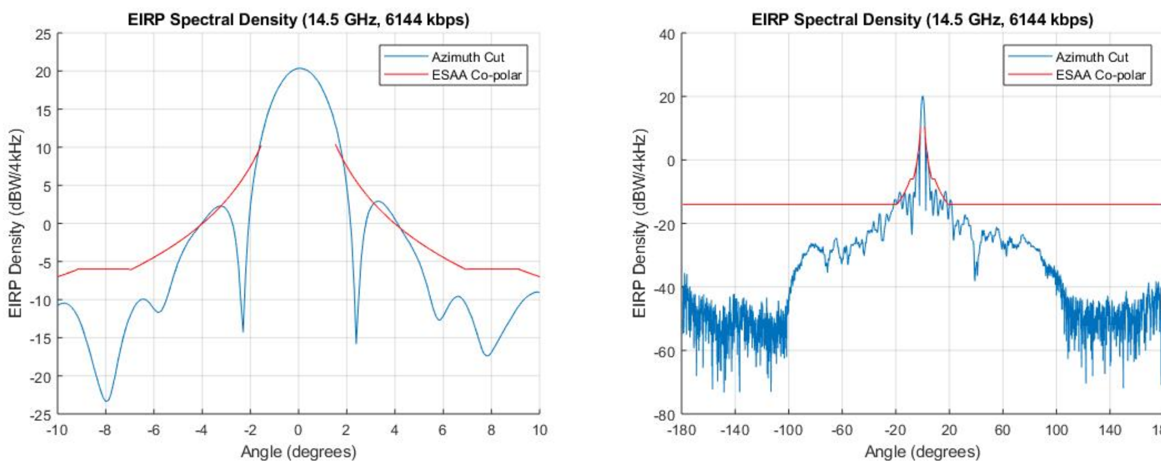

Figure 3-10 Off-Axis EIRP Density in the plane tangent to GSO Arc (14.5 GHz)

Co-polarized off-axis EIRP density in the plane perpendicular to the GSO arc.

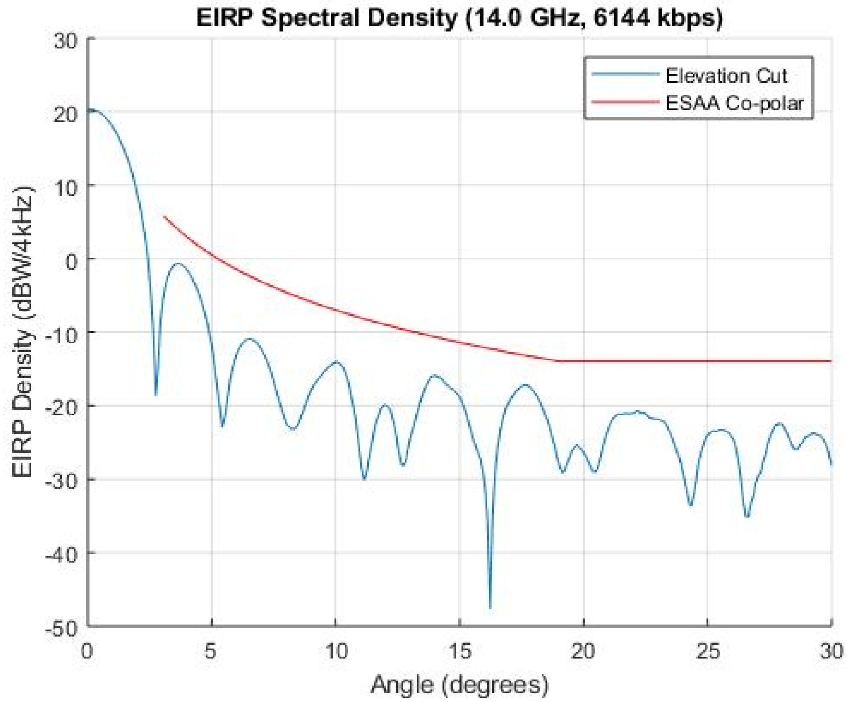

Figure 3-11 Off-Axis EIRP Density in the plane perpendicular to GSO Arc (14.0 GHz)

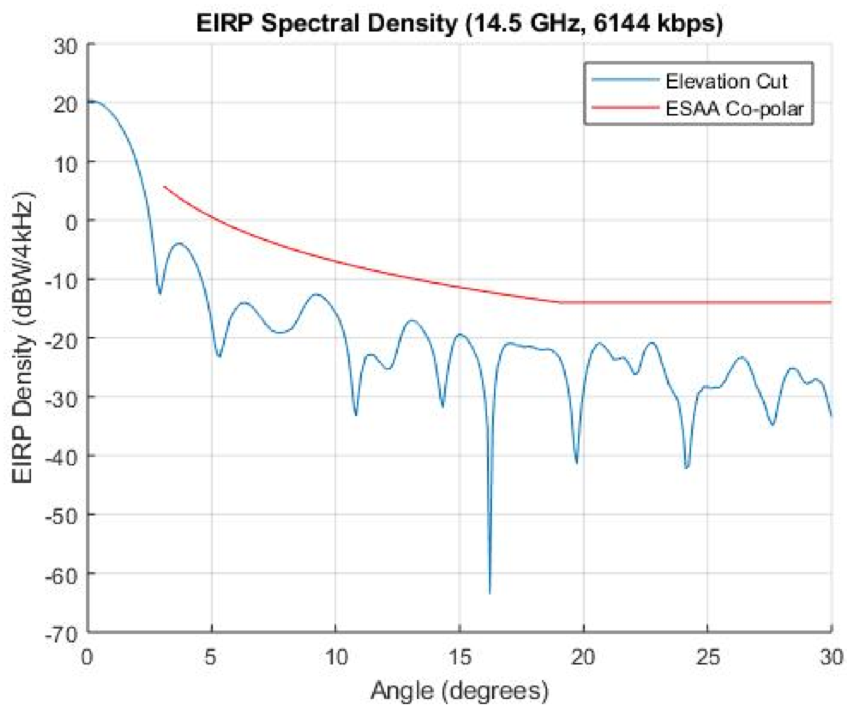

Figure 3-12 Off-Axis EIRP Density in the plane perpendicular to GSO Arc (14.5 GHz)

Cross-polarized off-axis EIRP density in the plane tangent to the GSO arc.

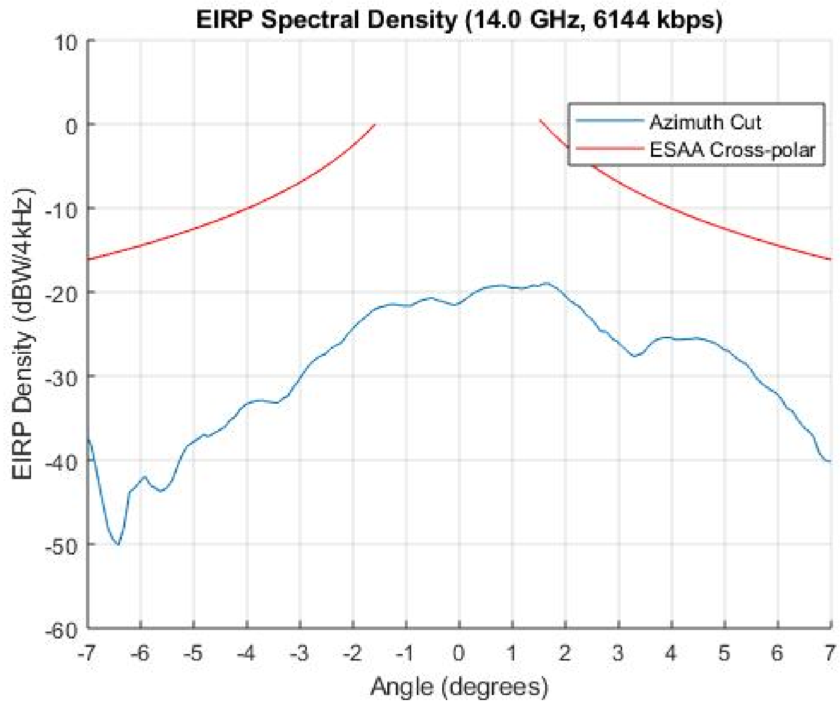

Figure 3-13 Cross-polarized Off-Axis EIRP Density in the plane of GSO Arc (14.0 GHz)

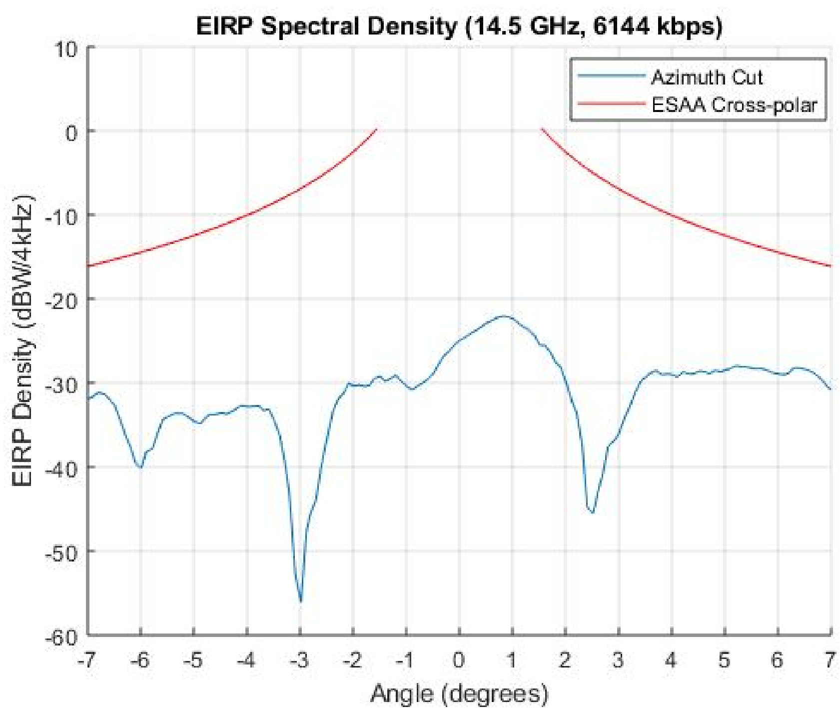

Figure 3-14 Cross-polarized Off-Axis EIRP Density in the plane of GSO Arc (14.5 GHz)

Co-polarized off-axis EIRP density in the plane perpendicular to the GSO arc.

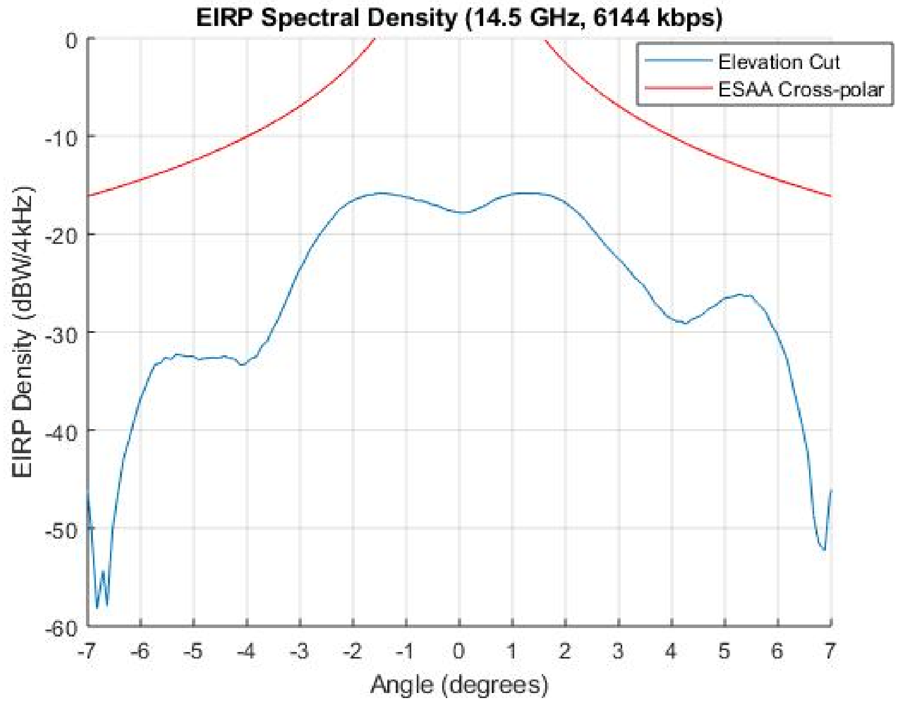

Figure 3-15 Cross-polarized Off-Axis EIRP Density in the plane perpendicular to GSO Arc (14.0 GHz)

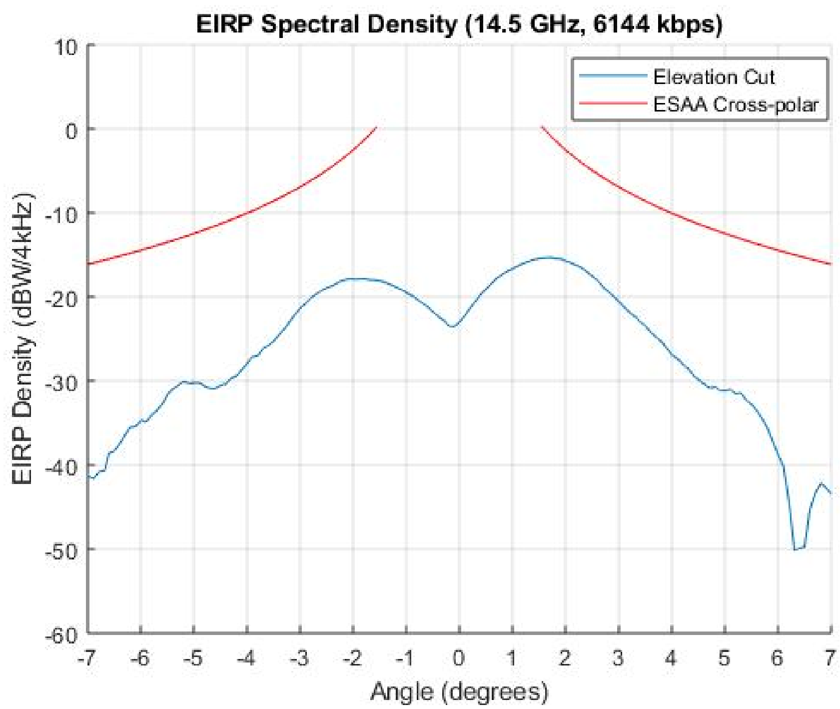

Figure 3-16 Cross-polarized Off-Axis EIRP Density in the plane perpendicular to GSO Arc (14.5 GHz)

3.3 EIRP SPECTRAL DENSITY FOR 9600 KBPS DATA RATE

The EIRP spectral density curves do not exceed the EIRP spectral density limits specified in §25.218(f).

The EIRP spectral density performance for the 9600 kbps data rate is shown in the following: Co-polarized off-axis EIRP density of the earth station antenna in the plane tangent to the GSO arc.

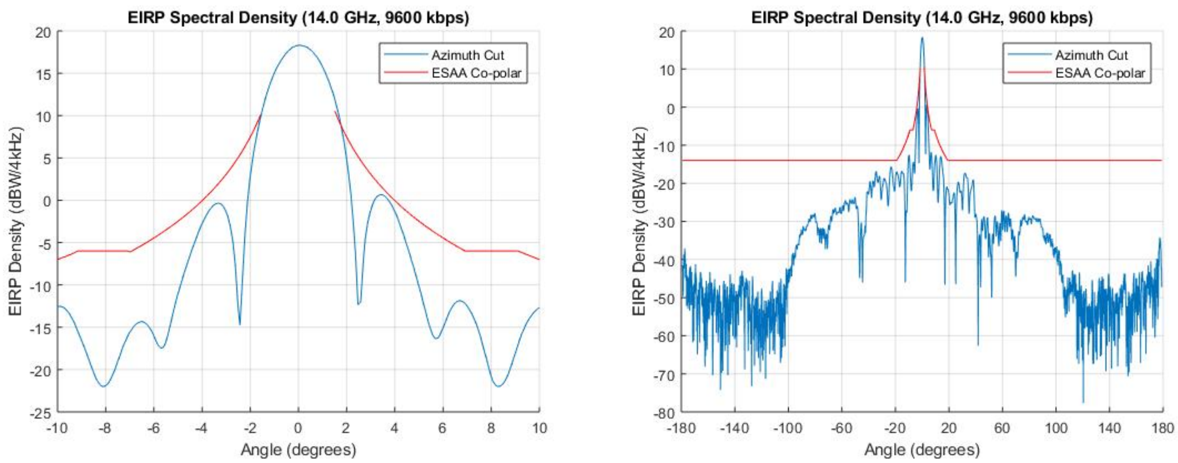

Figure 3-17 Off-Axis EIRP Density in the plane tangent to GSO Arc (14.0 GHz)

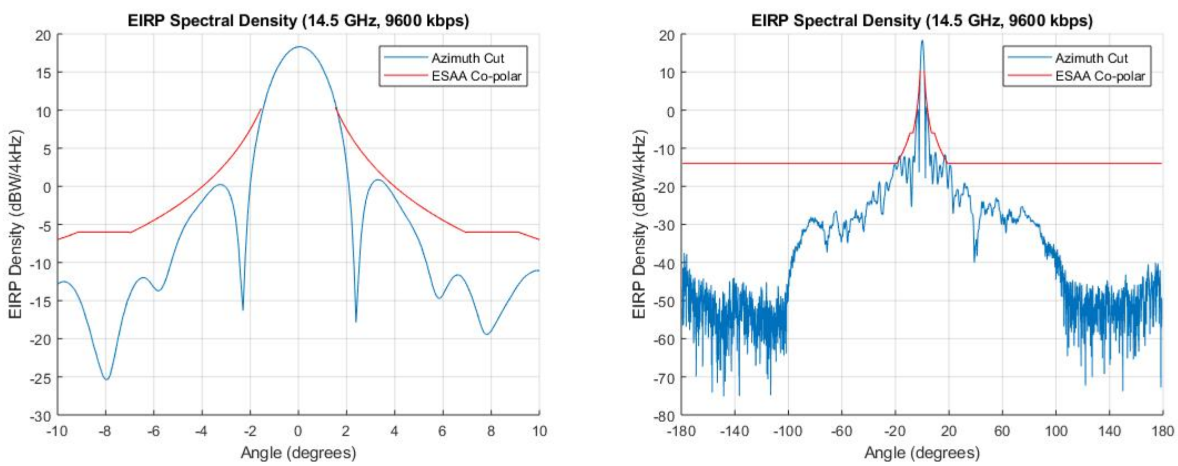

Figure 3-18 Off-Axis EIRP Density in the plane tangent to GSO Arc (14.5 GHz)

Co-polarized off-axis EIRP density in the plane perpendicular to the GSO arc.

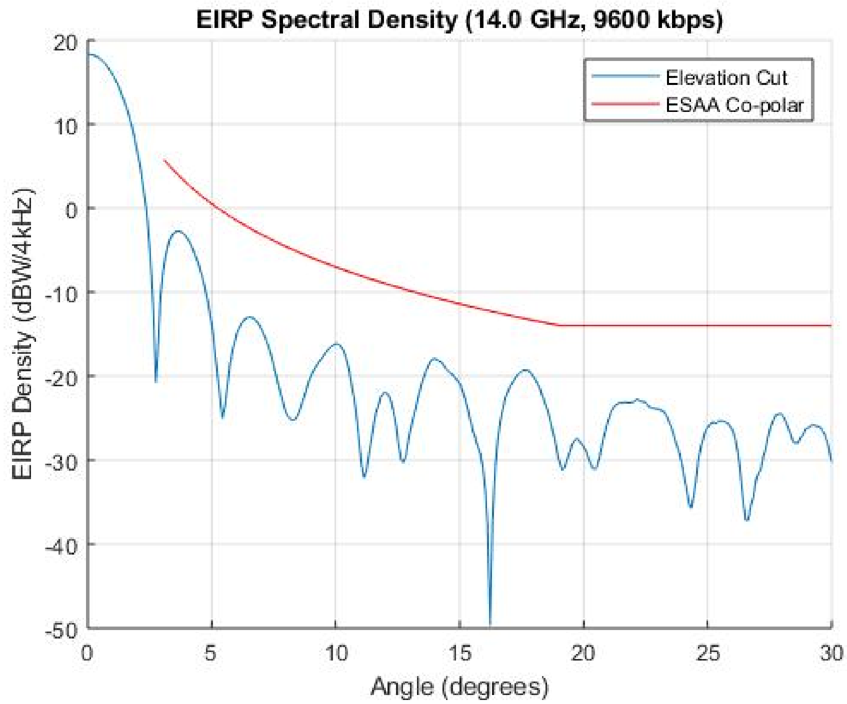

Figure 3-19 Off-Axis EIRP Density in the plane perpendicular to GSO Arc (14.0 GHz)

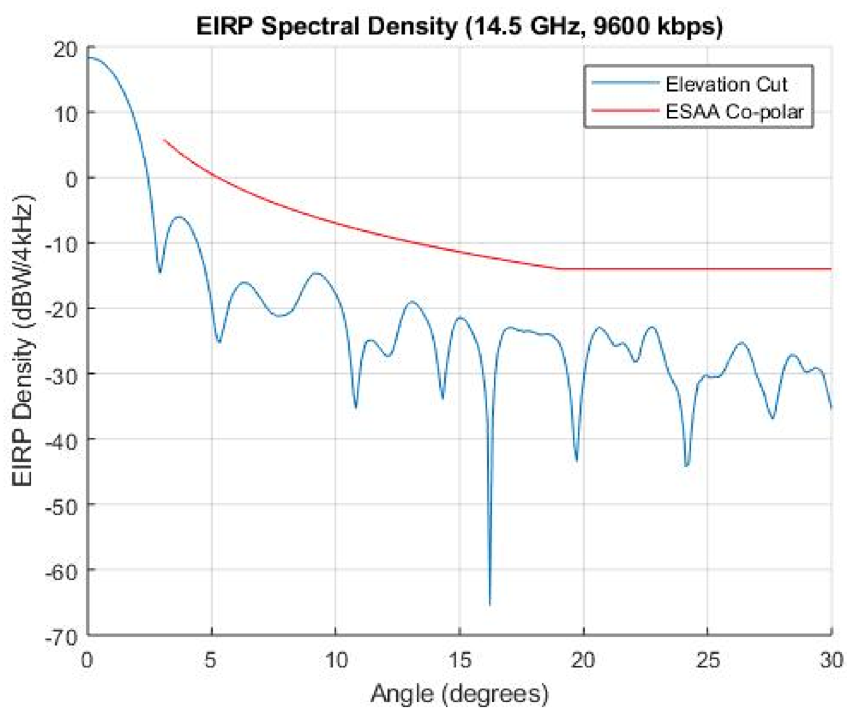

Figure 3-20 Off-Axis EIRP Density in the plane perpendicular to GSO Arc (14.5 GHz)

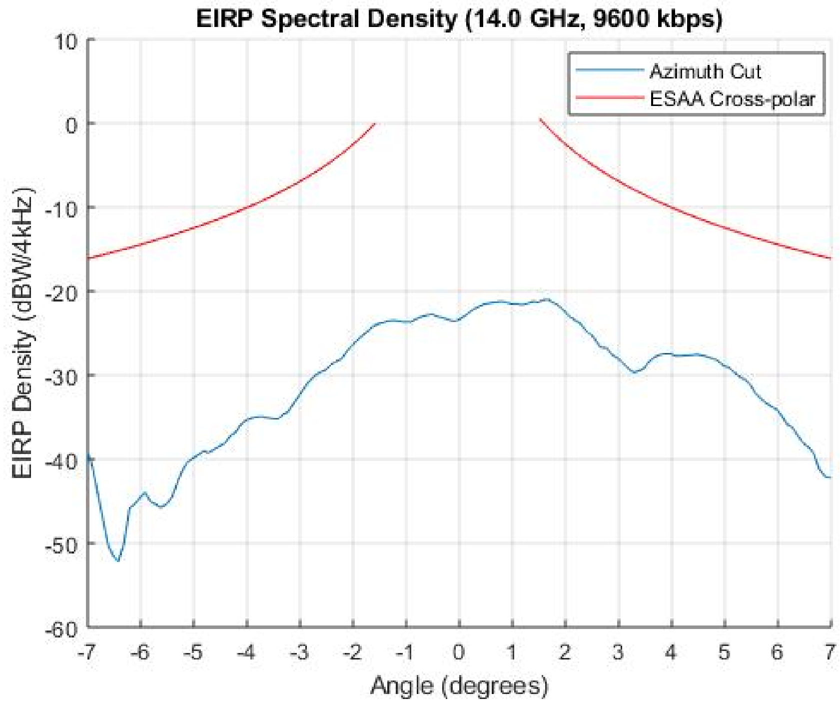

Figure 3-21 Cross-polarized Off-Axis EIRP Density in the plane of GSO Arc (14.0 GHz)

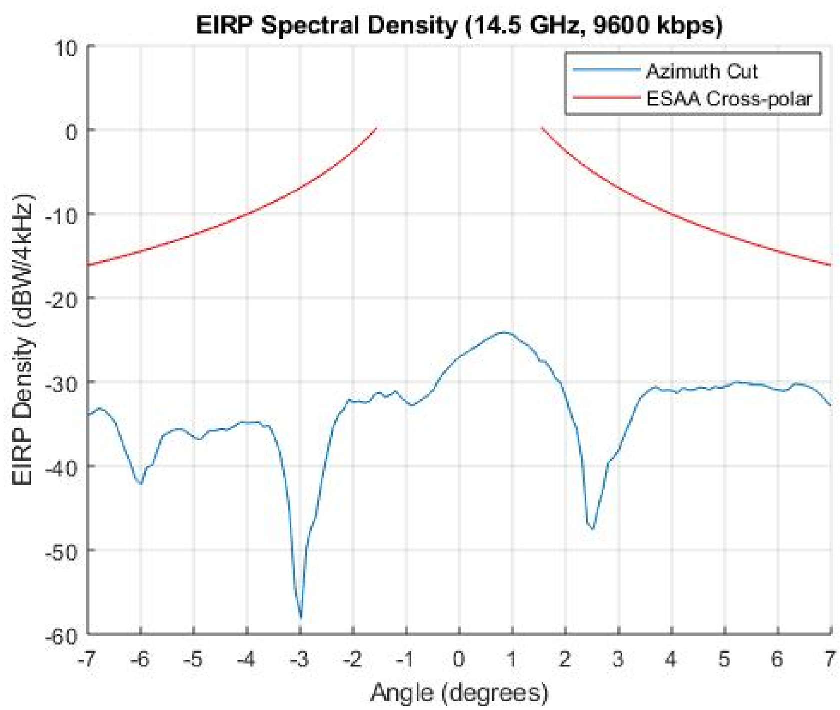

Figure 3-22 Cross-polarized Off-Axis EIRP Density in the plane of GSO Arc (14.5 GHz)

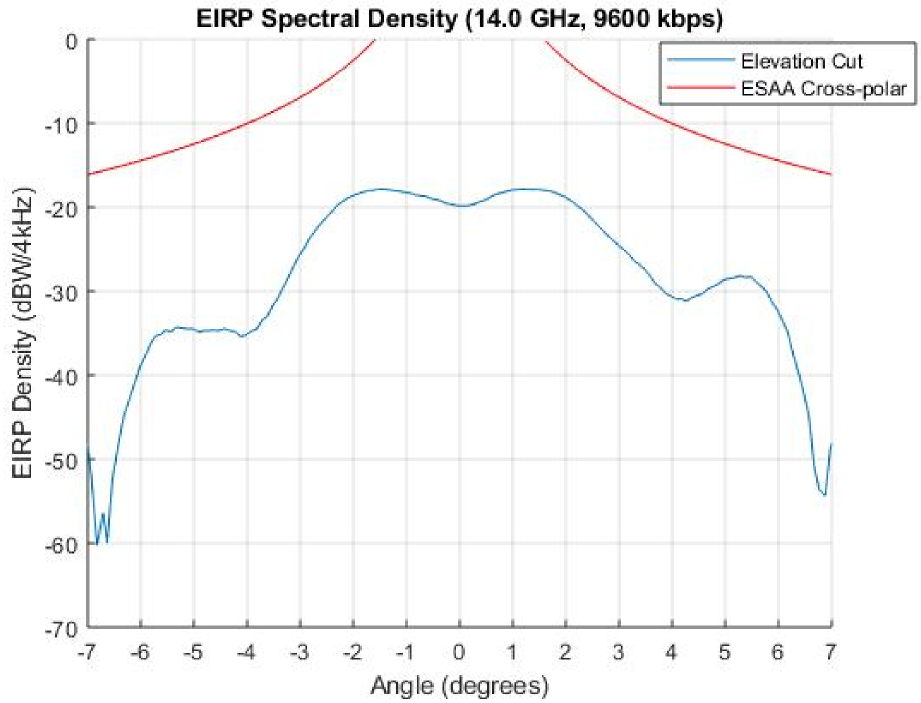

Figure 3-23 Cross-polarized Off-Axis EIRP Density in the plane perpendicular to GSO Arc (14.0 GHz)

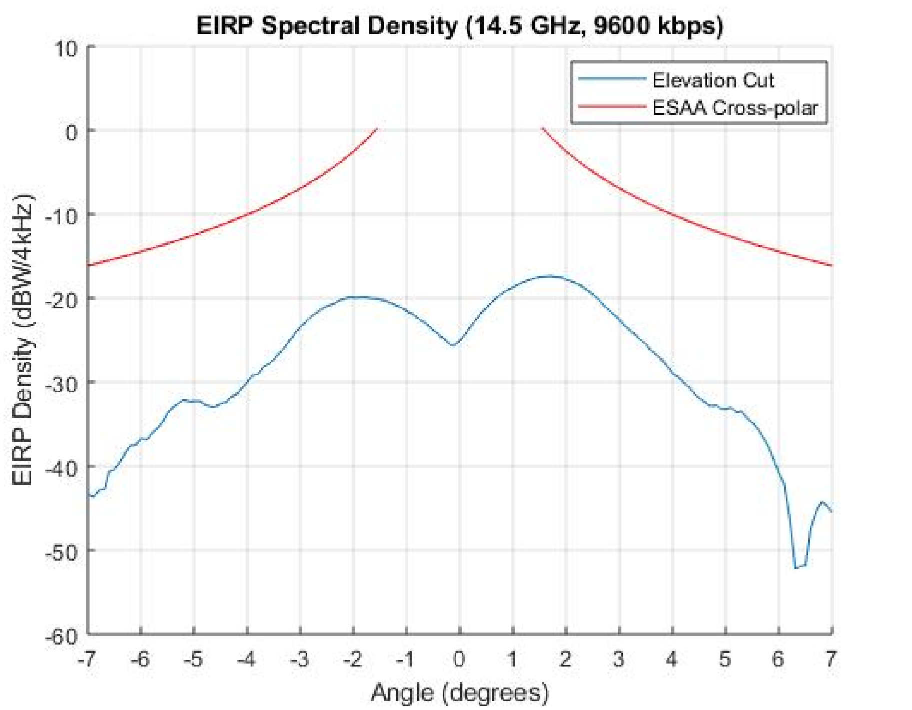

Figure 3-24 Cross-polarized Off-Axis EIRP Density in the plane perpendicular to GSO Arc (14.5 GHz)

4. SUPPLEMENTAL TABLE OF OFF-AXIS ANGLES THAT EXCEED EIRP DENSITY ENVELOPES

From §25.115(g)(1)(viii), *The showing must include a supplemental table for each off-axis angular range in which the relevant EIRP density envelope will be exceeded, specifying angular coordinates in degrees off-axis and corresponding calculated off-axis EIRP density at 0.2° increments over the angular range in which the routine envelope will be exceeded and one degree on each side of that range.*

This section contains the supplemental table for the off-axis angles in which the EIRP density envelopes exceed the relevant EIRP density envelopes specified in §25.218(f). The calculated off-axis EIRP densities shown in the following tables are below the maximum off-axis angular range exceedance levels specified for the EIRP density envelopes in §25.218(f).

Table 4-1 Off-Axis EIRP Density in the plane tangent to GSO Arc (14.0 GHz, 3072 kbps)

Co-pol tangent (14.0 GHz, 3072 kbps)					
Off-Axis Angle	Off-Axis EIRP Density	Off-Axis Angle	Off-Axis EIRP Density	Off-Axis Angle	Off-Axis EIRP Density
-36.11	-15.59	-22.92	-11.26	-3.81	2.94
-35.11	-13.98	-22.81	-11.40	-3.71	3.42
-35.03	-13.77	-22.73	-11.48	-3.63	3.71
-34.93	-13.35	-22.62	-11.65	-3.53	4.04
-34.82	-12.87	-22.52	-11.91	-3.42	4.23
-34.71	-12.50	-22.42	-12.28	-3.33	4.30
-34.63	-12.28	-22.31	-12.66	-3.22	4.19
-34.53	-12.17	-22.23	-12.94	-3.11	3.89
-34.43	-12.17	-22.13	-13.26	-3.01	3.31
-34.32	-12.29	-22.01	-13.63	-2.02	7.09
-34.22	-12.45	-21.93	-13.92	-1.5	15.16
-34.11	-12.71	-20.91	-17.17	-1.91	9.35
-34	-12.98	-20.81	-17.29	-1.83	10.79
-33.92	-13.30	-19.83	-13.69	-1.72	12.46
-33.81	-13.67	-19.72	-13.27	-1.62	13.86
-32.81	-15.00	-19.61	-12.95	-1.51	15.16
-33.32	-15.02	-19.53	-12.75	1.57	15.91
-32.31	-13.99	-19.42	-12.50	1.68	14.66
-32.23	-13.85	-19.31	-12.34	1.78	13.23
-32.13	-13.64	-19.22	-12.28	1.89	11.60
-32.02	-13.46	-19.11	-12.31	1.99	9.65
-31.91	-13.44	-19.03	-12.36	2.07	7.97

-31.81	-13.51	-18.92	-12.43	3.09	4.25
-31.73	-13.72	-18.82	-12.50	1.99	9.65
-30.73	-19.60	-18.71	-12.65	2.99	3.38
-25.21	-20.81	-18.61	-12.77	3.09	4.25
-24.22	-13.51	-18.54	-12.85	3.17	4.72
-24.11	-12.88	-18.43	-13.03	3.27	5.10
-24.03	-12.56	-18.32	-13.12	3.38	5.28
-23.93	-12.26	-18.21	-13.18	3.48	5.30
-23.82	-11.97	-18.11	-13.24	3.58	5.11
-23.72	-11.74	-18.03	-13.31	3.69	4.81
-23.61	-11.54	-17.02	-16.01	3.76	4.53
-23.53	-11.33	-5.32	-10.09	3.87	4.06
-23.42	-11.13	-4.31	-0.37	3.97	3.46
-23.31	-11.02	-4.23	0.24	4.08	2.81
-23.24	-11.00	-4.13	1.04	4.18	2.01
-23.11	-11.12	-4.02	1.75	4.29	1.12
-23.03	-11.20	-3.91	2.40	4.37	0.49

Co-pol tangent (14.0 GHz, 3072 kbps)			
Off-Axis Angle	Off-Axis EIRP Density	Off-Axis Angle	Off-Axis EIRP Density
4.47	-0.43	32.57	-13.05
4.58	-1.35	32.68	-13.24
5.57	-11.30	32.78	-13.48
12.27	-17.99	32.89	-13.75
13.28	-9.72	32.97	-13.86
13.39	-9.25	33.07	-13.97
13.47	-8.93	33.18	-13.96
13.57	-8.60	33.28	-13.94
13.67	-8.38	33.39	-13.77
13.78	-8.28	33.5	-13.78
13.88	-8.27	33.58	-13.81
13.97	-8.32	33.69	-13.87
14.08	-8.44	33.79	-13.97
14.18	-8.62	34.78	-21.36
14.29	-8.84		
14.39	-9.08		
14.5	-9.41		

14.58	-9.68		
14.69	-10.01		
14.77	-10.29		
14.88	-10.61		
14.99	-10.99		
15.06	-11.25		
16.07	-14.93		
30.18	-22.19		
31.18	-13.93		
31.27	-13.57		
31.38	-13.21		
31.48	-13.02		
31.59	-12.85		
31.69	-12.76		
31.77	-12.77		
31.87	-12.71		
31.99	-12.71		
32.06	-12.72		
32.17	-12.77		
32.29	-12.78		
32.36	-12.78		
32.47	-12.89		

Table 4-2 Off-Axis EIRP Density in the plane tangent to GSO Arc (14.5 GHz, 3072 kbps)

Co-pol tangent (14.5 GHz, 3072 kbps)					
Off-Axis Angle	Off-Axis EIRP Density	Off-Axis Angle	Off-Axis EIRP Density	Off-Axis Angle	Off-Axis EIRP Density
-22.5	-15.84239965	-17.91	-11.59239965	3.39	2.657600347
-21.51	-13.82239965	-17.8	-11.31239965	3.5	2.467600347
-21.4	-13.44239965	-17.69	-11.09239965	3.6	2.137600347
-21.3	-13.15239965	-17.61	-10.92239965	3.71	1.727600347
-21.19	-12.89239965	-17.51	-10.75239965	3.78	1.407600347
-21.1	-12.78239965	-17.4	-10.56239965	3.89	0.927600347
-21	-12.62239965	-17.29	-10.33239965	3.99	0.377600347
-20.9	-12.51239965	-17.21	-10.22239965	4.09	-0.122399653
-20.79	-12.43239965	-17.11	-10.12239965	5.1	-6.082399653

-20.68	-12.38239965	-17	-10.10239965	15.01	-15.08239965
-20.6	-12.35239965	-16.89	-10.15239965	16.01	-11.88239965
-20.5	-12.39239965	-16.79	-10.28239965	16.09	-11.69239965
-20.39	-12.40239965	-16.7	-10.39239965	16.19	-11.41239965
-20.3	-12.43239965	-16.6	-10.57239965	16.3	-11.14239965
-20.2	-12.46239965	-16.5	-10.77239965	16.41	-10.87239965
-20.1	-12.52239965	-16.4	-11.03239965	16.49	-10.68239965
-19.99	-12.68239965	-16.29	-11.35239965	16.59	-10.45239965
-19.89	-12.84239965	-16.21	-11.63239965	16.69	-10.21239965
-19.81	-13.00239965	-16.1	-12.02239965	16.79	-10.02239965
-19.7	-13.23239965	-15	-15.36239965	16.9	-9.912399653
-19.59	-13.46239965	-4.9	-4.602399653	16.99	-9.832399653
-19.51	-13.60239965	-3.89	0.337600347	17.1	-9.832399653
-19.4	-13.75239965	-3.79	0.737600347	17.21	-9.922399653
-19.28	-13.78239965	-3.69	1.117600347	17.29	-10.02239965
-19.2	-13.84239965	-3.61	1.377600347	17.39	-10.15239965
-19.09	-13.83239965	-3.51	1.707600347	17.5	-10.32239965
-19.01	-13.79239965	-3.39	1.947600347	17.6	-10.59239965
-18.9	-13.71239965	-3.3	2.067600347	17.71	-10.91239965
-18.8	-13.65239965	-2.3	-14.49239965	17.79	-11.19239965
-18.7	-13.57239965	-1.6	10.23760035	17.89	-11.67239965
-18.59	-13.46239965	1.59	12.03760035	18	-12.27239965
-18.52	-13.32239965	1.69	10.55760035	18.1	-12.96239965
-18.41	-13.12239965	1.8	8.827600347	19.1	-18.75239965
-18.3	-12.86239965	2.8	-0.042399653	19.29	-18.56239965
-18.19	-12.58239965	2.2	-1.912399653	20.29	-13.67239965
-18.09	-12.19239965	3.18	2.607600347	20.4	-13.26239965
-18.01	-11.97239965	3.29	2.717600347	20.51	-12.93239965

Co-pol tangent (14.5 GHz, 3072 kbps)	
Off-Axis Angle	Off-Axis EIRP Density
20.59	-12.76239965
20.7	-12.60239965
20.79	-12.59239965
20.9	-12.58239965
21	-12.60239965
21.1	-12.68239965

21.2	-12.77239965
21.28	-12.85239965
21.39	-13.04239965
21.5	-13.33239965
21.61	-13.69239965
22.6	-20.74239965

Table 4-3 Off-Axis EIRP Density in the plane tangent to GSO Arc (14.0 GHz, 6144 kbps)

Co-pol tangent (14.0 GHz, 6144 kbps)	
Off-Axis Angle	Off-Axis EIRP Density
-24.51	-17.82269961
-23.53	-13.92269961
-23.42	-13.72269961
-23.31	-13.61269961
-23.24	-13.59269961
-23.11	-13.71269961
-23.03	-13.79269961
-22.92	-13.85269961
-22.81	-13.99269961
-21.82	-16.91269961
-4.73	-6.45269961
-3.71	0.82730039
-3.63	1.11730039
-3.53	1.44730039
-2.51	-10.45269961
-2.72	-2.86269961
-1.72	9.86730039
-1.62	11.26730039
-1.51	12.56730039
1.57	13.31730039
1.68	12.06730039
1.78	10.63730039
1.89	9.00730039
2.88	-0.49269961
2.29	-1.10269961

3.27	2.50730039
3.38	2.68730039
3.48	2.70730039
3.58	2.51730039
3.69	2.21730039
3.76	1.93730039
3.87	1.46730039
3.97	0.86730039
4.08	0.21730039
5.08	-8.91269961

Table 4-4 Off-Axis EIRP Density in the plane tangent to GSO Arc (14.5 GHz, 6144 kbps)

Co-pol tangent (14.5 GHz, 6144 kbps)					
Off-Axis Angle	Off-Axis EIRP Density	Off-Axis Angle	Off-Axis EIRP Density	Off-Axis Angle	Off-Axis EIRP Density
-22.21	-15.53269961	-17.4	-10.56269961	5.1	-6.08269961
-21.19	-12.89269961	-17.29	-10.33269961	15.01	-15.08269961
-21.1	-12.78269961	-17.21	-10.22269961	16.01	-11.88269961
-21	-12.62269961	-17.11	-10.12269961	16.09	-11.69269961
-20.9	-12.51269961	-17	-10.10269961	16.19	-11.41269961
-20.79	-12.43269961	-16.89	-10.15269961	16.3	-11.14269961
-20.68	-12.38269961	-16.79	-10.28269961	16.41	-10.87269961
-20.6	-12.35269961	-16.7	-10.39269961	16.49	-10.68269961
-20.5	-12.39269961	-16.6	-10.57269961	16.59	-10.45269961
-20.39	-12.40269961	-16.5	-10.77269961	16.69	-10.21269961
-20.3	-12.43269961	-16.4	-11.03269961	16.79	-10.02269961
-20.2	-12.46269961	-16.29	-11.35269961	16.9	-9.91269961
-20.1	-12.52269961	-16.21	-11.63269961	16.99	-9.83269961
-19.99	-12.68269961	-16.1	-12.02269961	17.1	-9.83269961
-19.89	-12.84269961	-15.08	-15.48269961	17.21	-9.92269961
-19.81	-13.00269961	-4.9	-4.60269961	17.29	-10.02269961
-19.7	-13.23269961	-3.89	0.33730039	17.39	-10.15269961
-19.59	-13.46269961	-3.79	0.73730039	17.5	-10.32269961
-19.51	-13.60269961	-3.69	1.11730039	17.6	-10.59269961
-19.4	-13.75269961	-3.61	1.37730039	17.71	-10.91269961
-19.28	-13.78269961	-3.51	1.70730039	17.79	-11.19269961

-19.2	-13.84269961	-3.39	1.94730039	17.89	-11.67269961
-19.09	-13.83269961	-3.3	2.06730039	18	-12.27269961
-19.01	-13.79269961	-2.3	-14.49269961	18.1	-12.96269961
-18.9	-13.71269961	1.59	12.03730039	19.1	-18.75269961
-18.8	-13.65269961	1.69	10.55730039	19.21	-18.80269961
-18.7	-13.57269961	1.8	8.82730039	20.21	-13.99269961
-18.59	-13.46269961	2.8	-0.04269961	20.29	-13.67269961
-18.52	-13.32269961	2.2	-1.91269961	20.4	-13.26269961
-18.41	-13.12269961	3.18	2.60730039	20.51	-12.93269961
-18.3	-12.86269961	3.29	2.71730039	20.59	-12.76269961
-18.19	-12.58269961	3.39	2.65730039	20.7	-12.60269961
-18.09	-12.19269961	3.5	2.46730039	20.79	-12.59269961
-18.01	-11.97269961	3.6	2.13730039	20.9	-12.58269961
-17.91	-11.59269961	3.71	1.72730039	21	-12.60269961
-17.8	-11.31269961	3.78	1.40730039	21.1	-12.68269961
-17.69	-11.09269961	3.89	0.92730039	21.2	-12.77269961
-17.61	-10.92269961	3.99	0.37730039	21.28	-12.85269961
-17.51	-10.75269961	4.09	-0.12269961	21.39	-13.04269961

Co-pol tangent (14.5 GHz, 6144 kbps)	
Off-Axis Angle	Off-Axis EIRP Density
21.5	-13.33269961
21.61	-13.69269961
21.61	-13.69269961

5. §25.228(B) & §25.228(C) ANTENNA MONITORING AND CESSATION OF EMISSIONS

From §25.228, *(b) Each ESIM must be self-monitoring and, should a condition occur that would cause the ESIM to exceed its authorized off-axis EIRP density limits, the ESIM must automatically cease transmissions within 100 milliseconds, and not resume transmissions until the condition that caused the ESIM to exceed those limits is corrected.*

(c) Each ESIM must be monitored and controlled by a network control and monitoring center (NCMC) or equivalent facility. Each ESIM must comply with a "disable transmission" command from the NCMC within 100 milliseconds of receiving the command. In addition, the NCMC must monitor the operation of each ESIM in its network, and transmit a "disable transmission" command to any ESIM that operates in such a way as to exceed the authorized off-axis EIRP density limit for that ESIM or for all ESIMs that simultaneously transmit on the same frequency to the same target satellite receiving beam. The NCMC must not allow the ESIM(s) under its control to resume transmissions until the condition that caused the ESIM(s) to exceed the authorized EIRP density limits is corrected.

The M17-27A Ku-Band Antenna is defined as an Earth Station in Motion (ESIM). The M17-27A terminal has a pointing and tracking system that makes use of a closed-loop servo/stabilization architecture, supports real-time continuous built-in-test (BIT), and actively measures the receive satellite beacon/carrier signal. As part of its antenna pointing function, the antenna mutes the uplink transmitter to satisfy the cessation of emission requirement as determined by transmit control logic embedded in the antenna control unit (ACU) software. General Atomics confirms the proposed ESIM contains a software/hardware controlled feature set which will mute the uplink transmitter and ensure that emissions cease if the ESIM violates its transmit-control logic. The cessation of emissions requirement is validated with the inherent antenna pointing and stabilization design and thru the embedded transmit control logic. Both validation means are summarized below.

a) The proposed ESIM antenna utilizes the Inertial Navigation System (INS) GPS position to determine its location. The GPS location information is updated at fixed intervals but not overly critical for accurate antenna pointing on geostationary satellites. The most critical function of this GPS-derived location information is for initial acquisition of the satellite signal.
b) Once the ESIM terminal is in normal operation, the antenna's on-satellite position is constantly updated through the closed-loop servo control. Any long term position or rate drift is nulled by the antenna's closed loop servo architecture in combination with track-hold mode. Track-hold utilizes both open loop pointing and closed loop tracking (antenna peaks up on satellite beacon or carrier signal) to keep the antenna line of sight (LOS) pointing angles optimized for the target satellite.
c) The aircraft-mounted INS used by ESIM terminals provides constantly-updated information on the attitude (heading, pitch, roll) of the ESIM platform. The INS provides attitude data relative to true north/flat-level operation. The INS must provide accurate attitude measurements with low latency and short time intervals to permit calculation of the intended antenna look angles. In practice, the INS provides attitude information to an

accuracy on the order of 0.02 degrees at an interval between measurements of not more than ~20 milliseconds. The alignment between the INS and antenna is also under acceptable limits to prevent gross errors during initial satellite acquisition.

d) The antenna augments the INS attitude information with on-board position and rate sensors. Position sensors mounted within the azimuth, elevation, and polarization gimbal assemblies accurately measure antenna pointing angles relative to the ESIM. The position sensors measure antenna pointing angles to an accuracy of 0.03 degrees or better across temperature. Position sensor information is closed within the antenna's position loop at an interval between calculations of not more than ~10 milliseconds.
e) The antenna is boresighted (i.e. Minimize computed position and desired position) thru a combination of tight mechanical tolerances, sensor calibration, factory alignment, and intermittent on-satellite tracking during acquisition and operation.
f) High-bandwidth, low noise gyros are mounted to the payload reference frame and measure angular disturbance rates with respect to the line of sight. The gyro loops are updated at less than 0.5ms intervals, operate at a null, and provides the ESIM the ability to respond to disturbances quickly without allowing low frequency noise from creeping into the servo system.
g) The control loop architecture supports low-bandwidth outer position loops for drift mitigation and noise cancellation while high-bandwidth inner rate loops handles the majority of disturbance rejection functionality.

The antenna's transmit control logic is continuously monitored, with transmit mute state defined at every processor interrupt cycle. Conditions that impact the transmit state are summarized below.

a) The antenna supports built-in-test (BIT) which monitors antenna sensor and component health. Any reported BIT by an individual module is analyzed and determine to be a minor or fatal fault. Fatal faults are those determined to be detrimental to ESIM performance. Fatal faults result in the ESIM's ACU muting the transmitter.
b) A loss in receive signal, which results in the ESIM-mounted tracking receiver from reporting a phase lock loop (PLL) unlock, will trigger a mute command from the ACU to the SSPB.
c) The antenna receives operational commands from the modem integrated within the aircraft. The commands are provided by the open architecture modem-antenna interface protocol (OpenAMIP). The OpenAMIP interface allows the modem to command and query the antenna, including the ability to enable/mute the ESIM transmitter (external to the antenna-derived transmit control logic)
d) The ESIM is highly parameterized for factory configuration such that transmit turn-off and turn-on threshold can be modified as needed based on regulatory guidelines. The ESIM computes LOS error to determine how far off satellite the antenna is pointed during operation and ensures that transmissions are interrupted if the ESIM antenna pointing error exceeds desired value. Transmissions are not restored until the ESIM pointing error is not less than or equal to 0.2 degrees (Or another value, depending on EIRP Spectral Density (ESD) limits).

Field measurements have shown that when a mute condition is necessary, the ESIM performs this function well within 100 milliseconds (~30 ms typical). In summary, the factors that trigger a mute condition include

a) Fatal fault condition (reported by continuous BIT)
b) Loss of receive signal (i.e. on-board TRB reports PLL unlock)
c) Mute command from host computer or modem
d) Pointing error beyond factory-set threshold

6. ESAA OPERATIONS

6.1 §25.228(G)(1) POINT OF CONTACT

From §25.228(g)(1), *(1) There must be a point of contact in the United States, with phone number and address, available 24 hours a day, seven days a week, with authority and ability to cease all emissions from the ESAAs.*

The contact information of the points of contact with the authority and ability to cease all emissions from the ESAAs are shown in table 6-1.

Table 6-1 Points of Contact

	Yuma Proving Grounds	Gray Butte/ El Mirage	Grand Forks/ FTTC
Telephone	Flightline Operations Manager 661-478-4584 YPG Site Manager 661-618-0656	Flightline Operations Manager 661-224-5960	Onsite Airfield Manager 701-620-1842
Address	Laguna Army Airfield, bldg 2882 Yuma, Az 85365	25500 E Ave R 8, Palmdale, CA 93591	122 Grand Sky Blvd Emerado, ND 58228

6.2 §25.228(D) RADIATION HAZARD

From §25.228(d), *(d) ESIM licensees must ensure installation of ESIM terminals on vehicles by qualified installers who have an understanding of the antenna's radiation environment and the measures best suited to maximize protection of the general public and persons operating the vehicle and equipment. An ESIM terminal exhibiting radiation exposure levels exceeding 1.0 mW/cm2 in accessible areas, such as at the exterior surface of the radome, must have a label attached to the surface of the terminal warning about the radiation hazard and must include thereon a diagram showing the regions around the terminal where the radiation levels could exceed the maximum radiation exposure limit specified in 47 CFR 1.1310 Table 1.*

GA-ASI understands the proposed ESIM terminal antenna's radiation environment and have qualified installers best suited to operate the equipment. A radiation hazard analysis was performed for the proposed ESIM terminal antenna and is attached in appendix A of this document.

6.3 §25.228(J) ESIMS TRANSMITTING TO GSO SATELLITES IN THE FIXED-SATELLITE SERVICE IN THE 14.0-14.5 GHZ BAND

From §25.228(j), *(j) The following requirements govern all ESIMs transmitting to GSO satellites in the Fixed-Satellite Service in the 14.0-14.5 GHz band:*

(1) Operations of ESIMs in the 14.0-14.2 GHz (Earth-to-space) frequency band within 125 km (for ESVs and VMESs) or within radio line of sight (for ESAAs) of the NASA TDRSS facilities on Guam (latitude 13°36'55" N, longitude 144°51'22" E), White Sands, New Mexico (latitude 32°20'59" N, longitude 106°36'31" W and latitude 32°32'40" N, longitude 106°36'48" W), or Blossom Point, Maryland (latitude 38°25'44" N, longitude 77°05'02" W) are subject to coordination with the National Aeronautics and Space Administration (NASA) through the National Telecommunications and Information Administration (NTIA) Interdepartment Radio Advisory Committee (IRAC). Licensees must notify the International Bureau once they have completed coordination. Upon receipt of such notification from a licensee, the International Bureau will issue a public notice stating that the licensee may commence operations within the coordination zone in 30 days if no party has opposed the operations. When NTIA seeks to provide similar protection to future TDRSS sites that have been coordinated through the IRAC Frequency Assignment Subcommittee process, NTIA will notify the Commission's International Bureau that the site is nearing operational status. Upon public notice from the International Bureau, all Ku-band ESIM licensees must cease operations in the 14.0-14.2 GHz band within 125 km (for ESVs and VMESs) or within radio line of sight (for ESAAs) of the new TDRSS site until the licensees complete coordination with NTIA/IRAC for the new TDRSS facility. Licensees must notify the International Bureau once they have completed coordination for the new TDRSS site. Upon receipt of such notification from a licensee, the International Bureau will issue a public notice stating that the licensee may commence operations within the coordination zone in 30 days if no party has opposed the operations. The ESIM licensee then will be permitted to commence operations in the 14.0-14.2 GHz band within 125 km (for ESVs and VMESs) or within radio line of sight (for ESAAs) of the new TDRSS site, subject to any operational constraints developed in the coordination process.

(2) Within 125 km (for ESVs and VMESs) or within radio line of sight (for ESAAs) of the NASA TDRSS facilities identified in paragraph (j)(1) of this section, ESIM transmissions in the 14.0-14.2 GHz (Earth-to-space) band shall not exceed an EIRP spectral density towards the horizon of 12.5 dBW/MHz, and shall not exceed an EIRP towards the horizon of 16.3 dBW.

(3) Operations of ESIMs in the 14.47-14.5 GHz (Earth-to-space) frequency band in the vicinity (for ESVs and VMESs) or within radio line of sight (for ESAAs) of radio astronomy service (RAS) observatories observing in the 14.47-14.5 GHz band are subject to coordination with the National Science Foundation (NSF). The appropriate NSF contact point to initiate coordination is Electromagnetic Spectrum Management Unit, NSF, Division of Astronomical Sciences, 2415 Eisenhower Avenue, Arlington VA 22314; Email: esm@nsf.gov. Licensees must notify the International Bureau once they have completed coordination. Upon receipt of the coordination agreement from a licensee, the International Bureau will issue a public notice stating that the licensee may commence operations within the coordination zone in 30 days if no

party has opposed the operations. Table 1 provides a list of each applicable RAS site, its location, and the applicable coordination zone.

TABLE 1 TO §25.228(j)(3)—APPLICABLE RADIO ASTRONOMY SERVICE (RAS) FACILITIES AND ASSOCIATED COORDINATION DISTANCES

Observatory	***Latitude (north)***	***Longitude (west)***	***Radius (km) of coordination zone***
Arecibo, Observatory, Arecibo, PR	*18°20'37"*	*66°45'11"*	*Island of Puerto Rico.*
Green Bank, WV	*38°25'59"*	*79°50'23"*	*160.*
Very Large Array, near Socorro, NM	*34°04'44"*	*107°37'06"*	*160.*
Pisgah Astronomical Research Institute, Rosman, NC	*35°11'59"*	*82°52'19"*	*160.*
U of Michigan Radio Astronomy Observatory, Stinchfield Woods, MI	*42°23'56"*	*83°56'11"*	*160.*
Very Long Baseline Array (VLBA) stations:			
Owens Valley, CA	*37°13'54"*	*118°16'37"*	*160*.*
Mauna Kea, HI	*19°48'05"*	*155°27'20"*	*50.*
Brewster, WA	*48°07'52"*	*119°41'00"*	*50.*
Kitt Peak, AZ	*31°57'23"*	*111°36'45"*	*50.*
Pie Town, NM	*34°18'04"*	*108°07'09"*	*50.*
Los Alamos, NM	*35°46'30"*	*106°14'44"*	*50.*
Fort Davis, TX	*30°38'06"*	*103°56'41"*	*50.*
North Liberty, IA	*41°46'17"*	*91°34'27"*	*50.*
Hancock, NH	*42°56'01"*	*71°59'12"*	*50.*
St. Croix, VI	*17°45'24"*	*64°35'01"*	*50.*

**Owens Valley, CA operates both a VLBA station and single-dish telescopes.*

(4) When NTIA seeks to provide similar protection to future RAS sites that have been coordinated through the IRAC Frequency Assignment Subcommittee process, NTIA will notify the Commission's International Bureau that the site is nearing operational status. Upon public notice from the International Bureau, all Ku-band ESIMs licensees must cease operations in the 14.47-14.5 GHz band within the relevant geographic zone (160 kms for single-dish radio observatories and Very Large Array antenna systems and 50 kms for Very Long Baseline Array

antenna systems for ESVs and VMESs, radio line of sight for ESAAs) of the new RAS site until the licensees complete coordination for the new RAS facility. Licensees must notify the International Bureau once they have completed coordination for the new RAS site and must submit the coordination agreement to the Commission. Upon receipt of such notification from a licensee, the International Bureau will issue a public notice stating that the licensee may commence operations within the coordination zone in 30 days if no party opposed the operations. The ESIMs licensee then will be permitted to commence operations in the 14.47-14.5 GHz band within the relevant coordination distance around the new RAS site, subject to any operational constraints developed in the coordination process.

The proposed ESIM terminals will operate in primarily in three locations: Gray Butte/ El Mirage, California, Yuma Proving Ground, Arizona, and Grand Forks, North Dakota. The operating radii, centered at the geographical coordinates, of the proposed ESIM terminals at each location are shown in the table below. The proposed ESIM terminals will not operate in proximity to the facilities specified in paragraph (j)(1), (j)(2), and (j)(3).

Table 6-2 Station Locations and Operating Radii

Station Location	Coordinates	Radius (Km)
Gray Butte/ El Mirage	NL 34-33-49; WL 117-40-46	325
Yuma Proving Ground	NL 32-51-36; WL 114-23-48	200
Grand Forks	NL 47-56-19; WL 97-24-30	325

(5) ESIMs licensees must use Global Positioning Satellite-related or other similar position location technology to ensure compliance with the provisions of subparagraphs 1-3 of this paragraph.

The proposed ESIM terminals are equipped with a combined INS unit and GPS receiver to determine its location.

7. NOTES

7.1 LIST OF ACRONYMS

The following is an alphabetical listing of acronyms used in this document.

ACU	Antenna Control Unit
BIT	Built-in-test
EIRP	Effective Isotropic Radiated Power
ESD	EIRP Spectral Density
ESIM	Earth Station in Motion
GA-ASI	General Atomics Aeronautical Systems
GCS	Ground Control Station
GSO	Geostationary Orbit
INS	Inertial Navigation System
LOS	Line of Sight
PLL	Phase Lock Loop
RPA	Remotely Piloted Aircraft
SCPC	Single Channel Per Carrier
UA	Unmanned Aircraft

APPENDIX A. RADIATION HAZARD ANALYSIS

RF Radiation Hazard Calculations

Calculations are based on OET Bulletin 65 equations 11-18

Input Values		
Frequency of operation	14393.50	MHz
Wavelength	0.02	Meters
Reflector Diameter	0.69	Meters
Reflector Area	0.37	
Antenna Gain	38.40	dBi
Input Power	14.77	dBW
Input Power	29.99	W
Resultant EIRP	53.17	dBW
	207491.35	W

Power Density At Antenna Surface

Maximum Power Density At Antenna Surface	324.77	W/m^2
Maximum Power Density At Antenna Surface	32.48	mW/cm^2
Maximum Power Density At Antenna Surface	15.12	dBW/cm^2

Is this compliant with limits?	
For occupational/ controlled exposure (5 mW/cm^2)	NO
For general population/ uncontrolled exposure (1 mW/cm^2)	NO

Power Density in the Near-Field Region

Extent of the Near-Field	5.64	Meters
Aperture Efficiency	0.65	
On-Axis Near-Field Power Density	210.28	W/m^2
	21.03	mW/cm^2

Is this compliant with limits?	
For occupational/ controlled exposure (5 mW/cm^2)	NO
For general population/ uncontrolled exposure (1 mW/cm^2)	NO

Power Density in the Transition Region

Beginning of the Far-Field Region			13.54	Meters
Transition Region Power Density				
Power density (near-field)	21.03	mW/cm^2	5.64	Meters
Power density (far-field)	8.76	mW/cm^2	13.54	Meters

Is this compliant with limits?		
For occupational/ controlled exposure (5 mW/cm^2)	NO	
For general population/ uncontrolled exposure (1 mW/cm^2)	NO	

Power Density in the Far-Field Region

Far-Field starts at	13.54	Meters
Power density at the start of Far-Field Region	9.01	mW/cm^2

At what range is power density compliant with limits?		
For occupational/ controlled exposure (5 mW/cm^2)	18.17	Meters
For general population/ uncontrolled exposure (1 mW/cm^2)	40.64	Meters