Attachment 1

Purpose of Experiment

Row 44, Inc. ("Row 44")[1] hereby seeks authorization for the experimental operation of a new Ka Band antenna.

Row 44 is proposing to operate within the 29.25-30.0 GHz Ka uplink band and the 18.3-18.8, 18.8-19.3, and 19.7-20.2 GHz downlink bands using the QEST Q09000 Ka-Band Horn-Array-Aperture Antenna. (See Table 1 for details.)

The QEST Q09000 Antenna's transmit gain is 33.4 dBi nominal, at 29.0 GHz; the receive gain 35.5 dBi nominal, at 19.2 GHz. (See Table 2 for details.) It operates in either a Left-Hand or Right-Hand Circular Polarization mode. The QEST Q09000 incorporates independent, linear-polarized array antennas compliant with the off-axis antenna envelope established in Section 25.209(a)(3) of the Commission's Rules. The Q09000's aperture has dimensions: D = 0.617 meters; H = 0.161 meters, and a surface area A = 0.099 m^2.

The proposed transmit bandwidth, EIRP density, and skew relationships for the QEST Q09000 in the 29.25 to 30.0 GHz band are indicated in Table 3. The associated maximum input power flux density at the antenna flange will be 12.9 dBW/MHz. The antenna's emissions, as radiated under the conditions of skew angle up to 60 degrees, will not exceed the uplink off-axis EIRP density mask of 25.138(a)(1), applicable to those tangent to the Geostationary Arc.

The Ka Antenna, as designed for installation on an aircraft fuselage, exhibits an aperture which is dimensionally-restricted, so as to minimize aerodynamic drag. Due to these limitations, the antenna's elevation pattern is wider than its azimuth, thereby complying with the gain limits of 25.209(a)(3) (tangent to the GSO arc), 25.209(b)(3) (cross-pol), but exhibiting limited compliance with 25.209(a)(6) (perpendicular to the GSO arc). (See the included Ka Antenna gain plots.)

In its functions, the Ka transmitter will adjust the transmit signal level applied to the antenna flange based on the skew angle to the satellite. In the unlikely event the antenna's pointing-direction is *predicted* to deviate from the target satellite, such that the EIRP Density limits of 25.138 would be violated, the Row 44 System will pre-emptively mute the transmitter, and will continue doing so only until unmuting of the transmitter would result in emissions compliant with the applicable 25.138 limits.

The Row 44 ESAA antennas will be installed and operated in accordance with the above conditions and/or any other operational requirements specified in the Experimental FCC Authorization proposed to be granted to Row 44. If the use of this Ka Antenna should cause unacceptable interference into other systems, Row 44 will terminate transmissions immediately upon notice from Hughes, the FCC, or any other affected parties.

[1] Row 44, Inc. is the FCC-licensee entity authorized to operate an Earth Stations Aboard Aircraft ("ESAA") network in the Ku-band. The service is operated under the name of Row 44's parent company, Global Eagle Entertainment. For consistency, the licensee entity name, Row 44, is used throughout this document.

Table 1 – Ka Antenna General Characteristics

Antenna Make	QEST Q09000
Antenna Type	Horn Array Aperture
Width / Height / Area	0.617 m / 0.161 m / 0.099 m^2
RX Frequency Range	18.3 – 20.2 GHz
RX Gain, beam-center	34.4 – 35.9 dBi
TX Frequency Range	28.3 – 30.0 GHz
TX Gain, beam-center	33.0 – 33.7 dBi
TX Beamwidth, Azimuth (-3 dB)	1.0 Degree
TX Beamwidth, Elevation (-3 dB)	3.4 Degrees
Polarization	LHCP, RHCP

Table 2 - Ka Antenna Transmit Gain vs. Frequency, Applicable to Echostar 19 / Jupiter 2 Inroute Frequencies

Frequency (GHz)	Antenna Gain (dBi)	Minimum Added Losses (dB)
29.0	33.4	1.5
29.5	33.7	1.5
30.0	33.7	1.5

Table 3 – Proposed Operational TX Bandwidths and EIRP Density Limits based on Skew Angle

1.024 MHz Bandwidth	2.048 MHz Bandwidth	4.096 MHz Bandwidth	Skew Range
40.9 dBW/MHz	40.9 dBW/MHz	39.8 dBW/MHz	0, 5 Degrees
43.2 dBW/MHz	42.8 dBW/MHz	39.8 dBW/MHz	10, 15, 20, 60 Degrees
45.8 dBW/MHz	42.8 dBW/MHz	39.8 dBW/MHz	25 - 55 Degrees

Attachment 2

Co-Polarized EIRP Density Plots

The following pages collectively-depict the EIRP Density plots for each of 29.0 and 30.0 GHz, for both LHP and RHP, for skew angles over the range 0 to 60 degrees. 25.138 EIRP Density limits for both nominal and 10% of sidelobes are referenced.

(Please note that since the Ka Antenna is of a Horn-Array-Aperture design exhibiting no back-lobes, the data is limited to the -90 to +90 degree range.)

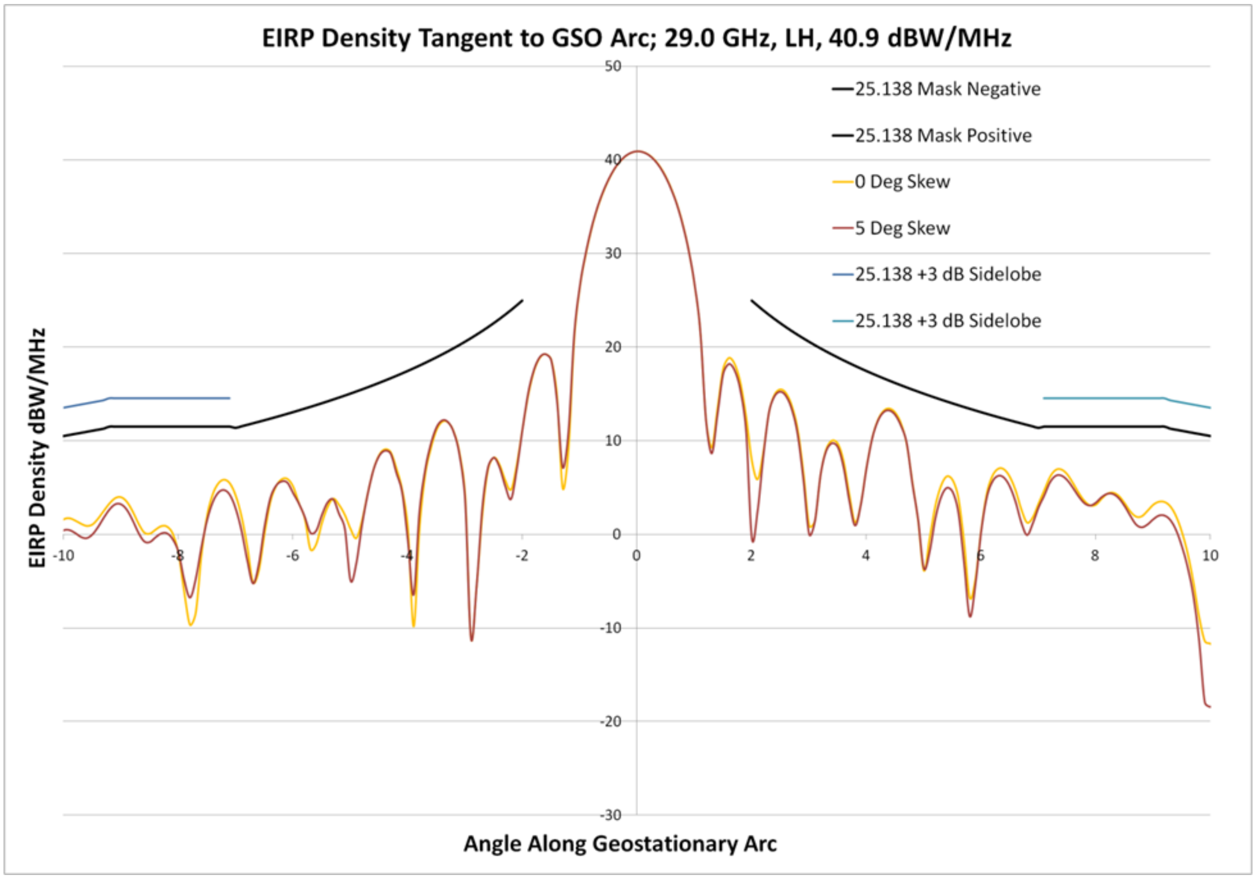


Figure 1 – EIRP Density tangent to GSO Arc, 29.0 GHz, LHP, 40.9 dBW/MHz, -10 to +10 deg., 25.138(a)(1) limits

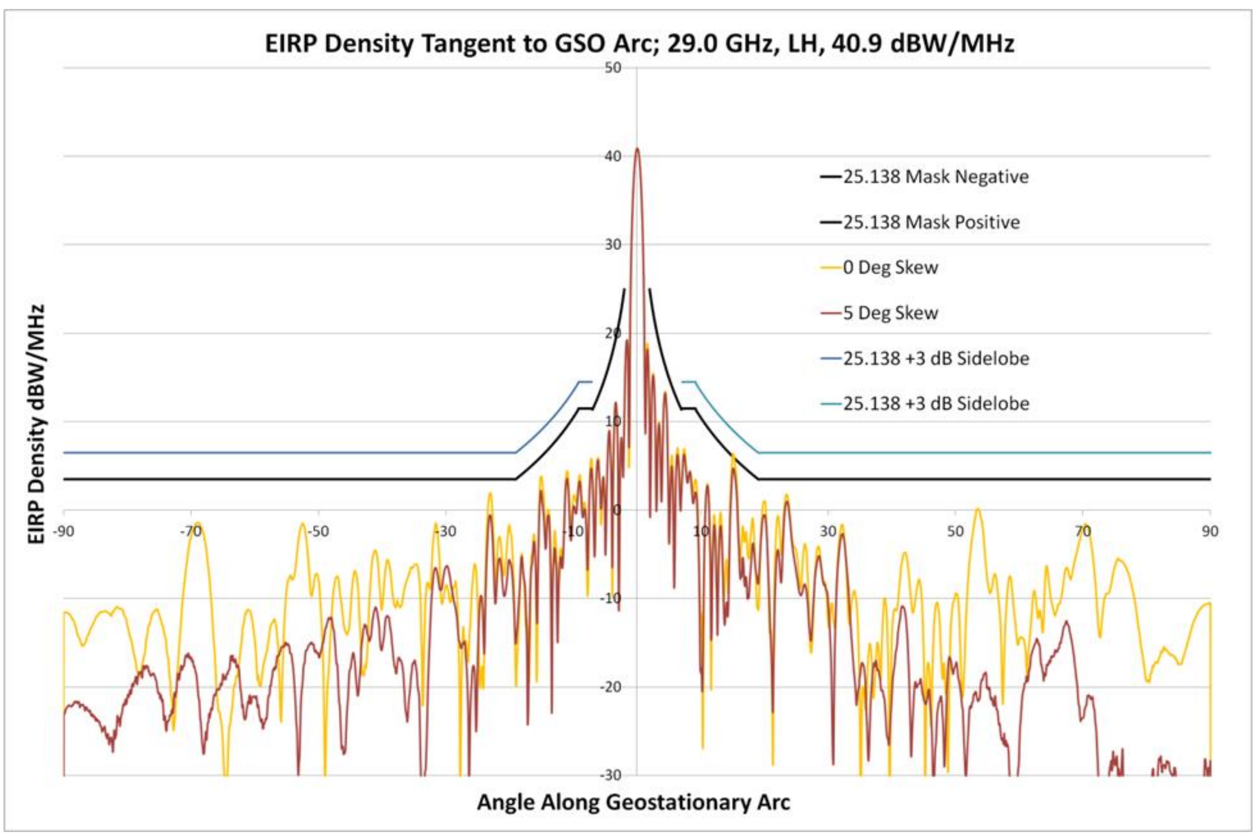


Figure 2 – EIRP Density tangent to GSO Arc, 29.0 GHz, LHP, 40.9 dBW/MHz, -90 to +90 deg., 25.138(a)(1) limits

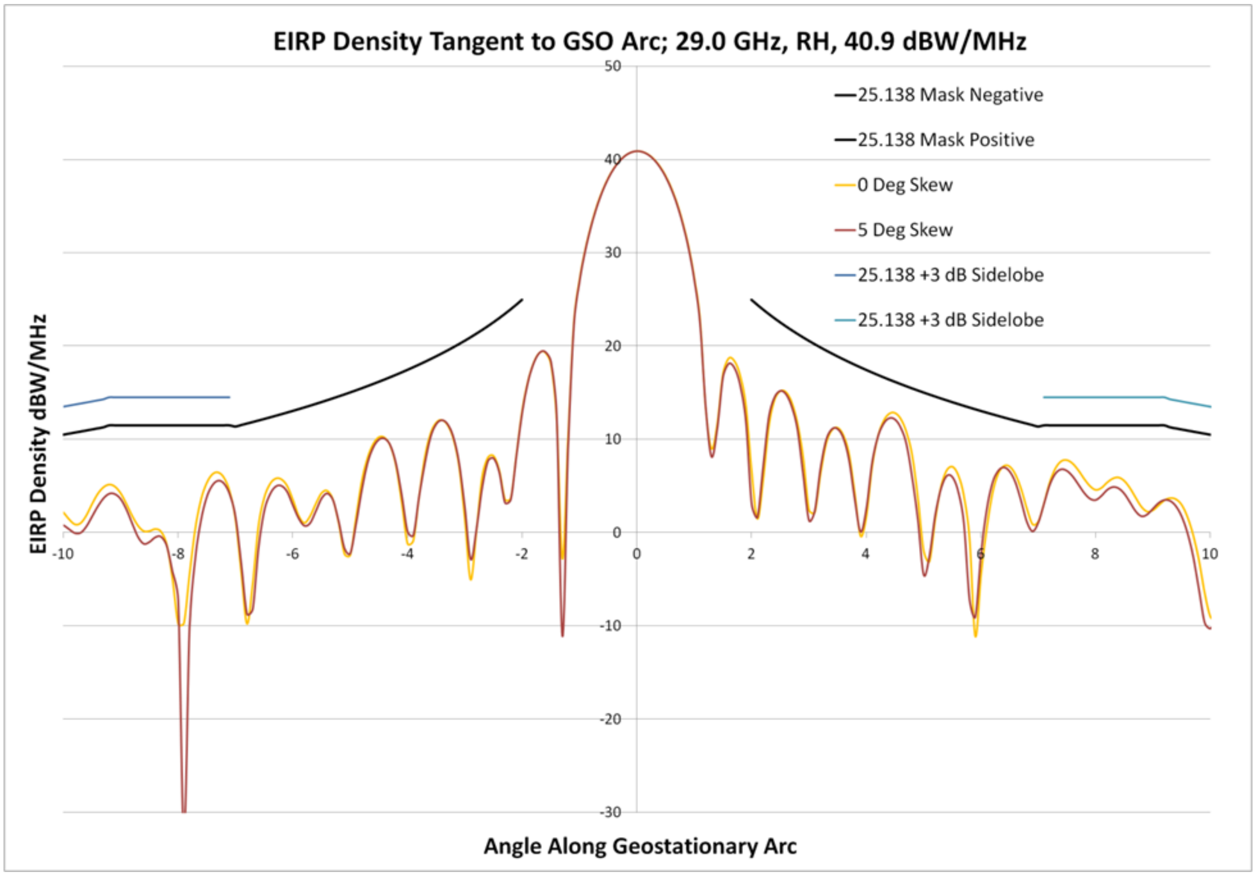


Figure 3 – EIRP Density tangent to GSO Arc, 29.0 GHz, RHP, 40.9 dBW/MHz, -10 to +10 deg., 25.138(a)(1) limits

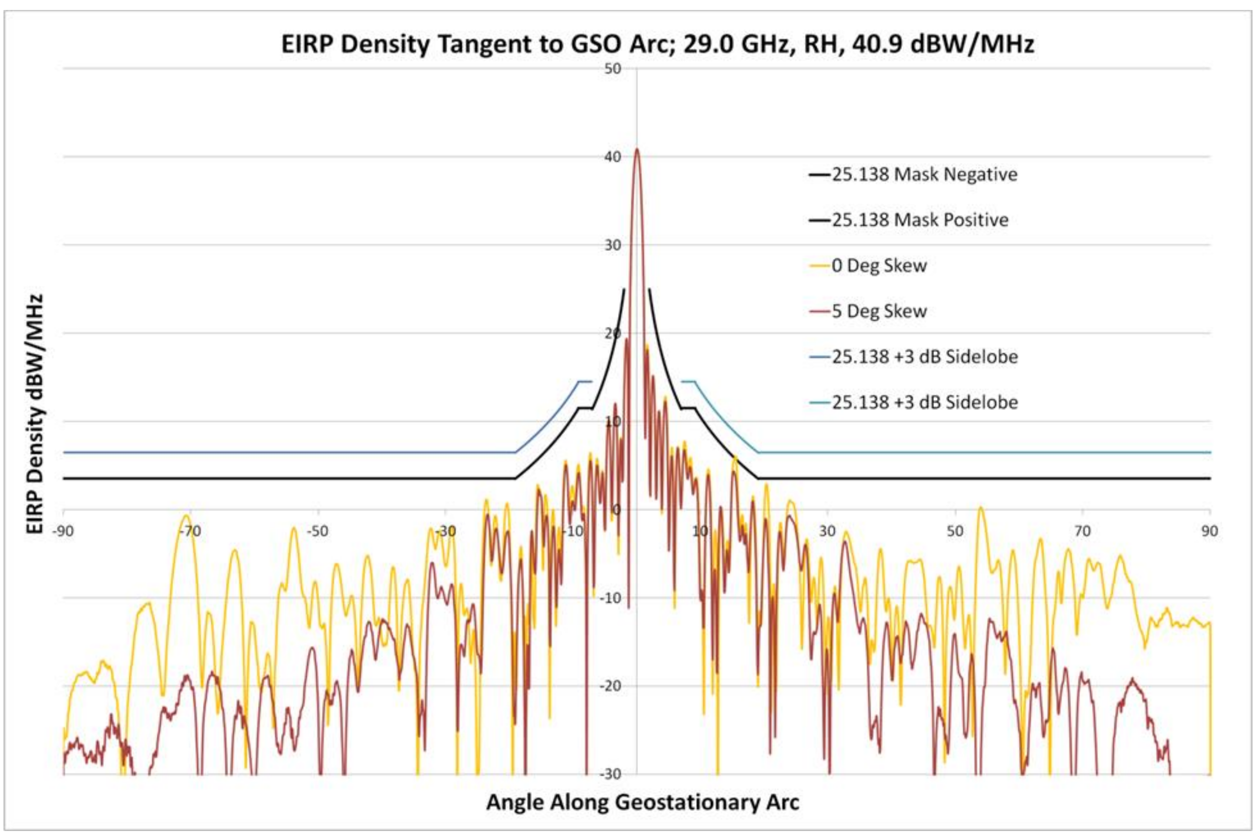


Figure 4 – EIRP Density tangent to GSO Arc, 29.0 GHz, RHP, 40.9 dBW/MHz, -90 to +90 deg., 25.138(a)(1) limits

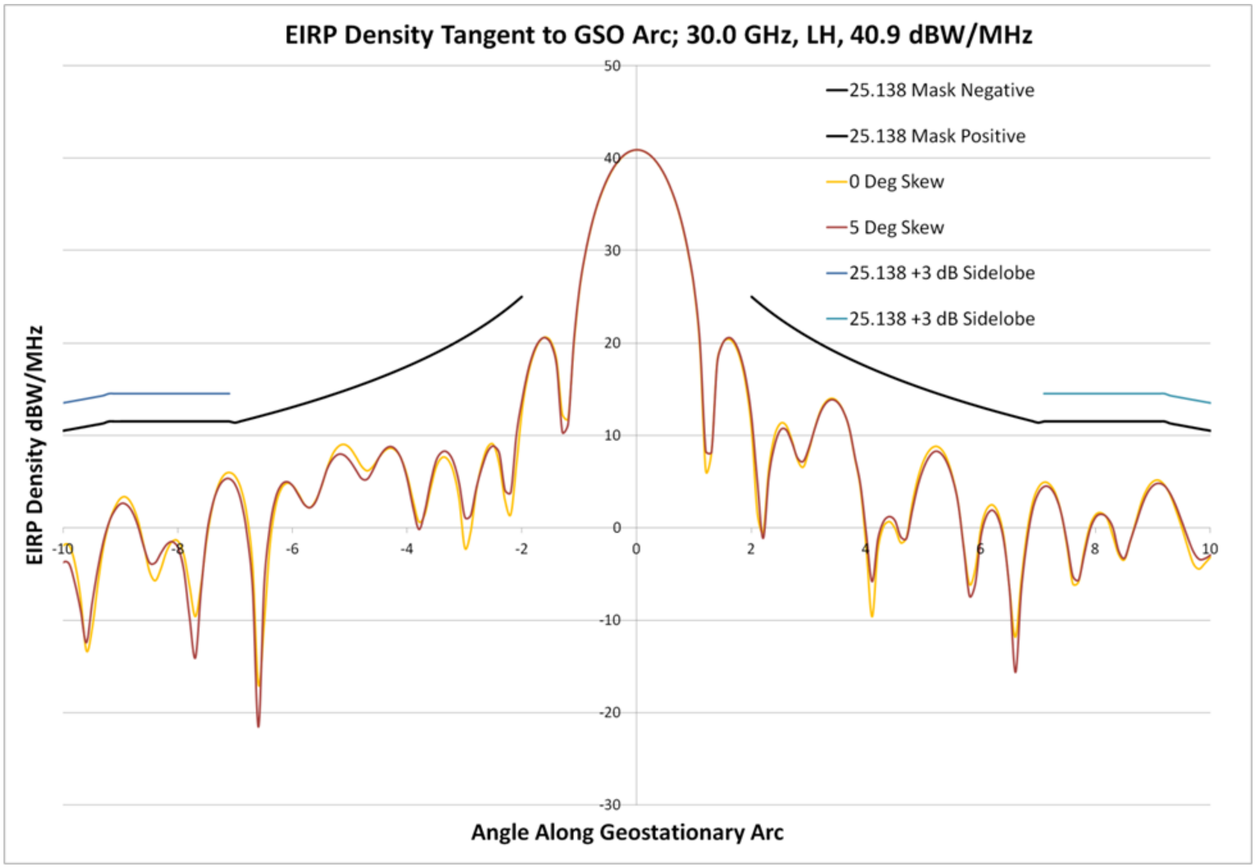


Figure 5 – EIRP Density tangent to GSO Arc, 30.0 GHz, LHP, 40.9 dBW/MHz, -10 to +10 deg., 25.138(a)(1) limits

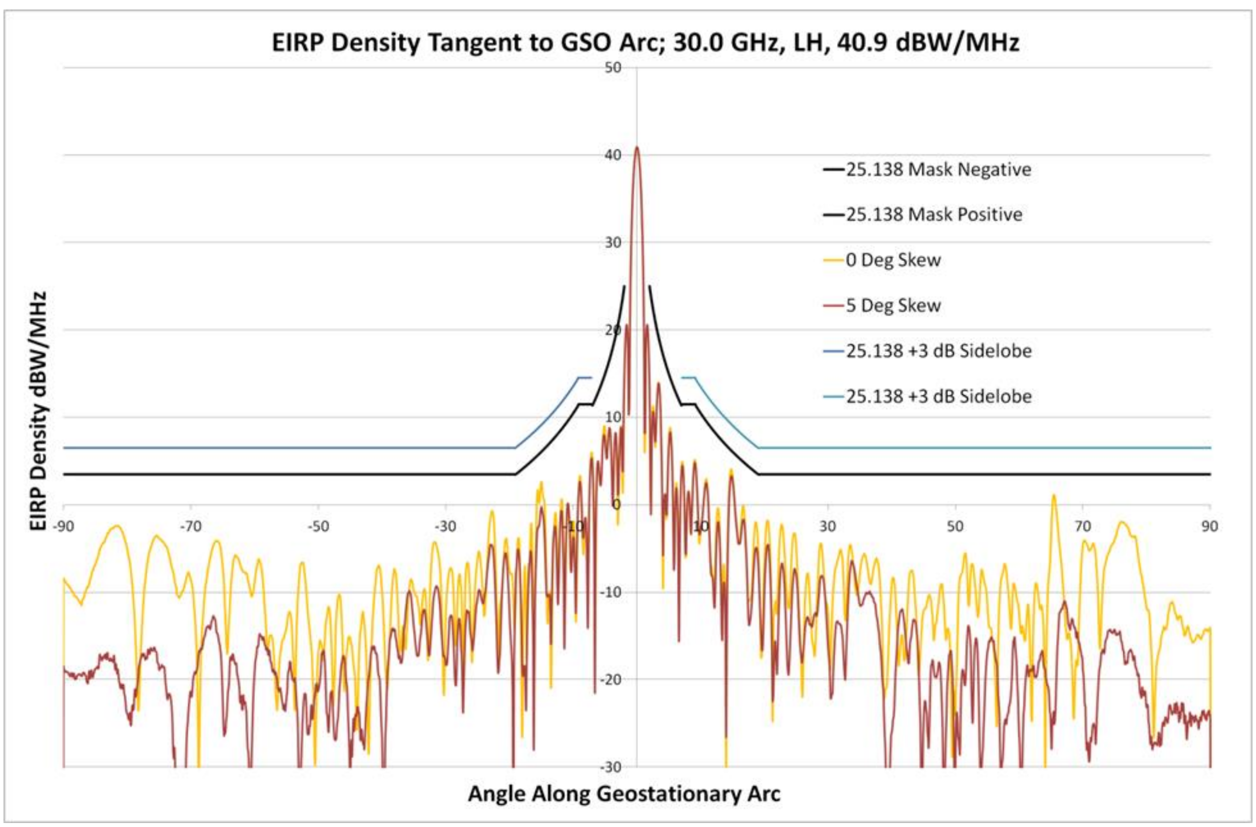


Figure 6 – EIRP Density tangent to GSO Arc, 30.0 GHz, LHP, 40.9 dBW/MHz, -90 to +90 deg., 25.138(a)(1) limits

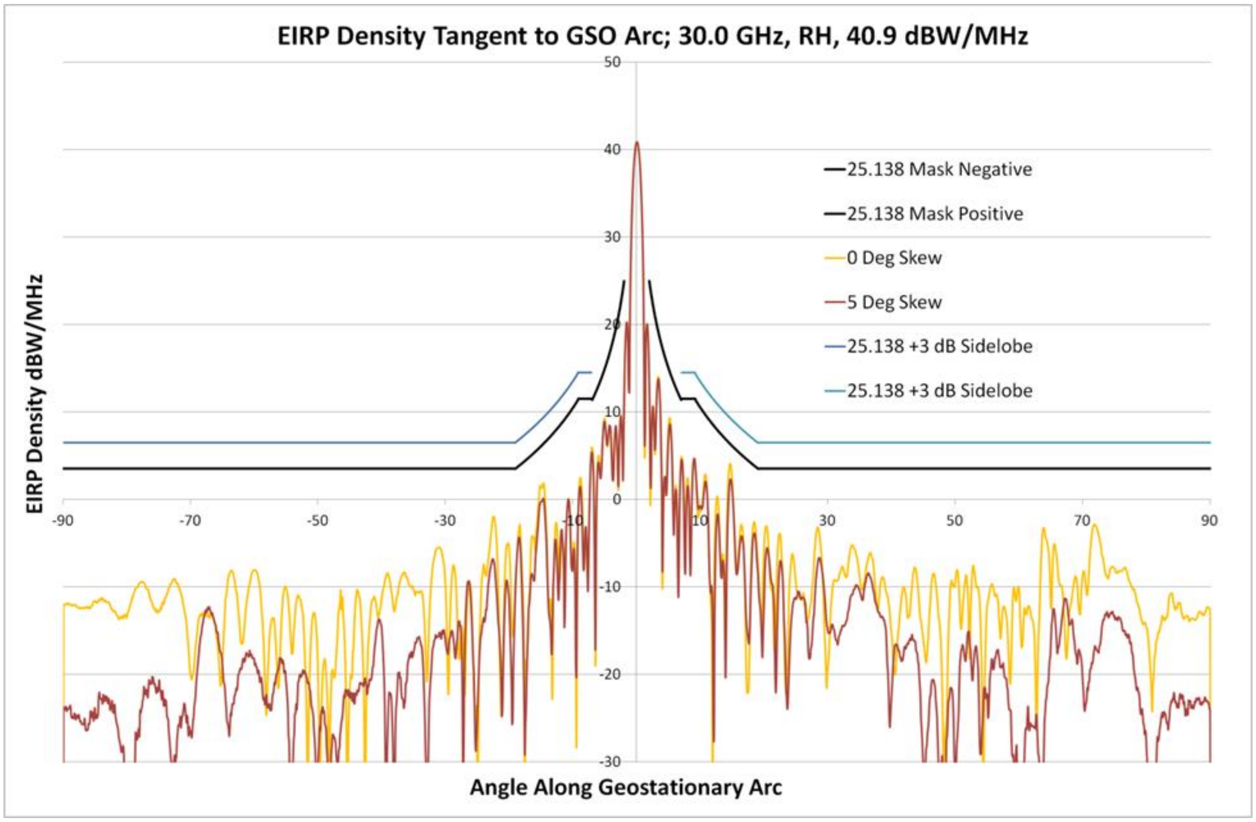


Figure 7 – EIRP Density tangent to GSO Arc, 30.0 GHz, RHP, 40.9 dBW/MHz, -10 to +10 deg., 25.138(a)(1) limits

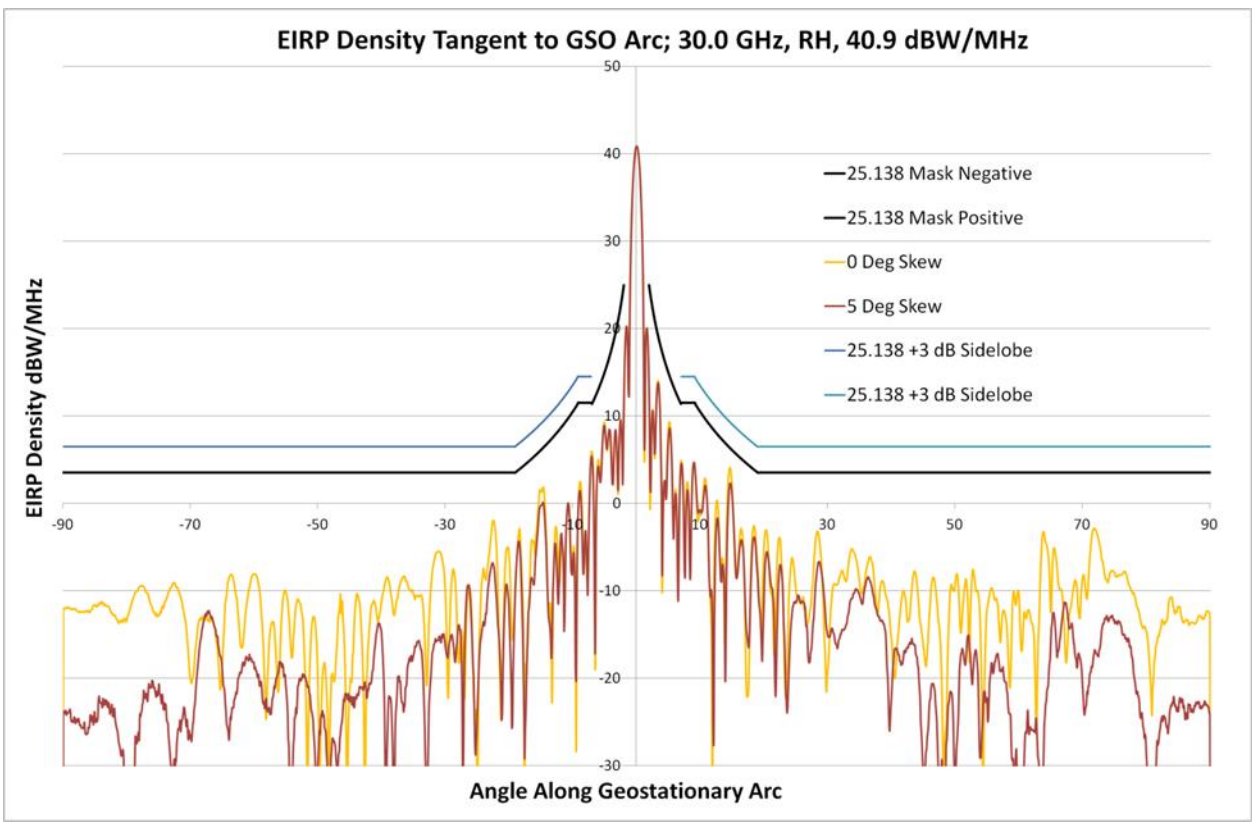


Figure 8 – EIRP Density tangent to GSO Arc, 30.0 GHz, RHP, 40.9 dBW/MHz, -90 to +90 deg., 25.138(a)(1) limits

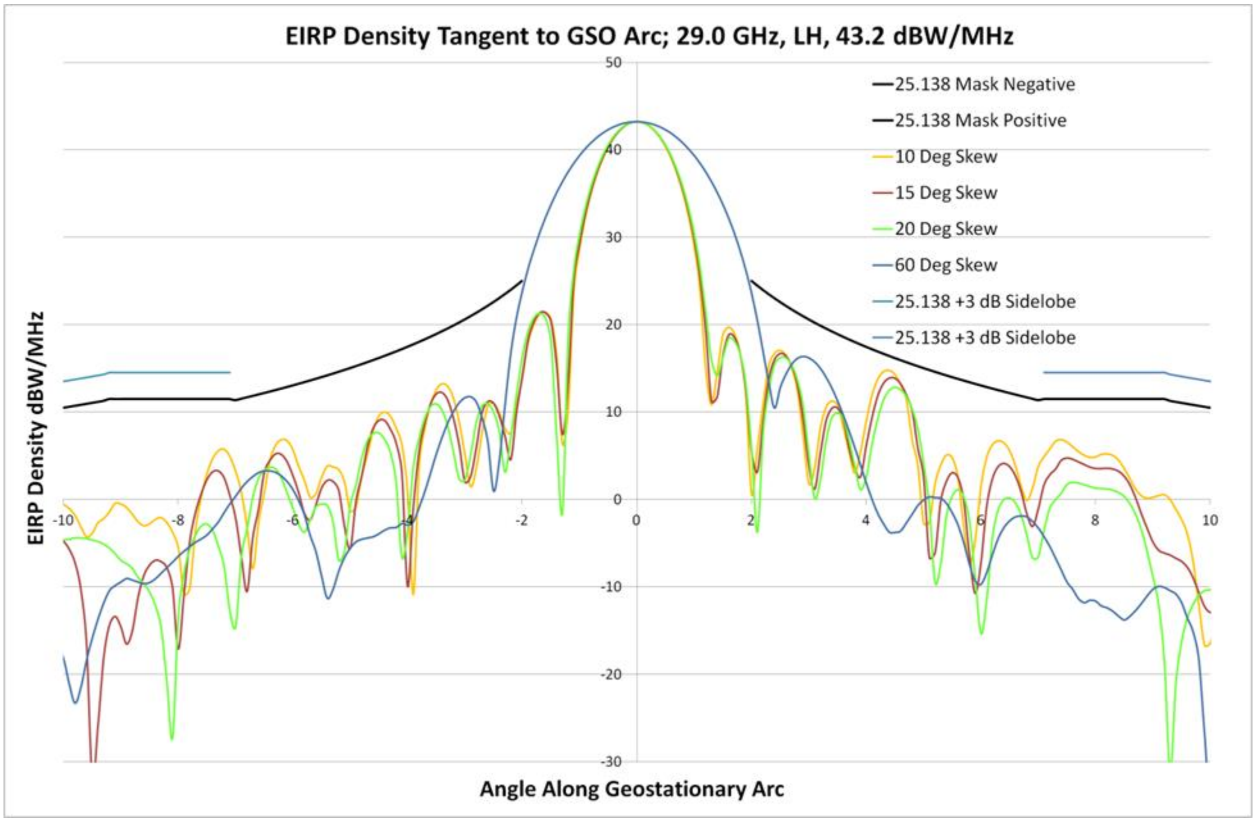


Figure 9 – EIRP Density tangent to GSO Arc, 29.0 GHz, LHP, 43.2 dBW/MHz, -10 to +10 deg., 25.138(a)(1) limits

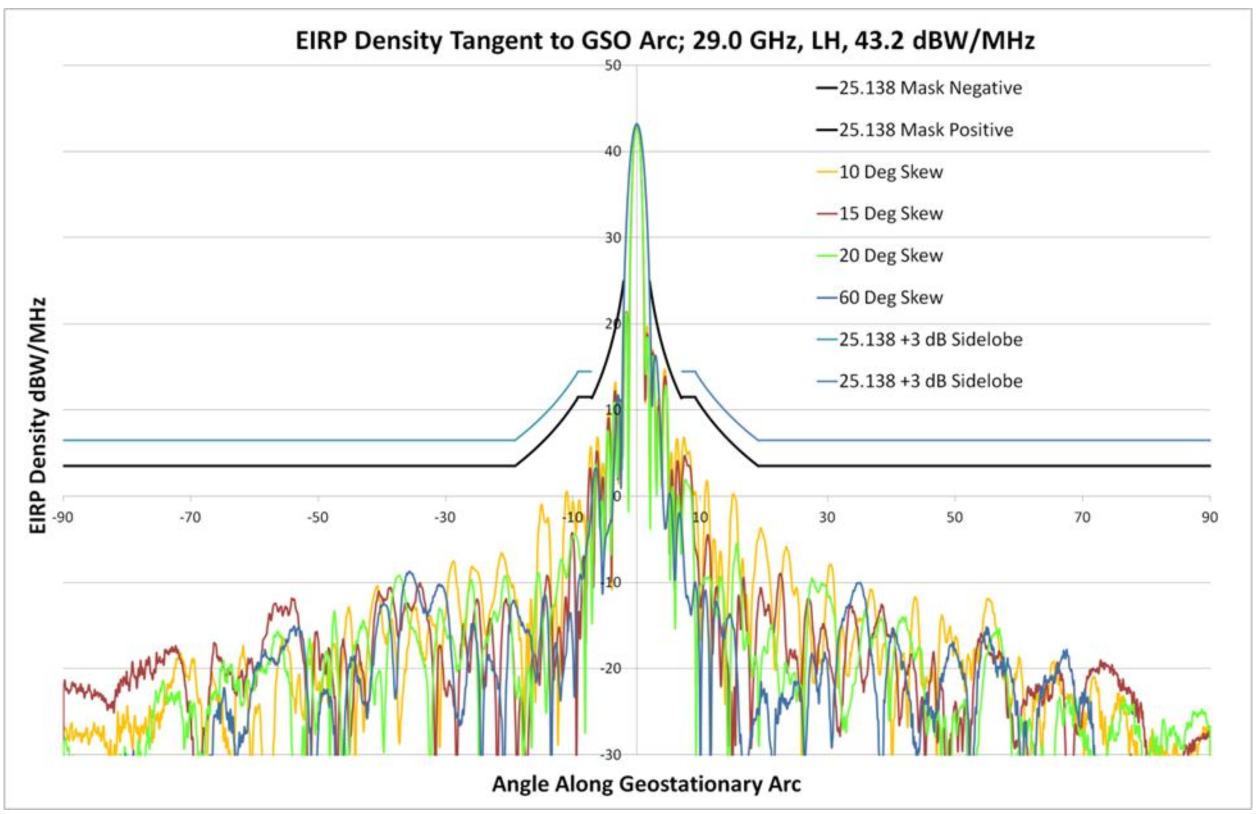


Figure 10 – EIRP Density tangent to GSO Arc, 29.0 GHz, LHP, 43.2 dBW/MHz, -90 to +90 deg., 25.138(a)(1) limits

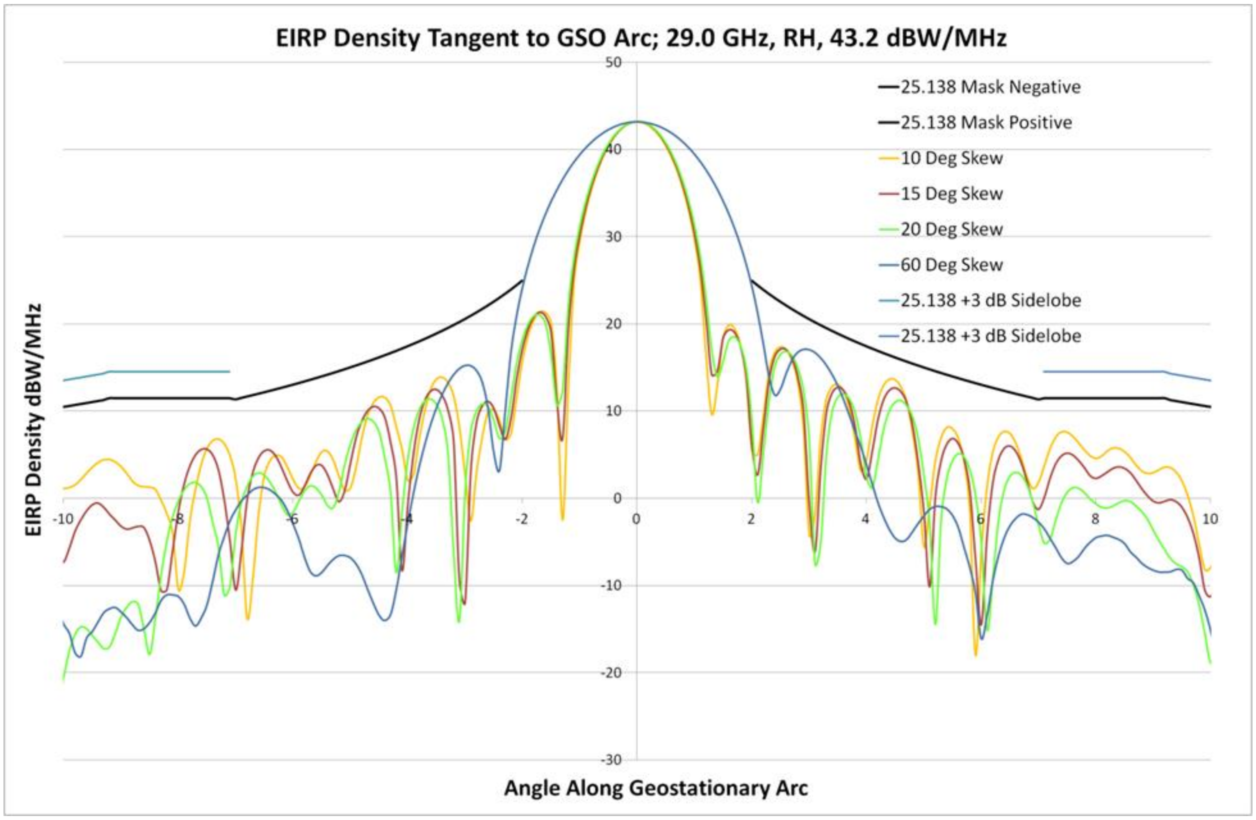


Figure 11 – EIRP Density tangent to GSO Arc, 29.0 GHz, RHP, 43.2 dBW/MHz, -10 to +10 deg., 25.138(a)(1) limits

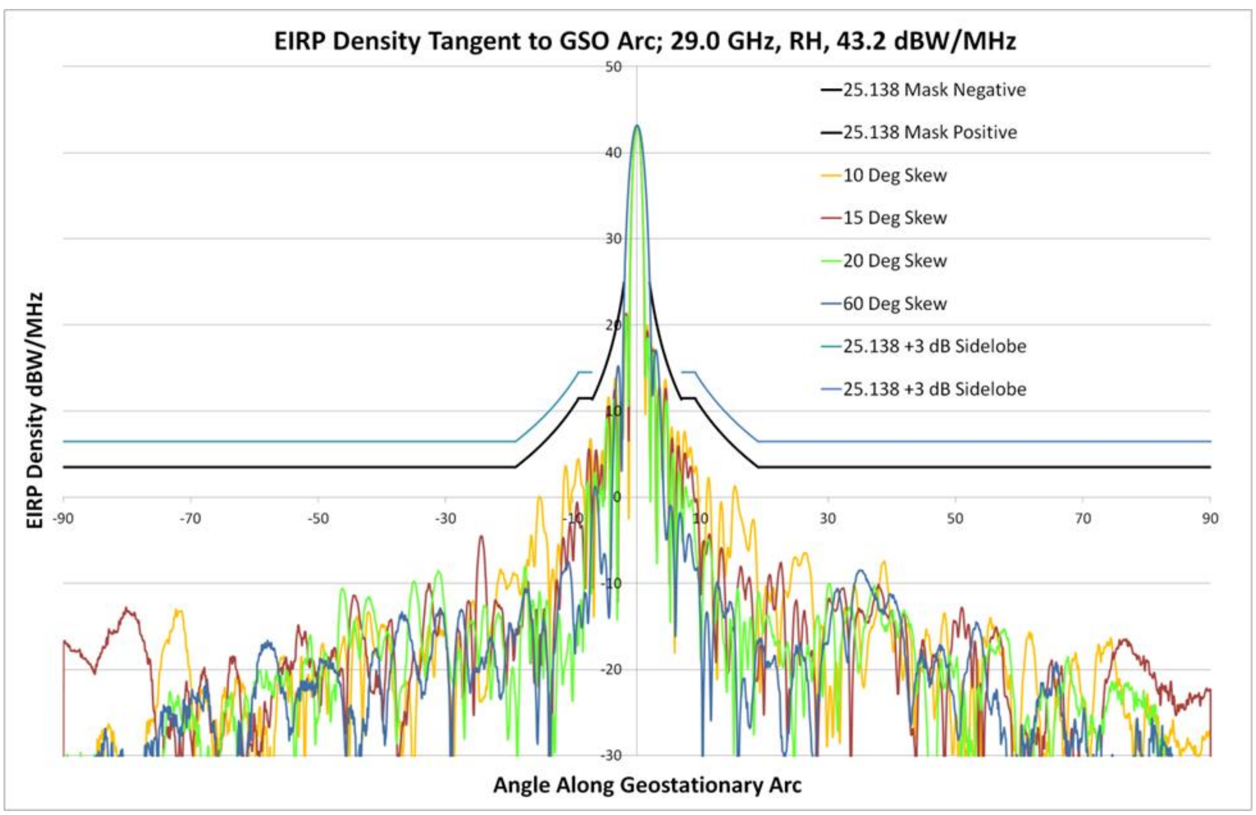


Figure 12 – EIRP Density tangent to GSO Arc, 29.0 GHz, RHP, 43.2 dBW/MHz, -90 to +90 deg., 25.138(a)(1) limits

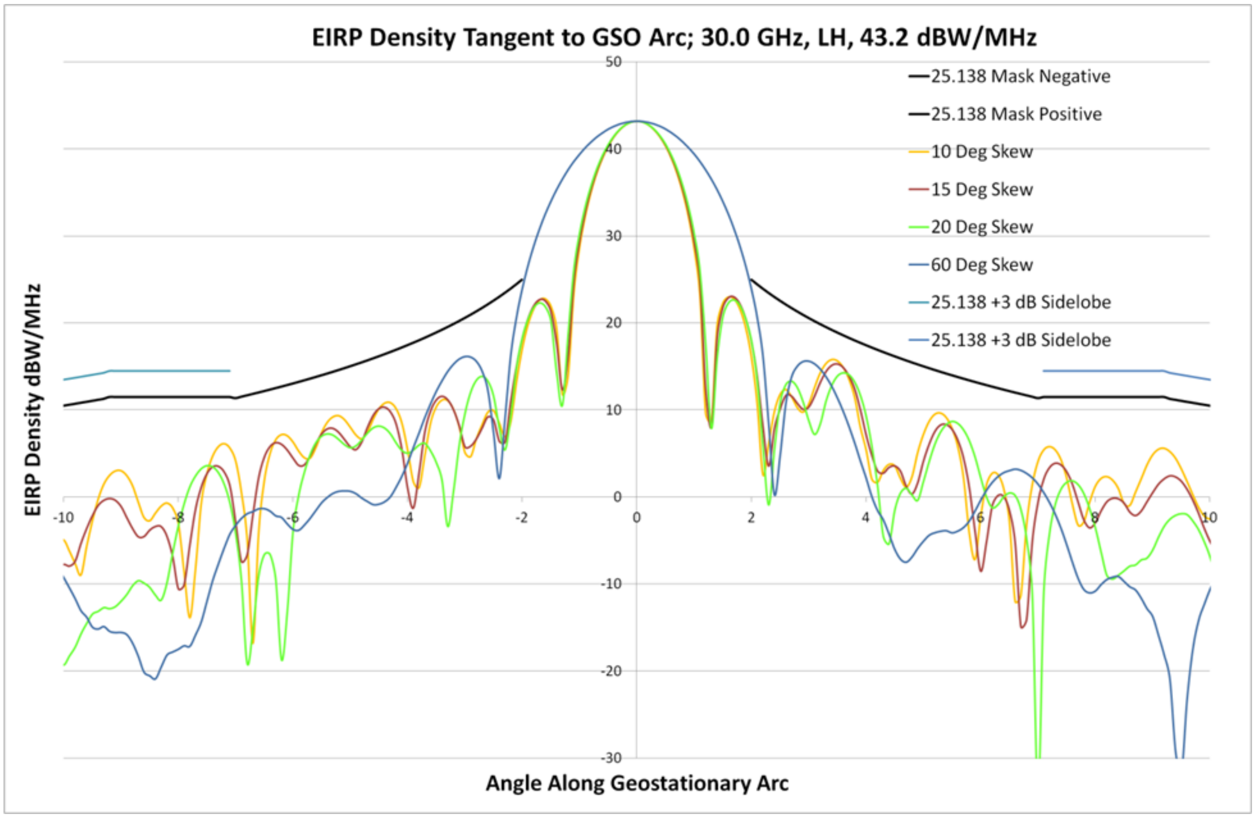


Figure 13 – EIRP Density tangent to GSO Arc, 30.0 GHz, LHP, 43.2 dBW/MHz, -10 to +10 deg., 25.138(a)(1) limits

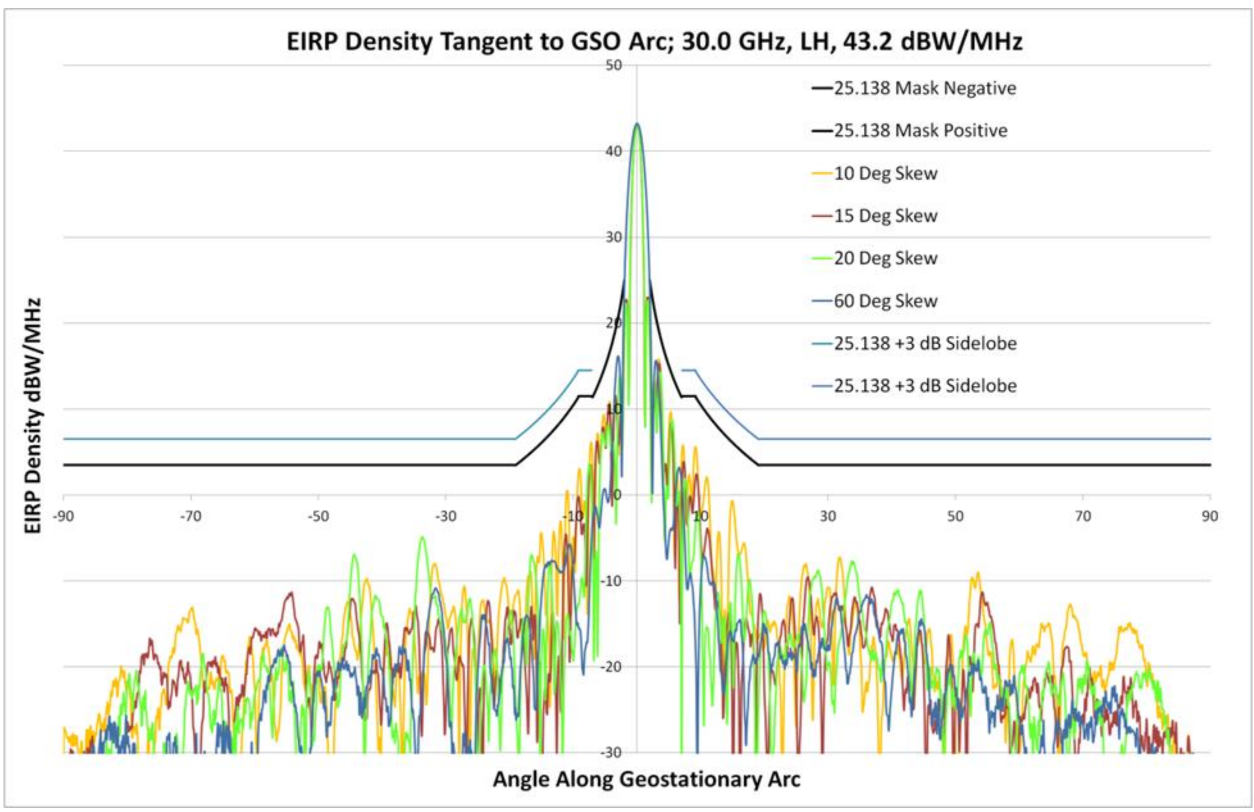


Figure 14 – EIRP Density tangent to GSO Arc, 30.0 GHz, LHP, 43.2 dBW/MHz, -90 to +90 deg., 25.138(a)(1) limits

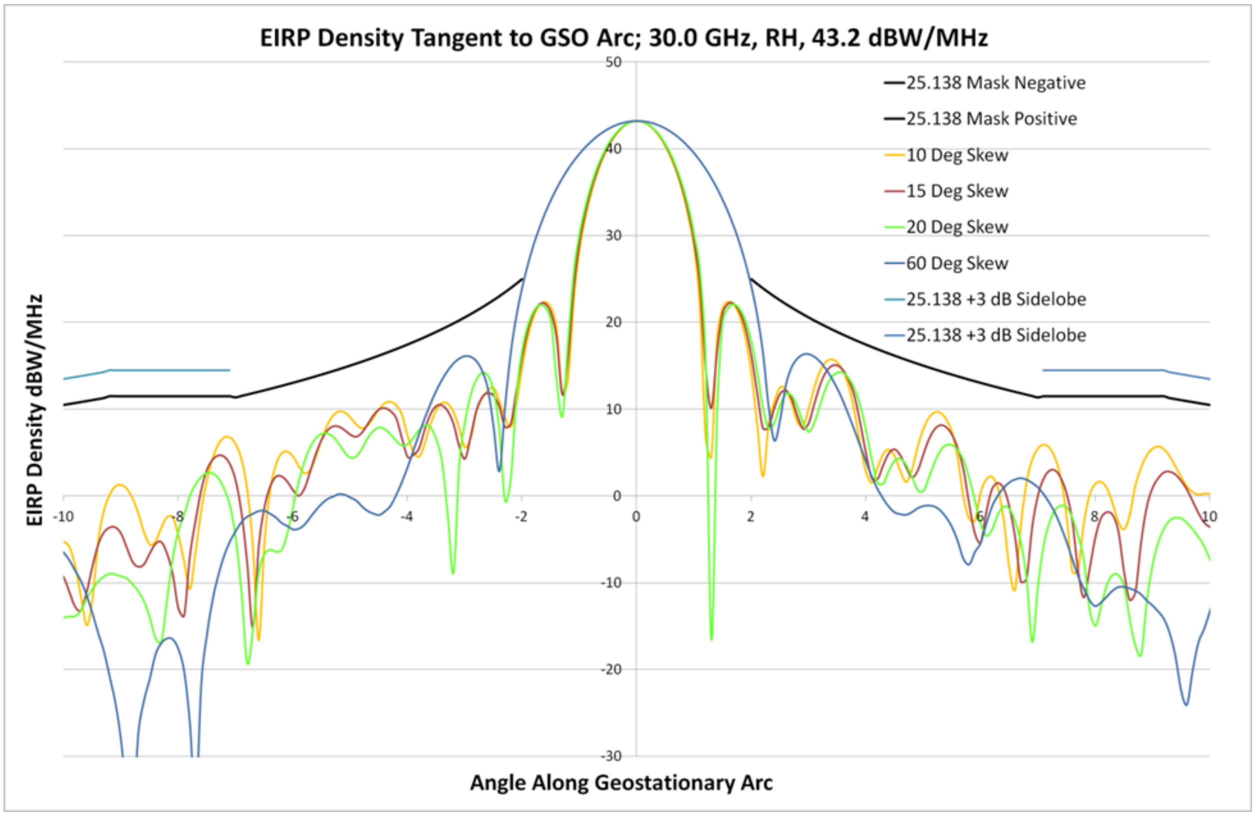


Figure 15 – EIRP Density tangent to GSO Arc, 30.0 GHz, RHP, 43.2 dBW/MHz, -10 to +10 deg., 25.138(a)(1) limits

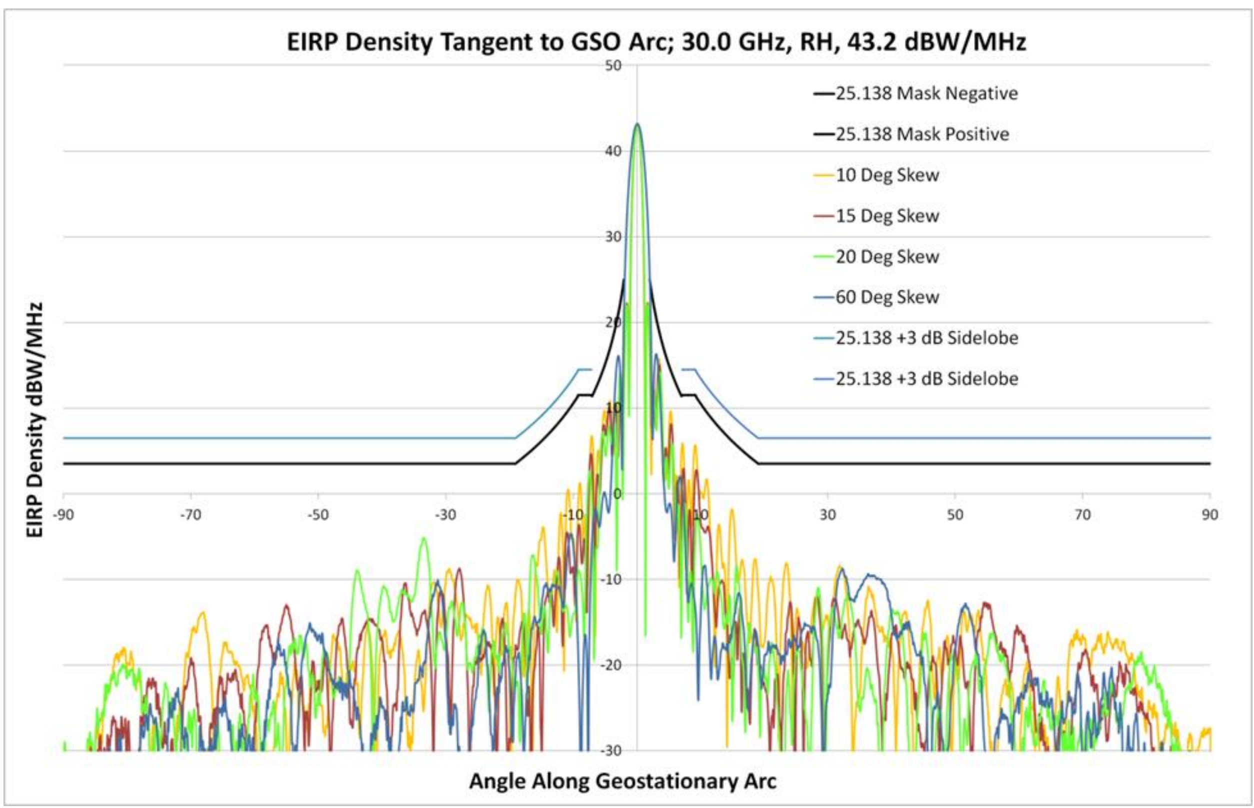


Figure 16 – EIRP Density tangent to GSO Arc, 30.0 GHz, RHP, 43.2 dBW/MHz, -90 to +90 deg., 25.138(a)(1) limits

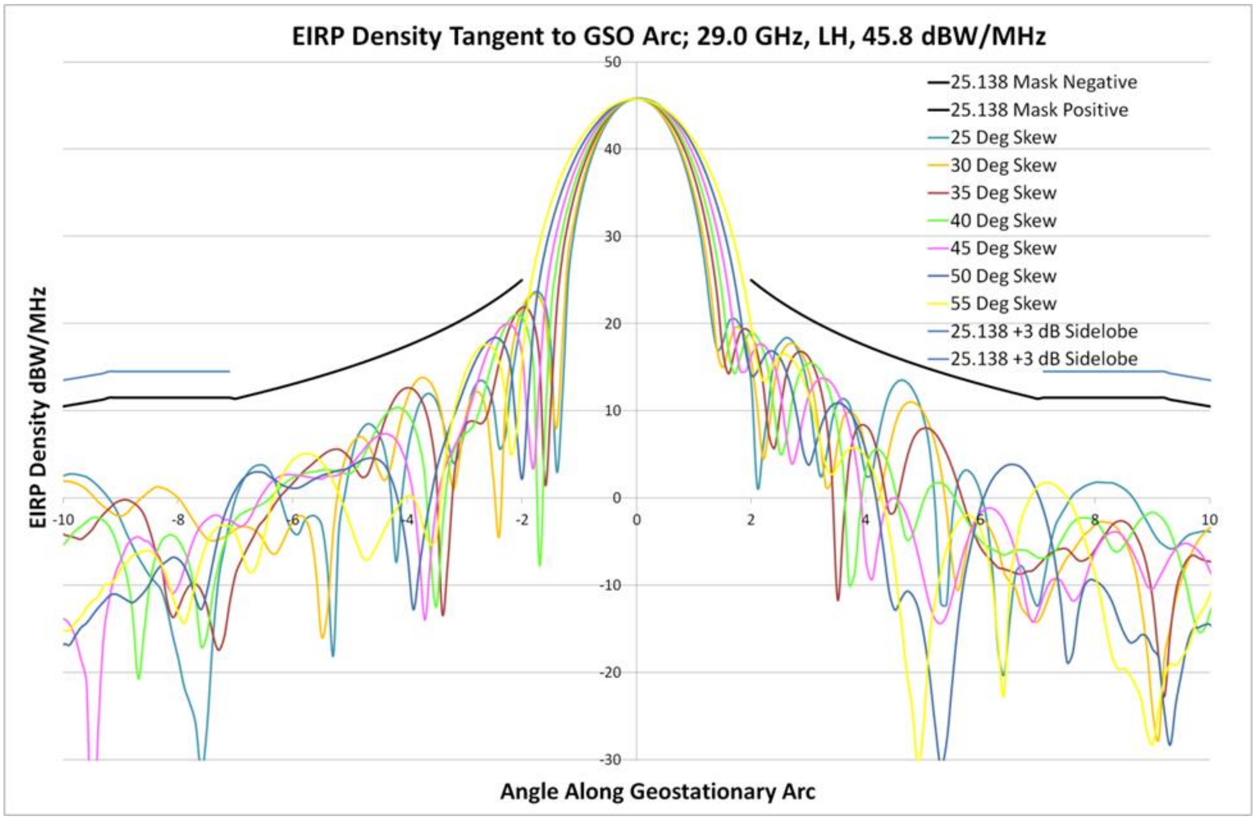


Figure 17 – EIRP Density tangent to GSO Arc, 29.0 GHz, LHP, 45.8 dBW/MHz, -10 to +10 deg., 25.138(a)(1) limits

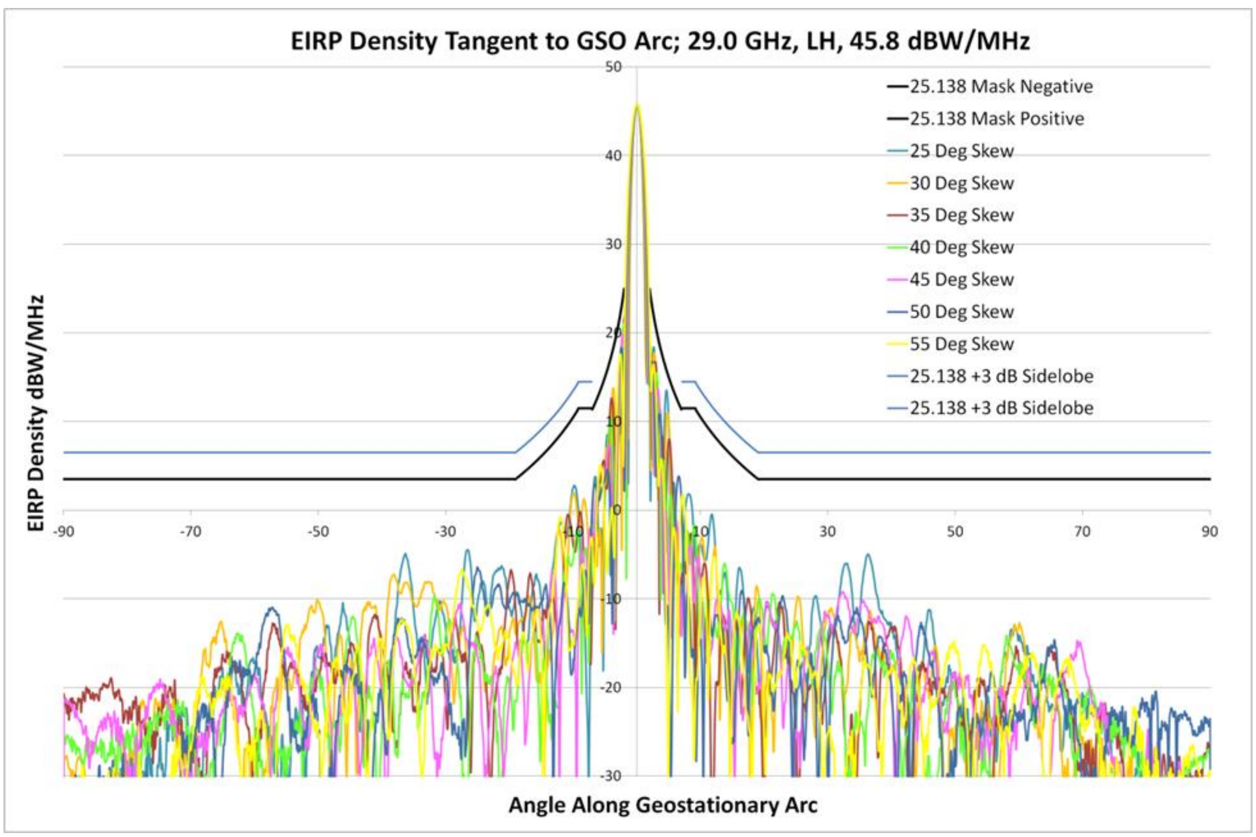


Figure 18 – EIRP Density tangent to GSO Arc, 29.0 GHz, LHP, 45.8 dBW/MHz, -90 to +90 deg., 25.138(a)(1) limits

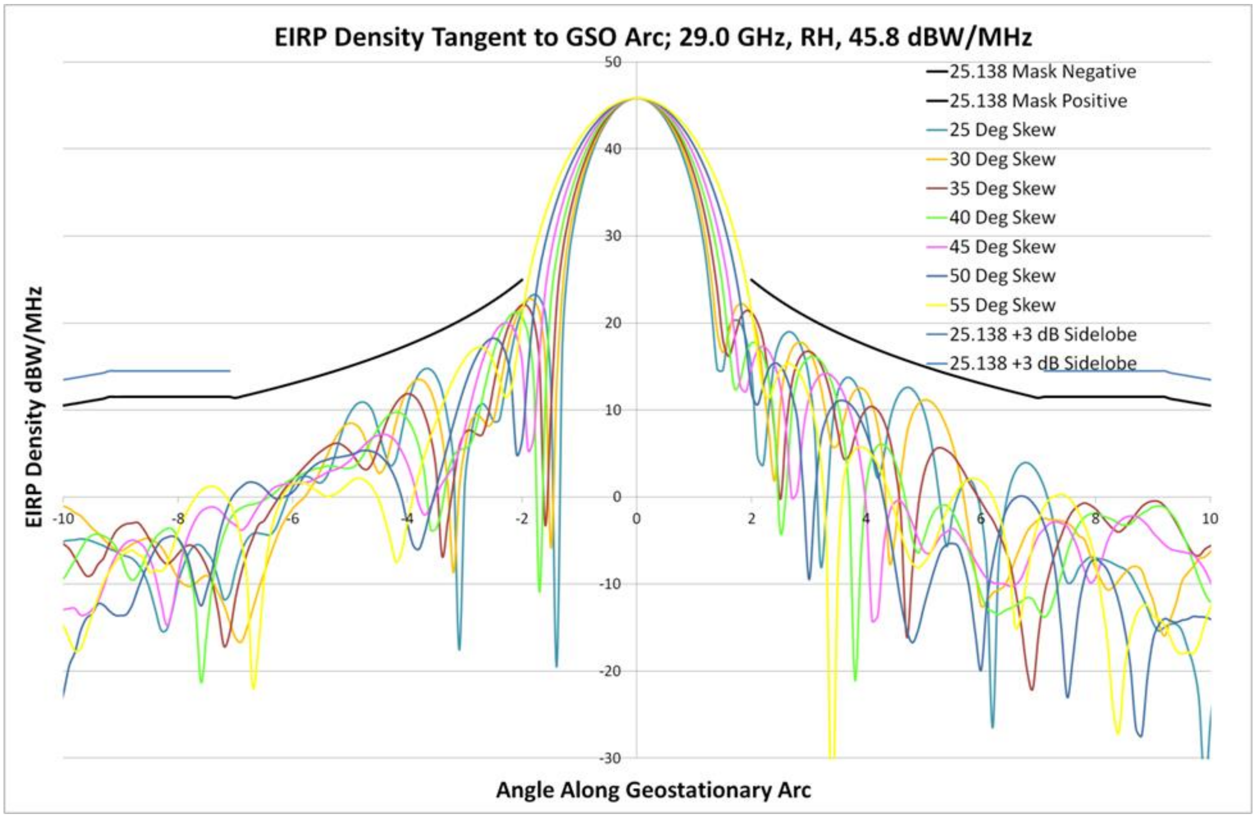


Figure 19 – EIRP Density tangent to GSO Arc, 29.0 GHz, RHP, 45.8 dBW/MHz, -10 to +10 deg., 25.138(a)(1) limits

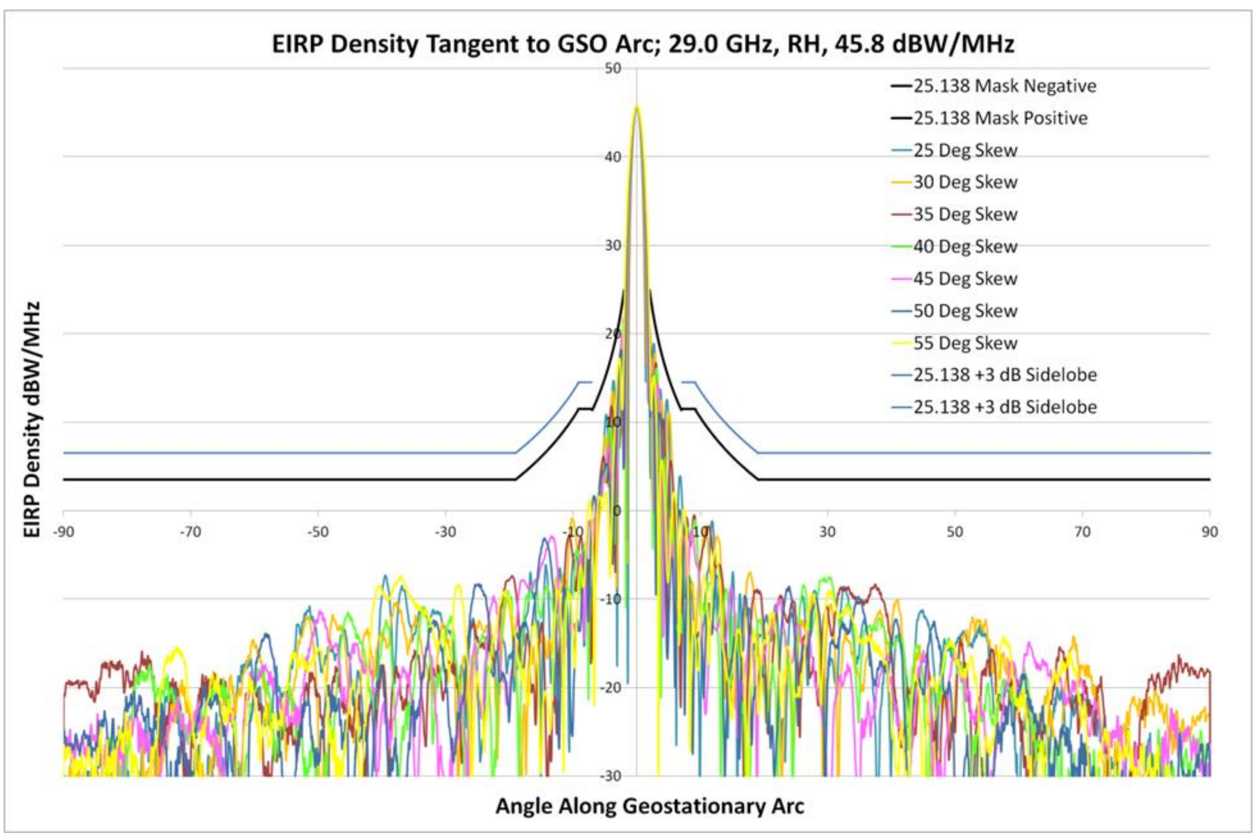


Figure 20 – EIRP Density tangent to GSO Arc, 29.0 GHz, RHP, 45.8 dBW/MHz, -90 to +90 deg., 25.138(a)(1) limits

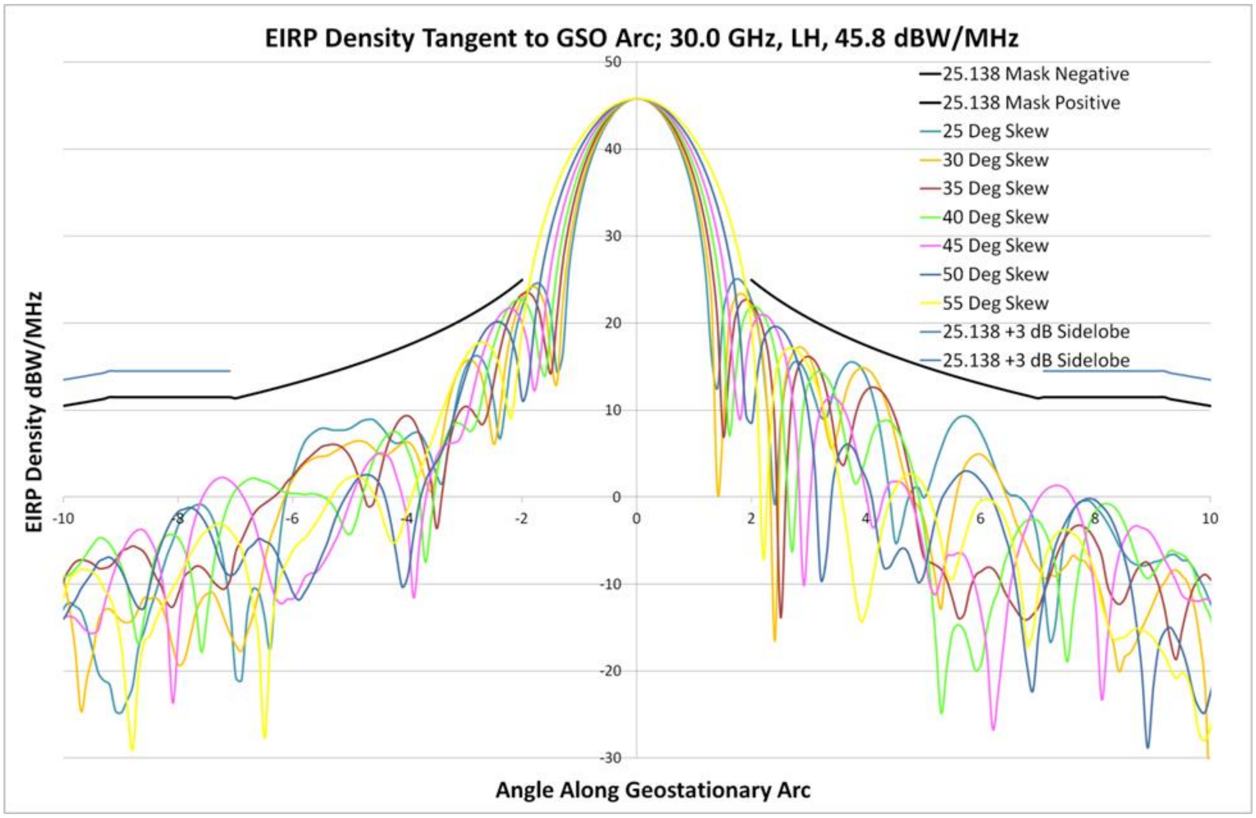


Figure 21 – EIRP Density tangent to GSO Arc, 30.0 GHz, LHP, 45.8 dBW/MHz, -10 to +10 deg., 25.138(a)(1) limits

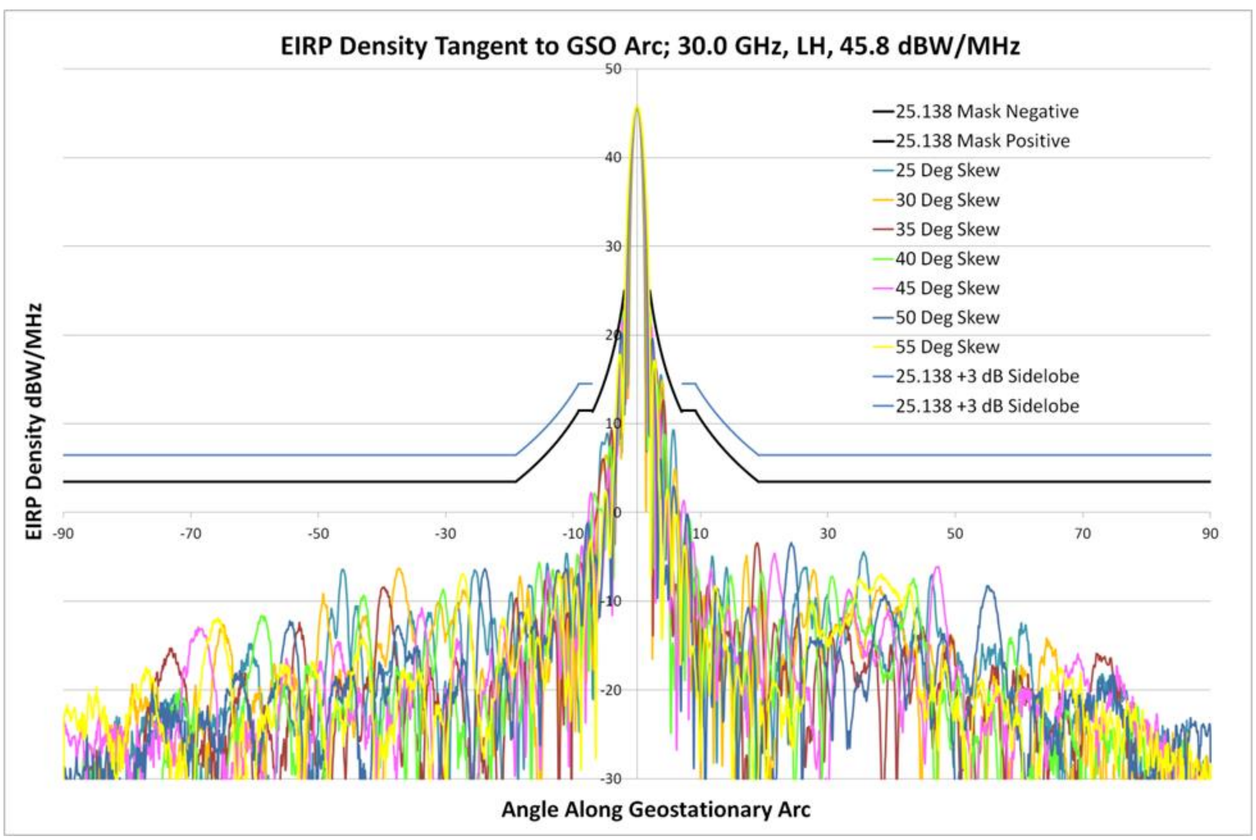


Figure 22 – EIRP Density tangent to GSO Arc, 30.0 GHz, LHP, 45.8 dBW/MHz, -90 to +90 deg., 25.138(a)(1) limits

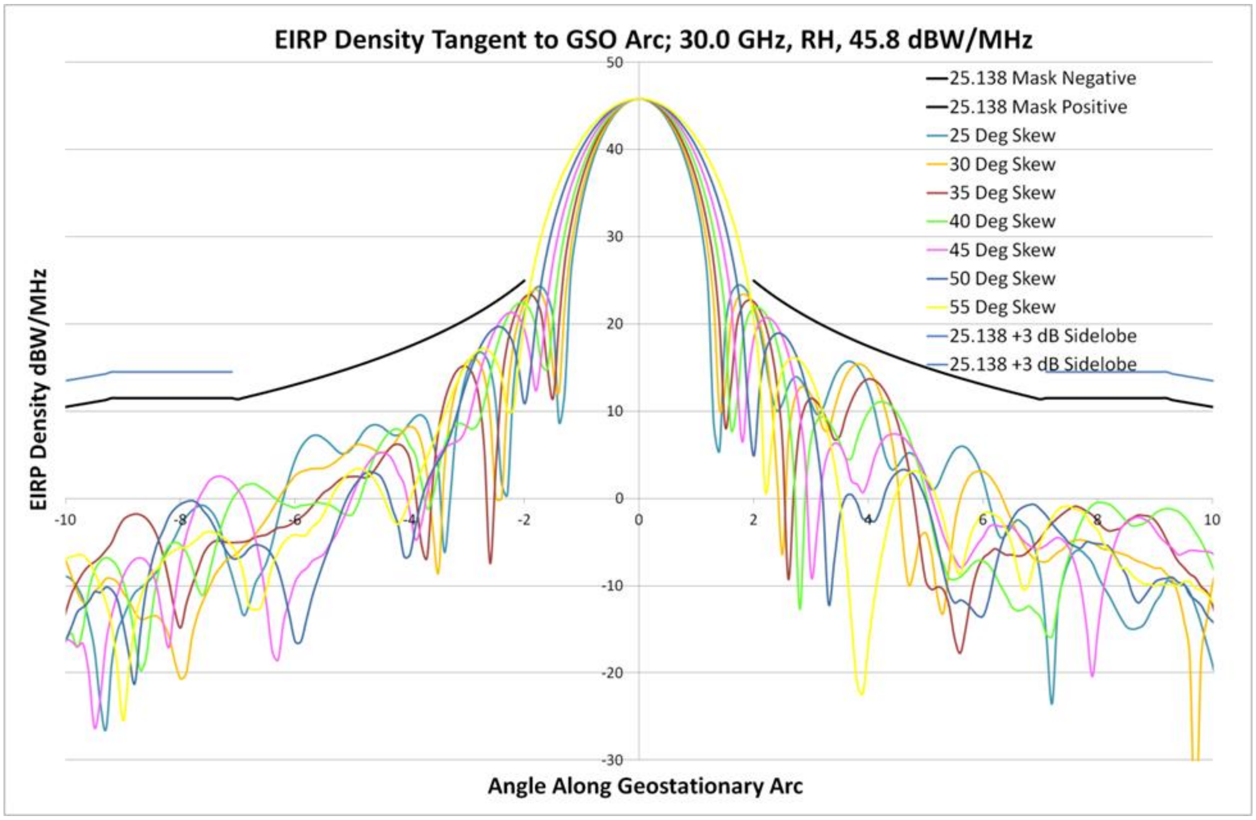


Figure 23 – EIRP Density tangent to GSO Arc, 30.0 GHz, RHP, 45.8 dBW/MHz, -10 to +10 deg., 25.138(a)(1) limits

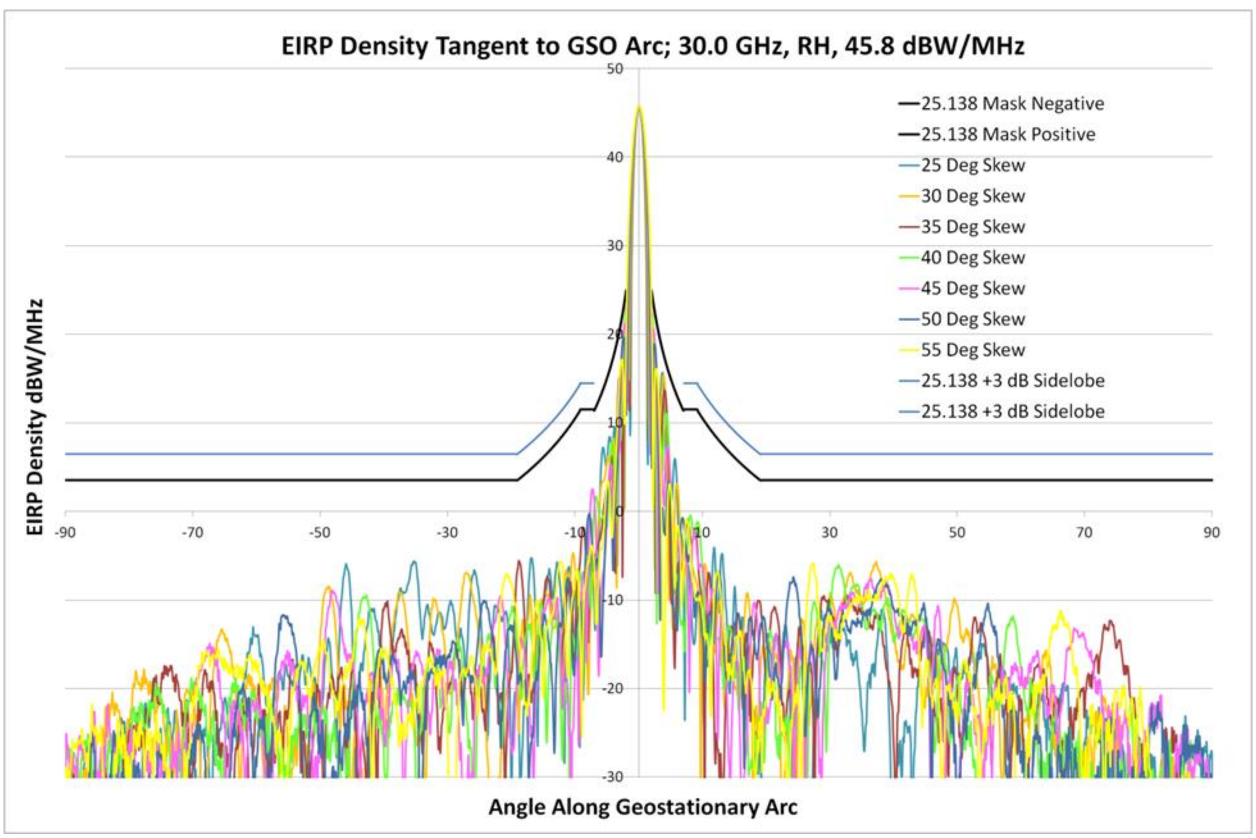


Figure 24 – EIRP Density tangent to GSO Arc, 30.0 GHz, RHP, 45.8 dBW/MHz, -90 to +90 deg., 25.138(a)(1) limits

Attachment 3

Cross-Polarized EIRP Density Plots

The following pages depict the cross-polarized EIRP Density plots for each of 29.0 and 30.0 GHz, for both LHP and RHP, for skew angles over the range 0 to 60 degrees. The 25.138(a)(4) EIRP Density limits are referenced.

(Please note that since the Ka Antenna is of a Horn-Array-Aperture design exhibiting no back-lobes, the data is limited to the -90 to +90 degree range.)

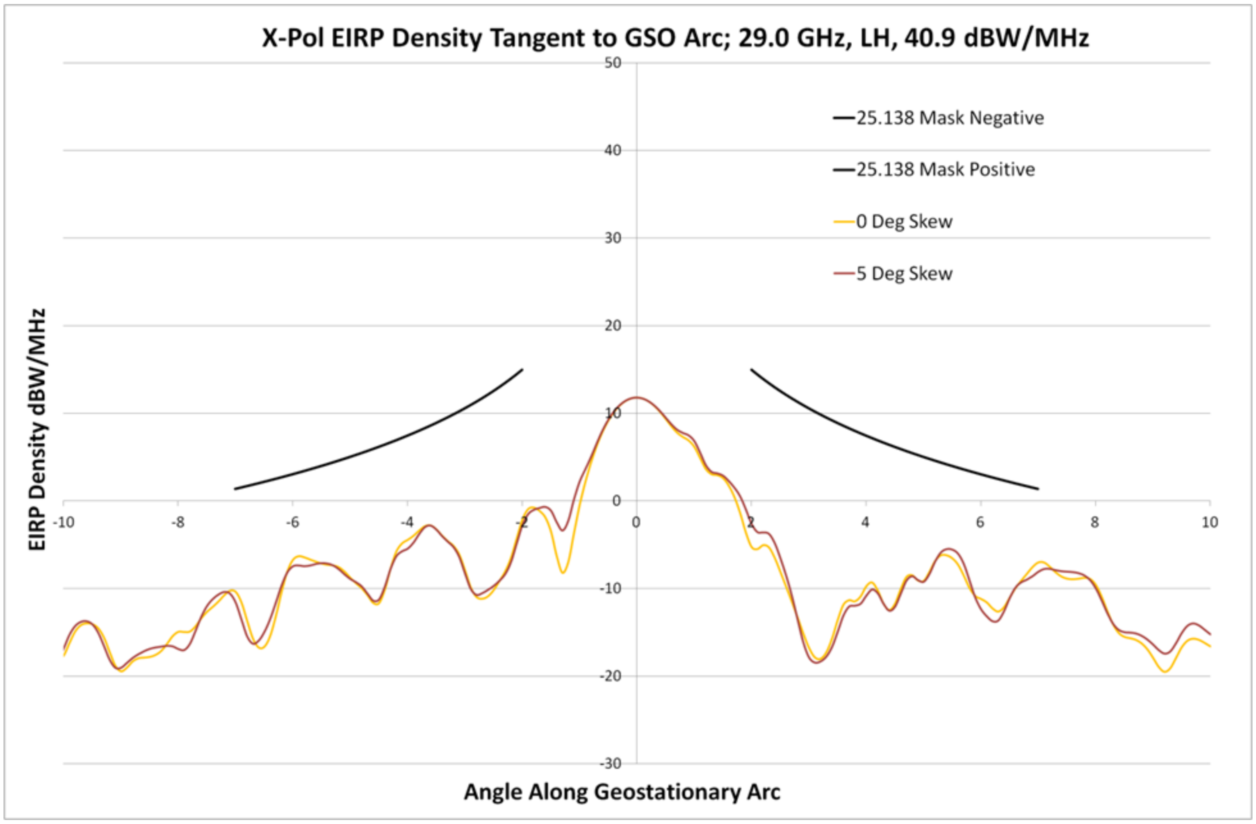


Figure 25 – X-Pol EIRP Density tangent to GSO Arc, 29.0 GHz, LHP, 40.9 dBW/MHz, -10 to +10 deg., 25.138(a)(4) limits

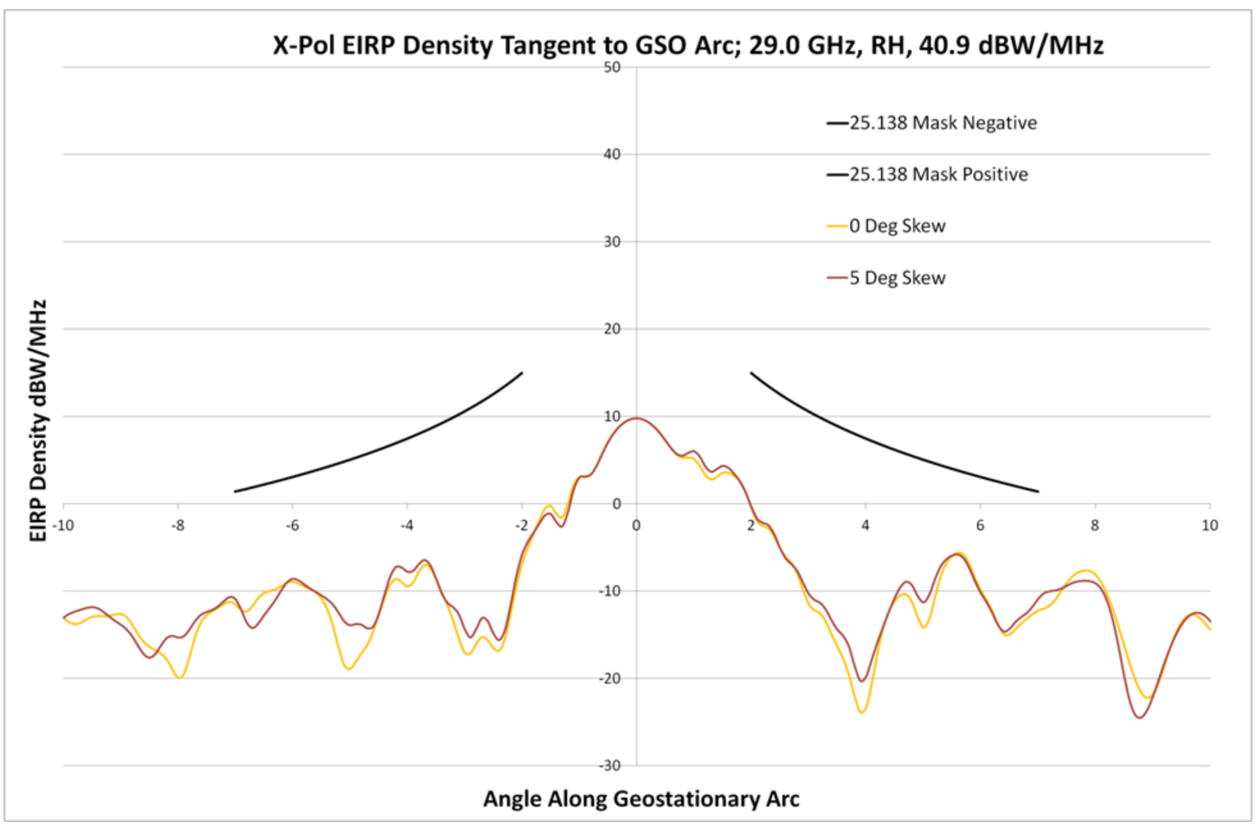


Figure 26 – X-Pol EIRP Density tangent to GSO Arc, 29.0 GHz, RHP, 40.9 dBW/MHz, -10 to +10 deg., 25.138(a)(4) limits

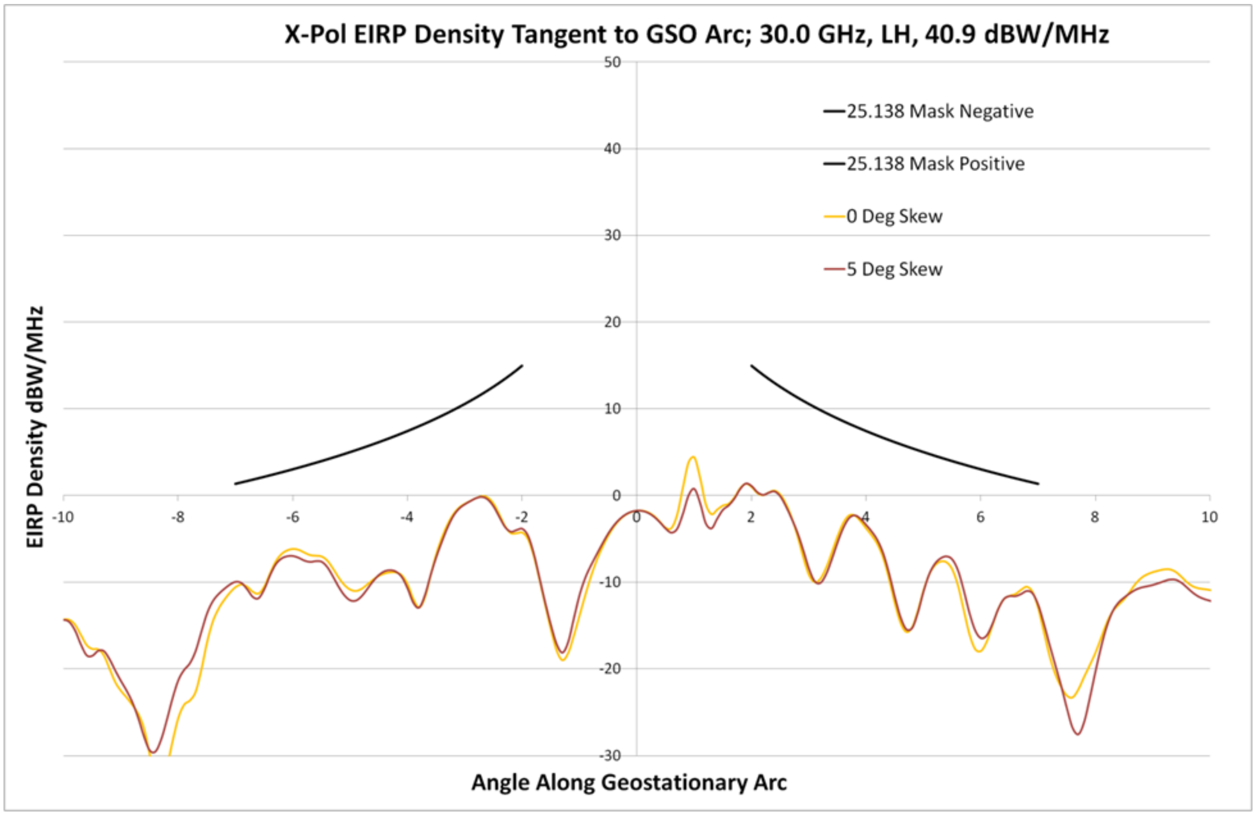


Figure 27 – X-Pol EIRP Density tangent to GSO Arc, 30.0 GHz, LHP, 40.9 dBW/MHz, -10 to +10 deg., 25.138(a)(4) limits

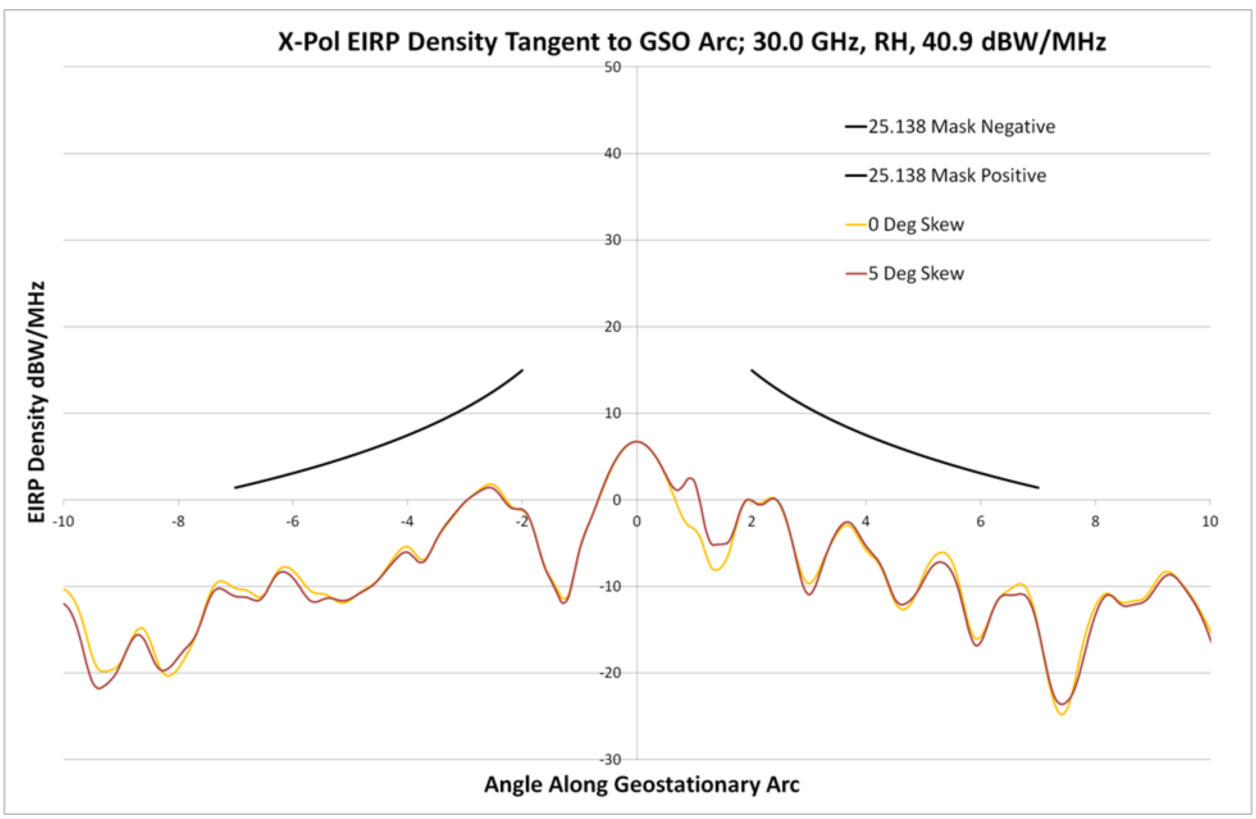


Figure 28 – X-Pol EIRP Density tangent to GSO Arc, 30.0 GHz, RHP, 40.9 dBW/MHz, -10 to +10 deg., 25.138(a)(4) limits

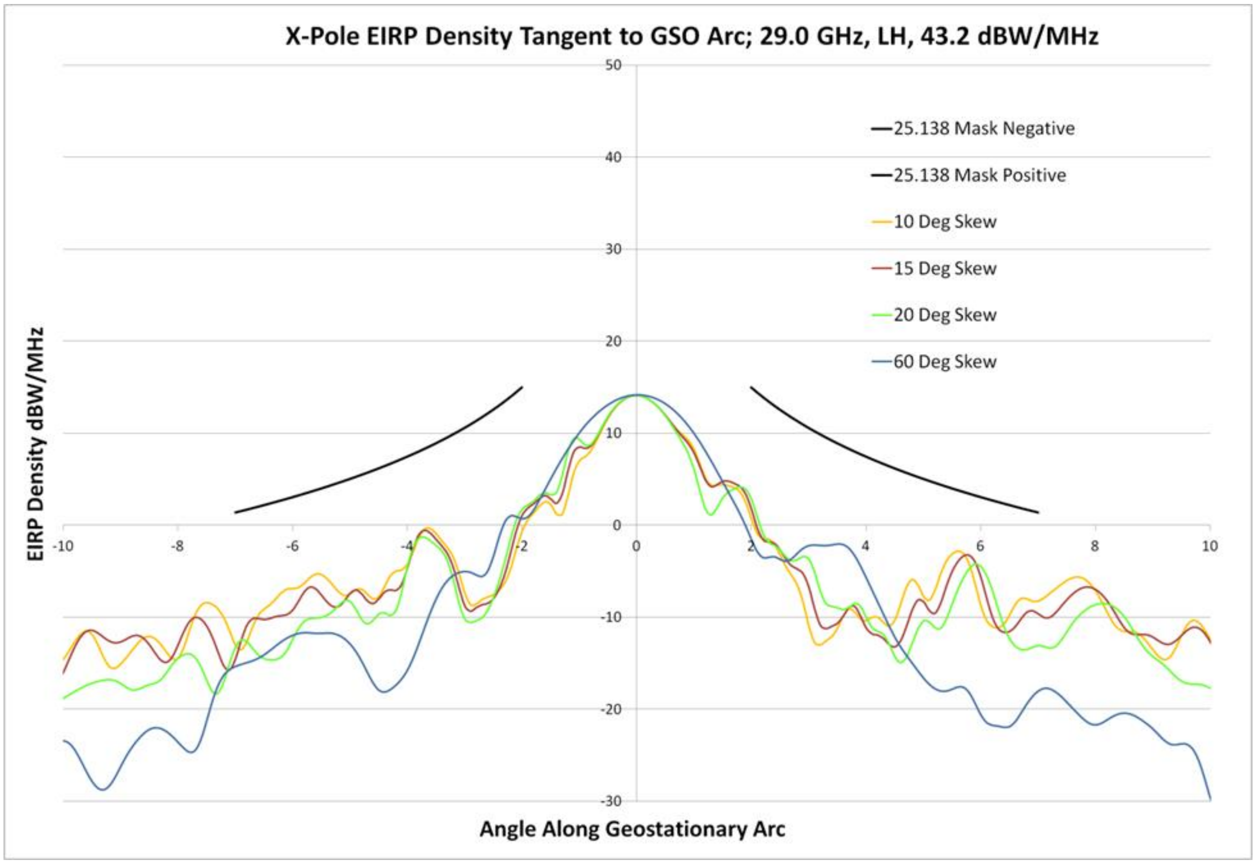


Figure 29 – X-Pol EIRP Density tangent to GSO Arc, 29.0 GHz, LHP, 43.2 dBW/MHz, -10 to +10 deg., 25.138(a)(4) limits

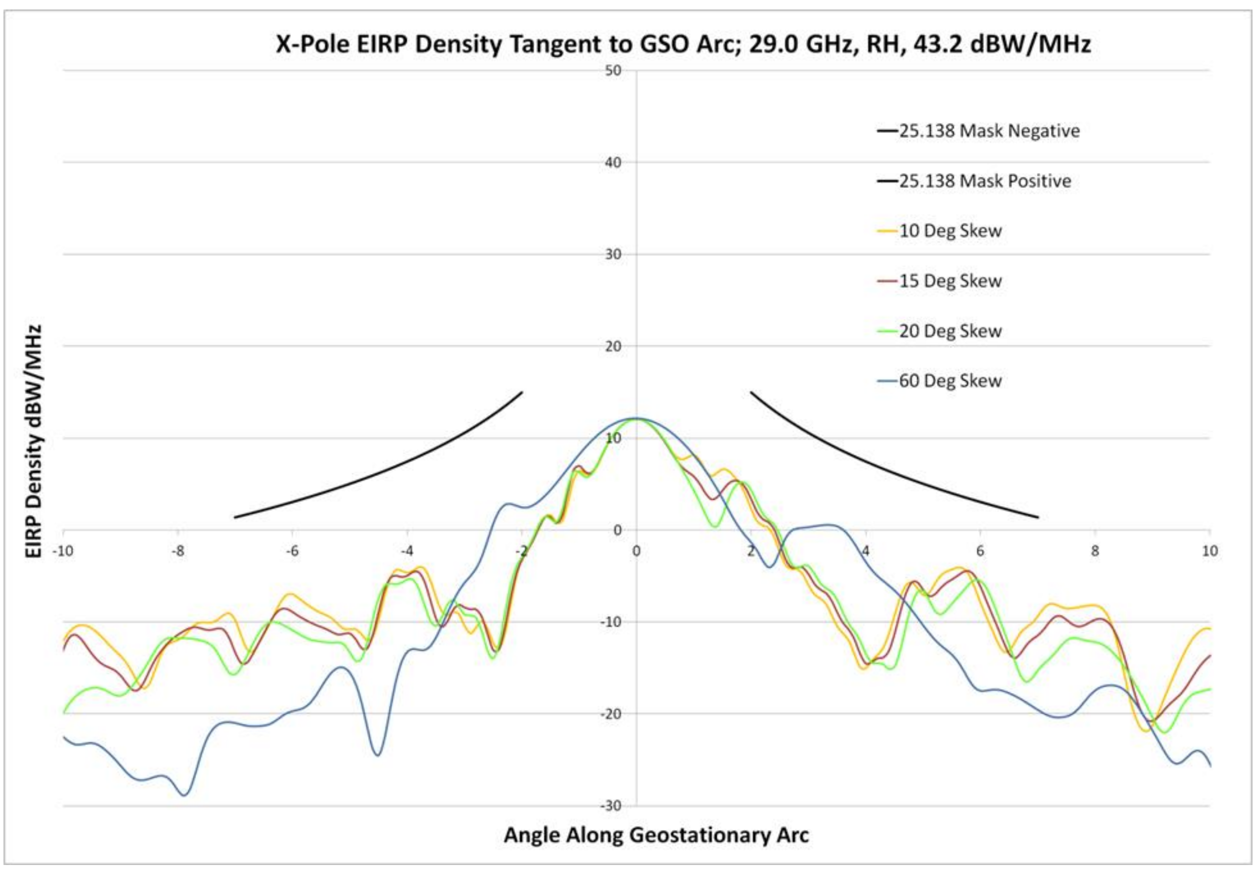


Figure 30 – X-Pol EIRP Density tangent to GSO Arc, 29.0 GHz, RHP, 43.2 dBW/MHz, -10 to +10 deg., 25.138(a)(4) limits

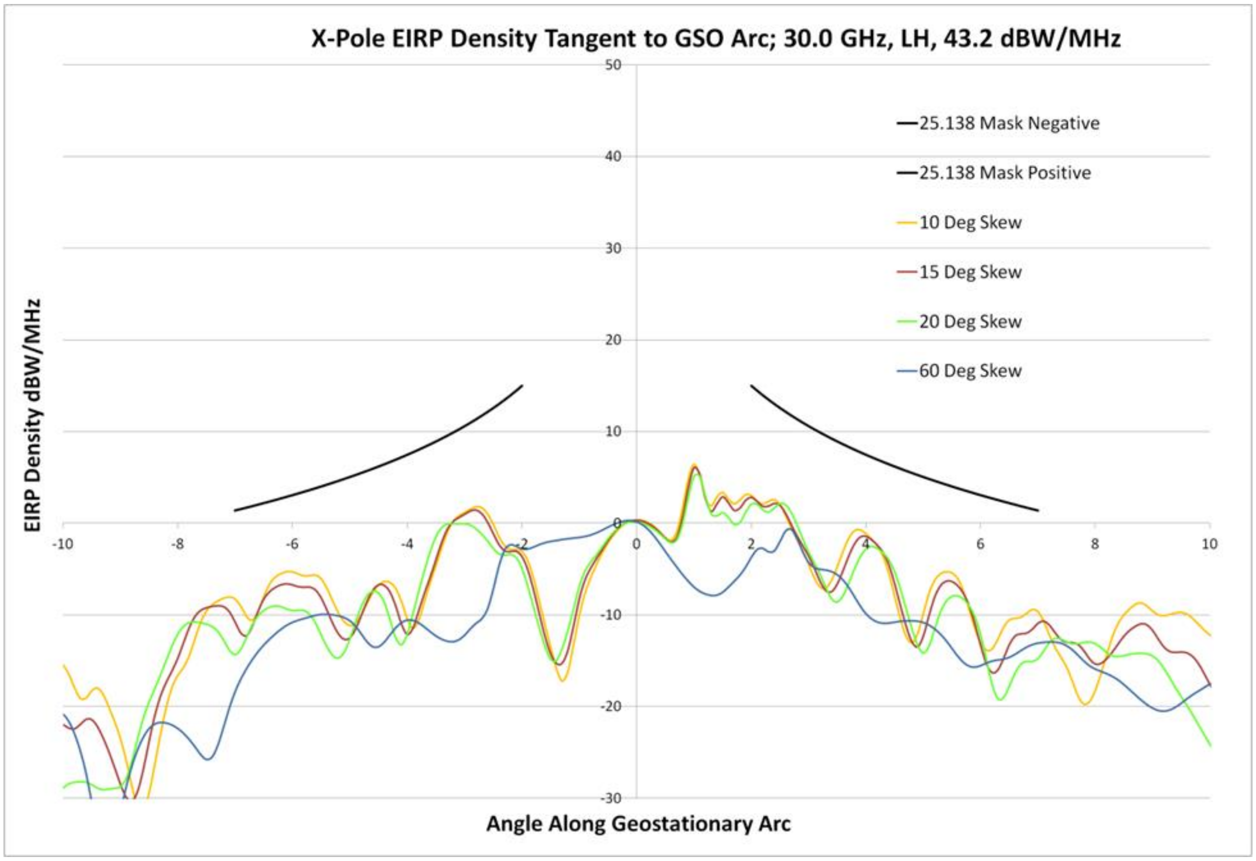


Figure 31 – X-Pol EIRP Density tangent to GSO Arc, 30.0 GHz, LHP, 43.2 dBW/MHz, -10 to +10 deg., 25.138(a)(4) limits

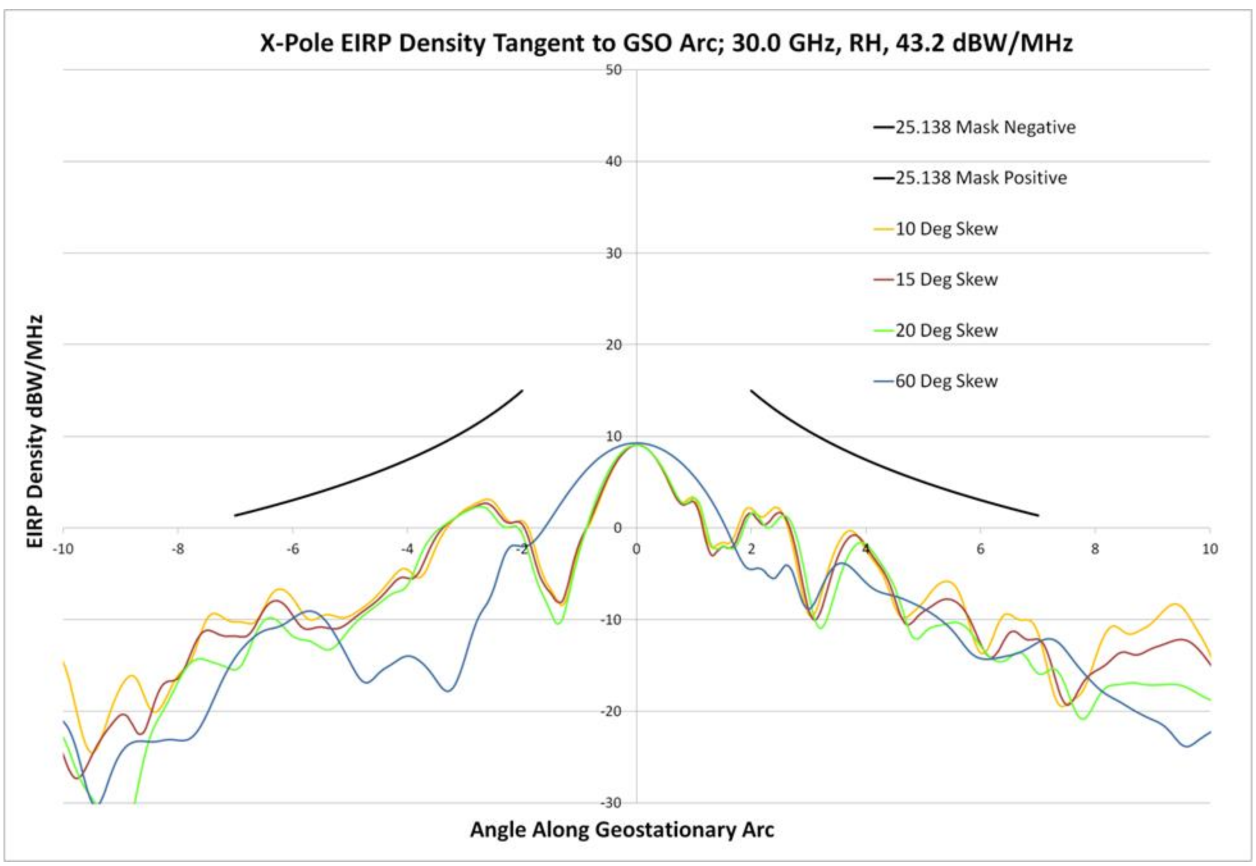


Figure 32 – X-Pol EIRP Density tangent to GSO Arc, 30.0 GHz, RHP, 43.2 dBW/MHz, -10 to +10 deg., 25.138(a)(4) limits

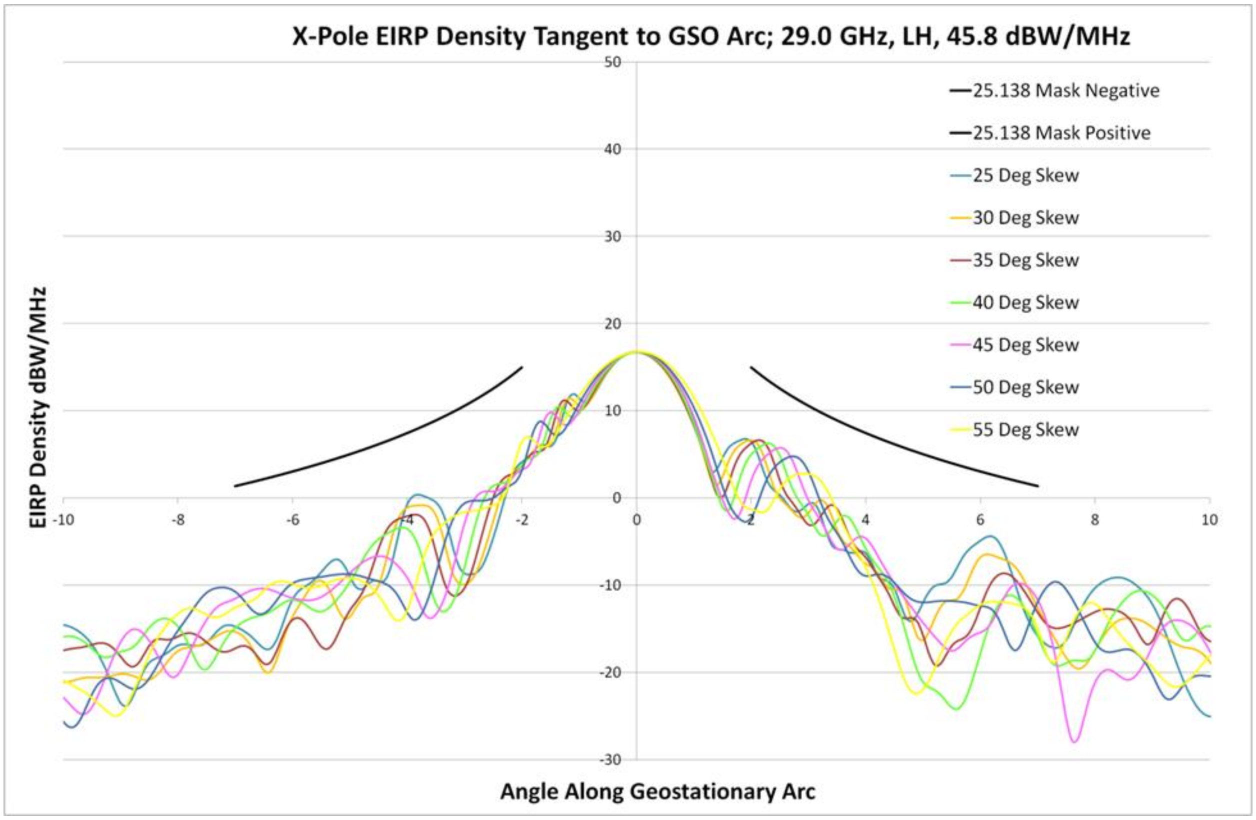


Figure 33 – X-Pol EIRP Density tangent to GSO Arc, 29.0 GHz, LHP, 45.8 dBW/MHz, -10 to +10 deg., 25.138(a)(4) limits

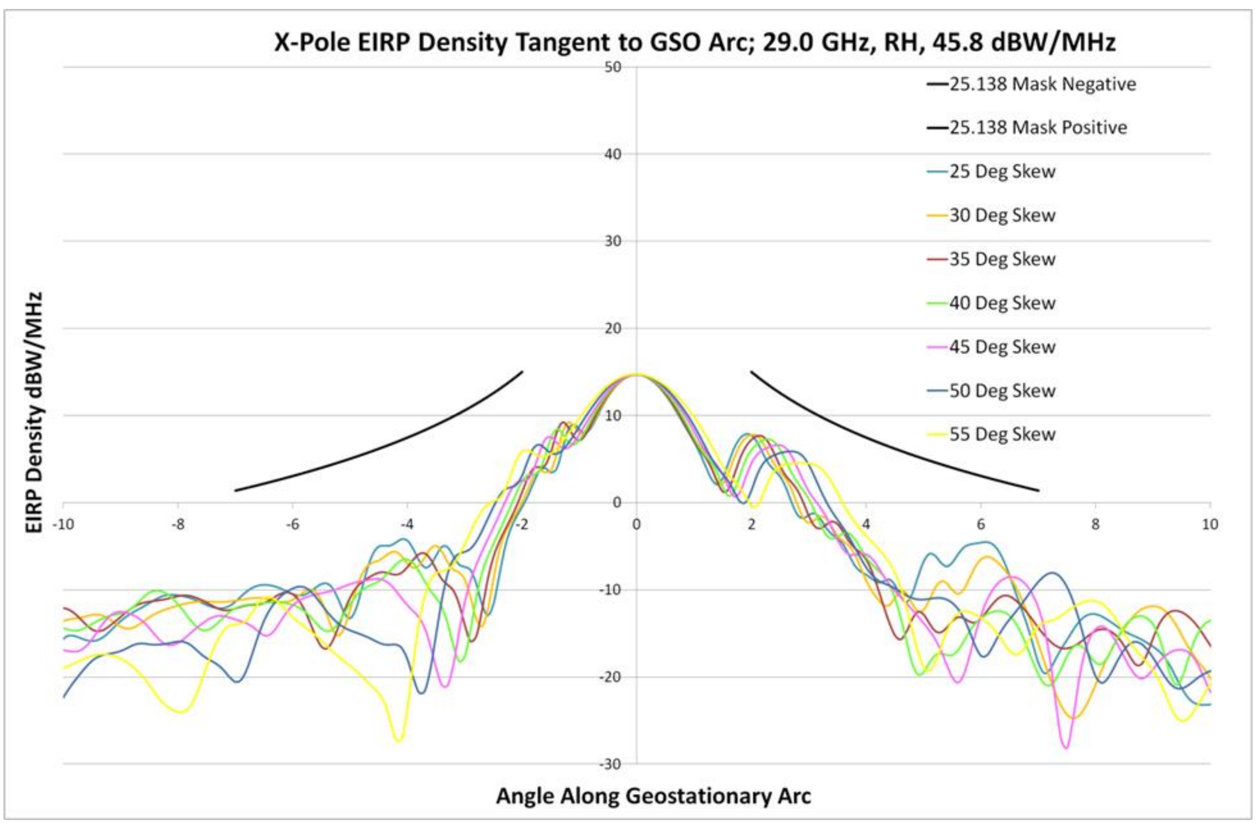


Figure 34 – X-Pol EIRP Density tangent to GSO Arc, 29.0 GHz, RHP, 45.8 dBW/MHz, -10 to +10 deg., 25.138(a)(4) limits

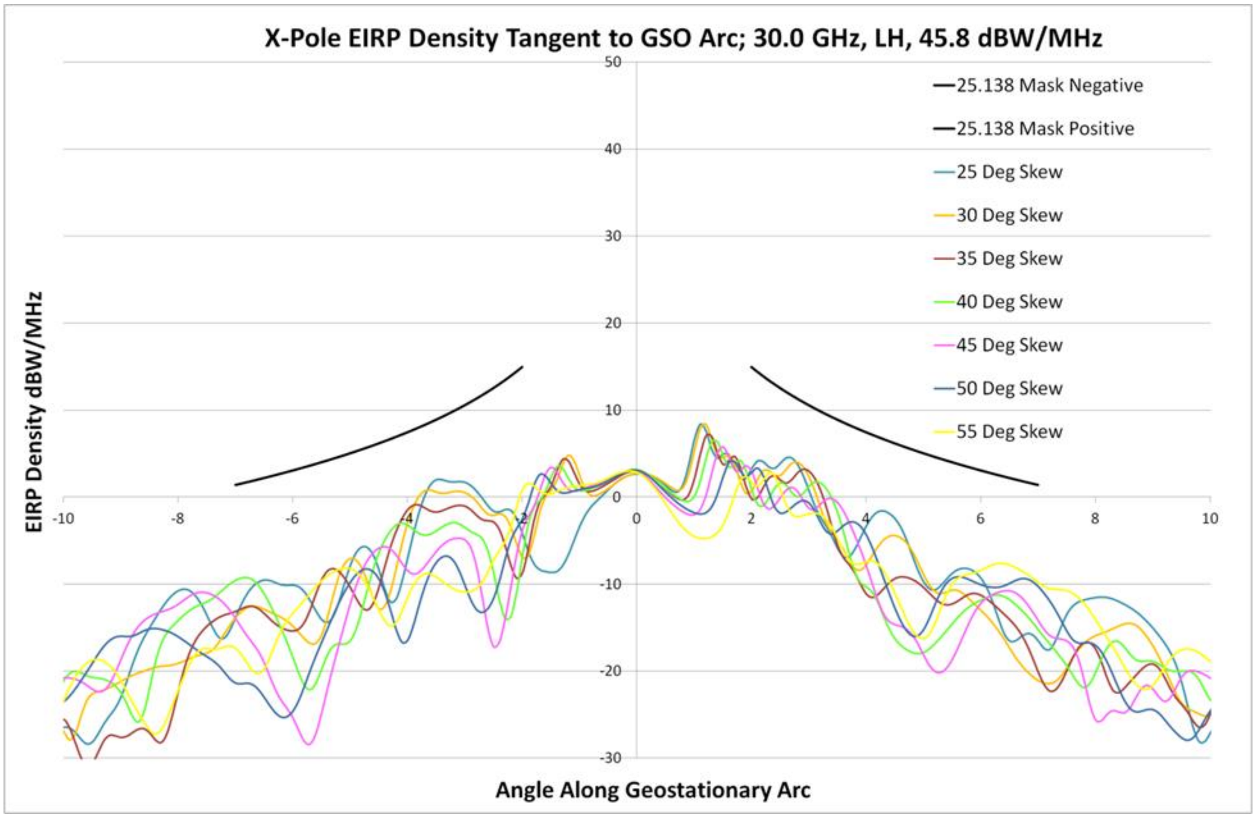


Figure 35 – X-Pol EIRP Density tangent to GSO Arc, 30.0 GHz, LHP, 45.8 dBW/MHz, -10 to +10 deg., 25.138(a)(4) limits

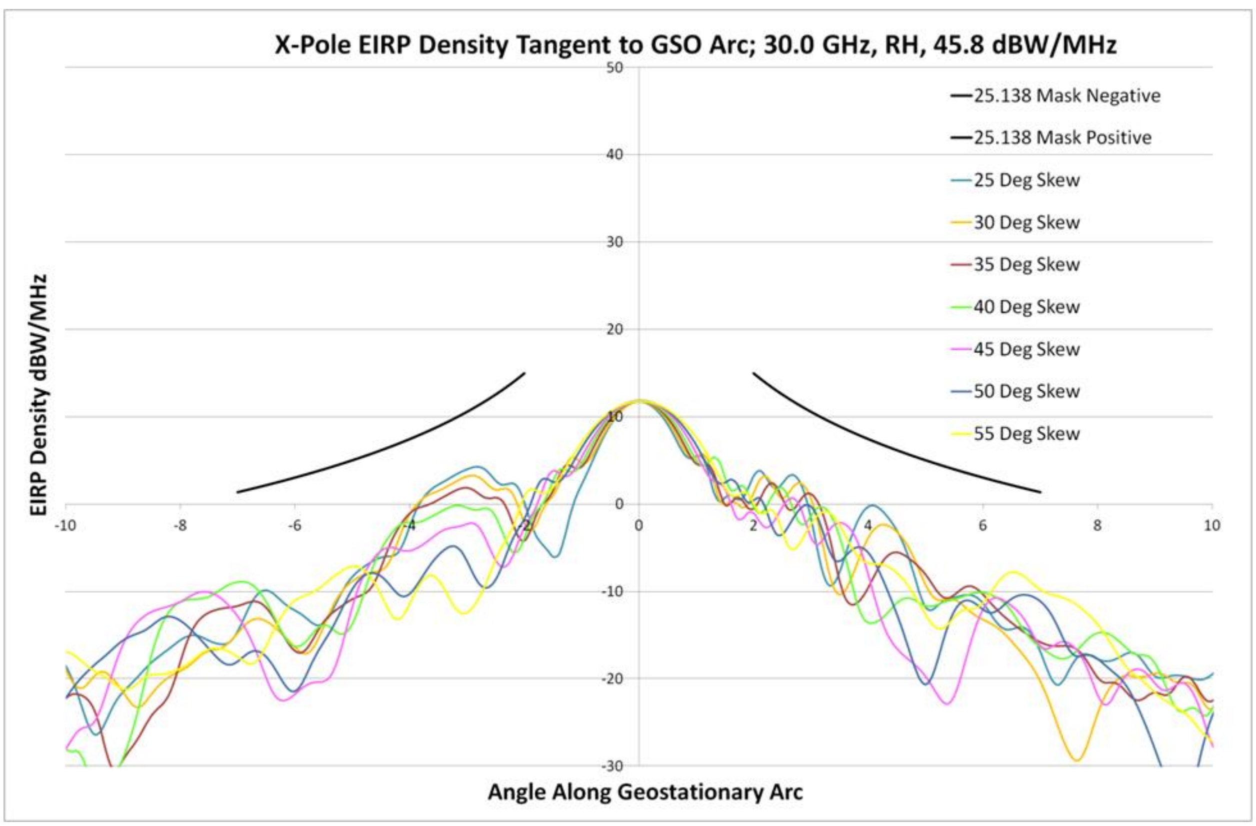


Figure 36 – X-Pol EIRP Density tangent to GSO Arc, 30.0 GHz, RHP, 45.8 dBW/MHz, -10 to +10 deg., 25.138(a)(4) limits

Attachment 4

Ka Antenna Gain Plots

(Tangent to GSO Arc, Perpendicular to GSO Arc, Co-Pol)

The following pages depict the Ka Antenna gain plots for 29.0 MHz, for both LHP and RHP, for skew angles over the range 0 to 60 degrees, applicable to (1) Tangent to the GSO arc, (2) Perpendicular to the GSO arc, and (3) Tangent cross-polarized gain.

(Please note that since the Ka Antenna is of a Horn-Array-Aperture design exhibiting no back-lobes, the data is limited to the -90 to +90 degree range.)

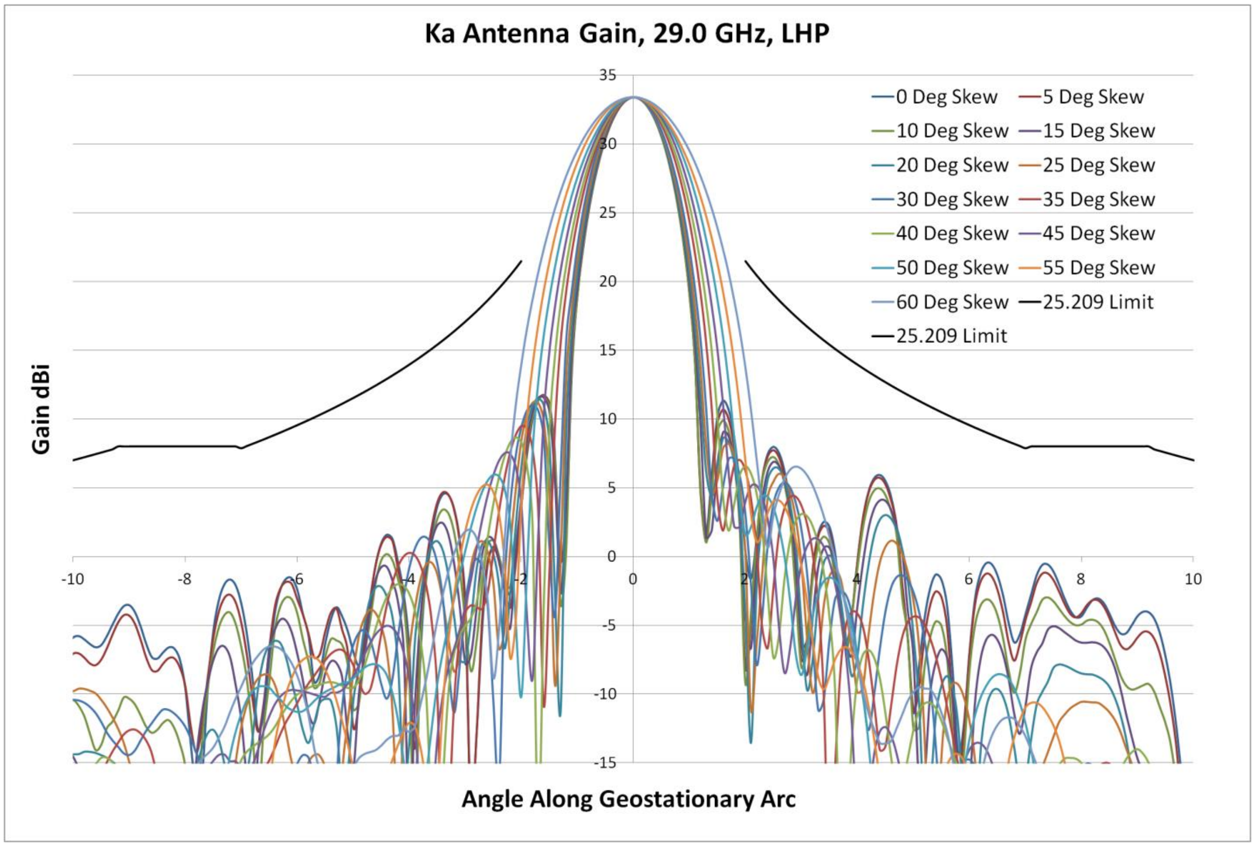


Figure 37 – Ka Antenna Gain Tangent to GSO Arc, 29.0 GHz, LHP, -10 to +10 degrees, 25.209(a)(3) limits

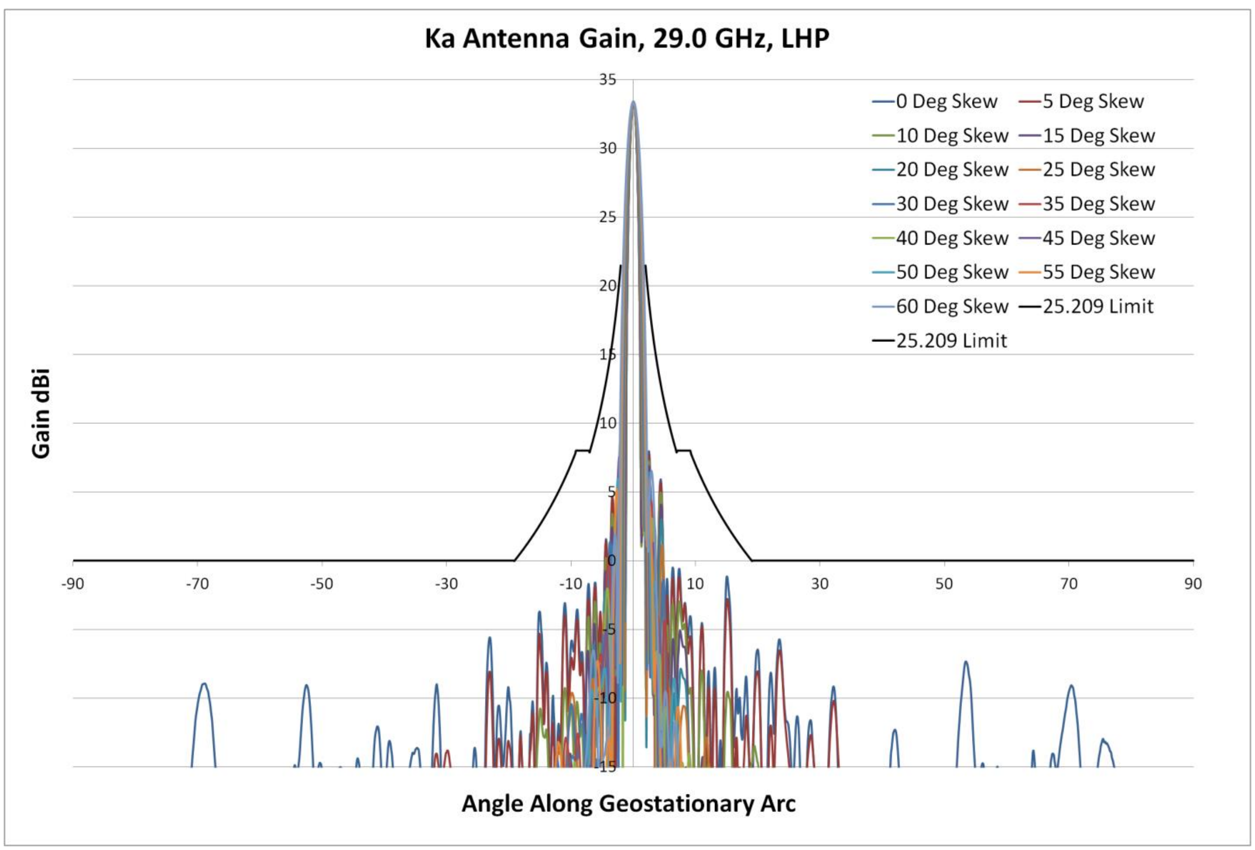


Figure 38 – Ka Antenna Gain Tangent to GSO Arc, 29.0 GHz, LHP, -90 to +90 degrees, 25.209(a)(3) limits

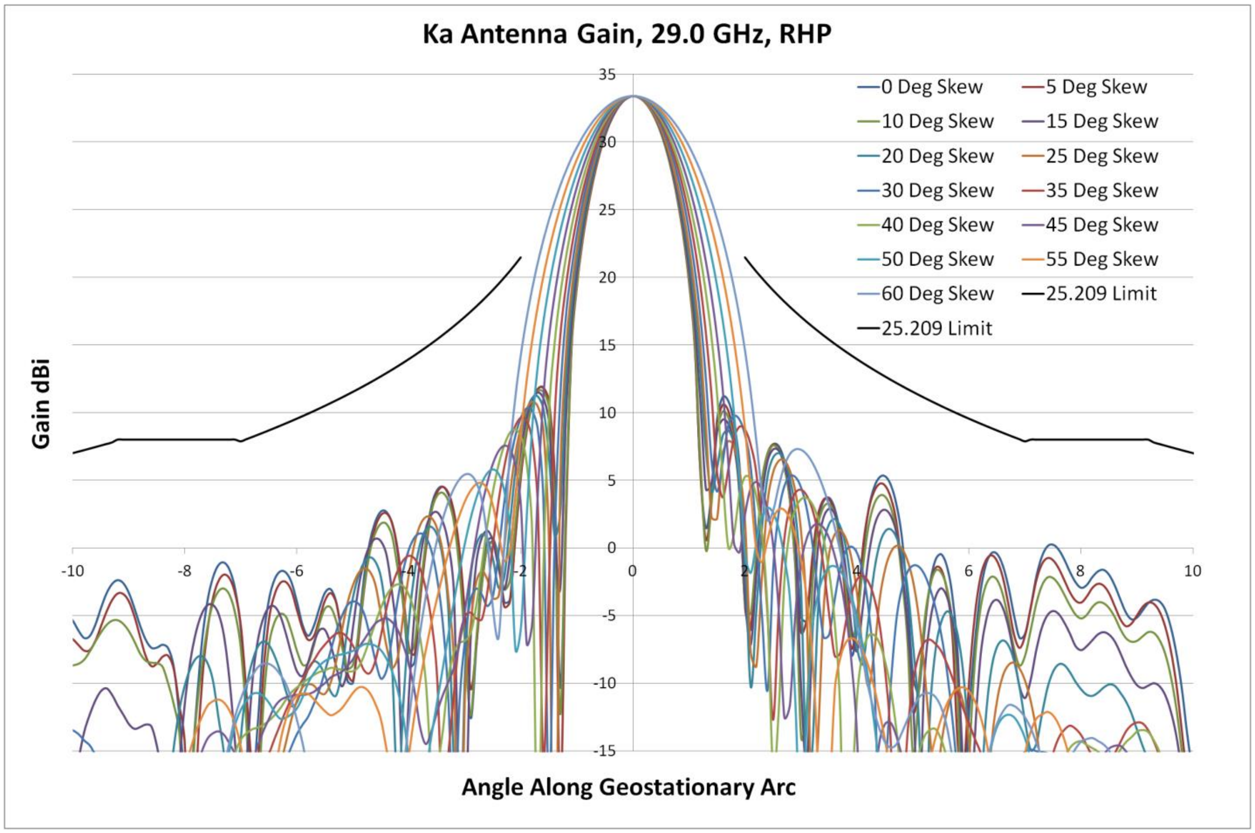


Figure 39 – Ka Antenna Gain Tangent to GSO Arc, 29.0 GHz, RHP, -10 to +10 degrees, 25.209(a)(3) limits

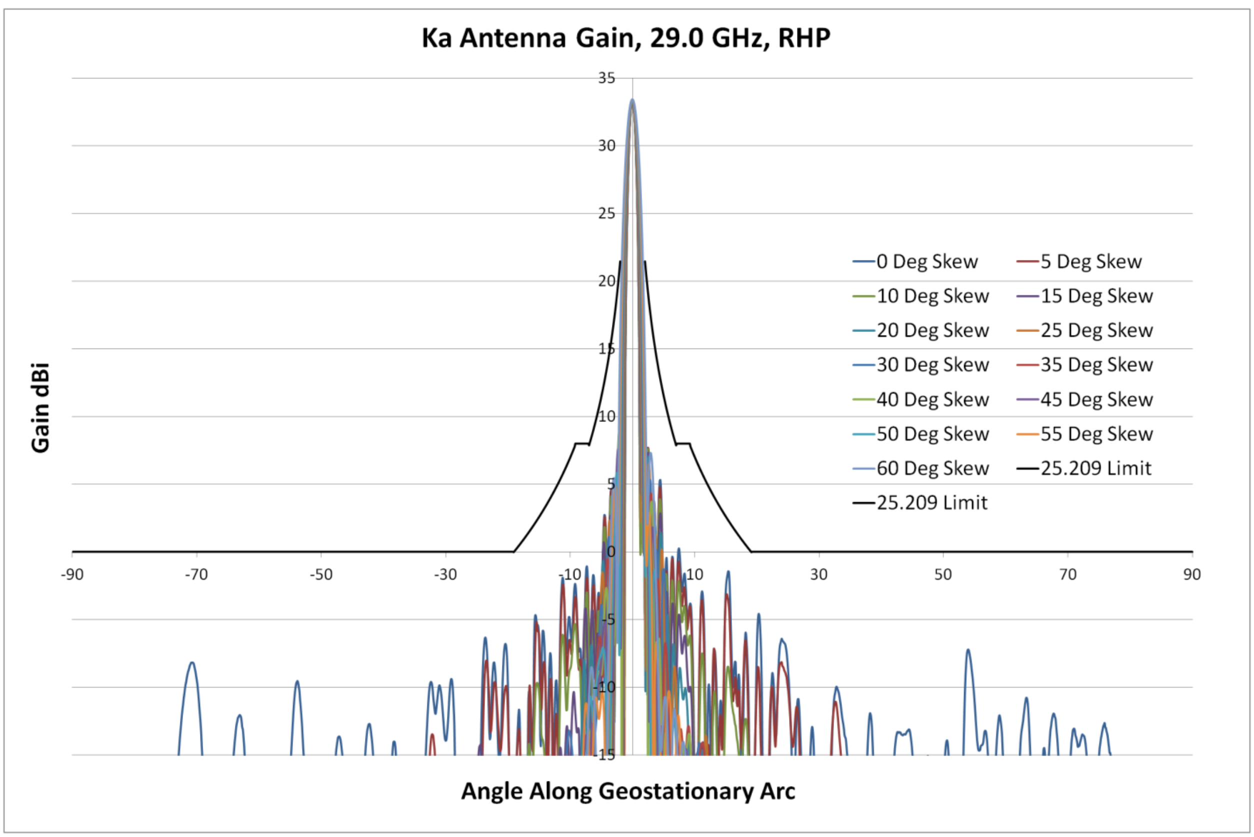


Figure 40 – Ka Antenna Gain Tangent to GSO Arc, 29.0 GHz, RHP, -90 to +90 degrees, 25.209(a)(3) limits

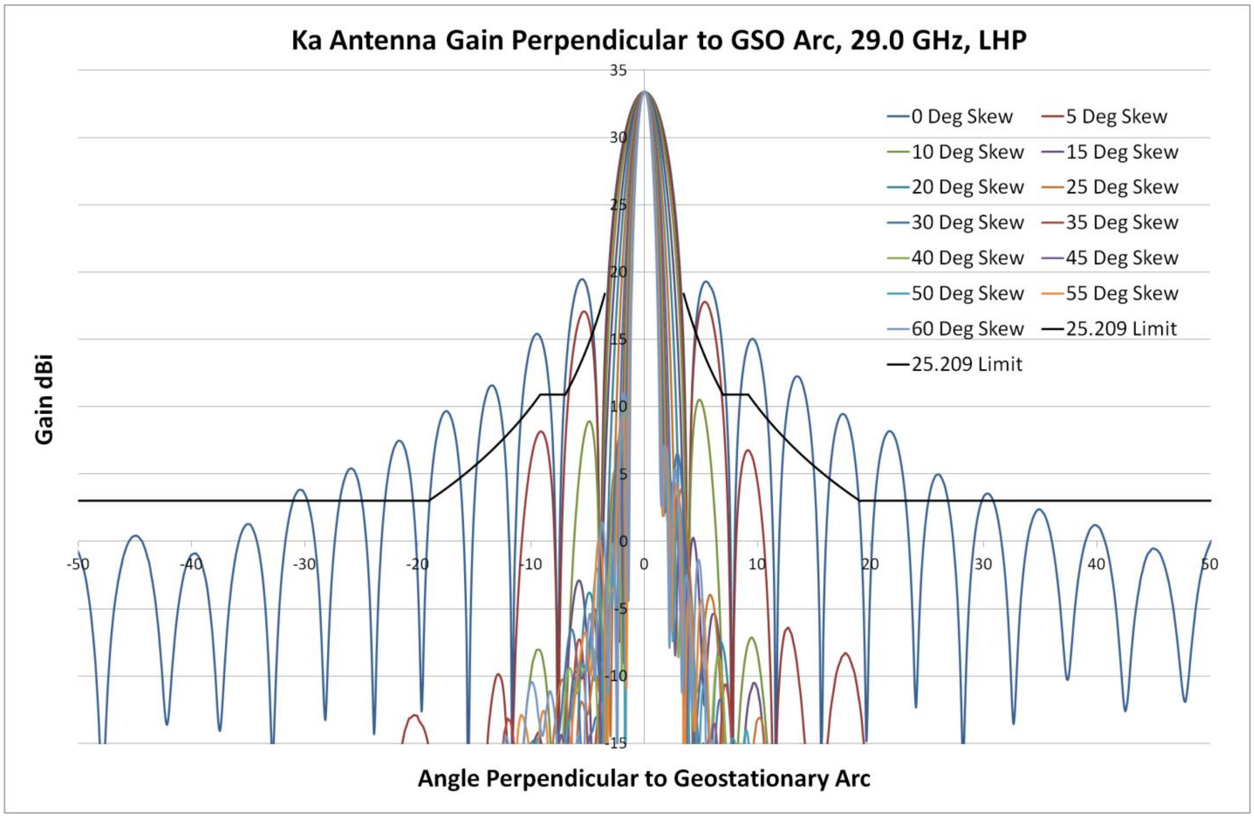


Figure 41 – Ka Antenna Gain Perpendicular to GSO Arc, 29.0 GHz, LHP, -50 to +50 degrees, 25.209(a)(6) limits

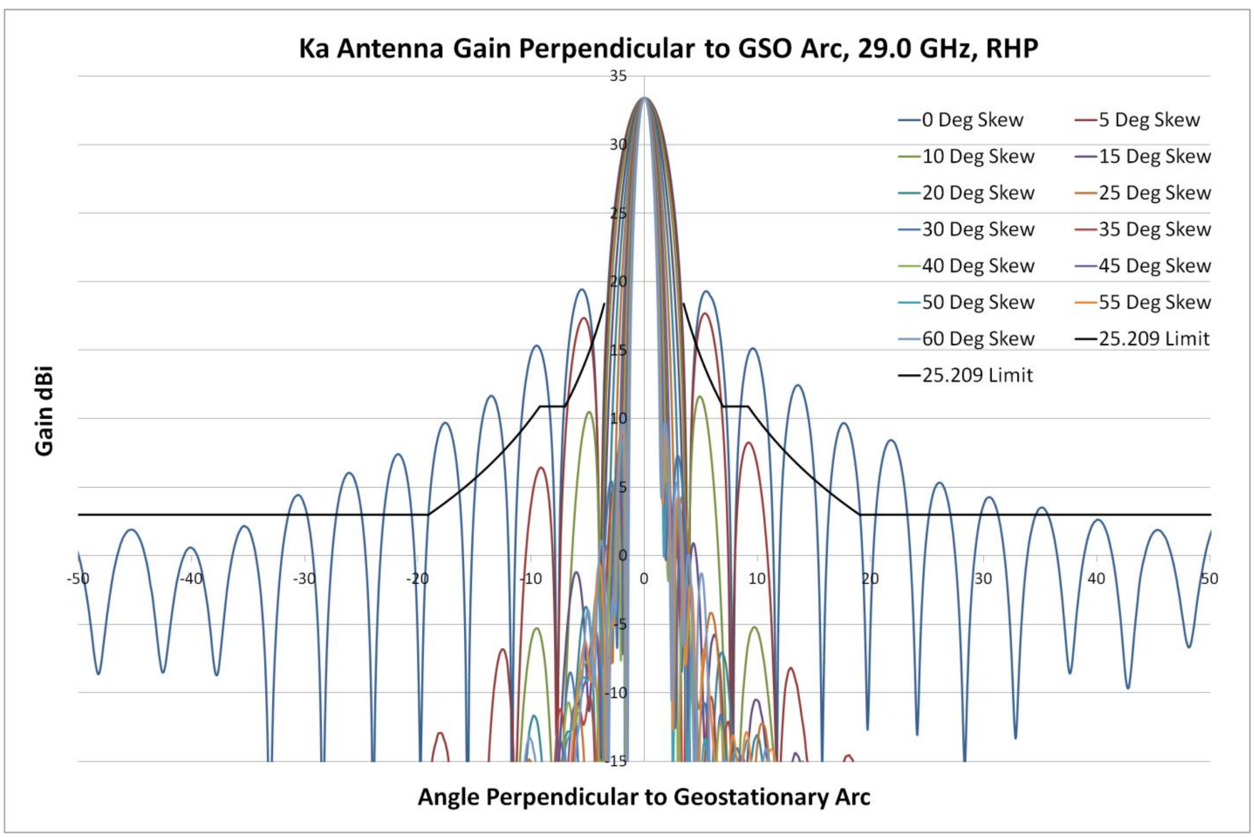


Figure 42 – Ka Antenna Gain Perpendicular to GSO Arc, 29.0 GHz, RHP, -50 to +50 degrees, 25.209(a)(6) limits

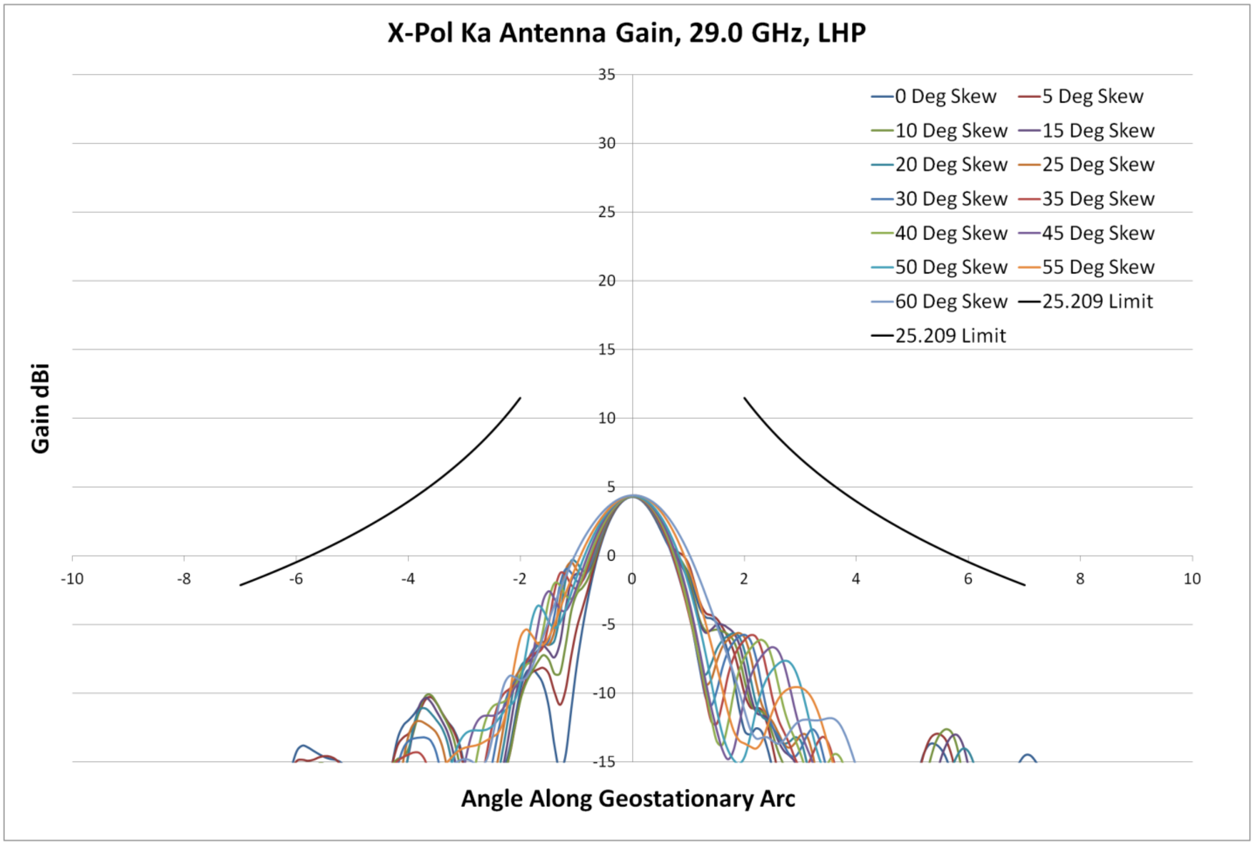


Figure 43 – X-Pol Ka Antenna Gain Along GSO Arc, 29.0 GHz, LHP, -10 to +10 degrees, 25.209(b)(3) limits

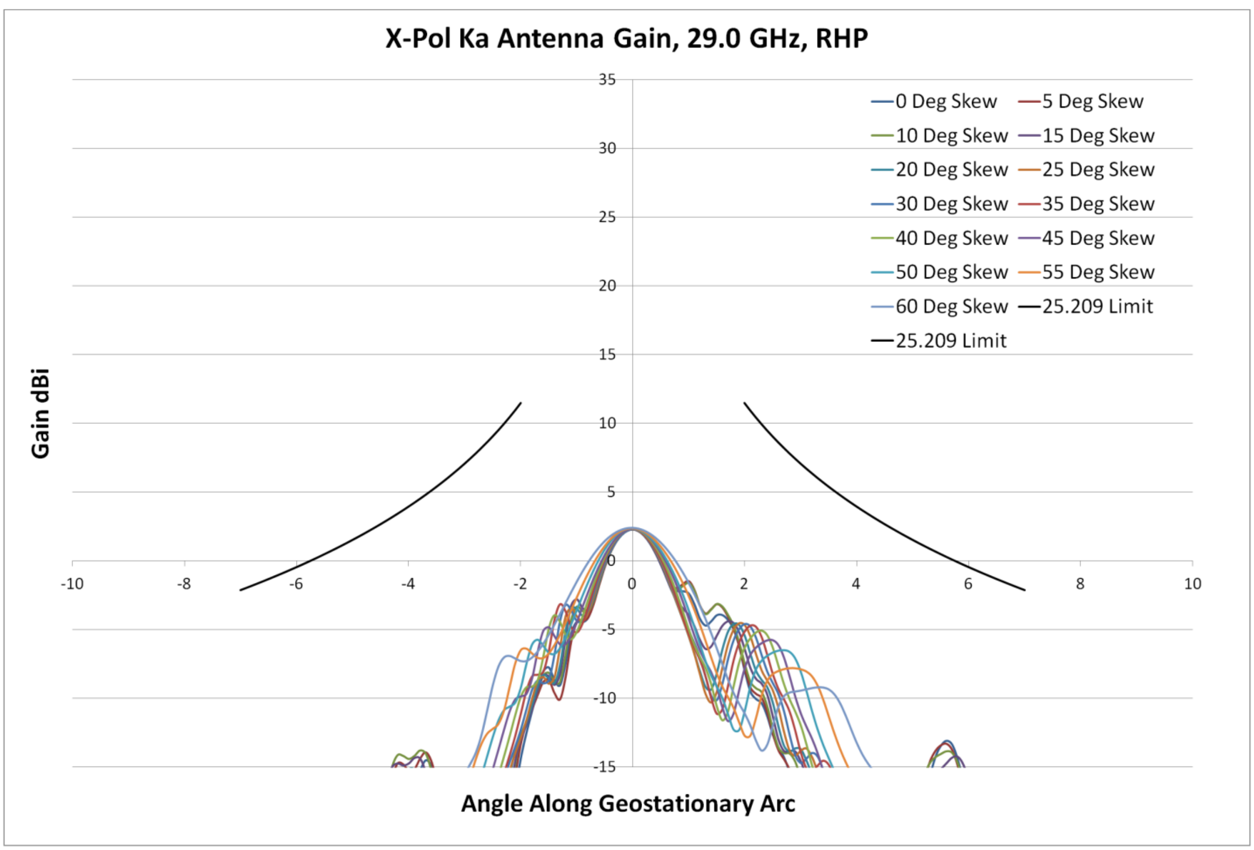


Figure 44 – X-Pol Ka Antenna Gain Along GSO Arc, 29.0 GHz, RHP, -10 to +10 degrees, 25.209(b)(3) limits

Attachment 5

Sample Link Budget

The following pages provide a sample link budget using satellite (97.1 degrees WL) Echostar 19 / Jupiter 2's U 068 beam*, for an aircraft located in Washington DC.

(* The associated Hughes Gateway being located in San Diego)

Ka Antenna Link Budget

Inroute Signal:	QPSK 1/2
Uplink Frequency (MHz):	29500
Downlink Frequency (MHz):	20200
Baseband BW (MHz):	1.024
Spread BW (MHz):	1.024
Required C/N (dB):	3.5
Outroute Signal:	QPSK 1/2
Uplink Frequency (MHz):	29500
Downlink Frequency (MHz):	20200
Bandwidth (MHz):	30
Required C/N (dB):	2.1
Satellite:	Jupiter 2
Longitude (deg East):	-97
Maximum Saturated Downlink EIRP (dBW):	50
G/T towards Remote (dB/K):	6.00
G/T towards NOC (dB/K):	6.00
G/T Degradation (dB):	0
Saturation Flux Density (dBW/m^2):	-87
Attenuation Setting (dB):	8
Saturated EIRP towards NOC (dBW):	50
Saturated EIRP towards Remote (dBW):	50
Max Authorized Downlink EIRP (dBw/Hz):	-20
Downlink EIRP backoff (dB):	**unnecessary**
Adjusted Outroute EIRP to Remote (dBW):	**50.00**
Downlink EIRP Density to Remote (dBW/Hz):	**-24.77**
Downlink EIRP Inroute (dBW):	**16.67**
Remote:	Dulles
Latitude (deg North):	38.953
Longitude (deg East):	-77.448
TX Antenna Gain (dBi):	33.70
TX Power (dBm):	44
TX Backoff (dB):	0
Power into flange w losses (dBW/MHz):	**12.90**
Unimpaired EIRP Density (dBW/MHz)	**46.10**
RX G/T (dB/K):	13.50
Antenna Mispoint (dB):	0.5
Rain Attenuation (dB):	0
Atmospheric Attenuation (dB):	0.5

Link Budget for satellite Jupiter 2 at -97.0 degrees

Skew operational limit: 25 degrees

Inroute signal:	**QPSK 1/2**	rate	**1.024**	**Msps**	in bandwidth	**1.024**	**MHz**
Outroute signal:	**QPSK 1/2**	rate	**30**	**Msps**	in bandwidth	**30**	**MHz**

		Lat	Long
Remote:	Dulles	38.953	-77.448
NOC:	San Diego	32.896	-117.202

Inroute Path:	**Ideal Link**	**Mispoint/ Rain/ Atmospheric Losses**	**Intermod/ Satellite/ Cross-pol Interference**
EIRP towards satellite (dBW)	46.20	45.20	45.20
Uplink Path Loss (dB)	213.40	213.40	213.40
Spreading Loss (dB)	-162.53	-162.53	-162.53
Flux Density at Satellite (dBW/m^2)	-116.33	-117.33	-117.33
Uplink C/T (dB)	-161.20	-162.20	-162.20
C/No (dB)	67.40	66.40	66.40
Noise BW (dB-Hz)	60.10	60.10	60.10
Interference (dB)	N/A	N/A	-14.87
Uplink C/N (dB)	**7.30**	**6.30**	**5.73**
Satellite downlink EIRP (dBW)	18.67	16.67	16.67
Downlink Path Loss (dB)	210.02	210.02	210.02
Downlink C/T (dB)	-155.85	-157.85	-157.85
C/No (dB)	72.75	70.75	70.75
Noise BW (dB-Hz)	60.10	60.10	60.10
Interference (dB)	N/A	N/A	-18.19
Downlink C/N (dB)	**12.65**	**10.65**	**9.94**
Cumulative C/N (dB)	6.19	4.94	4.34
Necessary C/N (dB)	3.50	3.50	3.50
Cumulative Inroute Link Margin (dB)	**2.69**	**1.44**	**0.84**

Ka Antenna Link Budget

Link Budget for satellite Jupiter 2 at -97.0 degrees

Skew operational limit: 25 degrees

Inroute Uplink Interference

Adjacent Channel Uplink (dB):	-30.0
Adjacent Satellite Uplink (dB):	-19.7
Cross-Pol Uplink (dB):	-19.7
Intermod Uplink (dB):	-20.0
Cumulative Interf. Uplink (dB):	**-14.87**

Outroute Downlink Interference

Adjacent Channel Downlink (dB):	-30.0
Adjacent Satellite Downlink (dB):	-10.0
Cross-Pol Downlink (dB):	-20.0
Intermod Downlink (dB):	-20.0
Cumulative Interf. Downlink (dB):	**-9.17**

NOC:	San Diego
Latitude (deg North):	32.896
Longitude (deg East):	-117.202
Antennna diameter (m):	5.8 m
RX Antenna Gain (dBi):	53
Antenna Noise Temp (K):	56
Antenna LNA Temp (K):	70
Total Noise Temp (K):	126
Antenna G/T (dB/K):	35.50
TX Antenna Gain (dBi):	56.5
Conducted TX Power to Antenna (dBW):	**20.94**
TX backoff (dB):	**unnecessary**
Power into flange (dBW/ MHz):	**6.17**
Antenna mis-point (dB):	0.5
Rain Attenuation (dB):	0
Atmospheric Attenuation (dB):	0.5

Inroute Downlink Interference

Adjacent Channel Downlink (dB):	-30.0
Adjacent Satellite Downlink (dB):	-25.0
Cross-Pol Downlink (dB):	-20.0
Intermod Downlink (dB):	-30.0
Cumulative Interf. Downlink (dB):	**-18.19**

Outroute Uplink Interference

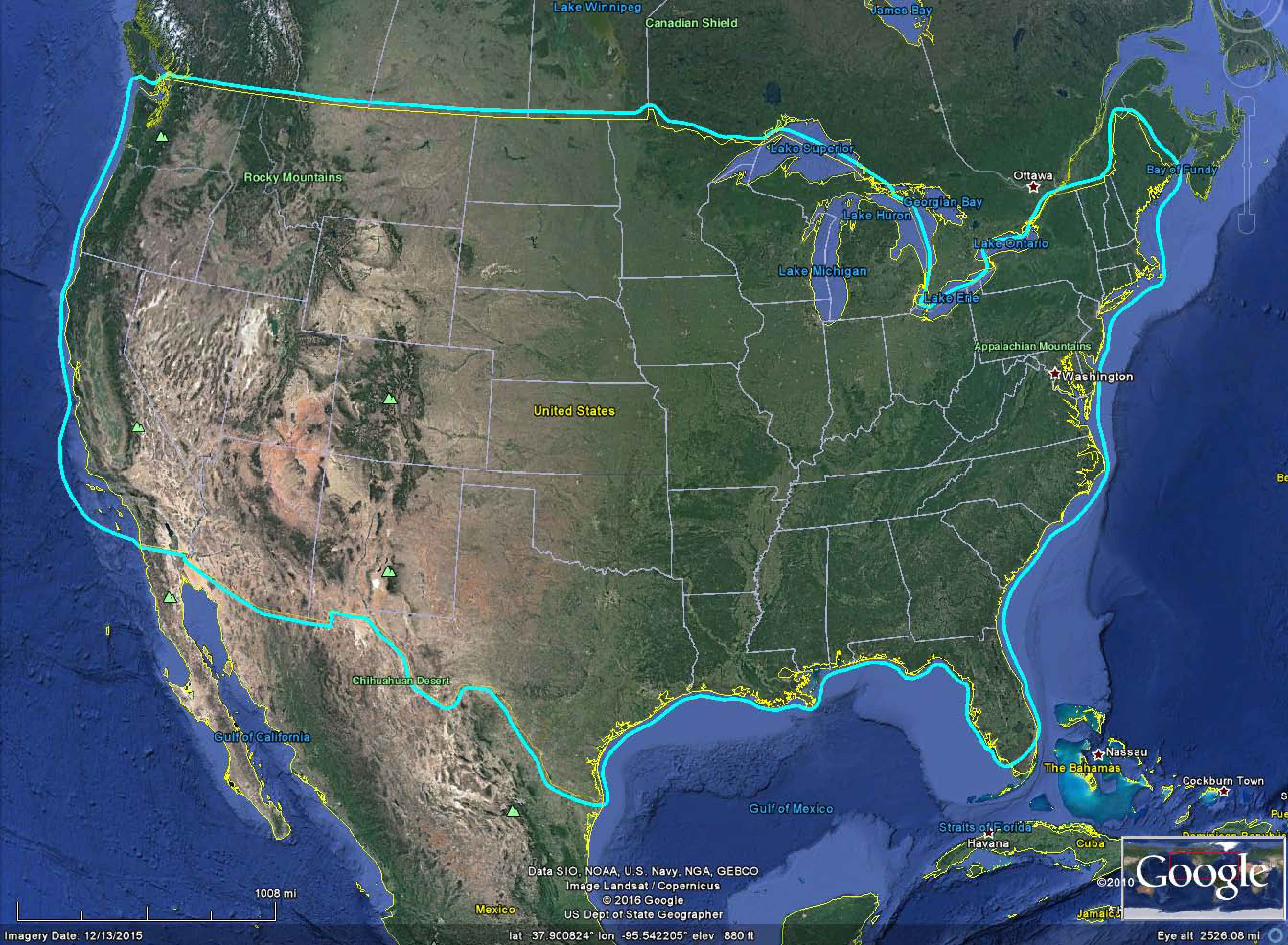
Adjacent Channel Uplink (dB):	-30.0
Adjacent Satellite Uplink (dB):	-30.0
Cross-Pol Uplink (dB):	-20.0
Intermod Uplink (dB):	-30.0
Cumulative Interf. Uplink (dB):	**-18.86**

Outroute Path:	**Ideal Link**	**Mispoint/ Rain/ Atmospheric Losses**	**Intermod/ Satellite/ Cross-pol Interference**
EIRP towards satellite (dBW)	77.44	76.44	76.44
Uplink Path Loss (dB)	213.31	213.31	213.31
Spreading Loss (dB)	-162.44	-162.44	-162.44
Flux Density at Satellite (dBW/m^2)	-85.00	-86.00	-86.00
Uplink C/T (dB)	-129.87	-130.87	-130.87
C/No (dB)	98.73	97.73	97.73
Noise BW (dB-Hz)	74.77	74.77	74.77
Interference (dB)	N/A	N/A	-18.86
Uplink C/N (dB)	**23.96**	**22.96**	**17.43**
Satellite downlink EIRP (dBW)	50.00	49.00	49.00
Downlink Path Loss (dB)	210.11	210.11	210.11
Downlink C/T (dB)	-146.61	-148.61	-148.61
C/No (dB)	7.22	5.22	5.22
Noise BW (dB-Hz)	74.77	74.77	74.77
Interference (dB)	N/A	N/A	-9.17
Downlink C/N (dB)	**7.22**	**5.22**	**3.75**
Cumulative C/N (dB)	7.13	5.15	3.57
Necessary C/N (dB)	2.1	2.1	2.1
Cumulative Outroute Link Margin (dB)	**5.03**	**3.05**	**1.47**

Attachment 6

Echostar 19 / Jupiter 2 Coverage Area Depiction

The following page provides a depiction of the CONUS Echostar 19 / Jupiter 2 coverage area applicable to the Row 44 Ka Antenna.


Lake Winnipeg
James Bay
Canadian Shield
Lake Superior
Ottawa
Bay of Fundy
Rocky Mountains
Georgian Bay
Lake Huron
Lake Ontario
Lake Michigan
Lake Erie
Appalachian Mountains
Washington
United States
Chihuahuan Desert
Gulf of California
Nassau
The Bahamas
Cockburn Town
Gulf of Mexico
Straits of Florida
Havana
Cuba
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
© 2016 Google
US Dept of State Geographer
1008 mi
Mexico
Google
©2010
Imagery Date: 12/13/2015
lat 37.900824° lon -95.542205° elev 880 ft
Eye alt 2526.08 mi

Attachment 7

Echostar 19 / Jupiter 2 Gateway Call Locations and Signs

Row 44 proposes to communicate using the existing gateway earth stations set forth in the chart below, all of which are currently licensed to HNS License Sub, LLC (Hughes) by the International Bureau, under the call signs listed.

Call Sign	Location
E150076	Gilbert AZ
E150077	Cheyenne WY
E150078	Duluth MN
E150079	Roseburg OR
E150080	North Platte NE
E150081	Seattle WA
E150082	Bismarck ND
E150083	Amarillo TX
E150084	Albuquerque NM
E150085	Bellevue NE
E150086	Lindon UT
E150087	Santa Clara CA
E150088	San Diego CA
E150089	North Las Vegas NV
E150090	Boise ID
E150091	Missoula MT
E150092	Billings MT

Attachment 8
Radiation Hazard Analysis – Ka Antenna

Introduction

This exhibit constitutes the Radiation Hazard Analysis for Row 44's Ka transmitter considering the FCC procedure outlined in FCC Bulletin #65. The limit for exposure to RF energy, (frequencies greater than 1.5 GHz), is 5 mW/cm^2 up to a 6 minute duration (categorized as Occupational / 'Controlled Exposure'), and 1 mW/cm^2 up to a 30 minute duration (categorized as General Population / 'Uncontrolled Exposure').[1]

Analysis regarding radiation exposure is presented considering behavior in the Near Field, Far Field and Transition 'regions'. Appropriate separation-distances are provided for the 'Controlled' and 'Uncontrolled Exposure' scenarios, considering individuals located in the direction of either the antenna's main beam or its side-lobes.

Analysis

The extent of the Near Field region in the main beam is defined as distances out to a radius R_{nf} according to the relation

$$R_{nf} = D^2/4\lambda$$

where D is the antenna panel width and λ is the transmit wavelength.

The Near Field maximum Power Density, S_{nf}, is determined from

$$S_{nf} = 0.1\eta\ P_{PA}/A \text{ (in mW/cm}^2\text{)}$$

where P_{PA} is the transmit power (after cable losses), A is the surface area of the antenna aperture, and η the efficiency of the antenna aperture. (With an antenna height h, the surface area A = Dh.)

The Far Field region for the main beam is defined as beginning and continuing out-from a radius R_{ff}, given by

$$R_{ff} = 0.60\ D^2/\lambda$$

[1] "Questions and Answers about Biological Effects and Potential Hazards of Radiofrequency Electromagnetic Fields," Federal Communications Commission, Office of Engineering and Technology, Bulletin 65, Fourth Edition, August, 1999, p.15.
http://www.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet56/oet56e4.pdf

The Far Field Power Density S_{ff} at the Far Field radius and farther is determined (in terms of the EIRP, denoted by P_{EIRP}) from

$$S_{ff} = P_{EIRP}/4\pi R_{ff}^2 \text{ (in mW/cm}^2\text{)}$$

(The value of P_{EIRP} should already consider coax losses and aperture efficiency.)

Note that when the radius is expressed in meters, the Power Density is in units of W/m^2. The results are converted to units consistent with the FCC limits (mW/cm^2) by multiplying values in W/m^2 by 0.1.

Exposure from the Main Antenna Beam

Row 44's antenna has dimensions D = 0.617 m, h = 0.161 m, and a surface area A = 0.099 m^2. At the highest transmit frequency of 30.0 GHz, the wavelength is 0.010 m. The Near Field radius is then

R_{nf} = 9.52 m

The antenna aperture efficiency factor is 0.64 and the total added losses are 6.80 dB.

Based on the wavelength and panel-width given farther above, the Far Field radius is then

R_{ff} = 22.84 m

In the operation of Row 44's system, the antenna may be driven with various TX signal levels, as regulatorily-authorized, based on the prevailing value of antenna skew. Starting from the Ka maximum TX power of 44 dBm, and working-down in 0.5 dB increments, Tables 1 provides the associated Near Field radius Power Density values:

Table 1 Transmit Power and Near Field Power Density at Distance Rnf

Transmit power (dBm)	EIRP (dBW)	S_{nf} (mW/cm^2)
44	46.2	11.495
43.5	45.7	10.245
43	45.2	9.130
42.5	44.7	8.138
42	44.2	7.253
41.5	43.7	6.464
41	43.2	5.761
40.5	42.7	5.134
40	42.2	4.576
39.5	41.7	4.078
39	41.2	3.635
38.5	40.7	3.240
38	40.2	2.887
37.5	39.7	2.573
37	39.2	2.293
36.5	38.7	2.044
36	38.2	1.822

35.5	37.7	1.624
35	37.2	1.447
34.5	36.7	1.290
34	36.2	1.149
33.5	35.7	1.024

(Note that the equation for the maximum Power Density in the Near Field considers a given radiated signal/ power confined-to and passing-through a physical area corresponding to that of the antenna aperture. Along these lines, the Snf values cannot be assumed to vary with distance from the antenna, for locations within the Near Field.)

The associated Far Field radius Power Density values are provided in Table 2:

Table 2 Transmit Power, EIRP and Far Field Power Density at Distance Rff

Transmit power (dBm)	EIRP (dBW)	S_{ff} (mW/cm^2)
44	46.2	0.6358
43.5	45.7	0.5667
43	45.2	0.5051
42.5	44.7	0.4501
42	44.2	0.4012
41.5	43.7	0.3576
41	43.2	0.3187
40.5	42.7	0.2840
40	42.2	0.2531
39.5	41.7	0.2256
39	41.2	0.2011
38.5	40.7	0.1792
38	40.2	0.1597
37.5	39.7	0.1423
37	39.2	0.1269
36.5	38.7	0.1131
36	38.2	0.1008
35.5	37.7	0.0898
35	37.2	0.0800
34.5	36.7	0.0713
34	36.2	0.0636
33.5	35.7	0.0567

We are considering exposure to two values of Power Density: 5 mW/cm^2 and 1 mW/cm^2.

<u>5 mW/cm^2 Analysis</u>

Some of the Snf values in Table 1 are greater than 5 mW/cm^2, and some are less than 5 mW/cm^2. As the Near Field analysis assumes that the Power Density in the Near Field does not vary with distance, for cases where Snf exceeds 5 mW/cm^2, there is no location in the Near Field where the Power Density is less. An individual therefore cannot be located in the Near Field anywhere whatsoever at all to avoid such an exposure level.

Assuming that the Power Density decreases linearly between the Near Field radius and the Far Field radius, the distances at which the Power Density will equal 5 mW/cm^2 are given in Table 3. For cases where the 'apparent' distance where 5 mW/cm^2 is encountered would be closer than Rnf, the value of Rnf itself is adopted as a precautionary measure.

Table 3 Separation for 'Controlled Exposure' Limit (Main Beam)

Transmit power (dBm)	Separation for 'Controlled' Limit (5 mW/cm^2)	
	meters	feet
44	17.49	57.37
43.5	16.74	54.91
43	15.90	52.16
42.5	14.96	49.07
42	13.90	45.60
41.5	12.71	41.70
41	11.38	37.34
40.5	9.89	32.44
40	9.52	31.22
39.5	9.52	31.22
39	9.52	31.22
38.5	9.52	31.22
38	9.52	31.22
37.5	9.52	31.22
37	9.52	31.22
36.5	9.52	31.22
36	9.52	31.22
35.5	9.52	31.22
35	9.52	31.22
34.5	9.52	31.22
34	9.52	31.22
33.5	9.52	31.22

1 mW/cm^2 Analysis

As the Snf values are each greater than 1 mW/cm^2, we need consider distances greater than Rnf where the 1 mW/cm^2 will be encountered:

The EIRP and the resulting Far Field Power Density at distance Rff are once again provided in Table 4 for each transmit power value:

Table 4 Transmit Power, EIRP and Far Field Power Density at Distance Rff

Transmit power (dBm)	EIRP (dBW)	S_{ff} (mW/cm^2)
44	46.2	0.6358
43.5	45.7	0.5667
43	45.2	0.5051
42.5	44.7	0.4501
42	44.2	0.4012
41.5	43.7	0.3576
41	43.2	0.3187
40.5	42.7	0.2840
40	42.2	0.2531
39.5	41.7	0.2256
39	41.2	0.2011
38.5	40.7	0.1792
38	40.2	0.1597
37.5	39.7	0.1423
37	39.2	0.1269

36.5	38.7	0.1131
36	38.2	0.1008
35.5	37.7	0.0898
35	37.2	0.0800
34.5	36.7	0.0713
34	36.2	0.0636
33.5	35.7	0.0567

Notice that no Sff values exceed 1 mW/cm$^{2.}$ For all the TX levels, we therefore need interpolate the Power Density values between Rnf and Rff to project the location at which 1 mW/cm^2 exists.

Assuming that the Power Density decreases linearly between the Near Field radius and the Far Field radius, the distances at which the Power Density equals 1 mW/cm^2 are projected according to Table 5.

Table 5 Separation for 'Uncontrolled Exposure' Limit (Main Beam)

Transmit power (dBm)	Separation for 'Uncontrolled' Limit (1 mW/cm^2)	
	meters	feet
44	22.39	73.47
43.5	22.24	72.98
43	22.08	72.43
42.5	21.89	71.81
42	21.68	71.12
41.5	21.44	70.34
41	21.17	69.47
40.5	20.87	68.49
40	20.54	67.39
39.5	20.16	66.15
39	19.74	64.77
38.5	19.27	63.21
38	18.74	61.47
37.5	18.14	59.52
37	17.47	57.32
36.5	16.72	54.86
36	15.88	52.10
35.5	14.93	49.00
35	13.87	45.52
34.5	12.69	41.62
34	11.35	37.24
33.5	9.85	32.33

Exposure from Antenna Beam Side-Lobes

The previous calculations assumed the individual was located in the 'sight' of the main antenna beam. (The 'widest' portion of the main antenna beam, i.e., in the elevation plane, is approximately 3.4 degrees.) The following analysis provides insight into the exposure when an individual is located to-the-side or behind the antenna.

Table 6 provides Power Density values at distances R_{nf} and R_{ff} when an individual is located in the direction of the highest-possible antenna side-lobe (which corresponds to a 20 dB gain reduction from the main beam).

Table 6 TX Power, Sidelobe Attenuation, and Power Density at Rnf and Rff

Tx power (dBm)	Sidelobe (dB)	S_{nf} (mW/cm^2)	S_{ff} (mW/cm^2)
44	-20	0.1149	0.0064
43.5	-20	0.1024	0.0057
43	-20	0.0913	0.0051
42.5	-20	0.0814	0.0045
42	-20	0.0725	0.0040
41.5	-20	0.0646	0.0036
41	-20	0.0576	0.0032
40.5	-20	0.0513	0.0028
40	-20	0.0458	0.0025
39.5	-20	0.0408	0.0023
39	-20	0.0363	0.0020
38.5	-20	0.0324	0.0018
38	-20	0.0289	0.0016
37.5	-20	0.0257	0.0014
37	-20	0.0229	0.0013
36.5	-20	0.0204	0.0011
36	-20	0.0182	0.0010
35.5	-20	0.0162	0.0009
35	-20	0.0145	0.0008
34.5	-20	0.0129	0.0007
34	-20	0.0115	0.0006
33.5	-20	0.0102	0.0006

As is obvious, neither the Snf or Sff values (at distances Rnf and Rff) exceed even the 'Uncontrolled' Limit of 1 mW/cm^2. Therefore, no minimum distance of separation will apply for individuals located in directions outside the antenna's main beam.

Summary

This document presents the radiation hazard analysis for Row 44's transmitter transmitting at various EIRP values between 46.2 and 35.7 dBW. Considering the worst-case (46.2 dBW), individuals positioned in the direction of the main beam of the antenna, and in a 'Controlled Exposure' environment should be at least 17.49 meters (57.37 feet) away from the antenna aperture (for a 6 minute duration). Under the same circumstances, individuals in an 'Uncontrolled Exposure' environment should be at least 22.39 meters (73.47 feet) away from the antenna aperture (for a 30 minute duration).

For individuals located in directions which are outside the antenna's main beam, no minimum distance of separation is applicable.