Attachment A

TECHNICAL ANNEX

A.1 Scope and Purpose

The purpose of this Attachment is to provide the Commission with the salient technical characteristics of the Inmarsat-5 F2 satellite, as required by 47 C.F.R. §25.114 and other sections of the FCC's Part 25 rules, that cannot be captured by the Schedule S software.

A.2 General Description of Overall System Facilities, Operations and Services (§25.114(d)(1))

The Inmarsat-5 F2 satellite will operate at the nominal 55° W.L. orbital location and will provide fixed-satellite service ("FSS") to earth stations in North, Central and South America, including the Caribbean, Europe, West Africa, the Atlantic Ocean region, and a portion of the Pacific Ocean region (see coverage diagram in Figure A.2.2). The satellite will operate in the 27.5-30.0 GHz band (Earth-to-space) and 17.7-20.2 GHz band (space-to-Earth). The satellite network will employ two large gateway antennas and will provide service to widely-deployed, small user antennas.

The gateway antennas will be capable of communicating with the spacecraft throughout the 27.5-30.0 GHz and 17.7-20.2 GHz bands. One gateway antenna will be located in Lino Lakes, Minnesota (the "Lino Lakes Gateway"). The other gateway antenna will be located sufficiently far from the Lino Lakes Gateway so that gateway diversity can be effective.

The Inmarsat-5 F2 satellite will have two identical steerable spot beams that will be pointed at the same location on earth, effectively forming one single beam, and that will be used by the gateway antennas ("Gateway Beam"). The currently planned coverage of the Gateway Beams is shown in Figure A.2.1 below.

User antennas will operate in the 29.0-30.0 GHz and 19.2-20.2 GHz bands. The satellite will have 89 contiguous, fixed spot beams that will be used principally by the user antennas ("Global Payload Beams" or "GP Spot Beams"). A representative depiction of the coverage of these beams is depicted in Figure A.2.2. A sample Global Payload Beam coverage pattern is shown in Figure A.2.3. The satellite also includes six steerable spot beams ("High Capacity Spot

Beams" or "HCP Spot Beams") that will be used principally by user antennas and will contain greater capacity than the Global Payload Spot Beams. These beams can be pointed at any visible location on the Earth's surface. An example of a High Capacity Spot Beam coverage pattern is shown in Figure A.2.4 below.

Figure A.2.1. Planned Coverage Pattern of Gateway Beam

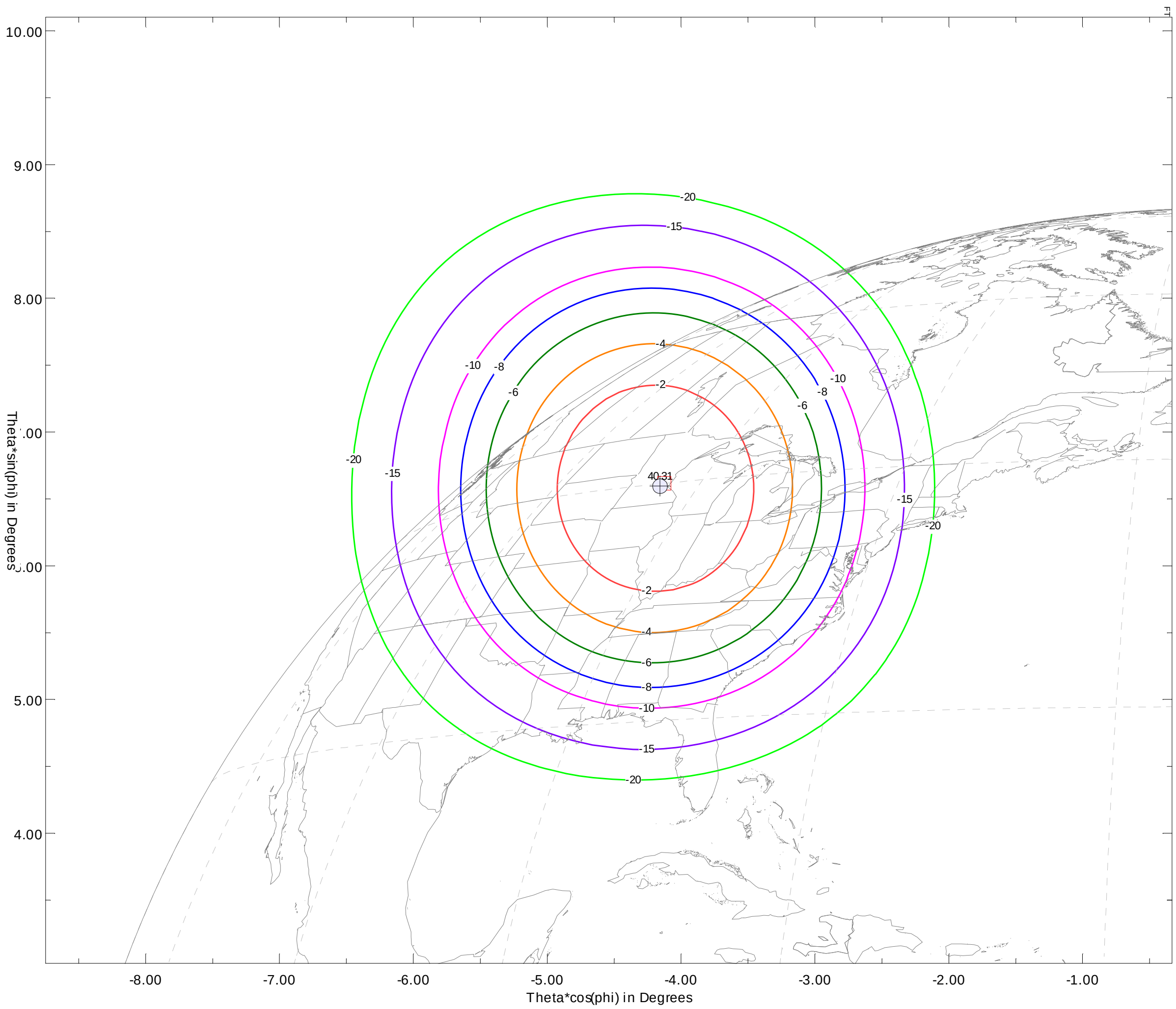


Figure A.2.2. Representative Global Payload Spot Beam Coverage

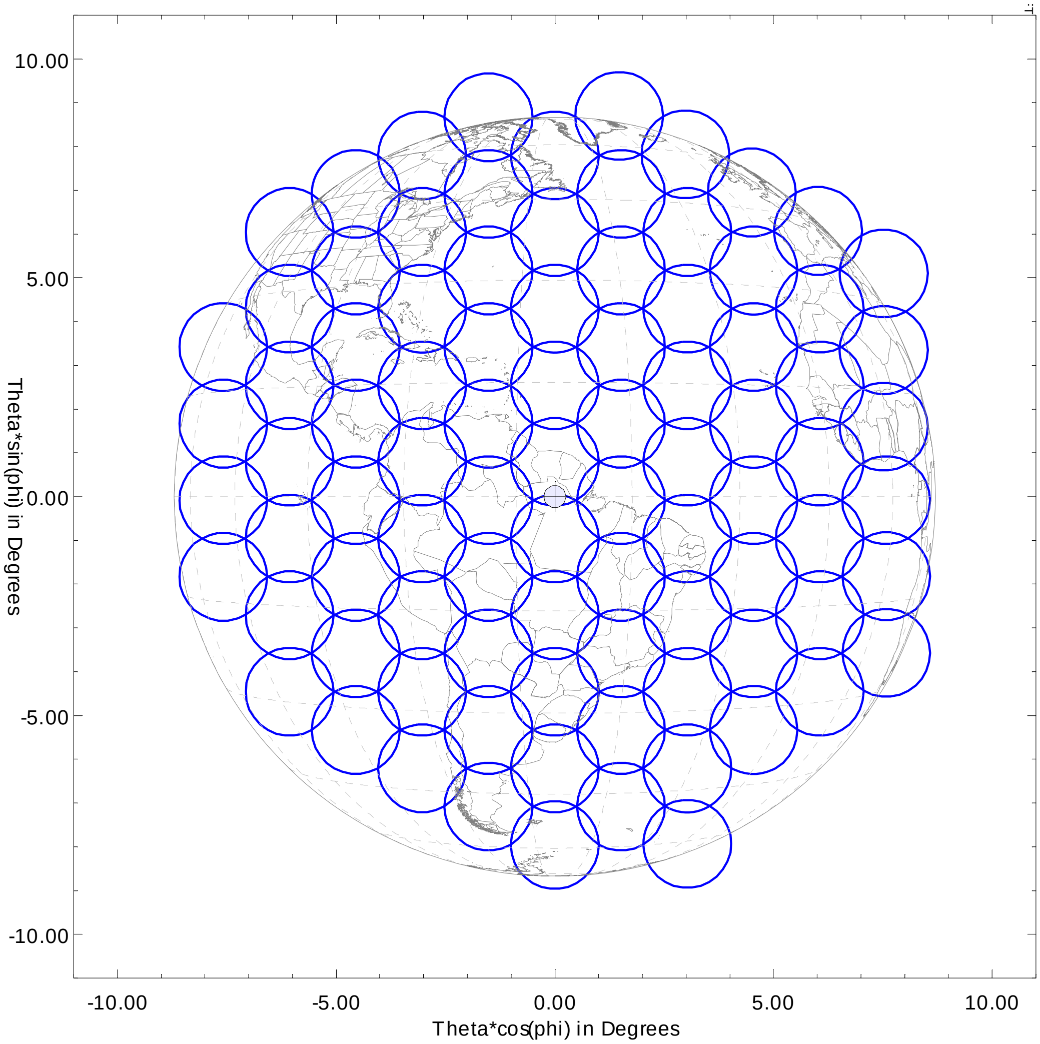


Figure A.2.3. Sample Global Payload Spot Beam Coverage Pattern

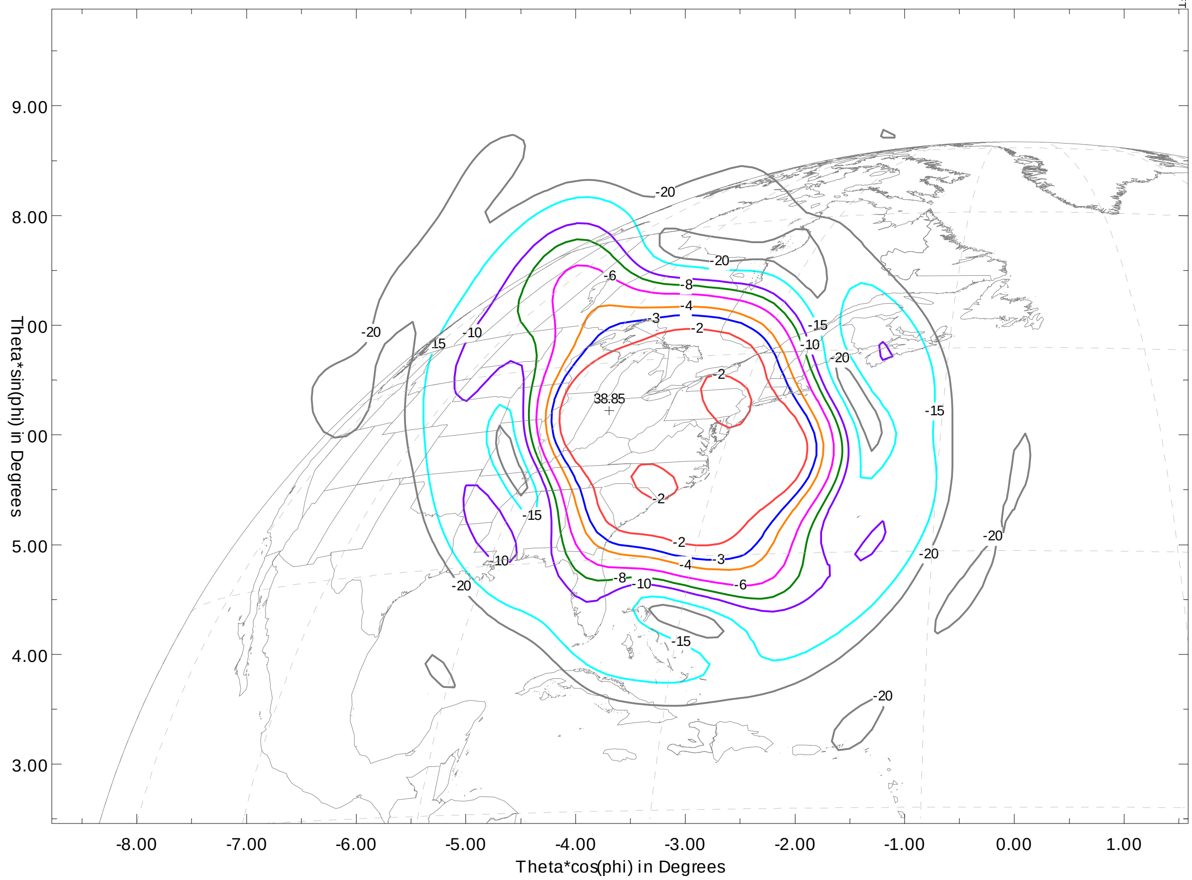
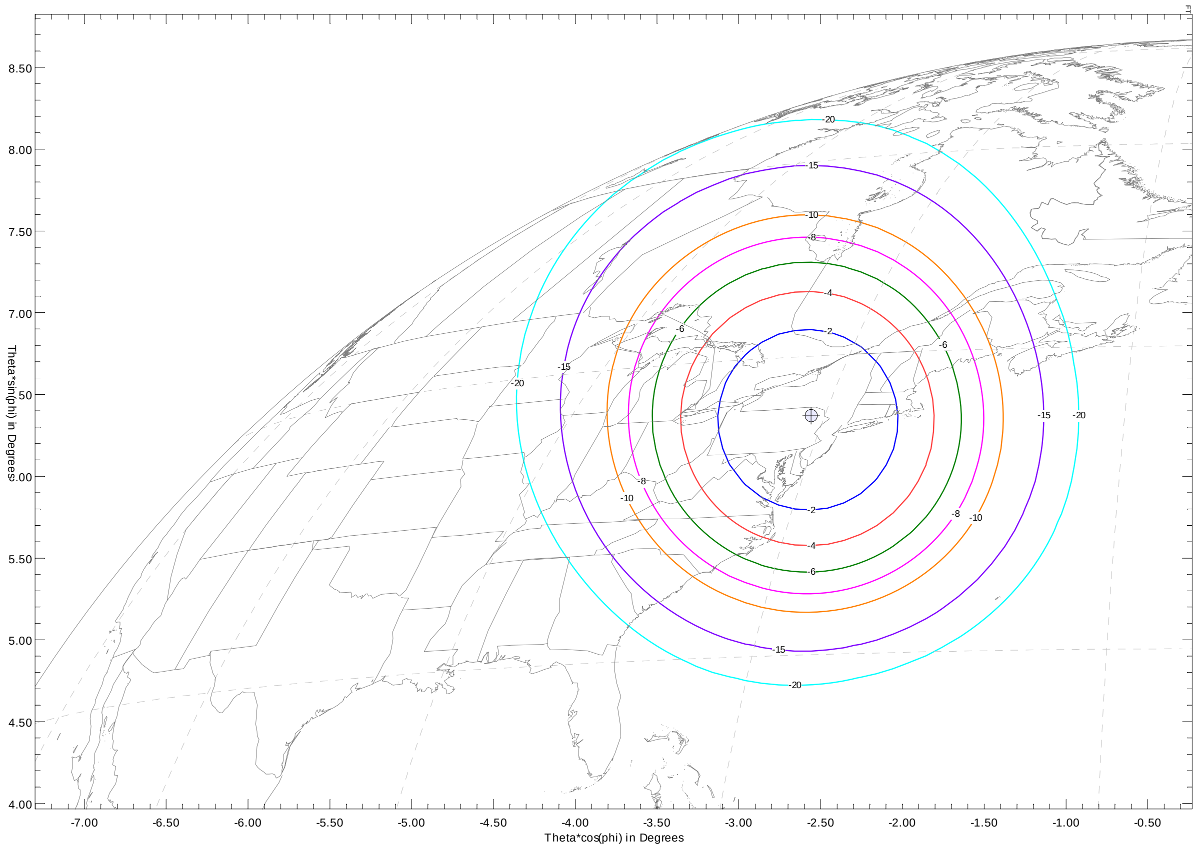


Figure A.2.4. Sample High Capacity Spot Beam Coverage Pattern



In addition to the beams described above, the Inmarsat-5 F2 satellite carries a global ("Earth Coverage" or "EC") beam intended for signaling carriers within a relatively small frequency segment (see Section A.4 below). On-station TT&C transmissions will occur in the Ka-band frequencies listed in Section A.7 below and will be provided by the Lino Lakes Gateway.

The spacecraft also will be capable of using C-band frequencies at 4199.0 MHz, 4199.5 MHz, 5926.2 MHz and 6422.5 MHz for TT&C during transfer orbit and for emergency purposes. Certain of the beams described above will be switchable to also enable communications in portions of the 20.2-21.2 GHz and 30.0-31.0 GHz bands, which are not allocated for commercial service in the United States. Authority to serve the United States using the frequency segments described in this paragraph is not being requested in this application.

A.3 Predicted Space Station Antenna Gain Contours (§25.114(d)(3))

The Inmarsat-5 F2 satellite antenna gain contours for the receive and transmit beams, as required by §25.114(d)(3), are given in GXT format. Because the Schedule S software would not accept the uploading of the large number of GXT files, all GXT files of the above beams (transmit and receive) are being provided to the Commission as a separate data package.

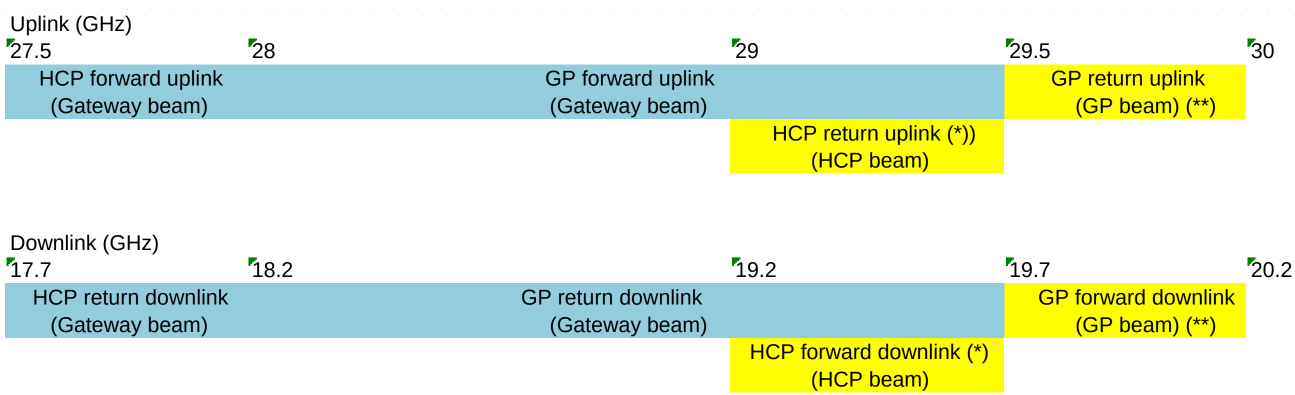
For the two steerable Gateway Beams and the six steerable HCP Spot Beams, the GXT files provide gain contours for representative beam pointing directions, although the beams may be independently steered to any point on the visible Earth.

A.4 Frequency and Polarization Plan (§25.114(c)(4)(i))

Details of the satellite's frequency plan for which authority is sought are given in the associated Schedule S submission. For additional clarification these frequency plans are shown diagrammatically in Figures A.4.1 to A.4.3 below for forward (gateway-to-end user) and return (end user-to-gateway) links.

Figure A.4.1 shows the portions of the 27.5-30.0 GHz and 17.7-20.2 GHz bands that can be employed in the Gateway Beams, the GP Spot Beams, and the HCP Spot Beams, with the spectrum used in the Gateway Beams shown in blue and the spectrum used by the GP Spot Beams and the HCP Spot Beams shown in yellow.

Figure A.4.1. Inmarsat-5 F2 Frequency Plan



(*) The HCP Spot Beams will be operated with sufficient geographical isolation from the Gateway Beams to avoid intra-system interference.
(**) The gateway terminals will be capable of using the GP beams as well as the Gateway Beams.

The Gateway Beams operate in Right Hand Circular Polarization (RHCP) and Left Hand Circular Polarization (LHCP) on both uplink and downlink. The GP Spot Beams operate in RHCP on the uplink and LHCP on the downlink. The HCP Spot Beams operate in Right Hand Circular Polarization (RHCP) and Left Hand Circular Polarization (LHCP) on both uplink and downlink.

Consistent with Section 25.210(d), the Gateway Beams employ state-of-the-art full frequency re-use in their coverage area by means of dual orthogonal polarization. The GP Spot Beams employ an average six-fold frequency re-use by spatial separation of co-frequency beams while the HCP Spot Beams reuse spectrum on a co-frequency basis based on spatial separation between co-frequency HCP Spot Beams as well as between the HCP Spot Beams and the Gateway Beams.

In the GP Spot Beams, 72 channels are available in the forward link direction and 72 are available in the return link direction, each with 40 MHz spacing and 32 MHz useful bandwidth. These 72 channels in each direction are allocated among the 89 GP Spot Beams, with two channels available in certain beams. The possible channel to beam allocation configurations in the GP Spot Beams are as shown below.

	Number of available channels	Number of GP Spot Beams	Number of channels per GP Spot Beam
	48 channels	48 beams	1 channel (fixed)/beam
	24 channels	12 beams	1 or 2 channels/beam
		29 beams	Up to 1 channel/beam
Total	72 channels	89 beams	

In the HCP Spot Beams, 8 channels are available in the forward link direction and 8 are available in the return link direction at any given time, each with 125 MHz spacing and 100 MHz of useful bandwidth. These 8 channels in each direction are allocated among the 6 HCP Spot Beams with the maximum number of channels per beam varying between two and four. The possible channel to beam allocation configurations in the HCP Spot Beams are as shown below.

Channel #	HCP Spot Beam #

	1A	5 or 3
	2A	1 or 6
	3A (3B)	4 (5)
	4A (4B)	2 (6)
	5A	4
	6A	2
	7A	3 or 5
	8A	1 or 5
Total	8 channels	6 beams

Note:
In the return link; A = RHCP up / LHCP down, B = LHCP up / RHCP down
In the forward link; A = LHCP up / RHCP down, B = RHCP up / LHCP down

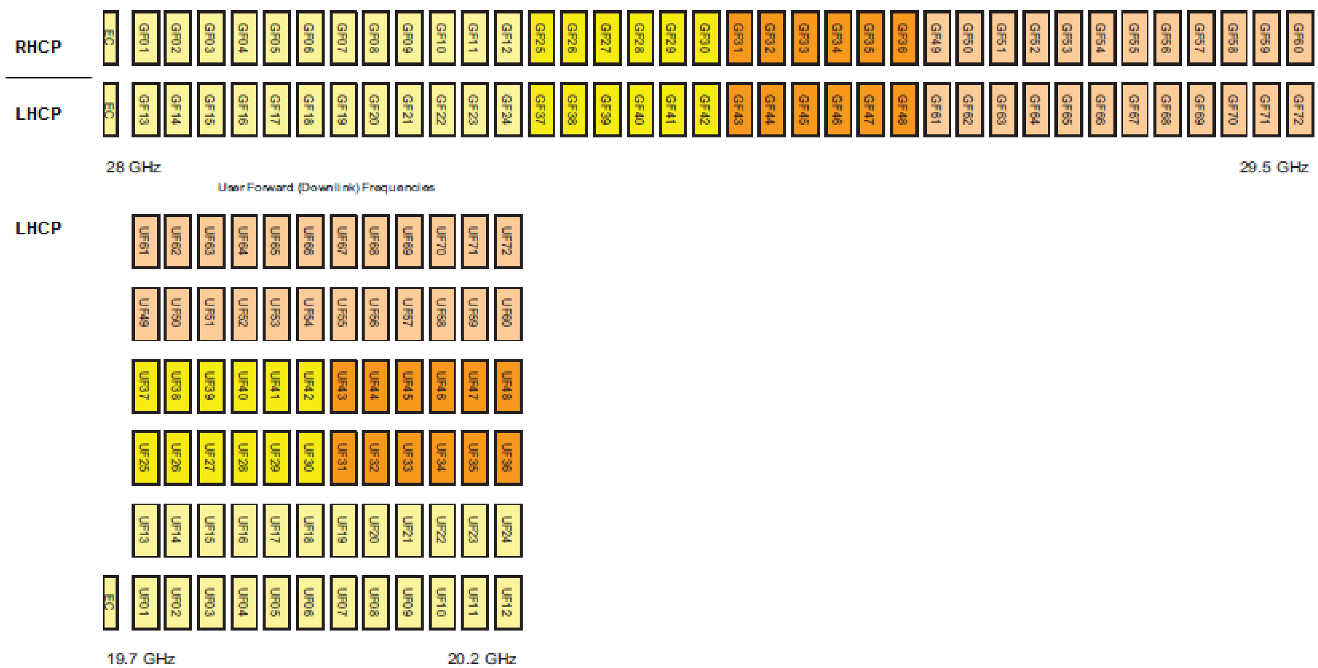
The Inmarsat-5 F2 satellite also carries a global ("Earth Coverage" or "EC") beam intended for signaling carriers within a relatively small frequency segment, as described below:

- Earth-to-space direction: 28.0045-28.0095 GHz (RHCP and LHCP), 29.5045-29.5095 GHz (RHCP);
- Space-to-Earth direction: 18.2045-18.2095 GHz (RHCP and LHCP), 19.7045-19.7095 GHz (LHCP).

The above channel and polarization layouts are depicted in Figures A.4.2 and A.4.3 below.

Figure A.4.2. GP Spot Beam Frequency Plan (including EC Beam Channels)

Forward Direction



Return Direction

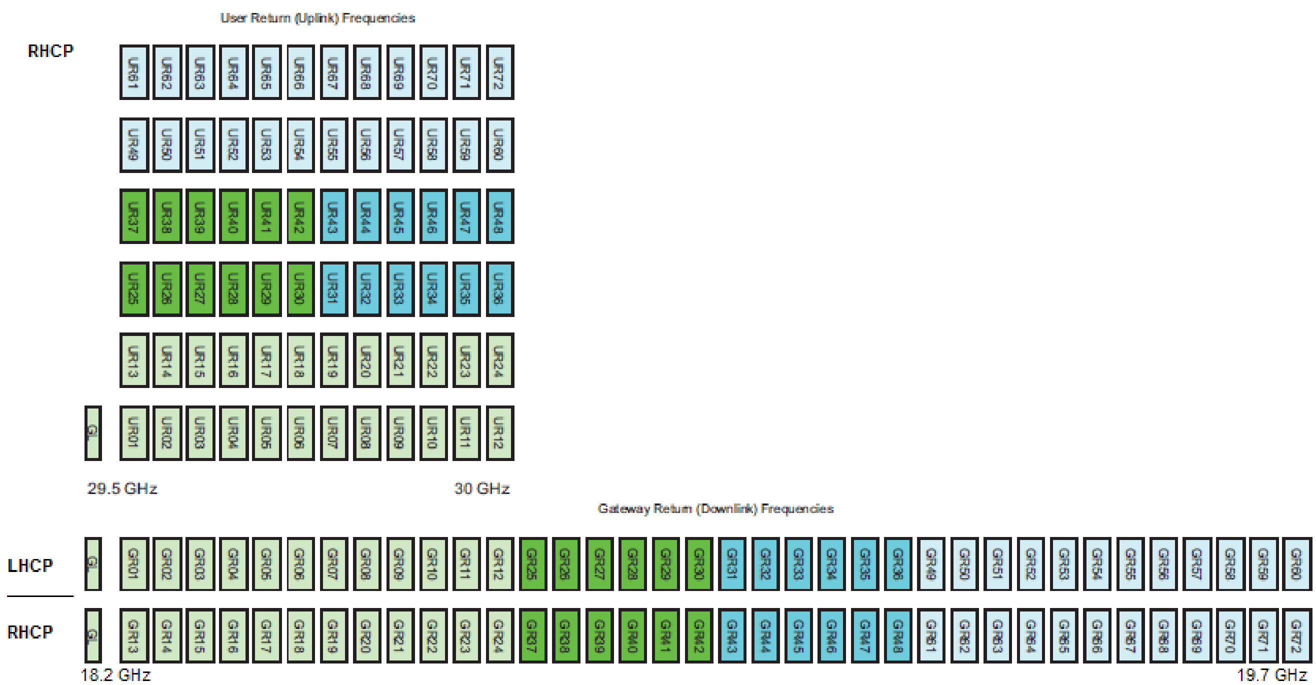
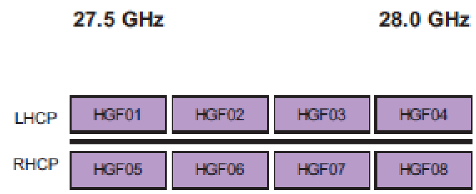


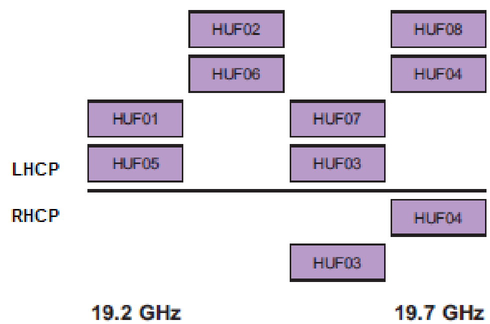
Figure A.4.3. HCP Spot Beam Frequency Plan

Forward Direction

Uplink

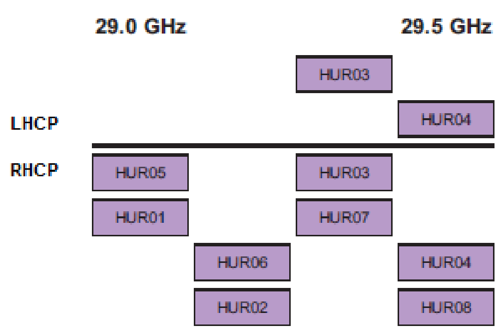


Downlink

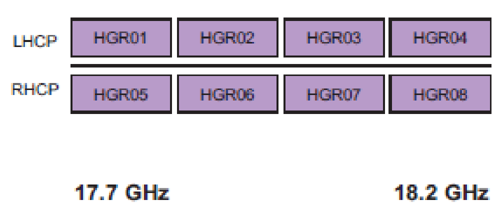


Return Direction

Uplink



Downlink



A.5 Transponder Configuration

The satellite has a total of 67 simultaneously active TWTAs, excluding TT&C functions. This consists of 61 active TWTAs in the forward link direction (gateway-to-user) and 6 active TWTAs in the return link direction (user-to-gateway).

Note that in the associated Schedule S the term "transponder" refers to the useful bandwidth of each channel (which is 32 MHz for the GP Spot Beams and 100 MHz for the HCP Spot Beams) and not to the number of active TWTAs.

A.6 Services to be Provided (§25.114(d)(4))

The Inmarsat-5 F2 satellite will provide a variety of two-way communications services to small user terminals including broadband Internet access, multimedia, voice and other applications.

Representative link budgets, which include details of the transmission characteristics, performance objectives and earth station characteristics, are provided in the associated Schedule S submission.

A.7 TT&C Characteristics (§25.114(c)(4)(i) and §25.114(c)(9))

As noted above in Section A.2, on-station TT&C for Inmarsat-5 F2 will be provided by the Lino Lakes Gateway. The following description of Inmarsat-5 F2 TT&C operations complements that provided in the associated Schedule S submission.

The TT&C sub-system provides for communications during pre-launch, transfer orbit and on-station operations, as well as during spacecraft emergencies. During transfer orbit and on-station emergencies the TT&C subsystem employs a composite omni-directional antenna configuration. During normal on-station operation, the telecommand transmissions will be received via one of the two uplink gateway beams. Authorization only for on-station Ka-band operations is sought in this application.

A summary of the on-station TT&C subsystem characteristics is given in Table A.7.1.

Table A.7.1. Ka-band On-Station TT&C Performance Characteristics

Command / Ranging Frequencies and Polarization	29,494.0 MHz / LHCP (on-station) 29,468.0 MHz / RHCP (on-station)
Telemetry / Ranging Frequencies and Polarization	19,700.5 MHz / RHCP & LHCP (on-station) 19,702.5 MHz / RHCP & LHCP (on-station)
Satellite Transmit Antenna Types	Communications antenna during normal on-station operations for Command.

The uplink power spectral density of the Ka-band telecommand carriers and the downlink power spectral density of the Ka-band telemetry carriers will not exceed the highest power spectral density of the communications carriers and therefore the TT&C carriers will not cause any more interference to neighboring systems than other Inmarsat-5 F2 carriers.

A.8 Satellite Transponder Frequency Responses (§25.114(c)(4)(vii))

The predicted receive and transmit channel filter response performance is given in Tables A.8.1 and A.8.2 below. The receive response is measured from the satellite receive antenna up to the input of the TWTA. The transmit response is measured from the input of the TWTA to the satellite transmit antenna.

Table A.8.1. GP Spot Beam Typical Receiver and Transmitter Filter Responses

Frequency offset from channel center	Gain relative to channel center frequency (dB)		Comments
	Receive	Transmit	
CF +/- 11.2 MHz	1	1	<u>In-Band</u> Value does not exceed these p-p values
CF +/- 12.8 MHz	1.3	1.3	
CF +/- 14.4 MHz	2	2	
CF +/- 16 MHz	3	3	
CF +/- 20.8 MHz	-1	-1	<u>Out-of-Band</u> Attenuation is not less than these values
CF +/- 24 MHz	-10	-7	
CF +/- 27.2 MHz	-25	-20	

Table A.8.2. HCP Spot Beam Typical Receiver and Transmitter Filter Responses

Frequency offset from channel center	Gain relative to channel center frequency (dB)		Comments
	Receive	Transmit	
CF +/- 35 MHz	1.25	1.25	In-Band
CF +/- 40 MHz	1.75	1.75	Value does not exceed these p-p values
CF +/- 45 MHz	2	2	
CF +/- 50 MHz	3	3	
CF +/- 65 MHz	-1	-1	Out-of-Band
CF +/- 75 MHz	-10	-7	Attenuation is not less than these values
CF +/- 85 MHz	-25	-20	

A.9 Cessation of Emissions (§25.207)

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

A.10 Power Flux Density at the Earth's Surface (§25.208(c))

§25.208(c) contains PFD limits that apply in the 17.7–17.8 GHz, 18.3–18.8 GHz, and 19.3–19.7 GHz bands. 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.

§25.208 does not contain any PFD limits that apply in the 17.8-18.3 GHz or 18.8-19.3 GHz bands for GSO satellite networks, however it is noted that Article 21 of the ITU Radio Regulations does include PFD limits applicable to GSO satellites using the 17.8-18.3 GHz and 18.8-19.3 GHz bands and these limits are identical to those in §25.208(c).

§25.208 similarly does not contain any PFD limits that apply in the 19.7-20.2 GHz band for GSO satellite networks, and it is noted also that Article 21 of the ITU Radio Regulations does not have any PFD limits that apply in this band.

Compliance with all applicable FCC and ITU PFD limits in the 17.7-19.7 GHz is demonstrated below using a simple worst-case methodology. The maximum downlink EIRP density that the Inmarsat-5 F2 satellite will transmit in the 17.7-19.7 GHz band is 57 dBW in an occupied bandwidth of 50 MHz, which translates into 40 dBW in 1 MHz.[1] The shortest distance from the satellite to the Earth is 35,786 km, corresponding to a spreading loss of 162.06 dB. Therefore the maximum possible PFD at the Earth's surface at an elevation angle of 90° will not exceed -122.06 dBW/m^2 in 1 MHz (*i.e.*, 40 -162.06). This 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 PFD limits is ensured.

A.11 Two Degree Compatibility (§25.138)

No transmissions in the Inmarsat-5 F2 satellite network will exceed the uplink off-axis EIRP density and downlink PFD levels of §25.138, regardless of whether the frequency band used is subject to §25.138.

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[1] The maximum downlink EIRP density of the telemetry transmissions from the Inmarsat-5 F2 satellite will also not exceed -122 dBW/m^2/MHz, as provided in the Schedule S.

A.11.1 Frequency Bands Subject to §25.138

§25.138 of the Commission's rules defines the uplink and downlink parameters that permit routine blanket licensing of Ka-band earth stations in certain frequency bands which define the acceptable levels of adjacent satellite interference permitted in the Ka-band by the FCC, absent specific coordination agreements with neighboring satellites. The frequency bands planned to be used by the Inmarsat-5 F2 satellite network, which are subject to §25.138, are as follows:

- Uplink: 28.35-28.6 GHz and 29.25-30.0 GHz
- Downlink: 18.3-18.8 GHz and 19.7-20.2 GHz

For these frequency bands compliance with the Commission's two-degree spacing policy is ensured provided:

- The uplink off-axis EIRP density levels given in §25.138(a)(1) of the Commission's rules are not exceeded; and
- The maximum downlink PFD levels given in §25.138(a)(6) of the Commission's rules are not exceeded.

The clear sky uplink off-axis EIRP density limits of §25.138(a)(1) are equivalent to a maximum uplink input power density of -56.5 dBW/Hz for earth stations in compliance with off-axis transmit gain masks in §25.209(a)(2) and (4).

Table A.11.1 compares the uplink input power densities derived from the uplink link budgets that are contained in the Schedule S with the clear sky limits of §25.138 (a)(1). It can be seen that in all cases the clear sky uplink power limits are met.

Table A.11.1. Demonstration of Compliance with the Uplink Power limits of §25.138 (a)(1)

Uplink Antenna Diameter	Maximum Clear Sky Uplink Input Power Density (dBW/Hz)	Clear Sky Uplink Input Power Density Limit of §25.138 (a)(1) (dBW/Hz)	Margin (dB)
13.2m	-70.0	-56.5	13.5
Typical-60cm	-58.4	-56.5	1.9
Typical-100cm	-58.5	-56.5	2.0
Typical-150cm	-57.9	-56.5	1.4

Section A.10 above demonstrates that the PFD that could be transmitted by the Inmarsat-5 F2 satellite in the band 18.3-18.8 GHz, at an elevation angle of 90 degrees, does not exceed -122.06 dBW/m^2/MHz and therefore the PFD levels at other elevation angles will necessarily be lower due to the increased spreading loss.

In the band 19.7-20.2 GHz, the maximum downlink EIRP density that the Inmarsat-5 F2 satellite will transmit is 56.1 dBW in an occupied bandwidth of 32 MHz. This translates into 41 dBW in 1 MHz. The shortest distance from the satellite to the Earth is 35,786 km, corresponding to a spreading loss of 162.06 dB. Therefore the maximum possible PFD at the Earth's surface at an elevation angle of 90° will not exceed -121.06 dBW/m^2 in 1 MHz (*i.e.*, 41 -162.06).

In summary, all downlink transmissions from the Inmarsat-5 F2 satellite will comply with the -118 dBW/m^2/MHz limit set forth in §25.138 (a)(6) of the Commission's rules.

A.11.2 Frequency Bands Not Subject to §25.138

The portions of Ka-band spectrum, planned to be used by the Inmarsat-5 F2 satellite network, which are not subject to §25.138, are as follows:

- Uplink: 27.5-28.35 GHz and 28.6-29.25 GHz
- Downlink: 17.7-18.3 GHz and 18.8-19.7 GHz

This section demonstrates that uplink transmissions in these bands are two-degree compatible. Currently there are no operational GSO Ka-band satellites that use the 27.5-28.35 GHz, 28.6-29.25 GHz, 17.7-18.3 GHz or 18.8-19.7 GHz bands within two degrees of the 55º W.L. location. There are no other pending applications before the Commission for use of these bands by a GSO satellite within two degrees.

In order to demonstrate two-degree compatibility in this situation, the transmission parameters of the Inmarsat-5 F2 satellite have been assumed as both the wanted and victim transmissions. Table A.11.2 provides a summary of the uplink and downlink transmission parameters. The interference analysis assumes a nominal orbital separation of 1.9 degrees as opposed to 2 degrees in order to take into account the east-west station-keeping of 0.05 degrees. The analysis also assumes a 1.1 factor (or 1 dB advantage) for topocentric-to-geocentric conversion. All wanted and interfering carriers are co-polarized.

Table A.11.3 shows the results of the interference calculations in terms of the C/I margins. The format is similar to that of the output of the Sharp Adjacent Satellite Interference Analysis program. It can be seen that the C/I margins are all positive.

Table A.11.2. Inmarsat-5 F2 transmission parameters.

Uplink

E/W station keeping (deg.):	0.05
Worst case separation (deg.):	1.9
Worst case topocentric angle (deg):	2.09

Carrier ID	Emission Designator	Occupied BW (kHz)	Tx Antenna Type	Tx Antenna Gain (dBi)	Uplink EIRP (dBW)	Uplink EIRP density (dBW/kHz)	Tx Antenna Off-axis Gain at 2.09 deg. (dB)	C/I Criterion (dB)
1	3M16G7W	2630.3	Typ-60cm	43.6	49.2	15.0	21.0	11.2
2	2M45G7W	2041.7	Typ-100cm	48.0	52.5	19.4	21.0	14.2
3	4M78G7W	3981.1	Typ-150cm	51.5	59.5	23.5	21.0	17.8
4	3M16G7W	2630.3	Typ-60cm	43.4	49.2	15.0	21.0	13.2
5	2M45G7W	2041.7	Typ-100cm	47.9	52.5	19.4	21.0	17.8
6	4M78G7W	3981.1	Typ-150cm	51.4	59.5	23.5	21.0	20.4
7	32M0G7W	32000.0	Typ-13.2m	68.9	77	31.9	21.0	14.7
8	32M0G7W	32000.0	Typ-13.2m	68.9	77	31.9	21.0	17.7
9	32M0G7W	32000.0	Typ-13.2m	68.9	77	31.9	21.0	21.8
10	50M0G7W	50000.0	Typ-13.2m	68.7	77	30.0	21.0	13.2
11	50M0G7W	50000.0	Typ-13.2m	68.7	77	30.0	21.0	17.1
12	50M0G7W	50000.0	Typ-13.2m	68.7	77	30.0	21.0	20.7
13	900KF3X (TLC)	700.0	Typ-13.2m	69.5	74	45.5	21.0	23.2
14	5M00G1W (Rtn Signalling)	5000.0	Typ-60cm	43.5	49.2	12.2	21.0	-9.8
15	5M00G1W (Rtn Signalling)	5000.0	Typ-100cm	47.9	52.5	15.5	21.0	-9.8
16	5M00G1W (Rtn Signalling)	5000.0	Typ-150cm	51.5	59.5	22.5	21.0	-9.8
17	5M00G1W (Fwd Signalling)	140.0	Typ-13.2m	68.7	67.7	46.2	21.0	10.2
18	32M0G7W (TEST-F1)	32000.0	Typ-13.2m	68.9	77	31.9	21.0	26
19	50M0G7W (TEST-F2)	50000.0	Typ-13.2m	68.7	77	30.0	21.0	26
20	5M00G1W (TEST-F3)	140.0	Typ-13.2m	68.7	67.7	46.2	21.0	10.2
21	3M16G7W (TEST-R1)	2630.3	Typ-13.2m	69.3	49.2	15.0	21.0	11.2
22	2M45G7W (TEST-R2)	2041.7	Typ-13.2m	69.3	52.5	19.4	21.0	14.2
23	4M78G7W (TEST-R3)	3981.1	Typ-13.2m	69.3	59.5	23.5	21.0	17.8
24	3M16G7W (TEST-R4)	2630.3	Typ-13.2m	69.1	49.2	15.0	21.0	11.2

25	2M45G7W (TEST-R5)	2041.7	Typ-13.2m	69.1	52.5	19.4	21.0	14.2
26	4M78G7W (TEST-R6)	3981.1	Typ-13.2m	69.1	59.5	23.5	21.0	17.8
27	5M00G1W (TEST-R7)	5000.0	Typ-13.2m	69.2	67.7	30.7	21.0	-9.8
28	5M00G1W (TEST-R8)	5000.0	Typ-13.2m	69.2	67.7	30.7	21.0	-9.8
29	5M00G1W (TEST-R9)	5000.0	Typ-13.2m	69.2	67.7	30.7	21.0	-9.8

Downlink

E/W station keeping (deg.): 0.05
Worst case separation (deg.): 1.9
Worst case topocentric angle (deg): 2.09

Carrier ID	Emission Designator	Occupied BW (kHz)	Rx Antenna Type	Rx Antenna Gain (dBi)	Downlink EIRP (dBW)	Downlink EIRP density (dBW/kHz)	Rx Antenna Off-axis Gain at 2.09 deg. (dB)	C/I Criterion (dB)
1	3M16G7W	2630.3	Typ-13.2m	66.1	19.3	-14.9	21.0	11.2
2	2M45G7W	2041.7	Typ-13.2m	66.1	22.6	-10.5	21.0	14.2
3	4M78G7W	3981.1	Typ-13.2m	66.1	26.6	-9.4	21.0	17.8
4	3M16G7W	2630.3	Typ-13.2m	65.7	24.4	-9.8	21.0	13.2
5	2M45G7W	2041.7	Typ-13.2m	65.7	27.7	-5.4	21.0	17.8
6	4M78G7W	3981.1	Typ-13.2m	65.7	29.1	-6.9	21.0	20.4
7	32M0G7W	32000.0	Typ-60cm	40.1	53.1	8.0	21.0	14.7
8	32M0G7W	32000.0	Typ-100cm	44.5	53.1	8.0	21.0	17.7
9	32M0G7W	32000.0	Typ-150cm	48.1	53.1	8.0	21.0	21.8
10	50M0G7W	50000.0	Typ-60cm	39.9	54.0	7.0	21.0	13.2
11	50M0G7W	50000.0	Typ-100cm	44.3	54.0	7.0	21.0	17.1
12	50M0G7W	50000.0	Typ-150cm	47.8	54.0	7.0	21.0	20.7
13	150KG3X (TLM)	130.0	Typ-13.2m	66.4	28.8	7.7	21.0	23.2
14	5M00G1W (Rtn Signalling)	5000.0	Typ-13.2m	65.8	23.9	-13.1	21.0	-9.8
15	5M00G1W (Rtn Signalling)	5000.0	Typ-13.2m	65.8	27.2	-9.8	21.0	-9.8
16	5M00G1W (Rtn Signalling)	5000.0	Typ-13.2m	65.8	35.2	-1.8	21.0	-9.8
17	5M00G1W (Fwd Signalling)	140.0	Typ-60cm	40.0	30.0	8.5	21.0	10.2
18	5M00G1W (Fwd Signalling)	140.0	Typ-100cm	44.4	30.0	8.5	21.0	10.2
19	5M00G1W (Fwd Signalling)	140.0	Typ-150cm	47.9	30.0	8.5	21.0	10.2
20	32M0G7W (TEST-F1)	32000.0	Typ-13.2m	66.6	53.1	8.0	21.0	26
21	50M0G7W (TEST-F2)	50000.0	Typ-13.2m	66.4	54.0	7.0	21.0	26

22	5M00G1W (TEST-F3)	140.0	Typ-13.2m	66.5	30.0	8.5	21.0	10.2
23	3M16G7W (TEST-R1)	2630.3	Typ-13.2m	66.1	19.3	-14.9	21.0	11.2
24	2M45G7W (TEST-R2)	2041.7	Typ-13.2m	66.1	22.6	-10.5	21.0	14.2
25	4M78G7W (TEST-R3)	3981.1	Typ-13.2m	66.1	26.6	-9.4	21.0	17.8
26	3M16G7W (TEST-R4)	2630.3	Typ-13.2m	66.4	24.4	-9.8	21.0	11.2
27	2M45G7W (TEST-R5)	2041.7	Typ-13.2m	66.4	27.7	-5.4	21.0	14.2
28	4M78G7W (TEST-R6)	3981.1	Typ-13.2m	66.4	29.1	-6.9	21.0	17.8
29	5M00G1W (TEST-R7)	5000.0	Typ-13.2m	65.8	23.9	-13.1	21.0	-9.8
30	5M00G1W (TEST-R8)	5000.0	Typ-13.2m	65.8	27.2	-9.8	21.0	-9.8
31	5M00G1W (TEST-R9)	5000.0	Typ-13.2m	65.8	35.2	-1.8	21.0	-9.8

Table A.11.3. Summary of the C/I margins (dB)

Uplink

	Interfering Carrier																													
	Crx ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Wanted Carrier	1	11.4	11.4	10.8	11.2	11.3	10.7	19.8	19.8	19.8	21.5	21.5	21.5	6.8	14.1	15.2	11.8	5.3	19.8	21.5	5.3	37.1	32.7	28.6	36.9	32.5	28.4	21.3	21.3	21.3
	2	12.8	12.8	12.2	12.6	12.7	12.1	21.2	21.2	21.2	22.9	22.9	22.9	8.2	15.5	16.6	13.2	6.7	21.2	22.9	6.7	38.5	34.1	30.0	38.3	33.9	29.8	22.7	22.7	22.7
	3	13.3	13.3	12.7	13.1	13.2	12.6	21.7	21.7	21.7	23.4	23.4	23.4	8.7	16.0	17.1	13.7	7.2	21.7	23.4	7.2	39.0	34.6	30.5	38.8	34.4	30.3	23.2	23.2	23.2
	4	9.4	9.4	8.8	9.2	9.3	8.7	17.8	17.8	17.8	19.5	19.5	19.5	4.8	12.1	13.2	9.8	3.3	17.8	19.5	3.3	35.1	30.7	26.6	34.9	30.5	26.4	19.3	19.3	19.3
	5	9.2	9.2	8.6	9.0	9.1	8.5	17.6	17.6	17.6	19.3	19.3	19.3	4.6	11.9	13.0	9.6	3.1	17.6	19.3	3.1	34.9	30.5	26.4	34.7	30.3	26.2	19.1	19.1	19.1
	6	10.7	10.7	10.1	10.5	10.6	10.0	19.1	19.1	19.1	20.8	20.8	20.8	6.1	13.4	14.5	11.1	4.6	19.1	20.8	4.6	36.4	32.0	27.9	36.2	31.8	27.7	20.6	20.6	20.6
	7	24.8	24.9	24.3	24.7	24.7	24.1	33.2	33.2	33.2	34.9	34.9	34.9	20.2	27.5	28.6	25.2	18.7	33.2	34.9	18.7	50.6	46.2	42.1	50.4	46.0	41.9	34.7	34.7	34.7
	8	21.8	21.9	21.3	21.7	21.7	21.1	30.2	30.2	30.2	31.9	31.9	31.9	17.2	24.5	25.6	22.2	15.7	30.2	31.9	15.7	47.6	43.2	39.1	47.4	43.0	38.9	31.7	31.7	31.7
	9	17.7	17.8	17.2	17.6	17.6	17.0	26.1	26.1	26.1	27.8	27.8	27.8	13.1	20.4	21.5	18.1	11.6	26.1	27.8	11.6	43.5	39.1	35.0	43.3	38.9	34.8	27.6	27.6	27.6
	10	24.4	24.4	23.8	24.2	24.3	23.7	32.8	32.8	32.8	34.5	34.5	34.5	19.8	27.1	28.2	24.8	18.3	32.8	34.5	18.3	50.1	45.7	41.6	49.9	45.5	41.4	34.3	34.3	34.3
	11	20.5	20.5	19.9	20.3	20.4	19.8	28.9	28.9	28.9	30.6	30.6	30.6	15.9	23.2	24.3	20.9	14.4	28.9	30.6	14.4	46.2	41.8	37.7	46.0	41.6	37.5	30.4	30.4	30.4
	12	16.9	16.9	16.3	16.7	16.8	16.2	25.3	25.3	25.3	27.0	27.0	27.0	12.3	19.6	20.7	17.3	10.8	25.3	27.0	10.8	42.6	38.2	34.1	42.4	38.0	33.9	26.8	26.8	26.8
	13	29.9	30.0	29.4	29.8	29.8	29.2	38.3	38.3	38.3	40.0	40.0	40.0	25.3	32.6	33.7	30.3	23.8	38.3	40.0	23.8	55.7	51.3	47.2	55.5	51.1	47.0	39.8	39.8	39.8
	14	29.6	29.6	29.0	29.4	29.5	28.9	38.0	38.0	38.0	39.7	39.7	39.7	25.0	32.3	33.4	30.0	23.5	38.0	39.7	23.5	55.3	50.9	46.8	55.1	50.7	46.6	39.5	39.5	39.5
	15	32.9	32.9	32.3	32.7	32.8	32.2	41.3	41.3	41.3	43.0	43.0	43.0	28.3	35.6	36.7	33.3	26.8	41.3	43.0	26.8	58.6	54.2	50.1	58.4	54.0	49.9	42.8	42.8	42.8
	16	39.9	39.9	39.3	39.7	39.8	39.2	48.3	48.3	48.3	50.0	50.0	50.0	35.3	42.6	43.7	40.3	33.8	48.3	50.0	33.8	65.6	61.2	57.1	65.4	61.0	56.9	49.8	49.8	49.8
	17	43.6	43.6	43.1	43.5	43.5	42.9	52.0	52.0	52.0	53.7	53.7	53.7	39.0	46.3	47.4	44.0	37.5	52.0	53.7	37.5	69.3	64.9	60.8	69.1	64.7	60.6	53.5	53.5	53.5
	18	13.5	13.6	13.0	13.4	13.4	12.8	21.9	21.9	21.9	23.6	23.6	23.6	8.9	16.2	17.3	13.9	7.4	21.9	23.6	7.4	39.3	34.9	30.8	39.1	34.7	30.6	23.4	23.4	23.4
	19	11.6	11.6	11.0	11.4	11.5	10.9	20.0	20.0	20.0	21.7	21.7	21.7	7.0	14.3	15.4	12.0	5.5	20.0	21.7	5.5	37.3	32.9	28.8	37.1	32.7	28.6	21.5	21.5	21.5
	20	43.6	43.6	43.1	43.5	43.5	42.9	52.0	52.0	52.0	53.7	53.7	53.7	39.0	46.3	47.4	44.0	37.5	52.0	53.7	37.5	69.3	64.9	60.8	69.1	64.7	60.6	53.5	53.5	53.5
	21	11.4	11.4	10.8	11.2	11.3	10.7	19.8	19.8	19.8	21.5	21.5	21.5	6.8	14.1	15.2	11.8	5.3	19.8	21.5	5.3	37.1	32.7	28.6	36.9	32.5	28.4	21.3	21.3	21.3
	22	12.8	12.8	12.2	12.6	12.7	12.1	21.2	21.2	21.2	22.9	22.9	22.9	8.2	15.5	16.6	13.2	6.7	21.2	22.9	6.7	38.5	34.1	30.0	38.3	33.9	29.8	22.7	22.7	22.7
	23	13.3	13.3	12.7	13.1	13.2	12.6	21.7	21.7	21.7	23.4	23.4	23.4	8.7	16.0	17.1	13.7	7.2	21.7	23.4	7.2	39.0	34.6	30.5	38.8	34.4	30.3	23.2	23.2	23.2
	24	11.4	11.4	10.8	11.2	11.3	10.7	19.8	19.8	19.8	21.5	21.5	21.5	6.8	14.1	15.2	11.8	5.3	19.8	21.5	5.3	37.1	32.7	28.6	36.9	32.5	28.4	21.3	21.3	21.3
	25	12.8	12.8	12.2	12.6	12.7	12.1	21.2	21.2	21.2	22.9	22.9	22.9	8.2	15.5	16.6	13.2	6.7	21.2	22.9	6.7	38.5	34.1	30.0	38.3	33.9	29.8	22.7	22.7	22.7
	26	13.3	13.3	12.7	13.1	13.2	12.6	21.7	21.7	21.7	23.4	23.4	23.4	8.7	16.0	17.1	13.7	7.2	21.7	23.4	7.2	39.0	34.6	30.5	38.8	34.4	30.3	23.2	23.2	23.2
	27	48.1	48.1	47.5	47.9	48.0	47.4	56.5	56.5	56.5	58.2	58.2	58.2	43.5	50.8	51.9	48.5	42.0	56.5	58.2	42.0	73.8	69.4	65.3	73.6	69.2	65.1	58.0	58.0	58.0
	28	48.1	48.1	47.5	47.9	48.0	47.4	56.5	56.5	56.5	58.2	58.2	58.2	43.5	50.8	51.9	48.5	42.0	56.5	58.2	42.0	73.8	69.4	65.3	73.6	69.2	65.1	58.0	58.0	58.0
	29	48.1	48.1	47.5	47.9	48.0	47.4	56.5	56.5	56.5	58.2	58.2	58.2	43.5	50.8	51.9	48.5	42.0	56.5	58.2	42.0	73.8	69.4	65.3	73.6	69.2	65.1	58.0	58.0	58.0
Minimum C/I margin =		3.1	dB																											

Downlink

		Interfering Carrier																													
	Crx ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	1	33.9	29.5	28.4	28.8	24.4	25.9	11.0	11.0	11.0	12.1	12.1	12.1	11.4	32.1	28.8	20.8	10.5	10.5	10.5	11.0	12.0	10.5	33.9	29.5	28.4	28.8	24.4	25.9	32.1	28.8	20.8
	2	35.3	30.9	29.8	30.2	25.8	27.3	12.4	12.4	12.4	13.5	13.5	13.5	12.8	33.5	30.2	22.2	11.9	11.9	11.9	12.4	13.4	11.9	35.3	30.9	29.8	30.2	25.8	27.3	33.5	30.2	22.2
	3	32.8	28.4	27.3	27.7	23.3	24.8	9.9	9.9	9.9	11.0	11.0	11.0	10.3	31.0	27.7	19.7	9.4	9.4	9.4	9.9	10.9	9.4	32.8	28.4	27.3	27.7	23.3	24.8	31.0	27.7	19.7
	4	36.6	32.2	31.1	31.5	27.1	28.6	13.7	13.7	13.7	14.7	14.7	14.7	14.0	34.8	31.5	23.5	13.2	13.2	13.2	13.7	14.7	13.2	36.6	32.2	31.1	31.5	27.1	28.6	34.8	31.5	23.5
	5	36.4	32.0	30.9	31.3	26.9	28.4	13.5	13.5	13.5	14.5	14.5	14.5	13.8	34.6	31.3	23.3	13.0	13.0	13.0	13.5	14.5	13.0	36.4	32.0	30.9	31.3	26.9	28.4	34.6	31.3	23.3
	6	32.3	27.9	26.8	27.2	22.8	24.3	9.4	9.4	9.4	10.4	10.4	10.4	9.7	30.5	27.2	19.2	8.9	8.9	8.9	9.4	10.4	8.9	32.3	27.9	26.8	27.2	22.8	24.3	30.5	27.2	19.2
	7	27.3	22.9	21.8	22.2	17.8	19.3	4.4	4.4	4.4	5.4	5.4	5.4	4.7	25.5	22.2	14.2	3.9	3.9	3.9	4.3	5.4	3.9	27.3	22.9	21.8	22.2	17.8	19.3	25.5	22.2	14.2
	8	28.7	24.3	23.2	23.6	19.2	20.7	5.8	5.8	5.8	6.8	6.8	6.8	6.2	26.9	23.6	15.6	5.3	5.3	5.3	5.8	6.8	5.3	28.7	24.3	23.2	23.6	19.2	20.7	26.9	23.6	15.6
	9	28.2	23.8	22.7	23.1	18.7	20.2	5.3	5.3	5.3	6.3	6.3	6.3	5.6	26.3	23.0	15.0	4.7	4.7	4.7	5.2	6.2	4.7	28.2	23.8	22.7	23.1	18.7	20.2	26.3	23.0	15.0
	10	27.6	23.2	22.1	22.5	18.1	19.6	4.7	4.7	4.7	5.7	5.7	5.7	5.0	25.8	22.5	14.5	4.1	4.1	4.1	4.6	5.7	4.1	27.6	23.2	22.1	22.5	18.1	19.6	25.8	22.5	14.5
	11	28.1	23.7	22.6	23.0	18.6	20.1	5.2	5.2	5.2	6.2	6.2	6.2	5.5	26.3	23.0	15.0	4.7	4.7	4.7	5.2	6.2	4.7	28.1	23.7	22.6	23.0	18.6	20.1	26.3	23.0	15.0
	12	28.0	23.6	22.5	22.9	18.5	20.0	5.1	5.1	5.1	6.1	6.1	6.1	5.5	26.2	22.9	14.9	4.6	4.6	4.6	5.1	6.1	4.6	28.0	23.6	22.5	22.9	18.5	20.0	26.2	22.9	14.9
Wanted Carrier	13	44.8	40.4	39.3	39.7	35.3	36.8	21.9	21.9	21.9	22.9	22.9	22.9	22.2	43.0	39.7	31.7	21.3	21.3	21.3	21.8	22.9	21.3	44.8	40.4	39.3	39.7	35.3	36.8	43.0	39.7	31.7
	14	56.4	52.0	50.9	51.3	46.9	48.4	33.5	33.5	33.5	34.5	34.5	34.5	33.9	54.6	51.3	43.3	33.0	33.0	33.0	33.5	34.5	33.0	56.4	52.0	50.9	51.3	46.9	48.4	54.6	51.3	43.3
	15	59.7	55.3	54.2	54.6	50.2	51.7	36.8	36.8	36.8	37.8	37.8	37.8	37.2	57.9	54.6	46.6	36.3	36.3	36.3	36.8	37.8	36.3	59.7	55.3	54.2	54.6	50.2	51.7	57.9	54.6	46.6
	16	67.7	63.3	62.2	62.6	58.2	59.7	44.8	44.8	44.8	45.8	45.8	45.8	45.2	65.9	62.6	54.6	44.3	44.3	44.3	44.8	45.8	44.3	67.7	63.3	62.2	62.6	58.2	59.7	65.9	62.6	54.6
	17	32.2	27.8	26.7	27.1	22.7	24.2	9.3	9.3	9.3	10.3	10.3	10.3	9.7	30.4	27.1	19.1	8.8	8.8	8.8	9.3	10.3	8.8	32.2	27.8	26.7	27.1	22.7	24.2	30.4	27.1	19.1
	18	36.6	32.2	31.1	31.5	27.1	28.6	13.7	13.7	13.7	14.7	14.7	14.7	14.1	34.8	31.5	23.5	13.2	13.2	13.2	13.7	14.7	13.2	36.6	32.2	31.1	31.5	27.1	28.6	34.8	31.5	23.5
	19	40.1	35.7	34.6	35.0	30.6	32.1	17.2	17.2	17.2	18.2	18.2	18.2	17.6	38.3	35.0	27.0	16.7	16.7	16.7	17.2	18.2	16.7	40.1	35.7	34.6	35.0	30.6	32.1	38.3	35.0	27.0
	20	42.6	38.2	37.1	37.5	33.1	34.6	19.7	19.7	19.7	20.7	20.7	20.7	20.0	40.7	37.4	29.4	19.1	19.1	19.1	19.6	20.6	19.1	42.6	38.2	37.1	37.5	33.1	34.6	40.7	37.4	29.4
	21	41.3	36.9	35.8	36.2	31.8	33.3	18.4	18.4	18.4	19.4	19.4	19.4	18.8	39.5	36.2	28.2	17.9	17.9	17.9	18.4	19.4	17.9	41.3	36.9	35.8	36.2	31.8	33.3	39.5	36.2	28.2
	22	58.7	54.3	53.2	53.6	49.2	50.7	35.8	35.8	35.8	36.8	36.8	36.8	36.2	56.9	53.6	45.6	35.3	35.3	35.3	35.8	36.8	35.3	58.7	54.3	53.2	53.6	49.2	50.7	56.9	53.6	45.6
	23	33.9	29.5	28.4	28.8	24.4	25.9	11.0	11.0	11.0	12.0	12.0	12.0	11.3	32.1	28.8	20.8	10.5	10.5	10.5	11.0	12.0	10.5	33.9	29.5	28.4	28.8	24.4	25.9	32.1	28.8	20.8
	24	35.3	30.9	29.8	30.2	25.8	27.3	12.4	12.4	12.4	13.4	13.4	13.4	12.7	33.5	30.2	22.2	11.9	11.9	11.9	12.4	13.4	11.9	35.3	30.9	29.8	30.2	25.8	27.3	33.5	30.2	22.2
	25	32.8	28.4	27.3	27.7	23.3	24.8	9.9	9.9	9.9	10.9	10.9	10.9	10.2	31.0	27.7	19.7	9.4	9.4	9.4	9.9	10.9	9.4	32.8	28.4	27.3	27.7	23.3	24.8	31.0	27.7	19.7
	26	39.3	34.9	33.8	34.2	29.8	31.3	16.4	16.4	16.4	17.4	17.4	17.4	16.7	37.5	34.2	26.2	15.9	15.9	15.9	16.4	17.4	15.9	39.3	34.9	33.8	34.2	29.8	31.3	37.5	34.2	26.2
	27	40.7	36.3	35.2	35.6	31.2	32.7	17.8	17.8	17.8	18.8	18.8	18.8	18.1	38.9	35.6	27.6	17.3	17.3	17.3	17.8	18.8	17.3	40.7	36.3	35.2	35.6	31.2	32.7	38.9	35.6	27.6
	28	35.6	31.2	30.1	30.5	26.1	27.6	12.7	12.7	12.7	13.7	13.7	13.7	13.0	33.8	30.5	22.5	12.2	12.2	12.2	12.7	13.7	12.2	35.6	31.2	30.1	30.5	26.1	27.6	33.8	30.5	22.5
	29	56.4	52.0	50.9	51.3	46.9	48.4	33.5	33.5	33.5	34.5	34.5	34.5	33.9	54.6	51.3	43.3	33.0	33.0	33.0	33.5	34.5	33.0	56.4	52.0	50.9	51.3	46.9	48.4	54.6	51.3	43.3
	30	59.7	55.3	54.2	54.6	50.2	51.7	36.8	36.8	36.8	37.8	37.8	37.8	37.2	57.9	54.6	46.6	36.3	36.3	36.3	36.8	37.8	36.3	59.7	55.3	54.2	54.6	50.2	51.7	57.9	54.6	46.6
	31	67.7	63.3	62.2	62.6	58.2	59.7	44.8	44.8	44.8	45.8	45.8	45.8	45.2	65.9	62.6	54.6	44.3	44.3	44.3	44.8	45.8	44.3	67.7	63.3	62.2	62.6	58.2	59.7	65.9	62.6	54.6

Minimum C/I margin = 3.9 dB

A.12 Sharing with BSS Systems in the 17.7-17.8 GHz Band

The 17.7-17.8 GHz band is allocated under the U.S. Table of Frequency Allocations for FSS Earth-to-space communications that are limited to feeder links for the Broadcasting-Satellite Service ("BSS"). The International Table allows this band segment to be used for BSS in the space-to-Earth direction, although the U.S. Table does not provide for such use. The following analysis demonstrates compatibility with these allocated uses.

A.12.1 BSS downlinks in the 17.7-17.8 GHz band

This section provides an analysis to assess potential interference from the Inmarsat-5 F2 downlink transmission into a BSS earth station that receives signals in the 17.7-17.8 GHz band (space-to-Earth). It also provides an analysis of the potential for interference from BSS downlinks into an Inmarsat-5 F2 earth station. These analyses are based on the once-authorized U.S. "reverse band" BSS satellite that was closest to Inmarsat-5 F2, which was at the 62.15^{o} W.L. orbital location with an orbital separation of 7.15 degrees to Inmarsat-5 F2. There is no U.S. allocation for BSS downlinks in the U.S. in the 17.7-17.8 GHz band. Therefore, this analysis is only relevant to a BSS downlink in the 17.7-17.8 GHz band that is received outside of the U.S.

For interference into BSS, the result in Table A.12.1a below shows that the ΔT/T is lower than the single entry criterion of 6% (or -12.2 dB) which illustrates that harmful interference is unlikely to occur. For interference into an Inmarsat-5 F2 earth station, the result in table A.12.1b below shows a slight delta T/T deficit of 1.4 dB, which is acceptable in this case.

Table A.12.1a. Co-direction Interference Analysis into BSS

Wanted system	BSS	BSS	
Nominal sat. location	-62.15	-62.15	deg. E
E/W station keeping	0.05	0.05	(+/-)
Frequency	17.75	17.75	GHz
Direction	downlink	downlink	
System temperature	200	125	K
Interfering system	INM-KA	INM-KA	
Nominal sat. location	-55	-55	deg. E
E/W station keeping	0.05	0.05	(+/-)

Frequency	17.75	17.75	GHz
Direction	downlink	downlink	
Maximum EIRP density	-25.4	-25.4	dBW/Hz
Sat. longitude difference	**7.15**	**7.15**	**deg.**
Sat. longitude difference (incl. st. keeping)	7.05	7.05	deg.
Topocentric angle	7.755	7.755	deg.
Satellite distance	35800.0	35800.0	km
Free space loss	208.5	208.5	dB
Wanted e/s antenna rx gain sidelobe formula	32-25log(t)	29-25log(t)	
Wanted e/s antenna rx gain sidelobe	9.8	6.8	dB
I	-224.1	-227.1	dBW/Hz
N	-205.6	-207.6	dBW/Hz
I/N (delta T/T)	-18.6	-19.5	dB
6% single entry criteria	-12.2	-12.2	dB
Margin	**6.4**	**7.3**	**dB**

Table A.12.1b. Co-direction Interference Analysis into an Inmarsat-5 F2 Earth Station

			Note
Wanted system	INM-KA		
Nominal sat. location	-55	deg. E	
E/W station keeping	0.05	(+/-)	
Frequency	17.75	GHz	
Direction	downlink		
System temperature	300	K	maximum
Interfering system	BSS		
Nominal sat. location	-62.15	deg. E	Nearest US BSS
E/W station keeping	0.05	(+/-)	
Frequency	17.75	GHz	
Direction	downlink		
Maximum EIRP density	-12.9	dBW/Hz	-115 dB(W/m2)/ 1 MHz pfd
Sat. longitude difference	**7.15**	**deg.**	
Sat. longitude difference (incl. st. keeping)	7.05	deg.	
Topocentric angle	7.755	deg.	
Satellite distance	35800.0	km	
Free space loss	208.5	dB	
Wanted e/s antenna rx gain sidelobe formula	29-25log(t)		

Wanted e/s antenna rx gain sidelobe	6.8	dB
I	-214.6	dBW/Hz
N	-203.8	dBW/Hz
I/N (delta T/T)	-10.8	dB
6% single entry criteria	-12.2	dB
Margin	**-1.4**	**dB**

A.12.2 BSS Feeder Links in the 17.7-17.8 GHz band

This section provides an analysis to assess potential interference from the Inmarsat-5 F2 downlink transmission into a BSS space station that operates in the 17.7-17.8 GHz band (Earth-to-space), and from a BSS space station into an Inmarsat-5 F2 gateway earth station. The nearest U.S. BSS Region 2 Plan orbital location to Inmarsat-5 F2 is 61.5^o W.L. which provides an orbital separation of 6.5 degrees.

For interference into a BSS space station, the reverse direction interference analysis shows that the off-axis power flux density is significantly lower than the -117 dBW/m^2/100kHz coordination trigger. In addition, the ΔT/T is significantly lower than the single entry criterion of 6% (or -12.2 dB) which illustrates that harmful interference is very unlikely to occur.

Table A.12.2. Reverse Direction Interference Analysis

			Note
Wanted system	DBS		
Nominal sat. location	-61.5	deg. E	
E/W station keeping	0.05	(+/-)	
Frequency	17.75	GHz	
Direction	uplink		
Wanted satellite antenna rx gain (peak)	40	dBi	
System temperature	600	K	
Interfering system	INM-KA		
Nominal sat. location	-55	deg. E	
E/W station keeping	0.05	(+/-)	
Frequency	17.75	GHz	
Direction	downlink		
Maximum EIRP density	-25.4	dBW/Hz	
Interferer tx gain isolation	**30**	dB	estimated
EIRP density transmitted towards the wanted sat.	-55.4	dBW/Hz	

Sat. longitude difference	**6.5**	**deg.**
Sat. longitude difference (incl. st. keeping)	6.4	deg.
Satellite distance (minimum, approx.)	4711.1	km
Free space loss	190.9	dB
Wanted satellite antenna rx gain (sidelobe)	0.0	dB
Wanted rx gain isolation	40.0	dB
PFD at the at the receiving antenna of the wanted satellite	-149.9	dBW/m2/100kHz
I	-246.3	dBW/Hz
N	-200.8	dBW/Hz
I/N (delta T/T)	**-45.5**	**dB**

In addition, interference from BSS feeder uplinks into Inmarsat's gateway operations is unlikely as shown in the following analysis. The parameters assumed for the Lino Lakes gateway are given in Table A.12.2.3, and the assumed BSS feeder link parameters are provided in Table A.12.2.4.

Table A.12.2.3. Lino Lakes Gateway Station Parameters

Minimum downlink EIRP Density	-28.9	dBW/MHz
Earth station antenna receive gain @17.75 GHz	65.6	dBi
Earth station antenna pattern	Rec 580	
Latitude of Earth Station	45°7' 56"1	N
Longitude of Earth Station	93°5' 44"	W
Orbital location of the Inmarsat-5 F2 satellite	55	deg W.L.
Gateway System Noise Temp	302	K
Required C/I criterion	23.2	dB

Table A.12.2.4. BSS Feeder Link Parameters

Orbital location of the BSS satellite	61.5	deg W.L.
Emission bandwidth	24	MHz
Assumed Transmit Power	16.1	dBW
Feeder Link Station Tx Antenna Gain	65.8	dBi
Antenna radiation pattern	Rec 580	
Assumed BSS Feeder Link Location (antenna height 10 m above the ground)	Co-located with Inmarsat	

	Gateway station	
System Noise Temperature	600	Deg K

Table A.12.2.5. The worst case interference calculation for the co-located situation (Gateway station and BSS feeder link station are 20 m apart)

Wanted carrier bandwidth	1	MHz
Tx Power	-28.9	dBW
I5 Sat Antenna Tx Gain	41	dBi
Path Loss (free space + water absorption etc)	-209.58	dB
Receive earth station Gain @ 17.75 GHz	65.6	dB
Noise Temp	302	K
Feeder loss	1	dB
Received carrier power C	**-132.88**	dBW
Interferer Bandwidth	24	MHz
Interferer Power	16.1	dBW
Interferer EIRP	6.1	dBW
Interferer Gain	-10	dBW
Relative Gain	-75.8	dBW
Peak Gain	65.8	dBi
Path Loss for 20 meters	83.52	dB
Wanted Gain	-10	dB
Relative Gain	-75.6	dB
Peak Gain	65.6	dBi
Interfering signal Strength	-88.42	dBW
Bandwidth Advantage	-13.8	dB
I	-102.22	dBW
C/I	**-30.65**	dB
Required C/I objective	23.2	dB
Margin	**-53.85**	dB

Initially, a worst case analysis was performed where the BSS feeder link station was located next to gateway site at a distance of 20 meters. The details of interference calculations are given in Table A.12.2.5. In this scenario, based on the assumed parameters the worst case C/I achieved is equal to -30.65 dB. Then an area analysis was performed by moving the BSS feeder link earth station over a certain area. The contours indicating the locations which produce a C/I of 23.2 dB with Rec 580 pattern and measured pattern for gateway station antenna are shown in Fig A.12.1 and A.12.2, respectively. The maximum distances to this contour in four directions are given in Table A.12.2.6.

Fig A.12.1. C/I contour of 23.2 dB with Rec 580 pattern for Gateway Station (BSS feeder link antenna pointed towards BSS satellite at 61.5 W.L.)

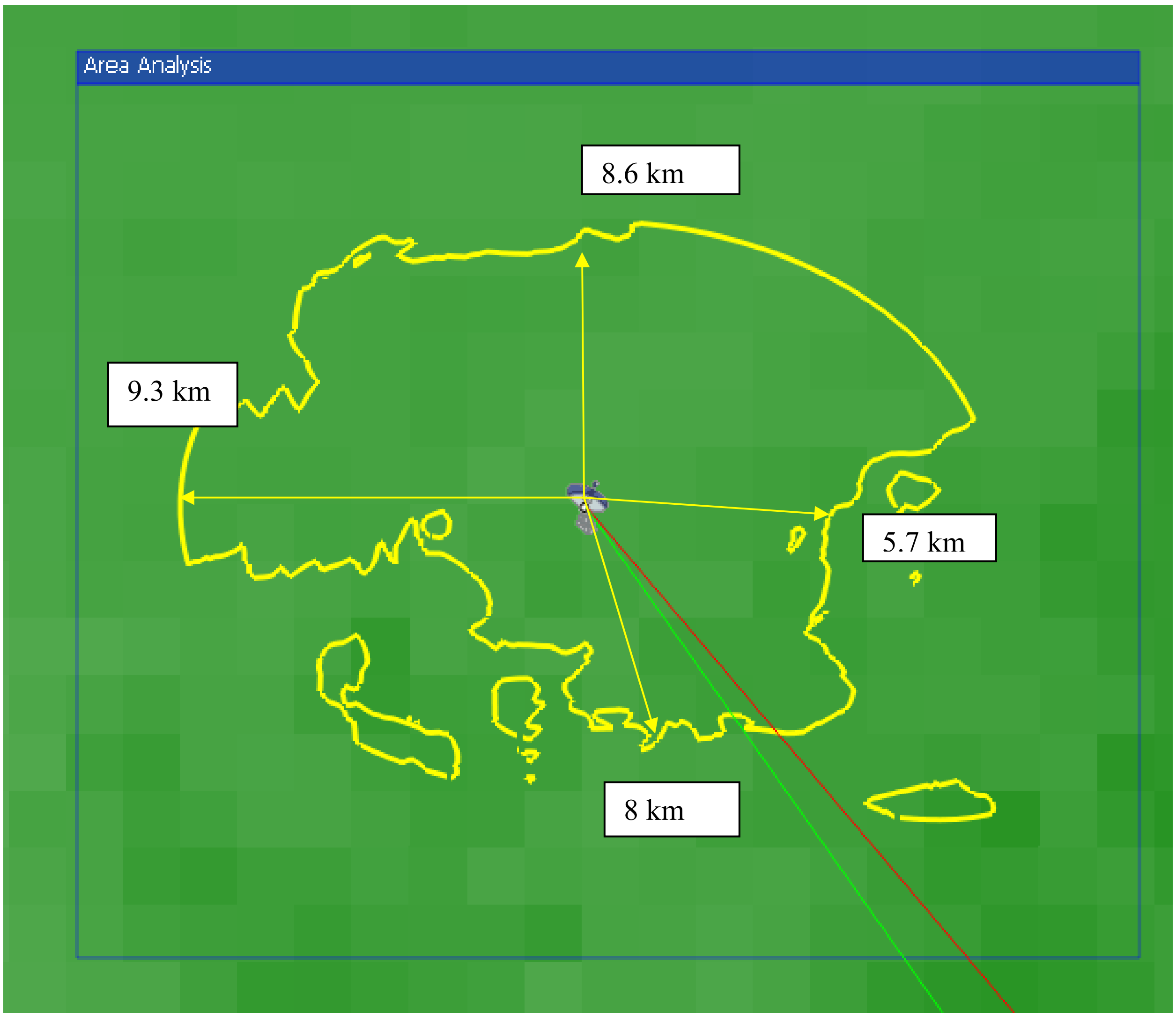


Fig A.12.2. C/I contour of 23.2 dB with the measured antenna pattern for Gateway Station (BSS feeder link antenna pointed towards BSS satellite at 61.5 W.L.)

Table A.12.2.6. Distances in four directions where C/I value of 23.2 dB is achieved

	North	South/SE	East	West
Rec 580 antenna pattern	**8.6 km**	**8 km**	**5.7 km**	**9.3 km**
Measured antenna pattern	**1 km**	**8.9 km**	**5.6 km**	**1 km**

With the Rec 580 antenna radiation pattern for the gateway station, the separation distances in four directions to North, South, East and West where the required C/I criterion of 23.2 dB is met are 8.6 km, 8 km, 5.7 km and 9.3 km respectively. However, with the measured antenna pattern for the gateway station, the separation distances in four directions to North, SE, East and West are 1 km, 8.9 km, 5.6 km and 1 km respectively.

The C/I contour diagrams for the above two cases when the BSS feeder link station is pointing to the satellite in 119.2º W.L. orbital location are given in Figures A.12.3 and A.12.4 respectively.

Fig A.12.3. C/I contour of 23.2 dB with Rec 580 pattern for Gateway Station (BSS feeder link antenna pointed towards BSS satellite at 119.2 W.L.)

Fig A.12.4. C/I contour of 23.2 dB with the measured antenna pattern for Gateway Station (BSS feeder link antenna pointed towards BSS satellite at 119.2 W.L.)

From the above two contour diagrams it can be seen that when the feeder link station pointing direction is changed from 61.5º W.L. to 119.2º W.L., that there are no significant changes to the shape of the C/I contours.

Based on this, it can be concluded that the required separation distances for any new BSS feeder link station deployment towards the BSS satellite anywhere in the orbital arc of 61.5º W.L. to 119.2º W.L. is no more than 8.9 km in the direction of Inmarsat-5 F2 satellite. It is possible to avoid interference with additional mitigation measures, such as site shielding in the unlikely event that it is required.

A.13 Sharing with FS in the 17.7-18.3 GHz and 19.3-19.7 GHz Bands

The U.S. Table includes an allocation for the Fixed Service ("FS") and for government FSS systems in the 17.7-18.3 GHz and 19.3-19.7 GHz frequency bands; it does not include an allocation for commercial FSS systems in these bands. The International Table does include an allocation for the FSS in these bands. This section analyzes the sharing scenarios between the FSS and the FS in these bands.

As an initial matter, and as discussed above, downlinks from the Inmarsat-5 F2 satellite will comply with all applicable FCC and ITU PDF limits in the 17.7-18.3 GHz and 19.3-19.7 GHz bands, and the potential always exists for FSS systems that are deployed to serve Canada, Mexico, or the Atlantic or Pacific Oceans to have "spill-over" coverage of the United States. Thus, FS systems in the U.S. should be designed to operate in such an RF environment. FS systems also should be designed to withstand the downlink power levels of U.S. government FSS systems that transmit within the 17.8-21.2 GHz band, and which are specified in the relevant ITU filings as being able to operate at power levels that are approximately 6 dB higher than the power levels from Inmarsat-5 F2 downlinks.

A.13.1 Interference from Inmarsat-5 satellite into FS Receivers

A hypothetical case was analyzed to assess the potential for interference from the Inmarsat-5 F2 satellite into typical FS receiver stations in the downlink direction. Two scenarios were examined: first, interference into potential FS receivers inside the downlink beam, and second, interference into potential FS receivers at the lowest possible elevation angle within the U.S.

In the first case, the lowest elevation angle possible towards the 55° W.L. within the coverage area of the downlink beam shown in Figure A.2.1 was identified. This occurs approximately at the coordinates 49°N, 109.7°W and results in an elevation angle towards 55° W.L. of about 13.8°. As for the second case, the lowest elevation angles towards 55° W.L. occur close to Seattle, WA at the approximate coordinates 48°N, 124°W.

The worst-case interference would occur if an FS receiver station is located at these coordinates and is pointing in the azimuth direction of the 55° W.L. satellite. Table A.13.1 provides the interference calculations for the two cases.

Table A.13.1. Calculation of interference from Inmarsat-5 F2 into hypothetical FS receivers

Assumptions	Within gateway beam	Lowest U.S. elevation	Units
FS Rx coordinates	49°North, 109.7°West	48°North, 124°West	-
Elevation angle	13.8°	5.2°	-
FS receiver elevation angle	0°	0°	-
Peak FS antenna gain	41	41	dBi
FS antenna D/λ	46.24	46.24	-
FS antenna gain towards 55 W.L. (Rec. 699)	6.9	17.4	dBi
FS receiver noise (N)	-137.94	-137.94	dBW/MHz
Satellite peak EIRP density	40	40	dBW/MHz
Satellite antenna discrimination towards FS	0	6	dB
Slant range Sat - FS	40182	41104	km
Free space loss Sat - FS	209.6	209.8	dB
pfd at FS receiver	-121.6	-121.8	$dBW/m^2/MHz$
Interference power (I)	-161.3	-156.9	dBW/MHz
I/N	-23.3	-18.9	dB
I/N requirement	-10	-10	dB
Margin	14.8	10.4	dB

Even with the very pessimistic assumptions made in the above analysis, it can be seen that the impact from the Inmarsat-5 F2 satellite into FS receivers is acceptable.

The above analysis assumes that the FS receiver is pointing in the azimuth direction toward 55º W.L. but horizontally at a 0° elevation angle, which is a reasonable assumption since the vast majority of FS stations point very close to the horizontal direction. With this assumption, the smallest off-axis angle between the FS receiver and the Inmarsat-5 F2 satellite at 55° W.L. is about 5°. Although very unlikely, it is possible for an FS receiver to point at a higher elevation angle, or even directly toward the satellite. Table A.13.2 calculates the minimum off-axis angles ensuring the protection of FS receivers with the same assumptions as in Table A.13.1.

Table A.13.2. Minimum off-axis angle using the assumptions of Table A.13.1

Assumptions	Minimum off-axis angle with Table A.13.1 assumptions within gateway beam	Minimum off-axis angle with Table A.13.1 assumptions outside gateway beam	Units
Off-axis angle	3.5°	1.6°	-
FS receiver elevation angle	10.3°	3.6°	-
Peak FS antenna gain	41	41	dBi

FS antenna D/λ	46.24	46.24	-
FS antenna gain towards 55 W.L. (Rec. 699)	21.7	27.9	dBi
FS receiver noise (N)	-137.94	-137.94	dBW/MHz
Satellite peak EIRP density	40	40	dBW/MHz
Satellite antenna discrimination towards FS	0	6	dB
Slant range Sat - FS	40182	41104	km
Free space loss Sat - FS	209.6	209.8	dB
Interference power (I)	-147.9	-147.9	dBW/MHz
I/N	-10	-10	dB
I/N requirement	-10	-10	dB
Margin	0	0	dB

Table A.13.2 shows that the elevation angle of the FS receiver must be very high for interference to be possible and thus, the probability that Inmarsat-5 F2 downlink emissions in the bands 17.7-18.3 GHz and 19.3-19.7 GHz would cause interference to FS receivers is extremely low. In the unlikely event that an FS station is deployed in such a way that interference may be caused, Inmarsat would take measures to avoid interference, such as turning off offending carriers and operating with EIRP levels that do not cause interference. Table A.13.3 derives the satellite EIRP density level that would protect an FS receiver with the assumed characteristics pointing directly at the Inmarsat-5 F2 satellite. It is noted that a number of Inmarsat-5 F2 carriers are planned to operate at EIRP density levels that are lower than the levels derived in Table A.13.3.

Table A.13.3. Maximum satellite EIRP density required to protect FS stations pointing directly at the Inmarsat-5 F2 satellite, using the same FS parameters as in Table A.13.1

Assumptions	**O° off-axis angle within gateway beam**	**O° off-axis angle outside gateway beam**	**Units**
Off-axis angle	0.0°	0.0°	-
FS receiver elevation angle	13.8°	5.2°	-
Peak FS antenna gain	41	41	dBi
FS antenna D/λ	46.24	46.24	-
FS antenna gain towards 55 W.L. (Rec. 699)	41.0	41.0	dBi
FS receiver noise (N)	-137.94	-137.94	dBW/MHz
Satellite peak EIRP density	**20.7**	**26.9**	dBW/MHz
Satellite antenna discrimination towards FS	0	6	dB
Slant range Sat - FS	40182	41104	km

Free space loss Sat - FS	209.6	209.8	dB
Interference power (I)	-147.9	-147.9	dBW/MHz
I/N	-10	-10	dB
I/N requirement	-10	-10	dB
Margin	0	0	dB

A.13.2 Interference from FS Transmitters into Inmarsat-5 Earth Stations

Based on a coordination conducted by Comsearch with FS systems in the vicinity of the Lino Lakes Gateway, there is no anticipated impact from any FS systems on Inmarsat's proposed gateway operations. A copy of Comsearch's report is attached as Exhibit B to this application. The following analysis assesses potential interference from future FS systems into the Lino Lakes Gateway receiver, which illustrates that such interference into the gateway is very unlikely to occur and can be mitigated if required.

The parameters assumed for the Lino Lakes Gateway are given in Table A.13.4 below and the assumed FS parameters are given in Table A.13.5.

Table A.13.4. Lino Lakes Gateway Station Parameters

Uplink Frequency of operation	28.0	GHz
Downlink Frequency of operation	18.0	GHz
Maximum uplink Power density	-6.85	dBW/MHz
Minimum downlink Power Density	-28.9	dBW/MHz
Satellite Peak Transmit Gain	41	dBi
Earth station antenna receive gain @17.75 GHz	65.6	dBi
Earth station antenna pattern	Rec 580	
Satellite 3 dB beam width	1.7	Deg
Latitude of Earth Station	45°7' 56"1	N
Longitude of Earth Station	93°5' 44"	W
Assumed orbital location of the Inmarsat-5 F2 satellite	55	deg W
Satellite G/T	9	dB/K
Earth Station G/T	40.8	dB/K
Earth Station height above the terrain	9.5	meters
Gateway System Noise Temp	302	K
Required C/I criterion	23.2	dB

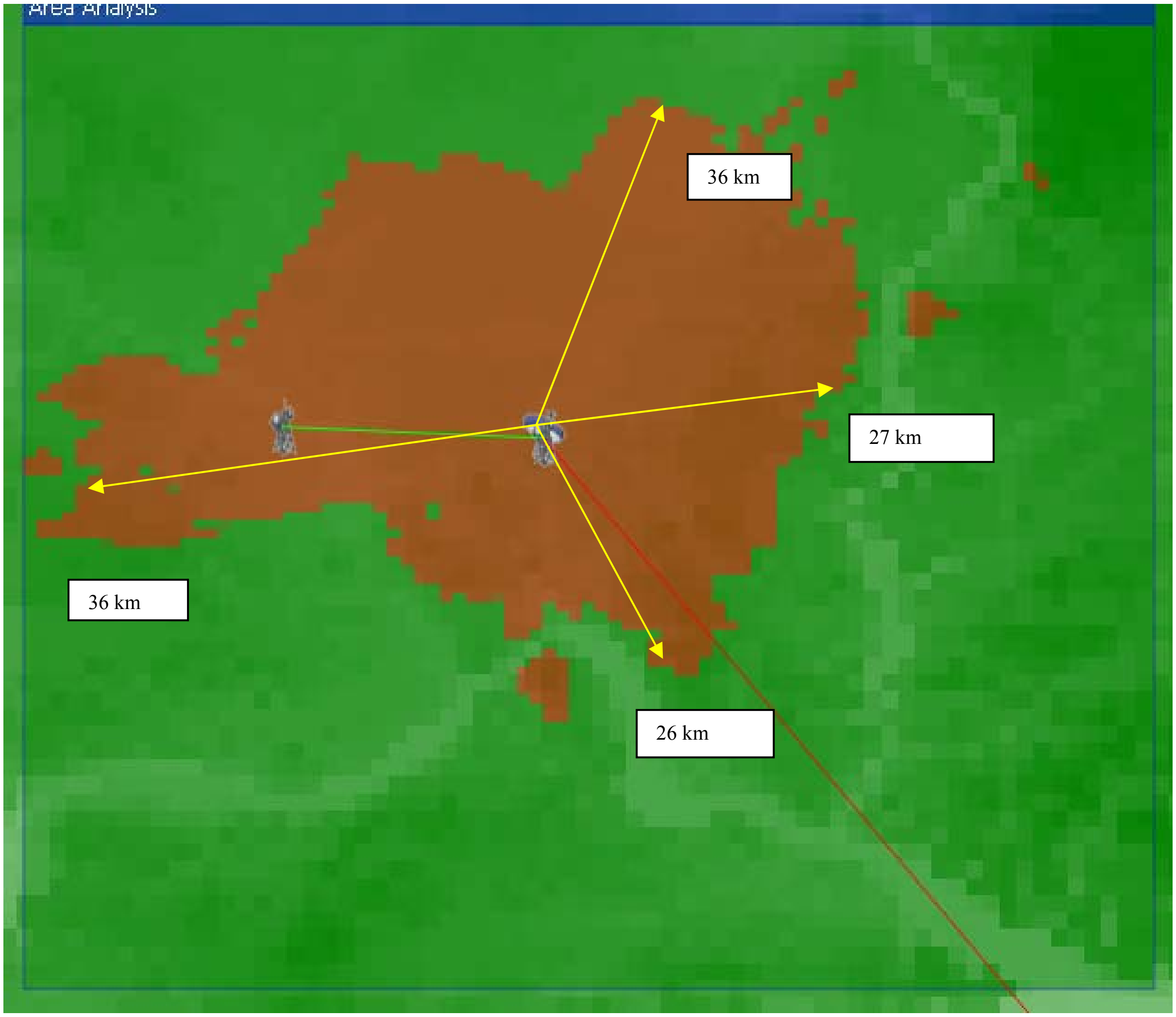
Table A.13.5. FS System Parameters

Downlink Frequency of operation	18.0	GHz
Assumed Transmit Power density	-31.22	dBW/MHz
FS Station Tx Antenna Gain	41	dBi
FS Station Receive Antenna gain	41	dBi
Antenna radiation pattern	Rec 699	
Assumed FS Receiver Location (antenna height 45 m above the ground)	See Table A.13.3 below	
Assumed FS Transmitter Location (antenna height 45m above the ground)	Varied over the test area	
System Noise Figure	6	dB

The propagation model used for the interfering FS link was ITU-R Recommendation P452.

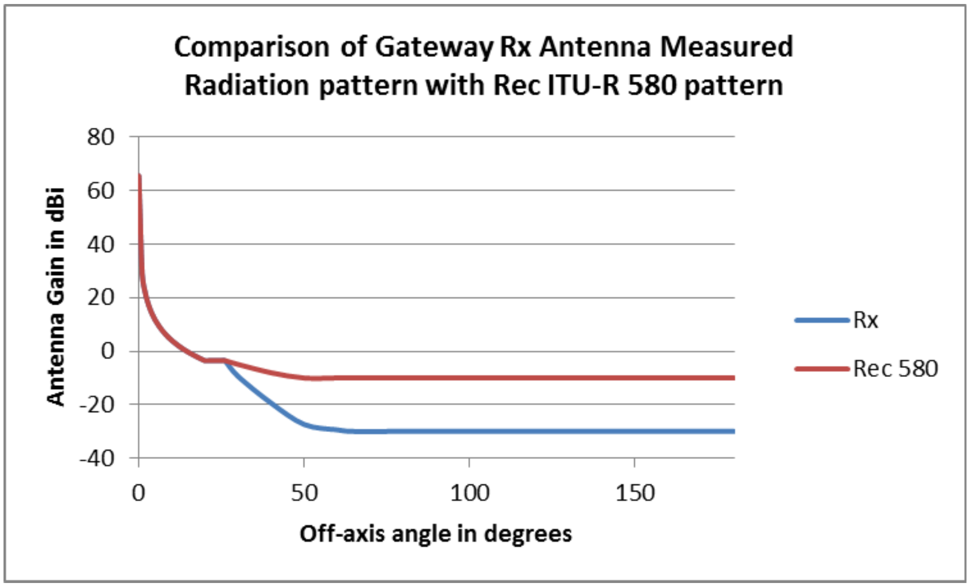
Initially a worst-case analysis (Case A) was performed where the FS receive station was co-located with the Lino Lakes Gateway site and the FS transmit antenna was pointed directly towards the (collocated) FS receive station (Figure A.13.1). In this scenario, based on the assumed parameters the required separation distances from the proposed gateway site vary from 28 km to the east to 36 km to the west and from 36 km to the north to 26 km to the south.

Fig A.13.1. Required C/I criterion (23.2 dB) contour (Case A)



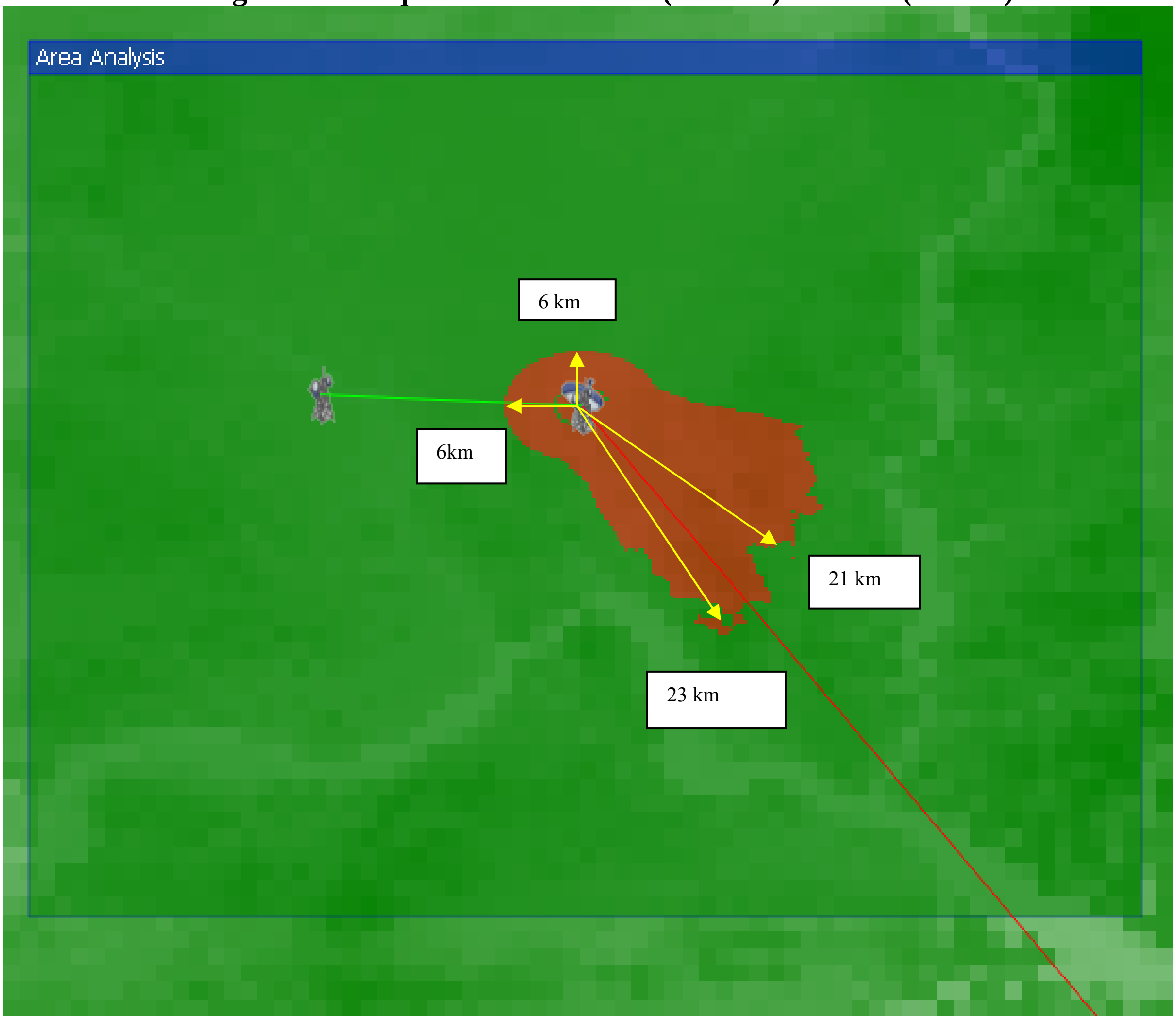
It is noted that this scenario is a highly hypothetical worst case and in practice various improvement factors apply. For example, the analysis is based on the standard Rec. 580 pattern for the gateway antenna. Actual patterns for real antennas typically provide significantly more discrimination, especially in the far sidelobes of the antenna. As an example, Figure A.13.2 shows a typical measured receive pattern for a 13.2m Ka-band antenna.

Fig A.13.2. Typical measured earth station antenna pattern (18GHz)



Repeating the analysis using this antenna pattern (Case B) effectively removes any interference potential in all directions, except in the direction of the GSO satellite, as shown in Fig A.13.3.

Fig A.13.3. Required C/I criterion (23.2 dB) contour (Case B)



In practice, it is also very likely that the FS transmitter will not point exactly in the direction of the gateway. When the FS transmit station is pointing away from the victim gateway station, the required separation distances will be much smaller. Two specific examples of this more realistic scenario were modeled. In the first example (Case C), the FS Receive station was located at 45 10N and 93 0 34W (Figure A.13.4) and in the second example (Case D) it was located at 44 50 N and 93 20 34W (Figure A.13.5). Then the interfering FS transmitter station was moved over a certain area and at each instant, the C/I value for the Ka-band downlink was computed. The contours indicating the locations which produce a C/I of 23.2 dB are shown in

Fig A.13.4 and A.13.5. The results are also summarized in Table A.13.6. It should be noted that Case C and Case D were computed using the Rec 580 earth station antenna pattern.

Based on the limited extent of the interference contours in Fig A.13.2, A.13.4 and A.13.5, it can be concluded that the probability that new FS deployments would cause interference into the earth station is very low. Finally, mitigation, such as site shielding, can be deployed at the gateway to eliminate any interference in the unlikely event that it is required.

Fig A.13.4. Required C/I criterion (23.2 dB) contour (Case C)

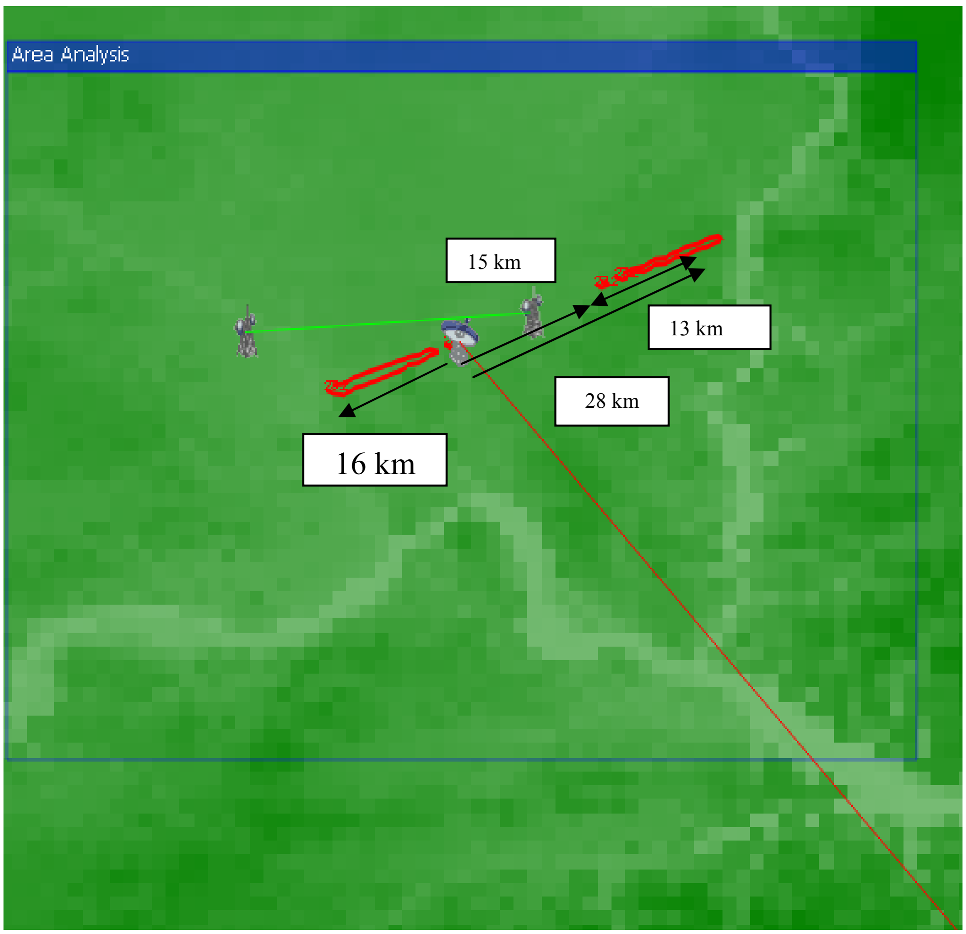


Fig A.13.5. Required C/I criterion (23.2 dB) contour (Case D)

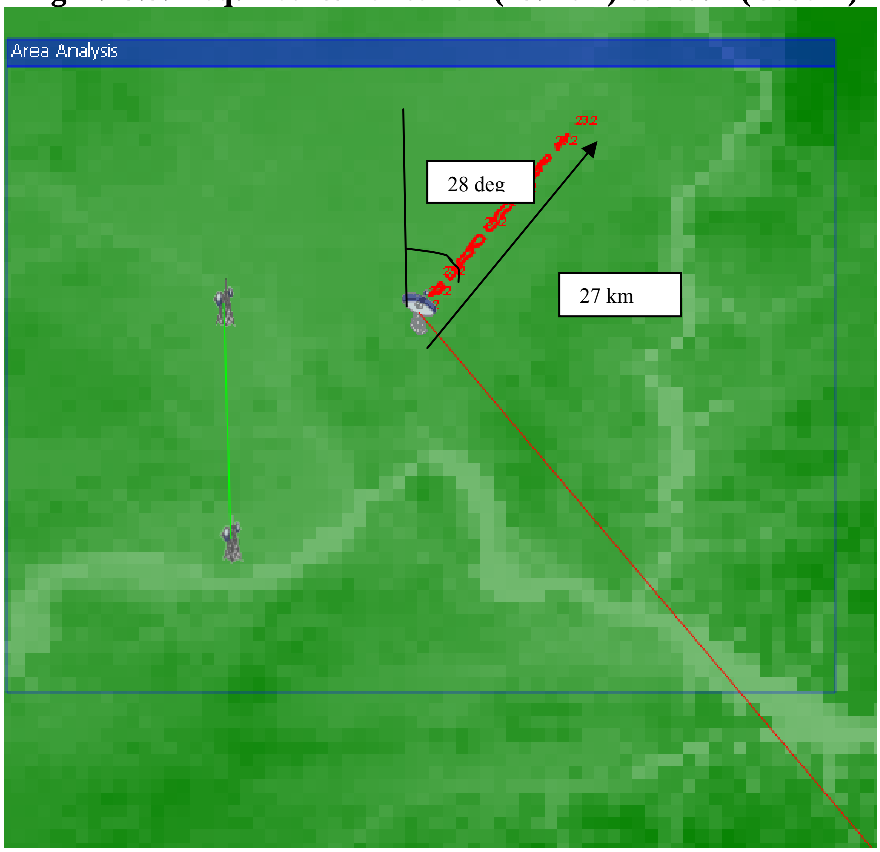


Table A.13.6. Required separation distances

FS Rx and Gateway <u>co-located</u> FS Rx: Lat 45° 7' 56''N; Long 93° 5' 44" W GW: Lat: 45° 7' 56"N; Long 93° 5' 44" W (Fig 2a)	**FS Rx and Gateway <u>not co-located</u>** FS Rx: Lat: 45° 10' N; Long: 93 0 34W GW: Lat: 45° 7' 56''N; Long 93° 5' 44" W (Fig 2b)	**FS Rx and Gateway <u>not co-located</u>** FS Rx: Lat: 44° 50' N; Long: 93 20 34W GW: Lat: 45° 7' 56''N; Long 93° 5' 44" W (Fig 2c)
Distance in km North: 36 South: 26 West: 36 East: 28	Inside the contours of length 16 km and 13 km in SW and NE directions respectively, the required C/I is not met. For all other FS Tx locations outside these contours there is no interference to the Gateway station	Along the radial distance of length 27 km along the azimuth direction of 28 degrees to the north the required C/I is not met. For all other FS Tx locations there is no interference to the Gateway station

A.14 Sharing with NGSO FSS in the 28.6-29.1 GHz and 18.8-19.3 GHz Bands

The 28.6-29.1 GHz uplink band is designated for NGSO FSS on a primary basis and it is designated for the GSO FSS on a secondary basis under FCC decisions. The 18.8-19.3 GHz downlink band is allocated exclusively to NGSO FSS. The following analysis demonstrates compatibility with NGSO FSS operations in these band segments.

The highest interference levels that could occur into NGSO networks from the Inmarsat-5 F2 network are when there is an "in-line" event. On the uplink for example, 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. As long as the GSO earth station does not transmit when the NGSO satellite is within a certain angle, no harmful interference to the NGSO satellite will occur. A similar situation exists on the downlink. The amount of angular separation required will be dependent on the parameters of the NGSO FSS networks and their interference criteria.

Currently there are no NGSO networks authorized by the Commission to use the 28.6-29.1 GHz or 18.8-19.3 GHz bands. O3b Limited ("O3b") has applied for U.S. market access for its constellation of NGSO satellites.[2] O3b proposes to communicate with a gateway earth station to be located in Hawaii using the 28.6-29.1 GHz and 18.8-19.3 GHz bands. Inmarsat and the O3b network operator are currently finalizing a frequency coordination agreement which would enable operations of both networks without any harmful interference to each other.

The O3b constellation will use eight satellites in a medium earth orbit with an altitude of 8062 km and an inclination of zero degrees (*i.e.*, an equatorial orbit). The satellites have steerable spot beams which are maintained on the gateway location as the satellites traverse their orbit until a minimum elevation angle is no longer met. Table A.14.1 shows the pertinent parameters of the Inmarsat-5 F2 network and the O3b system. Notably, the 55° W.L. GSO orbital location is not visible to the proposed O3b Hawaii gateway earth station, or vice versa.

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2 *See* SES-LIC-20100723-00952.

Table A.14.1. Summary of Inmarsat-5 F2 and O3b parameters.

Parameters	Inmarsat-5 F2	O3b System
Minimum Operational Elevation Angle		3°
Earth Station Uplink Input Power Density	-67 dBW/Hz	
Satellite Rx Antenna Gain		34.5 dBi
Satellite Rx System Noise Temp		1000 K
Satellite Tx EIRP Density		-28.32 dBW/Hz
Earth Station Rx System Noise Temperature	302 K	

The Inmarsat-5 F2 gateway uplink input power density value of -67 dBW/Hz is not clear sky, but rather assumes a worst-case faded uplink condition.

The minimum elevation angle for service to O3b's Hawaiian gateway is stated as being 3 degrees. From this we can determine the eastern-most location of an O3b satellite, just before it can no longer communicate with the Hawaiian gateway, as being at 99.67° W.L. This orbital location provides the smallest angular separation with respect to the Inmarsat-5 F2 network. Any location of an O3b satellite further west will necessarily create a larger angular separation with respect to the Inmarsat-5 F2 network.

Given the Inmarsat-5 F2 gateway antenna location, and with the O3b satellite assumed to be at a static 99.67° W.L. location, the angular separation (off-axis angle) subtended at the Inmarsat-5 F2 gateway can be calculated. In addition, the calculations take into account the fact that the O3b satellites communicating with the Hawaiian gateway provide at least 20 dB of satellite antenna discrimination towards the Inmarsat-5 F2 gateway antenna location in both uplink and downlink directions.

Table A.14.2 shows the predicted interference degradations to the O3b system due to operation of the Inmarsat-5 F2 network and vice versa. The results show that the O3b system is adequately protected. The calculated $\Delta T/T$ values in all cases are extremely small, demonstrating the technical compatibility of the Inmarsat-5 F2 satellite network with the proposed operation of O3b's Hawaii gateway.

Table A.14.2. Interference calculations between Inmarsat-5 F2 and O3b (Hawaii).

Victim network		O3b (Hawaii)	INMARSAT-5 F2
Interfering network		INMARSAT-5 F2	O3b (Hawaii)
E/S Latitude	degrees	21.67	45.13
E/S Longitude	degrees	-158.03	-93.1
Uplink:			
Frequency band	GHz	28.85	
Interfering uplink input power density	dBW/Hz	-67.0	
Angular separation between interfering E/S and victim satellite	degrees	52.54	
Slant range (Interfering path)	km	10961	NOT VISIBLE
Free space path loss (Interfering path)	dB	202.4	
Atmospheric losses	dB	1.2	
Victim satellite receive antenna gain	dBi	34.5	
Victim Satellite's Antenna Discrimination towards Interfering E/S	dB	20	
Victim satellite Rx system noise temperature	K	1000	
No	dBW/Hz	-198.6	
Io	dBW/Hz	-266.1	
Io/No	dB	-67.5	
?T/T	%	0.00002	0.0000
Downlink:			
Frequency band	GHz		19.05
Interfering satellite downlink EIRP density	dBW/Hz		-28.32
Slant range (Interfering path)	dB	NOT VISIBLE	10961
Free space path loss (Interfering path)	dB		198.8
Atmospheric & scintillation losses	dB		1
Angular separation between interfering satellite and victim E/S	degrees		52.54
Interfering Satellite's Antenna Discrimination towards Victim E/S	dB		20
Victim Rx earth station system noise temperature	K		302
No	dBW/Hz		-203.8
Io	dBW/Hz		-258.2
Io/No	dB		-54.4
?T/T	%	0.0000	0.0004

In order to demonstrate compatibility between the Inmarsat-5 F2 network and other types of NGSO networks, the parameters of the GESN and ATCONTACT NGSO networks, previously authorized by the Commission to use the 28.6-29.1 GHz and 18.8-19.3 GHz bands, have been used. Both networks were to utilize highly elliptical orbits ("HEO").

Table A.14.3 summarizes the salient parameters of the GESN and ATCONTACT HEO satellite networks for the purpose of this interference assessment. These parameters are identical to those used by Northrop Grumman and ATCONTACT to demonstrate independently that their GSO operations in the 28.6-29.1 GHz and 18.8-19.3 GHz bands were compatible with the other's proposed NGSO operations. It can be seen that the two networks' orbital and transmission parameters are identical, which allows a single interference analysis to be performed.

Table A.14.3. GESN and ATCONTACT HEO satellite characteristics.

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

In order to demonstrate compatibility with these two NGSO networks, a worst-case, static 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 A.14.4 shows the results of interference calculations from the Inmarsat-5 F2 network into the GESN and ATCONTACT networks and vice versa. The calculated $\Delta T/T$ values in all cases are less than 1%, indicating the technical compatibility of the Inmarsat-5 F2 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, an in-line interference event can occur. Inmarsat will coordinate with future NGSO operators in these band segments to determine the minimum angular separation required to protect any future NGSO system.

If required, Inmarsat would cease transmissions in this band from the relevant beam of the Inmarsat-5 F2 satellite and its associated earth station that is causing the in-line event, such that a minimum amount of angular separation with the NGSO network is always maintained, thereby avoiding interference in the NGSO system.

Table A.14.4. Worst-case interference calculations between the Inmarsat-5 F2 network and the GESN / ATCONTACT networks.

Uplink					
Victim network		GESN / ATCONTACT	INMARSAT-5 F2 (GP forward uplink)	GESN / ATCONTACT	INMARSAT-5 F2 (HCP return uplink)
Interfering network		INMARSAT-5 F2 (GP forward uplink)	GESN / ATCONTACT	INMARSAT-5 F2 (HCP return uplink)	GESN / ATCONTACT
Centre frequency	GHz	28.75	28.75	29.05	29.05
Interfering e/s uplink input power density	dBW/Hz	-70	-70	-57.9	-63.45
Angular separation	degrees	27.4	27.4	27.4	27.4
Interfering e/s transmit gain (off-axis)	dB	-6.94	-6.94	**-6.94**	-6.94
Slant range (Interfering path)	km	21046	40586	21046	40586
Space loss (Interfering path)	dB	208.2	213.9	208.2	213.9
Victim satellite receive antenna gain	dBi	46.5	42.4	46.5	45.4
Victim satellite Rx system noise temperature	K	504	1377	504	1346
N0	dBW/Hz	-201.6	-197.2	-201.6	-197.3
I0	dBW/Hz	-238.6	-248.4	-226.5	-238.9
I0/N0	dB	-37.1	-51.2	-25.0	-41.6
dT/T	%	0.020	0.001	0.319	0.007
Downlink					
Victim network		GESN / ATCONTACT	INMARSAT-5 F2 (GP return downlink)	GESN / ATCONTACT	INMARSAT-5 F2 (HCP forward downlink)
Interfering network		INMARSAT-5 F2 (GP return downlink)	GESN / ATCONTACT	INMARSAT-5 F2 (HCP forward downlink)	GESN / ATCONTACT
Centre frequency	GHz	19.05	19.05	19.25	19.25
Interfering satellite downlink EIRP density	dBW/Hz	-29.4	-18	-20	-18
Slant range (Interfering path)	km	40586	21046	40586	21046
Space loss (Interfering path)	dB	210.2	204.5	210.2	204.5
Angular separation	degrees	27.4	27.4	27.4	27.4
Victim e/s receive antenna gain (off-axis)	dB	-6.94	-6.94	-6.94	**-6.94**
Victim e/s Rx system noise temperature	K	315	302	315	302
N0	dBW/Hz	-203.6	-203.8	-203.6	-203.8
I0	dBW/Hz	-246.5	-229.4	-237.1	-229.4
I0/N0	dB	-42.9	-25.6	-33.5	-25.6
dT/T	%	0.005	0.273	0.044	0.273

A.15 Sharing with MSS Feeder Links in the 29.1-29.5 GHz and 19.3-19.7 GHz Bands

The 29.1-29.25 GHz uplink band and the 19.3-19.7 GHz downlink band are allocated to MSS feeder links with no allocation for GSO FSS.[3] The 29.25-29.5 GHz band is allocated to MSS feeder links and GSO/FSS on a co-primary basis. The only licensed MSS feeder links in these bands are used with the Iridium system. The analysis below demonstrates that Inmarsat's operation of the Inmarsat-5 F2 satellite and the Lino Lakes Gateway is compatible with feeder links to and from the Iridium system in the 29.1-29.5 GHz and 19.3-19.7 GHz bands.

Iridium operates HIBLEO-2FL feeder links and TT&C in Ka-band with earth stations currently licensed in Hawaii, Tempe (Arizona), and Alaska in RHC polarization in the frequency bands 19415.5 – 19584.5 MHz in the space-to-Earth direction and 29115.5 – 29284.5 MHz in the Earth-to-space direction.

Interference analysis was performed through dynamic simulation using Visualyze software, assuming Iridium gateway earth station located in Tempe, AZ, and the proposed Lino Lakes Gateway.

The analysis results show that the I/N for interference into both Iridium and Inmarsat operations are very low. For example, I/N into Iridium uplinks never exceeds -60 dB and I/N into Iridium downlinks never exceeds -19 dB. In practice the interference levels will be even lower since the simulation has assumed the worst-case earth station antenna gain envelope instead of the actual off-axis gain plot which would invariably be better.

Taking into account these results, Inmarsat believes that there would be no harmful interference between Inmarsat-5 F2 operations into HIBLEO-2FL feeder links with respect to Iridium earth station in Tempe, AZ, and the proposed Lino Lakes Gateway. The interference scenario is even more benign for Iridium feeder link stations in Hawaii and Alaska due to the larger distance between these stations and the Lino Lakes Gateway.

In addition, Inmarsat's operations in these bands can be compatible with future MSS feeder link deployments. As a practical matter, any such future MSS feeder link deployments are likely to use, at least in part, the co-primary 29.25-29.5 GHz band segment, and thus will need to

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[3] There is an allocation for FS in the 19.3-19.7 GHz band, which is addressed above, which is co-primary with the MSS feeder links.

ensure adequate geographic isolation from Inmarsat's gateway in order to successfully coordinate operations in that co-primary band segment. Thus, adequate geographic isolation also should exist between the Inmarsat gateway and future MSS feeder link operations in the 19.3-19.7 GHz and 29.1-29.25 GHz bands. Further, Inmarsat has reached out to Iridium and will coordinate the proposed operations with them.

Details of the parameters used and results of the interference analysis are as shown below.

(i) Simulation parameters

Parameters used in the interference analysis are as shown below.

(i).a HIBLEO-2FL parameters

(i).a.1 HIBLEO Satellites

Orbital parameters (as extracted from HIBLEO-2FL ITU filings):

orb_id	nbr_sat_pl	right_asc	inclin_ang	prd_ddd	prd_hh	prd_mm	apog	apog_exp	perig	perig_exp	perig_arg
1	11	195.38	86.4	0	1	40	775		775	0	90
2	11	226.96	86.4	0	1	40	775		775	0	90
3	11	258.54	86.4	0	1	40	775		775	0	90
4	11	290.13	86.4	0	1	40	775		775	0	90
5	11	321.72	86.4	0	1	40	775		775	0	90
6	11	353.31	86.4	0	1	40	775		775	0	90

Antenna transmit / receive contour: ITU-Rec. S.465-5 (see Figure A.15.1 below for transmit beam contour).

Transmit gain: 26.9 dBi (beam peak).

Receive gain: 30.1 dBi (beam peak).

Temperature: 1295K.

G/T: -1 dB/K (beam peak).

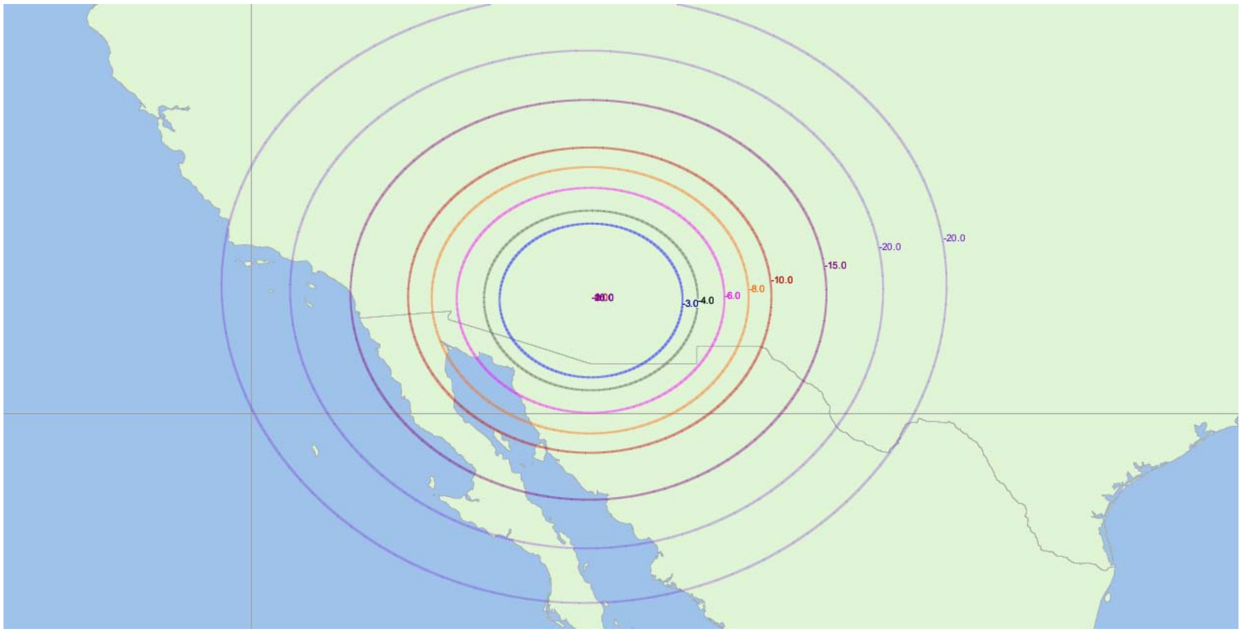
Downlink power s.d. (maximum): -68.1 dBW/Hz.

HIBLEO Satellite Tracking:

- Minimum elevation: 8 degrees.

- Tracking based on: Longest holding time taking into account the minimum elevation angle.

Figure A.15.1.
HIBLEO-2FL feeder link transmit beam contour based on ITU-Rec. S.465-5.



(i).a.2 HIBLEO Earth Station

Antenna transmit / receive side lobe contour: ITU-Rec. S.580.

Transmit gain: 56.3 dBi .

Receive gain: 53.2 dBi.

Temperature: 731K.

G/T: 24.6 dB/K.

Uplink power s.d. (maximum): -52.9 dBW/Hz.

HIBLEO earth station location: Tempe, AZ (33°N, 111°W).

(i).b Inmarsat-5 F2 parameters

(i).b.1. INMARSAT Satellite

Orbital location: 55°W

Gateway beam antenna transmit / receive contour: See Figure A.15.2 below for transmit beam contour.

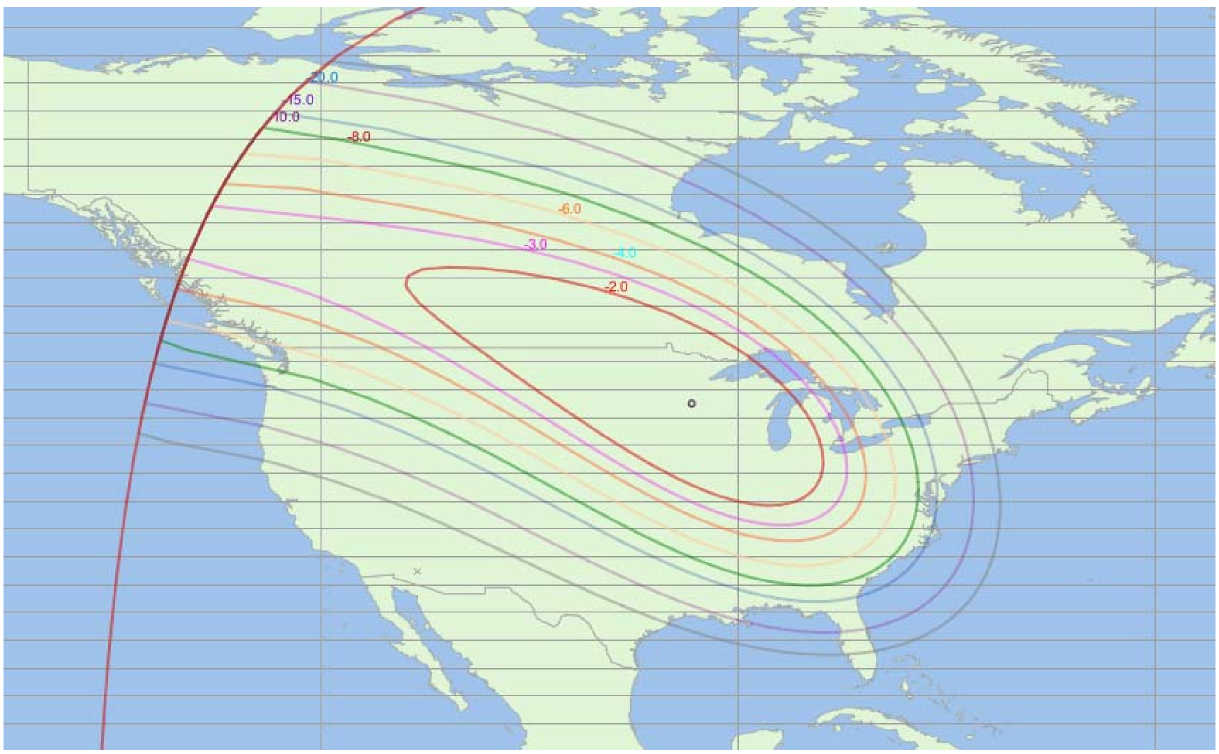
Transmit gain: 40.3 dBi (typical, beam peak).

Peak G/T: 11.1 dB/K

Number of beams within the band 19415.5 – 19584.5 MHz / 29115.5 – 29284.5 MHz: 2 (steerable, to be pointed at the same location so effectively 1 beam).

Downlink EIRP s.d. (maximum to the gateway antenna in the above frequency band): -29.4 dBW/Hz.

Figure A.15.2. Inmarsat-5 F2 gateway transmit beam contour (satellite at 55º W)



(i).b.2 INMARSAT Earth Station

Gateway antenna transmit / receive side lobe contour: ITU-Rec. S.580.

Diameter: 13.2 m

Transmit gain: 69.1 dBi @ 29.25 GHz.

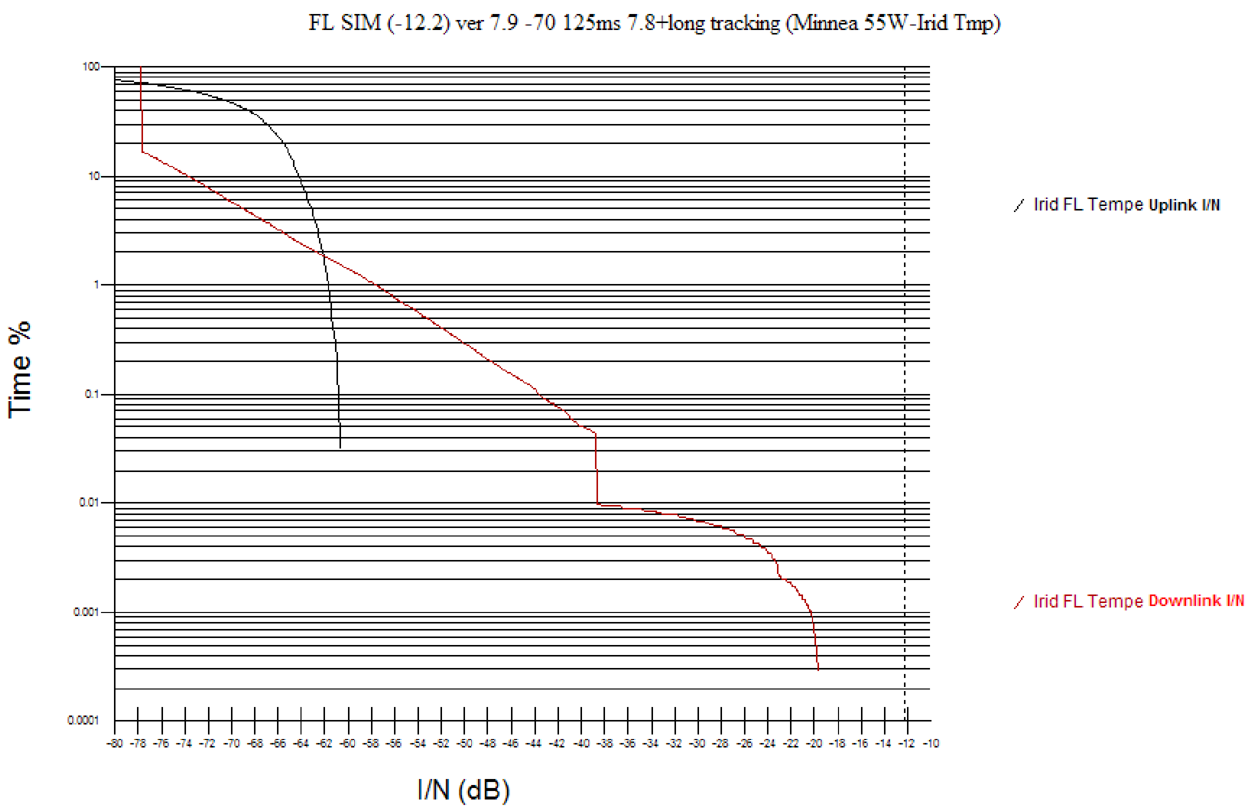
G/T: 41 dB/K

Clear sky uplink p.s.d. (maximum): -70 dBW/Hz.

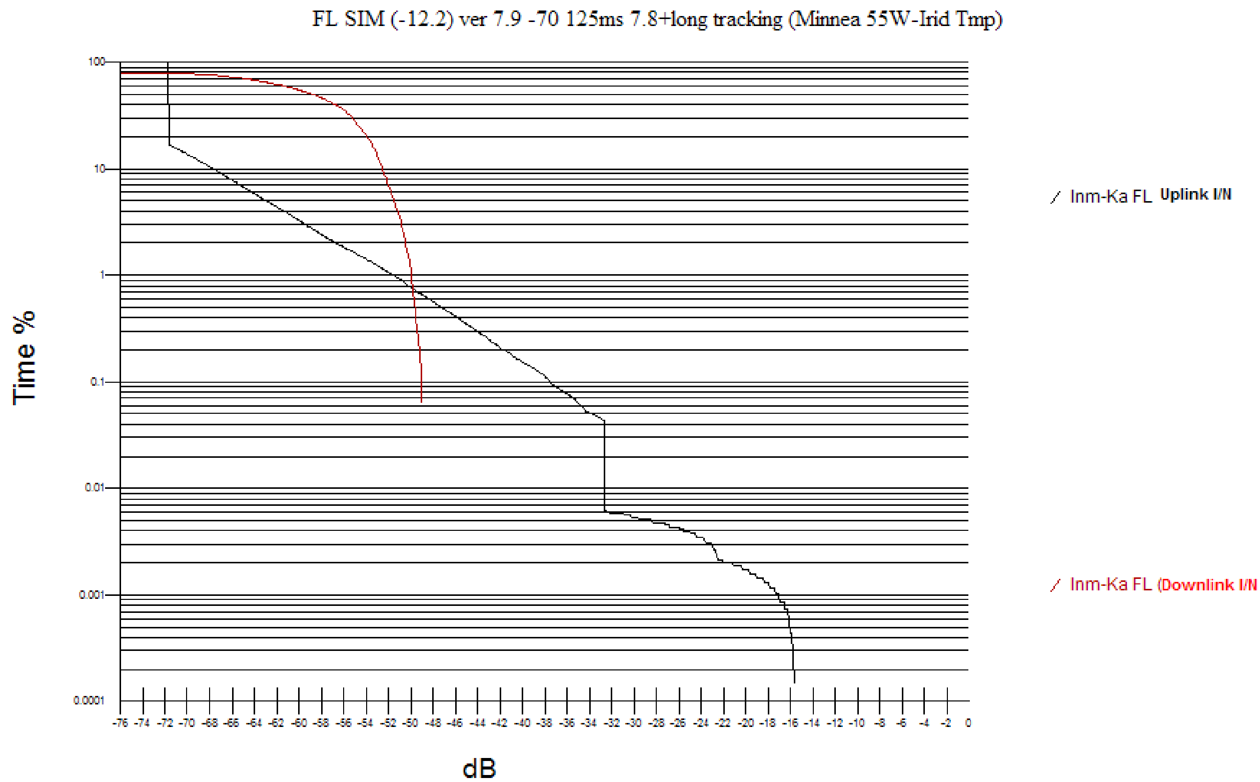
Earth station location: Lino Lakes, Minnesota (45°N, 93.25°W)

(ii) Simulation result

(ii).1 Interference into Iridium



(ii).2 Interference into Inmarsat



A.16 Sharing in the 27.5-29.5 GHz Bands

In addition to FSS allocations, portions of the 27.5-29.5 band are allocated on a primary basis to LMDS and FS. The 27.5-28.35 GHz band is allocated to LMDS on a primary basis and to FSS on a secondary basis. The 29.1-29.25 GHz band is allocated to LMDS on a co-primary basis with MSS feeder links. Compatibility with MSS feeder link operations in the 29.1-29.25 GHz band is addressed above. In addition, there are a limited number of grandfathered FS temporary-fixed facilities authorized to operate in the 27.5-29.5 GHz band. These FS licensees are co-primary with FSS in the 29.25-29.5 GHz band.

Comsearch has conducted a study of the FS and LMDS licensees in the vicinity of the Lino Lakes Gateway and has concluded that there are only three FS licensees and one LMDS licensee that are potentially affected by Inmarsat's proposed operations in this band. None of these licensees has objected to the deployment of the Lino Lakes Gateway on a secondary basis. A copy of Comsearch's report is included in this application as Exhibit C.

The following paragraphs provide an interference analysis between the Lino Lakes Gateway station and LMDS receivers to illustrate that protection of future LMDS deployments is feasible. This analysis concludes that interference from the Lino Lakes Gateway into LMDS receivers is unlikely given the low probability that a receiver would be deployed in close proximity to the gateway and in alignment with gateway transmissions. Moreover, shielding and other interference mitigation techniques could be employed at the gateway to protect LMDS receivers. These conclusions apply equally to potential deployment of FS terminals in the vicinity of the Lino Lakes Gateway, and thus, interference into any future deployment of FS receivers is not likely to occur.

The parameters assumed for the Lino Lakes Gateway are given in Table A.16.1 below and the assumed LMDS parameters are given in Table A.16.2.

Table A.16.1. Lino Lakes Gateway Station Parameters

Uplink Frequency of operation	28.0	GHz
Maximum uplink Power density	-6.85	dBW/MHz
Earth station antenna transmit gain @ 28.5 GHz	68.9	dBi
Earth station antenna pattern	Rec 580	
Latitude of Earth Station	45°7' 56"1	N
Longitude of Earth Station	93°5' 44"	W
Orbital location of the Inmarsat-5 F2 satellite	55	deg W
Earth station height above the terrain	9.5	meters

Table A.16.2. LMDS System Parameters

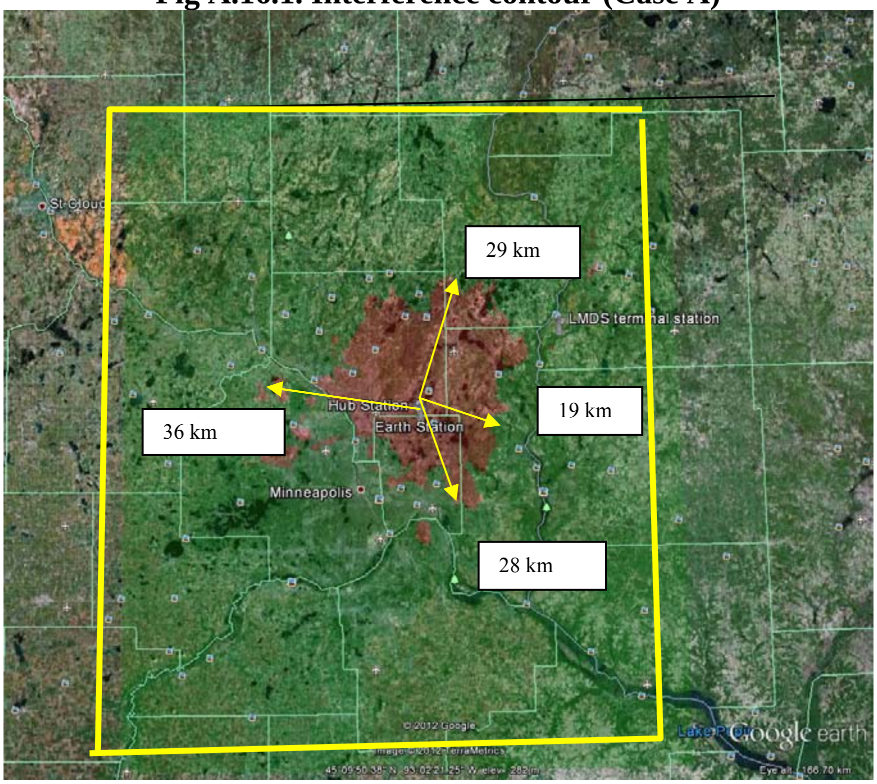
Uplink Frequency of operation	28.0	GHz
Assumed Transmit Power density	-14.45	dBW/MHz
Hub Station Antenna Gain	35	dBi
LMDS Receiver Station Antenna gain	31	dBi
Antenna radiation pattern	Rec 699	
Assumed Hub Station Location (antenna height 20m above the ground)	See Table A.18.3 below	
Assumed LMDS Station location (antenna height 20m above the ground)	Varied over the test area	
System Noise Figure	6	dB
Assumed I/N criterion	-10	dB

The propagation models used were:

- Wanted LMDS link: P 525 and P 530
- Interfering FSS uplink: P 452

Initially a worst-case analysis was performed where the LMDS hub station was co-located with the gateway site and the LMDS receive antenna was pointed directly towards the hub/gateway station (Case A, see Fig A.16.1). In this scenario, based on the assumed parameters the required separation distances from the proposed gateway site to protect LMDS systems vary from 19 km to the east to 36 km to the west and from 29 km to the north to 28 km to the south.

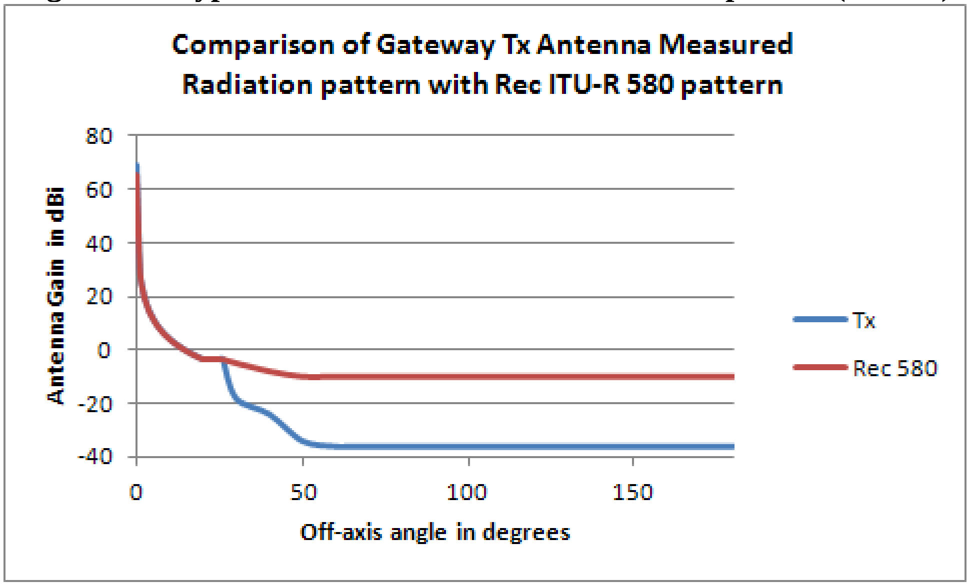
Fig A.16.1. Interference contour (Case A)



Note: The boundaries for the area analysis are shown in yellow lines

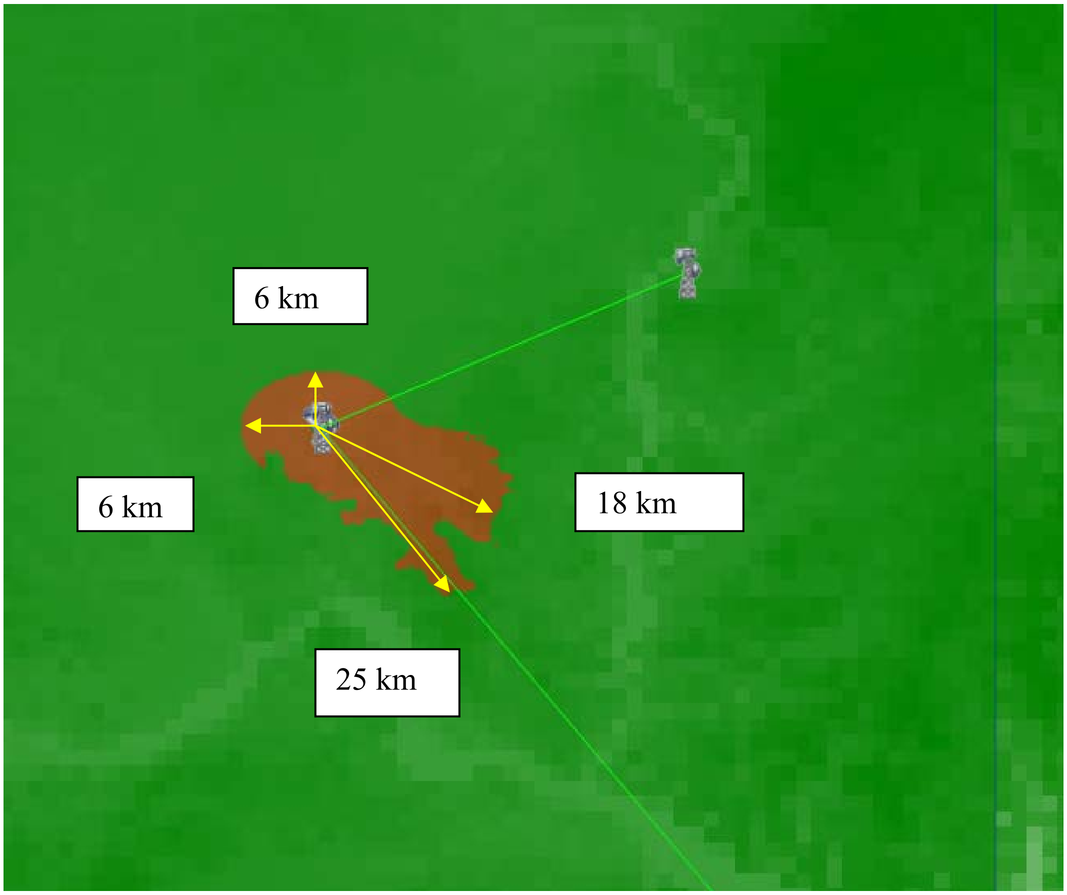
In practice various improvement factors would apply, and thus this scenario is highly unlikely to arise. This analysis is based on the standard Rec. 580 pattern for the gateway antenna. However, actual patterns for real antennas typically provide significantly more discrimination. As an example, Figure A.16.2 shows a typical measured transmit pattern for a 13.2m Ka-band antenna.

Fig A.16.2. Typical measured earth station antenna pattern (28GHz)



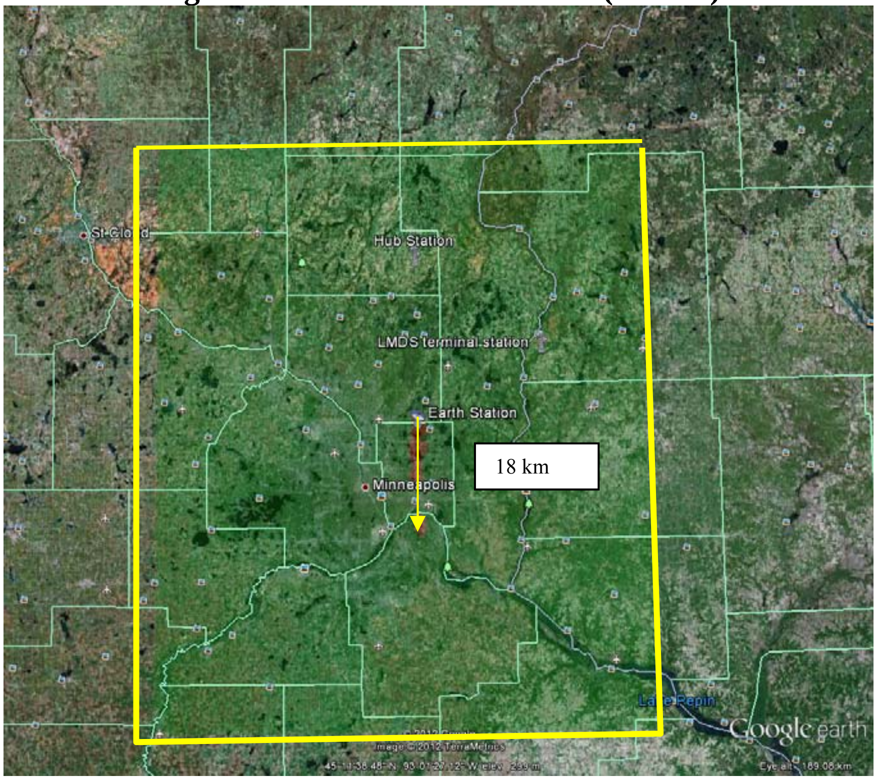
Repeating the analysis using this antenna pattern (Case B) effectively removes any interference potential in all directions, except in the direction of the GSO satellite, as shown in Fig A.16.3. It should also be noted that the area to the south-east of the planned gateway site does not appear to be a likely location for LMDS receivers, since it has very low population density and contains several lakes.

Fig A.16.3. Interference contour (Case B)



In most practical cases, the LMDS receiver will not point straight at the gateway station. When the victim LMDS receive station is pointing away from the interfering gateway station, the required separation distances will be much smaller. Two examples of this more realistic scenario were modeled. In the first example (Case C), when the LMDS hub station was located at 45.5N and 93.1W, the required separation distances varied from 1.5 km to the east to 18 to the South (Fig A.16.4). In the second example (Case D), when the LMDS hub station was located at 45.2N and 92.5W, the required separation distances varied from 1.5 km to the East to 18.5 km to the West (Fig A.16.5). A summary of the results is also give in Table A.16.3. It should be noted that Case C and Case D were computed using the Rec 580 earth station antenna pattern.

Fig A.16.4. Interference contour (Case C)



Note: The boundaries for the area analysis are shown in yellow lines

Fig A.16.5. Interference contour (Case D)

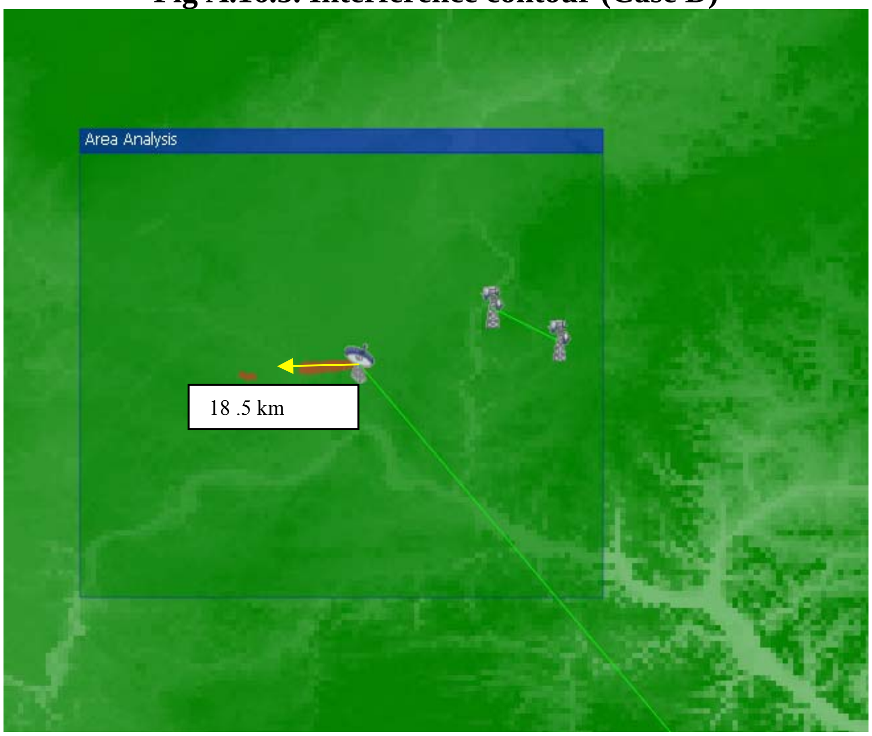


Table A.16.3. Required separation distances from the Lino Lakes Gateway site

	Hub and Gateway co-located Hub: Lat 45° 7' 56"N; Long 93° 5' 44" W GW: Lat: 45° 7' 56"N; Long 93° 5' 44" W (Fig A.18.1)	Hub and Gateway not co-located Hub: Lat: 45.5N; Long: 93.1W GW: Lat: 45° 7' 56"N; Long 93° 5' 44" W (Fig A.18.2b)	Hub and Gateway not co-located Hub: Lat: 45.2N; Long: 92.5W GW: Lat: 45.1N; Long 93.1 W (Fig A.18.3)
Direction	Distance in km	Distance in km	Distance in km
North	29	2	2.5
West	36	2.27	18.5
East	19	1.5	1.5
South	28	18	2

Based on the limited extent of the interference contours in Fig A.16.2, A.16.4 and A.16.5, it can be concluded that the probability that the planned gateway would cause interference to new LMDS deployments is very low. In addition, mitigation, such as site shielding, can be deployed at the gateway to eliminate any interference in the unlikely event that it is required.

Based on these analyses, Inmarsat concludes that its operations will be able to protect LMDS stations.

A.17 Orbital Debris Mitigation Plan (§25.114(d)(14))

Inmarsat has incorporated the material objectives of §25.114(d)(14) of the Commission's Rules into the design of the satellite through the satellite's Technical Specifications, Statement of Work and Test Plans. The Statement of Work includes provisions to review orbital debris mitigation, and compliance with §25.114(d)(14), as part of the preliminary design review ("PDR") and the critical design review ("CDR") and to incorporate its 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.

A.17.1 Spacecraft Hardware Design

The satellite is based on the heritage Boeing 702 HP flight proven platform.

Inmarsat will ensure that the satellite does not release any 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 satellite manufacturer, Inmarsat has assessed and limited the probability of the satellite becoming a source of debris by collisions with small debris or meteoroids of less than one centimeter in diameter that could cause loss of control and prevent post-mission disposal. Inmarsat and the satellite manufacturer have taken steps to limit the effects of such collisions through shielding, the placement of components, and the use of redundant systems.

The Inmarsat-5 F2 satellite includes redundant TT&C and propulsion subsystems to ensure successful end-of-life disposal. The spacecraft TT&C system, vital for orbit raising, will be extremely rugged with regard to meteoroids smaller than 1 cm, by virtue of its redundancy, shielding, separation of components and physical characteristics. The TT&C subsystem will have no single points of failure. Near-omni-directional antenna coverage is provided through the use of a combination of independent bicone and forward/aft pipe antennas. These antenna feeds are extremely rugged and capable of providing adequate coverage even if struck, bent or otherwise damaged by a small or medium sized particle. The command receivers and decoders and telemetry encoders and transmitters will be located within a shielded area and will be totally redundant and physically separated. Two shielded xenon tanks and a redundant pairs of thrusters provide the energy for orbit-raising.

A.17.2 Accidental Explosion Assessment (§25.144(d)(14)(ii))

In conjunction with the satellite manufacturer, Inmarsat will assess and limit the probability of accidental explosions during and after completion of mission operations through a failure mode verification analysis. The satellite manufacturer will take steps to ensure that debris generation will not result from the conversion of energy sources on board the satellite into energy that fragments the satellite. All pressures, including those of the batteries, will be monitored by telemetry. At end-of-life and once the satellite has been placed into its final disposal orbit, Inmarsat will remove 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.17.3 Safe Flight Profiles (§25.144(d)(14)(iii))

In considering current and planned satellites that may have a station-keeping volume that overlaps the Inmarsat-5 F2 satellite, Inmarsat has reviewed the lists of FCC licensed satellite networks, as well as those that are currently under consideration by the FCC. In addition, networks for which a request for coordination has been published by the ITU within ±0.15° of 55.0° W.L. have also been reviewed.

There are no FCC licensed satellite networks nor are there any pending applications before the Commission to operate a satellite within ±0.15° of 55.0° W.L. With respect to published ITU filings, the only non-Inmarsat network filed within this sub-arc is the UAE's YAHSAT-G5-55W network at 55° W.L. Inmarsat can find no evidence that this network is being progressed towards launch.

Based on the preceding, Inmarsat therefore concludes that physical coordination of the Inmarsat-5 F2 satellite with another party is not required at the present time.

A.17.4 Post-Mission Disposal

At the end of the operational life of the Inmarsat-5 F2 satellite, Inmarsat will maneuver the satellite 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" = 93.1 m^2

"M" = Dry Mass of Satellite = 3663 kg

"CR" = Solar Pressure Radiation Coefficient = 1.29

Therefore the Minimum Disposal Orbit Perigee Altitude is calculated as:

= 36,021 km + 1000 x CR x A/M

= 36,021 km + 1000 x 1.29 x 93.1/3663

= 36,053.8 km

= 267.8 km above GSO (35,786 km)

To provide adequate margin, the disposal orbit will be increased to at least 300 km. This will require approximately 1.4 kg of xenon propellant, taking account of all fuel measurement uncertainties, which will be allocated and reserved in order to perform the final orbit raising maneuver.

ENGINEERING CERTIFICATION

I hereby declare, under penalty of perjury, that the following statements are true and correct to the best of my information and belief:

(i) I am the technically qualified person responsible for the engineering information contained in the foregoing Application,

(ii) I am familiar with Part 25 of the Commission's Rules, and

(iii) I have either prepared or reviewed the engineering information contained in the foregoing Application and found it to be complete and accurate.

/s/____________________________________

Jonas Eneberg
Director,
International Spectrum Management
Inmarsat

Dated: April 24, 2012