Attachment A

TECHNICAL ANNEX

A.1 Scope and Purpose

The purpose of this Attachment is to provide the Commission with the technical characteristics of the INMARSAT-KA 63W 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))

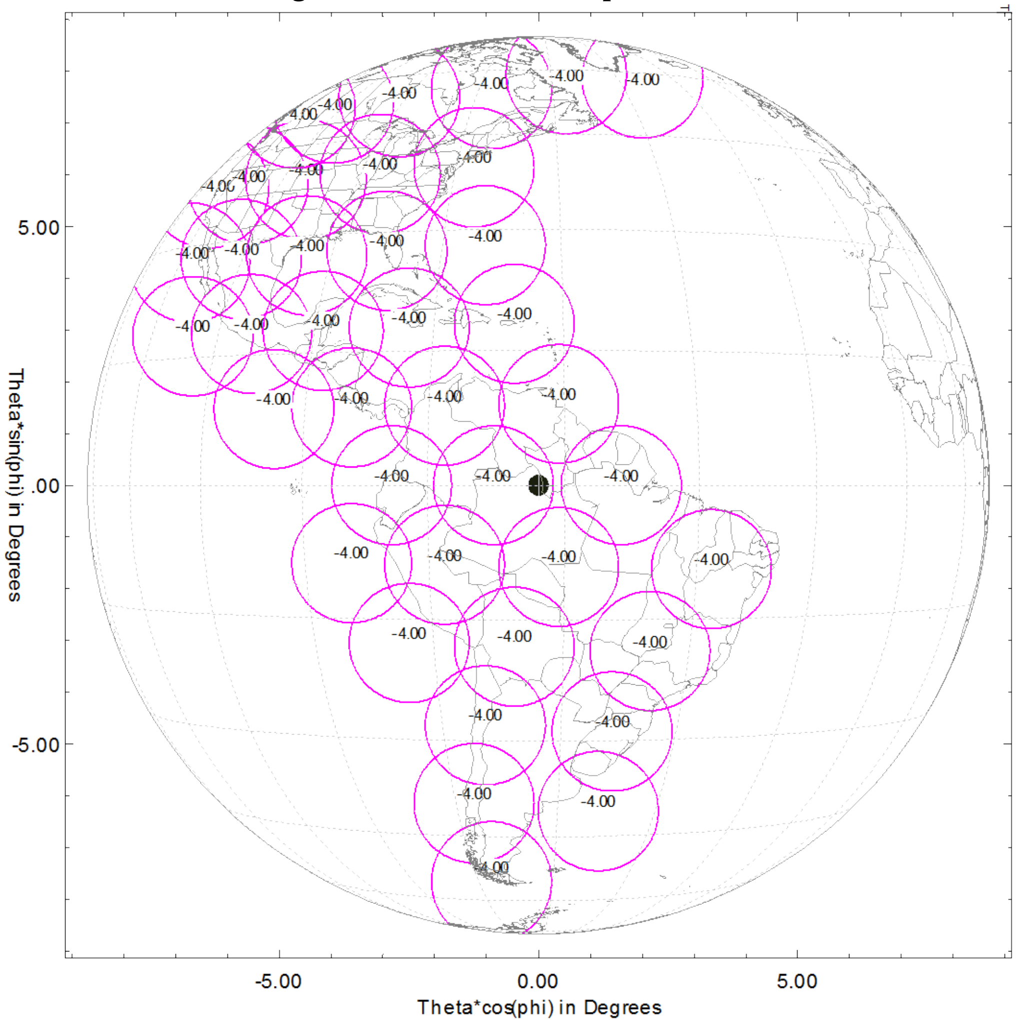
The INMARSAT-KA 63W satellite will operate at the nominal 63° W.L. orbital location and will provide fixed-satellite service ("FSS") to North, Central and South America, as well as the Caribbean.

In order to avoid physical collision with the TELSTAR 14R (ESTRELA DO SUL 2)satellite which is currently operating at 63° W.L. orbital location, Inmarsat proposes to offset the INMARSAT-KA 63W satellite by 0.15° from 63° W.L. and to centre the station-keeping box at 62.85° W.L.

The INMARSAT-KA 63W satellite will operate in the 28.1-29.1 GHz and 29.5-30.0 GHz bands (Earth-to-space) and the 18.3-19.3 GHz and 19.7-20.2 GHz bands (space-to-Earth). The satellite will employ forward links (gateway-to-end user transmissions) and return links (end user-to-gateway transmissions) in separate portions of these frequency bands.

Gateway coverage will be provided through two identical steerable gateway spot beams, each capable of providing all the necessary gateway communications for the satellite. The use of two such gateway beams and associated gateway earth stations provides redundancy in the event of failure as well as the ability to provide gateway diversity and hence the ability to avoid causing interference to, or receiving interference from, non-geostationary satellite systems operating in the 28.6-29.1 GHz and 18.8-19.3 GHz bands. The final locations of the gateway earth stations have not yet been determined although they will be located sufficiently far from each other that gateway diversity can be effective. Coverage will be provided for end-user communications through 40 fixed-coverage spot beams, which are shown (for information only) in Figure A.2-1 below.

Figure A.2-1. User Link Spot Beams



Inmarsat does not anticipate that any TT&C earth stations will be located within U.S. territory and therefore is not requesting that this authorization cover TT&C operations at this time.

However, information concerning the TT&C aspects of the INMARSAT-KA 63W satellite is provided in this application. TT&C transmissions will occur in the Ka-band for both on-station operation and during transfer orbit and emergency purposes.

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

The INMARSAT-KA 63W satellite antenna gain contours for the receive and transmit beams, as required by §25.114(d)(3), are given in GXT format. Due to the number of GXT files associated with the INMARSAT-KA 63W satellite, the GXT files have not been embedded in the Schedule S form, but rather are being provided to the Commission in a separate data package.

Note that for the two steerable gateway 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))

Detail of the INMARSAT-KA 63W satellite's frequency plan is given in the associated Schedule S submission. For additional clarification these frequency plans are shown diagrammatically in Figures A.4-1 and A.4-2 below for the forward (gateway-to-end user) and return (end user-to-gateway) links. All channels are nominally 32 MHz useful bandwidth. The spectrum accessed by the gateway earth stations is shown in blue and that accessed by the end-user terminals is shown in yellow.

The gateway spectrum employs full frequency re-use by means of orthogonal polarizations. The end-user link spectrum employs an average four-fold frequency re-use by spatial separation of co-frequency beams.

The gateway links operate in Right Hand Circular Polarization (RHCP) and Left Hand Circular Polarization (LHCP) on both uplink and downlink. The end-user links operate in RHCP on the uplink and LHCP on the downlink.

Figure A.4-1. Forward Link Frequency Plan

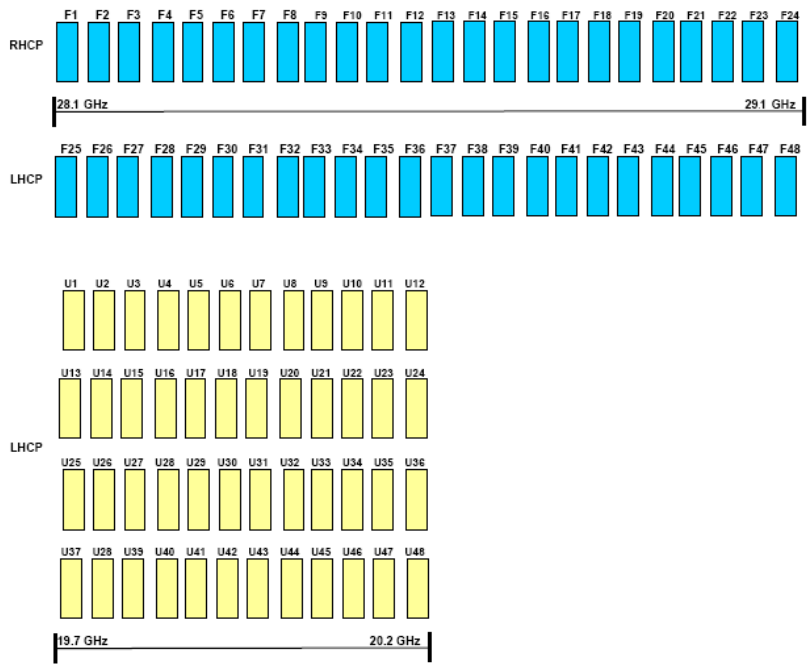
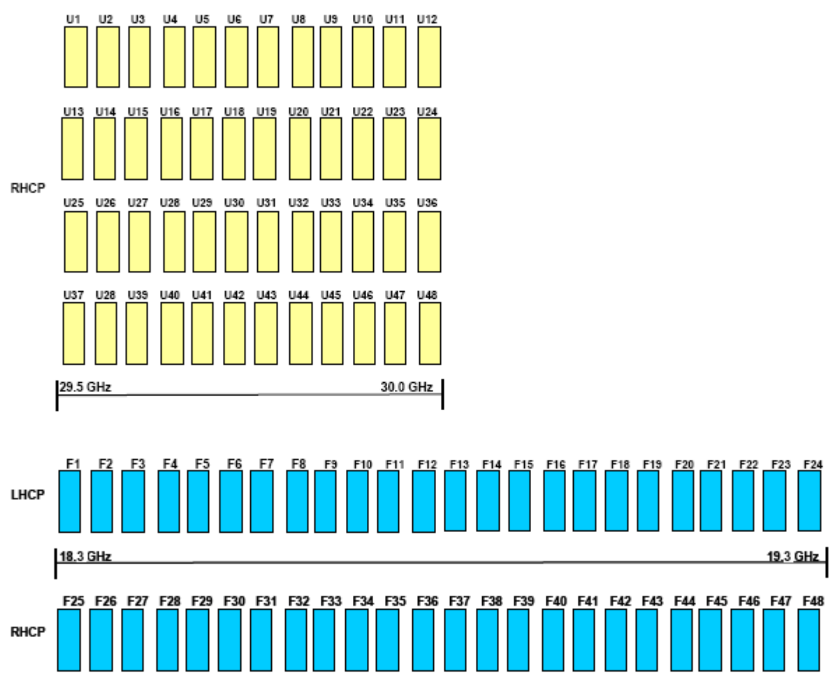


Figure A.4-2. Return Link Frequency Plan



As shown in Figures A.4-1 and A.4-2 above there are 48 channels available in the forward link direction and 48 in the return link direction. These 48 channels in each direction can be flexibly allocated to the 40 user link spot beams such that up to three channels may be used in each user beam and connected to either of the two gateway beams. This flexible arrangement is defined in the associated Schedule S, giving rise to 240 channel-beam routings in the forward direction and 240 channel-beam routings in the return direction.

A.5 Transponder Configuration

In the forward link direction (gateway-to-user) each channel is dedicated to one active TWTA (Travelling Wave Tube Amplifier) in the satellite. In the return link direction (user-to-gateway) four channels are shared by each active TWTA due to the lower required downlink EIRP towards the gateway earth stations. There are therefore a total of 60 simultaneously active TWTAs, excluding TT&C functions.

Note in the associated Schedule S the term “transponder” refers to the 32 MHz bandwidth spectrum channel and not to the number of active TWTAs.

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

The INMARSAT-KA 63W satellite will provide a variety of two-way communications services to small user terminals including broadband Internet access, multimedia, voice and other data 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.

Typical earth stations will consist of:

- End-user terminals which will employ antennas in the range of 60 cm antenna diameter.

- Gateway earth stations, the locations of which have not yet been determined, that will have antenna diameters in the 7-13 meter range.

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

As noted above in Section A.2, Inmarsat does not anticipate that any TT&C earth stations will be located within U.S. territory, and therefore is not requesting that this authorization cover TT&C operations at this time. Inmarsat is providing the following description of INMARSAT-KA 63W TT&C operations for informational purposes only. The information 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. The TT&C sub-system will operate at the edges of the 30/20 GHz frequency bands during all phases of the mission (i.e., on-station operations as well as launch and early orbit phases and 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 two uplink gateway beams.

A summary of the TT&C subsystem characteristics is given in Table A7-1.

Table A7-1: TT&C Performance Characteristics

Command/Ranging Frequencies	29,505.0 MHz 29,507.5 MHz
Uplink Flux Density (Minimum)	Omni Rx antennas: > -70 dBW/m^2 Comms Rx antenna: > -90 dBW/m^2
Satellite Receive Antenna Types and Modes of Operation	Omni antennas during transfer orbit and on-station emergencies, and for telecommand from earth stations other than the gateways. Communications antenna during on-normal on-station operations for telecommand from gateway/TT&C earth stations.
Polarization of Satellite Rx/Tx Antennas	RHCP for omni Rx antennas LHCP for omni Tx antennas RHCP for communications Rx antenna LHCP for communications Tx antenna
Telemetry/Ranging Frequencies	19,705.0 MHz 19,707.5 MHz
Satellite Transmit Antenna Types and Modes of Operation	Omni antennas during transfer orbit and on-station emergencies and for telemetry to earth stations other than gateways. Communications antenna during on-normal on-station operations for telemetry to gateway/TT&C earth stations.
Maximum Downlink EIRP	21.1 dBW (Omni antennas) 44.0 dBW (Communications antenna)

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

The predicted receive and transmit channel filter response performance is given in Table A8-1 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 A8-1 - Typical Receiver and Transmitter Filter Responses

Frequency offset from channel center	Gain relative to channel center frequency (dB)		Comments
	Receive	Transmit	
CF±7 MHz	0.15	0.1	In-Band Value does not exceed these p-p values
CF±9.5 MHz	0.2	0.15	
CF±12 MHz	0.3	0.2	
CF±15 MHz	1	0.4	
CF±16 MHz	2		
CF±20 MHz	-3		Out-of-Band Attenuation is not less than these values
CF±25 MHz		-3	
CF±33 MHz		-25	
CF±36 MHz	-30		

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 18.3-18.8 GHz band. The PFD limits of §25.208(c) are as follows:

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

In addition, §25.208(d) contains PFD limits that apply in the 18.6-18.8 GHz band produced by emissions from a space station under assumed free-space propagation conditions as follows:

- -95 dB(W/m^2) for all angles of arrival. This limit may be exceeded by up to 3 dB for no more than 5% of the time.

§25.208 does not contain any PFD limits that apply in the 18.8-19.3 GHz band 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 18.8-19.3 GHz band 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 limit that applies in this band.

Compliance with all applicable FCC and ITU PFD limits is demonstrated below using a simple worst-case methodology. The maximum downlink EIRP density that the INMARSAT-KA 63W satellite will transmit is 56 dBW in an occupied bandwidth of 32 MHz, which translates into 41 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 -121.06 dBW/m^2 in 1 MHz (i.e., 41 - 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 assured.

In addition, §25.208(d) provides an additional aggregate PFD limit in the 200 MHz wide band 18.6-18.8 GHz of -95 dBW/m^2. In the worst case, this would correspond to a PFD limit of -118 dBW/m^2/MHz (i.e., -95-10*log(200)). As demonstrated in the previous paragraph, downlink transmissions from the INMARSAT-KA 63W satellite will not exceed -121.06 dBW/m^2/MHz at any angle of arrival and therefore compliance with §25.208(d) is also assured.

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[1] The maximum downlink EIRP density of the telemetry transmissions from the INMARSAT-KA 63W satellite will also not exceed -121 dBW/m^2/MHz, as provided in the Schedule S.

A.11 Two Degree Compatibility (§25.138)

No transmissions in the INMARSAT-KA 63W 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.

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, and therefore 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-KA 63W satellite network, which are subject to §25.138, are as follows:

- Uplink: 28.35-28.6 GHz and 29.5-30.0 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;
- 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. 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 from Link Budgets (dBW/Hz)	Clear Sky Uplink Input Power Density Limit of §25.138 (a)(1) (dBW/Hz)	Margin (dB)
7.5 m	-62.7	-56.5	6.2
60 cm	-60	-56.5	3.5

Section A.10 above demonstrates that the maximum PFD that could be transmitted by the INMARSAT-KA 63W satellite, at an elevation angle of 90 degrees, is -121.06 dBW/m^2/MHz and therefore the PFD levels at other elevation angles will necessarily be lower due to the increased spreading loss. All downlink transmissions from the INMARSAT-KA 63W satellite will therefore have at least a 3 dB margin relative to 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-KA 63W satellite network, which are not subject to §25.138, are as follows:

- Uplink: 28.1-28.35 GHz and 28.6-29.1 GHz
- Downlink: 18.8-19.3 GHz

This section demonstrates that transmissions in these bands are two-degree compatible. In order to demonstrate two-degree compatibility, the transmission parameters of the INMARSAT-KA 63W 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. These parameters were derived from the INMARSAT-KA 63W link budgets that are embedded in the

Schedule S form and were used in the interference analysis. The interference calculations assumed a 1 dB advantage for topocentric-to-geocentric conversion, all wanted and interfering carriers are co-polarized and all earth station antennas conform to FCC 25.209.

Note that the bands 18.8-19.3 GHz, 28.1-28.35 GHz and 28.6-29.1 GHz bands are planned for gateway links only in the INMARSAT-KA 63W satellite network. The C/I calculations thus consider only the gateway uplink and gateway downlink interference.

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 positive in all cases.

Table A.11-2. INMARSAT-KA 63W transmission parameters.

Uplink

Carrier ID	Emission Designator	Occupied BW (kHz)	Tx Antenna Gain (dBi)	Uplink EIRP (dBW)	C/I Criterion (dB)	Uplink EIRP density (dBW/kHz)
1	32M0G7W	32000	64	76.4	18.7	31.3

Downlink

Carrier ID	Emission Designator	Occupied BW (kHz)	Rx Antenna Gain (dBi)	Downlink EIRP (dBW)	C/I Criterion (dB)	Downlink EIRP density (dBW/kHz)
1	3M78G7W	3780	61	33.8	17.8	-2.0

Table A.11-3. Summary of the C/I margins (dB)

Uplink

	Interfering Carrier	
Wanted Carrier	Carrier ID	1
	1	24.8

Downlink

	Interfering Carrier	
Wanted Carrier	Carrier ID	1
	1	22.7

A.11.3 Two-degree Analysis between INMARSAT-KA 63W and AMAZONAS-3 at 61 W.L

The AMAZONAS-3 satellite network is licensed with the FCC at 61 W.L. The following calculations shows interference situation between the INMARSAT-KA 63W and AMAZONAS-3 networks. AMAZONAS-3 carrier parameters are obtained from the FCC licence application.

Tables A.11-4 to A.11-7 provide a summary of the uplink and downlink parameters of both networks.

Table A.11-4. Summary of the uplink parameters (INMARSAT-KA 63W)

Carrier ID	Emission Designator	Occupied BW (kHz)	Tx Antenna Gain (dBi)	Uplink EIRP (dBW)	C/I Criterion (dB)
1	32M0G7W	32000.00	64.0	76.4	18.7
2	3M78G7W	3780.00	43.6	49.3	16.2

Table A.11-5. Summary of the downlink parameters (INMARSAT-KA 63W)

Carrier ID	Emission Designator	Occupied BW (kHz)	Rx Antenna Gain (dBi)	Downlink EIRP (dBW)	C/I Criterion (dB)
1	32M0G7W	32000.00	40.4	51.0	18.7
2	3M78G7W	3780.00	61.0	33.8	16.2

Table A.11-6. Summary of the uplink parameters (AMAZONAS-3)

Carrier ID	Emission Designator	Occupied BW (kHz)	Tx Antenna Gain (dBi)	Uplink EIRP (dBW)	C/I Criterion (dB)
1	450M0G7W	450000.00	63.0	82.6	22.9
2	450M0G7W	450000.00	63.0	83.4	20.5
3	45M0G7W	45000.00	63.0	74.1	22.9
4	45M0G7W	45000.00	63.0	72.6	20.5
5	5M60G7W	5600.00	44.9	52.5	19.7
6	4M00G7W	4000.00	46.6	57.2	23.8
7	1M00G7W	1000.00	44.9	51.3	23.8
8	1M40G7W	1400.00	38.9	46.5	19.7
9	45M0G7W	45000.00	63.0	74.6	19.2

Table A.11-7. Summary of the downlink parameters (AMAZONAS-3)

Carrier ID	Emission Designator	Occupied BW (kHz)	Rx Antenna Gain (dBi)	Downlink EIRP (dBW)	C/I Criterion (dB)
1	450M0G7W	450000.00	41.2	64.0	22.9
2	450M0G7W	450000.00	35.2	64.5	20.5
3	45M0G7W	45000.00	41.2	52.5	22.9
4	45M0G7W	45000.00	35.2	52.5	20.5
5	5M60G7W	5600.00	59.3	32.2	19.7
6	4M00G7W	4000.00	59.3	37.0	23.8
7	1M00G7W	1000.00	59.3	31.0	23.8
8	1M40G7W	1400.00	59.3	26.2	19.7
9	45M0G7W	45000.00	35.2	52.5	19.2

The interference calculations assumed a 1 dB advantage for topocentric-to-geocentric conversion, all wanted and interfering carriers are co-polarized and all earth station antennas conform to a sidelobe pattern of 29-25 log(θ). The interference calculations also assume a station keeping box of +/- 0.05 degrees for both satellites.

Tables A.11-8 and A.11-9 show the results of the interference calculations in terms of the uplink and downlink C/I margins, respectively.

In terms of uplink interference to AMAZONAS-3, it can be seen all C/I margins are positive.

As for downlink interference to AMAZONAS-3, C/I margins are positive except for the cases where AMAZONAS-3 carriers 1, 2, 3, 4, and 9 are interfered by INMARSAT-KA 63W carrier 1. The negative C/I margins are between -1.7 dB to -6.0 dB.

According to the AMAZONAS-3 FCC license application the above carriers are all in the forward direction in transponders FWRD 1 – FWRD 9 which occupy the frequency band 19.7-20.2 GHz and transmitted through 9 different spot beams. Inmarsat believes that compatible operation would be achievable through one or combination of the following frequency coordination methods including beam isolation, polarization isolation, band segmentation, and acceptance of slightly higher C/I as compared to the standard 6% noise.

In terms of interference to INMARSAT-KA 63W, the lowest C/I margin is -0.1 dB (in the uplink direction) and -1.3 dB (in the downlink direction) which would be acceptable in this case.

Table A.11-8. Summary of the uplink C/I margins (dB)

Uplink - AMAZONAS-3

	Interfering Carrier (INMARSAT)		
Wanted Carrier (AMAZONAS)	Carrier ID	1	2
	1	10.8	7.5
	2	14.0	10.7
	3	12.3	9.0
	4	13.2	9.9
	5	2.0	**-0.4**
	6	4.1	1.7
	7	4.2	1.6
	8	2.0	**-0.6**
	9	16.5	13.2

Uplink - INMARSAT-KA 63W

	Wanted Carrier (INMARSAT)		
Interfering Carrier (AMAZONAS)	Carrier ID	1	2
	1	28.6	13.3
	2	27.8	12.5

	3	27.1	11.8
	4	28.6	13.3
	5	21.5	6.2
	6	17.1	1.7
	7	15.3	**-0.1**
	8	15.5	0.2
	9	26.6	11.2

Table A.11-9. Summary of the downlink C/I margins (dB)

Downlink - AMAZONAS-3

	Interfering Carrier (INMARSAT)		
Wanted Carrier (AMAZONAS)	Carrier ID	1	2
	1	**-1.7**	5.5
	2	**-3.3**	3.9
	3	**-1.7**	5.5
	4	**-5.3**	1.9
	5	7.4	15.6
	6	9.5	17.7
	7	9.5	17.5
	8	7.4	15.3
	9	**-6.0**	1.2

Downlink - INMARSAT-KA 63W

	Wanted Carrier (INMARSAT)		
Interfering Carrier (AMAZONAS)	Carrier ID	1	2
	1	**-0.8**	14.4
	2	**-1.3**	13.9
	3	0.7	15.9
	4	0.7	15.9
	5	12.0	27.1
	6	5.7	20.8
	7	5.7	20.8
	8	11.9	27.1
	9	0.7	15.9

A.12 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 in the U.S. under FCC decisions. The 18.8-19.3 GHz downlink band is designated exclusively to NGSO FSS in the U.S. 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-KA 63W 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.

The FCC has authorized O3b Limited to operate gateway earth stations in Hawaii and Texas, to access the U.K.-authorized O3b NGSO system using the 28.6-29.1 GHz and 18.8-19.3 GHz bands where NGSO systems are primary under FCC rules. O3b also has pending before the FCC applications for a gateway in Virginia and for mobile user terminals operating with this NGSO system. 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.12.1 shows the pertinent parameters of the INMARSAT-KA 63W network and the O3b system. Notably, the 63° W.L. GSO orbital location is not visible to the O3b Hawaii gateway earth station, or vice versa.

Table A.12.1. Summary of INMARSAT-KA 63W and O3b parameters.

Parameters	INMARSAT-KA 63W	O3b System
Minimum Operational Elevation Angle	10°	3°
Earth Station Uplink Input Power Density	-62.7 dBW/Hz	-55 dBW/Hz
Satellite Rx Antenna Gain	45.4 dBi	34.5 dBi
Satellite Rx System Noise Temp	1346 K	1000 K
Satellite Tx EIRP Density	-20 dBW/Hz	-28.32 dBW/Hz
Earth Station Rx System Noise Temperature	302 K	230 K

The INMARSAT-KA 63W gateway uplink input power density value of -62.7 dBW/Hz is not clear sky, but rather assumes a worst-case faded uplink condition.

O3b Hawaii gateway earth station

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-KA 63W network. Any location of an O3b satellite further west will necessarily create a larger angular separation with respect to the INMARSAT-KA 63W network.

For the purpose of interference analysis, the INMARSAT-KA 63W gateway antenna is assumed to be located at the most southern part of the US West Coast area where the smallest angular separation occurs. Based on the assumed INMARSAT-KA 63W 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-KA 63W gateway can be determined.

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-KA 63W gateway antenna location in both uplink and downlink directions.

Table A.12.2a shows the predicted interference degradations to the O3b system due to operation of the INMARSAT-KA 63W network and vice versa. The results show that the O3b system is adequately protected. The calculated ΔT/T values in all cases are extremely small, demonstrating the technical compatibility of the INMARSAT-KA 63W satellite network with the operation of O3b's Hawaii gateway.

Table A.12.2a. Worst case interference calculations between INMARSAT-KA 63W and O3b (Hawaii).

Victim network		*O3b (Hawaii GW)*	*INMARSAT-KA 63W*
Interfering network		INMARSAT-KA 63W	O3b (Hawaii GW)
Victim E/S Latitude	degree	21.67	32.88
Victim E/S Longitude	degree	-158.03	-116.81
Uplink			
Frequency band	GHz	28.85	
Interfering E/S uplink p.s.d.	dBW/Hz	-62.7	
Angular separation between interfering E/S and victim satellite	degree	**31.3**	
Interfering E/S off-axis Tx gain	dB	-5.39	
Slant range (interfering path)	km	**10214**	
Free space path loss (Interfering path)	dB	201.83	
Atmospheric losses	dB	1.2	NOT VISIBLE
Victim satellite receive antenna gain	dBi	34.5	
Victim satellite's antenna discrimination towards interfering E/S	dB	20	
Victim satellite Rx noise temperature	km	1000	
No	dBW/Hz	-198.6	
Io	dBW/Hz	-256.6	
Io/No	dB	-58.0	
dT/T	%	0.000158	
Downlink			
Frequency band	GHz		19.05
Interfering satellte downlink EIRP density	dBW/Hz		-28.32
Slant range (interfering path)	km		**10214**
Free space path loss (Interfering path)	dB		198.22
Atmospheric losses	dB		1
Angular separation between interfering satellite and victim E/S	degree		**31.3**
Interfering satellite's antenna dicrimination towards victim E/S	dB	NOT VISIBLE	20
Victim E/S off-axis Rx gain	dB		-5.39
Victim E/S system noise temperature	km		302
No	dBW/Hz		-203.8
Io	dBW/Hz		-252.9
Io/No	dB		-49.1
dT/T	%		0.001221

O3b Texas gateway earth station

For the purpose of indentifying the worst case interference scenario, two scenarios based on two example locations of the INMARSAT-KA 63W gateway antenna are used in the interference analysis. The first one is co-located with the O3b Texas gateway where there is no satellite antenna discrimination. The second one is at the most southern part of Texas where the smallest angular separation occurs.

Based on the above INMARSAT-KA 63W gateway antenna locations and with the O3b satellite assumed to be at a static 71.18° W.L. (for the first INMARSAT-KA 63W gateway antenna location) and 71.5° W.L. (for the second one), the angular separations (off-axis angles) subtended at the earth station locations can be determined.

In addition, the calculations take into account the fact that the O3b satellites communicating with the O3b Texas gateway provide at least 3 dB of satellite antenna discrimination towards the second example location of the INMARSAT-KA 63W gateway antenna in both uplink and downlink directions.

Table A.12.2b and A.12.2c below show the predicted interference levels to the O3b system due to operation of the INMARSAT-KA 63W network and vice versa. The results show that the O3b system is adequately protected. The calculated $\Delta T/T$ values in all cases are far below 6%, demonstrating the technical compatibility of the INMARSAT-KA 63W satellite network with the operation of O3b's Texas gateway.

Table A.12.2b. Worst case interference calculations between INMARSAT-KA 63W (co-located) and O3b (Texas)

Victim network		*O3b (Texas GW)*	*INMARSAT-KA 63W*
Interfering network		INMARSAT-KA 63W	O3b (Texas GW)
Victim E/S Latitude	degree	34.7	34.7
Victim E/S Longitude	degree	-99.3	-99.3
Uplink			
Frequency band	GHz	28.85	28.85
Interfering E/S uplink p.s.d.	dBW/Hz	-62.7	-55
Angular separation between interfering E/S and victim satellite	degree	**14.3**	**14.3**
Interfering E/S off-axis Tx gain	dB	3.12	3.12
Slant range (interfering path)	km	**10753**	**38237**
Free space path loss (Interfering path)	dB	202.28	213.29
Atmospheric losses	dB	1.2	1.2
Victim satellite receive antenna gain	dBi	34.5	45.4
Victim satellite's antenna discrimination towards interfering E/S	dB	**0**	**0**
Victim satellite Rx noise temperature	K	1000	1346
No	dBW/Hz	-198.6	-197.3
Io	dBW/Hz	-228.6	-221.0
Io/No	dB	-30.0	-23.7
dT/T	%	0.100956	0.429713
Downlink			
Frequency band	GHz	19.05	19.05
Interfering satellite downlink EIRP density	dBW/Hz	-20	-28.32
Slant range (interfering path)	km	**38237**	**10753**
Free space path loss (Interfering path)	dB	209.69	198.67
Atmospheric losses	dB	1	1
Angular separation between interfering satellite and victim E/S	degree	**14.3**	**14.3**
Interfering satellite's antenna dicrimination towards victim E/S	dB	**0**	**0**
Victim E/S off-axis Rx gain	dB	3.12	3.12
Victim E/S system noise temperature	K	230	302
No	dBW/Hz	-205.0	-203.8
Io	dBW/Hz	-227.6	-224.9
Io/No	dB	-22.6	-21.1
dT/T	%	0.550804	0.780956

Table A.12.2c. Worst case interference calculations between INMARSAT-KA 63W (non co-located) and O3b (Texas)

Victim network		*O3b (Texas)*	*INMARSAT-KA 63W*
Interfering network		INMARSAT-KA 63W	O3b (Texas)
Victim E/S Latitude	degree	34.7	26.34
Victim E/S Longitude	degree	-99.3	-97.88
Uplink			
Frequency band	GHz	28.85	28.85
Interfering E/S uplink p.s.d.	dBW/Hz	-62.7	-55
Angular separation between interfering E/S and victim satellite	degree	**12.1**	**14.3**
Interfering E/S off-axis Tx gain	dB	4.93	3.12
Slant range (interfering path)	km	**10064**	**38237**
Free space path loss (Interfering path)	dB	201.70	213.29
Atmospheric losses	dB	1.2	1.2
Victim satellite receive antenna gain	dBi	34.5	45.4
Victim satellite's antenna discrimination towards interfering E/S	dB	**3**	**3**
Victim satellite Rx noise temperature	K	1000	1346
No	dBW/Hz	-198.6	-197.3
Io	dBW/Hz	-229.2	-224.0
Io/No	dB	-30.6	-26.7
dT/T	%	0.087705	0.215367
Downlink			
Frequency band	GHz	19.05	19.05
Interfering satellite downlink EIRP density	dBW/Hz	-20	-28.32
Slant range (interfering path)	km	**38237**	**10064**
Free space path loss (Interfering path)	dB	209.69	198.10
Atmospheric losses	dB	1	1
Angular separation between interfering satellite and victim E/S	degree	**14.3**	**12.1**
Interfering satellite's antenna dicrimination towards victim E/S	dB	**3**	**3**
Victim E/S off-axis Rx gain	dB	3.12	4.93
Victim E/S system noise temperature	K	230	302
No	dBW/Hz	-205.0	-203.8
Io	dBW/Hz	-230.6	-225.5
Io/No	dB	-25.6	-21.7
dT/T	%	0.276056	0.678455

O3b Virginia gateway earth station

For the purpose of identifying the worst case interference scenario, two scenarios based on two example locations of the INMARSAT-KA 63W gateway antenna are used in the interference analysis. The first one is co-located with the O3b Virginia gateway where there is no satellite antenna discrimination. The second one is at the most southern part of Texas where the smallest angular separation occurs.

Based on the above INMARSAT-KA 63W gateway antenna locations and with the O3b satellite assumed to be at a static 72.06° W.L. (for the first INMARSAT-KA 63W gateway antenna location) and 66.16° W.L. (for the second one), the angular separations (off-axis angles) subtended at the earth station locations can be determined.

In addition, the calculations take into account the fact that the O3b satellites communicating with the O3b Virginia gateway provide at least 3 dB of satellite antenna discrimination towards the second example location of the INMARSAT-KA 63W gateway antenna in both uplink and downlink directions.

Table A.12.2d and A.12.2e below show the predicted interference levels to the O3b system due to operation of the INMARSAT-KA 63W network and vice versa. The results show that the O3b system is adequately protected. The calculated ΔT/T values in all cases are far below 6%, demonstrating the technical compatibility of the INMARSAT-KA 63W satellite network with the operation of O3b's Virginia gateway.

Table A.12.2d. Worst case interference calculations between INMARSAT-KA 63W (co-located) and O3b (Virginia)

Victim network		*O3b (Virginia)*	*INMARSAT-KA 63W*
Interfering network		INMARSAT-KA 63W	O3b (Virginia)
Victim E/S Latitude	degree	34.75	34.75
Victim E/S Longitude	degree	-77.48	-77.48
Uplink			
Frequency band	GHz	28.85	28.85
Interfering E/S uplink p.s.d.	dBW/Hz	-62.7	-55
Angular separation between interfering E/S and victim satellite	degree	**16.5**	**16.5**
Interfering E/S off-axis Tx gain	dB	1.56	1.56
Slant range (interfering path)	km	**10408**	**37581**
Free space path loss (Interfering path)	dB	201.99	213.14
Atmospheric losses	dB	1.2	1.2
Victim satellite receive antenna gain	dBi	34.5	45.4
Victim satellite's antenna discrimination towards interfering E/S	dB	**0**	**0**
Victim satellite Rx noise temperature	K	1000	1346
No	dBW/Hz	-198.6	-197.3
Io	dBW/Hz	-229.8	-222.4
Io/No	dB	-31.2	-25.1
dT/T	%	0.075351	0.311057
Downlink			
Frequency band	GHz	19.05	19.05
Interfering satellite downlink EIRP density	dBW/Hz	-20	-28.32
Slant range (interfering path)	km	**37581**	**10408**
Free space path loss (Interfering path)	dB	209.54	198.39
Atmospheric losses	dB	1	1
Angular separation between interfering satellite and victim E/S	degree	**16.5**	**16.5**
Interfering satellite's antenna dicrimination towards victim E/S	dB	**0**	**0**
Victim E/S off-axis Rx gain	dB	1.56	1.56
Victim E/S system noise temperature	K	230	302
No	dBW/Hz	-205.0	-203.8
Io	dBW/Hz	-229.0	-226.1
Io/No	dB	-24.0	-22.3
dT/T	%	0.398711	0.582883

Table A.12.2e. Worst case interference calculations between INMARSAT-KA 63W (non co-located) and O3b (Virginia)

Victim network		*O3b (Virginia)*	*INMARSAT-KA 63W*
Interfering network		INMARSAT-KA 63W	O3b (Virginia)
Victim E/S Latitude	degree	34.75	26.34
Victim E/S Longitude	degree	-77.48	-97.88
Uplink			
Frequency band	GHz	28.85	28.85
Interfering E/S uplink p.s.d.	dBW/Hz	-62.7	-55
Angular separation between interfering E/S and victim satellite	degree	**12.1**	**18.4**
Interfering E/S off-axis Tx gain	dB	4.93	0.38
Slant range (interfering path)	km	**10029**	**37581**
Free space path loss (Interfering path)	dB	201.67	213.14
Atmospheric losses	dB	1.2	1.2
Victim satellite receive antenna gain	dBi	34.5	45.4
Victim satellite's antenna discrimination towards interfering E/S	dB	**3**	**3**
Victim satellite Rx noise temperature	K	1000	1346
No	dBW/Hz	-198.6	-197.3
Io	dBW/Hz	-229.1	-226.6
Io/No	dB	-30.5	-29.3
dT/T	%	0.088319	0.118715
Downlink			
Frequency band	GHz	19.05	19.05
Interfering satellite downlink EIRP density	dBW/Hz	-20	-28.32
Slant range (interfering path)	km	**37581**	**10029**
Free space path loss (Interfering path)	dB	209.54	198.06
Atmospheric losses	dB	1	1
Angular separation between interfering satellite and victim E/S	degree	**18.4**	**12.1**
Interfering satellite's antenna dicrimination towards victim E/S	dB	**3**	**3**
Victim E/S off-axis Rx gain	dB	0.38	4.93
Victim E/S system noise temperature	K	230	302
No	dBW/Hz	-205.0	-203.8
Io	dBW/Hz	-233.2	-225.5
Io/No	dB	-28.2	-21.7
dT/T	%	0.152168	0.683199

O3b User Terminal ("UT")

For the purpose of identifying the worst case interference scenario, it is assumed that the INMARSAT-KA 63W gateway antenna is co-located with the O3b UT at the most southern part of Texas where the smallest angular separation occurs.

Based on the above INMARSAT-KA 63W gateway antenna location and with the O3b satellite assumed to be at a static 72.0° W.L., the angular separation (off-axis angle) subtended at the victim earth station locations can be determined.

In addition, the calculations take into account the fact that the O3b satellites communicating with the O3b Texas gateway provide at least 3 dB of satellite antenna discrimination towards the example location of the INMARSAT-KA 63W gateway antenna in both uplink and downlink directions.

Table A.12.2d below shows the predicted interference levels to the O3b system due to operation of the INMARSAT-KA 63W network and vice versa. The results show that the O3b system is adequately protected. The calculated ΔT/T values in all cases are far below 6%, demonstrating the technical compatibility of the INMARSAT-KA 63W satellite network with the operation of O3b's UT in the continental United States.

Table A.12.2d. Worst case interference calculations between INMARSAT-KA 63W (co-located) and O3b (UT)

Victim network		*O3b (UT)*	*INMARSAT-KA 63W*
Interfering network		INMARSAT-KA 63W	O3b (UT)
Victim E/S Latitude	degree	26.34	26.34
Victim E/S Longitude	degree	-97.88	-97.88
Uplink			
Frequency band	GHz	28.85	28.85
Interfering E/S uplink p.s.d.	dBW/Hz	-62.7	-55
Angular separation between interfering E/S and victim satellite	degree	**12.1**	**12.1**
Interfering E/S off-axis Tx gain	dB	4.93	4.93
Slant range (interfering path)	km	**10034**	**37724**
Free space path loss (Interfering path)	dB	201.67	213.18
Atmospheric losses	dB	1.2	1.2
Victim satellite receive antenna gain	dBi	34.5	45.4
Victim satellite's antenna discrimination towards interfering E/S	dB	**0**	**0**
Victim satellite Rx noise temperature	K	1000	1346
No	dBW/Hz	-198.6	-197.3
Io	dBW/Hz	-226.1	-219.0
Io/No	dB	-27.5	-21.7
dT/T	%	0.176043	0.670328
Downlink			
Frequency band	GHz	19.05	19.05
Interfering satellite downlink EIRP density	dBW/Hz	-20	-28.32
Slant range (interfering path)	km	**37724**	**10034**
Free space path loss (Interfering path)	dB	209.57	198.07
Atmospheric losses	dB	1	1
Angular separation between interfering satellite and victim E/S	degree	**12.1**	**12.1**
Interfering satellite's antenna dicrimination towards victim E/S	dB	**0**	**0**
Victim E/S off-axis Rx gain	dB	4.93	4.93
Victim E/S system noise temperature	K	230	302
No	dBW/Hz	-205.0	-203.8
Io	dBW/Hz	-225.6	-222.5
Io/No	dB	-20.7	-18.7
dT/T	%	0.859223	1.361803

Other NGSO networks

In order to demonstrate compatibility between the INMARSAT-KA 63W 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.12.3 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.12.3. 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.12.4 shows the results of interference calculations from the INMARSAT-KA 63W 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-KA 63W 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.

Table A.12.4. Worst case interference calculations.

Victim network Interfering network		GESN / ATCONTACT INMARSAT-KA-63W	INMARSAT-KA-63W GESN / ATCONTACT
Uplink:			
Frequency band	GHz	29	29
Interfering uplink input power density	dBW/Hz	-62.65	-63.45
Angular separation	degrees	27.4	27.4
Slant range (Interfering path)	km	21046	40586
Space loss (Interfering path)	dB	208.2	213.9
Atmospheric & scintillation losses	dB	1.2	1.2
Victim satellite receive antenna gain	dBi	46.5	39
Victim satellite Rx system noise temperature	K	504	794
No	dBW/Hz	-201.6	-199.6
Io	dBW/Hz	-232.5	-246.5
Io/No	dB	-30.9	-46.9
dT/T	%	0.08	0.002
Downlink:			
Frequency band	GHz	19	19
Interfering satellite downlink EIRP density	dBW/Hz	-19.05	-18
Slant range (Interfering path)	km	40586	21046
Space loss (Interfering path)	dB	210.2	204.5
Atmospheric & scintillation losses	dB	1	1
Angular separation	degrees	27.4	27.4
Victim Rx earth station system noise temperature	K	315	300
No	dBW/Hz	-203.6	-203.8
Io	dBW/Hz	-237.2	-230.5
Io/No	dB	-33.6	-26.7
dT/T	%	0.04	0.22

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-KA 63W 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.

A.13 Orbital Debris Mitigation Plan (§25.114(d)(14))

The spacecraft manufacturer for the INMARSAT-KA 63W satellite has not yet been selected and therefore Inmarsat's Orbital Debris Mitigation Plan is necessarily forward looking. Inmarsat plans to reflect the material objectives of §25.114(d)(14) of the Commission's Rules in the design of the satellite through the satellite's Technical Specifications, Statement of Work and Test Plans. The Statement of Work will include provisions to address orbital debris mitigation under the scenarios described in §25.114(d)(14) as part of the preliminary design review ("PDR") and the critical design review ("CDR") and to incorporate the requirements of §25.114(d)(14), as appropriate, into its Test Plan, including a formal Failure Mode Verification Analysis ("FMVA") for orbital debris mitigation involving particularly the TT&C, propulsion and energy systems. During this process Inmarsat will provide the Commission with updated information, as appropriate.

A.13.1 Spacecraft Hardware Design

Although the INMARSAT-KA 63W satellite has not been completely designed, 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 will assess and limit the probability of the satellite becoming a source of debris by collisions with small debris or meteoroids of less than one centimeter in diameter that could cause loss of control and prevent post-mission disposal. Inmarsat will take steps to limit the effects of such collisions through shielding, the placement of components, and the use of redundant systems.

The INMARSAT-KA 63W satellite includes separate TT&C and propulsion subsystems that are necessary for 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 feeds are mounted on opposite sides of the spacecraft to create a composite omni antenna configuration. 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. Either one of the two omni-directional antenna feeds, for both command and telemetry, will be sufficient to enable orbit raising. The command receivers and decoders and telemetry encoders and transmitters will be located within a shielded area and will be totally redundant and physically separated. A single rugged thruster and shielded propellant tank provide the energy for orbit-raising.

A.13.2 Accidental Explosion Assessment (§25.144(d)(14)(ii))

In conjunction with 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.13.3 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-KA 63W 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 62.85° W.L. have also been reviewed.

Telesat operates the TELSTAR 14R (ESTRELA DO SUL 2) satellite at 63°W with ±0.05° east-west station-keeping. Inmarsat proposes to locate the INMARSAT-KA 63W satellite at 62.85° W.L. in order to eliminate the possibility of any station-keeping volume overlap with this satellite. There are no other operational satellites within ±0.15° of 62.85° W.L., nor are there any pending applications before the Commission to operate a satellite within this sub-arc. With respect to published ITU filings, there are no other networks filed within ±0.15° of 62.85° W.L.

Based on the preceding, Inmarsat therefore concludes that physical coordination of the INMARSAT-KA 63W satellite with another party is not required at the present time.

A.13.4 Post-Mission Disposal

At the end of the operational life of the INMARSAT-KA 63W satellite, Inmarsat will manoeuvre 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 = 3497 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 93.1/3497
= 36,055.3 km
= 270 km above GSO (35,786 km)

To provide adequate margin, the disposal orbit will be increased to 300 km. This will require approximately 15 kg of propellant, taking account of all fuel measurement uncertainties, which will be allocated and reserved in order to perform the final orbit raising manoeuvre.

A.14 Additional Information Concerning Certain Data in the Associated Schedule S

The Schedule S software does not accept the embedding of a large number of GXT files into the Schedule S form. Therefore all GXT files are being provided to the Commission as a separate data package.

ENGINEERING CERTIFICATION

I hereby certify 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
Jonas Eneberg
VP, International Spectrum Management

Dated: March 26, 2014