COMSEARCH

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Radiation Safety Evaluation of Four (4) INMARSAT Satellite Terminals

Purpose: The purpose of this document is to describe the calculations and analysis used to evaluate the radiation levels of four INMARSAT Satellite Terminals. The four terminals are HNS, T&T, Nera and Addvalue. The methods used for the analysis and calculations are those described in the FCC Office of Science and Technology (OST) Bulletin No. 65, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields, Revision 97-01," August 1997. The FCC adopted limits for the maximum permissible exposure for areas occupied by personnel in their R&O (FCC 96-326) released 1 August 1996. The safety thresholds for personnel are described in Figure 1 of this document and in Tabular form in Table 6.

Table 1. INMARSAT Terminal Transmit Parameters

	HNS
Frequency of Operation	1626.5 – 1660.5 MHz
Wavelength (WL)	0.184 – 0.181 meters
Transmit Power	5.5 Watt Maximum
Net Power to Antenna	4.57 Watts or 6.6 dBW
Antenna Gain	14.9 dBi
EIRP	141 Watts or 21.5 dBW
Antenna Type	Planar Patch Array
Largest Antenna Dimension	0.350 meter
Antenna Area (A)	0.091 meter^2
Antenna Efficiency	80 %
Antenna Gain off Axis	Θ>30˚, -6.0 dB, 0.25

	T&T
Frequency of Operation	1626.5 – 1660.5 MHz
Wavelength (WL)	0.184 – 0.181 meters
Transmit Power	4.0 Watt Maximum
Net Power to Antenna	3.31 Watts or 5.2 dBW
Antenna Gain	11.4 dBi
EIRP	45.7 Watts or 16.6 dBW
Antenna Type	Planar Patch Array
Largest Antenna Dimension	0.210 meter
Antenna Area (A)	0.0378 meter^2
Antenna Efficiency	80 %
Antenna Gain off Axis	Θ>45˚, -6.0 dB, 0.25

	Nera
Frequency of Operation	1626.5 – 1660.5 MHz
Wavelength (WL)	0.184 – 0.181 meters
Transmit Power	3.5 Watt Maximum
Net Power to Antenna	1.78 Watts or 2.5 dBW
Antenna Gain	9.0 dBi
EIRP	14.1 Watts or 11.5 dBW
Antenna Type	Planar Patch Array
Largest Antenna Dimension	0.125 meter
Antenna Area (A)	0.01563 $meter^2$
Antenna Efficiency	80 %
Antenna Gain off Axis	$\Theta > 60^\circ$, -6.0 dB, 0.25

	Addvalue
Frequency of Operation	1626.5 – 1660.5 MHz
Wavelength (WL)	0.184 – 0.181 meters
Transmit Power	3.5 Watt Maximum
Net Power to Antenna	2.24 Watts or 3.5 dBW
Antenna Gain	8.0 dBi
EIRP	14.1 Watts or 11.5 dBW
Antenna Type	Planar Patch Array
Largest Antenna Dimension	0.200 meter
Antenna Area (A)	0.03 $meter^2$
Antenna Efficiency	80 %
Antenna Gain off Axis	$\Theta > 60^\circ$, -6.0 dB, 0.25

Calculations: For the calculation of the radiated power densities of the INMARSAT system there are three zones that must be considered. They are the INMARSAT antenna's near field, intermediate zone and far field. The INMARSAT antenna's near field extends out to 6.6 inches for the HNS, 2.4 inches for T&T, 0.85 inches for the Nera and 2.2 inches for the Addvalue. This zone is directly in front of the antenna and represents the maximum power density levels that can be produced by the satellite systems. The intermediate zone extends out from the end of near field to the beginning of the far field. The far field for the HNS is 15.9 inches, for the T&T is 5.7 inches, for the Nera is 4.1 inches and for the Addvalue is 5.2 inches. In the intermediate zone the power density radiated by the antennas decreases in proportion to the increase of separation distance. The levels in the transition zone are always below the levels in the near field. The equation for calculating the power density in the near field is shown below.

$$P_{dnf} = 0.1*4* E* P_t / A$$

Where,

P_{dnf} = Radiated power density in the near-field (milliWatts/cm^2)
E = Efficiency factor of antenna. O.8
P_t = Transmitter power output from Table 1, Watts
A = Antenna Area (A) from Table 1, $meters^2$
0.1 = Factor that converts Watts/$meter^2$ to milliWatts/cm^2

Table 2 Calculated Power Density in the Near Field

System	**Power Density** milliWatts/cm^2
HNS	16.1
T&T	28.9
Nera	36.5
Addvalue	23.9

The equation for calculating the power density in the far field or toward points off the axis of the antenna is shown below.

$$P_d = 0.1 * P_t * G/(4*\pi)*R^2$$

Where,

P_d = INMARSAT system radiated power density at the calculation point, milliWatt/cm^2
P_t = Transmit power of INMARSAT system from Table 1, Watts
G = Gain of the INMARSAT antenna in the direction of the calculation point, dBi
R = Distance to the calculation point from the INMARSAT antennas, meters

Calculation Results: The calculations of power densities were made at the end of the transition zone for each antenna and the beginning of the far field with the above equation. The results of the calculation are shown in Table 3

Table 3 Power Density Calculated Results in the Main Beam at Beginning of Far Field

System	**Separation Distance Feet**	**Power Density milliWatt/cm^2**
HNS	1.33	7.0
T&T	0.48	17.3
Nera	0.34	10.7
Addvalue	0.43	6.4

Table 4 shows how the calculated power density radiated by each of the INMARSAT systems rolls off with increasing separation distance. The levels calculated should be referenced to the FCC MPE limits, which are 5.0 milliWatt/cm^2 for controlled zones and 1 milliWatt/cm^2 for uncontrolled zones.

Table 4 Power Density Calculated Results for Increasing Separation Distances

	Pd@0.5m	Pd@0.75m	Pd@1m	Pd@1.2m	Pd@1.1m
HNS	4.50	2.00	1.12	0.78	0.93
T&T	1.46	0.65	0.36	0.25	0.30
Nera	0.45	0.20	0.11	0.08	0.09
Addvalue	0.45	0.20	0.11	0.08	0.09

Table 5 shows the safe distance in front of the INMARSAT system antennas for the Uncontrolled Zone (General Public) FCC MPE criteria.

Table 5 Safe Distance Calculated Results for Uncontrolled Zone Personnel

	Separation Distance (Feet)
HNS	3.5
T&T	2.0
Nera	1.1
Addvalue	1.1

The power density levels calculated outside of the main beam for all of the INMARSAT systems considered in this study were all well below the FCC MPE criteria for controlled and uncontrolled zones.

The calculation methods of FCC Office of Science and Technology (OST) Bulletin No. 65 is designed to produce power density levels that are higher than those normally measured. The reason for this is that there is a bias designed into the method of evaluation that will err on the high or safe side. That is, the calculations will predict power density levels that are higher so that unsafe conditions will not be missed even though in some cases unsafe conditions will be identified by the calculations when in reality they do not exist

Radiated Safety Limits: The FCC and OSHA limits for maximum permissible exposure are shown in the following table and figure. For the frequency range of the various INMARSAT satellite systems (1626.5 – 1660.5 MHz) the occupational limit is 5 milliWatt/cm^2 and the general public limit is 1 milliWatt/cm^2.

Table 6 Limits for Maximum Permissible Exposure (MPE)

(A) Limits for Occupational/Controlled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm^2)	Averaging Time $\|E\|^2$, $\|H\|^2$ or S (minutes)
0.3-3.0	614	1.63	(100)*	6
3.0-30	1842/f	4.89/f	$(900/f^2)$*	6
30-300	61.4	0.163	1.0	6
300-1500	--	--	f/300	6
1500-100,000	--	--	5	6

(B) Limits for General Population/Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm^2)	Averaging Time $\|E\|^2$, $\|H\|^2$ or S (minutes)
0.3-1.34	614	1.63	(100)*	30
1.34-30	824/f	2.19/f	$(180/f^2)$*	30
30-300	27.5	0.073	0.2	30
300-1500	--	--	f/1500	30
1500-100,000	--	--	1.0	30

f = frequency in MHz *Plane-wave equivalent power density

NOTE 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

NOTE 2: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or cannot exercise control over their exposure.

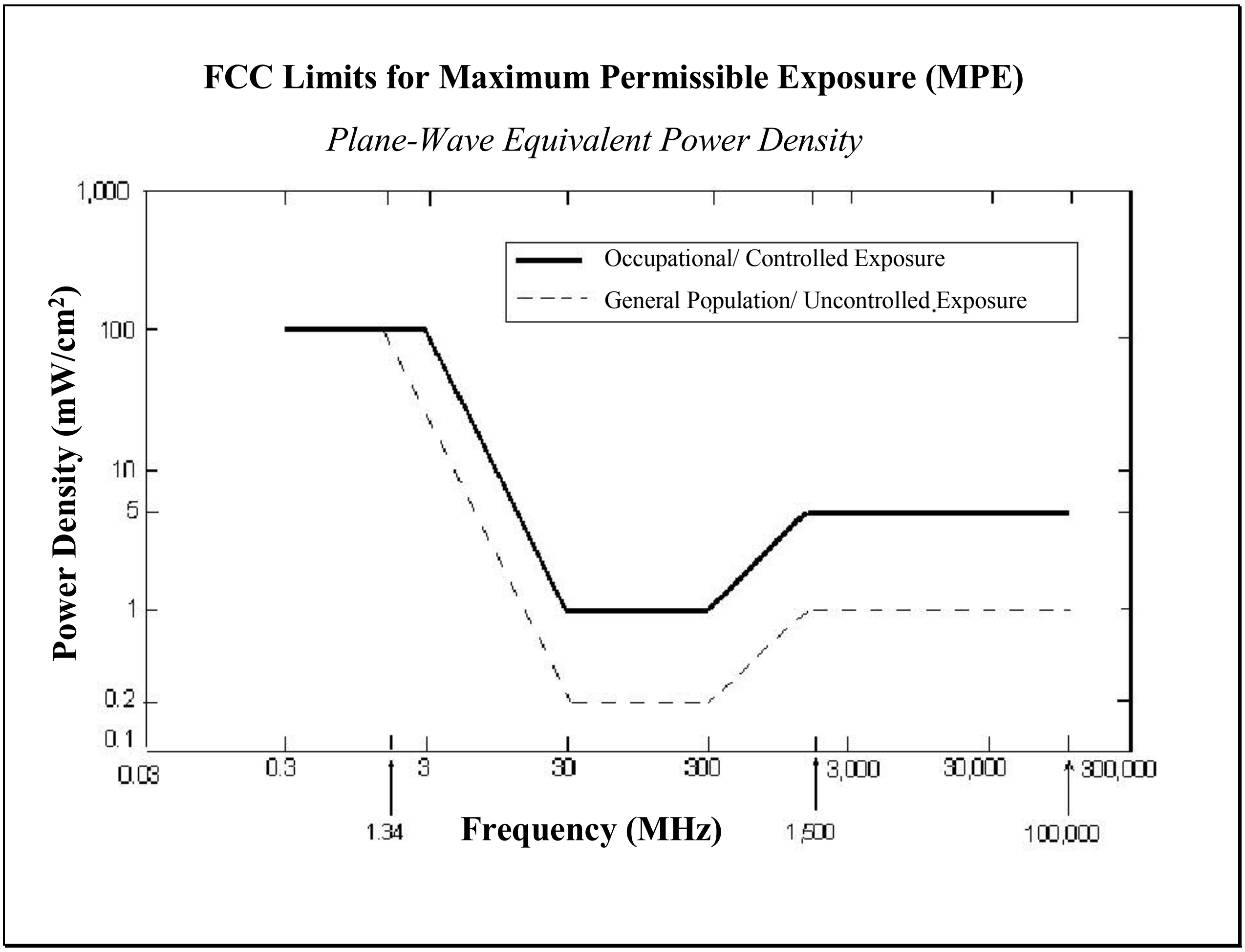

Figure 1. FCC Limits for Maximum Permissible Exposure (MPE)

Conclusions: Based on the calculations performed in this task it is concluded that the area directly in front of all of the INMARSAT systems' antennas considered in this study should be avoided when the systems are transmitting. Personnel who are tasked and are responsible for the operation of these systems should be knowledgeable of the radiation levels of the equipment and maintain a safety zone for the general public out to a distance of 3.5 feet from the HNS system, 2 feet from the T&T system and 1.1 feet from the Nera and Addvalue systems. Personnel operating these systems should be trained to be aware of the high power densities for all four systems in their antenna near fields and slightly beyond. Operational personnel should avoid the area directly in front of the antennas out to a distance of 1.6 feet for the HNS system, 0.9 feet for the T&T system and 0.5 feet for the Nera and Addvalue systems

Certification: I have prepared this report and I certify that the information and results reported are accurate and in conformance with the FCC safety requirements.

Lester E. Polisky

INMARSAT 4F2
ATTACHMENT A

TECHNICAL DESCRIPTION

A.1 GENERAL DESCRIPTION

The Inmarsat 4F2 satellite, licensed in the United Kingdom, will provide Mobile-Satellite Services to small User Terminals ("UTs") in North America and other regions visible from the satellite, using the 1525 - 1559 MHz band for space-to-Earth transmissions and the 1626.5-1660.5 MHz band for Earth-to-space transmissions[1]. A new service to be launched on the satellite is the Broadband Global Area Network ("BGAN"), which delivers simultaneous broadband data and voice to a variety of small, lightweight UTs. The broadband service is IP based, offering variable data rates up to 492 kbit/s, including fully symmetric services, and for certain UTs, guaranteed bandwidth streaming services. The circuit-based services include both voice and 64 kbit/s ISDN. The Inmarsat 4F2 satellite will also support services initially designed for, and operated over, Inmarsat's earlier generation satellites. These are referred to in this document as existing and evolved ("E&E") services, and are supported over the Inmarsat 4F2 satellite's global and regional beams.

This request for authority to communicate with Inmarsat 4F2 should be treated as a request to communicate with a replacement satellite for purposes of the Commission's satellite application processing procedures. Inmarsat 4F2, to be located at 52.75° W.L will replace the existing Inmarsat 3 satellite at 54° W.L., will serve the same geographic regions as Inmarsat 3, and will operate over the same L-band service link frequencies that are authorized for use on Inmarsat 3

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[1] These bands are collectively known as the "L-band" frequencies.

under existing Commission authority.[2] For the reasons provided below, this application therefore should be processed on a streamlined basis, and without a modified processing round.

Because the L-band payload of Inmarsat 4F2 that is the subject of this application will provide mobile satellite service ("MSS"), it is considered NGSO-like for Commission processing purposes. The modified processing round procedure that generally applies to requests to communicate with NGSO-like satellite systems[3] is inapplicable in situations such as this one, where an NGSO-like satellite will use the same L-band service link frequencies already authorized for use over an existing satellite in the operator's network. Commission precedent is clear that such requests are to be processed without instituting a modified processing round.[4]

In fact, Inmarsat 4F2 is appropriately considered a replacement for Inmarsat 3. As noted above, the L-band frequency range on Inmarsat 4F2 is the same as the frequency range that the Commission has authorized for communication with Inmarsat 3 at 54º W.L. and Inmarsat 4F2 will serve the same geographic area as Inmarsat 3. The Commission has indicated that streamlined processing and "grant stamp" approvals are appropriate for replacement satellite authority if the applicant is otherwise qualified.[5] In its recent order granting MSV authority to launch and operate an L-band MSS satellite at 101° W.L., the Commission confirmed that its general policy about replacement expectancies are fully applicable in cases such as this that involve a follow-on NGSO-like satellite.[6]

Furthermore, under Section 25.165(e) of the Commission's rules, no bond need be posted with respect to this application. As set forth above, Inmarsat 4F2 will operate on the same L-band

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[2] *See Comsat Corporation d/b/a Comsat Mobile Communications*, Memorandum Opinion, Order and Authorization, 16 FCC Rcd 21,661, ¶ 1 (2001).

[3] *Amendment of the Commission's Space Station Licensing Rules and Policies*, First Report and Order and Further Notice of Proposed Rulemaking, 18 FCC Rcd 10,760, ¶ 29 (2003) ("*Space Station Licensing Reform Order*").

[4] *See, e.g., Mobile Satellite Ventures Subsidiary LLC, Application for Authority to Launch and Operate an L-band Mobile-Satellite Service Satellite at 101° W.L.*, Order and Authorization, DA 05-1492, ¶ 14 (rel. May 23, 2005) ("*MSV 101° W.L. Authorization*"); *see also Mobile Satellite Ventures Subsidiary LLC, Application for Authority to Launch and Operate an L-band Mobile Satellite Service Satellite at 63.5° W.L.*, Order and Authorization, DA 05-50, ¶ 8 (rel. Jan. 10, 2005) (new L-band MSS satellite operating at a different location and serving a different geographic area is still processed without instituting a modified processing round as long as the same frequencies are used).

[5] *Space Station Licensing Reform Order* at ¶ 253.

[6] *MSV 101° W.L. Authorization* at ¶ 13.

service link frequencies, and serve the same geographic area, as Inmarsat 3. Moreover, Inmarsat anticipates retiring Inmarsat 3 from service at 54º W.L. by relocating it elsewhere shortly after bringing Inmarsat 4F2 into commercial service. Inmarsat 4F2 will be located at essentially the same orbital location as Inmarsat 3, and no other operator will be able to implement an L-band MSS spacecraft at 54º W.L., using the same frequencies and geographic coverage as Inmarsat 4F2, once Inmarsat 4F2 is placed into service 1.25 degrees away at 52.75º W.L.

This application seeks authority to provide service to, from and within the United States only in the L-Band. In the interest of providing a complete description of the operations of the spacecraft related to the subject L-band service links, and as provided in Section 25.114 of the Commission's rules, a brief description of feeder link and TT&C communications over the satellite also is being provided. Signals to and from UTs in the L-band are connected, through the spacecraft, back to a gateway earth station(s) via feeder links in the Fixed-Satellite Service ("FSS") using the 3550 – 3660 MHz band in the space-to-Earth direction and the 6425 – 6520 MHz band in the Earth-to-space direction[7]. For BGAN services, two gateway earth stations known as Satellite Access Stations ("SAS") will be used in the network's initial configuration, both of which will be located outside the United States; one located in Burum, the Netherlands, and one in Fucino, Italy. For the E&E services, the earlier network of gateway earth stations known as Land Earth Stations ("LES") will be used. TT&C signals between the Inmarsat 4F2 satellite and TT&C earth stations will occur in the 3945 – 3955 MHz downlink band and the 6338 – 6342 MHz uplink band[8]. None of the TT&C earth stations that are planned to be used to communicate with Inmarsat 4F2 will be located in the United States. The primary TT&C facility for this spacecraft is located in Italy. It is noted that none of these gateway or TT&C earth stations are the subject of the present application.

The satellite also is capable of providing services in the Radio-Navigation Satellite Service and has some capability of providing C-to-C-band and L-to-L-band links. These capabilities are not relevant to the provision of the proposed services that are the subject of this application and therefore are not described herein. This technical annex describes only the L-band MSS and

[7] These bands are within what is collectively known as the "extended C-band" frequencies.
[8] These sub-bands are within what is collectively known as the "conventional C-band" frequencies.

associated feeder link capabilities of the satellite, which are used to provide services through the UTs for which authority is sought.

The Inmarsat 4F2 satellite features a single 9 m aperture unfurlable reflector, which, combined with the 120 element feed array, forms the L-band antenna, used for both transmit and receive. The 9 m reflector is stowed during the launch and transfer orbit phases of the mission, and is deployed once the satellite is in geo-synchronous orbit. The use of a single reflector ensures that a high level of coverage congruency is provided between all transmit and receive beams. Two separate horns serve as the C-band antennas.

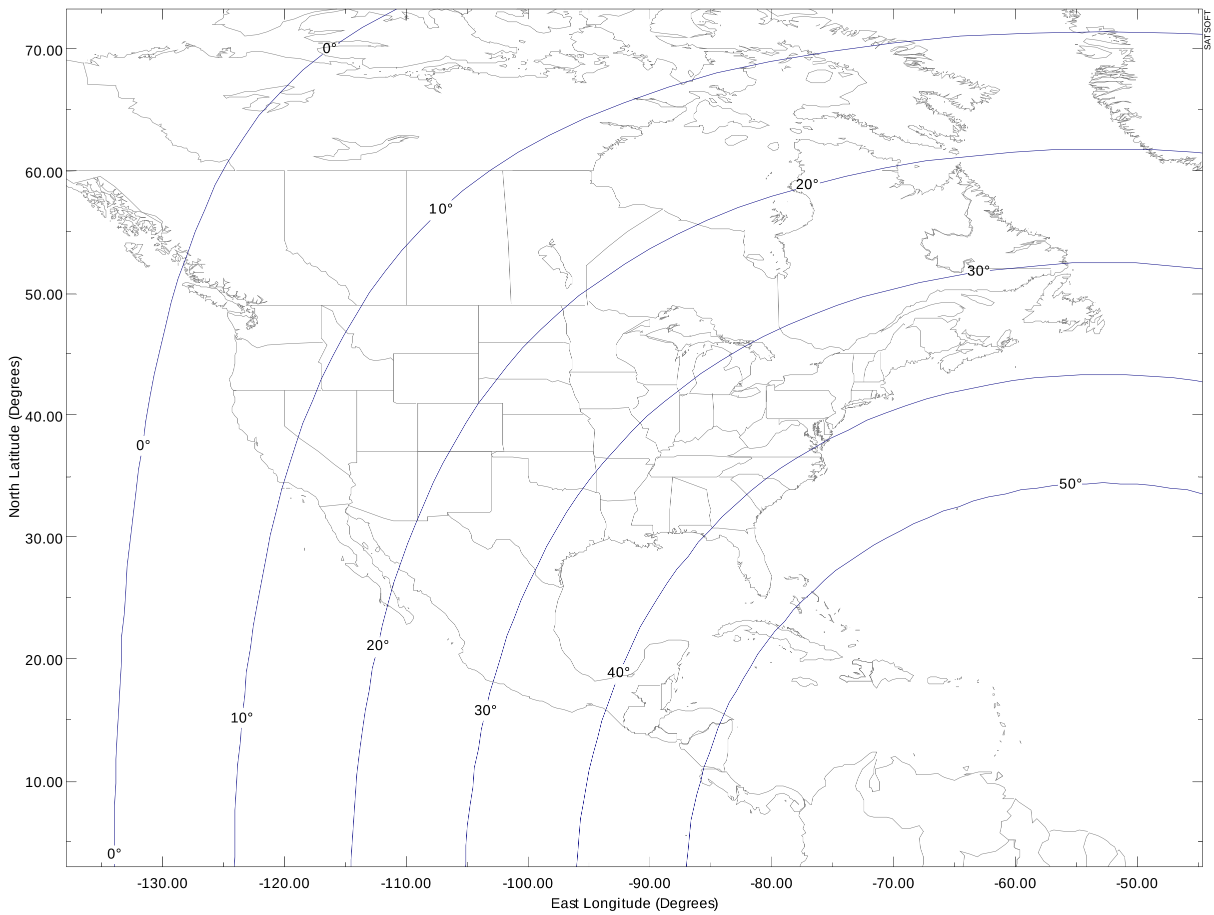
The heart of the payload is a digital signal processor ("DSP") that performs the channelization and beam-forming functions. Developed and built by Astrium, the DSP provides very fine granularity in the allocation of bandwidth to the various beams and also enables the generation of a variety of different types of beams, with the required pointing. The DSP provides the capability to steer the antenna beams to accommodate the motion of the spacecraft when operating in inclined orbit. The DSP also dynamically allocates the satellite channels to the various beams, allowing the Inmarsat 4F2 satellite to manage variable traffic patterns. Section A18, Communications Payload, provides additional explanation as well as a simplified block diagram of the Inmarsat 4F2 payload.

A.2 ORBITAL LOCATION

The Inmarsat 4F2 satellite will operate at the 52.75° W.L. geostationary orbital location. The Inmarsat 3 satellite, which will be replaced by the Inmarsat 4F2 satellite, and over which the Commission has already authorized the provision of service, currently operates at 54° W.L.

Figure A.2-1 shows the elevation angles over North America from the 52.75° W.L. orbital location. Inmarsat 4F2 will operate at a 0.25 degree offset from 53° W.L., where another spacecraft is located, in order to prevent the stationkeeping volume of Inmarsat 4F2 from overlapping the stationkeeping volume of the adjacent spacecraft. *See* Section A.20 below.

Figure A.2-1 – Elevation Angles from the 52.75° W.L. Orbital Location



A.3 SATELLITE COVERAGE

The Inmarsat 4F2 satellite will provide two-way services to user terminals using the L-band, for which the spot beam and regional beam coverage of U.S. territories in the service area is depicted by figures A.3-1 and A.3-2 below. All beam locations are nominally identical for both the uplink and downlink directions. The satellite also carries an uplink and downlink L-band global beam.

Figure A.3-1 – BGAN L-band service link spot beams covering U.S. territory

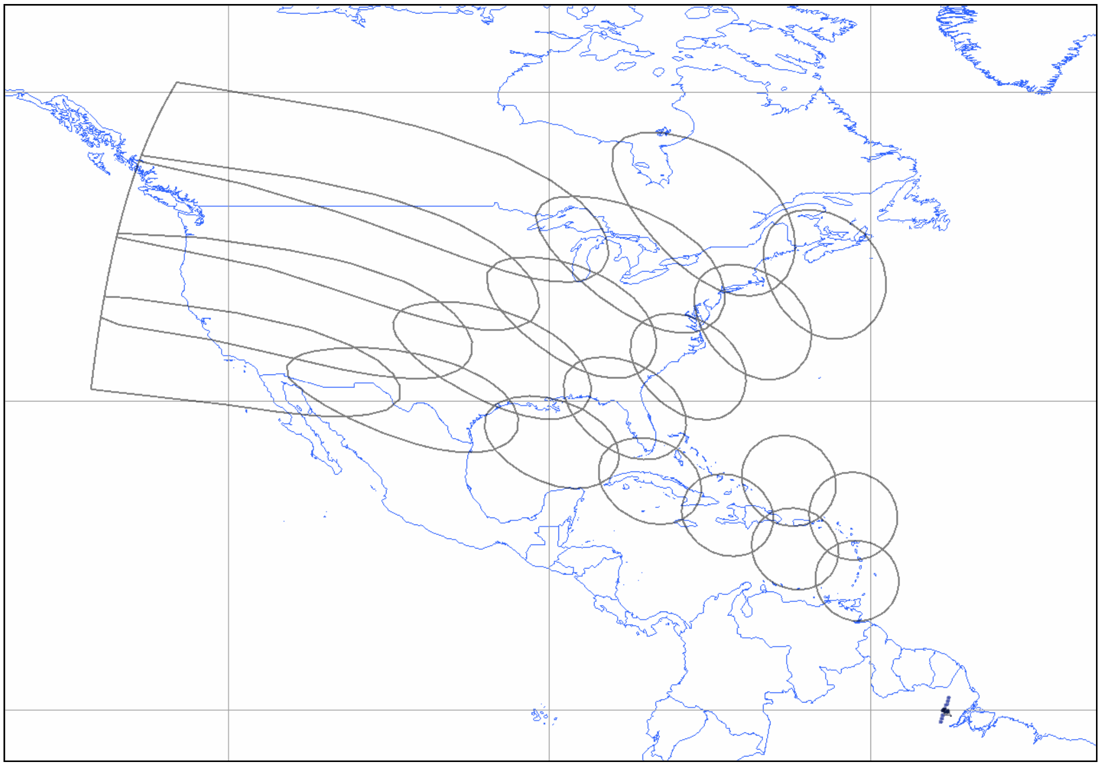
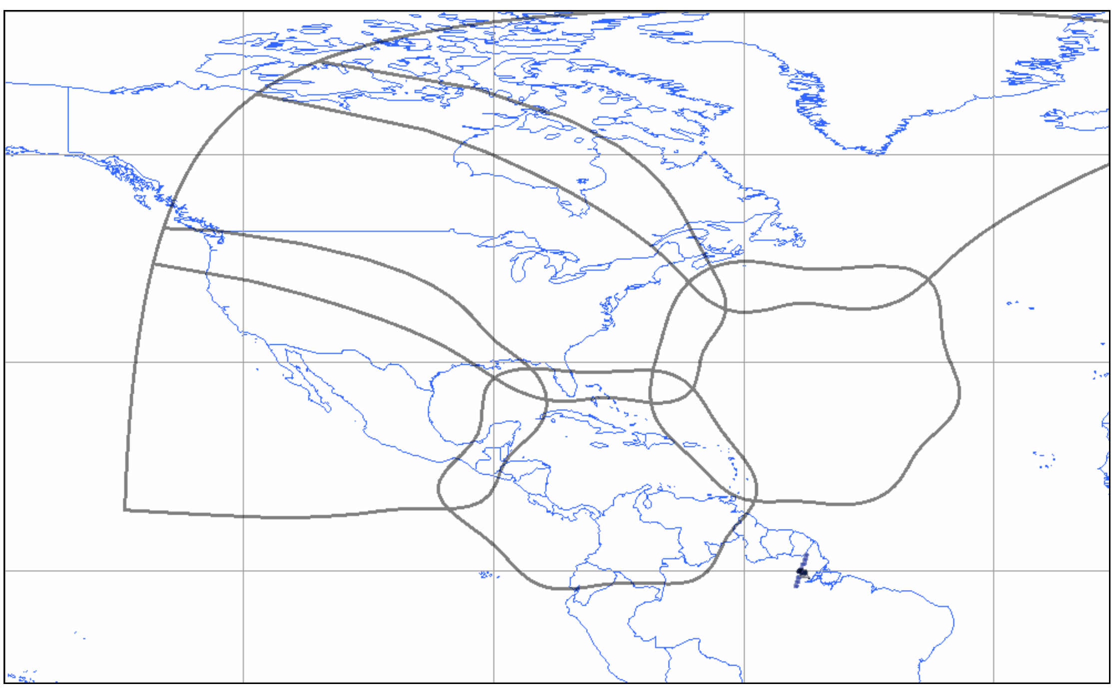


Figure A.3-2 – Regional L-Band Beams covering U.S. Territory



A.4 FREQUENCY AND POLARIZATION PLANS FOR COMMUNICATIONS LINKS

The Inmarsat 4F2 satellite is capable of operating over any portion of the 1525 - 1559 MHz and 1626.5-1660.5 MHz bands. Right Hand Circular (RHC) polarization is used on both uplink and downlink transmissions in the L-band.

The DSP allows Inmarsat to tailor the satellite coverage and refine the beam sets, so as to better meet the traffic and service demands, and allows additional flexibility in dealing with any failed SSPA or LNA. The satellite channels are dynamically allocated to the various beams, allowing Inmarsat to manage variable traffic patterns. There is no fixed frequency relationship between the L-band frequencies and the extended C-band feeder link frequencies. The L-band links are channelized onto a 200 kHz grid across the available spectrum. Beam forming and channelization of the transponders is realized with state of the art digital technology that enables 630 satellite channels, in both the forward and return directions, to be switched dynamically between the various beams. Each of the 630 channels can be considered similar to a conventional transponder.

The feeder link spectrum is re-used twice by means of dual orthogonal circular polarizations.

TT&C operations will take place in portions of the conventional C-band, as discussed in Section A.16, but no authority is sought in this application to communicate to, from or within the United States in the C-band.

Table A.4-1 shows the frequency plan, polarization and connectivity of the Inmarsat 4F2 satellite. The TT&C frequency plan is also provided.

Table A.4-1. Inmarsat 4F2 L-band and C-band Frequency Plan.

	UPLINK			DOWNLINK		
Description	**Beam**	**Polarization**	**Frequency Band (MHz)**	**Beam**	**Polarization**	**Frequency Band (MHz)**
Forward Link	Global (CGUR)	RHCP	6425-6515.8	Spot (LSD), Regional (LRD) and/or Global (LGD)	RHCP	1525-1559
	Global (CGUL)	LHCP	6425-6515.8	Spot (LSD), Regional (LRD) and/or Global (LGD)	RHCP	1525-1559
Return Link	Spot (LSU), Regional (LRU) and/or Global (LGU)	RHCP	1626.5-1660.5	Global (CGDR)	RHCP	3551.4-3657.8
	Spot (LSU), Regional (LRU) and/or Global (LGU)	RHCP	1626.5-1660.5	Global (CGDL)	LHCP	3551.4-3657.8
Telecommand	Global (TCNR)	RHCP	6338-6342			
Telecommand	Global (TCNL)	LHCP	6338-6342			
Telemetry				Global (CRDR)	RHCP	3945-3955
Telemetry				Global (CRDL)	LHCP	3945-3955

A.5 SATELLITE TRANSMIT CAPABILITY

A.5.1 Feeder Downlink

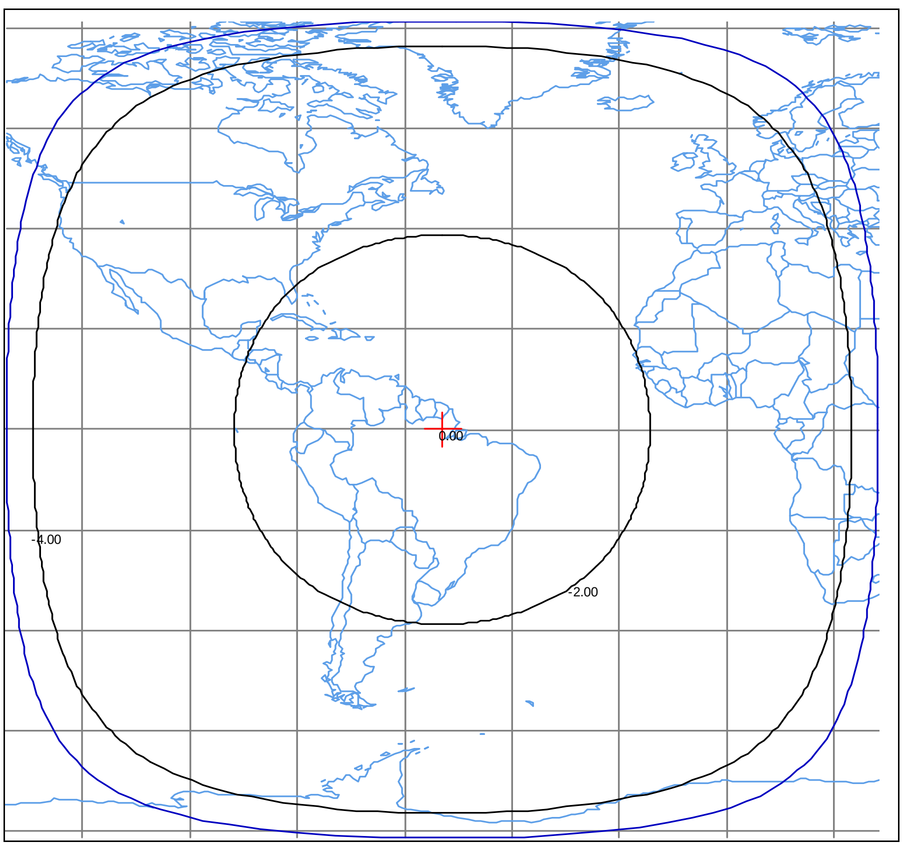
The signals received by the L-band antenna are amplified by the low noise amplifiers (LNA) and fed to the L-band pre-processor, which performs the required filtering and down-conversion of the signals to baseband, before passing them to A/D converters that feed the DSP. The DSP performs the required channelizing and beam-forming functions, and passes the signals to the required D/A converters, which then feed the C-band up-converter. High power SSPA's, operating in a 6x4 redundancy configuration, are used on the C-band output section to provide the required amount of power to the C-band antenna.

The Inmarsat 4F2 satellite provides two C-band global beams, one in RHCP and the other one in LHCP. The beams are nominally identical in each polarization. The beams cover all the points within the satellite's field of view, with a peak gain of 22 dBi, providing a maximum of up to 35 dBW of downlink EIRP on each polarization. The maximum available power to the antenna before losses is 44 watts. Typical line losses amount to 3.4 dB. The cross-polarization isolation of the beams is 30 dB across the service area.

Figure A.5-1 shows the gain contours of the downlink C-band global beam.

Figure A.5-1 – Downlink C-Band Global Beam Gain Contours

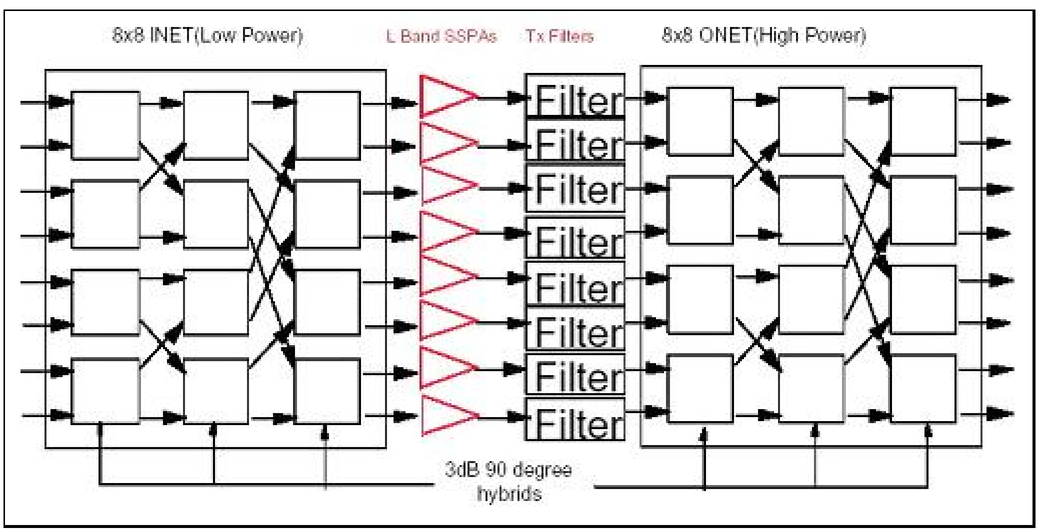
(Contours shown are -2 and -4 dB relative to the beam peak)



A.5.2 Service Downlink

On the forward C-to-L link, the signals received from the satellite gateway earth station are received by the C-band antenna, filtered and passed to the C-band receiver. The amplified signal is filtered and down converted by the C-band down converter and, after going through the required analog-to-digital (A/D) converters, is fed to the DSP. The DSP is responsible for breaking the signals into the appropriate 200 kHz channels, and for applying the correct beam forming coefficients to each channel. The channelized and beam-formed signals, after being converted to analog signals by digital-to-analog (D/A) converters, are then fed to the L- band post-processor, which employ SAW technology to filter and converts the signals to L- band, before feeding them to the Multi Port Amplifier (MPA). The MPA comprises Input Networks (INet), the solid-state power amplifiers (SSPA) and the Output Networks (ONet) that amplify the signal, and feed it to the appropriate feed elements. The purpose of the MPA, which is shown in Figure A.5-2, is to ensure a more even loading of the various SSPA's.

Figure A.5-2 – The Multi Port Amplifier

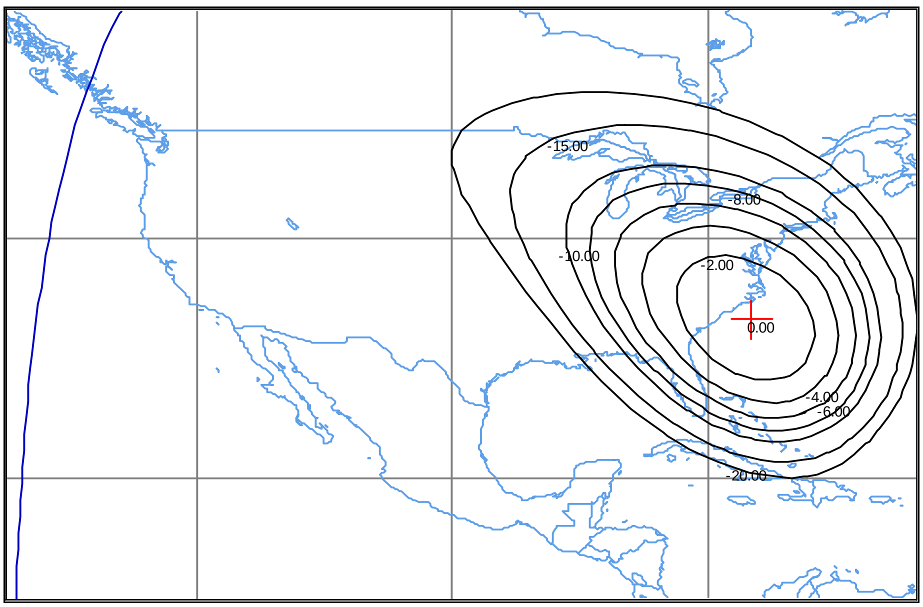


There are 120 active SSPA's, configured in groups of 5x4 to provide the required redundancy, resulting in a total of 150 SSPA's per spacecraft. Figure A.5-3 provides the gain contours of a typical spot beam. The spot beams transmit in RHCP only. The peak antenna gain of these beams ranges from 40 dBi to 42 dBi, depending on their pointing direction.

The maximum available power to the antenna before losses is 1800 watts, on which there is an average line loss of 4.1 dB. This total available power can be dynamically apportioned between the three categories of service beams, whose nominal peak gains are 22 dBi, 34 dBi and 42 dBi for the global, regional and spot beams respectively. The maximum attainable downlink EIRP values are 43 dBW, 58 dBW, and 70 dBW for the global, regional and spot beams, respectively. These maximum downlink EIRP levels cannot occur simultaneously. In the event one of the maximum levels occurs, there will be a corresponding reduction in the power available to the other beam types.

Figure A.5-3 – Example Service Downlink Spot Beam Gain Contours

(Contours shown are -2, -4, -6, -8, -10, -15, and -20 dB relative to the beam peak)

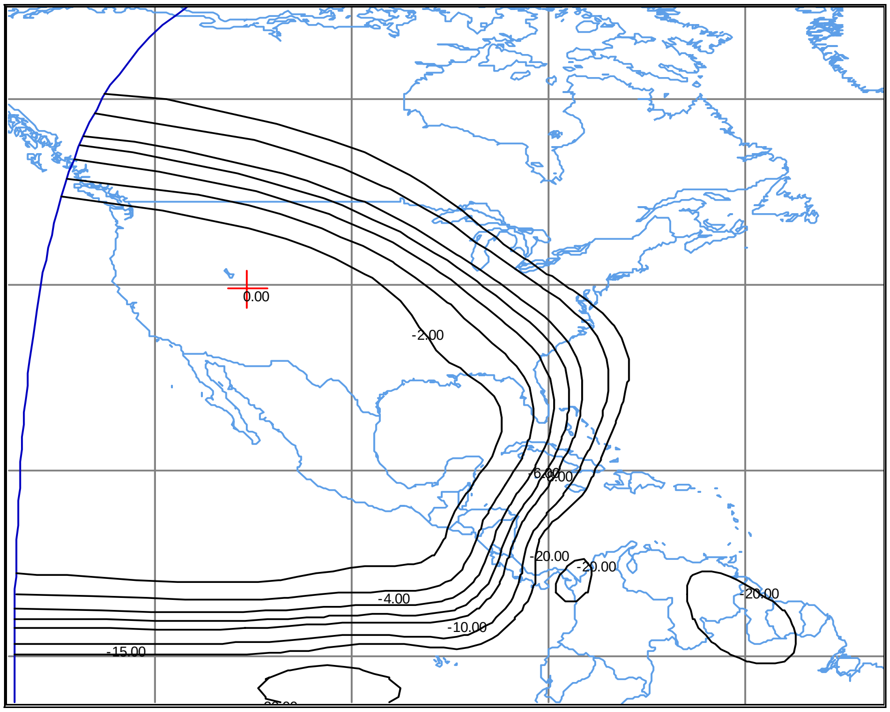


A.5.3 Regional Beam Downlink

Figure A.5-4 shows the gain contours of an example regional beam over North America. The regional beams transmit in RHCP only. The peak gain of the beams is 34 dBi.

Figure A.5-4 – Example Regional beam Downlink Beam Gain Contours

(Contours shown are -2, -4, -6, -8, -10, -15, and -20 dB relative to the beam peak)

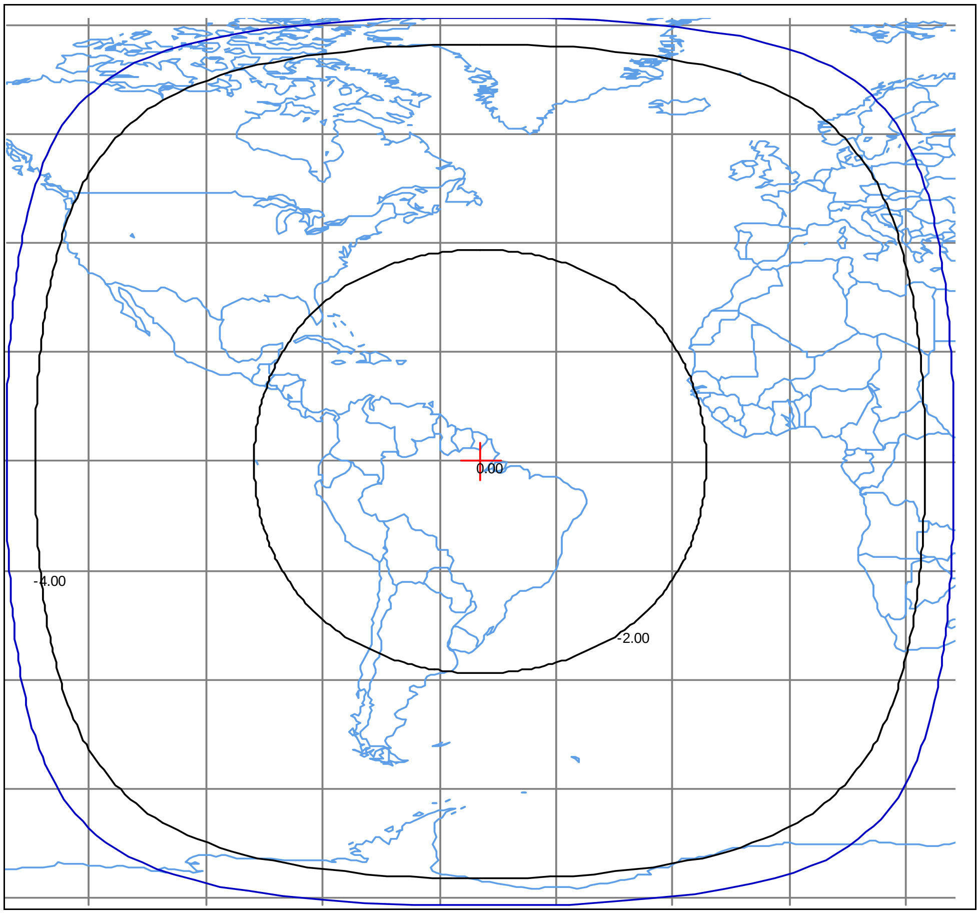


A.5.4 Global Beam Downlink

The gain contours of the global beam are shown in Figure A.5-5. The global beam transmits in RHCP only. The peak gain of the beam is 22 dBi.

Figure A.5-5 – Downlink L-Band Global Beam Gain Contours

(Contours shown are -2 and -4 dB relative to the beam peak)



A.6 SATELLITE RECEIVE CAPABILITY

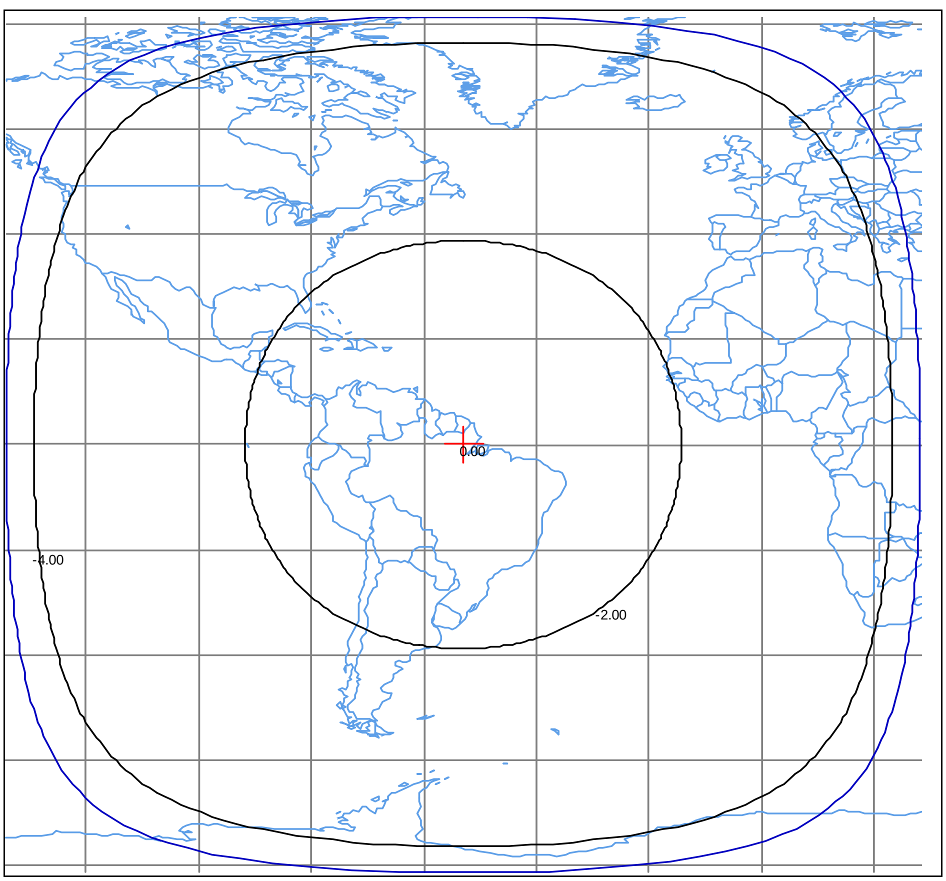
A.6.1 Feeder Uplink

The Inmarsat 4F2 satellite employs two C-band global beams, one in RHCP and the other one in LHCP. The beams are nominally identical in each polarization. The beams cover all the points within the satellite field of view, with a peak gain of 22 dBi and a total system noise temperature of approximately 692 K. The peak G/T of the C-band global beams is -6.4 dB/K. The cross-polarization isolation of the beams is 30 dB across the service area.

Figure A.6-1 shows the gain contours of the uplink C-band global beam.

Figure A.6-1 –Uplink C-Band Global Beam Gain Contours

(Contours shown are -2 and -4 dB relative to the beam peak)



A.6.2 Service Uplink

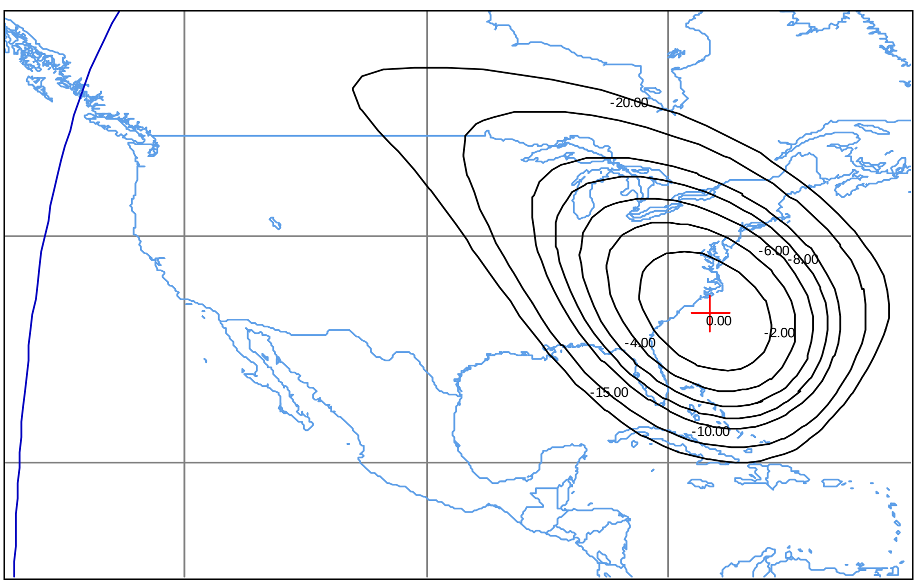
The user link uplink utilizes the same 9 m reflector used for the service link downlink, achieving similar beam characteristics.

Example antenna gain contours are given in Figure A.6-2, for a beam located at the east coast of the United States. The peak antenna gain of these beams ranges from 40 dBi to 42 dBi, depending on their pointing direction. The spot beams receive in RHCP only.

The total effective system noise temperature for the satellite spot beam receiver is approximately 583 K, including antenna losses. Therefore the beam peak G/T performance will range from 12.3 dB/K to 14.3 dB/K.

Figure A.6-2 – Example Service Uplink Spot Beam Gain Contours

(Contours shown are -2, -4, -6, -8, -10, -15, and -20 dB relative to the beam peak)



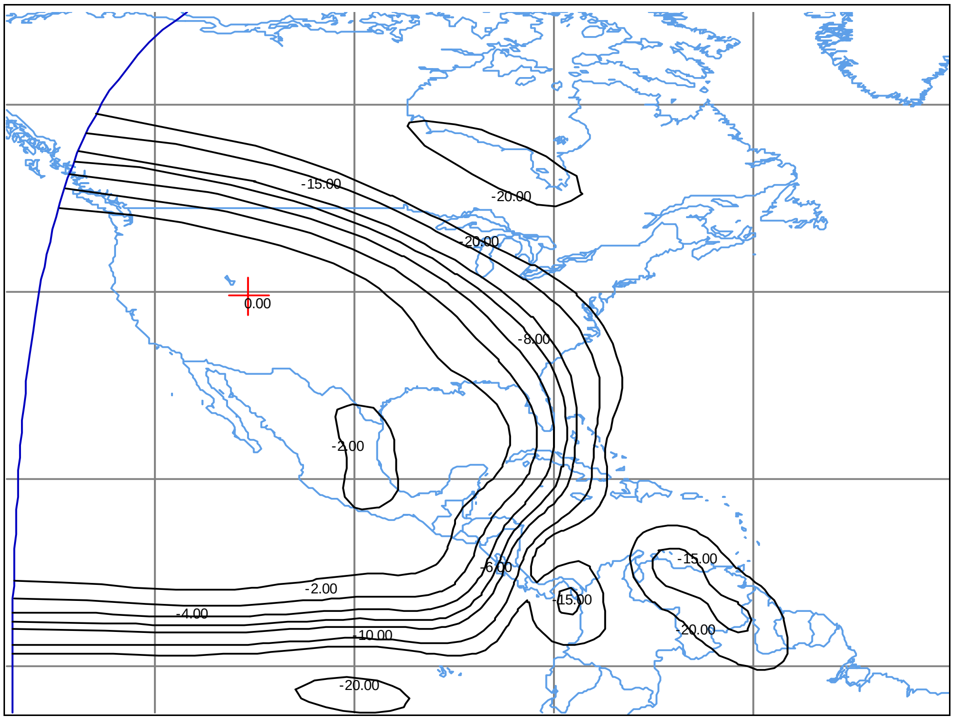
A.6.3 Regional Beam Uplink

Figure A.6-3 shows the coverage area and gain contours of an example regional beam over North America.

The peak antenna gain of these beams is 34 dBi. The regional beams receive in RHCP only. The total effective system noise temperature for the satellite regional beam receiver is approximately 1259 K, including antenna losses. Therefore the beam peak G/T performance is 3.0 dB/K.

Figure A.6-3 – Example Regional beam Uplink Beam Gain Contours

(Contours shown are -2, -4, -6, -8, -10, -15, and -20 dB relative to the beam peak)



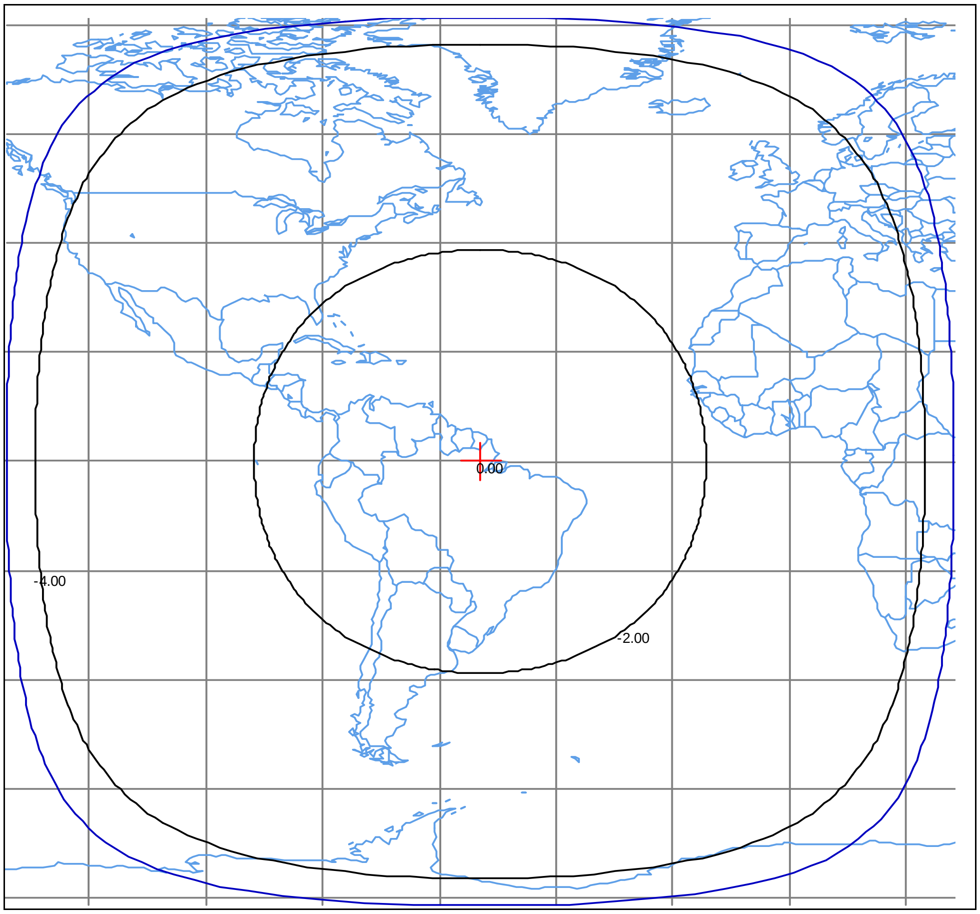
A.6.4 Global Beam Uplink

Figure A.6-4 shows the coverage area and gain contours of the uplink global beam.

The peak antenna gain of the beams is 22 dBi. The global beam receives in RHCP only. The total effective system noise temperature for the satellite's global beam receiver is approximately 632 K, including antenna losses. Therefore the beam peak G/T performance is -6.0 dB/K.

Figure A.6-4 – Uplink L-Band Global Beam Gain Contours

(Contours shown are -2 and -4 dB relative to the beam peak)



A.7 TRANSPONDER GAIN CONTROL AND SATURATING FLUX DENSITY

In order to ensure that the drive level to the SSPA's is kept within the specified range, and the linearity performance is maintained, a power control loop samples the current driven by the L-band SSPA's on the forward link, and controls the gain at the C-band receivers, while on the return link automatic level control circuits are used on the C-band SSPA's.

For channels using the spot beams, it is possible to command the gain of any transmission channel on both the forward link and return links between 176 dB and 192 dB. For channels using the regional beams or the global beam, it is possible to command the gain of any transmission channel, on both the forward link and the return link, between 160 dB and 176 dB. On the forward link the commandable gain step is 1 dB, while on the return link the gain step is 2 dB.

The minimum SFD for each uplink beam type is included in the Schedule S form. The SFDs vary over the 16 dB attenuation range.

A.8 UNWANTED EMISSIONS

The out-of-band emissions will not exceed the limits of §25.202(f) (1), (2) and (3).

A.9 EMISSION DESIGNATORS AND ALLOCATED BANDWIDTH OF EMISSION

The communications signals will utilize carriers of varying bandwidths and different modulation schemes. All communications carriers will be digitally modulated. Typical emission designators and their associated allocated bandwidths are provided in Table A.9-1.

Table A.9-1. Emission Designators and Allocated Bandwidths

Emission Designator	Allocated Bandwidth
200KG7W	200 kHz
200KD7W	200 kHz
100KG1X	100 kHz
60K0D1W	60 kHz
50K0G7W	50 kHz
50K0D7W	50 kHz
25K0G7W	25 kHz
20K0G1E	20 kHz
20K0G1X	20 kHz
12K5G7W	12.5 kHz
10K0G1W	10 kHz
10K0G1X	10 kHz
5K00G1E	5 kHz
5K00G1W	5 kHz

5K00G1D	5 kHz
2K50F1D	5 kHz

A.10 EARTH STATIONS

A.10.1 BGAN User Terminals

The Inmarsat 4F2 satellite is designed to operate with a range of user terminals meaning that customers will have a choice of different BGAN terminals. The user terminals have been designed and developed together with selected manufacturers and will deliver a differentiated range of mobile communication devices to suit the varying needs of new and existing customers.

The available terminals will vary in price, performance and portability, in order to address a broad range of different market requirements. These range from experienced legacy users of satellite communications with more advanced needs, to new users in new industry sectors who are considering a satellite solution for the first time.

Representative characteristics of the terminals expected to be available as of service launch are given in Table A.10-1 for each of the three classes of terminals.

Table A.10-1 – Representative characteristics of the User Terminal Classes

	Class 1	Class 2	Class3
Typical Peak Transmit Gain (dBi)	14 to 16	11 to 13	8 to 10
Typical Peak G/T (dB/K)	-8 to -10	-11 to -13	-15 to -17

A.10.2 E&E User Terminals

The Inmarsat 4F2 satellite will also support Inmarsat’s existing and evolved (“E&E”) services through the satellite’s global and regional beams. A brief description of the E&E terminals is given below.

Inmarsat-B terminals:

Inmarsat-B terminals provide voice, fax, data and 64 kbps services. A typical antenna gain is 21 dBi and a typical G/T is -4 dB/K.

Inmarsat M terminals:

Inmarsat M terminals provide voice, data and fax services. Typical antenna gains range between 12 and 14 dBi and typical G/Ts range between -10 and -12 dBi.

Inmarsat Mini-M terminal:

Inmarsat Mini-M terminals provide voice, data and fax services. Typical antenna gains range between 8 and 18 dBi and typical G/Ts range between -7 and -17 dBi.

Inmarsat M4 terminal:

Inmarsat M4 terminals provide voice, fax, data and 64 kbps services. Typical antenna gain is 18 dBi and typical G/T is -7 dB/K.

Inmarsat-C terminal:

The Inmarsat-C terminals provide store and forward services. Typical antenna gains range between 0 and 2 dBi and typical G/Ts range between -23 and -21 dB/K.

Inmarsat-D, D+ terminals:

Inmarsat-D terminals provide uni-directional low data rate store-and-forward services, while Inmarsat D+ terminals provide bi-directional low data rate store-and-forward services. Typical antenna gains range between 0 and 6.5 dBi and typical G/Ts range between -19.1 dB/K and -25.1 dB/K.

A.10.3 Gateway Earth Stations

The gateway earth station antennas range between 9 and 13 meter antennas with peak transmit gains ranging between 54 dBi and 57 dBi and peak receive gains ranging between 49.2 dBi and 52.9 dBi. Typical G/Ts range between 30.7 dB/K and 32.3 dB/K. The gateway earth stations are not the subject of this application.

A.11 LINK BUDGETS

A.11.1 BGAN Services

The BGAN carriers are QPSK or 16-QAM modulated and use adaptive coding that provides a data rate of up to 492 kBits/second. The access technique is frequency division duplex - time division multiple access ("FDD-TDMA").

The BGAN communication carriers in the spot beams are transmitted in a 200 kHz channel. Within a given channel, the Inmarsat 4F2 network is capable of delivering a range of data rates by assigning one of the available FEC rates and associated C/N requirements, depending on available satellite EIRP and G/T at a specific location, fading loss, user terminal antenna G/T, and elevation angle. If a high data rate could not be supported due to, for example, unavailability of the required satellite EIRP or G/T at a specific location, or lower G/T of a certain terminal type, then a lower user data rate will be assigned to that particular transmission link.

The signaling carriers in the regional beams and global beams are transmitted with bandwidths of 50 kHz and 12.5 kHz, respectively.

Tables A.11-1 through A.11-3 show representative forward link budgets for the communication carriers to the Class-1, Class-2, and Class-3 user terminals, respectively, via the downlink spot beams.

Tables A.11-4 through A.11-6 show representative forward link budgets for the signaling carriers to the Class-1, Class-2, and Class-3 user terminals, respectively, via a downlink regional beam.

Tables A.11-7 through A.11-9 show representative forward link budgets for the signaling carriers to the Class-1, Class-2, and Class-3 user terminals, respectively, via the downlink global beam.

Tables A.11-10 through A.11-12 show representative return link budgets for the signaling carriers from the Class-1, Class-2, and Class-3 user terminals, respectively, to a receive regional beam.

Tables A.11-13 through A.11-15 show representative return link budgets for the communication carriers from the Class-1, Class-2, and Class-3 user terminals, respectively, to a receive spot beam.

Table A.11-1 – Link Budget for Communication Forward Link to Class-1 User Terminal (200 kHz carrier; Spot Beam)

General	Unit	
User terminal type	-	Class1
Modulation ID / Designator	-	C1F2/ 200KD7W
Data rate (kbps)	(kbps)	492
Coding rate	-	0.822
Modulation	-	16-QAM
Carrier bandwidth	(kHz)	189
Allocated bandwidth	(kHz)	200
Uplink		
Frequency	(GHz)	6.5
SAS elevation angle	(deg)	5.0
SAS EIRP towards satellite	(dBW)	57.3
Path loss	(dB)	200.9
Mean Atmospheric loss	(dB)	0.4
Satellite G/T	(dB/K)	-10.4
Boltzmann Constant	(dBW/K/Hz)	-228.6
Up-path C/No	(dBHz)	74.2
Downlink		
Frequency	(GHz)	1.5
User terminal elevation angle	(deg)	90.0
Satellite EIRP	(dBW)	44.5
Path loss	(dB)	188.4
Mean Atmospheric loss	(dB)	0.1
User terminal G/T	(dB/K)	-9.7
Boltzmann Constant	(dBW/K/Hz)	-228.6
Down-path C/No	(dBHz)	74.9
Total		
Mean satellite C/IMo	(dBHz)	71.9
Co-Channel Interference	(dBHz)	74.0
Adjacent satellite interference allocation	(dB)	1.0
Mean Overall C/No	(dBHz)	66.6
Mean Overall C/N	(dB)	13.8
Margin		
C/N objective	(dB)	12.3
C/N margin	(dB)	1.5

Table A.11-2 – Link Budget for Communication Forward Link to Class-2 User Terminal (200 kHz carrier; Spot Beam)

General	Unit	
User terminal type	-	Class-2
Modulation ID / Designator	-	C2F2/ 200KD7W
Data rate (kbps)	(kbps)	464
Coding rate	-	0.775
Modulation	-	16-QAM
Carrier bandwidth	(kHz)	189
Allocated bandwidth	(kHz)	200
Uplink		
Frequency	(GHz)	6.5
SAS elevation angle	(deg)	5.0
SAS EIRP towards satellite	(dBW)	57.3
Path loss	(dB)	200.9
Mean Atmospheric loss	(dB)	0.4
Satellite G/T	(dB/K)	-10.4
Boltzmann Constant	(dBW/K/Hz)	-228.6
Up-path C/No	(dBHz)	74.2
Downlink		
Frequency	(GHz)	1.5
User terminal elevation angle	(deg)	90.0
Satellite EIRP	(dBW)	44.5
Path loss	(dB)	188.4
Mean Atmospheric loss	(dB)	0.1
User terminal G/T	(dB/K)	-12.5
Boltzmann Constant	(dBW/K/Hz)	-228.6
Down-path C/No	(dBHz)	72.1
Total		
Mean satellite C/IMo	(dBHz)	71.9
Co-Channel Interference	(dBHz)	74.0
Adjacent satellite interference allocation	(dB)	1.0
Mean Overall C/No	(dBHz)	65.9
Mean Overall C/N	(dB)	13.1
Margin		
C/N objective	(dB)	11.4
C/N margin	(dB)	1.7

Table A.11-3 – Link Budget for Communication Forward Link to Class-3 User Terminal (200 kHz carrier; Spot Beam)

General	Unit	
User terminal type	-	Class-3
Modulation ID / Designator	-	C3F2/ 200KD7W
Data rate (kbps)	(kbps)	384
Coding rate	-	0.642
Modulation	-	16-QAM
Carrier bandwidth	(kHz)	189
Allocated bandwidth	(kHz)	200
Uplink		
Frequency	(GHz)	6.5
SAS elevation angle	(deg)	5.0
SAS EIRP towards satellite	(dBW)	57.3
Path loss	(dB)	200.9
Mean Atmospheric loss	(dB)	0.4
Satellite G/T	(dB/K)	-10.4
Boltzmann Constant	(dBW/K/Hz)	-228.6
Up-path C/No	(dBHz)	74.2
Downlink		
Frequency	(GHz)	1.5
User terminal elevation angle	(deg)	90.0
Satellite EIRP	(dBW)	44.5
Path loss	(dB)	188.4
Mean Atmospheric loss	(dB)	0.1
User terminal G/T	(dB/K)	-16.9
Boltzmann Constant	(dBW/K/Hz)	-228.6
Down-path C/No	(dBHz)	67.7
Total		
Mean satellite C/IMo	(dBHz)	71.9
Co-Channel Interference	(dBHz)	74.0
Adjacent satellite interference allocation	(dB)	1.0
Mean Overall C/No	(dBHz)	64.1
Mean Overall C/N	(dB)	11.3
Margin		
C/N objective	(dB)	9.1
C/N margin	(dB)	2.2

Table A.11-4 – Link Budget for Signaling Forward Link to Class-1 User Terminal (50 kHz bandwidth; Regional Beam)

General	Unit	
User terminal type	-	Class1
Modulation ID / Designator	-	C1F3/ 50K0D7W
Data rate (kbps)	(kbps)	98
Coding rate	-	0.766
Modulation	-	16-QAM
Carrier bandwidth	(kHz)	42
Allocated bandwidth	(kHz)	50
Uplink		
Frequency	(GHz)	6.5
SAS elevation angle	(deg)	5.0
SAS EIRP towards satellite	(dBW)	61.0
Path loss	(dB)	200.9
Mean Atmospheric loss	(dB)	0.4
Satellite G/T	(dB/K)	-10.4
Boltzmann Constant	(dBW/K/Hz)	-228.6
Up-path C/No	(dBHz)	77.9
Downlink		
Frequency	(GHz)	1.5
User terminal elevation angle	(deg)	90.0
Satellite EIRP	(dBW)	33.2
Path loss	(dB)	188.4
Mean Atmospheric loss	(dB)	0.1
User terminal G/T	(dB/K)	-9.7
Boltzmann Constant	(dBW/K/Hz)	-228.6
Down-path C/No	(dBHz)	63.6
Total		
Mean satellite C/IMo	(dBHz)	65.8
Co-Channel Interference	(dBHz)	70.0
Adjacent satellite interference allocation	(dB)	1.0
Mean Overall C/No	(dBHz)	59.9
Mean Overall C/N	(dB)	13.6
Margin		
C/N objective	(dB)	11.4
C/N margin	(dB)	2.3

Table A.11-5 – Link Budget for Signaling Forward Link to Class-2 User Terminal (50 kHz bandwidth; Regional Beam)

General	Unit	
User terminal type	-	Class-2
Modulation ID / Designator	-	C2F3/ 50K0D7W
Data rate (kbps)	(kbps)	90
Coding rate	-	0.703
Modulation	-	16-QAM
Carrier bandwidth	(kHz)	42
Allocated bandwidth	(kHz)	50
Uplink		
Frequency	(GHz)	6.5
SAS elevation angle	(deg)	5.0
SAS EIRP towards satellite	(dBW)	61.0
Path loss	(dB)	200.9
Mean Atmospheric loss	(dB)	0.4
Satellite G/T	(dB/K)	-10.4
Boltzmann Constant	(dBW/K/Hz)	-228.6
Up-path C/No	(dBHz)	77.9
Downlink		
Frequency	(GHz)	1.5
User terminal elevation angle	(deg)	90.0
Satellite EIRP	(dBW)	33.2
Path loss	(dB)	188.4
Mean Atmospheric loss	(dB)	0.1
User terminal G/T	(dB/K)	-12.5
Boltzmann Constant	(dBW/K/Hz)	-228.6
Down-path C/No	(dBHz)	60.8
Total		
Mean satellite C/IMo	(dBHz)	65.8
Co-Channel Interference	(dBHz)	70.0
Adjacent satellite interference allocation	(dB)	1.0
Mean Overall C/No	(dBHz)	58.2
Mean Overall C/N	(dB)	11.9
Margin		
C/N objective	(dB)	10.3
C/N margin	(dB)	1.7

Table A.11-6 – Link Budget for Signaling Forward Link to Class-3 User Terminal (50 kHz bandwidth; Regional Beam)

General	Unit	
User terminal type	-	Class-3
Modulation ID / Designator	-	C3F3/ 50K0G7W
Data rate (kbps)	(kbps)	49.2
Coding rate	-	0.796
Modulation	-	QPSK
Carrier bandwidth	(kHz)	42
Allocated bandwidth	(kHz)	50
Uplink		
Frequency	(GHz)	6.5
SAS elevation angle	(deg)	5.0
SAS EIRP towards satellite	(dBW)	61.0
Path loss	(dB)	200.9
Mean Atmospheric loss	(dB)	0.4
Satellite G/T	(dB/K)	-10.4
Boltzmann Constant	(dBW/K/Hz)	-228.6
Up-path C/No	(dBHz)	77.9
Downlink		
Frequency	(GHz)	1.5
User terminal elevation angle	(deg)	90.0
Satellite EIRP	(dBW)	33.2
Path loss	(dB)	188.4
Mean Atmospheric loss	(dB)	0.1
User terminal G/T	(dB/K)	-16.9
Boltzmann Constant	(dBW/K/Hz)	-228.6
Down-path C/No	(dBHz)	56.4
Total		
Mean satellite C/IMo	(dBHz)	65.8
Co-Channel Interference	(dBHz)	70.0
Adjacent satellite interference allocation	(dB)	1.0
Mean Overall C/No	(dBHz)	54.7
Mean Overall C/N	(dB)	8.5
Margin		
C/N objective	(dB)	5.4
C/N margin	(dB)	3.1

Table A.11-7 – Link Budget for Signaling Forward Link to Class-1 User Terminal (12.5 kHz bandwidth; Global Beam)

General	Unit	
User terminal type	-	Class1
Modulation ID / Designator	-	C1F4/ 12K5G7W
Data rate (kbps)	(kbps)	12.2
Coding rate	-	0.897
Modulation	-	QPSK
Carrier bandwidth	(kHz)	10.5
Allocated bandwidth	(kHz)	12.5
Uplink		
Frequency	(GHz)	6.5
SAS elevation angle	(deg)	5.0
SAS EIRP towards satellite	(dBW)	60.3
Path loss	(dB)	200.9
Mean Atmospheric loss	(dB)	0.4
Satellite G/T	(dB/K)	-10.4
Boltzmann Constant	(dBW/K/Hz)	-228.6
Up-path C/No	(dBHz)	77.2
Downlink		
Frequency	(GHz)	1.5
User terminal elevation angle	(deg)	90.0
Satellite EIRP	(dBW)	33.0
Path loss	(dB)	188.4
Mean Atmospheric loss	(dB)	0.1
User terminal G/T	(dB/K)	-9.7
Boltzmann Constant	(dBW/K/Hz)	-228.6
Down-path C/No	(dBHz)	63.4
Total		
Mean satellite C/IMo	(dBHz)	60.0
Co-Channel Interference	(dBHz)	999.0
Adjacent satellite interference allocation	(dB)	1.0
Mean Overall C/No	(dBHz)	57.3
Mean Overall C/N	(dB)	17.1
Margin		
C/N objective	(dB)	8.1
C/N margin	(dB)	9.0

Table A.11-8 – Link Budget for Signaling Forward Link to Class-2 User Terminal (12.5 kHz bandwidth, via Global Beam)

General	Unit	
User terminal type	-	Class-2
Modulation ID / Designator	-	C2F4/ 12K5G7W
Data rate (kbps)	(kbps)	12.2
Coding rate	-	0.897
Modulation	-	QPSK
Carrier bandwidth	(kHz)	10.5
Allocated bandwidth	(kHz)	12.5
Uplink		
Frequency	(GHz)	6.5
SAS elevation angle	(deg)	5.0
SAS EIRP towards satellite	(dBW)	60.3
Path loss	(dB)	200.9
Mean Atmospheric loss	(dB)	0.4
Satellite G/T	(dB/K)	-10.4
Boltzmann Constant	(dBW/K/Hz)	-228.6
Up-path C/No	(dBHz)	77.2
Downlink		
Frequency	(GHz)	1.5
User terminal elevation angle	(deg)	90.0
Satellite EIRP	(dBW)	33.0
Path loss	(dB)	188.4
Mean Atmospheric loss	(dB)	0.1
User terminal G/T	(dB/K)	-12.5
Boltzmann Constant	(dBW/K/Hz)	-228.6
Down-path C/No	(dBHz)	60.6
Total		
Mean satellite C/IMo	(dBHz)	60.0
Co-Channel Interference	(dBHz)	999.0
Adjacent satellite interference allocation	(dB)	1.0
Mean Overall C/No	(dBHz)	56.2
Mean Overall C/N	(dB)	16.0
Margin		
C/N objective	(dB)	8.1
C/N margin	(dB)	7.9

Table A.11-9 – Link Budget for Signaling Forward Link to Class-3 User Terminal (12.5 kHz bandwidth, via Global Beam)

General	Unit	
User terminal type	-	Class-3
Modulation ID / Designator	-	C3F4/ 12K5G7W
Data rate (kbps)	(kbps)	12.2
Coding rate	-	0.897
Modulation	-	QPSK
Carrier bandwidth	(kHz)	10.5
Allocated bandwidth	(kHz)	12.5
Uplink		
Frequency	(GHz)	6.5
SAS elevation angle	(deg)	5.0
SAS EIRP towards satellite	(dBW)	60.3
Path loss	(dB)	200.9
Mean Atmospheric loss	(dB)	0.4
Satellite G/T	(dB/K)	-10.4
Boltzmann Constant	(dBW/K/Hz)	-228.6
Up-path C/No	(dBHz)	77.2
Downlink		
Frequency	(GHz)	1.5
User terminal elevation angle	(deg)	90.0
Satellite EIRP	(dBW)	33.0
Path loss	(dB)	188.4
Mean Atmospheric loss	(dB)	0.1
User terminal G/T	(dB/K)	-16.9
Boltzmann Constant	(dBW/K/Hz)	-228.6
Down-path C/No	(dBHz)	56.2
Total		
Mean satellite C/IMo	(dBHz)	60.0
Co-Channel Interference	(dBHz)	999.0
Adjacent satellite interference allocation	(dB)	1.0
Mean Overall C/No	(dBHz)	53.7
Mean Overall C/N	(dB)	13.4
Margin		
C/N objective	(dB)	8.1
C/N margin	(dB)	5.4

Table A.11-10 – Link Budget for Signaling Return Link from Class-1 User Terminal (50 kHz bandwidth; Regional Beam)

General	Unit	
User terminal type	-	Class-1
Modulation ID / Designator	-	C1R3 / 50K0D7W
Data rate (kbps)	(kbps)	101.6
Coding rate	-	0.852
Modulation	-	16-QAM
Carrier bandwidth	(kHz)	42
Allocated bandwidth	(kHz)	50
Uplink		
Frequency	(GHz)	1.6
User terminal elevation angle	(deg)	90
User terminal EIRP towards satellite	(dBW)	21.0
Path loss	(dB)	188.9
Atmospheric loss	(dB)	0.1
Satellite G/T	(dB/K)	2.2
Boltzmann Constant	(dBW/K/Hz)	-228.6
Adjacent Channel Interference	(dB)	0.2
Up-path C/No	(dBHz)	62.6
Downlink		
Frequency	(GHz)	3.6
SAS elevation angle	(deg)	5
Satellite EIRP	(dBW)	6.5
Path loss	(dB)	195.7
Atmospheric loss	(dB)	0.4
SAS G/T	(dB/K)	32.3
Boltzmann Constant	(dBW/K/Hz)	-228.6
Random Loss (99%)	(dB)	0.5
Down-path C/No	(dBHz)	70.8
Total		
Mean satellite C/IMo	(dBHz)	75.0
Co-Channel Interference	(dBHz)	73.4
Adjacent satellite interference allocation	(dB)	1.0
Mean Overall C/No	(dBHz)	60.5
Mean Overall C/N	(dB)	14.3
Margin		
C/N objective	(dB)	12.0
C/N margin	(dB)	2.2

Table A.11-11 – Link Budget for Signaling Return Link from Class-2 User Terminal (50 kHz bandwidth; Regional Beam)

General	Unit	
User terminal type	-	Class-2
Modulation ID / Designator	-	C2R3 / 50K0G7W
Data rate (kbps)	(kbps)	52.8
Coding rate	-	0.87
Modulation	-	pi/4 QPSK
Carrier bandwidth	(kHz)	42
Allocated bandwidth	(kHz)	50
Uplink		
Frequency	(GHz)	1.6
User terminal elevation angle	(deg)	90
User terminal EIRP towards satellite	(dBW)	16.1
Path loss	(dB)	188.9
Atmospheric loss	(dB)	0.1
Satellite G/T	(dB/K)	2.2
Boltzmann Constant	(dBW/K/Hz)	-228.6
Adjacent Channel Interference	(dB)	0.2
Up-path C/No	(dBHz)	57.7
Downlink		
Frequency	(GHz)	3.6
SAS elevation angle	(deg)	5
Satellite EIRP	(dBW)	1.6
Path loss	(dB)	195.7
Atmospheric loss	(dB)	0.4
SAS G/T	(dB/K)	32.3
Boltzmann Constant	(dBW/K/Hz)	-228.6
Random Loss (99%)	(dB)	0.5
Down-path C/No	(dBHz)	65.9
Total		
Mean satellite C/IMo	(dBHz)	70.1
Co-Channel Interference	(dBHz)	68.3
Adjacent satellite interference allocation	(dB)	1.0
Mean Overall C/No	(dBHz)	55.6
Mean Overall C/N	(dB)	9.3
Margin		
C/N objective	(dB)	6.6
C/N margin	(dB)	2.7

Table A.11-12 – Link Budget for Signaling Return Link from Class-3 User Terminal (25 kHz bandwidth; Regional Beam)

General	Unit	
User terminal type	-	Class-3
Modulation ID / Designator	-	C3R3 / 25K0G7W
Data rate (kbps)	(kbps)	20
Coding rate	-	0.73
Modulation	-	pi/4 QPSK
Carrier bandwidth	(kHz)	21
Allocated bandwidth	(kHz)	25
Uplink		
Frequency	(GHz)	1.6
User terminal elevation angle	(deg)	90
User terminal EIRP towards satellite	(dBW)	11.0
Path loss	(dB)	188.9
Atmospheric loss	(dB)	0.1
Satellite G/T	(dB/K)	2.2
Boltzmann Constant	(dBW/K/Hz)	-228.6
Adjacent Channel Interference	(dB)	0.2
Up-path C/No	(dBHz)	52.6
Downlink		
Frequency	(GHz)	3.6
SAS elevation angle	(deg)	5
Satellite EIRP	(dBW)	-3.5
Path loss	(dB)	195.7
Atmospheric loss	(dB)	0.4
SAS G/T	(dB/K)	32.3
Boltzmann Constant	(dBW/K/Hz)	-228.6
Random Loss (99%)	(dB)	0.5
Down-path C/No	(dBHz)	60.8
Total		
Mean satellite C/IMo	(dBHz)	65.0
Co-Channel Interference	(dBHz)	63.2
Adjacent satellite interference allocation	(dB)	1.0
Mean Overall C/No	(dBHz)	50.5
Mean Overall C/N	(dB)	7.3
Margin		
C/N objective	(dB)	4.4
C/N margin	(dB)	2.8

Table A.11-13 – Link Budget for Communication Return Link to Class-1 User Terminal (200 kHz carrier; Spot Beam)

General	Unit	
User terminal type	-	Class-1
Modulation ID / Designator	-	C1RT / 200KD7W
Data rate (kbps)	(kbps)	492.8
Coding rate	-	0.852
Modulation	-	16-QAM
Carrier bandwidth	(kHz)	189
Allocated bandwidth	(kHz)	200
Uplink		
Frequency	(GHz)	1.6
User terminal elevation angle	(deg)	90
User terminal EIRP towards satellite	(dBW)	21.0
Path loss	(dB)	188.9
Atmospheric loss	(dB)	0.1
Satellite G/T	(dB/K)	12.7
Boltzmann Constant	(dBW/K/Hz)	-228.6
Adjacent Channel Interference	(dB)	0.2
Up-path C/No	(dBHz)	73.1
Downlink		
Frequency	(GHz)	3.6
SAS elevation angle	(deg)	5
Satellite EIRP	(dBW)	14.5
Path loss	(dB)	195.7
Atmospheric loss	(dB)	0.4
SAS G/T	(dB/K)	32.3
Boltzmann Constant	(dBW/K/Hz)	-228.6
Random Loss (99%)	(dB)	0.5
Down-path C/No	(dBHz)	78.8
Total		
Mean satellite C/IMo	(dBHz)	83.0
Co-Channel Interference	(dBHz)	78.9
Adjacent satellite interference allocation	(dB)	1.0
Mean Overall C/No	(dBHz)	70.0
Mean Overall C/N	(dB)	17.2
Margin		
C/N objective	(dB)	12.7
C/N margin	(dB)	4.5

Table A.11-14 – Link Budget for Communication Return Link to Class-2 User Terminal (200 kHz carrier; Spot Beam)

General	Unit	
User terminal type	-	Class-2
Modulation ID / Designator	-	C2RT / 200KD7W
Data rate (kbps)	(kbps)	448
Coding rate	-	0.775
Modulation	-	16-QAM
Carrier bandwidth	(kHz)	189
Allocated bandwidth	(kHz)	200
Uplink		
Frequency	(GHz)	1.6
User terminal elevation angle	(deg)	90
User terminal EIRP towards satellite	(dBW)	16.1
Path loss	(dB)	188.9
Atmospheric loss	(dB)	0.1
Satellite G/T	(dB/K)	12.7
Boltzmann Constant	(dBW/K/Hz)	-228.6
Adjacent Channel Interference	(dB)	0.2
Up-path C/No	(dBHz)	68.2
Downlink		
Frequency	(GHz)	3.6
SAS elevation angle	(deg)	5
Satellite EIRP	(dBW)	9.6
Path loss	(dB)	195.7
Atmospheric loss	(dB)	0.4
SAS G/T	(dB/K)	32.3
Boltzmann Constant	(dBW/K/Hz)	-228.6
Random Loss (99%)	(dB)	0.5
Down-path C/No	(dBHz)	73.9
Total		
Mean satellite C/IMo	(dBHz)	78.1
Co-Channel Interference	(dBHz)	74.0
Adjacent satellite interference allocation	(dB)	1.0
Mean Overall C/No	(dBHz)	65.1
Mean Overall C/N	(dB)	12.3
Margin		
C/N objective	(dB)	10.8
C/N margin	(dB)	1.5

Table A.11-15 – Link Budget for Communication Return Link to Class-3 User Terminal (200 kHz carrier; Spot Beam))

General	Unit	
User terminal type	-	Class-3
Modulation ID / Designator	-	C3RT / 200KG7W
Data rate (kbps)	(kbps)	239.6
Coding rate	-	0.83
Modulation	-	pi/4 QPSK
Carrier bandwidth	(kHz)	189
Allocated bandwidth	(kHz)	200
Uplink		
Frequency	(GHz)	1.6
User terminal elevation angle	(deg)	90
User terminal EIRP towards satellite	(dBW)	11.0
Path loss	(dB)	188.9
Atmospheric loss	(dB)	0.1
Satellite G/T	(dB/K)	12.7
Boltzmann Constant	(dBW/K/Hz)	-228.6
Adjacent Channel Interference	(dB)	0.2
Up-path C/No	(dBHz)	63.1
Downlink		
Frequency	(GHz)	3.6
SAS elevation angle	(deg)	5
Satellite EIRP	(dBW)	4.5
Path loss	(dB)	195.7
Atmospheric loss	(dB)	0.4
SAS G/T	(dB/K)	32.3
Boltzmann Constant	(dBW/K/Hz)	-228.6
Random Loss (99%)	(dB)	0.5
Down-path C/No	(dBHz)	68.8
Total		
Mean satellite C/IMo	(dBHz)	73.0
Co-Channel Interference	(dBHz)	68.9
Adjacent satellite interference allocation	(dB)	1.0
Mean Overall C/No	(dBHz)	60.0
Mean Overall C/N	(dB)	7.2
Margin		
C/N objective	(dB)	4.8
C/N margin	(dB)	2.4

A.11.2 E&E Services

Tables A.11-16 and A.11-17 provide the E&E forward and return link budgets, respectively, via the global beam. Tables A.11-18 and A.11-19 provide the E&E forward and return link budgets, respectively, via the regional beams.

Certain terminal classes (e.g., Mini-M) can have different antenna sizes (e.g., low gain, medium gain, etc.). In such cases, only one representative antenna size has been provided in the link budgets.

Table A.11-16. E&E terminals. Global beam forward link budgets.

General	Unit									
User terminal type		INM-B	INM-B	INM-B	INM-M (Med. Gain)	INM-M (Med. Gain)	MINI-M (Low Gain)	M4	INM-C	INM-D/D+
Emission Designator		20K0G1E	100KG1X	10K0G1X	10K0G1W	10K0G1X	10K0G1X	10K0G1X	5K00G1D	2K50F1D
Modulation		O-QPSK	O-QPSK	BPSK	O-QPSK	BPSK	BPSK	BPSK	BPSK	32-FSK
Uplink										
Frequency	GHz	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
LES elevation angle	(deg)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
LES EIRP towards satellite	(dBW)	52.6	55.9	45.1	53.7	51.5	57.0	57.0	55.1	54.4
Path Loss	(dB)	200.9	200.9	200.9	200.9	200.9	200.9	200.9	200.9	200.9
Mean atmospheric loss	(dB)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Satellite G/T	(dB/K)	-10.4	-10.4	-10.4	-10.4	-10.4	-10.4	-10.4	-10.4	-10.4
Up-path C/No	(dBW/Hz)	69.5	72.8	62.0	70.6	68.4	73.9	73.9	72.0	71.3
Downlink										
Frequency	GHz	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
User terminal elevation angle	(deg)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Satellite EIRP	(dBW)	17.3	20.6	9.8	18.4	16.2	21.7	21.7	19.8	20.5
Path Loss	(dB)	188.3	188.3	188.3	188.3	188.3	188.3	188.3	188.3	188.3
Mean atmospheric loss	(dB)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
User terminal G/T	(dB/K)	-4.0	-4.0	-4.0	-10.0	-10.0	-17.0	-7.0	-23.0	-22.1
Down-path C/No	(dBW/Hz)	53.5	56.8	46.0	48.6	46.4	44.9	54.9	37.0	38.6
Total										
Mean satellite C/IMo	(dB/Hz)	66.7	69.9	59.1	67.7	65.5	71.0	71.0	69.1	69.8
Co-channel interference	(dB/Hz)	67.8	75.1	61.8	63.0	64.8	64.8	64.8	54.8	33.0
Adjacent sat. interference allocation	(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Mean overall C/No	(dB/Hz)	52.1	55.4	44.6	47.3	45.3	43.8	53.3	36.0	31.0
Mean overall C/N	(dB)	10.3	6.4	5.8	10.3	6.5	5.1	14.6	7.2	3.0
Margin										
C/N objective	(dB)	5.1	5.0	0.6	5.0	1.1	1.1	1.1	3.5	-10.9
C/N margin	(dB)	5.2	1.4	5.2	5.3	5.4	3.9	13.4	3.7	14.0

Table A.11-17. E&E terminals. Global beam return link budgets.

General	Unit								
User terminal type		INM-B	INM-B	INM-B	INM-M (Med. Gain)	INM-M (Med. Gain)	MINI-M (Low Gain)	INM-C	INM-D+
Emission Designator		20K0G1E	100KG1X	20K0G1X	10K0G1W	20K0G1X	20K0G1X	5K00G1D	2K50F1D
Modulation		O-QPSK	O-QPSK	O-QPSK	O-QPSK	BPSK	BPSK	BPSK	2-FSK
Uplink									
Frequency	GHz	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
User terminal elevation angle	(deg)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
User terminal EIRP towards satellite	(dBW)	30.0	33.0	29.3	25.0	21.0	17.0	13.6	2.6
Path Loss	(dB)	188.8	188.8	188.8	188.8	188.8	188.8	188.8	188.8
Mean atmospheric loss	(dB)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Satellite G/T	(dB/K)	-10	-10	-10	-10	-10	-10	-10	-10
Adjacent channel interference allocati	(dB)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Up-path C/No	(dBW/Hz)	59.5	62.5	58.8	54.5	50.5	46.5	43.1	32.1
Downlink									
Frequency	GHz	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
LES elevation angle	(deg)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Satellite EIRP	(dBW)	-8.4	-1.4	-9.1	-13.4	-17.4	-21.4	-23.0	-30.2
Path Loss	(dB)	195.7	195.7	195.7	195.7	195.7	195.7	195.7	195.7
Mean atmospheric loss	(dB)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
LES G/T	(dB/K)	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7
Random loss	(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Down-path C/No	(dBW/Hz)	54.1	61.1	53.4	49.1	45.1	41.1	39.5	32.3
Total									
Mean satellite C/IMo	(dB/Hz)	50.9	57.9	50.2	45.9	41.9	56.0	36.3	29.1
Co-channel interference	(dB/Hz)	67.8	75.1	67.8	63.0	61.8	61.8	54.8	48.1
Adjacent sat. interference allocation	(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Mean overall C/No	(dB/Hz)	47.8	54.2	47.1	42.8	38.8	38.9	33.0	25.1
Mean overall C/N	(dB)	6.0	5.2	5.3	5.8	3.1	3.1	4.2	1.0
Margin									
C/N objective	(dB)	5.1	5.0	4.4	5.0	1.7	1.2	3.5	-3.7
C/N margin	(dB)	0.9	0.2	0.9	0.8	1.4	2.0	0.7	4.7

Table A.11-18. E&E terminals. Regional beam forward link budgets.

General	Unit								
User terminal type		INM-B	INM-B	INM-M (Low Gain)	MINI-M (High Gain)	M4	M4	INM-C	INM-D/D+
Emission Designator		20K0G1E	100KG1X	10K0G1W	5K00G1E	60K0D1W	5K00G1W	5K00G1D	2K50F1D
Modulation		O-QPSK	QPSK	O-QPSK	O-QPSK	16 QAM	O-QPSK	BPSK	32-FSK
Uplink									
Frequency	GHz	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
LES elevation angle	(deg)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
LES EIRP towards satellite	(dBW)	54.8	59.8	56.4	50.9	64.1	50.9	55.4	54.4
Path Loss	(dB)	200.9	200.9	200.9	200.9	200.9	200.9	200.9	200.9
Mean atmospheric loss	(dB)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Satellite G/T	(dB/K)	-10.4	-10.4	-10.4	-10.4	-10.4	-10.4	-10.4	-10.4
Up-path C/No	(dBW/Hz)	71.7	76.7	73.3	67.8	81.0	67.8	72.3	71.3
Downlink									
Frequency	GHz	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
User terminal elevation angle	(deg)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Satellite EIRP	(dBW)	19.5	24.5	21.1	15.6	28.8	15.6	20.1	20.5
Path Loss	(dB)	188.3	188.3	188.3	188.3	188.3	188.3	188.3	188.3
Mean atmospheric loss	(dB)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
User terminal G/T	(dB/K)	-4.0	-4.0	-12.0	-7.0	-7.0	-7.0	-23.0	-22.1
Down-path C/No	(dBW/Hz)	55.7	60.7	49.3	48.8	62.0	48.8	37.3	38.6
Total									
Mean satellite C/IMo	(dB/Hz)	52.9	57.8	54.4	48.9	62.1	48.9	53.4	53.8
Co-channel interference	(dB/Hz)	58.3	65.5	53.5	52.0	62.7	52.0	45.3	33.0
Adjacent sat. interference allocation	(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Mean overall C/No	(dB/Hz)	49.3	54.5	46.0	43.9	56.5	43.9	35.6	30.9
Mean overall C/N	(dB)	7.5	5.5	9.0	8.4	10.5	8.4	6.8	3.0
Margin									
C/N objective	(dB)	5.1	5.0	5.0	5.4	7.7	5.4	3.5	-10.9
C/N margin	(dB)	2.4	0.5	4.0	3.1	2.8	3.1	3.3	13.9

Table A.11-19. E&E terminals. Regional beam return link budgets.

General	Unit								
User terminal type		INM-B	INM-B	INM-M (Low Gain)	MINI-M (High Gain)	M4	M4	INM-C	INM-D+
Emission Designator		20K0G1E	100KG1X	10K0G1W	5K00G1E	60K0D1W	5K00G1W	5K00G1D	2K50F1D
Modulation		O-QPSK	QPSK	O-QPSK	O-QPSK	16 QAM	O-QPSK	BPSK	2-FSK
Uplink									
Frequency	GHz	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
User terminal elevation angle	(deg)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
User terminal EIRP towards satellite	(dBW)	17.7	20.8	12.8	11.5	25.0	11.5	1.2	-2.2
Path Loss	(dB)	188.8	188.8	188.8	188.8	188.8	188.8	188.8	188.8
Mean atmospheric loss	(dB)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Satellite G/T	(dB/K)	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Adjacent channel interference allocation	(dB)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Up-path C/No	(dBW/Hz)	59.4	62.5	54.5	53.2	66.7	53.2	42.9	39.5
Downlink									
Frequency	GHz	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
LES elevation angle	(deg)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Satellite EIRP	(dBW)	-10.7	-3.6	-15.6	-16.9	-3.4	-16.9	-25.4	-25.0
Path Loss	(dB)	195.7	195.7	195.7	195.7	195.7	195.7	195.7	195.7
Mean atmospheric loss	(dB)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
LES G/T	(dB/K)	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7
Random loss	(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Down-path C/No	(dBW/Hz)	51.8	58.9	46.9	45.6	59.1	45.6	37.1	37.5
Total									
Mean satellite C/IMo	(dB/Hz)	54.3	61.4	49.4	48.1	61.6	48.1	39.6	40.0
Co-channel interference	(dB/Hz)	58.3	65.5	53.5	52.0	62.7	52.0	45.3	38.6
Adjacent sat. interference allocation	(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Mean overall C/No	(dB/Hz)	47.9	54.4	43.0	41.7	54.7	41.7	33.1	31.8
Mean overall C/N	(dB)	6.1	5.4	6.0	6.2	8.7	6.2	4.4	7.7
Margin									
C/N objective	(dB)	5.1	5.0	5.0	5.4	7.7	5.4	3.5	2.3
C/N margin	(dB)	1.0	0.4	1.0	0.9	1.0	0.9	0.8	5.4

A.12 STATION-KEEPING AND ANTENNA POINTING ACCURACY

The Inmarsat 4F2 satellite will be maintained in longitude within ±0.1° of its nominal orbital location for all latitudes within ±3.0° of the equator. The Inmarsat 4F2 satellite will operate in an inclined geostationary orbit, with the inclination permitted to fluctuate naturally between 0º and 3º degrees due to the celestial forces imparted on the satellite during its lifetime.

As the satellite orbit changes, the satellite's attitude control system will continuously adjust the antenna boresight pointing and the network gateway will periodically update payload antenna beam coefficients, to automatically adjust the satellite's antenna patterns in order to optimally position the footprints over the desired service areas.

The operations of Inmarsat 4F2 will be consistent with Commission requirements regarding longitudinal tolerance, which expressly do not apply to MSS spacecraft. *Mitigation of Orbital Debris*, 19 FCC Rcd 11567 (para. 44) (2004). As set forth below in Section A.20, there are not expected to be any other satellites within the same station-keeping volume as Inmarsat 4F2. *See Mitigation of Orbital Debris*, 19 FCC Rcd 11567 at para. 51. Moreover, the Inmarsat 4F2 satellite will operate in a manner consistent with the Commission's requirements for inclined orbit satellite operations, as specified in §25.280 of the Commission's rules.

The antenna axis attitude will be maintained within ±0.1° of nominal.

A.13 POWER FLUX DENSITY AT THE EARTH'S SURFACE

There are no Power Flux Density ("PFD") limits in the 3550-3700 MHz downlink frequency band according to the FCC Rules. However there are PFD limits in this band in Article 21 of the ITU Radio Regulations, as follows:

Limit in dB(W/m^2) for angles of arrival (δ) above the horizontal plane	Reference bandwidth

0°-5°	5°-25°	25°-90°	
–152	$-152 + 0.5(\delta - 5)$	–142	4 kHz

Note: These limits are the same as those specified by the FCC in §25.208(a) for the 3700-4200 MHz frequency band.

Compliance with these limits is demonstrated below using a simple worst-case methodology.

The maximum C-band downlink EIRP density arises from the return link budget shown in Table A.11-13, corresponding to a satellite EIRP level of +14.5 dBW in a 189 kHz occupied bandwidth. 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 would not exceed 14.5-162.06 = -147.6 dBW/m^2/189kHz. In any 4 kHz band this would correspond to a maximum PFD at the Earth's surface measured in a 4 kHz band of -147.6 + 10log(4E3/189E3) = -164.3 dBW/m^2/MHz. This is significantly less than the -152 dBW/m^2/MHz PFD limit that applies at elevation angles between 0° and 5°. Therefore compliance with the PFD limit is assured. No Inmarsat C-band transmissions will exceed the PFD limits of §25.208(a).

A.14 FREQUENCY TOLERANCE

The frequency translation accuracy is better than 1 part in 10^7, including periods of eclipse, over the operational life of the spacecraft

A.15 CESSATION OF EMISSIONS

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

A.16 TT&C

The telemetry, tracking, and command subsystem provides the satellite communications links for pre-launch, orbit-raising, and on-station operations. The TT&C system receives commands from the satellite mission control operations center, authenticates the commands, and distributes the commands to the appropriate satellite control units. The TT&C system also transmits satellite telemetry and receives and transmits ranging signals to the mission control operations center. The TT&C system is a standard C-Band system, and incorporates redundant command receivers, telemetry transmitters, and power amplifiers. The TT&C signals use the 6338 – 6342 MHz band for commanding and the 3945 – 3955 MHz band for telemetry. The signals are received / transmitted via a Global horn antenna in both polarizations. The primary TT&C earth station site for the Inmarsat 4F2 satellite is located in Italy.

A.17 SPACECRAFT CHARACTERISTICS

A summary of the satellite design is provided in Table A.17-1 below.

Table A.17-1: Satellite Summary

Satellite Manufacturer	EADS Astrium
Design Life	12 years
Satellite Platform	Astrium E3000 (Geo-mobile configuration)
Power Available (EOL)	11.7kW solstice to 13.7kW equinox
Batteries	2*NiH2 batteries
Solar Arrays	2*5-panel wings, 3 panels silicon and 2 panels GaAs cells, sun tracking with solar sailing biases
Station-keeping	Up to 3 degrees inclination, +/- 0.1 degrees longitude
Attitude Control	3-axis, momentum bias, chemical thrusters (during stationkeeping)
Communications Antenna	120-element phased array in conjunction with a 9m L-Band unfurlable mesh reflector One C-Band conical horn Two L-Band navigation, each 12 radiating patch elements
Command and Telemetry	One C-Band global horn with a west bias (on-station) 2 C-Band hemispherical (transfer and emergency)

The satellite platform, structure, attitude control, propulsion, power, thermal, and telemetry, tracking, and command subsystems are in the subsequent sections.

A.17.1 Spacecraft Bus

The spacecraft consists of a rectangular main structural body comprising a service module and a communications module mounted above. The structure houses the electronic equipment internally and externally mounts the solar arrays, attitude sensors, TT&C and communications feed array, L-Band and C-Band antennas and the 9 meter deployable L-Band mesh antenna. The service module is a standard E3000 platform with the 5 momentum wheel and 5-panel solar array options, flying in the Geo-Mobile configuration (90 degree rotation with mechanical –X axis earth-pointing).

The satellite mass summary is provided in Table A.17-2 below.

Table A.17-2: Spacecraft Mass Summary

	Mass (kg)
Satellite Payload	1655
Satellite Bus	1616
Satellite Dry Mass	3271
Margin	69
Fuel	2619
Launch Mass	5959

A.17.2 Attitude Control Subsystem

The momentum-biased attitude control subsystem (ACS) is composed of earth and sun sensors, gyros, momentum wheels, thrusters, and the electronics equipment required to maintain control of the satellite at all times.

A.17.3 Propulsion Subsystem

The liquid propulsion subsystem is a bipropellant system. Propellant and Helium pressurant are stored in tanks within the satellite body. One main thruster attached to the Liquid Apogee Engine

(LAE) is used to raise the orbit during the launch phase to geostationary orbit. Seven ACS thrusters are mounted around the outside of the satellite. The thrusters provide the impulse necessary for transfer orbit reorientation, 3-axis attitude control, East/West station-keeping, station changes and disposal orbit maneuvers. In addition, the satellite has two plasma thrusters using Xenon fuel for north-south station-keeping. The satellite has been designed to perform a graveyard maneuver at end-of-life. This propulsion system is the standard design for the Astrium E3000 series product line.

A.17.4 Electrical Power Subsystem

The electrical power subsystem is designed to provide more than 13 kW of power at the end of life equinox. Power generation is accomplished by two (2) x five (5) panel solar arrays populated with both silicon (Si) and gallium arsenide (GaAs) solar cells. The solar arrays track the sun using two Solar Array Drives (SADs). Two rechargeable nickel hydrogen batteries are used to store power for eclipse operations when the solar array is not illuminated. Power is supplied to units via two non-redundant power buses. This power system is essentially the same as the standard design for the Astrium E3000 product line.

Full details of the spacecraft's electrical characteristics are provided in the Schedule S form.

A.17.5 Thermal Control Subsystem

The thermal control subsystem provides a controlled thermal environment throughout the mission. The thermal control system consists of heat-pipes, surface treatments, radiators, blankets, insulators, and heaters to maintain all the equipment within the required operating environments. The service module thermal system is essentially the same as the standard design for the Astrium E3000 product line system. The communications payload additionally uses heat pipes.

A.17.6 Reliability

Payload reliability is 0.74 and bus reliability is 0.89 with an overall spacecraft reliability of approximately 0.66. Amplifier and receiver sparing is consistent with documented failure rates that allow the attainment of the overall spacecraft reliability numbers stated.

A.18 COMMUNICATIONS PAYLOAD

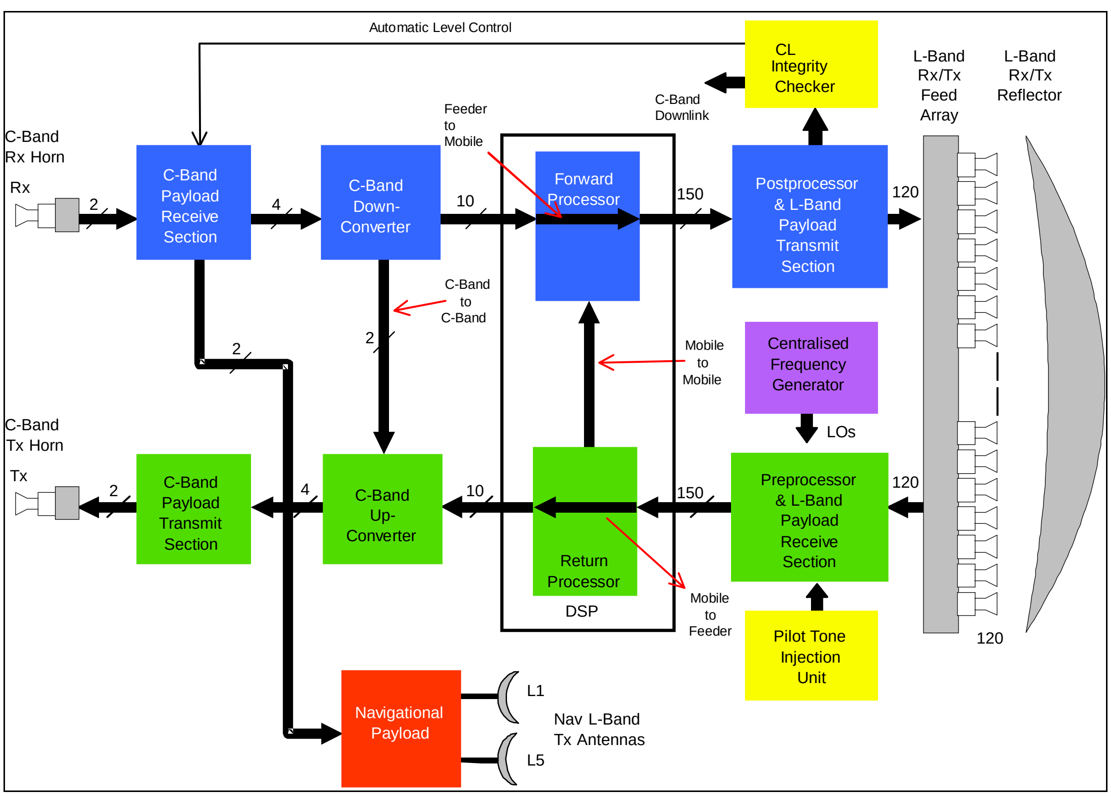
The communications payload includes all the necessary antennas and transponder hardware to receive, amplify, configure and transmit signals among user terminals and satellite access stations. The forward link provides communications between the gateway earth stations and the user terminals using C-band on the uplink and L-Band on the downlink. The return link provides communications between the user terminals and the gateway earth stations using L-Band on the uplink and C-band on the downlink. Digital beam forming enables up to 256 L-Band beams to be created; nominal configuration will have 1 global beam, 19 regional beams and on the order of 200 spot beams.

The Forward link receives signals at C-Band and transmits at L-Band. The signals are received by a dual circular polarized horn in either LHCP or RHCP before being amplified in the C-Band LNA. Each polarization is connected to the C-Band downconverter where the receive bandwidth is divided into sub-bands prior to connecting to the DSP where the channel mapping and beam forming functions take place on a channel by channel case. The DSP is followed by the L-Band Post-processor where the signals are filtered and up converted to L-Band via 120 active paths in the Post-processor one for each element of the Transmit Feed. To achieve the required output power the Post-processor outputs are connected to Modular Power Amplifier's, each comprising an INET, input switch network, SSPA's, output switch network and an ONET. The outputs of the MPA's are connected to 120 helix elements, which form the mobile antenna feed array to transmit the signals via the antenna paraboloid reflector. The different beams are produced by selected groups of helix elements illuminating the reflector as defined by the beam weights of the DSP.

The Return link receives signals at L-Band and transmits at C-Band. The mobile receive antenna operates in exactly the same way as the transmit antenna. The receive beams share a common reflector and 120 feed elements with the transmit beams. Each element is connected to an LNA where the signals are amplified before connecting to the L-Band Pre-processor. The Pre-processor provides conversion of mobile receive signals to base band for processing within the DSP; this includes beam forming multiplexing and channelization. The DSP is followed by the C-Band Upconverter. The signals are up-converted and filtered within the C-Band Upconverter before being amplified to the required transmit power in the C-Band MPA's, one for the LHCP and one for the RHCP. Each MPA comprises a C-Band Splitter, input switch network, High Power Amplifier's, output switch network and a Combiner. LHCP has an extra switch in the switch networks so that one of the C-Band HPA's can be in used in an emergency during the LEOP to amplify the telemetry channel. The MPA's are followed by output filters one on each polarization before the signals are transmitted by the C-Band dual polarized horn.

The block diagram for the communications payload is shown in Figure A.18-1.

Figure A.18-1: Block Diagram of the Communications Payload



A.19 TWO- DEGREE COMPATIBILITY ANALYSIS

With respect to the extended C-band (feeder links), there are no operational satellites within two degrees using the bands. The nearest satellite using the extended C-bands is the INTELSAT-805 satellite at 55.5° W.L.; a nominal orbital separation of 2.75 degrees. With respect to the conventional C-band (TT&C), the nearest satellite using the bands is the INTELSAT-707 satellite at 53° W.L. Inmarsat and Intelsat have reached a frequency coordination agreement for use of both the extended and conventional C-band frequencies.

In order to show two-degree compatibility, the C-band transmission parameters of the Inmarsat 4F2 have been assumed as both the wanted and victim transmissions. Tables A.19-1 and A.19-2 provide a summary of the uplink and downlink C-band feeder link and TT&C transmission parameters, respectively.

Table A.19-1. Summary of the uplink C-band feeder link and TT&C transmission parameters.

Carrier ID	Emission Designator	Occupied BW (kHz)	Tx Antenna Gain (dBi)	Uplink EIRP (dBW)	C/I Criterion (dB)	Comments
1	200KD7W	189	57.0	57.3	24.5	
2	50K0D7W	42	57.0	61.0	23.6	
3	50K0G7W	42	57.0	61.0	23.6	
4	12K5G7W	10.5	57.0	60.3	20.3	1 operational carrier per satellite.
5	1M40F3X (Telecommand)	900	57.0	75.0	23.0	Normal operation assumed.
6	20K0G1E	15	54.0	52.6	17.3	
7	100KG1X	80	54.0	55.9	17.2	
8	10K0G1X	7.5	54.0	45.1	12.8	
9	10K0G1W	5	54.0	53.7	17.2	
10	10K0G1X	7.5	54.0	51.5	13.3	
11	10K0G1X	7.5	54.0	57.0	13.3	
12	5K00G1D	0.75	54.0	55.1	15.7	Carriers are spaced 10 kHz apart.
13	2K50F1D	0.62	54.0	54.4	1.3	Carriers are spaced 5 kHz apart.
14	20K0G1E	15	54.0	54.8	17.3	
15	100KG1X	80	54.0	59.8	17.2	
16	10K0G1W	5	54.0	56.4	17.2	
17	5K00G1E	3.5	54.0	50.9	17.3	
18	60K0D1W	40	54.0	64.1	19.9	
19	5K00G1W	3.5	54.0	50.9	17.6	
20	5K00G1D	0.75	54.0	55.4	15.7	Carriers are spaced 10 kHz apart.
21	2K50F1D	0.62	54.0	54.4	1.3	Carriers are spaced 5 kHz apart.

Table A.19-2. Summary of the downlink C-band feeder link and TT&C parameters.

Carrier ID	Emission Designator	Occupied BW (kHz)	Rx Antenna Gain (dBi)	Downlink EIRP (dBW)	C/I Criterion (dB)	Comments
1	50K0D7W	42	52.9	6.5	24.2	
2	50K0G7W	42	52.9	1.5	18.8	
3	25K0G7W	21	52.9	-3.5	16.6	
4	200KD7W	189	52.9	14.5	24.9	
5	200KD7W	189	52.9	9.6	23.0	
6	200KG7W	189	52.9	4.5	17.0	
7	180KG3X (Telemetry)	130	52.9	11.5	23.0	
8	20K0G1E	15.00	49.2	-8.4	17.3	
9	100KG1X	80.00	49.2	-1.4	17.2	
10	20K0G1X	15.00	49.2	-9.1	16.6	
11	10K0G1W	5.00	49.2	-13.4	17.2	
12	20K0G1X	3.75	49.2	-17.4	13.9	
13	20K0G1X	3.75	49.2	-21.4	13.4	
14	5K00G1D	0.75	49.2	-23.0	15.7	
15	2K50F1D	0.26	49.2	-30.2	8.5	
16	20K0G1E	15.00	49.2	-10.7	17.3	
17	100KG1X	80.00	49.2	-3.6	17.2	
18	10K0G1W	5.00	49.2	-15.6	17.2	
19	5K00G1E	3.50	49.2	-16.9	17.3	
20	60K0D1W	40.00	49.2	-3.4	19.9	
21	5K00G1W	3.50	49.2	-16.9	17.6	
22	5K00G1D	0.75	49.2	-25.4	15.7	
23	2K50F1D	0.26	49.2	-25.0	14.5	

The interference calculations assumed a 1 dB advantage for topocentric-to-geocentric conversion, a worst case possible carrier spacing for the narrow band carriers, all wanted and interfering carriers are co-polarized and all earth station antennas conform to a sidelobe pattern of 29-25 log(θ). The analysis also assumes a nominal orbital separation of 1.95 degrees as opposed to two degrees in order to take into account the increased east-west station-keeping of 0.1 degrees.

Tables A.19-3 and A.19-4 show the results of the interference calculations in terms of the uplink and downlink C/I margins, respectively. The tables are provided in a format similar to that of the output of the Sharp Adjacent Satellite Interference Analysis program. In the uplink, there are a few negative C/I margins with the largest deficit being 4.1 dB. In the downlink, the largest C/I deficit is 3.8 dB. It is expected that such deficits could be coordinated with any future satellite operator located two degrees away.

Table A.19-3. Summary of the uplink C/I margins (dB).

		Interfering Carrier																				
	Carrier ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Wanted Carrier	1	11.8	2.3	1.6	8.8	0.9	3.7	7.4	8.2	-0.4	1.8	-3.7	-1.8	-1.1	1.5	3.5	-3.1	-0.6	-3.0	-0.6	-2.1	-4.1
	2	22.9	12.7	12.7	13.4	12.0	14.9	17.6	19.4	10.7	13.0	7.5	9.4	10.1	12.7	13.7	8.0	10.5	6.4	10.5	9.1	7.0
	3	22.9	12.7	12.7	13.4	12.0	14.9	17.6	19.4	10.7	13.0	7.5	9.4	10.1	12.7	13.7	8.0	10.5	6.4	10.5	9.1	7.0
	4	31.3	21.1	21.1	16.0	20.4	22.0	26.0	27.8	19.2	21.4	15.9	17.8	18.5	21.1	22.1	13.5	19.0	14.8	19.0	17.5	15.5
	5	24.2	14.7	14.0	28.0	13.3	16.2	19.8	20.6	12.0	14.2	8.7	10.6	11.3	14.0	15.9	9.3	11.8	9.4	11.8	10.3	8.3
	6	25.3	15.1	15.1	11.3	14.4	16.0	20.0	21.7	13.1	15.3	9.8	11.7	12.4	13.8	16.1	10.4	12.9	8.7	12.9	11.4	9.4
	7	21.4	11.9	11.2	14.7	10.5	13.4	16.1	17.9	9.2	11.5	6.0	7.9	8.6	11.2	12.2	6.5	9.0	6.6	9.0	7.6	5.5
	8	25.3	15.1	15.1	9.9	14.4	16.0	20.0	20.5	10.1	14.1	8.6	10.5	11.2	13.8	16.1	9.2	12.9	8.8	12.9	10.2	9.4
	9	31.3	21.0	21.0	15.9	20.3	22.0	25.9	26.4	16.1	20.0	14.5	14.7	15.4	19.8	22.0	13.4	18.9	14.7	18.9	14.4	6.3
	10	31.2	21.0	21.0	15.8	20.3	21.9	25.9	26.4	16.0	20.0	14.5	16.4	17.1	19.7	22.0	15.1	18.8	14.7	18.8	16.1	15.3
	11	36.7	26.5	26.5	21.3	25.8	27.4	31.4	31.9	21.5	25.5	20.0	21.9	22.6	25.2	27.5	20.6	24.3	20.2	24.3	21.6	20.8
	12	42.4	32.2	32.2	15.4	31.5	33.1	37.1	37.6	27.2	31.2	25.7	17.6	17.5	30.9	33.2	24.5	28.5	25.9	28.5	17.3	17.5
	13	56.9	46.7	46.7	41.6	46.0	47.6	51.6	52.1	41.8	45.7	40.2	32.1	32.0	45.4	47.7	39.1	43.0	40.4	43.0	31.8	32.0
	14	27.5	17.3	17.3	13.5	16.6	18.2	22.2	23.9	15.3	17.5	12.0	13.9	14.6	16.0	18.3	12.6	15.1	10.9	15.1	13.6	11.6
	15	25.3	15.8	15.1	18.6	14.4	17.3	20.0	21.8	13.1	15.4	9.9	11.8	12.5	15.1	16.1	10.4	12.9	10.5	12.9	11.5	9.4
	16	34.0	23.7	23.7	18.6	23.0	24.7	28.6	29.1	18.8	22.7	17.2	17.4	18.1	22.5	24.7	16.1	21.6	17.4	21.6	17.1	9.0
	17	29.9	19.7	19.7	14.6	19.0	20.6	24.6	25.1	14.7	18.7	13.2	11.8	12.5	18.4	20.7	12.0	16.0	13.4	16.0	11.5	5.0
	18	29.9	19.7	19.7	20.2	19.0	21.9	24.6	26.4	17.8	20.0	14.5	16.4	17.1	19.7	20.7	15.1	17.6	13.4	17.6	16.1	14.1
	19	29.6	19.4	19.4	14.3	18.7	20.3	24.3	24.8	14.4	18.4	12.9	11.5	12.2	18.1	20.4	11.7	15.7	13.1	15.7	11.2	4.7
	20	42.7	32.5	32.5	27.3	31.8	33.4	37.4	37.9	27.5	31.5	26.0	17.9	17.8	31.2	33.5	24.8	28.8	26.2	28.8	17.6	17.8
	21	56.9	46.7	46.7	41.6	46.0	47.6	51.6	52.1	41.8	45.7	40.2	32.1	32.0	45.4	47.7	39.1	43.0	40.4	43.0	31.8	32.0

Table A.19-4. Summary of the downlink C/I margins (dB).

		Interfering Carrier																						
	Carrier ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Wanted Carrier	1	8.0	13.0	15.7	6.5	11.4	16.5	7.9	19.7	18.7	20.4	21.6	29.0	33.0	31.3	38.5	22.0	20.9	20.8	26.1	17.7	22.1	30.6	27.2
	2	8.4	13.4	16.1	6.9	11.8	16.9	8.3	20.1	19.1	20.8	22.0	29.4	33.4	31.7	38.9	22.4	21.3	21.2	26.5	18.1	22.5	31.0	27.6
	3	8.6	13.6	15.6	7.1	12.0	17.1	8.5	20.3	19.3	21.0	22.3	29.6	33.6	31.9	39.1	22.6	21.5	21.5	26.7	18.3	22.8	31.3	27.8
	4	9.5	14.5	16.5	7.3	12.2	17.3	8.7	20.4	20.4	21.1	22.4	29.7	33.7	32.0	39.2	22.7	21.7	22.6	26.9	20.2	22.9	31.4	28.0
	5	6.5	11.5	13.5	4.3	9.2	14.3	5.7	17.4	17.4	18.1	19.4	26.7	30.7	29.0	36.2	19.7	18.7	19.6	23.9	17.2	19.9	28.4	25.0
	6	7.4	12.4	14.4	5.2	10.1	15.2	6.6	18.3	18.3	19.0	20.3	27.6	31.6	29.9	37.1	20.6	19.6	20.5	24.8	18.1	20.8	29.3	25.9
	7	10.0	15.0	17.0	7.8	12.7	17.8	9.2	21.0	20.9	21.7	22.9	30.3	34.3	32.5	39.7	23.3	22.2	23.1	27.4	20.7	23.4	31.9	28.5
	8	0.8	5.8	7.7	-0.7	4.2	9.3	0.7	11.2	11.5	11.9	14.4	20.5	25.7	24.0	31.2	13.5	13.7	13.6	18.9	10.4	14.9	23.4	20.0
	9	0.6	5.6	8.3	-0.9	4.0	9.1	0.5	12.3	11.3	13.0	14.2	21.6	25.6	23.9	31.1	14.6	13.5	13.4	18.7	10.3	14.7	23.2	19.8
	10	0.8	5.8	7.7	-0.7	4.2	9.3	0.7	11.2	11.5	11.9	14.4	20.5	25.7	24.0	31.2	13.5	13.7	13.6	18.9	10.4	14.9	23.4	20.0
	11	0.6	5.6	7.6	-0.8	4.1	9.2	0.5	11.1	11.3	11.8	11.3	15.6	19.6	20.9	28.1	13.4	13.5	13.5	14.8	10.3	14.8	23.3	19.9
	12	1.2	6.2	8.2	-0.3	4.6	9.7	1.1	11.6	11.9	12.3	11.8	14.6	18.6	19.9	27.1	13.9	14.1	14.0	13.8	10.9	13.8	15.6	20.4
	13	-2.3	2.7	4.7	-3.8	1.1	6.2	-2.4	8.1	8.4	8.8	8.3	11.1	15.1	16.4	23.6	10.4	10.6	10.5	10.3	7.4	10.3	12.1	16.9
	14	0.8	5.8	7.8	-0.7	4.2	9.3	0.7	11.2	11.5	11.9	11.4	14.2	18.2	12.8	20.0	13.5	13.7	13.6	13.4	10.5	13.4	15.2	20.0
	15	5.4	10.4	12.4	3.9	8.8	13.9	5.3	15.8	16.1	16.5	16.0	18.8	22.8	17.4	20.0	18.1	18.3	18.2	18.0	15.1	18.0	19.8	14.8
	16	-1.5	3.5	5.4	-3.0	1.9	7.0	-1.6	8.9	9.2	9.6	12.1	18.2	23.4	21.7	28.9	11.2	11.4	11.3	16.6	8.1	12.6	21.1	17.7
	17	-0.9	4.1	6.1	-3.1	1.8	6.9	-1.7	10.1	9.1	10.8	12.0	19.4	23.4	21.7	28.9	12.4	11.3	11.2	16.5	8.1	12.5	21.0	17.6
	18	-1.6	3.4	5.4	-3.0	1.9	7.0	-1.7	8.9	9.1	9.6	9.1	13.4	17.4	18.7	25.9	11.2	11.3	11.3	12.6	8.1	12.6	21.1	17.7
	19	-1.4	3.6	5.6	-2.9	2.0	7.1	-1.5	9.0	9.3	9.7	9.2	12.0	16.0	17.3	24.5	11.3	11.5	11.4	11.2	8.3	11.2	13.0	17.8
	20	-1.1	3.9	6.6	-2.6	2.3	7.4	-1.2	10.6	9.6	11.3	12.6	19.9	23.9	22.2	29.4	12.9	11.8	11.8	17.0	8.6	13.1	21.6	18.1
	21	-1.7	3.3	5.3	-3.2	1.7	6.8	-1.8	8.7	9.0	9.4	8.9	11.7	15.7	17.0	24.2	11.0	11.2	11.1	10.9	8.0	10.9	12.7	17.5
	22	-1.6	3.4	5.4	-3.1	1.8	6.9	-1.7	8.8	9.1	9.5	9.0	11.8	15.8	10.4	17.6	11.1	11.3	11.2	11.0	8.1	11.0	12.8	17.6
	23	4.6	9.6	11.6	3.1	8.0	13.1	4.5	15.0	15.3	15.7	15.2	18.0	22.0	16.6	19.2	17.3	17.5	17.4	17.2	14.3	17.2	19.0	14.0

A.20 ORBITAL DEBRIS MITIGATION

Inmarsat has utilized a satellite and launch vehicle design that minimizes the amount of debris released during normal operations. Inmarsat and its satellite contractor have performed a careful assessment, and can confirm that no debris will be released by the space station during normal on-station operations. As noted below, Inmarsat has taken measures to ensure a safe operational configuration of its satellite system through hardware design and operational procedures. Each section below addresses specific measures taken by Inmarsat, as required under §25.114(d)(14) of the Commission's rules, to limit the possibility that its space station operations will generate orbital debris.

Collisions with small debris, meteoroids: Inmarsat has assessed and limited the probability of the space station becoming a source of debris by collisions with small debris or meteoroids less than one centimeter in diameter that could cause loss of control and prevent post-mission disposal. The possibility of collisions with the background environment, including meteoroids, is taken into account as part of the satellite design. These effects are considered on a statistical basis to determine collision risk. Inmarsat' satellite manufacturer, Astrium, includes meteoroid environments as part of the satellite Environmental Requirement Specifications. Literature is reviewed for large size space objects, particularly technical papers that present collision probability estimates for orbital conditions of interest. The satellite requirement was derived from these technical papers as well as NASA models to include debris and meteoroids of various sizes. Inmarsat has taken steps to limit the effects of such collisions through shielding, the placement of components, and the use of redundant systems. All sources of stored energy are located within the body of the spacecraft, thereby providing protection from small orbital debris. The propulsion system is fully enclosed within the spacecraft structure, with the exception of the thrusters themselves. In addition, the propulsion system is made of two fully redundant halves with no open connection between the two. A single collision is unlikely to reach the propulsion system and would not affect both halves.

Accidental explosions, energy sources on board: Inmarsat has assessed and limited the probability of accidental explosions during and after completion of mission operations. In designing the Inmarsat 4F2 satellite, the satellite manufacturer has taken 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. A failure mitigation design approach was utilized for the entire spacecraft design including failure propagation of the propulsion system. In addition, catastrophic failure by explosion is eliminated by design, qualification and test. All pressurized vessels have ample margins between operating and burst pressure. The satellite manufacturer advises that no structural failures of pressurized volumes have occurred on its satellites to date. Bipropellant mixing is prevented by the use of valves that prevent backwards flow in propellant lines and pressurization lines. Although NiH2 batteries retain fluids in a pressure vessel, pressure at end-of-life is maintained at a low level, and procedures will be undertaken by Inmarsat to assure that the battery does not retain a charge at the end of the mission. Pyrotechnics are only used in the mission as part of the initial deployment process. The pyrotechnic devices onboard the satellite have been designed to retain all physical debris. Upon reaching the final disposal orbit, all fuel tanks will be close to empty. All remaining propellants will be vented utilizing the on-board thrusters and all fuel line valves will be left open.

Collisions with large debris or operational space stations: Inmarsat has assessed and limited the probability of the space station becoming a source of debris by collisions with large debris or other operational space stations. Specifically Inmarsat has assessed the possibility of collision with satellites located at, or reasonably expected to be located at, the requested orbital location, or assigned in the vicinity of that location.

Inmarsat has examined whether its station-keeping volume might overlap with that of other operational or planned satellites in the vicinity of the 52.75° W.L. orbital location. In considering operational and planned satellites that may have a station-keeping volume that overlaps the Inmarsat 4F2 satellite, Inmarsat reviewed the lists of FCC licensed systems and systems that are currently under consideration by the FCC. In addition, networks for which a request for coordination has been submitted to the ITU for an orbital location between 52.55° W.L. and 53° W.L. have also been reviewed.

Based on the review, Intelsat has Commission authorization to operate the INTELSAT-707 satellite at 53° W.L. There are no networks currently under consideration by the Commission to use the 53° W.L. slot.

The only published ITU networks between 52.55° W.L. and 53° W.L. are Intelsat networks (U.S. and U.K.) at 53° W.L. and a U.S. Ku/V-band network at 53° W.L. that is not assigned to any U.S. operator. The operation of the Inmarsat 4F2 satellite at the 52.75° W.L. position avoids the possibility of an in-orbit collision by separating Inmarsat 4F2's station-keeping box from that of Intelsat's.

Inmarsat has selected one of the established launch agencies with a proven record of safe flight planning, taking care to minimize the possibilities of any collision. The launch contractor is responsible for collision avoidance maneuvers and launch analysis of in-flight profile planning for the launch vehicle. Inmarsat uses the services of the USSTRATCOM organization to perform collision avoidance analysis for the Inmarsat 4F2 satellite for the post-launch phase

Post-mission disposal plans (disposal altitude and calculations, fuel reserves): At the end of the operational life of the Inmarsat 4F2 satellite, Inmarsat plans to maneuver the satellite to a disposal orbit with a minimum perigee of 337 km above the normal GSO operational orbit. This proposed disposal orbit altitude is based on the following calculation, as required in §25.283:

Solar array area = 90 m^2
Satellite body area (oriented for max antenna exposure) = 17.4m^2
L-band antenna area = 32 m^2
C-band antenna area = 32 m^2
Total Solar Pressure Area "A" = 171.4 m^2

"M" = Dry Mass of Satellite = 3340 kg
"C_R" = Solar Pressure Radiation Coefficient (worst case) = 2.0

Therefore the Minimum Disposal Orbit Perigee Altitude:

= 36,021 km + 1000 x C_R x A/m
= 36,021 km + 1000 x 2 x 171.4/3340
= 36,123.6
= 337 km above GSO (35,786 km)

The propulsion subsystem design and the satellite fuel budget account for the post-mission disposal of the satellite. 15.6 kg of propellant has been allocated and reserved for the final orbit raising maneuvers. Inmarsat has assessed fuel gauging uncertainty and the 15.6 kg of propellant provides a sufficient margin of reserve fuel to address the uncertainty.

A.21 COMMENTS CONCERNING SCHEDULE S SUBMISSION

In this section, additional explanation is provided concerning specific areas of the Schedule S form where the advanced design of the Inmarsat 4F2 satellite design does not necessarily comport well with the mechanics of the Schedule S form. To the extent that the Commission considers any of these areas to be in non-compliance with the Schedule S requirements, the applicant requests a waiver, based on the justification and explanation given below.

1. S7 and S8 ("Antenna Beam" and "Beam Diagram tabs in Schedule S):

   (i) Only one representative uplink and downlink L-band spot beam (LSU and LSD beam) and one representative uplink and downlink L-band regional beam (LRU and LRD beam) has been included in the Schedule S form. The use of a phased array antenna provides complete flexibility in the generation of the spot and regional beams and therefore there are an infinite number of pointing directions for the spot and regional beams. A single representative beam for each of the beams LSU, LSD, LRU and LRD has been included in the Schedule S form. Should the Commission require it, Inmarsat will provide additional gain contour files for other example beam positions over the U.S.

   (ii) Item S7m: Transmit Max EIRP (dBW) for the "LSD" and "LRD" beams. The values entered here are 70 and 58 dBW, respectively, and are the aggregate EIRP values for the two beam types. In practice, for each beam type, the available power will be distributed across a number of the beams within that beam type.

2. S10 (“Space Station Transponders” tab in Schedule S):

The satellite does not have conventional transponders. There is no fixed frequency relationship between the L-band frequencies and the extended C-band feeder link frequencies. For purposes of completing the Schedule S form, the connectivity between the feeder link C-band spectrum and L-band spectrum, in both the forward and return directions, have been described as showing all available feeder link spectrum strapped to the available L-band spectrum.

CERTIFICATION OF PERSON RESPONSIBLE FOR PREPARING ENGINEERING INFORMATION

I hereby certify that I am the technically qualified person responsible for preparation of the engineering information contained in this pleading, that I am familiar with Part 25 of the Commission's rules that I have either prepared or reviewed the engineering information submitted in this pleading, and that it is complete and accurate to the best of my knowledge and belief.

/s/

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