

## APPENDIX A

### TECHNICAL DESCRIPTION

#### A.1 GENERAL DESCRIPTION

This Technical Description provides information on the proposed operations for the Inmarsat 3F5 satellite at 54° W.L., where Inmarsat has operated an identical satellite (Inmarsat 3F4) since 2009. This satellite will operate under the same technical parameters, subject to the same authorizing conditions, and provide the same types of “existing and evolved” Inmarsat services, as have been authorized and provided at this very location for the last six years.<sup>1</sup>

The Inmarsat-3 F5 satellite, licensed in the United Kingdom, provides Mobile-Satellite Services (“MSS”) to small User Terminals (“UTs”) in the USA, its territorial waters, and other regions visible from the satellite.

This filing seeks authority to use the Inmarsat 3F5 satellite to communicate in L-band service link frequencies. In the interest of providing a complete description of the operations of the spacecraft, descriptions of the extended C-band feeder link and conventional C-band TT&C parameters are also provided. Conventional C-band TT&C and extended C-band feeder links, however, are not the subject of the present filing.

Signals to and from user terminals (UTs) as well as certain gateway earth stations are connected through the spacecraft using the 1525-1559 MHz band for space-to-Earth transmissions and the 1626.5-1660.5 MHz band for Earth-to-space transmissions.<sup>2</sup> Signals to and from the gateway earth station(s) via feeder links are connected through the Fixed-Satellite Service (“FSS”) frequency bands using the 3600-3631.6 MHz band in the space-to-Earth direction and the 6425-

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<sup>1</sup> See IBFS File Nos. SAT-PPL-20090107-00003 and SAT-APL-20090115-00005 (the “I3F4 ISAT List PDR”). See also *Comsat Corp.*, 16 FCC Rcd 21611 (2001). The ISAT List references this same decision as the source of technical information for the currently authorized operations of two other Inmarsat-3 series spacecraft: I3F2 at 15.5° W.L. and I3F3 at 178° E.L. See *ISAT List*, available at <https://transition.fcc.gov/ib/sd/se/isat.html>. See also *Inmarsat, Inc. Request to Streamline Licensing of L-Band Mobile-Satellite Service Terminals Using Inmarsat Satellites as Points of Communication*, 23 FCC Rcd. 15268, Appendix (Int'l Bur. 2008) (“ISAT List Order”).

<sup>2</sup> These bands are collectively known as the “L-band” frequencies.

6456.6 MHz band in the Earth-to-space direction.<sup>3</sup> Applications to communicate in extended C-band frequencies will be the subject of one or more separately-filed earth station applications.

On-station TT&C signals between the Inmarsat-3 F5 satellite and TT&C earth stations occur in the 3945-3955 MHz downlink band and the 6338-6342 MHz uplink band. The primary TT&C facilities for the Inmarsat-3 satellites are currently located in Italy and China (near Beijing). None of the TT&C earth stations that are used to communicate with the Inmarsat-3 F5 satellite at 54° W.L. will be located in the United States.

The Inmarsat-3 satellite is also capable of providing services in the Radio-Navigation Satellite Service. Navigation carriers of 2.2 MHz bandwidth are transmitted in the bands 1574.4-1576.6/3629.4-3631.6 MHz in the space-to-Earth direction and the 6454.4-6456.6 MHz in the Earth-to-space direction.

The Inmarsat-3 satellite also has the capability of providing C-to-C-band links. The C-to-C band links are available in the band 3707.3-3608.2 MHz in the space-to-Earth direction and 6432.3-6433.2 MHz in the Earth-to-space direction. These links are intended to provide satellite ranging and data exchange between gateway earth stations within the Inmarsat 3F5 satellite's coverage area. The C-to-C band link operations will be consistent with the power limits in Section 25.212 of the Commission's rules.

The Inmarsat-3 satellites feature separate offset parabolic reflectors for L-band receive and transmit, each fed by a multi-element feed structure capable of creating a global beam and up to 7 regional spot beams. Two separate horns serve as the C-band antennas.<sup>3</sup>

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<sup>3</sup> These bands are within what is collectively known as the “extended C-band” frequencies.

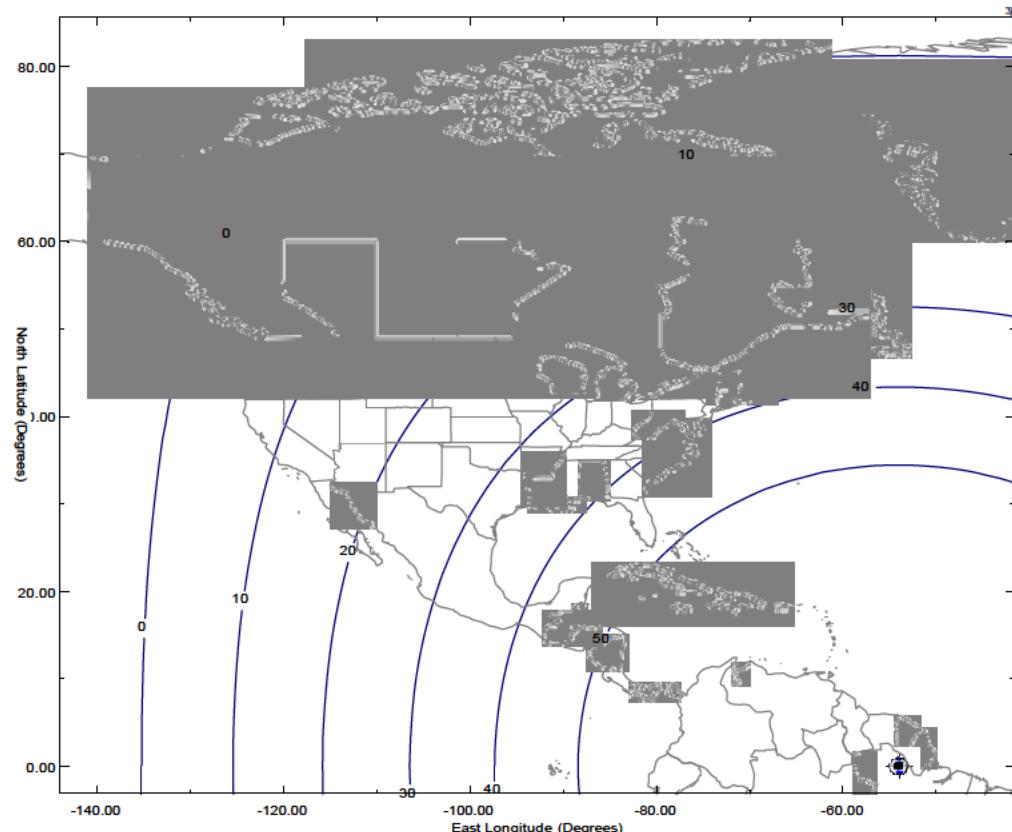
## A.2 ORBITAL LOCATION

Inmarsat is authorized by the United Kingdom to operate the Inmarsat-3 F5 satellite at the  $54^{\circ}$  W.L. geostationary orbital location.

## A.3 SATELLITE COVERAGE

The Inmarsat-3 F5 satellite provides two-way feeder links in the extended-C band through one global beam. Two way MSS services (*i.e.*, the service links) to user terminals using the L-band are provided through one L-band global beam and up to 7 regional spot beams. The elevation angles towards North America are shown in Figure A.2-1.

**Figure A.2-1 – Elevation Angles from the Inmarsat-3 F5  $54^{\circ}$  W.L. Orbital Location**



## A.4 FREQUENCY AND POLARIZATION PLAN

The Inmarsat-3 satellites are 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 feeder link spectrum is re-used twice by means of dual orthogonal circular polarizations. On-station TT&C operations will take place in portions of the conventional C-band, as discussed in Section A.15. This filing does not seek authority for TT&C transmissions.

Table A.4-1 shows the frequency plan, polarization and connectivity of the Inmarsat-3 satellites. The TT&C frequency plan is also provided.

**Table A.4-1. Inmarsat-3 Frequency Plan.**

Description	UPLINK			DOWNLINK		
	Beam	Polarization	Frequency Band (MHz)	Beam	Polarization	Frequency Band (MHz)
Forward Link	Global	RHCP	6425-6454	Regional or Global	RHCP	1525-1559
	Global	LHCP	6425-6454	Regional or Global	RHCP	1525-1559
Return Link	Regional or Global	RHCP	1626.5-1660.5	Global	RHCP	3600-3629
	Regional or Global	RHCP	1626.5-1660.5	Global	LHCP	3600-3629
Nav (C-C)	Global	RHCP	6454.4-6456.6	Global	LHCP	3629.4-3631.6
C to C Link	Global	LHCP	6432.3 -6433.2	Global	RHCP	3607.3-3608.2
Nav (C-L)	Global	RHCP	6454.4-6456.6	Global	RHCP	1574.4-1576.6
Telecommand (On-station)	Global	RHCP	6338-6342			
Telecommand (Emergency)	Omni	RHCP	6420-6425			
Telecommand (Emergency)	Omni	LHCP	6420-6425			
Telemetry (On-station)				Global	LHCP	3945-3955
Telemetry (Emergency)				Omni	RHCP	3945-3955
Telemetry (Emergency)				Omni	LHCP	3945-3955

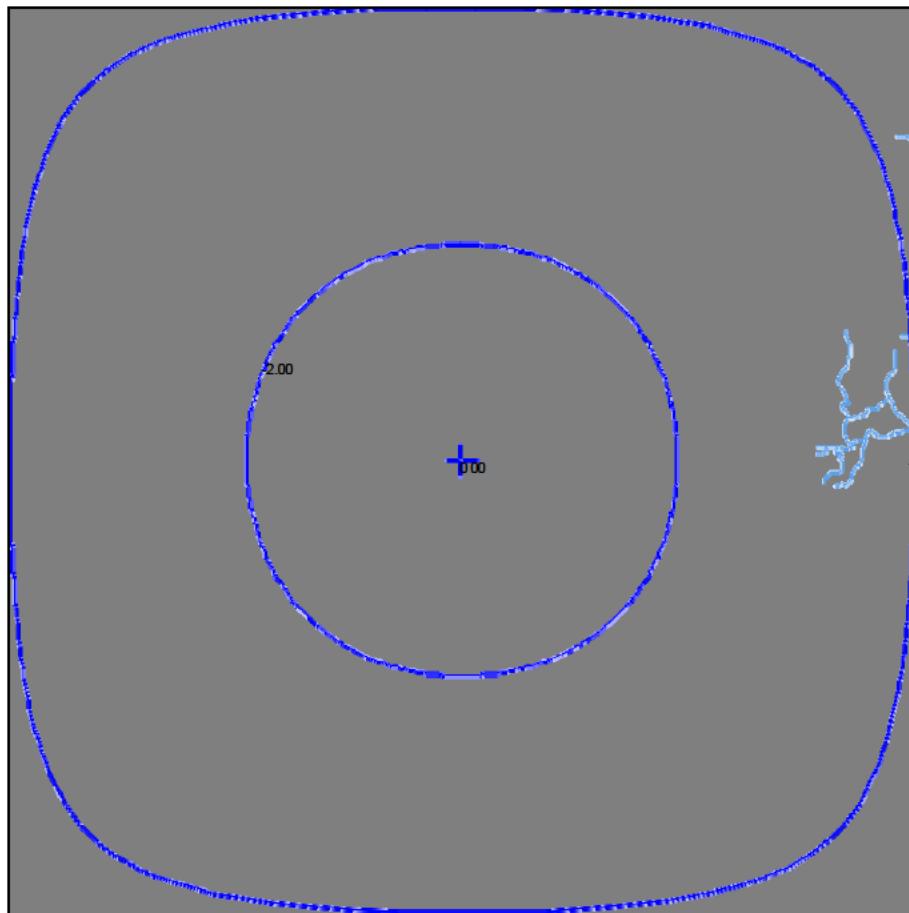
## A.5 SATELLITE TRANSMIT CAPABILITY

### A.5.1 Feeder Downlink

The Inmarsat-3 F5 satellite provides two C-band global downlink 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 20 dBi, providing a maximum of up to 30.5 dBW of downlink EIRP on each polarization. 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 beams for the Inmarsat-3 F5 satellite.

**Figure A.5-1 – Inmarsat-3 F5 downlink C-band global beam gain contours**  
(Contours are -2 dB and -4 dB relative to beam peak)



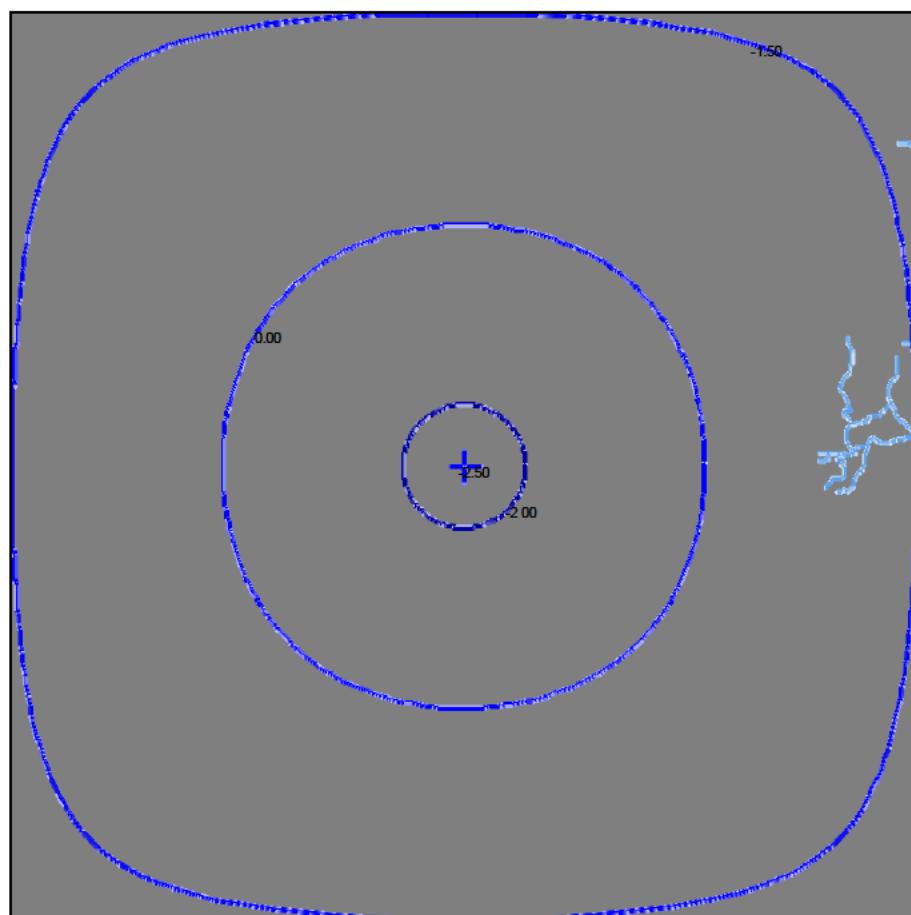
### A.5.2 Service Downlink – Global beam

The Inmarsat-3 satellites include an L-band global beam for the MSS services. The beam transmits in RHCP. The beam covers all the points within the satellite's field of view, with a peak gain of 19.5 dBi, providing a maximum of up to 41.5 dBW of downlink EIRP.

Figure A.5-2 shows the gain contours of the downlink L-band global beam for the Inmarsat-3 F5 satellite.

**Figure A.5-2 – Inmarsat-3 F5 downlink L-band global beam gain contours**

(Gain at sub-satellite point is -2.5 dB relative to beam peak. Contours are -2 dB, 0 dB and -1.5 dB relative to beam peak)



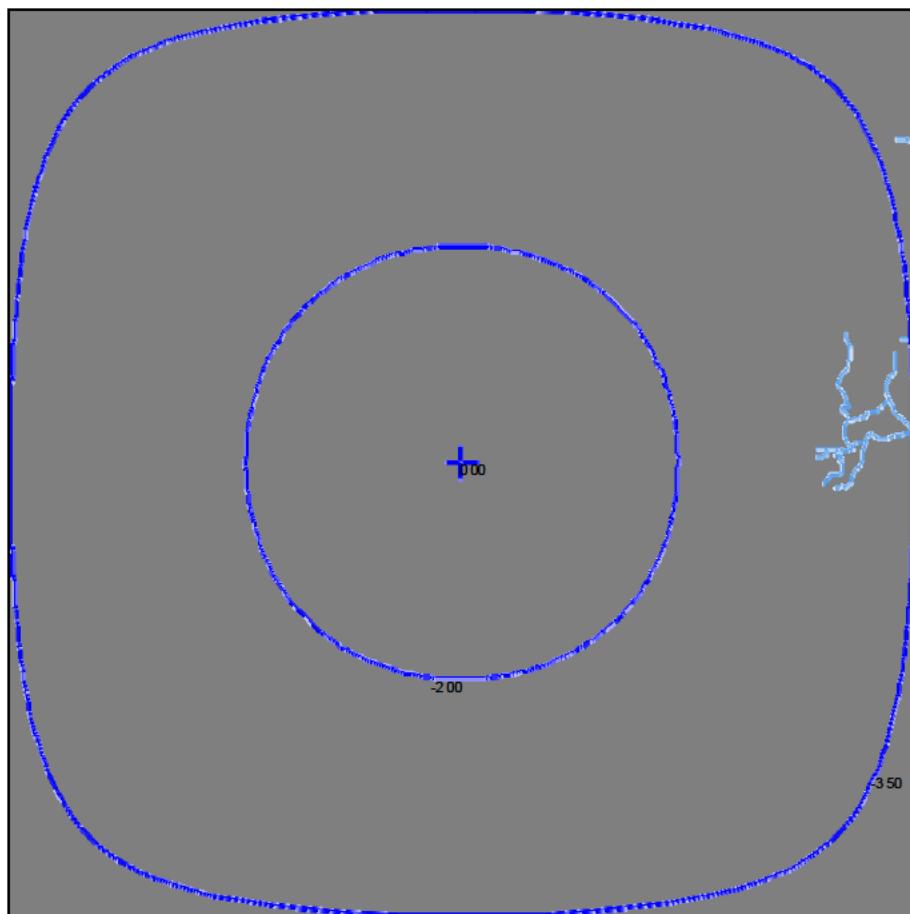
### A.5.3 Navigation Downlink

The Inmarsat-3 satellites also have a single L-band global beam for the navigation service. The beam transmits in RHCP. The beam covers all the points within the satellite's field of view, with a peak gain of 19 dBi and a maximum downlink EIRP of 33 dBW.

Figure A.5-3 shows the gain contours of the downlink navigation beam.

**Figure A.5-3 – Inmarsat-3 F5 downlink navigation beam gain contours**

Contours are -2 dB and -3.5 dB relative to beam peak)



### A.5.4 Service Downlink – Regional Spot beam

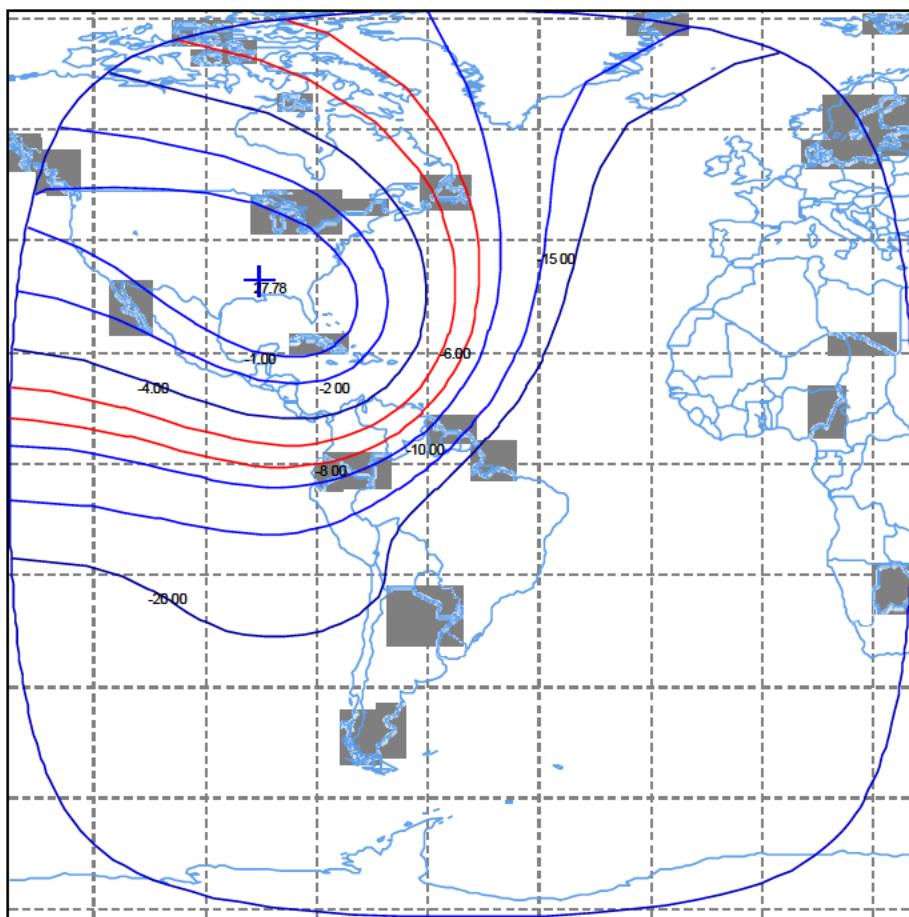
The Inmarsat-3 satellites include up to 7 L-band regional spot beam for the MSS services.

The beams transmit in RHCP. Multiple regional beams provide coverage at certain points within the satellite's field of view, with a peak gain of 28.2 dBi, providing a maximum of up to 51.4 dBW of downlink EIRP.

Figure A.5-4 shows the gain contours of an example downlink regional spot beam for the Inmarsat-3 F5 satellite.

**Figure A.5-4 – Inmarsat-3 F5 downlink regional spot beam gain contours**

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



## A.6 SATELLITE RECEIVE CAPABILITY

### A.6.1 Feeder Uplink

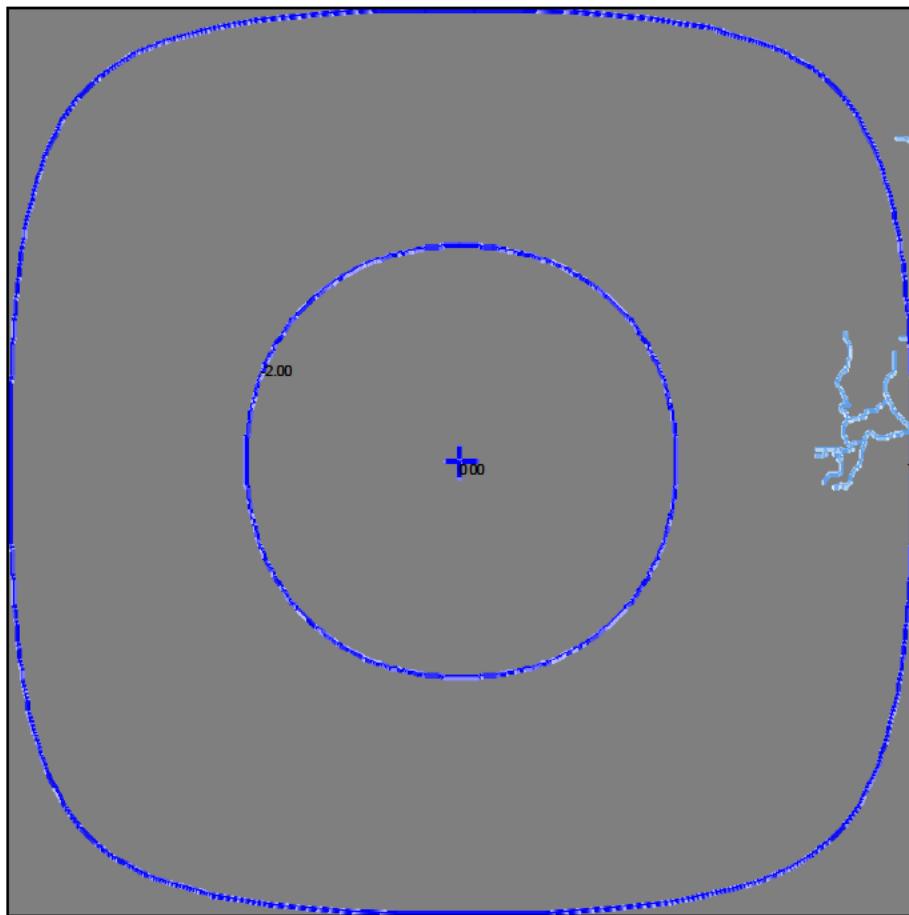
The Inmarsat-3 F5 satellite employs two C-band global uplink beams, one in RHCP and the other one in LHCP. The beams are nominally identical in each polarization. The beams cover all the points within the satellite field of view, with a peak gain of 20.5 dBi and a total system noise temperature of approximately 891 K. The peak G/T of the C-band uplink global beams is -9.0 dB/K. The cross-polarization isolation of the beams is 30 dB across the service area.

This beam is also used to receive the navigation feeder link carriers. The system noise temperature of the navigation receiver chain is approximately 1585 K, resulting in a peak G/T of -11.5 dB/K.

Figure A.6-1 shows the gain contours of the uplink C-band global beams for the Inmarsat-3 F5 satellite.

**Figure A.6-1 – Inmarsat-3 F5 uplink C-band global beam gain contours**

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

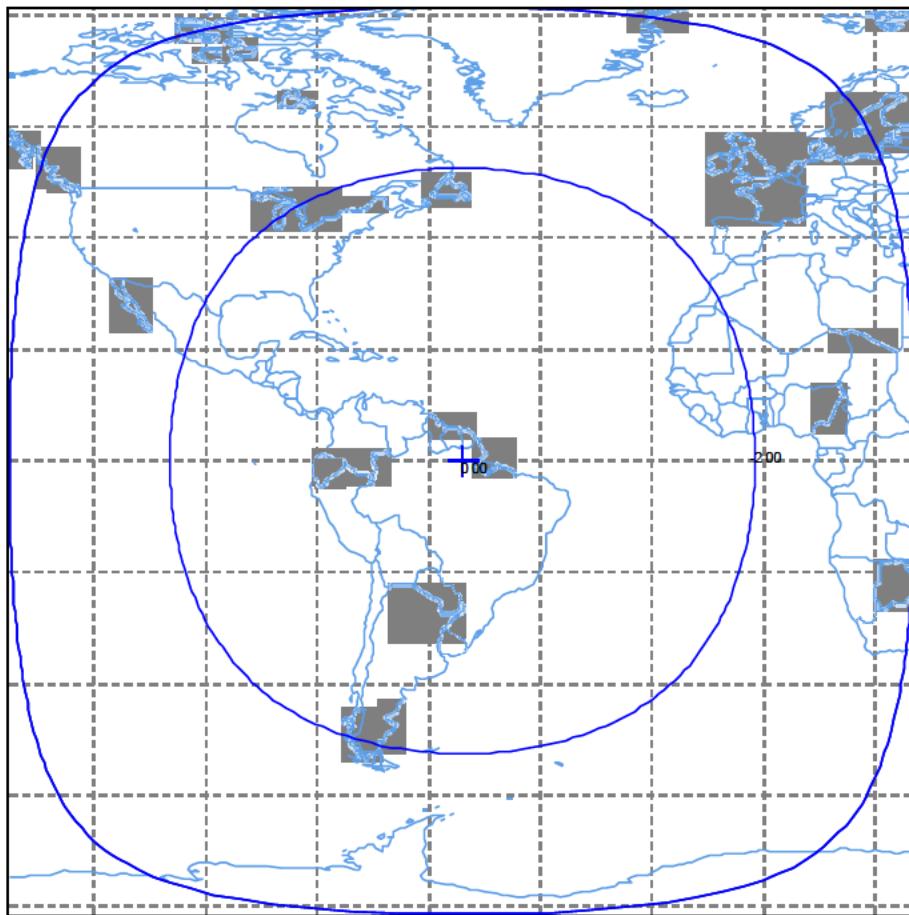


#### **A.6.2 Service Uplink – Global beam**

The Inmarsat-3 F5 satellite employs a single L-band global uplink beam which is in RHCP. The beam covers all the points within the satellite field of view, with a peak antenna gain of 18.5 dBi. The total effective system noise temperature for the satellite's global beam receiver is 562 K, including antenna losses. Therefore the beam peak G/T performance is -9.0 dB/K.

Figure A.6-2 shows the gain contours of the uplink L-band global beams for the Inmarsat-3 F5 satellite.

**Figure A.6-2 – Inmarsat-3 F5 uplink L-band global beam gain contours**  
(Contours are -2 dB and -2.5 dB relative to beam peak)



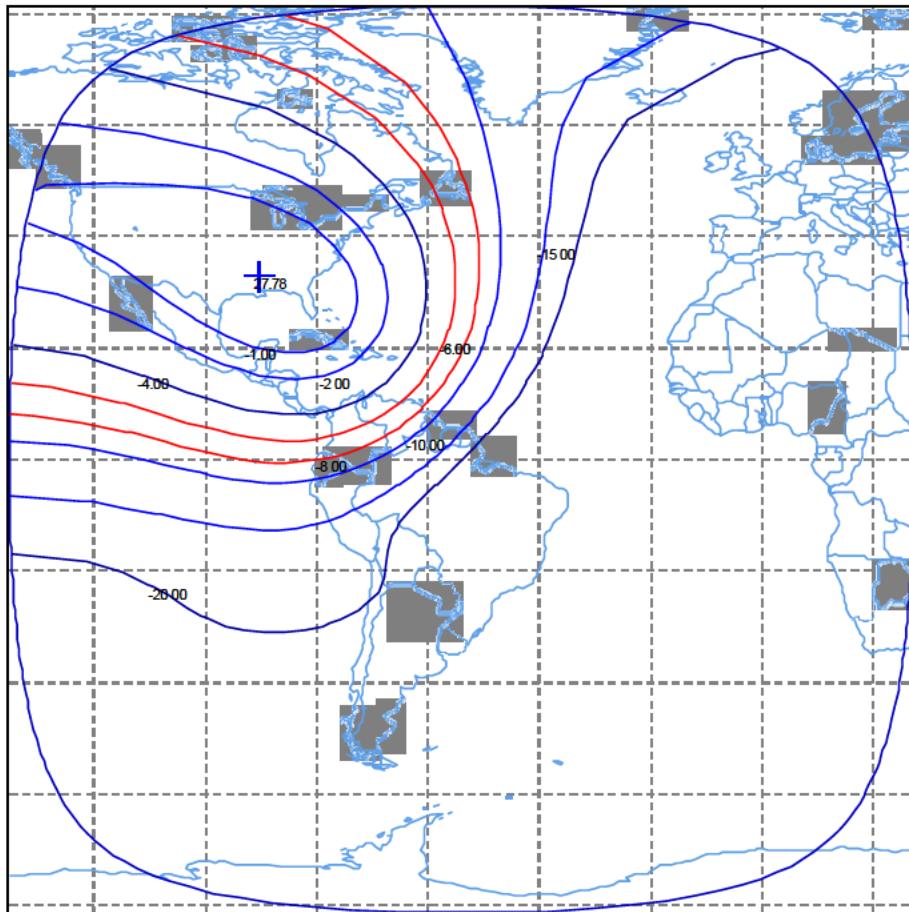
### A.6.3 Service Uplink – Regional Spot beam

The Inmarsat-3 satellites include up to 7 L-band regional spot beam for the MSS services which is in RHCP. Multiple regional beams provide coverage at all the points within the satellite's field of view, with a peak gain of 28.2 dBi. The total effective system noise temperature for the satellite's regional spot beam receiver is 740 K, including antenna losses. Therefore the beam peak G/T performance is -0.5 dB/K.

Figure A.6.3 shows the gain contours of an example uplink regional spot beam for the Inmarsat-3 F5 satellite.

**Figure A.6.3 – Example Inmarsat-3 F5 uplink regional spot beam gain contours**

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

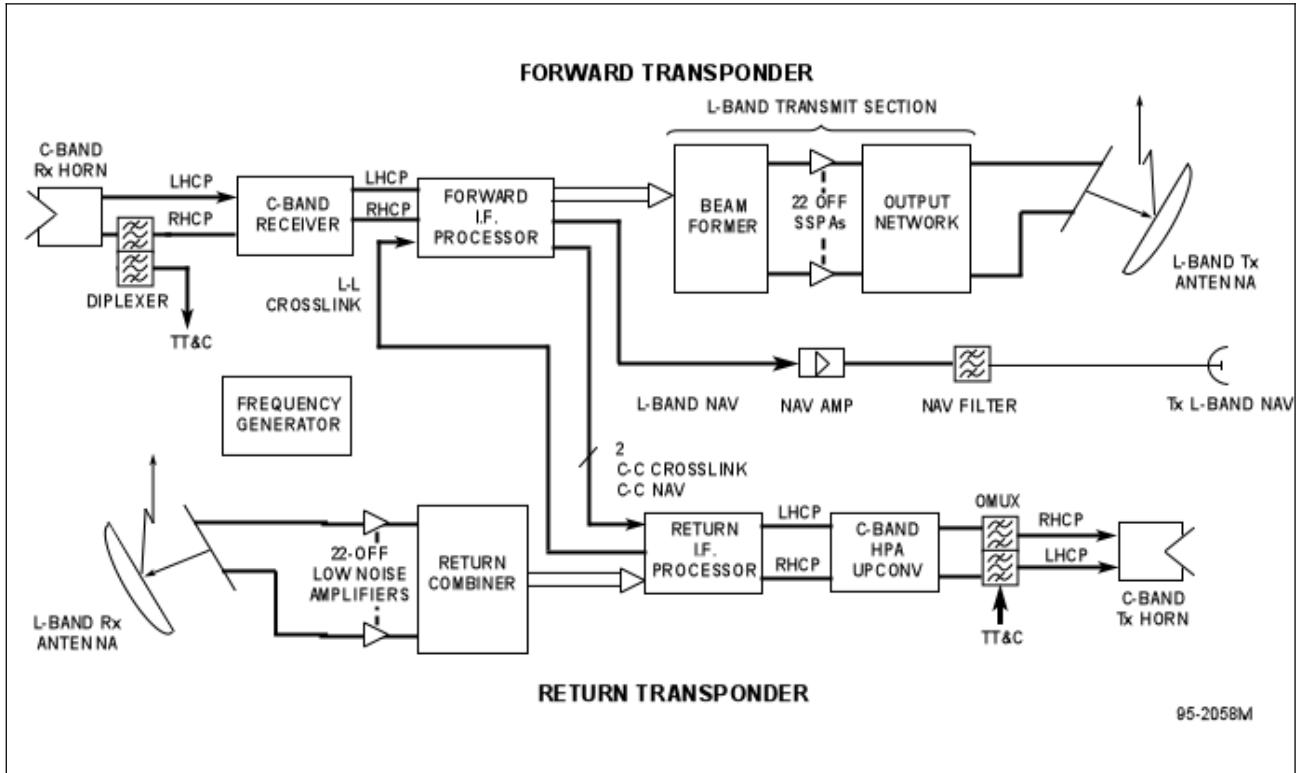


## A.7 COMMUNICATIONS PAYLOAD

The forward path receives signals from fixed earth stations at C-band (in the 6.4 GHz range) and relays them to mobile earth stations at L-band (in the 1.5 GHz range). The return path receives signals from mobile stations at L-band (in the 1.6 GHz range) and relays them to fixed earth stations at C-band (in the 3.6 GHz range).

A subsystem block diagram is provided below as Figure A.7-1.

**Figure A.7-1. Communications Subsystem.**



The L-band transmit antenna comprises a multi element feed and reflector structure mounted on the east face of the spacecraft. By selecting the phase and amplitude of the signals exciting the feed elements appropriately, up to seven regional beams as well as a global beam can be created. The L-band receive system operates in a similar manner, with the antenna mounted on the spacecraft's west face; in this case the beams are reconstructed by applying phase/gain weightings to the signals from the feed elements as they are combined.

On the forward path, uplink transmissions are received in a global beam. The antenna is dual circularly polarized. The LHCP antenna output port is connected directly to the C-band receiver while the RHCP port is connected to a C-band diplexer. One output of this diplexer provides for the telecommand signals received in the RHCP uplink to be connected to the telecommand receiver and the second output provides for the RHCP service uplink to be connected to the C-band receiver.

The C-band receiver down converts the input signal while establishing the forward link G/T and providing receive protect filtering. Each of the four C-band receivers has a separate output providing the L-band signals to the forward intermediate frequency processor (“FIFP”). The forward IF processor, with both input and output interfaces at L-band, provides the channelization function in the forward transponder. Channelization is carried out using surface acoustic wave (“SAW”) filters. Any one of the filter modules provides channelization for both polarization signals in a segment of the L-band spectrum. Each module contains down-converters from L-band to IF, SAW filters, a switch matrix providing full filter-to-beam connectivity, and up-converters from IF to L-band on each of the 8 beam outputs. The outputs for each of the 8 beams are passed to the FIFP beam amplifiers. These amplifiers provide the main telecommandable gain control for the forward transponder and output to the forward beamforming matrix.

A feature of the Inmarsat-3 F5 payload is the use of a multi-port amplifier for the L-band downlink signal generation. This comprises the forward beamformer, solid state power amplifiers and a matrix of output networks which results in the required drive being shared by all active power amplifiers.

The forward beamformer provides a unique set of amplitude and phase weightings for each of the eight beams of the forward transponder. The beamformer has eight inputs, (seven spot and one global), and 22 outputs. Each of the beam inputs feeds a splitter board which divides the input signal into 22 paths and generates the necessary amplitude and phase sets for each beam. Twenty- two eight-way combiners then combine the eight uniquely weighted beam signals to each of the 22 outputs.

The outputs from the beamformer are fed to 22 active L-band solid state power amplifiers (“SSPAs”). Each amplifier is a 22.5-watt unit containing preamplifiers, driver stages and an output stage which is isolated from the amplifier output. The L-band transmit antenna consists of a 22-element focal plane feed array and an offset parabolic reflector. The antenna generates RHCP signals.

The L-band receive module of the return transponder is designed in an analogous manner, with fully redundant low noise amplifiers being connected to each of the 22 receive antenna elements. The 22 L-band signals are then fed to the return combiner which reconstitutes the L-band spot beam and global beam signals. The input signals are down-converted and fed to the channeling SAW filters which perform a multiplexing function after the filter-to-beam switch matrixes. The combined spectra are up-converted, filtered and switched to one of four outputs, each representing a separate C-band transmit path. The telecommandable gain adjustment is provided in each SAW filter chain on a per channel basis. After the filter modules, in the output of the return processor, each of four 15-way combiners collect together all the signals destined for either polarization at C-band.

The C-band transmit section consists of a C-band amplifier, C-band output multiplexer (“OMUX”) and a C-band antenna. The C-band amplifier is a collection of four solid-state 12-watt SSPAs, at 3.6 GHz, preceded by four up-converter modules. The C-band OMUX provides transmit signal filtering on both polarizations and also multiplexes the TT&C signal into the C-band communications path.

The navigation payload has its own single feed and reflector mounted on the earth-pointing nadir panel providing global coverage. The navigation transponder is implemented in two parts, a C-L link and a C-C link. These two links are generated from the same uplink feeder link signal. The transponder receives navigational positioning signals in the C-band at 6.4 GHz for transmission to users in the L-band at 1.5 GHz together with a simultaneous transmission of the same signal in the C-band at 3.6 GHz. The purpose of the C-band downlink is to allow the feeder link earth station to make adjustments to the timing of the uplink feeder link signal.

## **A.8 TRANSPONDER GAIN CONTROL AND SATURATING FLUXDENSITY**

For channels using the regional spot beams, it is possible to command the gain of any transmission channel between 153 dB and 177 dB on the forward link, and between 142 dB and 165 dB on the return link. For channels using the global beam, it is possible to command the gain of any transmission channel between 153 dB and 177 dB on the forward link, and between 142 dB and 175 dB on the return link. The commandable gain step on both the forward and return links is 2 dB.

For Navigation channel (C-L), it is possible to command the gain between 145 dB and 169 dB at 2 dB gain step. For Navigation channel (C-C), it is possible to command the gain between 117 dB and 141 dB at 2 dB gain step.

For C to C channel, it is possible to command the gain between 128 dB and 148 dB at 2 dB gain step.

The minimum SFD for each uplink beam type is as shown below:

Feeder uplink: -172.1 dBW/m<sup>2</sup>

Service uplink - global beam: -171.3 dBW/m<sup>2</sup>

Service uplink - regional beam: -171.3 dBW/m<sup>2</sup>

The SFDs vary over the commandable attenuation range.

## **A.9 UNWANTED EMISSIONS**

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

## A.10 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.10-1.

**Table A.10-1. Emission Designators and Allocated Bandwidths**

<b>Emission Designator</b>	<b>Allocated Bandwidth</b>
2M20G1D	2.2 MHz
100KG1X	100 kHz
60K0D1W	60 kHz
50K0G7W	50 kHz
50K0D7W	50 kHz
45K0G7D	45 kHz
25K0G7W	25 kHz
20K0G1E	20 kHz
20K0G1X	20 kHz
17K5G1D	17.5 kHz
12K5G1D	12.5 kHz
12K5G7W	12.5 kHz
10K0G1W	10 kHz
10K0G1X	10 kHz
7K50G1D	7.5 kHz
7K50G1E	7.5 kHz
7K50G1W	7.5 kHz
5K00G1E	5 kHz
5K00G1W	5 kHz
5K00G1D	5 kHz
2K50G1D	2.5 kHz
2K50F1D	2.5 kHz

## **A.11 EARTH STATIONS**

### **A.11.1 User Terminals (UT)**

The Inmarsat 3F5 satellite supports Inmarsat's existing and evolved ("E&E") and Navigation services through the satellite's global and regional beams. A brief description of the E&E and Navigation 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.

### **Inmarsat-F (Fleet) terminals**

Inmarsat-F terminals provide voice, fax and up to 64 kbps packet data and ISDN services. Typical antenna gains range between 11.5 and 20 dBi and typical G/Ts range between -12.5 and -4 dB/K.

### **Aero terminals**

Inmarsat Aeronautical (“Aero”) terminals provide voice, fax and low rate data to users onboard aeroplanes. Typical antenna gains range between 0 and 12 dBi and typical G/Ts range between -13 and -26 dBi.

### **Swift-64 terminal**

Swift-64 terminal provides voice, fax, data and up to 64 kbps packet data and ISDN services to users onboard aeroplanes. Typical antenna gain is 11.5 dB and typical G/T is -13 dB/K.

### **Navigation Terminals:**

Antennas receiving the navigation signals can vary widely in gain. Typical G/T's are -26 dB/K and greater.

## **A.11.2 Gateway Earth Stations**

The gateway earth station antennas range between 9 and 16 meter antennas with peak transmit gains ranging between 54 dBi and 58.5 dBi and peak receive gains ranging between 49.2 dBi and 54 dBi. Typical G/Ts range between 30.7 dB/K and 33.2 dB/K.

## **A.12 LINK BUDGETS**

Tables A.12-1 and A.12-2 provide the E&E forward and return link budgets, respectively, via the global beam. Tables A.12-3 and A.12-4 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.

The navigation C-L and C-C link budgets are given in Table A.12-5.

**Table A.12-1. E&E Global beam forward link budgets.**

General		Unit	NM-B	INM-B	NM-B	INM-M (Med. Gain)	NM-M (Med. Gain)	MINI-M (Low Gain)	M4	INM-C	INM-D/D+	AERO-H P-105	AERO-I P-048	AERO-L P-012	FLEET-77	FLEET-55	FLEET-33
User terminal type	-		NM-B	INM-B	NM-B	INM-M (Med. Gain)	NM-M (Med. Gain)	MINI-M (Low Gain)	M4	INM-C	INM-D/D+	AERO-H P-105	AERO-I P-048	AERO-L P-012	FLEET-77	FLEET-55	FLEET-33
Emission Designator	-	20K0G1E	100KG1X	10K0G1X	10K0G1W	10K0G1X	10K0G1X	10K0G1X	5K00G1D	2K50F1D	7K50G1D	5K00G1D	2K50G1D	45K0G7D	5K00G1W	5K00G1W	
Data rate (kbps)	(kbps)	12	64	3	4	3	3	3	0.3	0.001	10.5	4.8	1.2	64	4.8	4.8	
Coding rate	-	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.242	0.5	0.5	0.5	0.5	0.5	0.5	
Modulation	-	O-QPSK	O-QPSK	BPSK	O-QPSK	BPSK	BPSK	BPSK	BPSK	32-FSK	A-QPSK	A-QPSK	A-QPSK	16 QAM	O-QPSK	O-QPSK	
Carrier bandwidth	(kHz)	15	80	7.5	5	7.5	7.5	7.5	0.75	0.63	6.56	3	1.5	40	3.5	3.5	
Allocated bandwidth	(kHz)	20	100	10	10	10	10	10	5	2.5	7.5	5	2.5	45	5	7.5	
<b>Uplink</b>																	
Frequency	(GHz)	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	
Earth Station EIRP	(dBW)	55.6	58.8	48.1	56.7	54.5	60.0	60.0	58.1	56.8	58.6	60.8	63.7	60.0	50.2	55.7	
Antenna diameter	m	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	
Antenna tx gain	dBi	58.5	58.5	58.5	58.5	58.5	58.5	58.5	58.5	58.5	58.5	58.5	58.5	58.5	58.5	58.5	
Uplink power	(dBW)	-2.9	0.3	-10.4	-1.8	-4.0	1.5	1.5	-0.4	-1.7	0.1	2.3	5.2	1.5	-8.3	-2.8	
Uplink p s d. avgd. in 4 kHz	(dBW/4kHz)	-8.7	-12.7	-13.2	-2.8	-6.8	-1.3	-1.3	-0.4	0.3	-2.1	2.3	7.2	-8.5	-8.3	-2.8	
Path loss	(dB)	200.9	200.9	200.9	200.9	200.9	200.9	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	0.4	0.4	0.4	0.4	0.4	0.4	
Satellite G/T	(dB/K)	-13.0	-13.0	-13.0	-13.0	-13.0	-13.0	-13.0	-13.0	-13.0	-13.0	-13.0	-13.0	-13.0	-13.0	-13.0	
Up-path C/No	(dBHz)	69.9	73.1	62.4	71.0	68.8	74.3	74.3	72.4	71.1	72.9	75.1	78.0	74.3	64.5	70.0	
<b>Downlink</b>																	
Frequency	(GHz)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	
Satellite EIRP	(dBW)	17.3	22.5	9.8	18.4	16.2	21.7	21.7	19.8	20.5	20.3	22.5	25.4	24.7	12.9	17.4	
Path loss	(dB)	188.4	188.4	188.4	188.4	188.4	188.4	188.4	188.4	188.4	188.4	188.4	188.4	188.4	188.4	188.4	
Mean Atmospheric loss	(dB)	0.1	0.1	0.1	0.1	0.1	0.1	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	-17.0	-23.0	-23.0	-13.0	-19.0	-26.0	-4.0	-7.0	-12.5	
Down-path C/No	(dBHz)	53.4	58.6	45.9	48.5	46.3	44.8	44.8	36.9	37.6	47.4	43.6	39.5	60.8	46.0	45.0	
<b>Total</b>																	
Mean satellite C/I/Mo	(dBHz)	53.8	59.0	42.3	50.9	48.7	54.2	54.2	52.3	53.0	52.8	55.0	57.9	57.2	45.4	49.9	
Co-Channel Interference	(dBHz)	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	
Other system interference allocation	(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Mean Overall C/No	(dBHz)	49.5	54.7	39.7	45.5	43.3	43.3	43.3	35.8	36.5	45.3	42.3	38.4	54.5	41.6	42.8	
Mean Overall C/N	(dB)	7.8	5.7	0.9	8.5	4.5	4.6	4.6	7.0	8.5	7.1	7.5	6.7	8.5	6.2	7.3	
<b>Margin</b>																	
C/N objective	(dB)	5.1	5.0	0.6	5.0	2.8	2.8	2.8	3.5	-10.9	5.0	4.7	3.2	7.7	5.4	5.4	
C/N margin	(dB)	2.7	0.7	0.3	3.5	1.7	1.8	1.8	3.5	19.4	2.1	2.8	3.5	0.8	0.8	1.9	

**Table A.12-2. E&E Global beam return link budgets.**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
<b>General</b>	Unit	INM-B	INM-B	INM-B	INM-M (Med. Gain)	INM-M (Med. Gain)	MINI-M (Low Gain)	INM-C	INM-D+	AERO-H P- 105	AERO-I P- 048	AERO-L P- 012	FLEET-77	FLEET-55	FLEET-33
User terminal type	-	20K0G1E	100KG1X	20KG1X	10K0G1W	20K0G1X	20K0G1X	5K00G1D	2K50F1D	7K50G1D	5K00G1D	2K50G1D	45K0G7D	5K00G1W	5K00G1W
Modulation ID/Designator	-	(kbps)	12	64	3	4	1.5	1.5	0.3	0.064	10.5	4.8	1.2	64	4.8
Data rate (kbps)	(kbps)		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Coding rate	-	O-QPSK	O-QPSK	O-QPSK	O-QPSK	BPSK	BPSK	BPSK	2-FSK	A-QPSK	A-QPSK	A-QPSK	16QAM	O-QPSK	O-QPSK
Modulation	-														
Carrier bandwidth	(kHz)	15	80	15	5	3.75	3.75	0.75	0.25	6.56	3	1.5	40	3.5	3.5
Allocated bandwidth	(kHz)	20	100	20	10	20	20	5	2.5	7.5	5	2.5	45	5	7.5
<b>Uplink</b>															
Frequency	(GHz)	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
User terminal EIRP towards satellite	(dBW)	30.0	33.0	29.3	25.0	21.0	17.0	10.5	2.6	19.6	15.9	11.8	30.0	20.1	20.1
User terminal tx gain	(dBi)	21.0	21.0	21.0	14.0	14.0	10.0	0.0	3.5	12.0	6.0	0.0	20.0	17.0	11.5
Uplink power	(dBW)	9.0	12.0	8.3	11.0	7.0	7.0	10.5	-0.9	7.6	9.9	11.8	10.0	3.1	8.6
Uplink p.s.d averaged in 4 kHz	(dBW/4kHz)	3.2	-1.0	2.5	10.0	7.0	7.0	10.5	1.1	5.4	9.9	13.8	0.0	3.1	8.6
Pa hloss	(dB)	188.8	188.8	188.8	188.8	188.8	188.8	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	0.1	0.1	0.1	0.1	0.1	0.1
Satellite G/T	(dB/K)	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0
Adjacent Channel Interference	(dB)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Up-path C/No	(dBHz)	59.5	62.5	58.8	54.5	50.5	46.5	40.0	32.1	49.1	45.4	41.3	59.5	49.6	49.6
<b>Downlink</b>															
Frequency	(GHz)	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
Satellite EIRP	(dBW)	-8.4	-1.4	-9.1	-13.4	-17.4	-21.4	-23.0	-30.2	-6.5	-10.2	-14.7	1.7	-10.3	-10.3
Pa hloss	(dB)	195.7	195.7	195.7	195.7	195.7	195.7	195.7	195.7	195.7	195.7	195.7	195.7	195.7	195.7
Mean Atmospheric loss	(dB)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Antenna diameter	m	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
Earthstation G/T	(dB/K)	33.2	33.2	33.2	33.2	33.2	33.2	33.2	33.2	33.2	33.2	33.2	33.2	33.2	33.2
Random Loss	(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Down-path C/No	(dBHz)	56.3	63.3	55.6	51.3	47.3	43.3	41.7	34.5	58.2	54.5	50.0	66.4	54.4	54.4
<b>Total</b>															
Mean satellite C/I/Mo	(dBHz)	60.1	67.1	59.4	55.1	51.1	47.1	45.5	38.3	62.0	58.3	53.8	70.2	58.2	58.2
Co-Channel Interference	(dBHz)	75.4	75.4	75.4	75.4	75.4	75.4	75.4	75.4	75.4	75.4	75.4	75.4	75.4	75.4
Other system interference allocation	(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Mean Overall C/No	(dBHz)	52.5	58.0	51.8	47.5	43.5	39.5	36.1	28.5	47.4	43.7	39.5	57.3	46.9	46.9
Mean Overall C/N	(dB)	10.7	9.0	10.0	10.5	7.8	3.8	7.3	4.5	9.2	8.9	7.8	11.3	11.5	11.5
<b>Margin</b>															
C/N objective	(dB)	5.1	5.0	4.4	5.0	1.7	1.2	3.5	-3.7	5.0	4.7	3.2	7.7	5.4	5.4
C/N margin	(dB)	5.6	4.0	5.6	5.5	6.1	2.6	3.8	8.2	4.2	4.2	4.6	3.6	6.1	6.1

**Table A.12-3. E&E Regional beam forward link budgets.**

General	Unit	INM-B	INM-B	INM-M (Low Gain)	MINI-M (High Gain)	M NI-M (Transportable)	M4	M4	NM-C	NM-D/D+	AERO-H P-105	AERO-I C-084	FLEET-77	FLEET-55	FLEET-33	SWIFT-64
User terminal type	-	20K0G1E	100KG1X	10K0G1W	5K00G1E	7K50G1E	60K0D1W	5K00G1W	5K00G1D	2K50F1D	7K50G1D	12K5G1D	45K0G7D	45K0G7D	17K5G1D	45K0G7D
Emission Designator	-	12	64	4	2.8	2.8	64	3.6	0.3	0.064	10.5	8.4	64	64	9.6	64
Data rate (kbps)	(kbps)	0.5	0.5	0.5	0.5	0.5	0.476	0.643	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Coding rate	-	O-QPSK	QPSK	O-QPSK	O-QPSK	O-QPSK	16-QAM	O-QPSK	BPSK	32-FSK	A-QPSK	A-QPSK	16 QAM	16 QAM	O-QPSK	16 QAM
Modulation	-	15	80	5	3.5	3.5	40	3.5	0.75	0.63	6.56	6.72	40	40	15	40
Carrier bandwidth	(kHz)	20	100	10	5	7.5	60	5	5	2.5	7.5	12.5	45	45	17.5	45
Allocated bandwidth	(kHz)															
<b>Uplink</b>																
Frequency	(GHz)	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
Earth Station E RP	(dBW)	54.8	59.8	56.4	50.9	59.5	64.1	50.9	55.4	54.4	54.6	59.3	59.7	62.6	60.8	65.5
Antenna diameter	m	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
Antenna tx gain	dBi	58.5	58.5	58.5	58.5	58.5	58.5	58.5	58.5	58.5	58.5	58.5	58.5	58.5	58.5	58.5
Uplink power	(dBW)	-3.7	1.3	-2.1	-7.6	1.0	5.6	-7.6	-3.1	-4.1	-3.9	0.8	1.2	4.1	2.3	7.0
Uplink p.s d. avgd. in 4 kHz	(dBW/4kHz)	-9.5	-11.7	-3.1	-7.6	1.0	-4.4	-7.6	-3.1	-2.1	-6.1	-1.5	-8.8	-5.9	-3.5	-3.0
Path loss	(dB)	200.9	200.9	200.9	200.9	200.9	200.9	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	0.4	0.4	0.4	0.4	0.4	0.4
Satellite G/T	(dB/K)	-13.0	-13.0	-13.0	-13.0	-13.0	-13.0	-13.0	-13.0	-13.0	-13.0	-13.0	-13.0	-13.0	-13.0	-13.0
Up-path C/No	(dBHz)	69.1	74.1	70.7	65.2	73.8	78.4	65.2	69.7	68.7	68.9	73.6	74.0	76.9	75.1	79.8
<b>Downlink</b>																
Frequency	(GHz)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Satellite EIRP	(dBW)	19.5	24.5	21.1	15.6	24.2	28.8	15.6	20.1	20.5	19.9	24.9	24.4	27.3	25.5	30.2
Path loss	(dB)	188.4	188.4	188.4	188.4	188.4	188.4	188.4	188.4	188.4	188.4	188.4	188.4	188.4	188.4	188.4
Mean Atmospheric loss	(dB)	0.1	0.1	0.1	0.1	0.1	0.1	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	-12.0	-7.0	-17.0	-7.0	-7.0	-23.0	-22.1	-13.0	-19.0	-4.0	-7.0	-12.5	-13.0
Down-path C/No	(dBHz)	55.6	60.6	49.2	48.7	47.3	61.9	48.7	37.2	38.5	47.0	46.0	60.5	60.4	53.1	57.3
<b>Total</b>																
Mean satellite C/I/Mo	(dBHz)	57.1	62.1	54.7	49.2	57.8	62.4	49.2	53.7	54.1	53.5	58.5	58.0	60.9	59.1	63.8
Co-Channel Interference	(dBHz)	66.0	73.0	63.0	60.0	61.8	70.8	60.0	60.0	57.0	61.8	64.0	69.5	69.5	65.4	69.5
Other system interference allocation	(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Mean Overall C/No	(dBHz)	51.9	57.0	46.9	44.7	45.8	57.8	44.7	36.1	37.3	45.0	44.7	54.8	56.3	50.9	55.2
Mean Overall C/N	(dB)	10.2	8.0	10.0	9.3	10.3	11.8	9.3	7.3	9.3	6.8	6.4	8.8	10.3	9.1	9.2
<b>Margin</b>																
C/N objective	(dB)	5.1	5.0	5.0	5.4	5.4	7.7	5.4	3.5	-10.9	5.0	2.9	7.7	7.7	4.5	7.7
C/N margin	(dB)	5.1	3.0	5.0	3.9	4.9	4.1	3.9	3.8	20.2	1.8	3.5	1.1	2.6	4.6	1.5

**Table A.12-4. E&E terminals. Regional beam return link budgets.**

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<b>General</b>	Unit	NM-B	INM-B	INM-M (Low Gain)	MINI-M (High Gain)	MINI-M (Transportable)	M4	M4	NM-C	INM-D+	AERO-H P-105	AERO-I C-084	FLEET-77	FLEET-55	FLEET-33	SW FT-64
User terminal type	-	20K0G1E	100KG1X	10K0G1W	5K00G1E	7K50G1E	60K0D1W	5K00G1W	5K00G1D	2K50F1D	7K50G1D	12K5G1D	45K0G7D	45K0G7D	17K5G1D	45K0G7D
Modulation D / Designator	-	12	64	4	28	28	64	36	03	0.064	10.5	8.4	64	64	9.6	64
Data rate (kbps)	(kbps)	0.5	0.5	0.5	0.5	0.5	0.476	0.643	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Coding rate	-	O-QPSK	QPSK	O-QPSK	O-QPSK	O-QPSK	16-QAM	O-QPSK	BPSK	2-FSK	A-QPSK	A-QPSK	16 QAM	16 QAM	O-QPSK	16 QAM
Modulation	-	15	80	5	3.5	3.5	40	3.5	0.75	0.63	6.56	6.72	40	40	15	40
Carrier bandwidth	(kHz)	20	100	10	5	7.5	60	5	5	2.5	7.5	12.5	45	45	17.5	45
Allocated bandwidth	(kHz)															
<b>Uplink</b>																
Frequency	(GHz)	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
User terminal EIRP towards satellite	(dBW)	17.7	20.8	12.8	11.5	11.5	25.0	11.5	12	-2.2	14.0	12.7	27.6	27.6	20.2	24.7
User terminal tx gain	(dB)	21.0	21.0	12.0	18.0	10.0	18.0	18.0	0.0	3.5	12.0	6.0	20.0	17.0	11.5	11.5
Uplink power	(dBW)	-3.3	-0.2	0.8	-6.5	1.5	7.0	-6.5	1.2	-5.7	2.0	6.7	7.6	10.6	8.7	13.2
Uplink p.s.d averaged in 4 kHz	(dBW/4kHz)	-9.1	-13.2	-0.2	-6.5	1.5	-3.0	-6.5	1.2	-3.7	-0.2	4.4	-2.4	0.6	2.9	3.2
Path loss	(dB)	188.8	188.8	188.8	188.8	188.8	188.8	188.8	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	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	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Adjacent Channel	(dB)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Interference																
Up-path C/No	(dBHz)	59.4	62.5	54.5	53.2	53.2	66.7	53.2	42.9	39.5	55.7	54.4	69.3	69.3	61.9	66.4
<b>Downlink</b>																
Frequency	(GHz)	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
Satellite EIRP	(dBW)	-10.7	-3.6	-15.6	-16.9	-16.9	-3.4	-16.9	-25.4	-25.0	-9.7	-11.8	1.2	1.2	-6.2	1.3
Path loss	(dB)	195.7	195.7	195.7	195.7	195.7	195.7	195.7	195.7	195.7	195.7	195.7	195.7	195.7	195.7	195.7
Mean Atmospheric loss	(dB)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Earth station G/T	(dB/K)	33.2	33.2	33.2	33.2	33.2	33.2	33.2	33.2	33.2	33.2	33.2	33.2	33.2	33.2	33.2
Random Loss	(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Down-path C/No	(dBHz)	54.0	61.1	49.1	47.8	47.8	61.3	47.8	39.3	39.7	55.0	52.9	65.9	65.9	58.5	66.0
<b>Total</b>																
Mean satellite C/ Mo	(dBHz)	57.8	64.9	52.9	51.6	51.6	65.1	51.6	43.1	43.5	58.8	56.7	69.7	69.7	62.3	69.8
Co-Channel Interference	(dBHz)	75.4	75.4	75.4	75.4	75.4	75.4	75.4	75.4	75.4	75.4	75.4	75.4	75.4	75.4	75.4
Other system interference allocation	(dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Mean Overall C/No	(dBHz)	50.7	56.7	45.8	44.5	44.5	57.9	44.5	35.6	34.8	50.4	48.6	61.9	61.9	54.7	61.1
Mean Overall C/N	(dB)	8.9	7.7	8.8	9.0	9.0	11.9	9.0	6.9	6.8	12.3	10.3	15.9	15.9	13.0	15.1
<b>Margin</b>																
C/N objective	(dB)	5.1	5.0	5.0	5.4	5.4	7.7	5.4	3.5	2.3	5.0	2.9	7.7	7.7	4.5	7.7
C/N margin	(dB)	3.8	2.7	3.8	3.6	3.6	4.2	3.6	3.4	4.5	7.3	7.4	8.2	8.2	8.5	7.4

**Table A.12-5. Navigation C-L and C-C link budgets.**

General Emission Designator Modulation	Unit	2M20G1D BPSK	2M20G1D BPSK
<b>Uplink</b>			
Frequency	GHz	6.45	6.45
LES elevation angle	(deg)	5.0	5.0
LES maximum EIRP towards satellite	(dBW)	78.0	78.0
Path Loss	(dB)	200.9	200.9
Mean atmospheric loss	(dB)	0.4	0.4
Satellite G/T	(dB/K)	-15.5	-15.5
Up-path C/No	(dBW/Hz)	89.8	89.8
<b>Downlink</b>			
Frequency	GHz	1.5	3.6
User terminal elevation angle	(deg)	5.0	5.0
Satellite EIRP (EOC)	(dBW)	29.5	-0.2
Path Loss	(dB)	188.5	195.9
Mean atmospheric loss	(dB)	0.1	0.1
User terminal G/T	(dB/K)	-26.0	32.0
Down-path C/No	(dBW/Hz)	43.5	64.4
<b>Total</b>			
Adjacent sat. interference allocation	(dB)	1.0	1.0
Mean overall C/No	(dB/Hz)	42.5	63.4
Mean overall C/N	(dB)	-20.6	0.3
<b>Margin</b>			
C/N objective	(dB)	-28.0	-28.0
C/N margin	(dB)	7.4	28.3

### A.13 STATION-KEEPING AND ANTENNA POINTING ACCURACY

The Inmarsat-3 F5 satellite will be maintained in longitude within  $\pm 0.1^\circ$  of its nominal orbital location for all latitudes within  $\pm 2.7^\circ$  of the equator. The satellite will be operated in an inclined geostationary orbit, with the inclination permitted to fluctuate naturally between  $0^\circ$  and  $2.7^\circ$  degrees due to the celestial forces imparted on the satellite during its lifetime.

As the satellite orbit changes, the satellite's attitude control system continuously adjusts the antenna boresight pointing and the network gateway periodically updates the 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 the Inmarsat-3 F5 satellite 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, ¶ 44 (2004). As set forth below in Section A.19, there are not expected to be any other satellites within its same station-keeping volume. *See id.*, ¶ 51.

Moreover, the Inmarsat-3 F5 satellite will be operated in a manner consistent with the Commission's requirements for inclined orbit satellite operations, as specified in Section 25.280 of the Commission's rules.

The antenna axis attitude is maintained within  $\pm 0.1^\circ$  of nominal.

#### **A.14 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.15 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 on-station TT&C signals use the 6338-6342 MHz band for commanding and the 3945-3955 MHz band for telemetry. During nominal geosynchronous operations the signals are received/transmitted via the global horn antennas. A separate omni antenna is used for both receive and transmit during transfer orbit and as a failsafe in case of emergency modes of operation.

## A.16 SPACECRAFT CHARACTERISTICS

A summary of the satellite design is provided in Table A.16-1 below.

**Table A.16-1: Satellite Summary**

Satellite Manufacturer	Lockheed Martin Astro (spacecraft) Matra Marconi Space (payload)
Design Life	13 years
Satellite Platform	Space Series 4000 (Lockheed Martin)
Power Available (EOL)	> 2800 W Summer Solstice
Batteries	> 1900 W
Solar Arrays	> 2800 Watt end-of-life/ Summer Solstice
Station-keeping	Up to 2.7 degrees inclination, +/- 0.1 degrees longitude
Attitude Control	3-axis, momentum bias, chemical thrusters (during stationkeeping)
Communications Antenna	Offset parabolic reflectors for L-band receive and transmit, each fed by a multi-element feed structure capable of creating a global beam and up to 7 regional spot beams.  Two separate horns serve as the C-band antennas receive and transmit.
Command and Telemetry	Two separate horns for transmit and receive  Omni receive and transmit antenna

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

### A.16.1 Spacecraft Bus

The Inmarsat-3 F5 spacecraft is based on the Lockheed Martin Astro Space Series 4000 bus. This platform, or bus, provides all the service functions required to support the communications payload. The payload, also referred to as the communications subsystem (“CSS”), is a unique design specifically developed by Matra Marconi Space to satisfy the Inmarsat-3 service requirements. The spacecraft design employs a modular construction allowing the payload and platform to be integrated and tested as separate entities.

The satellite mass summary is given below.

**Table A.16-2: Spacecraft Mass Summary Inmarsat-3 F5 (Ariane launch)**

	Mass (kg)
Launch Mass	1198 kg
Satellite Dry Mass	895 kg
AKM expendables	820 kg
Hydrazine load	283 kg

### A.16.2 Attitude Control Subsystem

The attitude and orbit control subsystem (AOCS) is a momentum bias system that incorporates sensors, control actuators, and electronic processing to maintain satellite stability and pointing autonomously throughout all phases of the mission, *i.e.* transfer orbit, transition to synchronous orbit (drift orbit), initial earth acquisition and geosynchronous orbit (at inclinations of up to 2.7°).

The AOCS sensor complement includes a sun sensor assembly (SSA) and a horizon sensor assembly (HSA) for attitude measurement in the transfer orbit; three orthogonally mounted rate measuring assemblies (RMA) for attitude and rate sensing during on-orbit stationkeeping and to maintain the spacecraft attitude reference during the launch separation phase; and two earth sensor assemblies (ESA) for operational on-orbit pitch and roll attitude sensing. The AOCS also uses telemetry from the short-circuit current sensor on the solar arrays to achieve sun pointing in

the safe mode.

### **A.16.3 Propulsion Subsystem**

Propulsive functions for the Inmarsat-3 spacecraft are provided by a hydrazine (N2H4) monopropellant reaction control subsystem (RCS) utilizing 16 thrusters and, for Atlas launches, a solid propellant apogee kick motor (AKM). The RCS is used for attitude control and orbit maneuvers while the AKM is used for injection into drift orbit at the transfer orbit apogee. The Proton launch vehicle injects the spacecraft directly into drift orbit at geosynchronous altitude, thus an AKM is not required but all other RCS features remain the same.

### **A.16.4 Electrical Power Subsystem**

The electrical power subsystem (EPS) is a direct-energy-transfer configuration that provides a main bus voltage of 23.5 to 35.5 volts and consists of solar arrays for energy generation, two NiH2 batteries for energy storage, and a double-insulated main bus for processing and distribution of power. A centralized redundant fuse protection distribution system is used to protect the main bus against single faults within the EPS or the power distribution system. The two redundantly charged 23-cell NiH2 provide the main bus power required throughout the longest eclipse periods without either battery reaching 70% depth-of-discharge.

Full details of the spacecraft's electrical characteristics are provided in the Schedule S form previously provided and incorporated by reference herein.

### **A.16.5 Thermal Control Subsystem**

Functionally, the thermal control subsystem (TCS) consists of all the spacecraft elements associated with maintaining the spacecraft equipment and structures within a controlled range of temperatures throughout the spacecraft life. The subsystem uses a combination of heatpipe radiators, optical solar reflectors, multilayer blankets, heaters, thermostats, electronic heater controllers and various materials to control the thermal properties of spacecraft surfaces. The general design requirement of the thermal control subsystem is to maintain all spacecraft equipment and structures within a temperature range which is at least 20°C narrower than the

equipment/structure qualification range.

#### **A.16.6 Reliability**

Overall spacecraft reliability is approximately 0.65 at 13 years. However, to date the spacecraft has not suffered any platform equipment failures that would affect the original redundancy design. As a result, full platform subsystem redundancy remains intact. Amplifier and receiver sparing is consistent with documented failure rates that allow the attainment of the overall spacecraft reliability numbers stated.

#### **A.17 TWO- DEGREE COMPATIBILITY**

With respect to the extended C-band (feeder links), the nearest satellite using the extended C-band is the INTELSAT-805 satellite at 55.5° W.L. Inmarsat and Intelsat have reached a frequency coordination agreement for use of the extended C-band frequency.

In order to show two-degree compatibility, the C-band transmission parameters of the Inmarsat-3 F5 have been assumed as both the wanted and victim transmissions. Tables A.17-1 and A.17-2 provide a summary of the uplink and downlink C-band feeder link parameters, respectively.

**Table A.17-1. Summary of the uplink C-band feeder link parameters.**

Carrier ID	Emission Designator	Occupied BW (kHz)	Tx Antenna Gain (dBi)	Uplink EIRP (dBW)	C/I Criterion (dB)	Comments
1	20K0G1E	15.00	58.5	55.6	17.3	
2	100KG1X	80.00	58.5	58.8	17.2	
3	10K0G1X	7.50	58.5	48.1	12.8	
4	10K0G1W	5.00	58.5	56.7	17.2	
5	10K0G1X	7.50	58.5	54.5	15.0	
6	10K0G1X	7.50	58.5	60.0	15.0	
7	10K0G1X	7.50	58.5	60.0	15.0	
8	5K00G1D	0.75	58.5	58.1	15.7	Feeder uplink carrier spaced at 10 kHz
9	2K50F1D	0.63	58.5	56.8	8.6	Feeder uplink carrier spaced at 5 kHz
10	7K50G1D	6.56	58.5	58.6	17.2	
11	5K00G1D	3.00	58.5	60.8	16.9	
12	2K50G1D	1.50	58.5	63.7	15.4	Feeder uplink carrier spaced at 5 kHz
13	45K0G7D	40.00	58.5	60.0	19.9	
14	5K00G1W	3.50	58.5	50.2	17.6	
15	7K50G1W	3.50	58.5	55.7	17.6	
16	20K0G1E	15.00	58.5	54.8	17.3	
17	100KG1X	80.00	58.5	59.8	17.2	
18	10K0G1W	5.00	58.5	56.4	17.2	
19	5K00G1E	3.50	58.5	50.9	17.6	
20	7K50G1E	3.50	58.5	59.5	17.6	
21	60K0D1W	40.00	58.5	64.1	19.9	
22	5K00G1W	3.50	58.5	50.9	17.6	
23	5K00G1D	0.75	58.5	55.4	15.7	Feeder uplink carrier spaced at 10 kHz
24	2K50F1D	0.63	58.5	54.4	1.3	Feeder uplink carrier spaced at 5 kHz
25	7K50G1D	6.56	58.5	54.6	17.2	
26	12K5G1D	6.72	58.5	59.3	15.1	
27	45K0G7D	40.00	58.5	59.7	19.9	
28	45K0G7D	40.00	58.5	62.6	19.9	
29	17K5G1D	15.00	58.5	60.8	16.7	
30	45K0G7D	40.00	58.5	65.5	19.9	
31	2M20G1D	2043.00	54	78.0	-15.8	

**Table A.17-2. 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	20K0G1E	15.00	54.3	-8.4	17.3	
2	100KG1X	80.00	54.3	-1.4	17.2	
3	20K0G1X	15.00	54.3	-9.1	16.6	
4	10K0G1W	5.00	54.3	-13.4	17.2	
5	20K0G1X	3.75	54.3	-17.4	13.9	
6	20K0G1X	3.75	54.3	-21.4	13.4	
7	5K00G1D	0.75	54.3	-23.0	15.7	
8	2K50F1D	0.25	54.3	-30.2	8.5	
9	7K50G1D	6.56	54.3	-6.5	19.9	
10	5K00G1D	3.00	54.3	-10.2	19.6	
11	2K50G1D	1.50	54.3	-14.7	18.5	
12	45K0G7D	40.00	54.3	1.7	19.9	
13	5K00G1W	3.50	54.3	-10.3	17.6	
14	5K00G1W	3.50	54.3	-10.3	17.6	
15	20K0G1E	15.00	54.3	-10.7	17.3	
16	100KG1X	80.00	54.3	-3.6	17.2	
17	10K0G1W	5.00	54.3	-15.6	17.2	
18	5K00G1E	3.50	54.3	-16.9	17.6	
19	7K50G1E	3.50	54.3	-16.9	17.6	
20	60K0D1W	40.00	54.3	-3.4	19.9	
21	5K00G1W	3.50	54.3	-16.9	17.6	
22	5K00G1D	0.75	54.3	-25.4	15.7	
23	2K50F1D	0.63	54.3	-25.0	14.5	
24	7K50G1D	6.56	54.3	-9.7	17.2	
25	12K5G1D	6.72	54.3	-11.8	15.1	
26	45K0G7D	40.00	54.3	1.2	19.9	
27	45K0G7D	40.00	54.3	1.2	19.9	
28	17K5G1D	15.00	54.3	-6.2	16.7	
29	45K0G7D	40.00	54.3	1.3	19.9	
30	2M20G1D	2043.00	49.2	-0.2	-15.8	

The interference calculations assumed a 1 dB advantage for topocentric-to-geocentric conversion, all wanted and interfering carriers are co-polarized and all earth station antennas conform to a sidelobe pattern of  $29-25 \log(\theta)$ . The analysis also assumes a nominal orbital separation of 1.8 degrees as opposed to two degrees in order to take into account the increased east-west station-keeping of 0.1 degrees.

Tables A.17-3 and A.17-4 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. It can be seen that all C/I margins are positive.

**Table A.17-3. Summary of the uplink C/I margins (dB).**

**C/I Summary(Uplink)**

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	24	25	26	27	28	29	30	31	
W a n t e d	1	19.6	23.7	25.4	16.8	19.0	13.5	13.5	15.4	13.6	13.6	9.6	6.7	19.5	20.2	16.5	20.4	22.7	17.1	19.5	12.7	15.4	19.5	18.1	16.0	17.6	15.1	19.8	16.9	14.4	14.0	14.1
	2	16.9	19.7	21.4	12.8	15.0	9.5	9.5	11.4	9.7	9.6	5.7	2.8	16.0	16.3	12.5	17.7	18.7	13.1	15.6	8.7	13.2	15.6	14.1	12.1	13.6	11.2	16.3	13.4	11.1	10.5	10.1
	3	19.6	23.7	24.1	16.8	17.7	12.2	12.2	15.4	13.7	13.6	9.7	6.8	19.5	20.3	16.5	20.4	22.7	17.1	19.6	12.7	15.4	19.6	18.1	16.1	17.6	15.1	19.8	16.9	14.4	14.0	14.1
	4	25.6	29.7	30.1	19.7	23.7	18.2	18.2	21.3	19.6	19.0	15.6	12.7	25.4	26.2	22.5	26.4	28.7	20.0	25.5	18.7	21.3	25.5	24.0	22.0	23.0	18.4	25.7	22.8	20.4	19.9	20.0
	5	23.8	27.9	28.3	21.0	21.9	16.4	16.4	19.6	17.9	17.8	13.9	11.0	23.7	24.5	20.7	24.6	26.9	21.3	23.8	16.9	19.6	23.8	22.3	20.3	21.8	19.3	24.0	21.1	18.6	18.2	18.3
	6	29.3	33.4	33.8	26.5	27.4	21.9	21.9	25.1	23.4	23.3	19.4	16.5	29.2	30.0	26.2	30.1	32.4	26.8	29.3	22.4	25.1	29.3	27.8	25.8	27.3	24.8	29.5	26.6	24.1	23.7	23.8
	7	29.3	33.4	33.8	26.5	27.4	21.9	21.9	25.1	23.4	23.3	19.4	16.5	29.2	30.0	26.2	30.1	32.4	26.8	29.3	22.4	25.1	29.3	27.8	25.8	27.3	24.8	29.5	26.6	24.1	23.7	23.8
	8	36.7	40.8	41.2	30.9	34.8	29.3	29.3	32.1	30.8	30.1	24.5	18.6	36.6	35.8	30.3	37.5	39.8	31.2	35.1	26.5	32.5	35.1	35.2	33.2	34.1	29.5	36.9	34.0	31.5	31.1	31.2
	9	43.3	47.4	47.8	37.4	41.4	35.9	35.9	37.8	28.3	36.7	31.1	25.2	43.1	42.4	36.9	44.1	46.4	37.7	41.7	33.1	39.0	41.7	30.5	30.7	40.7	36.1	43.4	40.5	38.1	37.6	37.7
	10	26.3	30.4	30.8	23.4	24.4	18.9	18.9	22.0	20.3	19.7	16.3	13.4	26.2	26.9	23.2	27.1	29.4	23.7	26.2	19.4	22.1	26.2	24.7	22.7	23.7	19.1	26.5	23.6	21.1	20.7	20.8
C a r r i e r	11	32.2	36.3	36.7	26.3	30.3	24.8	24.8	27.9	26.2	25.6	20.0	19.3	32.1	31.3	25.8	33.0	35.3	26.6	30.6	22.0	28.0	30.6	30.6	28.6	29.6	25.0	32.4	29.5	27.0	26.6	26.6
	12	39.6	43.7	44.1	33.7	37.7	32.2	32.2	35.4	33.6	33.0	27.4	21.5	39.5	38.7	33.2	40.4	42.7	34.0	38.0	29.4	35.4	38.0	38.1	36.0	37.0	32.4	39.8	36.9	34.4	34.0	34.1
	13	18.4	21.2	22.9	14.3	16.5	11.0	11.0	12.9	11.2	11.1	7.2	4.3	17.0	17.8	14.0	19.2	20.2	14.6	17.1	10.2	12.9	17.1	15.6	13.6	15.1	12.7	17.3	14.4	12.6	11.5	11.6
	14	20.2	24.3	24.7	14.4	18.3	12.8	12.8	16.0	14.3	13.6	10.3	7.4	20.1	19.3	13.8	21.0	23.3	14.7	18.6	10.0	16.0	18.6	18.7	16.7	17.6	13.0	20.4	17.5	15.0	14.6	14.7
	15	25.7	29.8	30.2	19.9	23.8	18.3	18.3	21.5	19.8	19.1	15.8	12.9	25.6	24.8	19.3	26.5	28.8	20.2	24.1	15.5	21.5	24.1	24.2	22.2	23.1	18.5	25.9	23.0	20.5	20.1	20.2
	16	18.8	22.9	24.6	16.0	18.2	12.7	12.7	14.6	12.8	12.8	8.8	5.9	18.7	19.4	15.7	19.6	21.9	16.3	18.7	11.9	14.6	18.7	17.3	15.2	16.8	14.3	19.0	16.1	13.6	13.2	13.3
	17	17.9	20.7	22.4	13.8	16.0	10.5	10.5	12.4	10.7	10.6	6.7	3.8	17.0	17.3	13.5	18.7	19.7	14.1	16.6	9.7	14.2	16.6	15.1	13.1	14.6	12.2	17.3	14.4	12.1	11.5	11.1
	18	25.3	29.4	29.8	22.4	23.4	17.9	17.9	21.0	19.3	18.7	15.3	12.4	25.1	25.9	22.2	26.1	28.4	19.7	25.2	18.4	21.0	25.2	23.7	21.7	22.7	18.1	25.4	22.5	20.1	19.6	19.7
	19	20.9	25.0	25.4	15.1	19.0	13.5	13.5	16.7	15.0	14.3	11.0	8.1	20.8	20.0	14.5	21.7	24.0	15.4	19.3	10.7	16.7	19.3	19.4	17.4	18.3	13.7	21.1	18.2	15.7	15.3	15.4
	20	29.5	33.6	34.0	23.7	27.6	22.1	22.1	25.3	23.6	22.9	19.6	16.7	29.4	28.6	23.1	30.3	32.6	24.0	27.9	19.3	25.3	27.9	28.0	26.0	26.9	22.3	29.7	26.8	24.3	23.9	24.0
	21	22.5	25.3	27.0	18.4	20.6	15.1	15.1	17.0	15.3	15.2	11.3	8.4	21.1	21.9	18.1	23.3	24.3	18.7	21.2	14.3	17.0	21.2	19.7	17.7	19.2	16.8	21.4	18.5	16.7	15.6	15.7
C a r r i e r	22	20.9	25.0	25.4	15.1	19.0	13.5	13.5	16.7	15.0	14.3	11.0	8.1	20.8	20.0	14.5	21.7	24.0	15.4	19.3	10.7	16.7	19.3	19.4	17.4	18.3	13.7	21.1	18.2	15.7	15.3	15.4
	23	34.0	38.1	38.5	28.2	32.1	26.6	26.6	38.5	28.1	27.4	21.8	15.9	33.9	33.1	27.6	34.8	37.1	28.5	32.4	23.8	29.8	32.4	21.2	30.5	31.4	26.8	34.2	31.3	28.8	28.4	28.5
	24	48.2	52.3	52.7	42.3	46.3	40.8	40.8	32.7	42.2	41.6	36.0	30.1	48.0	47.3	41.8	49.0	51.3	42.6	46.6	38.0	43.9	46.6	35.4	35.6	45.6	41.0	48.3	45.4	43.0	42.5	42.6
	25	22.3	26.4	26.8	19.4	20.4	14.9	14.9	18.0	16.3	15.7	12.3	9.4	22.2	22.9	19.2	23.1	25.4	19.7	22.2	15.4	18.1	22.2	20.7	18.7	19.7	15.1	22.5	19.6	17.1	16.7	16.8
	26	29.0	33.1	33.5	26.1	27.1	21.6	21.6	24.7	23.0	23.0	19.0	16.1	28.9	29.6	25.9	29.8	32.1	26.4	28.9	22.1	24.8	28.9	27.4	25.4	27.0	21.8	29.2	26.3	23.8	23.4	23.4
	27	18.1	20.9	22.6	14.0	16.2	10.7	10.7	12.6	10.9	10.8	6.9	4.0	16.7	17.5	13.7	18.9	19.9	14.3	16.8	9.9	12.6	16.8	15.3	13.3	14.8	12.4	17.0	14.1	12.3	11.2	11.3
	28	21.0	23.8	25.5	16.9	19.1	13.6	13.6	15.5	13.8	13.7	9.8	6.9	19.6	20.4	16.6	21.8	22.8	17.2	19.7	12.8	15.5	19.7	18.2	16.2	17.7	15.3	19.9	17.0	15.2	14.1	14.2
	29	25.4	29.5	31.2	22.6	24.8	19.3	19.3	21.2	19.4	19.4	15.4	12.5	25.3	26.0	22.3	26.2	28.5	22.9	25.3	18.5	21.2	25.3	23.9	21.8	23.4	20.9	25.6	22.7	20.2	19.8	19.9
	30	23.9	26.7	28.4	19.8	22.0	16.5	16.5	18.4	16.7	16.6	12.7	9.8	22.5	23.3	19.5	24.7	25.7	20.1	22.6	15.7	18.4	22.6	21.1	19.1	20.6	18.2	22.8	19.9	18.1	17.0	17.1
	31	55.0	58.8	59.5	50.9	53.1	47.6	47.6	49.5	47.8	47.8	43.8	40.9	54.1	54.4	50.7	55.8	57.8	51.2	53.7	46.9	51.3	53.7	52.2	50.2	51.8	49.3	54.4	51.5	49.2	48.6	48.2

**Table A.17-3. Summary of the downlink C/I margins (dB).**

**C/I Summary (Downlink)**

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	24	25	26	27	28	29	30		
W a n t e d	1	15.4	15.7	16.1	18.7	25.7	29.7	25.2	29.4	10.5	12.4	13.9	9.6	12.5	14.3	17.7	17.9	20.9	19.1	20.9	14.7	19.1	27.6	24.2	13.7	18.0	10.1	10.1	13.2	10.0	28.6	
	2	16.5	15.5	17.2	18.5	25.5	29.5	25.1	29.3	10.3	12.3	13.8	9.9	12.4	14.1	18.8	17.7	20.7	19.0	20.7	16.3	19.0	27.5	24.1	13.5	17.9	10.4	10.4	13.7	10.3	28.4	
	3	15.4	15.7	16.1	18.7	25.7	29.7	25.2	29.4	10.5	12.4	13.9	9.6	12.5	14.3	17.7	17.9	20.9	19.1	20.9	14.7	19.1	27.6	24.2	13.7	18.0	10.1	10.1	13.2	10.0	28.6	
	4	15.3	15.6	16.0	15.5	25.5	29.5	25.1	29.3	9.8	12.3	13.8	9.4	12.4	14.2	17.6	17.8	17.7	19.0	20.8	14.5	19.0	27.5	24.1	13.0	15.2	9.9	9.9	13.1	9.8	28.4	
	5	15.8	16.1	16.5	16.1	18.8	22.8	25.7	29.9	10.3	12.9	14.4	10.0	13.0	14.7	18.1	18.3	18.3	19.6	21.3	15.1	19.6	28.1	24.7	13.5	15.8	10.5	10.5	13.6	10.4	29.0	
	6	12.3	12.6	13.0	12.6	15.3	19.3	22.2	26.4	6.8	9.4	10.9	6.5	9.5	11.2	14.6	14.8	14.8	16.1	17.8	11.6	16.1	24.6	21.2	10.0	12.3	7.0	7.0	10.1	6.9	25.5	
	7	15.4	15.7	16.1	15.7	18.4	22.4	17.0	29.4	9.9	10.2	11.7	9.6	11.0	11.0	17.7	17.9	17.9	17.6	17.6	14.7	17.6	19.4	24.2	13.1	15.3	10.1	10.1	13.2	10.0	28.6	
	8	20.2	20.5	20.9	20.4	23.2	27.2	21.8	24.2	14.7	15.0	16.5	14.4	15.8	15.8	22.5	22.7	22.6	22.4	22.4	19.5	22.4	24.2	23.0	17.9	20.1	14.9	14.9	18.0	14.8	33.3	
C a r r i e r	9	18.3	18.6	19.0	21.5	28.6	32.6	28.1	32.3	12.8	15.3	16.8	12.5	15.4	17.2	20.6	20.8	23.7	22.0	23.8	17.6	22.0	30.5	27.1	16.0	18.2	13.0	13.0	16.1	12.9	31.5	
	10	18.3	18.6	19.0	18.5	21.3	25.3	28.1	32.3	12.8	13.1	16.8	12.5	13.9	13.9	20.6	20.8	20.7	20.5	20.5	17.6	20.5	30.5	27.1	16.0	18.2	13.0	13.0	16.1	12.9	31.4	
	11	17.9	18.2	18.6	18.1	20.9	24.9	27.7	31.9	12.4	12.7	14.2	12.1	13.5	13.5	20.2	20.4	20.3	20.1	20.1	17.2	20.1	30.1	26.7	15.6	17.8	12.6	12.6	15.7	12.5	31.1	
	12	19.9	18.9	20.6	21.9	28.9	32.9	28.5	32.7	13.7	15.7	17.2	12.8	15.8	17.5	22.2	21.1	24.1	22.4	24.1	17.9	22.4	30.9	27.5	16.9	21.3	13.3	13.3	17.1	13.2	31.8	
	13	19.5	19.8	20.2	19.8	22.5	26.5	29.4	33.6	14.0	16.6	18.1	13.7	15.1	15.1	21.8	22.0	22.0	21.7	21.7	18.8	21.7	31.8	28.4	17.2	19.4	14.2	14.2	17.3	14.1	32.7	
	14	19.5	19.8	20.2	19.8	22.5	26.5	29.4	33.6	14.0	16.6	18.1	13.7	15.1	15.1	21.8	22.0	22.0	21.7	21.7	18.8	21.7	31.8	28.4	17.2	19.4	14.2	14.2	17.3	14.1	32.7	
	15	13.1	13.4	13.8	16.4	23.4	27.4	22.9	27.1	8.2	10.1	11.6	7.3	10.2	12.0	15.4	15.6	18.6	16.8	18.6	12.4	16.8	25.3	21.9	11.4	15.7	7.8	7.8	10.9	7.7	26.3	
	16	14.3	13.3	15.0	16.3	23.3	27.3	22.9	27.1	8.1	10.1	11.6	7.7	10.2	11.9	16.6	15.5	18.5	16.8	18.5	14.1	16.8	25.3	21.9	11.3	15.7	8.2	8.2	11.5	8.1	26.2	
	17	13.1	13.4	13.8	13.3	23.3	27.3	22.9	27.1	7.6	10.1	11.6	7.2	10.2	12.0	15.4	15.6	15.5	16.8	18.6	12.3	16.8	25.3	21.9	10.8	13.0	7.7	7.7	10.9	7.6	26.2	
	18	12.9	13.2	13.6	13.2	15.9	19.9	22.8	27.0	7.4	10.0	11.5	7.1	8.5	8.5	15.2	15.4	15.4	15.1	15.1	12.2	15.1	25.2	21.8	10.6	12.8	7.6	7.6	10.7	7.5	26.1	
	19	12.9	13.2	13.6	13.2	15.9	19.9	22.8	27.0	7.4	10.0	11.5	7.1	8.5	8.5	15.2	15.4	15.4	15.1	15.1	12.2	15.1	25.2	21.8	10.6	12.8	7.6	7.6	10.7	7.5	26.1	
	20	14.8	13.8	15.5	16.8	23.8	27.8	23.4	27.6	8.6	10.6	12.1	7.7	10.7	12.4	17.1	16.0	19.0	17.3	19.0	12.8	17.3	25.8	22.4	11.8	16.2	8.2	8.2	12.0	8.1	26.7	
	21	12.9	13.2	13.6	13.2	15.9	19.9	22.8	27.0	7.4	10.0	11.5	7.1	8.5	8.5	15.2	15.4	15.4	15.1	15.1	12.2	15.1	25.2	21.8	10.6	12.8	7.6	7.6	10.7	7.5	26.1	
	22	13.0	13.3	13.7	13.3	16.0	20.0	14.6	27.0	7.5	7.8	9.3	7.2	8.6	8.6	15.3	15.5	15.5	15.2	15.2	12.3	15.2	20.7	17.0	21.8	10.7	12.9	7.7	7.7	10.8	7.6	26.2
	23	15.4	15.7	16.1	15.6	18.4	22.4	17.0	29.4	9.9	10.2	11.7	9.5	11.0	11.0	17.7	17.9	17.8	17.6	17.6	14.6	17.6	19.4	18.2	13.1	15.3	10.0	10.0	13.2	9.9	28.5	
24 25 26 27 28 29 30	24	17.8	18.1	18.5	21.0	28.1	32.1	27.6	31.8	12.3	14.8	16.3	12.0	14.9	16.7	20.1	20.3	23.2	21.5	23.3	17.1	21.5	30.0	26.6	15.5	17.7	12.5	12.5	15.6	12.4	31.0	
	25	17.7	18.0	18.4	20.9	28.0	32.0	27.5	31.7	12.8	14.7	16.2	11.9	14.8	16.6	20.0	20.2	23.1	21.4	23.2	17.0	21.4	29.9	26.5	16.0	17.6	12.4	12.4	15.5	12.3	30.8	
	26	19.4	18.4	20.1	21.4	28.4	32.4	28.0	32.2	13.2	15.2	16.7	12.3	15.3	17.0	21.7	20.6	23.6	21.9	23.6	17.4	21.9	30.4	27.0	16.4	20.8	12.8	12.8	16.6	12.7	31.3	
	27	19.4	18.4	20.1	21.4	28.4	32.4	28.0	32.2	13.2	15.2	16.7	12.3	15.3	17.0	21.7	20.6	23.6	21.9	23.6	17.4	21.9	30.4	27.0	16.4	20.8	12.8	12.8	16.6	12.7	31.3	
	28	18.2	18.5	18.9	21.5	28.5	32.5	28.0	32.2	13.3	15.2	16.7	12.4	15.3	17.1	20.5	20.7	23.7	21.9	23.7	17.5	21.9	30.4	27.0	16.5	20.8	12.9	12.9	16.0	12.8	31.4	
	29	19.5	18.5	20.2	21.5	28.5	32.5	28.1	32.3	13.3	15.3	16.8	12.4	15.4	17.1	21.8	20.7	23.7	22.0	23.7	17.5	22.0	30.5	27.1	16.5	20.9	12.9	12.9	16.7	12.8	31.4	
	30	31.5	31.5	32.2	33.5	40.5	44.5	40.1	44.3	25.4	27.3	28.8	24.9	27.4	29.2	33.8	33.7	35.7	34.0	35.8	31.3	34.0	42.5	39.1	28.6	32.9	25.4	25.4	28.7	25.3	43.4	

## A.18 POWER FLUX DENSITY AT THE EARTH'S SURFACE

The Commission's rules do not have Power Flux Density ("PFD") limits for the 3600-3700 MHz band. However there are PFD limits in this band in Article 21 of the ITU Radio Regulations, as follows:

Limit in dB(W/m <sup>2</sup> ) for angles of arrival ( $\delta$ ) above the horizontal plane			Reference bandwidth
0°-5°	5°-25°	25°-90°	
-152	-152 + 0.5( $\delta$ - 5)	-142	4 kHz

These limits are the same as those specified by the Commission in Section 25.208(a) for the 3700-4200 MHz 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.12.2 column 9, corresponding to a satellite EIRP level of +3.5 dBW at the beam peak (*i.e.*, -6.5 dBW (edge of coverage EIRP) + 4 dB (edge of coverage to beam peak factor) + 6 dB (maximum increase due to user terminal uplink power control)), in a 6.56 kHz occupied bandwidth. The shortest distance from the satellite to the Earth is 35,786 km, corresponding to a spreading loss of dB.

Therefore, the maximum possible PFD at the Earth's surface would not exceed  $3.5 - 162.06 = -158.6$  dBW/m<sup>2</sup>/6.56kHz. In any 4 kHz band this would correspond to a maximum PFD at the Earth's surface measured in a 4 kHz band of  $-158.6 + 10\log(4E3/6.56E3) = -160.7$  dBW/m<sup>2</sup>/4kHz. This is significantly less than the -152 dBW/m<sup>2</sup>/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.19 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 Section 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's satellite manufacturer, Lockheed-Martin, 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 largely 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-3 satellites, 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. Although NiH<sub>2</sub> 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, within the uncertainty of the propellant measurement system. Any remaining propellants will then be vented in a controlled manner to ensure that the perigee height of the final disposal orbit is maintained, or increased, as a result of the deltaV imparted by the action of venting.

**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 orbital location of the Inmarsat-3 F5 satellite. Inmarsat has reviewed the list of Commission-licensed systems and systems that are currently under consideration by the Commission. In addition, networks for which a request for coordination has been submitted to the ITU for an orbital location within plus/minus 0.2 degrees of 54° W.L. have also been reviewed.

Based on the review, there are no commercial networks currently authorized or under consideration by the Commission to operate in the immediate vicinity of the 54° W.L. slot.<sup>4</sup> ITU

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<sup>4</sup> As noted previously, Inmarsat intends to place the I3F4 satellite in a holding orbit at 54.3° W.L. once it has been replaced. At that location, its stationkeeping volume will not overlap with that of I3F5.

requests for coordination filings in the immediate vicinity of 54° W.L. have been made on behalf of Inmarsat and Intelsat. Inmarsat has physically coordinated its operations with Intelsat. In addition, a request for coordination in this vicinity was recently filed by France, but Inmarsat has not yet been contacted with respect to coordination of that filing. Inmarsat will remain prepared to physically coordinate the Inmarsat-3 F5 satellite with any other satellite operator at this location. Inmarsat uses the services of the USSTRATCOM organization to perform collision avoidance analysis for the Inmarsat-3 satellites 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-3 F5 satellite, currently estimated for 2021, Inmarsat plans to maneuver the satellite to a disposal orbit with a minimum perigee height of 194 km above the normal GSO operational orbit. This proposed disposal orbit altitude is based on the original propellant budget wherein a delta velocity of 7.0 m/s was allocated at the time of construction of the Inmarsat-3 satellites, *i.e.*, in the early 1990s.

The propulsion subsystem design and the satellite fuel budget account for the post-mission disposal of the satellite. Approximately 5.4 kg of propellant has been allocated and reserved for the final orbit raising maneuvers. Inmarsat has assessed fuel gauging uncertainty and the 5.4 kg of propellant provides a sufficient margin of reserve fuel to address the uncertainty.

## A.20 WAIVER REQUESTS

Section 25.210(f) requires FSS space stations using the 3600-3700 MHz and 6425-6525 MHz bands to employ full frequency reuse. The uplink feeder link for the navigation carrier (“L1” carrier) uses the 6454.4-6456.6 MHz band in one polarization only. The same feeder link carrier also results in a downlink carrier in the 3629.4-3631.6 MHz band, in one polarization only.

The underlying objective of Section 25.210(f) is to establish efficient use of the spectrum for FSS communications carriers. In the case of the navigation sub-system, there is a requirement to transmit only a single L1 navigation carrier, which naturally leads to a requirement to transmit a single uplink feeder link carrier, obviously in one polarization only. The purpose of the C-band downlink is to allow the feeder link earth station to make adjustments to the timing of the uplink feeder link signal and is an integral part of the overall navigation sub-system.

Only a single C-band downlink carrier is required for this function, again resulting in the need for only one polarization. Based on these explanations, Inmarsat therefore respectfully requests a waiver for the navigation uplink feeder link transmission and associated C-band downlink transmission.

## **A.21 INCORPORATION BY REFERENCE OF PRIOR SCHEDULE S SUBMISSION**

As mentioned above, Inmarsat has operated the Inmarsat-3 F4 satellite at 54° W.L. for more than six years. The Inmarsat-3 F5 satellite has identical operating parameters to the satellite it will replace. Accordingly, Inmarsat hereby incorporates by reference the Schedule S information provided in connection with its application to place Inmarsat-3 F4 on the ISAT List. The relevant applications are:

1. The earth station application previously filed by Vizada Satellite, Inc., IBFS File No. SES-MFS-20071011-01413 (granted Feb. 20, 2008);
2. Inmarsat's request to modify the ISAT List to reflect the resumed operations of Inmarsat-3 F4 at the 54° W.L. orbital location, IBFS File No. SAT-PPL-20090107-00003; and
3. Inmarsat's amendment to that request to modify the ISAT List, which included a supplemental Schedule S submission, IBFS File No. SAT-APL-20090115-00005.

There are two non-material differences between the two satellites: (1) the launch mass, satellite dry mass, and mass of AKM expendables; and (2) the amount of fuel being allocated and reserved for the final orbit raising maneuvers (5.4 kg for Inmarsat-3 F5 compared to 3.5 kg for Inmarsat-3 F4).

**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/ Jonas Eneberg

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