ATTACHMENT A

INMARSAT-3 F4 (142° W.L.)

TECHNICAL DESCRIPTION

A.1 GENERAL DESCRIPTION

The Inmarsat-3 F4 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, 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]. In particular, the Inmarsat-3 F4 satellite provides Inmarsat-B and navigation (GPS augmentation) services.

Signals to and from UTs in the L-band are connected, through the spacecraft, back to gateway earth stations via feeder links in the Fixed-Satellite Service (“FSS”) using the 3600 – 3629 MHz band in the space-to-Earth direction and the 6425 – 6454 MHz band in the Earth-to-space direction[2] using the network of gateway earth stations known as Land Earth Stations (“LES”). On-station TT&C signals between the Inmarsat-3 F4 satellite and TT&C earth stations will 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 located in Italy, China (Beijing) and Canada (British Columbia~~ and Nova Scotia~~). None of the TT&C earth stations that are used to communicate with the Inmarsat-3 F4 satellite will be located in the United States. It is noted that the TT&C earth stations are not the subject of the present application.

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[1] These bands are collectively known as the “L-band” frequencies.
[2] These bands are within what is collectively known as the “extended C-band” frequencies.

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. The Inmarsat-3 F4 satellite is not expected to employ the regional beams while it is located at 142° W.L. and therefore only the global beam has been described herein. Two separate horns serve as the C-band antennas.

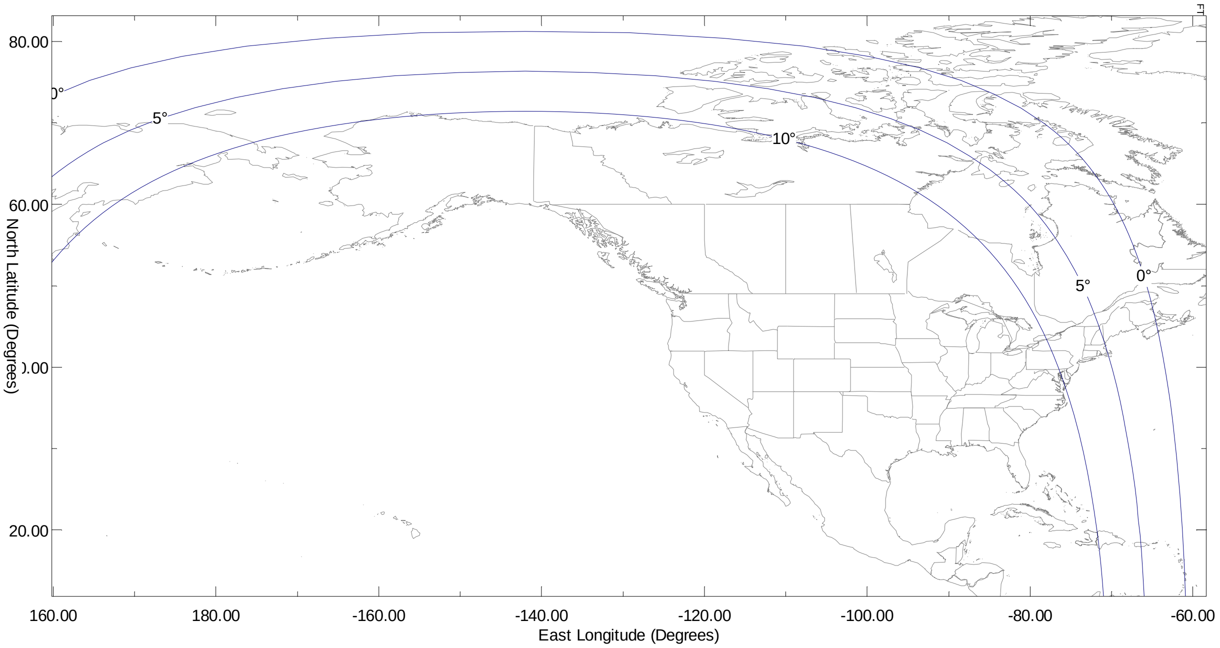
A.2 ORBITAL LOCATION

Inmarsat is authorized by the United Kingdom to operate the Inmarsat-3 F4 satellite at the 142° W.L. geostationary orbital location.

A.3 SATELLITE COVERAGE

The Inmarsat-3 F4 satellite provides two-way MSS services to user terminals using the L-band. The elevation angles towards North America are shown in Figure A.2-1.

Figure A.2-1 – Elevation Angles from the Inmarsat-3 F4 142° W.L. Orbital Location



A.4 FREQUENCY 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 application 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.

	UPLINK			**DOWNLINK**		
Description	**Beam**	**Polarization**	**Frequency Band (MHz)**	**Beam**	**Polarization**	**Frequency Band (MHz)**
Forward Link	Global	RHCP	6425-6454	Global	RHCP	1525-1559
	Global	LHCP	6425-6454	Global	RHCP	1525-1559
Return Link	Global	RHCP	1626.5-1660.5	Global	RHCP	3600-3629
	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
(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

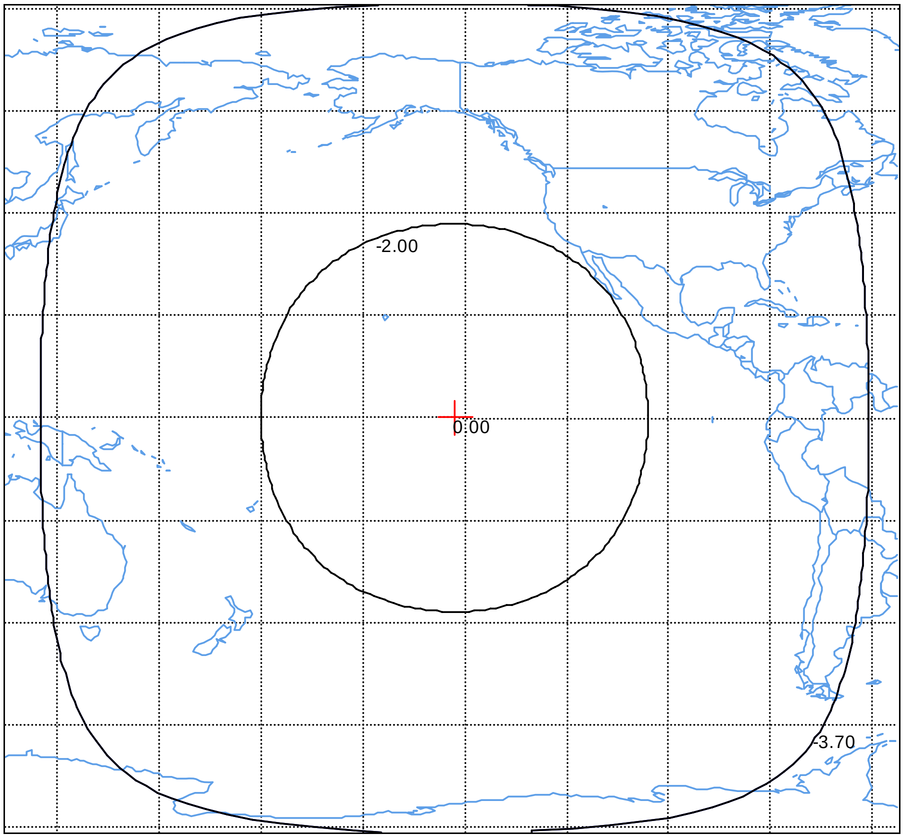
A.5.1 Feeder Downlink

The Inmarsat-3 F4 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 F4 satellite.

Figure A.5-1 – Inmarsat-3 F4 downlink C-band global beam gain contours

(Contours are -2 dB and -3.7 dB relative to beam peak)



A.5.2 Service Downlink – Global beam

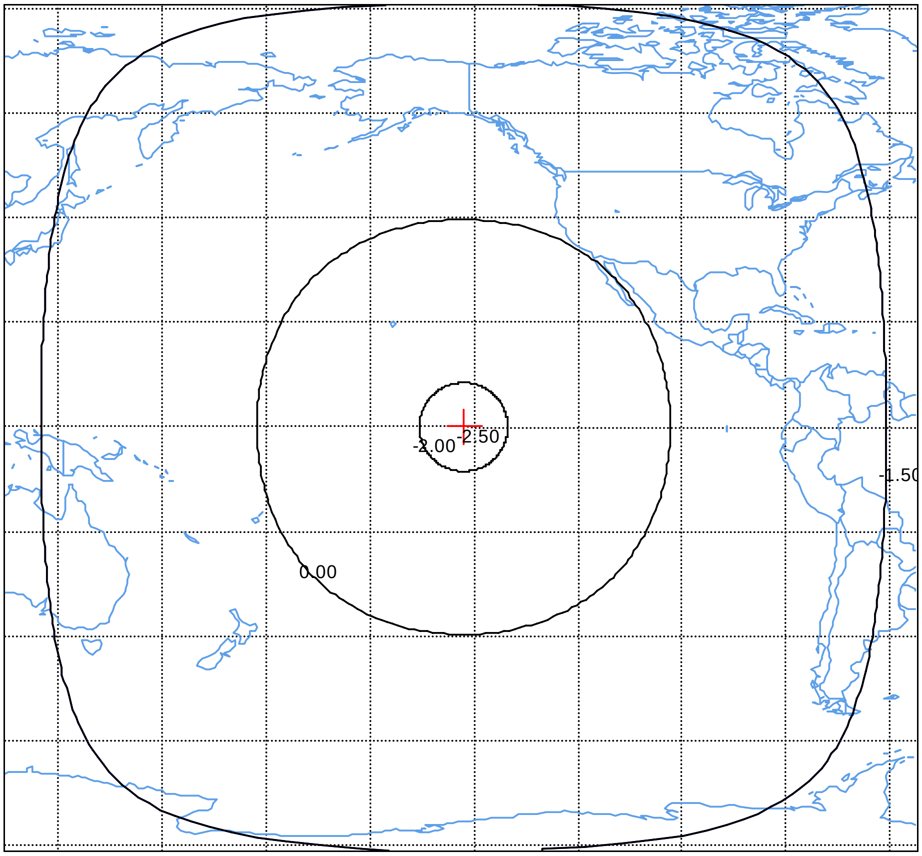
The Inmarsat-3 satellites include an L-band global beam for the MSS services. The beam transmits in RHCP. The beam covers all the points within the satellite's field of view, with a peak gain of 19.5 dBi, providing a maximum of up to 41.5 dBW of downlink EIRP.

Figure A.5-2 shows the gain contours of the downlink L-band global beam for the Inmarsat-3 F4 satellite.

Figure A.5-2 – Inmarsat-3 F4 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)



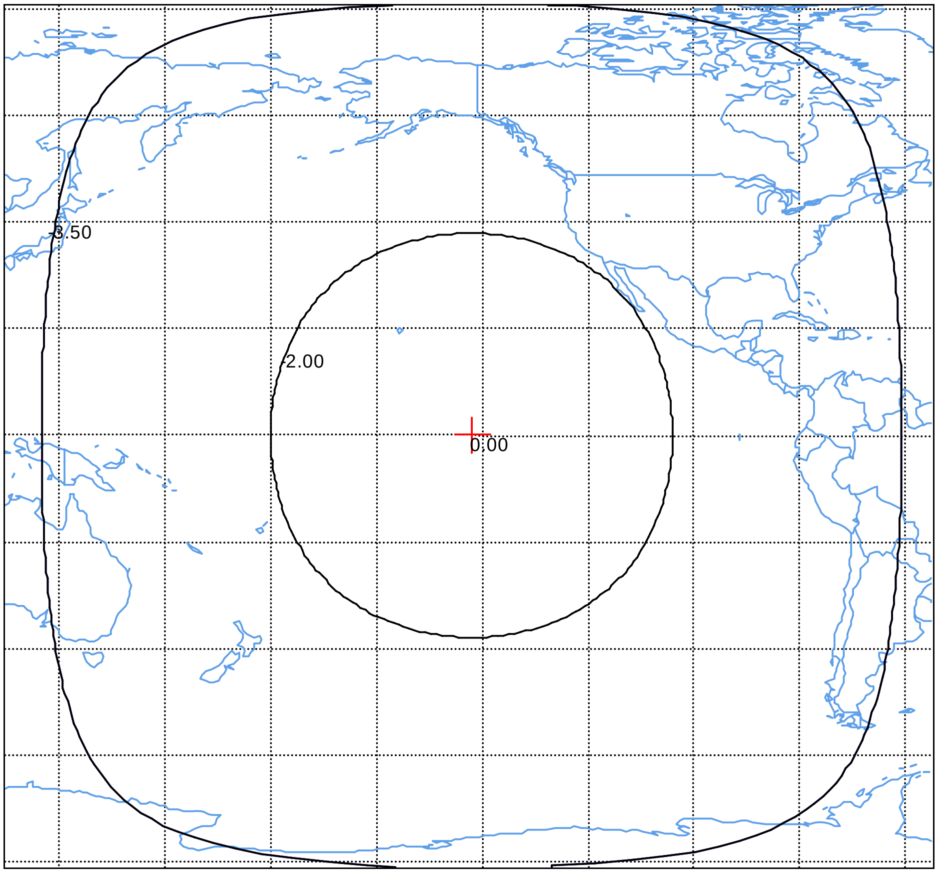
A.5.3 Navigation Downlink

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 F4 downlink navigation beam gain contours

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



A.6 SATELLITE RECEIVE CAPABILITY

A.6.1 Feeder Uplink

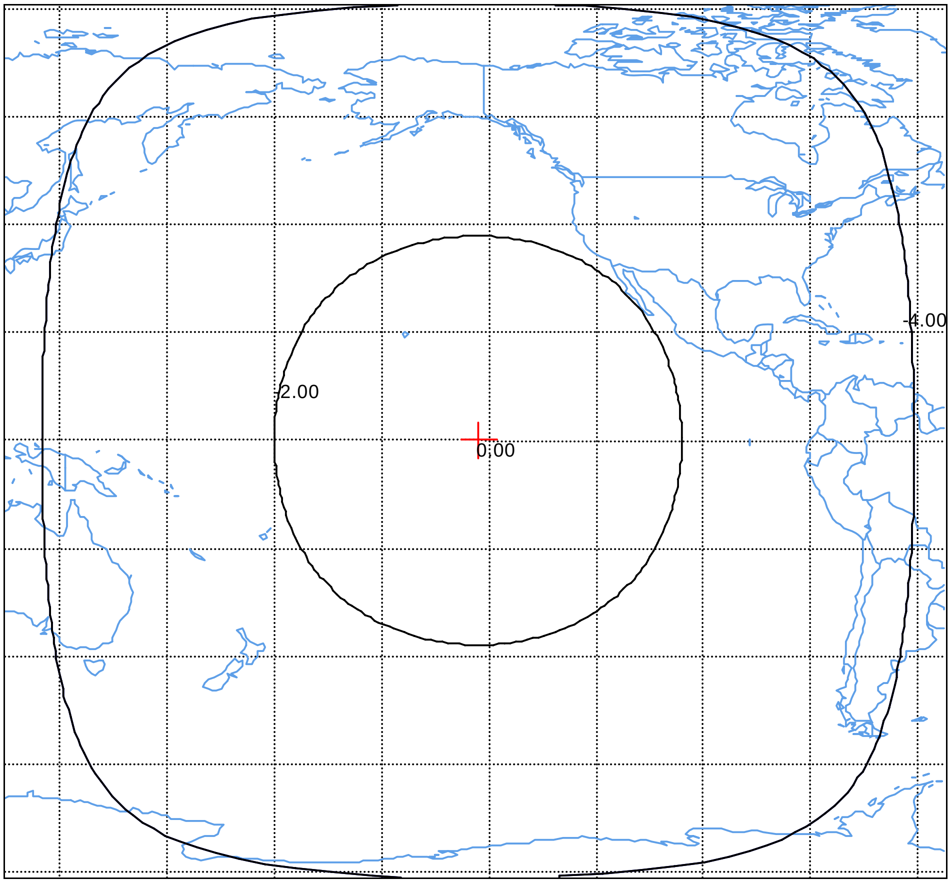
The Inmarsat-3 F4 satellite employs two C-band global uplink beams, one in RHCP and the other one in LHCP. The beams are nominally identical in each polarization. The beams cover all the points within the satellite field of view, with a peak gain of 20.5 dBi and a total system noise temperature of approximately 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 F4 satellite.

Figure A.6-1 – Inmarsat-3 F4 uplink C-band global beam gain contours

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



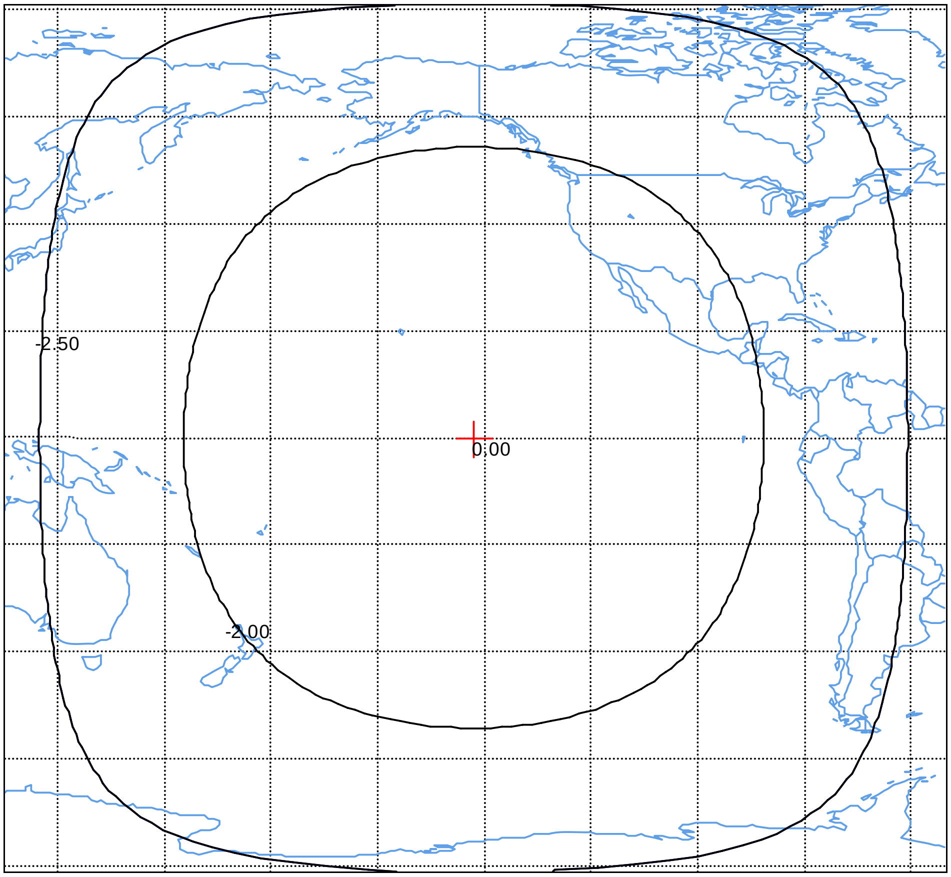
A.6.2 Service Uplink – Global beam

The Inmarsat-3 F4 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 F4 satellite.

Figure A.6-2 – Inmarsat-3 F4 uplink L-band global beam gain contours

(Contours are -2 dB and -2.5 dB relative to beam peak)

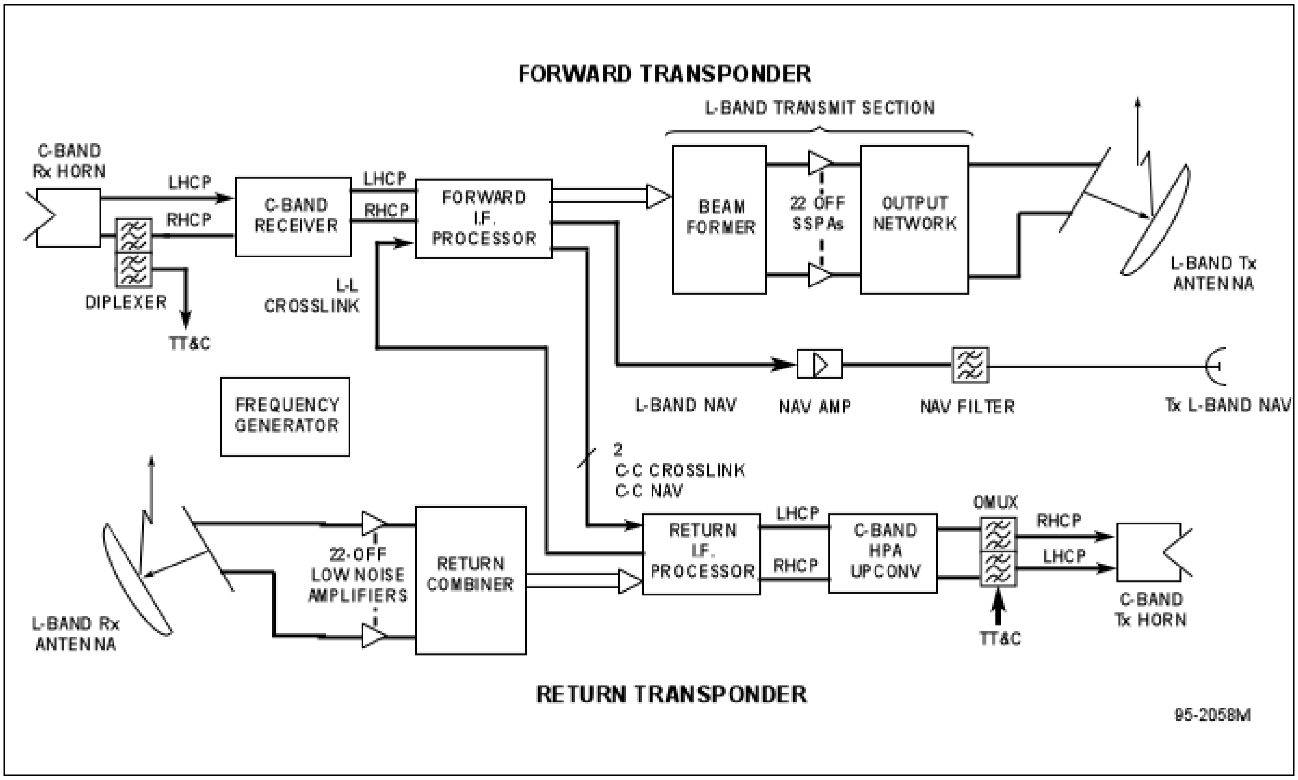


A.7 COMMUNICATIONS PAYLOAD

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 F4 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 right hand circular polarized 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 FLUX DENSITY

The maximum "transponder" gain between the output of the receiving antenna and the input of the transmitting antenna is 137 dB on the forward link and 127 dB on the return link for the MSS payload. For the navigation payload, the maximum transponder gain is 139 dB and 109 dB for the C-L link and C-C link, respectively. The gain of any transmission channel on the forward path is commandable in 2 dB steps over a 24 dB range. The gain of any transmission channel on the return path is commandable in 2 dB steps over a 23 dB range.

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

A.9 UNWANTED EMISSIONS

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

A.10 EMISSION DESIGNATORS AND ALLOCATED BANDWIDTH OF EMISSION

The emission designators and allocated bandwidths for the Inmarsat-B and navigation carriers are given in Table A.10-1.

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

Emission Designator	Allocated Bandwidth
100KG1X	100 kHz
20K0G1E	20 kHz
20K0G1X	20 kHz
10K0G1X	10 kHz
2M20G1D	2.2 MHz

A.11 EARTH STATIONS

A.11.1 User Terminals (UT)

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. 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 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.

A.12 LINK BUDGETS

Tables A.12-1 and A.12-2 provide the forward and return link budgets, respectively, of the Inmarsat-B service over the global beam. The navigation C-L and C-C link budgets are given in Table A.12-3.

Table A.12-1. Inmarsat-B global beam forward link budgets.

General	**Unit**			
User terminal type		INM-B	INM-B	INM-B
Emission Designator		20K0G1E	100KG1X	10K0G1X
Modulation		O-QPSK	O-QPSK	BPSK
Uplink				
Frequency	GHz	6.5	6.5	6.5
LES elevation angle	(deg)	5.0	5.0	5.0
LES maximum EIRP towards satellite	(dBW)	58.6	61.8	51.6
Path Loss	(dB)	200.9	200.9	200.9
Mean atmospheric loss	(dB)	0.4	0.4	0.4
Satellite G/T	(dB/K)	-13	-13	-13
Up-path C/No	(dBW/Hz)	72.9	76.1	65.9
Downlink				
Frequency	GHz	1.5	1.5	1.5
User terminal elevation angle	(deg)	5.0	5.0	5.0
Satellite EIRP	(dBW)	24.3	27.5	17.3
Path Loss	(dB)	188.5	188.5	188.5
Mean atmospheric loss	(dB)	0.1	0.1	0.1
User terminal G/T	(dB/K)	-4.0	-4.0	-4.0
Down-path C/No	(dBW/Hz)	60.3	63.5	53.3
Total				
Mean satellite C/IMo	(dB/Hz)	69.1	72.3	62.1
Co-channel interference	(dB/Hz)	67.8	75.1	61.8
Adjacent sat. interference allocation	(dB)	1.0	1.0	1.0
Mean overall C/No	(dB/Hz)	57.9	61.5	51.1
Mean overall C/N	(dB)	16.2	12.5	12.3
Margin				
C/N objective	(dB)	5.1	5.0	0.6
C/N margin	(dB)	11.0	7.5	11.7

Table A.12-2. Inmarsat-B global beam return link budgets.

General	Unit			
User terminal type		INM-B	INM-B	INM-B
Emission Designator		20K0G1E	100KG1X	20K0G1X
Modulation		O-QPSK	O-QPSK	O-QPSK
Uplink				
Frequency	GHz	1.6	1.6	1.6
User terminal elevation angle	(deg)	5.0	5.0	5.0
User terminal EIRP towards satellite	(dBW)	33.0	33.0	33.0
Path Loss	(dB)	188.9	188.9	188.9
Mean atmospheric loss	(dB)	0.1	0.1	0.1
Satellite G/T	(dB/K)	-8.1	-8.1	-8.1
Adjacent channel interference allocation	(dB)	0.2	0.2	0.2
Up-path C/No	(dBW/Hz)	64.3	64.3	64.3
Downlink				
Frequency	GHz	3.6	3.6	3.6
LES elevation angle	(deg)	5.0	5.0	5.0
Satellite EIRP	(dBW)	3.7	3.7	3.7
Path Loss	(dB)	195.9	195.9	195.9
Mean atmospheric loss	(dB)	0.2	0.2	0.2
LES G/T	(dB/K)	30.7	30.7	30.7
Down-path C/No	(dBW/Hz)	66.9	66.9	66.9
Total				
Mean satellite C/IMo	(dB/Hz)	72.0	72.0	72.0
Co-channel interference	(dB/Hz)	67.8	75.1	67.8
Adjacent sat. interference allocation	(dB)	1.0	1.0	1.0
Mean overall C/No	(dB/Hz)	59.9	60.7	59.9
Mean overall C/N	(dB)	18.2	11.7	18.2
Margin				
C/N objective	(dB)	5.1	5.0	4.4
C/N margin	(dB)	13.1	6.7	13.8

Table A.12-3. Navigation C-L and C-C link budgets.

General	**Unit**		
Emission Designator		2M20G1D	2M20G1D
Modulation		BPSK	BPSK
Uplink			
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
Downlink			
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
Total			
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
Margin			
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 F4 satellite is maintained in longitude within ±0.1° of its nominal orbital location for all latitudes within ±2.7° of the equator. The satellite is operated in an inclined geostationary orbit, with the inclination permitted to fluctuate naturally between 0^o and 2.7^o 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 F4 satellite is 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.19, there are not expected to be any other satellites within their same station-keeping volumes. *See Mitigation of Orbital Debris*, 19 FCC Rcd 11567 at para. 51. Moreover, the Inmarsat-3 F4 satellite is operated 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 is maintained within ±0.1° 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 F4 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 F4 (Ariane launch)

	Mass (kg)
Launch Mass	1956 kg
Satellite Dry Mass	870 kg
AKM expendables	803 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.

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 20ºC narrower than the equipment/structure qualification range.

A.16.6 Reliability

Overall spacecraft reliability is approximately 0.65 at 13 years. 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

There are no operational satellites within two degrees of 142° W.L. using the extended C-bands. In order to show two-degree compatibility, the C-band transmission parameters of the Inmarsat-3 F4 have been assumed as both the wanted and victim transmissions. Table A.17-1 provides a summary of the uplink and downlink C-band feeder link parameters.

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

Carrier ID	Emission Designator	Occupied BW (kHz)	Tx Antenna Gain (dBi)	Uplink EIRP (dBW)	Downlink EIRP (dBW)	Rx Antenna Gain (dBi)	C/I Criterion (dB)
1	20K0G1E	15	54.0	58.6			17.3
2	100KG1X	80	54.0	61.8			17.2
3	10K0G1X	7.5	54.0	51.6			12.8
4	2M20G1D	2046	54.0	78.0			-15.8
5	20K0G1E	15			3.7	49.2	17.3
6	100KG1X	80			3.7	49.2	17.2
7	20K0G1X	15			3.7	49.2	12.8
8	2M20G1D	2043			-0.2	49.2	-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(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.17-2 and A.17-3 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.17-2. Summary of the uplink C/I margins (dB).

		Interfering Carriers			
	Carrier ID	1	2	3	4
Wanted	1	15.9	20.0	19.9	17.9
	2	12.0	16.1	16.0	14.0
	3	16.4	20.5	20.4	18.4
	4	47.1	51.2	51.1	49.1

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

		Interfering Carriers			
	Carrier ID	5	6	7	8
Wanted	5	11.2	18.5	11.2	36.4
	6	4.0	11.3	4.0	29.3
	7	11.9	19.2	11.9	37.1
	8	19.0	26.3	19.0	44.3

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

The FCC 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^2) for angles of arrival (δ) above the horizontal plane			Reference bandwidth
0°-5°	**5°-25°**	**25°-90°**	
–152	–152 + 0.5(δ – 5)	–142	4 kHz

These limits are the same as those specified by the FCC in §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(s) associated with the 20K0G1X emission (see Table A.12-2), which corresponds to a satellite EIRP level of +3.7 dBW in a 15 kHz occupied bandwidth at the edge of coverage or 7.4 dBW at the beam peak. 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 7.4-162.06 = -154.7 dBW/m^2/15kHz. In any 4 kHz band this would correspond to a maximum PFD at the Earth's surface measured in a 4 kHz band of -154.7 + 10log(4E3/15E3) = -160.4 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.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 §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 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, within the uncertainty of the propellant measurement system. ~~All remaining propellants will be vented where possible regarding the requirement for stability of the final orbit minimum perigee height.~~ 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 F4 satellite. Inmarsat has reviewed the list 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 within plus/minus 0.2 degrees of 142° 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 142° W.L. slot. In addition, the only ITU filings in the immediate vicinity of 142° W.L. were filed on behalf of Inmarsat. Inmarsat therefore concludes there is no requirement to physically coordinate the Inmarsat-3 F4 satellite with any other satellite operator. 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 F4 satellite, 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, ie, in the early 1990s.

The propulsion subsystem design and the satellite fuel budget account for the post-mission disposal of the satellite. 3.5 kg of propellant has been allocated and reserved for the final orbit raising maneuvers. Inmarsat has assessed fuel gauging uncertainty and the 3.5 kg of propellant provides a sufficient margin of reserve fuel to address the uncertainty.

A.20 WAIVER REQUESTS

§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 §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 only transmit 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, the applicant therefore respectfully requests a waiver for the navigation uplink feeder link transmission and associated C-band downlink transmission.

A.21 COMMENTS CONCERNING SCHEDULE S SUBMISSION

In this section, additional explanation is provided concerning specific areas of the Schedule S form where the design of the Inmarsat-3 satellites 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. 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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