Engineering Statement

1 Introduction

Intelsat License LLC ("Intelsat") seeks authority in this application to redeploy the satellite designated as Galaxy 11 (Call Sign S2253) to 93.1° W.L. (266.9° E.L.).

The characteristics of the Galaxy 11 spacecraft, as well as its compliance with the various provisions of Part 25 of the Federal Communications Commission's ("FCC" or "Commission") rules, are provided in the remainder of this Engineering Statement, which updates the beam gain contours. In all other respects, the characteristics of Galaxy 11 are the same as those described in SAT-MOD-20160803-00077.

2 Spacecraft Overview

Galaxy 11 is a Boeing 702 spacecraft that is capable of operating in C-band and Ku-band frequencies listed below, which will provide service to North and South America.

Direction	Frequency
Uplink	5925 – 6425 MHz
	13750 – 14500 MHz
Downlink	3700 – 4200 MHz
	10950 – 11200 MHz
	11700 – 12200 MHz

2.1 Spacecraft Characteristics

Galaxy 11 is a Boeing 702 three-axis stabilized type spacecraft that has a rectangular outer body structure. Galaxy 11 utilizes two deployable solar array wings and a number of deployable and non-deployable antennas.

The Galaxy 11 spacecraft is composed of the following subsystems:

- Thermal
- Power
- Attitude Control
- Propulsion
- Telemetry, Command, and Ranging
- Uplink Power Control
- Communications

These subsystems maintain the correct position and attitude of the spacecraft; ensure that all internal units are maintained within the required temperature range; and ensure that the spacecraft can be commanded and controlled with a high level of reliability from launch to the end of its useful life. The spacecraft design incorporates redundancy in the various subsystems in order to avoid single-point failures.

The structural design of Galaxy 11 provides mechanical support for all subsystems. The structure supports the communication antennas, solar arrays, and thrusters. It also provides a stable platform for preserving the alignment of critical elements of the spacecraft.

2.2 Communication Subsystem

Galaxy 11 provides active communication channels at C-band and Ku-band frequencies, with C-band having a bandwidth of 36 MHz and Ku-band having bandwidths of 27 MHz and 36 MHz. The Galaxy 11 frequencies, polarization, and channel plan are provided in Schedule S.

The coverage contours and performance characteristics of Galaxy 11 beams are also provided in Schedule S. Exhibits 1 and 2 provide the beam parameters for the Galaxy 11 uplink and downlink beams, respectively.

2.3 Telemetry, Command, and Ranging Subsystem

The telemetry, command, and ranging ("TC&R") subsystem provides the following functions:

1) acquisition, processing, and transmission of spacecraft telemetry data;

2) reception and retransmission of ground station generated ranging signals; and

3) reception, processing, and distribution of telecommands.

The Galaxy 11 command and telemetry channel frequencies are shown in Exhibit 3. The coverage patterns of the on-station command and telemetry beams are provided in Schedule S. The coverage patterns of the emergency command and telemetry beams have gain contours that vary by less than 8 dB across the surface of the Earth and accordingly the gain at 8 dB below the peak falls beyond the edge of the Earth. Therefore, pursuant to Section 25.114(c)(4)(vi)(A) of the FCC's rules, contours for these beams are not required to be provided and the associated GXT files have not been included in Schedule S. The Galaxy 11 command and telemetry subsystem performance is summarized in Exhibit 3.

2.4 Uplink Power Control Subsystem

Galaxy 11 utilizes three Ku-band channels for uplink power control ("ULPC"), antenna tracking, and ranging. The coverage patterns of the ULPC beams have gain contours that vary by less than 8 dB across the surface of the Earth, and accordingly the gain at 8 dB below the peak falls beyond the edge of the Earth. Therefore, pursuant to Section 25.114(c)(4)(vi)(A) of the FCC's

rules, contours for these beams are not required to be provided and the associated GXT files have not been included in Schedule S. The Galaxy 11 ULPC frequencies and subsystem performance are summarized in Exhibit 3.

2.5 Satellite Station-Keeping

The spacecraft will be maintained within 0.05° of its nominal longitudinal position in the east-west direction. Accordingly, it will be in compliance with Section 25.210(j) of the FCC's rules.

The attitude of the spacecraft will be maintained with accuracy consistent with the achievement of the specified communications performance, after taking into account all error sources (i.e., attitude perturbations, thermal distortions, misalignments, orbital tolerances and thruster perturbations, etc.).

3 Services

Galaxy 11 is a general purpose communications satellite and has been designed to support various services offered by Intelsat. Depending upon the needs of the users, the transponders on Galaxy 11 can accommodate digital and analog communications. Typical communication services include:

a) compressed digital video;

b) high speed digital data; and

c) digital single channel per carrier ("SCPC") data channels.

Emission designators and allocated bandwidths for representative communication carriers are provided in Schedule S.

4 Power Flux Density

The power flux density ("PFD") limits for space stations operating in the 3700-4200 MHz and 10950-11200 MHz bands are contained in Section 25.208 of the Commission's rules. The maximum PFD levels for the Galaxy 11 transmissions were calculated for the 3700-4200 MHz and 10950-11200 MHz bands. The results are provided in Schedule S and show that the downlink power flux density levels of the Galaxy 11 carriers do not exceed the limits specified in Section 25.208 of the Commission's rules.

The Commission's rules do not specify PFD limits for the 11.7-12.2 GHz band. However, Appendix 5 of the International Telecommunication Union ("ITU") Radio Regulations contains PFD limits for this band. The maximum PFD levels for the Galaxy 11 transmissions in the 11.7-12.2 GHz band were verified to be compliant with Appendix 5 of the ITU Radio Regulations.

5 Emission Compliance

Section 25.202(e) of the Commission's rules requires that the carrier frequency of each space station transmitter be maintained within 0.002% of the reference frequency. Galaxy 11 is designed to be compliant with the provisions of this rule.

Intelsat will comply with the provisions of Section 25.202(f) of the Commission's rules with regard to Galaxy 11 emissions.

6 Orbital Location

Intelsat requests that it be assigned the 93.1° W.L. orbital location for Galaxy 11. The 93.1° W.L. location satisfies Galaxy 11 requirements for optimizing coverage, elevation angles, and service availability. Additionally, the location also ensures that the maximum operational, economic, and public interest benefits can be derived.

7 ITU Filling

Galaxy 11 operations in the 3700-4200 MHz, 5925-6425 MHz, 11700-12200 MHz, and 14000-14500 MHz frequency bands have been notified and coordinated under the Administration of the United States' ITU filings USASAT-24S and USASAT-35M.

Intelsat intends to operate Galaxy 11 pursuant to the German ODYSSEY-93W ITU satellite network filing (CR/C 4416) in the frequency bands 10950-11200 MHz and 13750-14000 MHz at the nominal orbital location of 93° W.L. To this end, Intelsat requests that the Commission state its non-objection to the use of Galaxy 11 to bring into use and operate against the ODYSSEY-93W satellite network filing.

8 Coordination with Co-frequency Space Stations

The frequency bands 5925-6425 MHz and 13750-14500 MHz (uplink) and the frequency bands 3700-4200 MHz, 10950-11200 MHz, and 11700-12200 MHz (downlink) do not require interference analysis or 2-degree analysis under 47 C.F.R. § 25.140 of the Commission's rules.

9 Orbital Debris Mitigation Plan

Intelsat is proactive in ensuring safe operation and disposal of this and all spacecraft under its control. The four elements of debris mitigation are addressed below.

9.1 Spacecraft Hardware Design

The spacecraft is designed such that no debris will be released during normal operations. Intelsat has assessed the probability of collision with meteoroids and other small debris (<1 cm diameter) and has taken the following steps to limit the effects of such collisions: (1) critical spacecraft components are located inside the protective body of the spacecraft and properly shielded; and (2) all spacecraft subsystems have redundant components to ensure no single-point failures. The

spacecraft does not use any subsystems for end-of-life disposal that are not used for normal operations.

9.2 Minimizing Accidental Explosions

Intelsat has assessed the probability of accidental explosions during and after completion of mission operations. The spacecraft is designed in a manner to minimize the potential for such explosions. Propellant tanks and thrusters are isolated using redundant valves and electrical power systems are shielded in accordance with standard industry practices. At the completion of the mission and upon disposal of the spacecraft, Intelsat will ensure that all active units are turned off. However, due to the design of Galaxy 11, Intelsat will not be able to vent all pressurized systems.[1]

9.3 Safe Flight Profiles

Intelsat has assessed and limited the probability of the space station becoming a source of debris as a result of collisions with large debris or other operational space stations. Subject to receipt of FCC approval, Galaxy 11 will be drifted to 93.1° W.L.

During the relocation of Galaxy 11, Intelsat will take all the necessary steps to coordinate the move internally to minimize the risk of collision or interference between Galaxy 11 and any other satellite Intelsat is not aware of any other FCC licensed system, or any other system applied for and under consideration by the FCC, that will have an overlapping station-keeping volume with Galaxy 11. Intelsat is also not aware of any system with an overlapping station-keeping volume with Galaxy 11 that is the subject of an ITU filing and that is either in orbit or progressing towards launch.

9.4 Post Mission Disposal

At the end of the mission, Intelsat intends to dispose of the spacecraft by moving it to an altitude of at least 175 kilometers above the geostationary arc as previously stated.[2] Intelsat has reserved 30.035 kilograms of fuel for this purpose. In its *Second Report and Order* in IB Docket 02-54, Mitigation of Orbital Debris,[3] the FCC designated satellites launched prior to March 18, 2002, such as the Galaxy 11 satellite, as grandfathered satellites not subject to a specific disposal

---

1 *See* Legal Narrative at Waiver Request.

2 *See* Request for Special Temporary Authority to Drift Galaxy 11 to, and Operate at, 60.1° E.L. and Notification of Revised Post-Mission Disposal Statement; Call Sign: S2253, File No. SAT-STA-20150505-00033 (filed May 5, 2015).

3 Mitigation of Orbital Debris, *Second Report and Order*, 19 FCC Rcd 11567 (2004).

altitude. Therefore, the planned disposal orbit for Galaxy 11, as revised, complies with the FCC's rules.

The reserved fuel figure was determined by the spacecraft manufacturer and provided for in the propellant budget. This figure was calculated taking into account the expected mass of the satellite at the end of life and the required delta-velocity to achieve the desired orbit. The fuel gauging uncertainty has been taken into account in these calculations.

10 TC&R Control Earth Stations

Intelsat will conduct TC&R operations through one or more of the following earth stations: Fuchsstadt, Germany; Hartebeeshoek, South Africa; Castle Rock, Colorado, United States; Ellenwood, Georgia, United States; Riverside, California, United States; Mountainside, Maryland, United States; and/or Fucino, Italy. Additionally, Intelsat is capable of remotely controlling Galaxy 11 from its facilities in McLean, VA or in Long Beach, CA.

Certification Statement

I hereby certify that I am a technically qualified person and am familiar with Part 25 of the Commission's rules. The contents of this engineering statement were prepared by me or under my direct supervision and to the best of my knowledge are complete and accurate.

/s/ Hazem Moakkit	December 31, 2018
Hazem Moakkit Intelsat Vice President, Spectrum Strategy	Date

EXHIBIT 1

COMMUNICATION SUBSYSTEM UPLINK BEAM PARAMETERS

Beam Name	C-Band North America	C-Band North America	Ku-Band North America	Ku-Band North America
Schedule S Beam ID	CNHU	CNVU	KNHU	KNVU
Frequency Band (MHz)	**5925 – 6425**	**5925 – 6425**	**14000 - 14500**	**14000 - 14500**
Polarization	Horizontal	Vertical	Horizontal	Vertical
G/T (dB/K)	2.5	4.2	6.3	4.8
Minimum SFD-- (dBW/m^2)	-96.2	-95.2	-99.8	-98.3
Maximum SFD-- (dBW/m^2)	-82.2	-81.2	-83.8	-82.3

Beam Name	Ext. Ku-Band CONUS	Ext. Ku-Band CONUS	Ku-Band Brazil	Ku-Band Brazil
Schedule S Beam ID	KCHU	KCVU	KBHU	KBVU
Frequency Band (MHz)	**13750 - 14000**	**13750 - 14000**	**14000 - 14250**	**14000 - 14250**
Polarization	Horizontal	Vertical	Horizontal	Vertical
G/T (dB/K)	5.2	5.2	5.7	6.3
Minimum SFD-- (dBW/m^2)	-94.3	-94.2	-98.3	-99.9
Maximum SFD-- (dBW/m2)	-78.3	-78.2	-82.3	-83.9

EXHIBIT 2

COMMUNICATION SUBSYSTEM DOWNLINK BEAM PARAMETERS

Beam Name	C-Band North America	C-Band North America	Ku-Band North America	Ku-Band North America
Schedule S Beam ID	CNHD	CNVD	KNHD	KNVD
Frequency Band (MHz)	3700 - 4200	3700 - 4200	11700 - 12200	11700 - 12200
Polarization	Horizontal	Vertical	Horizontal	Vertical
EIRP (dBW)	40.2	40.1	49.7	49.7
Maximum Beam Peak EIRP Density (dBW/4kHz)	0.7	0.6	10.2	10.2

Beam Name	Ku-Band CONUS	Ku-Band CONUS	Ku-Band Brazil	Ku-Band Brazil
Schedule S Beam ID	KCHD	KCVD	KBHD	KBVD
Frequency Band (MHz)	10950 - 11200	10950 - 11200	10950 - 11200	10950 - 11200
Polarization	Horizontal	Vertical	Horizontal	Vertical
EIRP (dBW)	52.1	52.0	52.5	51.9
Maximum Beam Peak EIRP Density (dBW/4kHz)	13.8	13.7	14.2	13.6

EXHIBIT 3

TC&R SUBSYSTEM CHARACTERISTICS

Beam Name	Command CONUS	Command Bicone	Command Pipe
Schedule S Beam ID	CMDC	CMDB	CMDP
Frequencies (MHz)	14498.5	14498.5	14000.5
Polarization	Vertical	Horizontal	LHCP
Peak Flux Density at Command Threshold (dBW/m^2-Hz)	-119.6	-91.8	-94.3

Beam Name	Telemetry CONUS	Telemetry Bicone	Telemetry Pipe	ULPC CONUS	ULPC Global
Schedule S Beam ID	TLMC	TLMB	TLMP	UPCC	UPGH/ UPGV
Frequencies (MHz)	11701.0 & 11702.0	11701.0 & 11702.0	11701.0 & 11702.0	12195.0	10951.0
Polarization	Vertical	Vertical	LHCP	Horizontal	Horizontal & Vertical
Maximum Channel EIRP (dBW)	12.91	11.16	11.19	23	16
Maximum Beam Peak EIRP Density (dBW/4kHz)	-5.8	-7.6	-7.6	15.0	8.0

Note: *RHCP: Right Hand Circular Polarization, LHCP: Left Hand Circular Polarization*

EXHIBIT 4

Beam Polarizations and GXT File Names

	Schedule S Beam Names							
	Linear Polarization				Circular Polarization			
Beam Designation	**Uplink (H-Pol.)**	**Uplink (V-Pol.)**	**Downlink (H-Pol.)**	**Downlink (V-Pol.)**	**Uplink (LHCP)**	**Uplink (RHCP)**	**Downlink (LHCP)**	**Downlink (RHCP)**
C-Band Beams								
C-band North America	CNHU	CNVU	CNHD	CNVD	----	----	----	----
Ku-band North America	KNHU	KNVU	KNHD	KNVD	----	----	----	----
Ext. Ku-band CONUS	KCHU	KCVU	KCHD	KCVD	----	----	----	----
Ku band Brazil	KBHU	KBVU	KBHD	KBVD	----	----	----	----
Ku-Band Beams								
Telemetry Global horn	----	----	----	TLMC*	----	----	----	----
Telemetry Pipe	----	----	----	----	----	----	TLMP*	----
Telemetry Bicone	----	----	----	TLMB*	----	----	----	----
Command Global horn	----	CMDC*	----	----	----	----	----	----
Command Bi-cone	CMDB*	----	----	----	----	----	----	----
Command Pipe	----	----	----	----	CMDP*	----	----	----
Ku-band ULPC	----	----	UPCC*		----	----	----	----
ULPC Global	----	----	UPGH*	UPGV*	----	----	----	----

** GXT files are not provided for the indicated beams because their -8 dB gain contours extend beyond the edge of the Earth*