Engineering Statement

1 Introduction

Intelsat License LLC ("Intelsat") seeks authority in this application to launch and operate the Galaxy 15R satellite at the 133.0° W.L. orbital location. Galaxy 15R will replace Galaxy 15, currently operating at 133.0° W.L. The characteristics of the Galaxy 15R spacecraft, as well as its compliance with the various provisions of Part 25 of the Federal Communication Commission's ("FCC or "Commission") rules, are provided in the remainder of this Engineering Statement.

2 Spacecraft Overview

Galaxy 15R is a Boeing model 702MP spacecraft that is capable of operating in the C-band and Ku-band frequencies listed in the table below.

Direction	Frequency
Uplink	5925–6425 MHz
	13750–14500 MHz
Downlink	3700–4200 MHz
	10950–11200 MHz
	11450–12200 MHz

The spacecraft provides the following coverage:

Frequency band	Beam	Coverage
C-Band	Wide Beam	United States including Alaska and Hawaii
Ku-Band	K1–K57	United States including Alaska and Hawaii

2.1 Spacecraft Characteristics

Galaxy 15R is a three-axis stabilized type spacecraft that has a rectangular outer body structure. Galaxy 15R utilizes two deployable solar array wings and a number of deployable and non-deployable antennas.

The Galaxy 15R spacecraft is composed of the following subsystems:

1) Thermal

2) Power
3) Attitude Control
4) Propulsion
5) Telemetry, Command and Ranging ("TC&R")
6) Uplink Power Control ("ULPC")
7) 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 each of the various subsystems in order to avoid single point failures.

The structural design of Galaxy 15R provides mechanical support for all subsystems. The structure supports the communication antennas, solar arrays, and the thrusters. It also provides a stable platform for preserving the alignment of critical elements of the spacecraft.

2.2 Communication Subsystem

Galaxy 15R provides active communication channels at C-band and Ku-band frequencies. The C-band payload employs channels with bandwidths of 36 MHz. The Ku-band payload employs channels having bandwidths of 36 MHz, 72 MHz, and 84 MHz. The Galaxy 15R frequency and polarization plan is provided in Schedule S.

Galaxy 15R utilizes a combination of wide-beam and multiple spot-beam architecture. A wide beam covers the United States, including Alaska and Hawaii operates in C-band. In Ku-band, there are 57 identical spot beams that collectively cover the United States, including Alaska and Hawaii. The coverage contours and performance characteristics for a single representative Ku-band spot beam is provided in Schedule S. The latitude and longitude of each Ku-band spot beam's maximum gain point on the Earth are provided in Exhibit 1 in conformance with Section 25.114(c)(4)(vii)(B) of the Commission's rules. Additionally, in Exhibit 2, Intelsat has included the Schedule S beam designation for all beams.

The performance characteristics of all Galaxy 15R beams are provided in Schedule S. The coverage contours of all Galaxy 15R beams, except for those with their -8.0 dB contour extending beyond the edge of the Earth, are provided with Schedule S.

Exhibits 3 and 4 provide the beam parameters for the Galaxy 15R uplink and downlink beams, respectively.

All C-band and Ku-band communication subsystems are inter-connected, which allows for any frequency combination for the uplink and downlink connectivity at sub-beam level. Additionally, a beam can have multiple connections to several other beams by

splitting the channels into sub-channels with variable sizes. The expected dominant application for Galaxy 15R will be comprised of hub and spoke networks wherein one earth station serves as the hub or gateway for a number of other earth stations. The earth stations' predominant communication links will be with the hub. All Galaxy 15R beams can be used for both gateway and service links.[1]

2.3 Telemetry, Command and Ranging Subsystem

The 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 15R command and telemetry subsystem performance is summarized in Exhibit 5 and in Schedule S. The beams used for orbital maneuvers and on-station emergencies as well as the on-station 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 Commission's rules, contours for these beams are not required to be provided and the associated GXT files have not been included in Schedule S.

2.4 Uplink Power Control Subsystem

Galaxy 15R utilizes one C-band channel and one Ku-band channel for 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 Commission'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 15R ULPC subsystem performance is summarized in Exhibit 5.

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 comply with Section 25.210(j) of the Commission'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

[1] Use of the band 27500 MHz-28350 MHz by earth stations will be subject to Section 25.136.

error sources (i.e., attitude perturbations, thermal distortions, misalignments, orbital tolerances, and thruster perturbations, etc.).

3 Services

Galaxy 15R will be a general purpose communications satellite and has been designed to support various services offered within Intelsat's satellite system. Depending upon the needs of the users, the transponders on Galaxy 15R can accommodate television, radio, voice, and data communications. Typical communication services include:

a) Compressed digital video

b) High speed digital data

c) Digital single channel per carrier ("SCPC") data channels

4 Power Flux Density ("PFD")

The power flux density ("PFD") limits for space stations operating in the 3700–4200 MHz, 10950–11200 MHz, 11450–11700 MHz, and 11700–12200 MHz are specified in Section 25.208 of the Commission's rules.

The maximum PFD levels for the Galaxy 15R transmissions were calculated for the bands 3700–4200 MHz, 10850–11700 MHz, and 12200–12750 MHz. The results are provided in Schedule S and show that the downlink PFD levels of the Galaxy 15R carriers do not exceed the limits specified in Sections 25.208 and 25.138 of the Commission's rules.

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 15R 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 15R emissions.

6 Orbital Location

Intelsat requests that it be assigned the 133.0° W.L. orbital location for Galaxy 15R. The 133.0° W.L. location satisfies Galaxy 15R's requirements for optimizing coverage, elevation angles, and service availability. Additionally, the location also ensures that the maximum operational, economic, and public interest benefits will be derived.

7 ITU Filings

Galaxy 15R's operations in the 3700–4200 MHz, 5925–6425 MHz bands have been coordinated under the Administration of the United States' International

Telecommunication Union ("ITU") filing USASAT-22A, USASAT-35Y, and USASAT-50B.

For the operation of Galaxy 15R in the frequencies 13750–14500 MHz, 10950–11200 MHz, and 11450–12200 MHz bands, Intelsat will be submitting as part of this application the corresponding Appendix 4 information for the new satellite network to be forwarded by the FCC to the ITU.

8 Coordination Statement and Certifications

The downlink EIRP density of Galaxy 15R's transmissions in the conventional C-band will not exceed 3 dBW/4kHz for digital transmissions or 8 dBW/4kHz for analog transmissions, and associated uplink transmissions will not exceed applicable EIRP density envelopes in Sections 25.218 or 25.221(a)(1) unless the non-routine uplink and/or downlink operation is coordinated with operators of authorized co-frequency space stations at assigned locations within six degrees of Galaxy 15R at 133.0° W.L.

The downlink EIRP density of Galaxy 15R's transmissions in the conventional and extended Ku-band will not exceed 14 dBW/4kHz for digital transmissions or 17 dBW/4kHz for analog transmissions, and associated uplink transmissions will not exceed applicable EIRP density envelopes in Sections 25.218, 25.222(a)(1), 25.226(a)(1), or 25.227(a)(1) unless the non-routine uplink and/or downlink operation is coordinated with operators of authorized co-frequency space stations at assigned locations within six degrees of Galaxy 15R at 133.0° W.L.

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

the removal of all stored energy on the spacecraft by depleting all propellant tanks, venting all pressurized systems and by leaving the batteries in a permanent discharge state.

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. With the potential exception of co-location during a traffic transition period, Galaxy 15R will not be located at the same orbital location as another satellite or at an orbital location that has an overlapping station keeping volume with another satellite.

Galaxy 15R will replace Galaxy 15 at 133.0° W.L. These satellites may be nominally collocated during transfer of traffic and Intelsat will ensure that sufficient spatial separation is achieved between these two satellites through the use of orbit eccentricity and inclination offsets and thus minimize the risk of collision. Intelsat is not aware of any other FCC licensed system, or any other system applied for and under consideration by the FCC, having an overlapping station-keeping volume with Galaxy 15R. Intelsat is also not aware of any system with an overlapping station-keeping volume with Galaxy 15R 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 will dispose of the spacecraft by moving it to an altitude of at least 280 kilometers above the geostationary arc. Intelsat has reserved 2.0 kilograms of xenon for that purpose.

In calculating the disposal orbit, Intelsat has used simplifying assumptions as permitted under the Commission's Orbital Debris Report and Order.[2] The effective area to mass ratio (Cr*A/M) of the Galaxy 15R spacecraft is 0.045 m^2/kg, resulting in a minimum perigee disposal altitude under the Inter-Agency Space Debris Coordination Committee formula of 280 kilometers above the geostationary arc. Accordingly, the Galaxy 15R planned disposal orbit 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

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

Intelsat will conduct TC&R operations through one or more of the following earth stations: Napa, CA, Hagerstown, MD, and Ellenwood, GA. Additionally, Intelsat is capable of remotely controlling Galaxy 15R from its facilities in McLean, VA or 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/ Alexander Gerdenitsch	May 24, 2017
Alexander Gerdenitsch Intelsat Manager, Spectrum Policy, Americas	Date

EXHIBIT 1
Ku-band SPOT BEAM BORESIGHT LOCATIONS

Beam Designation	Latitude (°N)	Longitude (°E)	Beam Designation	Latitude (°N)	Longitude (°E)
Ku-band Beams			Ku-band Beams		
K1	19.31	-68.32	K30	47.7	-82.63
K2	18.63	-82.34	K31	46.42	-95.95
K3	24.27	-71.48	K32	45.66	-105.85
K4	23.5	-84.59	K33	45.18	-114.3
K5	23.03	-93.67	K34	44.88	-122.03
K6	29.55	-72.89	K35	44.74	-129.38
K7	28.63	-86.08	K36	59.06	-59.98
K8	28.07	-95.29	K37	55.25	-91.6
K9	27.69	-102.91	K38	54.01	-104.72
K10	27.4	-109.65	K39	53.32	-115.06
K11	27.2	-115.86	K40	52.95	-124.26
K12	27.07	-121.74	K41	52.84	-133
K13	35.34	-72.37	K42	52.95	-141.74
K14	34.17	-86.71	K43	53.32	-150.94
K15	33.49	-96.4	K44	54.01	-161.28
K16	33.03	-104.36	K45	55.25	-174.4
K17	32.7	-111.4	K46	64.65	-139.32
K18	32.47	-117.89	K47	65.33	-152.9
K19	32.33	-124.05	K48	67.22	-171.38
K20	32.26	-130.03	K49	24.29	-153.21
K21	42.1	-67.93	K50	27.07	-144.26
K22	40.36	-86.04	K51	27.2	-150.14
K23	39.48	-96.81	K52	32.26	-135.97
K24	38.91	-105.43	K53	32.33	-141.95
K25	38.52	-112.98	K54	32.47	-148.11
K26	38.27	-119.93	K55	38.12	-139.46
K27	38.12	-126.54	K56	38.27	-146.07
K28	38.07	-133	K57	21.32	-156.83
K29	49.59	-56.41			

EXHIBIT 2
Beam Polarizations and GXT File Names

	Schedule S Beam GXT File Names							
	Linear Polarization				Circular Polarization			
Beam Description	**Uplink (H-Pol.)**	**Uplink (V-Pol.)**	**Downlink (H-Pol.)**	**Downlink (V-Pol.)**	**Uplink (LHCP)**	**Uplink (RHCP)**	**Downlink (LHCP)**	**Downlink (RHCP)**
C-Band Beams								
United States	CAHU	CAVU	CAHD	CAVD	----	----	----	----
ULPC1	----	----	CLHD*	----	----	----	----	----
Telemetry Global	----	----	TGHD*	----	----	----	----	----
Command Global	----	CMD*	----	----	----	----	----	----
Telemetry Pipe	----	----	----	----	----	----	TPLD*	----
Telemetry Hemi	----	----	----	----	----	----	THLD*	----
Command Pipe	----	----	----	----	CPLU*	----	----	----
Command Hemi	----	----	----	----	CHLU*	----	----	----
Ku-Band Beams								
Spot K1-K57	KSHU	KSVU	KSHD KSHE	KSVD KSVE	----	----	----	----
ULPC2	----	----	----	----	----	----	----	KLRD*

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

EXHIBIT 3

COMMUNICATION SUBSYSTEM UPLINK BEAM PARAMETERS

Beam Name	C-Band Wide	C-Band Wide	Ku-Band Spot	Ku-Band Spot
Schedule S Beam ID	CAHU	CAVU	KSHU	KSVU
Frequency Band (MHz)	5927.0-6403.0		13754.0-14482.0	
Polarization	Horizontal	Vertical	Horizontal	Vertical
G/T (dB/K)	4.8	4.8	18.1	18.1
Minimum SFD--(dBW/m^2)	**-106.1**	**-106.1**	-100.9	-100.9
Maximum SFD--(dBW/m^2)	**-78.1**	**-78.1**	-75.9	-75.9

EXHIBIT 4

COMMUNICATION SUBSYSTEM DOWNLINK BEAM PARAMETERS

Beam Name	C-Band Spot	C-Band Spot
Schedule S Beam ID	CAHD	CAVD
Frequency Band (MHz)	3702.0-4178.0	
Polarization	Horizontal	Vertical
Maximum Beam Peak EIRP (dBW)	49.5	49.5
Maximum Beam Peak EIRP Density (dBW/4kHz)	6.1	6.1
Maximum Beam Peak EIRP Density (dBW/Hz)	-29.9	-29.9

Beam Name	Ku-Band Spot	Ku-Band Spot	Ku-Band Spot	Ku-Band Spot
Schedule S Beam ID	KSHD	KSVD	KSHE	KSVE
Frequency Band (MHz)	10950.0-11198.0		11454.0-12194.0	
Polarization	Horizontal	Vertical	Horizontal	Vertical
Maximum Beam Peak EIRP (dBW)	62.0	62.0	62.0	62.0
Maximum Beam Peak EIRP Density (dBW/4kHz)	20.4	20.4	20.0	20.0
Maximum Beam Peak EIRP Density (dBW/Hz)	-15.6	-15.6	-15.6	-15.6

EXHIBIT 5
TC&R SUBSYSTEM CHARACTERISTICS

Beam Name	Command Global	Command Pipe	Command Hemi
Schedule S Beam ID	CMD	CPLU	CHLU
Center Frequencies (MHz)	6424.5	6424.5	5926.75
Command Carrier Bandwidth (MHz)	1.0	1.0	1.0
Polarization	Vertical	LHCP	LHCP
Peak Flux Density at Command Threshold (dBW/m^2-Hz)	-90	-80	-80

Beam Name	**Telemetry Global**	**Telemetry Pipe**	**Telemetry Bicone**
Schedule S Beam ID	TGHD	TPLD	THLD
Frequencies (MHz)	4197.75, 4198.25, 4198.75, & 4199.25	4197.75, 4198.25, 4198.75, & 4199.25	4197.75, 4198.25, 4198.75, & 4199.25
Polarization	Horizontal	LHCP	LHCP
Maximum Channel EIRP (dBW)	13.7	15.4	11.9
Maximum Beam Peak EIRP Density (dBW/4kHz)	-7.3	-5.6	-9.1
Maximum Beam Peak EIRP Density (dBW/Hz)	-43.3	-41.6	-45.1

Beam Name	**C-band Global**	**Ku-band Global**
Schedule S Beam ID	CLHD	KLRD
Frequencies (MHz)	4199.75	11451.0
Polarization	Horizontal	RHCP
Maximum Channel EIRP (dBW)	6.2	11
Maximum Beam Peak EIRP Density (dBW/4kHz)	-1.8	3.0
Maximum Beam Peak EIRP Density (dBW/Hz)	-37.8	-33.0

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