Engineering Statement

1 Introduction

Intelsat License LLC, as debtor in possession ("Intelsat"), seeks authority in this application to modify the Galaxy 30 (formally known as Galaxy 14R) satellite license to launch and operate at the 125.0° W.L. (235.0° E.L.) orbital location. The characteristics of Galaxy 30, as well as its compliance with the various provisions of Part 25 of the Federal Communications Commission's ("FCC or "Commission") rules,[1] are provided in this Engineering Statement.

2 Spacecraft Overview

Galaxy 30 is an Orbital ATK GeoStar-2 spacecraft capable of operating in the L-, C-, Ku-, and Ka-band frequencies listed in the table below.

Direction	Frequency
Uplink	6425-6725 MHz[2]
	5925-6425 MHz
	12750-13250 MHz
	13750-14500 MHz[3]
	27600-28600 MHz[4]

1 Unless otherwise stated, all references to rule sections in this document refer to sections in Title 47 of the Code of Federal Regulations.

2 This frequency band includes two Wide Area Augmentation System ("WAAS") uplink frequency bands: 6598.58-6618.58 MHz and 6649.73-6669.73 MHz.

3 Galaxy 30 has the capability to operate in the 14000-14500 MHz band, but Intelsat is not seeking authority to operate in this band at 125.0° W.L.

4 Intelsat is aware that geostationary satellite orbit ("GSO") fixed satellite services ("FSS") operations in the 27500-28350 MHz band are secondary to the Upper Microwave Flexible Use Service, except for FSS operations associated with earth stations authorized pursuant to §25.136. *See* 47 C.F.R. § 25.202(a)(1)(i).

Direction	Frequency
	29000-29100 MHz[5]
	29100-29250 MHz[6]
	29250-30000 MHz[7]
Downlink	1166.45-1186.45 MHz
	1565.42-1585.42 MHz
	3700-4200 MHz
	10700-10950 MHz
	10950-11200 MHz
	11200-11450 MHz
	11450-11700 MHz
	17800-18800 MHz[8]
	19200-19300 MHz[9]
	19300-19400 MHz
	19400-19600 MHz[10]
	19600-20200 MHz

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5 Intelsat is aware that GSO FSS operations in the 29000-29100 MHz band are secondary to non-geostationary orbit FSS. *See* 47 C.F.R. § 2.106, NG165.

6 Galaxy 30 has the capability to operate in the 29100-29250 MHz band, but Intelsat is not seeking authority to operate in this band at 125.0° W.L.

7 The band 29250-29300 MHz is allocated to mobile-satellite service (“MSS”) feeder links and FSS on a co-primary basis. Intelsat understands that its earth station uplink operations in this band will require coordination with the incumbent MSS feeder link operators.

8 Intelsat is aware FSS operations in the 17800-18300 MHz band are secondary to the Fixed Service. *See* 47 C.F.R. § 2.106, US334.

9 Intelsat is aware that GSO FSS operations in the 19200-19300 MHz band are secondary to non-geostationary orbit FSS. *See* 47 C.F.R. § 2.106, NG165.

10 Galaxy 30 has the capability to operate in the 19400-19600 MHz band, but Intelsat is not seeking authority to operate in this band at 125.0° W.L.

The spacecraft provides the following coverage:

Frequency Band	Beam	Coverage
C-band	Steerable Wide Beam	United States including Alaska and Hawaii
Ku-band	Steerable	United States including Alaska and Hawaii
Ka-band 1	Steerable	United States including Alaska and Hawaii
Ka-band 2	Steerable	United States including Alaska and Hawaii
L-band	Global	United States including Alaska and Hawaii

2.1 Spacecraft Characteristics

Galaxy 30 is a three-axis stabilized type spacecraft that has a rectangular outer-body structure. Galaxy 30 utilizes two deployable solar array wings and deployable and non-deployable antennas.

The Galaxy 30 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"); and
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 to avoid single point failures.

The structural design of Galaxy 30 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 30 provides active communication channels at L-, C-, Ku-, and Ka-band frequencies. The C-band payload employs channels with bandwidths of 36 MHz and

43 MHz. The Ku-band payload employs channels having bandwidths of 210 MHz and 460 MHz. The Ka-band payload employs channels having bandwidth of 210 MHz, 450 MHz, and 955 MHz. The L- and C-band frequencies for the WAAS payload employ channels having bandwidths of 20 MHz. A more detailed description of the WAAS payload can be found in Section 4. The satellite's frequency and polarization plan is provided in Schedule S.

Galaxy 30 utilizes a combination of wide-beam and steerable-beam architecture. The satellite utilizes a L-band global downlink beam and steerable C-, Ku-, and Ka-band beams—all of which cover the Continental United States ("CONUS"), Alaska, and Hawaii. The coverage contours and performance characteristics for the Ku-band steerable beam and a single representative Ka-band steerable beam are provided in Schedule S. Additionally, the Schedule S beam designation for all beams is included in Exhibit 1.

The performance characteristics of all Galaxy 30 beams are provided in Schedule S. The coverage contours of all Galaxy 30 beams, except for those with -8.0 dB contours extending beyond the edge of the Earth, are provided with Schedule S.

Exhibits 2 and 3 provide the beam parameters for the Galaxy 30 uplink and downlink beams, respectively.

The conventional C-band communication payload consists of 24 transponders, with both vertical and horizontal polarizations, that are connected to provide services over the CONUS, Alaska, and Hawaii. A portion of the upper extended C-band is interconnected with the WAAS payload.

All Ku- and Ka-band communication subsystems are inter-connected, which allows for any frequency combination for the uplink and downlink connectivity at beam level. Additionally, a beam can have multiple connections to several other beams by splitting the channels into sub-channels with variable sizes.[11] The expected dominant application for Galaxy 30 comprises of hub and spoke networks whereby one earth station serves as the hub or gateway for other earth stations. The earth stations' predominant communication links are with the hub. All Galaxy 30 Ku- and Ka-band beams can be used for both gateway and service links.[12]

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[11] With this feature to split channels into sub-channels Intelsat can ensure that the bands 19400-19600 MHz and 29100-29250 MHz will not be utilized.

[12] Intelsat understands that the use of the 27500-28350 MHz frequency band by earth stations is subject to Section 25.136.

The WAAS payload consists of portions of extended C-band uplink interconnected to the L-band downlink beam as shown in the table below.

Uplink Beam (Extended C-band)	Uplink Polarization	Downlink Beam In L-band (global)	Downlink Polarization
WALV C5’ (6649.73-6669.73 MHz)	LHCP	WARD L5’ (1166.45-1186.45 MHz)	RHCP
WALU C1’ (6598.58-6618.58 MHz)	LHCP	WARE L1’ (1565.42-1585.42 MHz)	RHCP

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 30 command and telemetry subsystem performance is summarized in Exhibit 4 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), 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 30 utilizes one C-, one Ku-, and one Ka-band channel for ULPC.

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), contours for these beams are not required to be provided and the associated GXT files have not been included in Schedule S. The Galaxy 30 ULPC subsystem performance is summarized in Exhibit 4.

2.5 Satellite Station-Keeping

The spacecraft will be maintained within 0.05° of its nominal longitudinal position in the east-west direction in compliance with Section 25.210(j).

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

3 Services

Galaxy 30 is a general-purpose communications satellite that has been designed to support various services offered within Intelsat's satellite system. Depending upon the needs of the users, the transponders on Galaxy 30 can accommodate television, radio, voice, and data communications. Typical communication services include:

a) Compressed digital video;

b) High speed digital data; and

c) Digital single channel per carrier data channels.

4 WAAS Payload services

The WAAS is a safety-critical system consisting of equipment and software that augments the Department of Defense Global Positioning System ("GPS") Standard Positioning Service.

The WAAS augments the GPS with:

- A ranging function, which improves availability;
- GPS corrections, which improve accuracy; and
- Integrity monitoring, which improves safety.

The primary mission of WAAS is to provide air navigation for all phases of flight in the National Airspace System. WAAS provides a Signal-in-Space to WAAS-certified avionics for Federal Aviation Administration approved phases of flight. As a ground segment provider, Intelsat is responsible for hosting and providing operations and maintenance for a Ground Uplink Station in Napa, California, with a backup in Brewster, Washington.

4.1 Coordination in the Global Navigation Satellite System (“GNSS”) Frequency Bands

In the GNSS frequency bands, 1559-1610 MHz (upper L-band) and 1151-1214 MHz band (lower L-band), there are two coordination requirements for the following systems:

- Aeronautical radio navigation satellite (“ARNS”) in the band 1164-1215 MHz; and
- GPS in the L1 and L2 bands.[13]

Resolution 609 (Rev. WRC-07) defines the protection of the ARNS from harmful interference. This resolution determined that protection of the ARNS from harmful interference can be achieved if the value of the equivalent power flux density produced by all the space stations of all radio navigation satellite service (space-to-Earth) systems in the 1164-1215 MHz band does not exceed the level of -121.5 dB(W/m^2) in any 1 MHz band.

With the submission of the corresponding Appendix 4 information for a new satellite network for the 1564.42-1586.42 MHz L1 band together with this application, Intelsat will fulfill the requirements defined in the Annex to Resolution 609 (Rev. WRC-07).

5 Power Flux Density (“PFD”)

The PFD limits for space stations operating in the 3700-4200 MHz, 10950-11200 MHz, 11450-11700 MHz, and 17700-19700 MHz frequency bands are specified in Section 25.208. Additionally, Section 25.140 specifies a PFD limit of -118 dBW/m^2/MHz for space stations operating in the 18300-18800 MHz and 19700-20200 MHz bands. The PFD limits for the 10700-10950 MHz and 11200-11450 MHz frequency bands are specified in No. 21.16 of the ITU Radio Regulations.

The maximum PFD levels for the Galaxy 30 transmissions were calculated for the bands 3700-4200 MHz, 10700-10950 MHz, 10950-11200 MHz, 11200-11450 MHz, 11450-11700 MHz, 17800-18300 MHz, 18300-18800 MHz, 19200-19300 MHz, 19300-19400 MHz, and 19600-20200 MHz. The results are provided in Schedule S and show that the downlink PFD levels of the Galaxy 30 carriers do not exceed applicable limits.

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13 The center frequencies for the L1 and L2 bands are 1575.5 MHz and 1227.60 MHz, respectively.

6 Emission Compliance

Section 25.202(e) requires that the carrier frequency of each space station transmitter be maintained within 0.002% of the reference frequency. Galaxy 30 is designed to be compliant with this rule.

Additionally, Intelsat will ensure that Galaxy 30 emissions comply with the provisions of Section 25.202(f).

7 Orbital Location

Intelsat requests that it be assigned the 125.0° W.L. orbital location for Galaxy 30. This location satisfies the satellite'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.

8 ITU Filings

Galaxy 30's operations in the 3700-4200 MHz and 5925-6425 MHz bands will rely on the United States' ITU filings USASAT-22B, USASAT-35D, and USASAT-50C. Operations in all other frequencies will rely on the United States' ITU filings USASAT-80C, USASAT-80C-1, and USASAT-101F.

9 Coordination Statement and Certifications

The downlink equivalent isotropically radiated power ("EIRP") density of the satellite's transmissions in the conventional and extended 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 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 30 at 125.0° W.L.

The downlink EIRP density of the satellite'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 the applicable EIRP density envelopes in Section 25.218, 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 30 at 125.0° W.L.

Operation of Galaxy 30 in the 10700-10950 MHz (space-to-Earth), 11200-11450 MHz (space-to-Earth), and 12750-13250 MHz (Earth-to-space) bands, will take into account the applicable requirements of Appendix 30B of the ITU Radio Regulations. Further, compatibility with other U.S. ITU filings under Appendix 30B is assured since there are no other U.S. ITU Filings under Appendix 30B within at least 10° of 125.0° W.L.

The PFD at the Earth's surface produced by emissions from Galaxy 30 in the conventional Ka-band for all conditions, including clear sky, and for all methods of modulation will not exceed a level of -118 dBW/m^2/MHz, and the associated uplink operations will not exceed the applicable EIRP density envelopes specified in Section 25.218. unless the non-routine operation is coordinated with operators of authorized co-frequency space stations at assigned locations within six degrees of Galaxy 30 at 125.0° W.L.

Galaxy 30 will also operate in several bands addressed by Section 25.140(a)(3)(vi). As there are no previously authorized co-frequency space stations located within two degrees of 125.0° W.L., Section 10, below, provides an interference analysis demonstrating compatibility with a hypothetical co-frequency space station two degrees away with the same receiving and transmitting characteristics as the proposed space station.

10 Interference Analysis

10.1 Ka-band

The compatibility of the proposed Galaxy 30 emissions in the 17800-18300 MHz, 19200-19400 MHz, 19600-19700 MHz, 27600-28350 MHz, and 29000-29100 MHz frequency bands with adjacent satellites located at 123.0° W.L. and 127.0° W.L. were analyzed. The interference analysis was conducted for a representative carrier in each beam type.

Other assumptions and adjustments made for the interference analysis were as follows:

a) in the plane of the geostationary satellite orbit, all transmitting and receiving earth station antennas have off-axis co-polar gains, which is compliant with the limits specified in Section 25.209(a);
b) all transmitting and receiving earth stations have a cross-polarization isolation value of at least 30 dB within their main beam lobe;
c) rain attenuation predictions were derived using Recommendation ITU-R P.618;
d) increase in noise temperature of the receiving earth station due to rain was taken into account; and

e) for the cases where the transponder operates in a multi-carrier mode, the effects due to intermodulation interference was taken into account.

All assumptions and the results of the analysis are documented in Exhibit 6. Each of the link budgets demonstrate positive link margin for the representative carrier in the presence of an identical carrier operating via a satellite two degrees away.

10.2 WAAS Payload

10.2.1 Interference analysis as required by Section 25.140(a)(3)(v).

The compatibility of the proposed Galaxy 30 emissions in the 1165.45-1187.45 MHz and 1564.42-1586.42 MHz frequency bands with an adjacent satellite located at 123° W.L. and 127.0° W.L. were analyzed. The interference analysis was conducted for a representative carrier in beams WARD and WARE—the only beams that operates in the 1165.45-1187.45 MHz and 1564.42-1586.42 MHz frequency bands.

Other assumptions and adjustments made for the interference analysis were as follows:

a) in the plane of the geostationary satellite orbit, all transmitting and receiving earth station antennas have off-axis co-polar gains, which is compliant with the limits specified in Section 25.209(a);
b) all transmitting and receiving earth stations have a cross-polarization isolation value of at least 30 dB within their main beam lobe;
c) rain attenuation predictions were derived using Recommendation ITU-R P.618;
d) increase in noise temperature of the receiving earth station due to rain was taken into account; and
e) for the cases where the transponder operates in a multi-carrier mode, effects due to intermodulation interference were taken into account.

All assumptions and the results of the analysis are documented in Exhibit 5. Both link budgets demonstrate positive link margin for the representative carrier in the presence of an identical carrier operating via a satellite two degrees away. Furthermore, Intelsat will follow the procedure set forth in ITU-R Resolution 609 to ensure compatibility with ARNS systems.

11 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.

11.1 Spacecraft Hardware Design

Galaxy 30 is designed such that no debris will be released during normal operations. Intelsat has assessed the probability of collision with meteoroids and other debris. In order to limit the effects of such unlikely collisions critical components are located inside the protective body of the satellite and are properly shielded. The satellite does not use any subsystems for end-of-life disposal that are not used for normal operations.

11.2 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.

11.3 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 30 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 30 will replace Galaxy 14 at 125.0° 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 using 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 30. Intelsat is also not aware of any system with an overlapping station-keeping volume with Galaxy 30 that is the subject of an ITU filing and that is either in orbit or progressing towards launch.

11.4 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.[14] The effective area to mass ratio (Cr*A/M) of the Galaxy 30 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 30 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 calculation takes 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.

12 TC&R Control Earth Stations

Intelsat will conduct TC&R operations through one or more of the following earth stations: Napa, California; Hagerstown, Maryland; and Ellenwood, Georgia. Additionally, Intelsat is capable of remotely controlling Galaxy 30 from its facilities in McLean, Virginia and Long Beach, California.

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

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/	August 4, 2020
Giselle Creeser Intelsat Director, Spectrum Policy & Engineering	Date

EXHIBIT 1
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)**
L-band Beams								
WAAS	----	----	----	----	----	----	----	WARD* WARE*
C-band Beams								
United States	CAHU	CAVU	CAHD	CAVD	WALU WALV	----	----	----
ULPC1	----	----	----	CLVD*	----	----	----	----
ULPC4				GLVD*				
Telemetry Global	----	----	TGHD* TGH1*	----	----	----	----	----
Command Global	----	CMD*	----	----	----	----	----	----
Telemetry Pipe	----	----	----	----	----	----	TPLD* TPL1*	----
Telemetry Hemi	----	----	----	----	----	----	THLD* THL1*	----
Command Pipe	----	----	----	----	----	CPRU*	----	----
Command Hemi	----	----	----	----	----	CHRU*	----	----
Ku-band Beams								
Ku Steerable	KSHU KSHV	KSVU KSVV	KSHD KSHE KSHF	KSVD KSVE KSVF	----	----	----	----
ULPC2	----	----	----	----	----	----	KLLD*	----
Ka-band Beams								
Ka Steerable 1	----	----	----	----	ASLU ASLV	ASRU ASRV	ASLD ASLE ASLH	ASRD ASRE ASRH
Ka Steerable 2	----	----	----	----	ASLW ASLX	ASRW ASRX	ASLF ASLG	ASRF ASRG
ULPC3	----	----	----	ALVD*	----	----	----	----

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

EXHIBIT 2
COMMUNICATION SUBSYSTEM UPLINK BEAM PARAMETERS

Beam Name	C-band Wide	C-band Wide	WAAS C1	WAAS C5
Schedule S Beam ID	CAHU	CAVU	WALU	WALV
Frequency Band (MHz)	5927.0-6703.0		6597.58.0-6619.58	6648.73.0-6670.73
Polarization	Horizontal	Vertical	LHCP	LHCP
G/T (dB/K)	4.8	4.8	-7.8	-7.8
Minimum SFD--(dBW/m^2)	-106.1	-106.1	-106.1	-106.1
Maximum SFD--(dBW/m^2)	-78.1	-78.1	-78.1	-78.1

Beam Name	Ku-band Steerable	Ku-band Steerable	Ku-band Steerable	Ku-band Steerable
Schedule S Beam ID	KSHU	KSVU	KSHV	KSVV
Frequency Band (MHz)	12770.0-13230.0		13770.0-14480.0	
Polarization	Horizontal	Vertical	Horizontal	Vertical
G/T (dB/K)	18.1	18.1	18.1	18.1
Minimum SFD--(dBW/m^2)	-100.9	-100.9	-100.9	-100.9
Maximum SFD--(dBW/m^2)	-75.9	-75.9	-75.9	-75.9

Beam Name	Ka-band Steerable	Ka-band Steerable	Ka-band Steerable	Ka-band Steerable
Schedule S Beam ID	ASRU	ASLU	ASRV	ASLV
Frequency Band (MHz)	27620.0-28575.0		29025.0-29975.0	
Polarization	RHCP	LHCP	RHCP	LHCP
G/T (dB/K)	19.0	19.0	19.0	19.0
Minimum SFD--(dBW/m^2)	-101.9	-101.9	-101.9	-101.9
Maximum SFD--(dBW/m^2)	-76.9	-76.9	-76.9	-76.9

Beam Name	Ka-band Steerable	Ka-band Steerable	Ka-band Steerable	Ka-band Steerable
Schedule S Beam ID	ASRW	ASLW	ASRX	ASLX
Frequency Band (MHz)	28125.0-28575.0		29525.0-29975.0	
Polarization	RHCP	LHCP	RHCP	LHCP
G/T (dB/K)	19.0	19.0	19.0	19.0
Minimum SFD--(dBW/m^2)	-101.9	-101.9	-101.9	-101.9
Maximum SFD--(dBW/ m^2)	-76.9	-76.9	-76.9	-76.9

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

EXHIBIT 3

COMMUNICATION SUBSYSTEM DOWNLINK BEAM PARAMETERS

Beam Name	C-band	C-band
Schedule S Beam ID	CAHD	CAVD
Frequency Band (MHz)	3702.0-4198.0	
Polarization	Horizontal	Vertical
Maximum Beam Peak EIRP (dBW)	45.5	45.5
Maximum Beam Peak EIRP Density (dBW/4kHz)	6.02	6.02
Maximum Beam Peak EIRP Density (dBW/Hz)	-30.0	-30.0

Beam Name	L-band Global L5	L-band Global L1
Schedule S Beam ID	WARD	WARE
Frequency Band (MHz)	1166.45-1186.45	1565.42-1585.42
Polarization	RHCP	RHCP
Maximum Beam Peak EIRP (dBW)	34.0	34.7
Maximum Beam Peak EIRP Density (dBW/4kHz)	-3.3	-2.3
Maximum Beam Peak EIRP Density (dBW/Hz)	-39.0	-38.3

Beam Name	Ku-band Steerable	Ku-band Steerable	Ku-band Steerable	Ku-band Steerable	Ku-band Steerable	Ku-band Steerable
Schedule S Beam ID	KSHD	KSVD	KSHE	KSVE	KSHF	KSVF
Frequency Band (MHz)	10720.0-11180.0		11220.0-11680.0		10720.0-11680.0	
Polarization	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical
Maximum Beam Peak EIRP (dBW)	62.0	62.0	62.0	62.0	62.0	62.0
Maximum Beam Peak EIRP Density (dBW/4kHz)	20.4	20.4	20.0	20.0	20.0	20.0
Maximum Beam Peak EIRP Density (dBW/Hz)	-15.6	-15.6	-15.6	-15.6	-15.6	-15.6

Beam Name	Ka-band Steerable	Ka-band Steerable	Ka-band Steerable	Ka-band Steerable	Ka-band Steerable	Ka-band Steerable
Schedule S Beam ID	ASLD	ASRD	ASLE	ASRE	ASLH	ASRH
Frequency Band (MHz)	17820.0-18775.0		19225.0-20175.0		17820.0-18775.0	
Polarization	LHCP	RHCP	LHCP	RHCP	LHCP	RHCP
Maximum Beam Peak EIRP (dBW)	64.0	64.0	64.0	64.0	64.0	64.0
Maximum Beam Peak EIRP Density (dBW/4kHz)	20.0	20.0	20.0	20.0	20.0	20.0
Maximum Beam Peak EIRP Density (dBW/Hz)	-16.0	-16.0	-16.0	-16.0	-16.0	-16.0

Beam Name	Ka-band Steerable	Ka-band Steerable	Ka-band Steerable	Ka-band Steerable
Schedule S Beam ID	ASLF	ASRF	ASLG	ASRG
Frequency Band (MHz)	18325.0-18775.0		19725.0-20175.0	
Polarization	LHCP	RHCP	LHCP	RHCP
Maximum Beam Peak EIRP (dBW)	64.0	64.0	64.0	64.0
Maximum Beam Peak EIRP Density (dBW/4kHz)	20.0	20.0	20.0	20.0
Maximum Beam Peak EIRP Density (dBW/Hz)	-16.0	-16.0	-16.0	-16.0

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

EXHIBIT 4

TC&R SUBSYSTEM CHARACTERISTICS

Beam Name	Command Global	Command Pipe	Command Hemi
Schedule S Beam ID	CMD	CPRU	CHRU
Center Frequencies (MHz)	6421.75 & 6424.25	6421.75 & 6424.25	6421.75 & 6424.25
Command Carrier Bandwidth (MHz)	1.0	1.0	1.0
Polarization	Vertical	RHCP	RHCP
Peak Flux Density at Command Threshold (dBW/m^2-Hz)	-96.9	-88.9	-88.9

Beam Name	Telemetry Global	Telemetry Global	Telemetry Pipe	Telemetry Pipe	Telemetry Hemi	Telemetry Hemi
Schedule S Beam ID	TGHD	TGH1	TPLD	TPL1	THLD	THL1
Frequencies (MHz)	4197.50	4198.50	4197.50	4198.5	4197.50	4198.50
Polarization	Horizontal	Horizontal	LHCP	LHCP	LHCP	LHCP
Maximum Channel EIRP (dBW)	13.7	13.7	15.4	15.4	11.9	11.9
Maximum Beam Peak EIRP Density (dBW/4kHz)	-7.3	-7.3	-5.6	-5.6	-9.1	-9.1
Maximum Beam Peak EIRP Density (dBW/Hz)	-43.3	-43.3	-41.6	-41.6	-45.1	-45.1

Beam Name	C-band Global		Ku-band Global	Ka-band Global
Schedule S Beam ID	CLVD	GLVD	KLLD	ALVD
Frequencies (MHz)	3700.25	4199.95	11199.5	19701.0
Polarization	Vertical	Vertical	LHCP	Vertical
Maximum Channel EIRP (dBW)	13.0	14.0	17.0	24.0
Maximum Beam Peak EIRP Density (dBW/4kHz)	5.0	6.0	9.0	16
Maximum Beam Peak EIRP Density (dBW/Hz)	-30.0	-29.0	-26.0	-20.0

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

EXHIBIT 5

Interference Analysis

Effect of Hypothetical Satellite at 123° W.L and 127° W.L on Galaxy 30
WAAS Beams: WALV / WARD, WALU / WARE,

UPLINK BEAM INFORMATION	C1	C5
Uplink Beam Name	WALU	WALV
Uplink Frequency (MHz)	6598.58-6618.58	6649.73-6669.73
Uplink Beam Polarization	LHCP	LHCP
Uplink Relative Contour Level (dB)	-3	-3
Uplink Contour G/T (dB/K)	-7.8	-7.8
Uplink SFD (dBW/m²)	-85	-85
Rain Rate (mm/hr)	23.5	23.5
DOWNLINK BEAM INFORMATION	L1	L5
Downlink Beam Name	WARE	WARD
Downlink Frequency (MHz)	1565.42 - 1585.42	1166.45 - 1186.45
Downlink Beam Polarization	RHCP	RHCP
Downlink Relative Contour Level (dB)	-1	-1
Downlink Contour EIRP (dBW)	34.7	34.0
Rain Rate (mm/hr)	48.22575038	48.22575038
ADJACENT SATELLITE 1		
Orbital Locations	123°W	123°W
Uplink Power Density (dBW/Hz)	-38.7	-38.7
Downlink EIRP Density (dBW/Hz)	-32	-32
ADJACENT SATELLITE 2		
Orbital Locations	127°W	127°W
Uplink Power Density (dBW/Hz)	-38.7	-38.7
Downlink EIRP Density (dBW/Hz)	-32	-32

CARRIER INFORMATION		
carrier ID	1	1
Emission Designation	20M5G7X	20M5G7X
Information Rate (kbps)	25625	25625
Carrier Modulation	QPSK	QPSK
Code Rate	0.75	0.75
Occupied Bandwidth (kHz)	17083.33	17083.33
Allocated Bandwidth (kHz)	20500	20500
Minimum C/N (dB)	7.3	7.3
UPLINK EARTH STATION		
Earth Station Diameter (meters)	11.1	11.1
Earth Station Gain (dBi)	56.3	56.3
Earth Station Elevation Angle	46	46
DOWNLINK EARTH STATION		
Earth Station Diameter (meters)	0.035	0.035
Earth Station Gain (dBi)	-6.4	-6.4
Earth Station G/T (dB/K)	-28.2	-28.2
Earth Station Elevation Angle	20	20
LINK FADE TYPE	Clear Sky	Clear Sky
UPLINK PERFORMANCE		
Uplink Earth Station EIRP (dBW)	80	80
Uplink Path Loss, Clear Sky (dB)	-200.5	-200.5
Uplink Rain Attenuation (dB)	0	0
Satellite G/T (dB/K)	-7.8	-7.8
Boltzman Constant (dBW/K-Hz)	228.6	228.6
Carrier Noise Bandwidth (dB-Hz)	72.3	72.3
Uplink C/N (dB)	25.0	25.0
DOWNLINK PERFORMANCE		

Downlink EIRP per Carrier (dBW)	34	34
Antenna Pointing Error (dB)	-0.5	-0.5
Downlink Path Loss, Clear Sky (dB)	-187.7	-187.7
Downlink Rain Attenuation (dB)	0	0
Earth Station G/T (dB/K)	-28.2	-28.2
Boltzman Constant (dBW/K-Hz)	228.6	228.6
Carrier Noise Bandwidth (dB-Hz)	72.3	72.3
Downlink C/N (dB)	-26.1	-26.1
COMPOSITE LINK PERFORMANCE		
C/N Uplink (dB)	25.0	25.0
C/N Downlink (dB)	-26.1	-26.1
C/I Other links (Co-channel & IM)	16	16
C/I Uplink Adjacent Satellites (dB)	34.8	34.8
C/I Downlink Adjacent Satellites (dB)	-29.4	-29.4
C/(N+I) Composite (dB)	-33.3	-33.3
Required System Margin (dB)	1	1
Minimum Required C/N (dB)	7.3	7.3
CARRIER DENSITY LEVELS		
Uplink Power Density (dBW/Hz)	-48.6	-48.6
Downlink EIRP Density at Beam Peak	-37.6	-38.3

EXHIBIT 6

Interference Analysis

Effect of Hypothetical Satellites at 123° W.L. and 127° W.L. on Galaxy 30

Beams: ASLD, ASRD, ASRF, and ASRH

UPLINK BEAM INFORMATION				
Uplink Beam Name	ASLU, ASRU & ASLW	ASLU, ASRU & ASLW	ASLU, ASRU & ASLW	ASLU, ASRU & ASLW
Uplink Frequency (MHz)	27600-28350 & 29000-29100	27600-28350 & 29000-29100	27600-28350 & 29000-29100	27600-28350 & 29000-29100
Uplink Beam Polarization	Circular	Circular	Circular	Circular
Uplink Relative Contour Level (dB)	-3.0	-3.0	-3.0	-3.0
Uplink Contour G/T (dB/K)	19.0	19.0	19.0	19.0
Uplink SFD (dBW/m²)	-89.6	-89.6	-89.6	-89.6
DOWNLINK BEAM INFORMATION				
Downlink Beam Name	ASLD, ASRD, ASRF & ASRH	ASLD, ASRD, ASRF & ASRH	ASLD, ASRD, ASRF & ASRH	ASLD, ASRD, ASRF & ASRH
Downlink Frequency (MHz)	17800-18300, 19200-19400 &19600-19700	17800-18300, 19200-19400 &19600-19700	17800-18300, 19200-19400 &19600-19700	17800-18300, 19200-19400 &19600-19700
Downlink Beam Polarization	Circular	Circular	Circular	Circular
Downlink Relative Contour Level (dB)	-3.0	-3.0	-3.0	-3.0
Downlink Contour EIRP (dBW)	64.0	64.0	64.0	64.0
Rain Rate (mm/hr)	48.2	48.2	48.2	48.2
ADJACENT SATELLITE				
Orbital Locations	123°W,127°W	123°W,127°W	123°W,127°W	123°W,127°W
Uplink Power Density (dBW/Hz)	-57.0	-57.0	-57.0	-57.0
Downlink EIRP Density (dBW/Hz)	-16.0	-16.0	-16.0	-16.0
CARRIER INFORMATION				
Emission Designation	36M0G7W	8M25G7W	1M73G7W	382KG7W
Information Rate (kbps)	36860.0	8448.0	1024.0	256.0
Carrier Modulation	QPSK	QPSK	BPSK	BPSK
Code Rate	0.8	0.8	0.5	0.5

Occupied Bandwidth (kHz)	26665	6111	1284	273
Allocated Bandwidth (kHz)	36000	8251	1733	382
Minimum C/N (dB)	7.30	7.30	1.80	1.20
UPLINK EARTH STATION				
Earth Station Diameter (meters)	2.4	2.4	2.4	2.4
Earth Station Gain (dBi)	55.8	55.8	55.8	55.8
Earth Station Elevation Angle	20.0	20.0	20.0	20.0
DOWNLINK EARTH STATION				
Earth Station Diameter (meters)	0.97	0.97	0.60	0.60
Earth Station Gain (dBi)	44.5	44.5	40.3	40.3
Earth Station G/T (dB/K)	22.7	22.7	18.5	18.5
Earth Station Elevation Angle	20.0	20.0	20.0	20.0
COMPOSITE LINK PERFORMANCE				
C/N Uplink (dB)	17.6	17.6	30.1	30.1
C/N Downlink (dB)	25.0	25.0	13.9	14.6
C/I Other links (Co-channel & IM)	16.0	16.0	16.0	16.0
C/I Uplink Adjacent Satellites (dB)	34.3	34.3	34.3	34.3
C/I Downlink Adjacent Satellites (dB)	19.5	19.5	15.3	15.3
C/(N+I) Composite (dB)	11.6	11.6	9.0	9.2
Required System Margin (dB)	1.0	1.0	1.0	1.0
Minimum Required C/N (dB)	7.3	7.3	7.3	7.3
CARRIER DENSITY LEVELS				
Uplink Power Density (dBW/Hz)	-57.0	-57.0	-57.0	-57.0
Downlink EIRP Density at Beam Peak	-16.0	-16.0	-16.0	-16.0