Engineering Statement

1 Introduction

Intelsat License LLC ("Intelsat") seeks authority in this application to launch and operate the Galaxy 30 satellite (previously known as Galaxy 14R) at the 125.0° W.L. orbital location. Galaxy 30 will replace Galaxy 14, currently operating at 125.0° W.L. The characteristics of the Galaxy 30 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.

2 Spacecraft Overview

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

Direction	Frequency
Uplink	5925-6725 MHz[1]
	12750-13250 MHz
	13750-14500 MHz[2]
	27500-28600 MHz[3]
	29000-29100 MHz[4]
	29100-29250 MHz[5]

[1] This frequency band includes the WAAS 1 and WAAS 2 uplink frequencies 6597.58-6619.58 MHz and 6648.73-6670.73 MHz.

[2] Galaxy 30 has the capability to operate in the 14.0-14.5 GHz band, but Intelsat will not utilize this band at this orbital location.

[3] Intelsat is aware that frequencies in the 27.5-28.35 GHz band are secondary for GSO FSS. *See* 47 C.F.R. § 25.202(a)(1)(i).

[4] Intelsat is aware that the 29.0-29.1 GHz frequencies are secondary for GSO FSS. *See* 47 C.F.R. § 2.106, NG165.

[5] Although Galaxy 30 includes this frequency band, Intelsat is not seeking authority to operate in this band.

	29250-30000 MHz[6]
Downlink	1165.45-1187.45 MHz
	1564.42-1586.42 MHz
	3700-4200 MHz
	10700-10950 MHz
	10950-11200 MHz
	11200-11450 MHz
	11450-11700 MHz
	17800-18800 MHz[7]
	19200-19300 MHz[8]
	19300-19400 MHz
	19400-19600 MHz[9]
	19600-20200 MHz

The spacecraft provides the following coverage:

[6] The band 29250-29300 MHz is allocated to MSS feeder links and FSS on a co-primary basis. Earth station uplink operation in this band will require coordination with the incumbent MSS feeder link operators.

[7] Intelsat is aware that the band 17800-18300 MHz is primary for FS and secondary for FSS. *See* 47 C.F.R. § 2.106, US334.

[8] Intelsat is aware that the 19.2-19.3 GHz frequencies are primary for NGSO FSS and secondary for FSS. *See* 47 C.F.R. § 2.106, NG165.

[9] Although Galaxy 30 includes this frequency band, Intelsat is not seeking authority to operate in this band.

Frequency band	Beam	Coverage
C-Band	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 a number of 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")
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 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-band, C-band, Ku-band and Ka-band frequencies. The C-band payload employs channels with bandwidths of 36 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-band and C-band frequencies for the Wide Area Augmentation System ("WAAS") payload employ channels having bandwidth of 22 MHz bandwidth. A more detailed description of the WAAS payload can be found in Section 4 of this engineering statement. The Galaxy 30 frequency and polarization plan is provided in Schedule S.

Galaxy 30 utilizes a combination of wide-beam and multiple steerable beam architecture. A wide beam that covers the United States, including Alaska and Hawaii, operates in C-band as well as the L-band downlink. The Ku-band and Ka-band steerable beams cover the United States, including 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 their -8.0 dB contour 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 on both polarization vertical and horizontal that are connected as loopback that provides services over the Continental U.S. ("CONUS"), Alaska and Hawaii. A portion of the upper extended C-band are interconnected with the WAAS payload.

All Ku-band 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.[10] The expected dominant application for Galaxy 30 comprises 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 are with the hub. All Galaxy 30 Ku-band and Ka beams band can be used for both gateway and service links.[11]

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

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[10] 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.

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

Uplink Beam (Extended C-band)	Uplink Polarization	Downlink Beam In L-band (global)	Downlink Polarization
WALU C5' (6648.73-6670.73 MHz)	LHCP	WARD L5 (1165.45-1187.45 MHz)	RHCP
WALV C1' (6597.58-6619.58 MHz)	LHCP	WARE L1 (1564.42-1886.42 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) 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 30 utilizes one C-band channel, one Ku-band channel, 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) 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 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. Accordingly, it is in compliance 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 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 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 30 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 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 ("FAA") approved phases of flight. As a ground segment provider, Intelsat is responsible for hosting and providing operations & maintenance for a Ground Uplink Station at Napa, California, Intelsat Teleport with a backup in Brewster, Washington.

4.1 Interference coordination in the GNSS Frequency Bands

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

- o Aeronautical radionavigation satellite ("ARNS") in the band 1164-1215 MHz;
- o GPS in the L1 and L2 bands

4.1.1 ARNS Coordination

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 pfd ("epfd") produced by all the space stations of all radionavigation satellite service ("RNSS") (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. Intelsat will further provide all the required information by the Resolution 609 (Rev. WRC-07) Consultation meeting to be forwarded by the FCC to the International Telecommunication Union ("ITU").

4.1.2 GPS Coordination

The Galaxy 30 WAAS payload is part of the United States GPS system managed by the FAA. Therefore, the FAA will take care of the interference management within the whole GPS system in the L1 and L5 bands.

5 Power Flux Density ("PFD")

The power flux density ("PFD") limits for space stations operating in the 3700-4200 MHz, 10950-11200 MHz, and 11450-11700 MHz are specified in Section 25.208 of the Commission's rules. Also, Section 25.138(a)(6) of the Commission's rules specify a PFD limit of -118 dBW/m^2/MHz for space stations operating in the 18300-18800 MHz,[12]and 19700-20200 MHz bands. The Commission's rules do not specify a PFD limit in the 17800-18300 MHz, 19200-19300 MHz, 19300-19400 MHz or 19600-19700

[12] Section 2.106, footnote US255 further limits the PFD at the surface of the earth in the 200 MHz wide band 18600-18800 MHz to -95 dBW/m^2 for all arrival angles. That level is equivalent to -118 dBW/m^2/MHz.

MHz bands. However, there are PFD limits specified in rule No. 21.16 of the ITU Radio Regulations.

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 1165.45-1187.45 MHz, 1564.42-1586.42 MHz, 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 power flux density levels of the Galaxy 30 carriers do not exceed the limits specified in Sections 25.208 and 25.138 of the Commission's rules, nor those in rule No. 21.16 of the ITU Radio Regulations, as applicable.

6 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 30 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 30 emissions.

7 Orbital Location

Intelsat requests that it be assigned the 125.0° W.L. orbital location for Galaxy 30. The 125.0° W.L. location satisfies Galaxy 30'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 have been coordinated under the Administration of the United States' ITU filings USASAT-22B, USASAT-35D, and USASAT-50C.

For the operation of Galaxy 30 in the frequencies 6425-6725 MHz, 13750-14000 MHz, 10950-11200 MHz, 11450-11700 MHz, 27500-29100 MHz, 29250-30000 MHz, 17800-19300 MHz, and 19700-20200 MHz, Intelsat will use the Administration of the United States' ITU filings USASAT-80C.

For the operation of the Galaxy 30 WAAS payload and to cover additional Ka-band frequencies on the satellite, Intelsat will be submitting an addendum to USASAT-80C with the corresponding Appendix 4 information for the frequencies 1165.45-1187.45

MHz, 1564.42-1586.42 MHz, 19300-19400 MHz, and 19600-19700 MHz to be forwarded by the FCC to the ITU.

For the operation of the Galaxy 30 AP30B payload in the frequencies 10700-10950 MHz, 11200-11450 MHz, and 12750-13250 MHz, 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.

9 Coordination Statement and Certifications

The downlink EIRP density of Galaxy 30'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 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 30 at 125.0° W.L.

The downlink EIRP density of Galaxy 30'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 30 at 125.0° W.L.

With respect to proposed operation in the 10700-10950 MHz (space-to-Earth), 11200-11450 MHz (space-to-Earth), and/or 12750-13250 MHz (Earth-to-space) bands, the proposed operation takes 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.

PFD at the Earth's surface produced by emissions from a space station in the conventional Ka-band, 18300-18800 MHz, and 19700-20200 MHz for all conditions, including clear sky, and for all methods of modulation shall not exceed a level of -118 dBW/m^2/MHz, and in addition will not exceed the limits specified in § 25.208(d). The associated uplink transmissions will not exceed applicable EIRP density envelopes in Section 25.138 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)(v). Because there are no previously authorized co-frequency space stations at location two degrees away, Section 10 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, 27500-28350 MHz, and 29000-29100 MHz bands with adjacent satellites located at 123.0° W.L. and 127.0° W.L. was analyzed. The interference analysis was conducted for a representative carrier in each beam type.

Other assumptions 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 that are compliant with the limits specified in section 25.209(a) of the FCC's rules.
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 are derived using Recommendation ITU-R P.618.
d) Increase in noise temperature of the receiving earth station due to rain is taken into account.
e) For the cases where the transponder operates in a multi-carrier mode, the effects due to intermodulation interference are 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 bands with an adjacent satellite located at 123°W.L. and 127.0° W.L. was analyzed. The interference analysis was conducted for a representative carrier in beams WARD and WARE, the only beams that operate in the 1165.45-1187.45 MHz and 1564.42-1586.42 MHz bands.

Other assumptions 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 that are compliant with the limits specified in Section 25.209(a) of the FCC's rules.
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 are derived using Recommendation ITU-R P.618.

d) Increase in noise temperature of the receiving earth station due to rain is taken into account.
e) For the cases where the transponder operates in a multi-carrier mode, the effects due to intermodulation interference are taken into account.

All assumptions and the results of the analysis are documented in Exhibit 5. Both 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. Furthermore, Intelsat will follow the procedure set forth in ITU-R Resolution 609 to ensure compatibility with ARNS systems.

10.2.2 Beacon Interference Analysis

The compatibility of the proposed Galaxy 30 C-band beacon at 3700.25 MHz with an adjacent satellite located at 123° W.L. and 127° W.L. was analyzed.

Other assumptions 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 that are compliant with the limits specified in Section 25.209(a) of the FCC's rules.
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 are derived using Recommendation ITU-R P.618.
d) Increase in noise temperature of the receiving earth station due to rain is taken into account.
e) For the cases where the transponder operates in a multi-carrier mode, the effects due to intermodulation interference are taken into account.

All assumptions and the results of the analysis are documented in Exhibit 5. Both 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.

Furthermore, the Galaxy 30 C-band beacon (3700.25 MHz) does not overlap with the frequencies of the adjacent satellites, Galaxy 18 at 123° W.L. and Galaxy 13 at 127° W.L. For the frequency band 3700-4200 MHz the 125°W.L orbital location is successfully coordinated with the orbital locations 123°W. L and 127°W.L. Both, Galaxy 18 and Galaxy 13, are controlled by Intelsat and Intelsat will manage the satellites' operations to avoid interference.

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

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.

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 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 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.[13] 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, or Long Beach, California.

[13] *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/ Alexander Gerdenitsch	April 10, 2018
Alexander Gerdenitsch Intelsat Manager, Spectrum Policy, Americas	Date

EXHIBIT 1
Beam Polarizations and GXT File Names

Beam Description	Schedule S Beam GXT File Names: Linear Polarization				Circular Polarization			
	Uplink (H-Pol.)	Uplink (V-Pol.)	Downlink (H-Pol.)	Downlink (V-Pol.)	Uplink (LHCP)	Uplink (RHCP)	Downlink (LHCP)	Downlink (RHCP)
L-Band Beams								
WAAS	----	----	----	----	WALU* WALV*	----	----	WARD* WARE*
C-Band Beams								
United States	CAHU	CAVU	CAHD	CAVD	----	----	----	----
ULPC1	----	----	----	CLVD*	----	----	----	----
Telemetry Global	----	----	TGHD*	----	----	----	----	----
Command Global	----	CMD*	----	----	----	----	----	----
Telemetry Pipe	----	----	----	----	----	----	TPLD*	----
Telemetry Hemi	----	----	----	----	----	----	THLD*	----
Command Pipe	----	----	----	----	----	CPRU*	----	----
Command Hemi	----	----	----	----	----	CHRU*	----	----
WAAS				WAVB*				
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	WAAS
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	4.8	4.8
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/m2)	-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	L-Band Global	C-Band Beacon
Schedule S Beam ID	WARD	WARE	WAVB
Frequency Band (MHz)	1165.45-1187.45	1564.42-1586.42	3700-3700.5
Polarization	RHCP	RHCP	Vertical
Maximum Beam Peak EIRP (dBW)	34.7	34	20
Maximum Beam Peak EIRP Density (dBW/4kHz)	-2.7	-3.4	-2.7
Maximum Beam Peak EIRP Density (dBW/Hz)	-38.7	-39.4	-38.7

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 Pipe	Telemetry Hemi
Schedule S Beam ID	TGHD	TPLD	THLD
Frequencies (MHz)	4196.75, 4197.50, 4198.50 & 4199.25	4197.50 & 4198.50	4197.50 & 4198.50
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	Ka-band Global
Schedule S Beam ID	CLVD	KLLD	ALVD
Frequencies (MHz)	3700.25	11199.5	19701.0
Polarization	Vertical	LHCP	Vertical
Maximum Channel EIRP (dBW)	6.2	21	13
Maximum Beam Peak EIRP Density (dBW/4kHz)	-1.8	13.04	5.04
Maximum Beam Peak EIRP Density (dBW/Hz)	-37.8	-22.98	-30.98

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: WARD, WARE and WAVB

UPLINK BEAM INFORMATION				
Uplink Beam Name	WALU	WALU	WALV	WALV
Uplink Frequency (MHz)	6597.58-6619.58	6597.58-6619.58	6648.73-6670.73	6648.73-6670.73
Uplink Beam Polarization	LHCP	LHCP	LHCP	LHCP
Uplink Relative Contour Level (dB)	-3.0	-3.0	-3.0	-3.0
Uplink Contour G/T (dB/K)	-5.6	-5.6	-5.8	-5.8
Uplink SFD (dBW/m²)	-87.1	-87.1	-87.1	-87.1
Rain Rate (mm/hr)	21.2	21.2	21.2	21.2
DOWNLINK BEAM INFORMATION				
Downlink Beam Name	WARD	WARD	WARE	WARE
Downlink Frequency (MHz)	1165.45-1187.45	1165.45-1187.45	1564.42-1586.42	1564.42-1586.42
Downlink Beam Polarization	RHCP	RHCP	RHCP	RHCP
Downlink Relative Contour Level (dB)	-3.0	-3.0	-3.0	-3.0
Downlink Contour EIRP (dBW)	31.7	31.7	31.0	31.0
Rain Rate (mm/hr)	21.2	21.2	21.2	21.2
ADJACENT SATELLITE 1				
Satellite 1 Orbital Location	123ºW	123ºW	123ºW	123ºW
Uplink Power Density (dBW/Hz)	-45.0	-45.0	-45.0	-45.0
Uplink Polarization Advantage (dB)	0	0	0	0
Downlink EIRP Density (dBWHz)	-38.7	-38.7	-38.7	-38.7
ADJACENT SATELLITE 2				
Satellite 1 Orbital Location	127ºW	127ºW	127ºW	127ºW
Uplink Power Density (dBW/Hz)	-45.0	-45.0	-45.0	-45.0
Uplink Polarization Advantage (dB)	0	0	0	0
Downlink EIRP Density (dBWHz)	-38.7	-38.7	-38.7	-38.7
CARRIER INFORMATION				
Carrier ID	1	2	1	2
Emission Designation	20M0G7X	2M00G7X	20M0G7X	2M00G7X
Information Rate (kbps)	23039.7	2304.0	23039.7	2304.0
Carrier Modulation	DIGITAL	DIGITAL	QPSK	QPSK
Occupied Bandwidth (kHz)	16667	1667	16667	1667
Allocated Bandwidth (kHz)	20000	2000	20000	2000
Minimum C/N, Clear Sky (dB)	-18.40	-18.40	-18.40	-18.40
Minimum C/N, Rain (dB)	-18.40	-18.40	-18.40	-18.40
UPLINK EARTH STATION				
Earth Station Diameter (meters)	4.5	4.5	4.5	4.5
Earth Station Gain (dBi)	48.0	48.0	48.1	48.1
Earth Station Elevation Angle	41.1	41.1	41.1	41.1
DOWNLINK EARTH STATION				
Earth Station Diameter (meters)	0.23	0.23	0.23	0.23
Earth Station Gain (dBi)	7.0	7.0	9.5	9.5
Earth Station G/T (dB/K)	-17.7	-17.7	-15.1	-15.1
Earth Station Elevation Angle	41.1	41.1	41.1	41.1
UPLINK PERFORMANCE				
Uplink Earth Station EIRP (dBW)	75.2	65.2	75.2	65.2
Uplink Path Loss, Clear Sky (dB)	200.4	200.4	200.4	200.4
Uplink Rain Attenuation (dB)	1.7	1.7	1.7	1.7
Satellite G/T (dB/K)	-5.6	-5.6	-5.8	-5.8
Boltzman Constant (dBW/K-Hz)	228.6	228.6	228.6	228.6
Carrier Noise Bandwidth (dB-Hz)	-72.2	-62.2	-72.2	-62.2
Uplink C/N (dB)	20.8	20.8	20.6	20.6
DOWNLINK PERFORMANCE				
Downlink EIRP per Carrier (dBW)	30.5	20.5	29.8	19.8
Antenna Pointing Error (dB)	0.0	0.0	0.0	0.0
Downlink Path Loss, Clear Sky (dB)	185.4	185.4	187.9	187.9
Downlink Rain Attenuation (dB)	0.0	0.0	0.0	0.0
Earth Station G/T (dB/K)	-17.7	-17.7	-15.1	-15.1
Boltzman Constant (dBW/K-Hz)	228.6	228.6	228.6	228.6
Carrier Noise Bandwidth (dB-Hz)	-72.2	-62.2	-72.2	-62.2
Downlink C/N (dB)	-16.2	-16.2	-16.9	-16.9
COMPOSITE LINK PERFORMANCE				
C/N Uplink (dB)	20.8	20.8	20.6	20.6
C/N Downlink (dB)	-16.2	-16.2	-16.9	-16.9
C/I Other links (Co-channel & IM)	25.0	16.0	25.0	16.0
C/I Uplink Adjacent Satellite 1 (dB)	26.5	26.5	26.5	26.5
C/I Downlink Adjacent Satellite 1 (dB)	-3.0	-3.0	-3.7	-3.7
C/I Uplink Adjacent Satellite 2 (dB)	26.5	26.5	26.5	26.5
C/I Downlink Adjacent Satellite 2 (dB)	-3.0	-3.0	-3.7	-3.7
C/(N+I) Composite (dB)	-16.6	-16.6	-17.3	-17.3
Required System Margin (dB)	1.1	1.1	1.1	1.1
Minimum Required C/N (dB)	-18.4	-18.4	-18.4	-18.4
Excess Link Margin (dB)	0.7	0.7	0.0	0.0
Number of Carriers	1	10	1	10
CARRIER DENSITY LEVELS				
Uplink Power Density (dBW/Hz)	-45.0	-45.0	-45.0	-45.0
Downlink EIRP Density at Beam Peak	-38.7	-38.7	-39.4	-39.4

DOWNLINK BEAM INFORMATION	
Downlink Beam Name	WAVB
Downlink Frequency (MHz)	3700.250
Downlink Beam Polarization	Linear
Downlink Relative Contour Level (dB)	-1.0
Downlink Contour EIRP (dBW)	20.0
Rain Rate (mm/hr)	48.2
ADJACENT SATELLITE	
Satellite 1 Orbital Location	123ºW, 127ºW
Downlink EIRP Density (dBWHz)	-38.7
CARRIER INFORMATION	
Emission Designation	500KG7X
Information Rate (kbps)	666.7
Carrier Modulation	QPSK
Code Rate	1
Allocated Bandwidth (kHz)	417
Minimum C/N, Clear Sky (dB)	500.00
Minimum C/N, Rain (dB)	-18.40
DOWNLINK EARTH STATION	
Earth Station Diameter (meters)	0.23
Earth Station Gain (dBi)	9.9
Earth Station G/T (dB/K)	-11.9
Earth Station Elevation Angle	41.1
DOWNLINK PERFORMANCE	
Downlink EIRP per Carrier (dBW)	17.5
Antenna Pointing Error (dB)	-0.5
Downlink Path Loss, Clear Sky (dB)	-187.7
Downlink Rain Attenuation (dB)	0.0
Earth Station G/T (dB/K)	-11.9
Boltzman Constant (dBW/K-Hz)	228.6
Carrier Noise Bandwidth (dB-Hz)	56.2
Downlink C/N (dB)	-10.2
COMPOSITE LINK PERFORMANCE	
C/N Downlink (dB)	-10.2
C/I Other links (Co-channel & IM)	25.0
C/I Downlink Adjacent Satellites (dB)	-13.1
C/(N+I) Composite (dB)	-17.1
Required System Margin (dB)	1.0
Minimum Required C/N (dB)	-18.4
Excess Link Margin (dB)	0.3
CARRIER DENSITY LEVELS	
Downlink EIRP Density at Beam Peak	-38.7

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)	27500-28350 & 29000-29100	27500-28350 & 29000-29100	27500-28350 & 29000-29100	27500-28350 & 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 (dBWHz)	-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