Engineering Statement

1 Introduction

Intelsat License LLC ("Intelsat") seeks authority in this application to modify the authorization to launch and operate the Horizons 3e (Call Sign S2947) satellite at the 169.0° E.L. orbital location to reflect the current design of the spacecraft. Horizons 3e will replace Intelsat 805 (Call Sign S2404), currently operating at 169.0° E.L. The characteristics of the Horizons 3e 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

Horizons 3e is a Boeing model 702MP spacecraft that is capable of operating in C-band and Ku-band frequencies listed in the table below.

Direction	Frequency
Uplink	5850-5853.5 MHz
	5925-6425 MHz
	12920-13250 MHz
	13750-14500 MHz
Downlink	3700-4200 MHz
	10850-11700 MHz
	12200-12750 MHz

The spacecraft provides the following coverage:

Frequency band	Beam	Coverage
C-Band	A1-A5	United States, Australia, Japan, China, New Zealand
	Global	Global
Ku-Band	U1-U19	Visible land area
	S1-S4	Japan
	T1-T9	Indonesia, Korea, China, New Zealand
	P1-P7	Global
	Steerable Spot Beam	Global

2.1 Spacecraft Characteristics

Horizons 3e is a three-axis stabilized type spacecraft that has a rectangular outer body structure. Horizons 3e utilizes two deployable solar array wings and a number of deployable and non-deployable antennas.

The Horizons 3e 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 Horizons 3e 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

Horizons 3e utilizes active communication channels at C-band and Ku-band frequencies. The C-band payload utilizes channels with bandwidths of 36 MHz, 72 MHz, 108 MHz, 224MHz, 362 MHz, and 370 MHz. The Ku-band payload utilizes channels having bandwidths of 27 MHz, 36 MHz, 54 MHz, 72 MHz, 81 MHz, 112 MHz, 162 MHz, 224 MHz, 290 MHz, and 448 MHz. The Horizons 3e frequency and polarization plan is provided in Schedule S.

Horizons 3e utilizes a multiple spot-beam architecture. There are five identical C-band spot beams in addition to the global beam. Since the five spot beams are identical, the coverage contours and performance characteristics for only a single representative spot beam are provided in the Schedule S. Similarly, there are four groups of identical Ku-band spot beams. Therefore, the coverage contours and performance characteristics for only a single representative spot beam from each group are provided in the Schedule S. The latitude and longitude of each C-band and Ku-band spot beam's maximum gain point on the Earth is provided in Exhibit 2 in conformance with Section 25.114(c)(4)(vii)(B) of the Commission's rules. Additionally, Intelsat has included the Schedule S beam designation for all beams in Exhibit 3.

The performance characteristics of all Horizons 3e beams are provided in Schedule S. The coverage contours of all Horizons 3e beams except for those with their -8.0 dB contour extending beyond the edge of the Earth are provided with Schedule S.

Horizons 3e is equipped with one Ku-band steerable spot beam. Gain contours are provided in Schedule S. The steerable beam may be pointed toward any location on the earth that is visible from 169.0° E.L., and the coverage contours will remain identical in gain and roll-off regardless of pointing. Intelsat will ensure that transmissions in this beam are consistent with the Commission's rules and the ITU Radio Regulations as they pertain to the Fixed Satellite Service.

Exhibits 3 and 4 provide the beam parameters for the Horizons 3e uplink and downlink beams, respectively.

All C-band and Ku-band communication subsystems are inter-connected, allowing 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 Horizons 3e will comprise 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 Horizons 3e beams can be used for both gateway and service links. Those beams that are currently expected to include gateway earth stations in their service areas are identified in Exhibit 1.

2.3 Telemetry, Command and Ranging Subsystem

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

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

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

3) Reception, processing and distribution of telecommands.

Horizons 3e can be commanded through the use of two tunable command channels with center frequencies in the ranges 5850.5-5853.0 MHz and 6422-6424.5 MHz, selectable via ground command in 100 kHz steps. The spacecraft telemetry is received through telemetry channels centered at the frequencies 4197.75 MHz, 4198.25 MHz, 4198.75 MHz and 4199.25 MHz.

- Selectable center frequencies for channels CMD1 may be calculated as: Frequency (MHz) = 6422.0 + 0.1*n, where n is an integer from 0 to 25, inclusive; and

- Selectable center frequencies for channel CMD2 may be calculated as: Frequency (MHz) = 5850.5 + 0.1*n, where n is an integer from 0 to 25, inclusive.

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. The Horizons 3e command and telemetry subsystem performance is summarized in Exhibit 5.

2.4 Uplink Power Control Subsystem

Horizons 3e utilizes two Ku-band channels and one C-band channel for uplink power control ("ULPC"), antenna tracking, and ranging.

The coverage patterns of the ULPC beams have gain contours that vary by less than 8 dB across the surface of the Earth, and accordingly the gain at 8 dB below the peak falls beyond the edge of the Earth. Therefore, pursuant to Section 25.114(c)(4)(vi)(A) of the 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 Horizons 3e 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 error sources (i.e., attitude perturbations, thermal distortions, misalignments, orbital tolerances, and thruster perturbations, etc.).

3 Services and Emission Designators

Horizons 3e 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 Horizons 3e 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, and 11450-11700 MHz are contained in Section 25.208 of the Commission's rules. With respect to the frequency bands 10850-10950 MHz, 11200-11450 MHz and 12200-12750 MHz, there are PFD limits specified in No. 21.16 of the ITU Radio Regulations.

The maximum PFD levels for the Horizons 3e transmissions were calculated for the 3700-4200 MHz, 10850-11700 MHz, and 12200-12750 MHz. The PFD levels were also calculated for the Horizons 3e telemetry and ULPC carriers. The results are provided in Schedule S and show that the downlink power flux density levels of the Horizons 3e carriers do not exceed the limits specified in Sections 25.208 of the Commission's rules or the limits specified in No. 21.16 of the ITU Radio Regulations.

5 Emission Compliance

Section 25.202(e) of the Commission's rules requires that the carrier frequency of each space station transmitter be maintained within 0.002% of the reference frequency. Horizons 3e 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 Horizons 3e emissions.

6 Orbital Location

Intelsat requests that it be assigned the 169.0° E.L. orbital location for Horizons 3e. The 169.0° E.L. location satisfies Horizons 3e 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

Horizons 3e's operations in the 3700-4200 MHz, 5925-6425 MHz, 12250-12750 MHz, and 14000-14500 MHz bands have been coordinated and notified under the Administration of the United States' International Telecommunication Union ("ITU") filing USASAT-60J.

Horizons 3e's operations in the 11450-11700 MHz band have been coordinated and notified under the Administration of the United States' ITU filing USASAT-55L.

Horizons 3e's operations in the 13750-14000 MHz band have been coordinated and notified under the Administration of the United States' ITU filing USASAT-55V.

Horizons 3e's operation in the frequency bands 12750-13250 MHz, 10700-10950 MHz, and 11200-11450 MHz bands will use the ITU filings of the Administration of the United States' USASAT-101C and the Administration of Papua New Guineas' NEW DAWN FSS-7.

Horizons 3e's operation in the frequency bands 5850-5853.5 MHz, 10950-11200 MHz and 12200-12250 MHz will use the ITU filings of the Administration of the United States' USASAT-60V and the Administration of Papua New Guineas' NEW DAWN 43.

8 Coordination Statement and Certifications

The downlink EIRP density of Horizons 3e'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 Horizons 3e at 169.0° E.L.

The downlink EIRP density of Horizons 3e'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 Horizons 3e at 169.0° E.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 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 169.0°E.L.

Horizons 3e will also operate in two bands addressed by Section 25.140(a)(3)(v): the 11450-11700 MHz and 12200-12750 MHz bands. Because there is no previously authorized co-frequency space station at a location two degrees away, Section 9 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.

Further, Intelsat will operate Horizons 3e in compliance with all existing or future coordination agreements for 169.0° E.L.

9 Interference Analysis

The compatibility of the proposed Horizons 3e emissions in the 11450-11700 MHz and 12200-12750 MHz bands with an adjacent satellite located at 167.0° E.L.[1] was analyzed. The interference analysis was conducted for a representative carrier in each beam type operating in the 11450-11700 MHz and 12200-12750 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 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) At Ku-band frequencies rain attenuation predictions are derived using Recommendation ITU-R P.618.
d) At Ku-band frequencies, 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.

[1]At the time of submission of this application, Luch-5A is located at 167° E.L. Its frequency plan overlaps Horizons 3e in the 12500 – 12750 MHz band. Luch-5A was not included in the interference analysis because it is not licensed by the United States, nor does it have U.S. market access. Intelsat is coordinating the use of the overlapping frequencies pursuant to ITU rules.

All assumptions and the results of the analysis are documented in Exhibit 6. Each of the four 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 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.

10.1 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.

10.2 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.

10.3 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, Horizons 3e 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.

Horizons 3e will replace Intelsat 805 at 169.0° E.L. Additionally, Intelsat is seeking a U.S. license to operate JCSAT-RA at 169.0° E.L. These satellites may be nominally collocated during transfer of traffic and Intelsat will ensure that sufficient spatial separation is achieved between these 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 Horizons 3e. Intelsat is also not aware of any system with an overlapping station-keeping volume with Horizons

3e that is the subject of an ITU filing and that is either in orbit or progressing towards launch.

10.4 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 Horizons 3e 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 Horizons 3e 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.

11 TC&R Control Earth Stations

Intelsat will conduct TC&R operations through one or more of the following earth stations: Napa, CA; Kumsan, Korea; or Mingenew, Australia. Additionally, Intelsat is capable of remotely controlling Horizons 3e from its facilities in McLean, VA or Long Beach, CA.

[2] *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	June 22, 2017
Alexander Gerdenitsch Intelsat Manager, Spectrum Policy, Americas	Date

EXHIBIT 1
SPOT BEAM BORESIGHT LOCATIONS

Beam Designation	Latitude (°N)	Longitude (°E)	Beam Designation	Latitude (°N)	Longitude (°E)
C-band Beams			**Ku-band Beams**		
A1*	26.5	-143.3	U3	45.93	188.63
A2*	-33.6	127.0	U4	45.44	169.17
A3*	38.0	133.7	U5	42.64	151.05
A4	59.0	-158.7	U6*	33.79	137.14
A5*	-41.0	173.8	U7	18.5	136.95
			U8	5.63	130.78
Ku-band Beams			U9	-6.31	131.53
S1	42.36	143.91	U10	-19.55	121.27
S2	38.47	141.13	U11	-19.21	144.72
S3	35.38	137.68	U12*	-31.57	126.89
S4	32.97	133.13	U13*	-33.34	148.26
			U14	-36.39	165.31
T1	27.88	115.67	U15	-15.82	183.27
T2	20.34	119.73	U16	-16.6	216.89
T3	16.7	112.03	U17	-18.12	161.21
T4	9.55	110.7	U18	-6.13	149.61
T5*	2.41	110.73	U19	5.75	146.1
T6	-5.24	111.36			
T7	28.15	128.49			
T8	36.16	118.67	P1	-23.97	183.86
T9	-74.68	170.21	P2	-19.49	146.39
T10	-37.78	175.07	P3	4.53	206.56
T11	-45.15	170.76	P4	8.52	169
			P5	13.31	130.09
U1*	27.98	213.81	P6	41.52	199.26
U2	39.42	205.13	P7	47.95	147.5

* indicates beam is expected to serve at least one gateway earth station.

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								
Global Beam	----	----	----	----	CGLR*	CGRR*	CGLD*	CGRD*
Spot A1-A5	CAHU	CAVU	CAHD	CAVD	----	----	----	----
ULPC1	----	----	CLHD*	----	----	----	----	----
Telemetry Global	----	----	TGHD*	----	----	----	----	----
Command Global	----	CGVU*	----	----	----	----	----	----
Telemetry Pipe	----	----	----	----	----	----	TPLD*	----
Telemetry Hemi	----	----	----	----	----	----	THLD*	----
Command Pipe	----	----	----	----	CPLU*	----	----	----
Command Hemi	----	----	----	----	CHLU*	----	----	----
Ku-Band Beams[3]								
Spot U1-19	KUHU KUHV KUHW	KUVU KUVV KUVW	KUHD KUHE	KUVD KUVE	----	----	----	----
Spot S1-4	KSHU	KSVU	KSHD	KSVD	----	----	----	----
Spot T1-11	KTHU KTHV	KTVU	KTHD KTHE	KTVD KTVE KTVF	----	----	----	----
Spot P1-7	KPHU	KPVU	KPHD KPHE	KPVD KPVE	----	----	----	----
Steerable Beam	----	KSBU KSBV	KSBD	----	----	----	----	----
ULPC	----	----	----	----	----	----	----	KLRD* KLRE*

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

[3] Two beam designators within a cell indicates that the beam includes two disjoint frequency ranges.

EXHIBIT 3

COMMUNICATION SUBSYSTEM UPLINK BEAM PARAMETERS

Beam Name	C-Band Spot	C-Band Spot	C-Band Global	C-Band Global
Schedule S Beam ID	CAHU	CAVU	CGLU	CGRU
Frequency Band (MHz)	5939.0 - 6329.0		6339.0 - 6415.0	
Polarization	Horizontal	Vertical	LHCP	RHCP
G/T (dB/K)	10.2	10.2	-4.9	-4.9
Minimum SFD-- (dBW/m^2)	-106.1	-106.1	-100	-100
Maximum SFD-- (dBW/m^2)	-78.1	-78.1	-72	-72

Beam Name	Ku-Band 2.5°	Ku-Band 2.5°	Ku-Band 2.5°	Ku-Band 2.5°	Ku-Band 2.5°	Ku-Band 2.5°
Schedule S Beam ID	KUHU	KUVU	KUHV	KUVV	KUHW	KUVW
Frequency Band (MHz)	14007.0-14358.0		12950.0-13240.0		13755.0-14358.0	
Polarization	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical
G/T (dB/K)	10.5	10.5	10.5	10.5	10.5	10.5
Minimum SFD-- (dBW/m^2)	-106.5	-106.5	-106.5	-106.5	-106.5	-106.5
Maximum SFD-- (dBW/m^2)	-78.5	-78.5	-78.5	-78.5	-78.5	-78.5

Beam Name	Ku-Band 1.3°	Ku-Band 1.3°	Ku-Band 1.3°
Schedule S Beam ID	KTHU	KTVU	KTHV
Frequency Band (MHz)	14007.0-14263.5	14011.5-14358.5	12950.0-13240.0
Polarization	Horizontal	Vertical	Horizontal
G/T (dB/K)	16.8	16.8	16.8
Minimum SFD-- (dBW/m^2)	-113.5	-113.5	-113.5
Maximum SFD-- (dBW/m^2)	-85.5	-85.5	-85.5

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

Beam Name	Ku-Band 0.8°	Ku-Band 0.8°	Ku-Band 6.9°	Ku-Band 6.9°
Schedule S Beam ID	KSHU	KSVU	KPHU	KPVU
Frequency Band (MHz)	14191.5-14353.5	14011.5-14173.5	14367.0-14496.0	
Polarization	Horizontal	Vertical	Horizontal	Vertical
G/T (dB/K)	19.6	19.6	3.6	3.6
Minimum SFD-- (dBW/m^2)	-113.9	-113.9	-103.7	-103.7
Maximum SFD-- (dBW/m^2)	-85.9	-85.9	-75.7	-75.7

Beam Name	Ku-Band Steerable	Ku-Band Steerable
Schedule S Beam ID	KSBU	KSBV
Frequency Band (MHz)	12924.0-12996.0	14425.0-14497.0
Polarization	Vertical	Vertical
G/T (dB/K)	12.0	12.0
Minimum SFD-- (dBW/m^2)	-110.0	-110.0
Maximum SFD-- (dBW/m^2)	-82.0	-82.0

EXHIBIT 4

COMMUNICATION SUBSYSTEM DOWNLINK BEAM PARAMETERS

Beam Name	C-Band Spot	C-Band Spot	C-Band Global	C-Band Global
Schedule S Beam ID	CAHD	CAVD	CGLD	CGRD
Frequency Band (MHz)	3711.5-4104.0		4114.0-4190.0	
Polarization	Horizontal	Vertical	LHCP	RHCP
Maximum Beam Peak EIRP (dBW)	49.5	49.5	37.2	37.2
Maximum Beam Peak EIRP Density (dBW/4kHz)	7.9	7.9	-1.4	-1.4
Maximum Beam Peak EIRP Density (dBW/Hz)	-28.1	-28.1	-37.4	-37.4

Beam Name	Ku-Band 2.5°	Ku-Band 2.5°	Ku-Band 2.5°	Ku-Band 2.5°
Schedule S Beam ID	KUHD	KUVD	KUHE	KUVE
Frequency Band (MHz)	12257.0-12744.0		10970.0-11418.0	
Polarization	Horizontal	Vertical	Horizontal	Vertical
Maximum Beam Peak EIRP (dBW)	57.4	57.4	57.4	57.4
Maximum Beam Peak EIRP Density (dBW/4kHz)	13.9	13.9	7.9	7.9
Maximum Beam Peak EIRP Density (dBW/Hz)	-22.1	-22.1	-28.1	-28.1

Beam Name	Ku-Band 0.8°	Ku-Band 0.8°	Ku-Band 1.3°	Ku-Band 1.3°
Schedule S Beam ID	KSHD	KSVD	KTHD	KTHE
Frequency Band (MHz)	12257.0-12494.0	12507.0-12744.0	11583.0-11637.0	12257.0-12744.0
Polarization	Horizontal	Vertical	Horizontal	Horizontal
Maximum Beam Peak EIRP (dBW)	65.9	65.9	65.0	65.0
Maximum Beam Peak EIRP Density (dBW/4kHz)	22.4	22.4	21.5	21.5
Maximum Beam Peak EIRP Density (dBW/Hz)	-13.6	-13.6	-14.5	-14.5

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

Beam Name	Ku-Band 1.3°	Ku-Band 1.3°	Ku-Band 1.3°	Ku-Band Steerable
Schedule S Beam ID	KTVD	KTVE	KTVF	KSBD
Frequency Band (MHz)	11463.0-11517.0	12257.0-12639.0	10970.0-11418.0	10850-10922 or 10954-11026
Polarization	Vertical	Vertical	Vertical	Horizontal
Maximum Beam Peak EIRP (dBW)	65.0	65.0	65.0	59.8
Maximum Beam Peak EIRP Density (dBW/4kHz)	21.5	18.5	15.5	18.2
Maximum Beam Peak EIRP Density (dBW/Hz)	-14.5	-17.5	-20.5	-17.8

Beam Name	Ku-Band 6.9°	Ku-Band 6.9°	Ku-Band 6.9°	Ku-Band 6.9°
Schedule S Beam ID	KPHD	KPHE	KPVD	KPVE
Frequency Band (MHz)	11463.0-11697.0	12211.0-12247.0	11463.0-11697.0	12211.0-12247.0
Polarization	Horizontal	Horizontal	Vertical	Vertical
Maximum Beam Peak EIRP (dBW)	47.0	47.0	47.0	47.0
Maximum Beam Peak EIRP Density (dBW/4kHz)	8.4	8.4	6.6	6.6
Maximum Beam Peak EIRP Density (dBW/Hz)	-27.6	-27.6	-29.4	-29.4

EXHIBIT 5
TC&R SUBSYSTEM CHARACTERISTICS

Beam Name	Command Global	Command Pipe	Command Hemi
Schedule S Beam ID	CGVU	CPLU	CHLU
Center Frequencies (MHz)	6422.0-6424.5*	6422.0-6424.5*	5850.5-5853.0*
Occupied Band (MHz)	6421.5-6425.0	6421.5-6425.0	5850.0-5853.5
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

* Tunable in 100 kHz steps

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 ULPC**	**Ku-band ULPC**	**Ku-band ULPC**
Schedule S Beam ID	CLHD	KLRD	KLRE
Frequencies (MHz)	4199.75	11451	12200.25
Polarization	Horizontal	RHCP	RHCP
Maximum Channel EIRP (dBW)	6.2	11.0	11.0
Maximum Beam Peak EIRP Density (dBW/4kHz)	-1.8	3.0	3.0
Maximum Beam Peak EIRP Density (dBW/Hz)	-37.8	-33.0	-33.0

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

EXHIBIT 6
INTERFERENCE ANALYSIS:
Effect of Hypothetical Satellite at 167°E on Horizons 3e

UPLINK BEAM INFORMATION				
Uplink Beam Name	**KUHU**	**KTVU**	**KSVU**	**KPHU**
Uplink Frequency (MHz)	**14030.626**	**14040.375**	**14040.375**	**14040.375**
Uplink Beam Polarization	**Horizontal**	**Vertical**	**Vertical**	**Horizontal**
Uplink Beam Peak G/T (dB/K)	**10.5**	**16.8**	**19.6**	**4.3**
Uplink Beam Peak SFD (dBW/m2)	**-87.0**	**-87.0**	**-87.0**	**-87.0**
Uplink Relative Contour Level (dB)	**-4.0**	**-4.0**	**-6.0**	**-3.2**
DOWNLINK BEAM INFORMATION				
Downlink Beam Name	**KUVD**	**KTHD**	**KSHD**	**KPHD**
Downlink Frequency (MHz)	**12280.626**	**12285.875**	**12285.875**	**12285.875**
Downlink Beam Polarization	**Vertical**	**Horizontal**	**Horizontal**	**Vertical**
Downlink Beam Peak EIRP (dBW)	**57.4**	**65.0**	**60.4**	**47.0**
Downlink Relative Contour Level (dB)	**-1.0**	**-4.0**	**-6.0**	**-2.0**
ADJACENT SATELLITE				
Satellite Name	**Hypothetical**	**Hypothetical**	**Hypothetical**	**Hypothetical**
Orbital Location	**167E**	**167E**	**167E**	**167E**
Uplink Power Density (dBW/Hz)	**-54.8**	**-51.9**	**-54.9**	**-53.2**
Beam Peak Downlink EIRP Density (dBW/Hz)	**-30.0**	**-22.4**	**-25.0**	**-33.1**
CARRIER INFORMATION				
Emission Designator	**5M25G7W**	**5M25G7W**	**5M25G7W**	**5M25G7W**
Carrier Modulation	**QPSK**	**QPSK**	**QPSK**	**QPSK**
Information Rate(kbps)	**10000**	**10000**	**10000**	**10000**
Code Rate	**2/3**	**2/3**	**2/3**	**2/3**
Occupied Bandwidth(kHz)	**5000**	**5000**	**5000**	**5000**
Allocated Bandwidth(kHz)	**5250**	**5250**	**5250**	**5250**
Minimum C/N, Rain (dB)	**6.6**	**6.6**	**6.6**	**6.6**
UPLINK EARTH STATION				
Earth Station Diameter (meters)	**2.4**	**2.4**	**2.4**	**2.4**
Earth Station Gain (dBi)	**49.1**	**49.1**	**49.1**	**49.1**
DOWNLINK EARTH STATION				
Earth Station Diameter (meters)	**2.4**	**2.4**	**2.4**	**2.4**
Earth Station Gain (dBi)	**47.0**	**47.0**	**47.0**	**47.0**
Earth Station G/T (dB/K)	**27.3**	**27.3**	**27.3**	**27.3**
COMPOSITE LINK PERFORMANCE				
C/N Thermal Uplink (dB)	**22.0**	**28.3**	**27.6**	**17.5**
Uplink Interference C/I (dB)	**22.6**	**28.7**	**22.9**	**36.9**
Uplink Adjacent Satellite C/I (dB)	**23.6**	**23.6**	**23.6**	**23.6**
Intermodulation C/IM (dB)	**25.3**	**19.9**	**15.9**	**31.7**
Downlink Thermal C/N (dB)	**15.0**	**12.8**	**17.2**	**15.8**
Downlink Interference C/I (dB)	**17.9**	**20.8**	**14.7**	**25.2**
Downlink Adjacent Satellite C/I (dB)	**23.6**	**23.6**	**23.6**	**23.6**
Subtotal C/N (dB)	**11.5**	**10.8**	**10.3**	**12.5**
Antenna Mispointing and Other Losses (dB)	**0.3**	**0.3**	**0.3**	**0.3**
Total C/(N+I) (dB)	**11.2**	**10.5**	**10.0**	**12.2**
Minimum Required C/N (dB)	**6.6**	**6.6**	**6.6**	**6.6**
CARRIER DENSITY LEVELS				
Uplink Power Density (dBW/Hz)	**-54.8**	**-51.9**	**-54.9**	**-53.2**
Downlink EIRP Density At Beam Peak (dBW/Hz)	**-30.0**	**-22.4**	**-25.0**	**-33.1**