EXHIBIT A
ENGINEERING STATEMENT

DIRECTV Enterprises, LLC ("DIRECTV") seeks to modify its authorization for T16 (call sign S3039)[1] to change the authorized orbital location of T16 from 102.70° W.L. to 100.85° W.L. and to provide Direct Broadcast Satellite ("DBS") service using the 12/17 GHz DBS frequency band and Fixed-Satellite Service ("FSS") using the Ka-FSS frequency band at the nominal 101° W.L. orbital location. As explained in the T16 application, DIRECTV has already provided the technical information for the satellite's Ka-band payload as well as the satellite's Ku-band DBS payload at the nominal 101° W.L. orbital location.[2] This engineering statement updates and supplements that information with respect to orbital location and orbital debris mitigation and provides representative link budgets for T16's Ku-band DBS payload in Appendix A. The remaining information (including the technical information submitted on Schedule S) remains unchanged and is incorporated by reference.

1. Orbital Location

The precise orbital location for T16 will be 100.85° W.L. The T16 satellite will be collocated with DIRECTV's T8 (call sign S2632), T9S (call sign S2669), and T4S (call sign S2430) satellites at the nominal 101° W.L. orbital location. In addition, the T16 satellite will be collocated with DIRECTV's T15 (call sign S2930) satellite at the 100.85° W.L. orbital location

[1] *Satellite Policy Branch Information; Actions Taken*, Public Notice, Report No. SAT-01381, File No. SAT-RPL-20180913-00071 (Mar. 29, 2019).

[2] *See* IBFS File No. SAT-RPL-20180913-00071, Narrative Exhibit at 7 n.11.

for approximately one month after T16 arrives at 100.85° W.L., during which time DBS services will be transferred from T15 to T16.[3]

2. Orbital Debris Mitigation

DIRECTV has incorporated the material objectives set forth in this application into the technical specifications established for construction of T16.

Spacecraft Hardware Design

DIRECTV has assessed and limited the amount of debris released in a planned manner during normal operations. T16 will not be a source of debris during launch, drift, or operating mode, as DIRECTV does not intend to release debris during the planned course of operations of the satellite.

DIRECTV has also considered the possibility of T16 becoming a source of debris by collisions with small debris or meteoroids that could cause loss of control of the spacecraft and prevent post-mission disposal. As such, DIRECTV has taken steps to address this possibility by incorporating redundancy, shielding, separation of components, and other physical characteristics into the satellite's design. For example, omni-directional antennas have been mounted on opposite sides of the spacecraft, and either will be sufficient to support orbit raising. The command receivers and decoders, telemetry encoders and transmitters, and the bus control electronics are fully redundant, physically separated, and located within a shielded area to minimize the probability of the spacecraft becoming a source of debris due to a collision.

[3] DIRECTV's T15 satellite is permanently licensed to operate at 102.75° W.L. but is currently providing DBS service at the 100.85° W.L. orbital location pursuant to a grant of special temporary authority. *See Satellite Policy Branch Information; Actions Taken*, Public Notice, Report No. SAT-01358, File No. SAT-STA-20180830-00064 (Nov. 2, 2018); *see also 180-Day STA Extension Request to Operate T15 (Call Sign S2930) at 101 WL*, File No. SAT-STA-20190416-00028.

DIRECTV will continue to review these aspects of on-orbit operations with the spacecraft manufacturer and will make such adjustments and improvements as appropriate to assure that its spacecraft will not become a source of debris during operations or become derelict in space due to a collision.

Minimizing the Chance of Accidental Explosions

DIRECTV, in direct consultation with the spacecraft manufacturer, has assessed and limited, to the maximum extent possible, the probability of accidental explosions during and after completion of mission operations. The key areas reviewed for this purpose have included leakage of propellant and mixing of fuel and oxidizer as well as battery pressure vessels. The basic propulsion design (including component and functional redundancy, and the placement of fuel tanks inside a central cylinder which provides a high level of shielding), propulsion subsystem component construction, preflight verification through both proof testing and analysis, and quality standards have been designed to ensure a very low risk of propellant leakage and fuel and oxidizer mixing that can result in subsequent explosions. During the mission, batteries and various critical areas of the propulsion subsystem will be continually monitored (for both pressure and temperature) to preclude conditions that could result in the remote possibility of explosion and subsequent generation of debris.

After T16 reaches its final disposal orbit, all on-board sources of stored energy will be depleted, all fuel line valves will be left "open," and all batteries will be left in a permanent discharge state. The solar cells will be slewed away from the sun to minimize power generation.

Safe Flight Profiles

DIRECTV has assessed and limited the probability of T16 becoming a source of debris by collisions with large debris or other operational space stations through detailed and

conscientious mission planning. DIRECTV has reviewed the list of licensed systems and systems that are under consideration by the Commission for the 100.85° W.L. orbital location it has requested. In addition, in order to address non-U.S. licensed systems, DIRECTV has reviewed the list of satellite networks in the vicinity of 100.85° W.L. for which a request for coordination has been submitted to the ITU. Only those networks that are operating, or are planned to be operating, within ±0.2° of T16 have been taken into account in this review.

As a consequence of this review, it has been determined that only three other systems have been licensed by the Commission for, and are currently operating within ±0.2° of, the requested location for T16: T8 at 100.75° W.L.,[4] T15 at 100.85º W.L.,[5] and SES-1 at 101.0° W.L. As the station keeping of T8 and SES-1 will be maintained within ±0.025°, there will be no overlap of station keeping volumes of these satellites with the station keeping volume of T16. For approximately one month after T16 arrives at 100.85° W.L., T15 and T16 will be collocated at 100.85° W.L. while DBS services are transferred from T15 to T16. As operator of both satellites, DIRECTV will be able to plan station keeping maneuvers to maintain T15 and T16 at the same nominal location without risk of collision with each other.

With regard to ITU filings within ±0.2 degrees of the requested location for T16, there are no additional satellite networks for which the ITU has published any information.

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[4] DIRECTV's T8 satellite is permanently licensed to operate at 100.85° W.L. but is currently operating at the 100.75° W.L. orbital location pursuant to a grant of special temporary authority. *See Satellite Policy Branch Information; Actions Taken*, Public Notice, Report No. SAT-01361, File No. SAT-STA-20180928-00077 (Nov. 30, 2018).

[5] As noted above, DIRECTV's T15 satellite is permanently licensed to operate at 102.75° W.L. but is currently providing DBS service at the 100.85° W.L. orbital location pursuant to a grant of special temporary authority. *See Satellite Policy Branch Information; Actions Taken*, Public Notice, Report No. SAT-01358, File No. SAT-STA-20180830-00064 (Nov. 2, 2018); *see also 180-Day STA Extension Request to Operate T15 (Call Sign S2930) at 101 WL*, File No. SAT-STA-20190416-00028.

Post-Mission Disposal

Consistent with the requirements of Section 25.283(a) of the Commission's rules, at the end of the operational life of the satellite, DIRECTV will maneuver T16 into a disposal orbit with an altitude no less than that calculated using the IADC formula:

$$36{,}021 \text{ km} + (1000 \cdot C_R \cdot A/m)$$

where C_R is the solar pressure radiation coefficient of the spacecraft, and A/m is the Area to mass ratio, in square meters per kilogram, of the spacecraft. The relevant values for the T16 satellite are:

$C_R = 1.25$

$A = 123.9 \text{ m}^2$

$m = 3381 \text{ kg}$

Inserting these values into the equation yields the following results:

$$36{,}021 \text{ km} + (1000*1.25*(123.9/3381)) = 36066.8 \text{ km}$$

Since geostationary altitude is generally considered to be 35,786 km,[6] this yields a desired disposal orbit of at least 280.8 km above the geostationary arc. DIRECTV intends to boost T16 to at least this height, and in fact will target a height of approximately 300 km above geostationary altitude.

DIRECTV currently intends to allocate and reserve approximately 16.8 kg of propellant for final orbit raising maneuvers to this altitude. This value was determined through a detailed launch vehicle propellant budget analysis applied to the parameters of one of DIRECTV's most recently designed satellites. In addition, DIRECTV has assessed fuel gauging uncertainty and

[6] *See, e.g.*, *Mitigation of Orbital Debris*, Second Report and Order, 19 FCC Rcd 11567, at ¶ 65 (2004).

this budgeted propellant provides an adequate margin of fuel reserve to ensure that the disposal orbit will be achieved despite such uncertainty.

ENGINEERING CERTIFICATION

The undersigned hereby certifies to the Federal Communications Commission as follows:

(i) I am the technically qualified person responsible for the engineering information contained in the foregoing Application,

(ii) I am familiar with Part 25 of the Commission's Rules, and

(iii) I have either prepared or reviewed the engineering information contained in the foregoing Application, and it is complete and accurate to the best of my knowledge and belief.

Signed:

/s/ Steve Dulac
Steve Dulac
Director, Content Technology and Regulatory Policy

May 8, 2019
Date

APPENDIX A

T16 KU-BAND DBS LINK BUDGET ANALYSIS

CONUS- Washington, D.C.	Clear Sky Up/ Clear Sk Down	Rain Up/ Rain Down
LABC Uplink		
Transmit power, dBW	7.0	12.0
Transmit losses, dB	-2.0	-2.0
Ground antenna gain, dB	60.0	60.0
Antenna pointing loss, dB	-0.5	-0.5
Free space loss, dB	-207.0	-207.0
Atmospheric loss, dB	-0.5	-0.5
Uplink rain loss, dB	0.0	-5.0
Satellite G/T, dB/K	18.0	18.0
Bandwidth, dB-Hz	-73.0	-73.0
Boltzmann's constant, dBW/Hz K	228.6	228.6
Aggregate Uplink C/I (dB)	25.0	20.0
Uplink C/N (thermal) (dB)	23.9	19.6
Satellite EIRP dBW/24MHz	55.2	55.2
Free space loss, dB	-205.9	-205.9
Downlink rain loss, dB	N/A	-2.4
Atmospheric loss, dB	-0.2	-0.2
Rain temp increase, dB	0.0	-2.5
Rcv. antenna pointing loss, dB	-0.5	-0.5
Ground G/T (0.45m dish), dB/K	13.0	13.0
Bandwidth, dB-Hz	-73.0	-73.0
Boltzmann's constant, dBW/Hz K	228.6	228.6
Downlink C/N (thermal) (dB)	17.2	12.3
	Clear Sky Up/ Clear Sk Down	Rain Up/ Rain Down
Uplink C/N+I , dB	23.9	19.6
Downlink C/N (thermal), dB	17.2	12.3
Total inter and intra-system C/I, dB (inc. X-pol, ASI, ACI, ABI)	16.5	16.0
Total C/(N+I), dB	13.4	10.2
Required C/(N+I), dB	8.2	8.2
Margin, dB	5.2	2.0

Table A-1. T16 Link Budget – Ku-band National Coverage – 0.45m region

Alaska 1.2m region - Juneau	Clear Sky Up/ Clear Sk Down	Rain Up/ Rain Down
LABC Uplink		
Transmit power, dBW	7.0	12.0
Transmit losses, dB	-2.0	-2.0
Ground antenna gain, dB	60.0	60.0
Antenna pointing loss, dB	-0.5	-0.5
Free space loss, dB	-207.0	-207.0
Atmospheric loss, dB	-0.5	-0.5
Uplink rain loss, dB	0.0	-5.0
Satellite G/T, dB/K	18.0	18.0
Bandwidth, dB-Hz	-73.0	-73.0
Boltzmann's constant, dBW/Hz K	228.6	228.6
Aggregate Uplink C/I (dB)	25.0	20.0
Uplink C/N (thermal) (dB)	23.9	19.6
Satellite EIRP dBW/24MHz	49.8	49.8
Free space loss, dB	-206.3	-206.3
Downlink rain loss, dB	N/A	-2.2
Atmospheric loss, dB	-0.4	-0.4
Rain temp increase, dB	0.0	-2.3
Rcv. antenna pointing loss, dB	-1.0	-1.0
Ground G/T (1.2m dish), dB/K	21.0	21.0
Bandwidth, dB-Hz	-73.0	-73.0
Boltzmann's constant, dBW/Hz K	228.6	228.6
Downlink C/N (thermal) (dB)	18.7	14.2
	Clear Sky Up/ Clear Sk Down	Rain Up/ Rain Down
Uplink C/N+I , dB	23.9	19.6
Downlink C/N (thermal), dB	18.7	14.2
Total inter and intra-system C/I, dB (inc. X-pol, ASI, ACI, ABI)	14.5	14.0
Total C/(N+I), dB	12.7	10.5
Required C/(N+I), dB	8.2	8.2
Margin, dB	4.5	2.3

Table A-2. T16 Link Budget – Ku-band Alaska Coverage – 1.2m region

Alaska 1.8m region - Kodiak Island	Clear Sky Up/ Clear Sk Down	Rain Up/ Rain Down
LABC Uplink		
Transmit power, dBW	7.0	12.0
Transmit losses, dB	-2.0	-2.0
Ground antenna gain, dB	60.0	60.0
Antenna pointing loss, dB	-0.5	-0.5
Free space loss, dB	-207.0	-207.0
Atmospheric loss, dB	-0.5	-0.5
Uplink rain loss, dB	0.0	-5.0
Satellite G/T, dB/K	18.0	18.0
Bandwidth, dB-Hz	-73.0	-73.0
Boltzmann's constant, dBW/Hz K	228.6	228.6
Aggregate Uplink C/I (dB)	25.0	20.0
Uplink C/N (thermal) (dB)	23.9	19.6
Satellite EIRP dBW/24MHz	49.9	49.9
Free space loss, dB	-206.5	-206.5
Downlink rain loss, dB	N/A	-1.6
Atmospheric loss, dB	-0.7	-0.7
Rain temp increase, dB	0.0	-1.9
Rcv. antenna pointing loss, dB	-1.0	-1.0
Ground G/T (1.8m dish), dB/K	25.4	25.4
Bandwidth, dB-Hz	-73.0	-73.0
Boltzmann's constant, dBW/Hz K	228.6	228.6
Downlink C/N (thermal) (dB)	22.7	19.2
	Clear Sky Up/ Clear Sk Down	Rain Up/ Rain Down
Uplink C/N+I , dB	23.9	19.6
Downlink C/N (thermal), dB	22.7	19.2
Total inter and intra-system C/I, dB (inc. X-pol, ASI, ACI, ABI)	14.6	14.2
Total C/(N+I), dB	13.5	12.1
Required C/(N+I), dB	8.2	8.2
Margin, dB	5.3	3.9

Table A-3. T16 Link Budget – Ku-band Alaska Coverage – 1.8m region

Puerto Rico - 0.65m region	Clear Sky Up/ Clear Sk Down	Rain Up/ Rain Down
LABC Uplink		
Transmit power, dBW	7.0	12.0
Transmit losses, dB	-2.0	-2.0
Ground antenna gain, dB	60.0	60.0
Antenna pointing loss, dB	-0.5	-0.5
Free space loss, dB	-207.0	-207.0
Atmospheric loss, dB	-0.5	-0.5
Uplink rain loss, dB	0.0	-5.0
Satellite G/T, dB/K	18.0	18.0
Bandwidth, dB-Hz	-73.0	-73.0
Boltzmann's constant, dBW/Hz K	228.6	228.6
Aggregate Uplink C/I (dB)	25.0	20.0
Uplink C/N (thermal) (dB)	23.9	19.6
Satellite EIRP dBW/24MHz	54.1	54.1
Free space loss, dB	-205.8	-205.8
Downlink rain loss, dB	N/A	-2.5
Atmospheric loss, dB	-0.3	-0.3
Rain temp increase, dB	0.0	-2.5
Rcv. antenna pointing loss, dB	-0.5	-0.5
Ground G/T (0.65m dish), dB/K	14.2	14.2
Bandwidth, dB-Hz	-73.0	-73.0
Boltzmann's constant, dBW/Hz K	228.6	228.6
Downlink C/N (thermal) (dB)	17.3	12.4
	Clear Sky Up/ Clear Sk Down	Rain Up/ Rain Down
Uplink C/N+I , dB	23.9	19.6
Downlink C/N (thermal), dB	17.3	12.4
Total inter and intra-system C/I, dB (inc. X-pol, ASI, ACI, ABI)	16.7	16.5
Total C/(N+I), dB	13.6	10.4
Required C/(N+I), dB	8.2	8.2
Margin, dB	5.3	2.2

Table A-4. T16 Link Budget – Ku-band Puerto Rico Coverage – 0.65m region

Hawaii - 1.2m region	Clear Sky Up/ Clear Sk Down	Rain Up/ Rain Down
LABC Uplink		
Transmit power, dBW	7.0	12.0
Transmit losses, dB	-2.0	-2.0
Ground antenna gain, dB	60.0	60.0
Antenna pointing loss, dB	-0.5	-0.5
Free space loss, dB	-207.0	-207.0
Atmospheric loss, dB	-0.5	-0.5
Uplink rain loss, dB	0.0	-5.0
Satellite G/T, dB/K	18.0	18.0
Bandwidth, dB-Hz	-73.0	-73.0
Boltzmann's constant, dBW/Hz K	228.6	228.6
Aggregate Uplink C/I (dB)	25.0	20.0
Uplink C/N (thermal) (dB)	23.9	19.6
Satellite EIRP dBW/24MHz	53.1	53.1
Free space loss, dB	-206.2	-206.2
Downlink rain loss, dB	N/A	-4.5
Atmospheric loss, dB	-0.4	-0.4
Rain temp increase, dB	0.0	-3.3
Rcv. antenna pointing loss, dB	-1.0	-1.0
Ground G/T (1.2m dish), dB/K	21.0	21.0
Bandwidth, dB-Hz	-73.0	-73.0
Boltzmann's constant, dBW/Hz K	228.6	228.6
Downlink C/N (thermal) (dB)	22.1	14.3
	Clear Sky Up/ Clear Sk Down	Rain Up/ Rain Down
Uplink C/N+I , dB	23.9	19.6
Downlink C/N (thermal), dB	22.1	14.3
Total inter and intra-system C/I, dB (inc. X-pol, ASI, ACI, ABI)	16.5	14.4
Total C/(N+I), dB	14.9	10.8
Required C/(N+I), dB	8.2	8.2
Margin, dB	6.6	2.5

Table A-5. T16 Link Budget – Ku-band Hawaii Coverage – 1.2m region