Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

Application of	)	
DIRECTV ENTERPRISES, LLC	)	Call Sign:
For Authorization to Launch and Operate T16 at Nominal 103° W.L.	)	File No. SAT-RPL-_____

APPLICATION FOR AUTHORIZATION
TO LAUNCH AND OPERATE T16

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APPLICATION FOR AUTHORITY
TO LAUNCH AND OPERATE T16

DIRECTV Enterprises, LLC ("DIRECTV") hereby requests that the Commission authorize the launch and operation of T16, a geostationary multi-band, multi-mission satellite[1] to be located initially at the nominal 103° W.L. position, where it will serve to replace and/or supplement DIRECTV's existing on-orbit capacity of the T15 (call sign S2930),[2] T10 (call sign S2641),[3] and T12 (call sign S2797)[4] satellites. At the nominal

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1 T16 is a hybrid multi-band satellite that includes payloads capable of operating in three frequency bands: Ka-FSS, 17/24 GHz BSS, and 12/17 GHz DBS. This application seeks operating authority to provide service using only the Ka-FSS and 17/24 GHz BSS portions of this satellite at the nominal 103º W.L. orbital location. DIRECTV also requests authority to operate the 12/17 GHz DBS payload for telemetry, tracking, and control ("TT&C") functions only.

2 DIRECTV's T15 satellite is licensed to provide services in the Ka-FSS band and the 17/24 GHz BSS band at the nominal 103° W.L. orbital location under Call Sign S2930. *See Application of DIRECTV Enterprises, LLC for Authorization to Launch and Operate DIRECTV 15 at 103° W.L.*, File No. SAT-LOA-20140825-00094 (stamp grant issued May 20, 2015); *Application of DIRECTV Enterprises, LLC for Minor Modification of Authorization to Launch and Operate DIRECTV RB-2*, File No. SAT-MOD-20140612-00066 (stamp grant issued May 14, 2015). (DIRECTV's T15 authority to provide services in the 17/24 GHz BSS band at the nominal 103° W.L. orbital location was originally issued under Call Sign S2712, which was consolidated with Call Sign S2930 in September 2017.) DIRECTV was recently granted special temporary authority to operate T15 temporarily at nominal 101° W.L. instead of nominal 103° W.L. *See 30-Day STA Request to Relocate T15 (Call Sign S2930) to 101 WL*, File No. SAT-STA-20180817-00063 (stamp grant issued Aug. 28, 2018).

3 DIRECTV's T10 satellite is authorized to provide services in the Ka-FSS band at the nominal 103° W.L. orbital location under Call Sign S2641. *See D10 Minor Mod*, File No. SAT-MOD-20150320-00012 (stamp grant issued Apr. 30, 2015).

4 DIRECTV's T12 satellite is authorized to provide services in the Ka-FSS band and the 17/24 GHz BSS band at the nominal 103° W.L. orbital location under Call Sign S2797. *See D12 Minor Mod*, File

103° W.L. slot, T16 will operate using the same Ka-band and 17/24 GHz frequencies already licensed to DIRECTV for this location. The capabilities of this satellite will be carefully integrated with those of DIRECTV's existing on-orbit Ka-band and 17/24 GHz-band satellites in order to optimize the efficient use of valuable spectrum resources at that location and to incorporate redundancy to DIRECTV's high definition ("HD") programming operations. Grant of this application will promote the continuing development of HDTV services, enable DIRECTV to maintain its position as the leader in digital home video entertainment and innovation, and enhance DIRECTV's ability to continue to offer U.S. consumers a powerful alternative to the services of incumbent cable operators.

DIRECTV has begun construction of T16 at its own risk[5] and expects the satellite to be ready for launch and operation in the first quarter of 2019. Accordingly, DIRECTV requests that the Commission grant this application as expeditiously as possible.

I. GRANT OF THIS APPLICATION WOULD SERVE THE PUBLIC INTEREST

As the nation's leading provider of satellite direct-to-home video services, DIRECTV has demonstrated the suitability of Ka-band and 17/24 GHz BSS spectrum for delivery of high quality multichannel video programming directly to consumers, helping to unlock the enormous potential of these bands. With seven Ka-band and/or 17/24 GHz BSS satellites currently providing direct-to-home services,[6] DIRECTV has been able to

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No. SAT-MOD-20150320-00013 (stamp grant issued May 14, 2015); *SAT-MOD-RB-2A*, File No. SAT-MOD-20120314-00042 (stamp grant issued Apr. 9, 2014). (DIRECTV's T12 authority to provide services in the 17/24 GHz BSS band at the nominal 103° W.L. orbital location was originally issued under Call Sign S2796, which was consolidated with Call Sign S2797 in September 2017.)

5 *See* 47 C.F.R. § 25.113(f).

6 DIRECTV transmits programming directly to consumers from the T10, T12, and T15 satellites at the nominal 103° W.L. location and from the T11 (call sign S2640), T14 (call sign S2869), and

achieve a quantum leap in the amount of HD digital television programming – including local broadcast stations in HD – available to consumers throughout the country. All new DIRECTV subscribers, and over 90% of the total DIRECTV customer base, subscribe to HD services. Continuing its tradition as the leader in innovative digital television services, DIRECTV intends to continue its development of advanced services and augment its impact for American consumers. In this application, DIRECTV seeks authority to launch and operate another vital element in its strategy to maintain its leadership position as an innovator in the digital revolution and to continue to build upon the nation's transition from analog to HD television.

T16 will be used to further expand DIRECTV's capability to provide HD services to American consumers. The satellite is fully compliant with Commission rules relating to Ka-band and 17/24 GHz band blanket earth station licensing.[7] Its operations will be carefully integrated with those of DIRECTV's existing on-orbit satellites at the nominal 103° W.L. orbital location in order to optimize the efficient use of valuable spectrum resources at that location and to incorporate redundancy to DIRECTV's HD operations. This satellite will give DIRECTV the ability to broadcast a significant number of additional channels of national HD programming at the nominal 103° W.L. orbital location. The satellite will also be capable of supporting multiple other missions, which

SPACEWAY 2 (call sign S2133) satellites at the nominal 99° W.L. location. DIRECTV is currently drifting the SPACEWAY 1 (call sign S2191) satellite to nominal 139° W.L. DIRECTV also operates Ka-band payloads on the T8 (call sign S2632) and T9S (call sign S2669) satellites at nominal 101° W.L., which are used for backhaul distribution rather than provision of programming directly to subscribers.

7 *See* 47 U.S.C. §§ 25.138, 25.208.

will thereby afford DIRECTV in-orbit redundancy within its satellite fleet.[8]

By granting this application, the Commission will enable DIRECTV to continue at the forefront of the development and delivery of HD television services. This capability will allow DIRECTV to maintain its leadership in digital entertainment and innovation and further enhance DIRECTV's ability to compete with incumbent cable operators to provide the best possible programming service to American consumers. The satellite's multi-band, multi-mission capabilities will also provide valuable redundancy to ensure continuity of service to over 20 million DIRECTV subscribers in the United States.

For the foregoing reasons, DIRECTV respectfully submits that grant of this application would serve the public interest and requests that the Commission act expeditiously so that DIRECTV can proceed to complete construction and launch T16 early in 2019.

II. INFORMATION REQUIRED UNDER SEC. 25.114 OF THE COMMISSION'S RULES

1. Name, Address, and Telephone Number of Applicant

DIRECTV Enterprises, LLC
2260 East Imperial Highway
El Segundo, CA 90245
(310) 964-0700

[8] T16 has been designed with the capability of performing national Ka-band and 17/24 GHz band transmissions from the nominal 103° W.L. or 99° W.L. locations (should it be repositioned to 99° W.L. at some time in the future). In addition, T16 carries a 12/17 GHz DBS payload capable of national transmissions from the nominal 101° W.L., 110° W.L., or 119° W.L. orbital locations (should it be repositioned to one of those locations at some time in the future).

2. Name, Address, and Telephone Number of Counsel

Jennifer D. Hindin
Daniel P. Brooks
WILEY REIN LLP
1776 K Street, NW
Washington, DC 20006
(202) 719-7000

3. Type of Authorization Requested

DIRECTV hereby applies for authority to launch and operate the Ka-band and 17/24 GHz BSS payloads of the T16 satellite at the nominal 103º W.L. orbital location, and to launch (but not operate except for limited TT&C) the 12/17 GHz DBS payload on the spacecraft.

4. General Description of Overall System Facilities, Operations and Services

T16 is a multi-band, multi-mission satellite designed to operate at any of DIRECTV's currently licensed Ka-band, 17/24 GHz BSS, or 12/17 GHz DBS orbital locations. The current primary mission of this satellite is to replace and supplement existing DIRECTV DTH services in the Ka- and 17/24 GHz bands at the requested nominal 103° W.L. orbital location. DIRECTV also requests authority to operate the spacecraft's 12/17 GHz DBS payload for TT&C functions only. DIRECTV is including technical details of this DBS payload for informational purposes and to support its request to operate the payload for TT&C functions. DIRECTV will seek Commission operating authority and provide any required additional information for this DBS payload in any future request to relocate and operate the DBS payload at the nominal 101° W.L., 110° W.L., or 119° W.L. orbital locations.

4.1 Ka-band DTH Description[9]

The T16 satellite is capable of transmitting up to twenty-eight of thirty-eight Ka-band transponders (nineteen LHCP and nineteen RHCP) providing national channels at any given time. The national channels will be delivered to the 48 contiguous states (CONUS) plus Alaska through a single beam, and to Hawaii and Puerto Rico through dedicated spot beams. All of these beams will carry identical national HD programming material. All Ka-band national programming material will be distributed from the DIRECTV broadcast facilities in Los Angeles, CA (LABC) and Castle Rock, CO (CRBC). Note that both of these Ka-band facilities operate in conjunction with diversity sites in order to ensure that the required uplink availability is achieved. The diversity site for LABC is located in Bakersfield, CA, and for CRBC in Englewood, CO. Using this combination of uplink facilities, the T16 system will have the capability to transmit more national channels of HD programming, though the number of channels actually transmitted will depend upon how T16 is integrated with DIRECTV's other Ka-band assets.

4.2 17/24 GHz Description[10]

T16 will broadcast on up to eighteen 17/24 GHz frequencies supporting U.S. transmissions. The national channels will be delivered to the 48 contiguous states (CONUS) and Alaska through a single beam, and to Hawaii and Puerto Rico through

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[9] The description of the Ka-band DTH capabilities provided throughout this application are for T16 operating at the nominal 103° W.L. location. Capabilities for operation at the nominal 99° W.L. location would be very similar and will be provided if and when DIRECTV requests authority to operate the satellite at that location.

[10] The description of the 17/24 GHz DTH capabilities provided throughout this application are for T16 operating at the nominal 103° W.L. location. Capabilities for operation at the nominal 99° W.L. location would be very similar and will be provided if and when DIRECTV requests authority to operate the satellite at that location.

dedicated spot beams. All of these beams will carry identical national HD programming material. All 17/24 GHz national programming material will be distributed from the DIRECTV broadcast facilities in Moxee, WA (NWUF) and New Hampton, NH (NEUF). All eighteen channels will have a usable bandwidth of 36 MHz.

4.3 DBS Description[11]

The T16 satellite is capable of supporting up to thirty-two DBS transponders (sixteen LHCP and sixteen RHCP) providing national channels. The national channels will be delivered to the 48 contiguous states (CONUS) plus Alaska through a single beam, and to Hawaii and Puerto Rico through dedicated spot beams. All of these beams will carry identical national HD programming material. All DBS national programming material will be distributed from the DIRECTV broadcast facilities in Los Angeles, CA and Castle Rock, CO.

5. Operational Characteristics

5.1 Ka-band Description of Frequencies and Beams

T16 will provide DTH service in the FSS Ka-band (28.35-28.6 GHz, 29.25-29.29 GHz, and 29.5-30.0 GHz (Earth-to-space), 18.3-18.59 GHz and 19.7-20.2 GHz (space-to-Earth)). The 28.35-28.6 GHz uplink band will be connected to the 18.3-18.55 GHz downlink band and the 29.25-29.29 GHz band will be connected to the 18.55-18.59 GHz band. The 29.5-30.0 GHz uplink band will be connected to the 19.7-20.2 GHz downlink band. Both senses of circular polarization (RHCP and LHCP) will be supported in all

[11] The description of the Ku-band DBS capabilities provided throughout this application are for T16 operating at the nominal 101° W.L. location, which would occur only subject to a future request for authority to operate the satellite at that location. Capabilities for operation at the nominal 110° W.L. or 119° W.L. locations would be very similar and will be provided if and when DIRECTV requests authority to operate the satellite at either of those locations.

frequency bands. Receive spot beams directed toward DIRECTV's LABC and CRBC facilities will receive the uplink national programming, which will be connected to both the CONUS plus Alaska transmit beam, and the Hawaii and Puerto Rico transmit spot beams. Any Ka-band uplink channel, the technical details of which (*i.e.,* center frequency, polarization, bandwidth) are included in the accompanying Schedule S as channels A1-A24 and B1-B14, can be received in either uplink spot beam defined in the Schedule S (*i.e.,* Los Angeles and Castlerock beams). The corresponding downlink channels A1-A24, whose technical details are also included in the accompanying Schedule S, are retransmitted in CONUS/Alaska fixed and Hawaii/Puerto Rico spot beams. Channels B1-B14 are transmitted in CONUS/Alaska and Hawaii/Puerto Rico spot beams. Because of the national downlink coverage, each channel can be used only once.

5.2 17/24 GHz Frequency/Channelization and Polarization Plan

Figure 5-1 shows the frequency/channelization and polarization plan of the BSS payload on the T16 satellite in the 17.3-17.7 GHz (space-to-Earth) and 24.75-25.15 GHz (Earth-to-space) frequency bands. All uplink channels will be fed to T16 from two distinct sites, these being the DIRECTV uplink facilities in Moxee, WA (NWUF) and New Hampton, NH (NEUF).

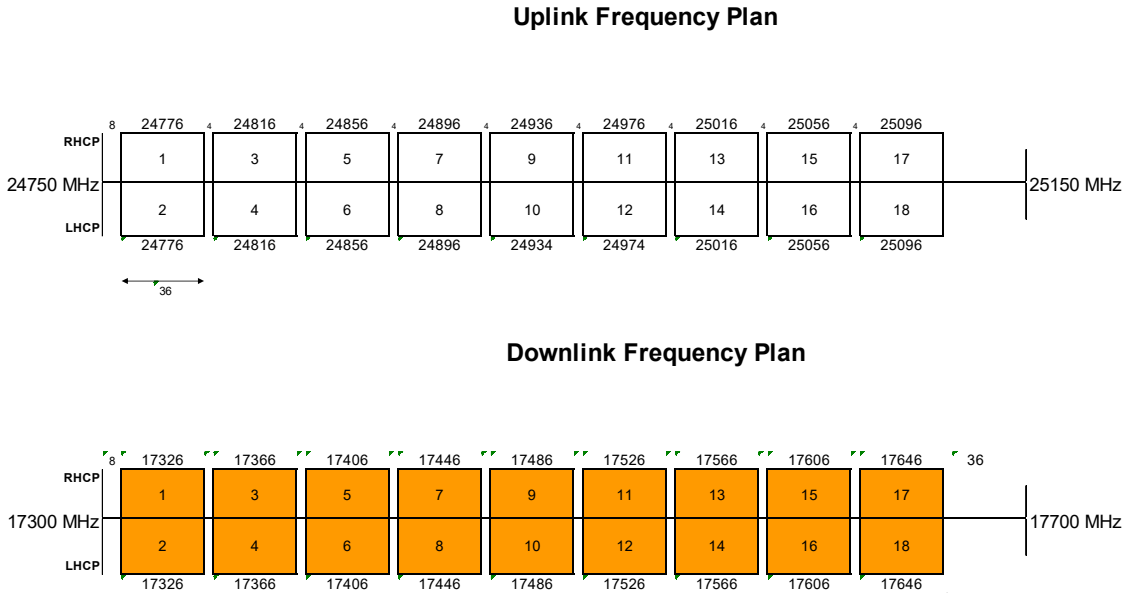


Figure 5-1. T16 17/24 GHz BSS Frequency/Channelization and Polarization Plan

Table 5-1 illustrates the connection of each uplink channel to its corresponding downlink channel.

Uplink Channel	Frequency (MHz)	Downlink Channel	Frequency (MHz
1, 2	24776	1, 2	17326
3, 4	24816	3, 4	17366
5, 6	24856	5, 6	17406
7, 8	24896	7, 8	17446
9, 10	24936	9, 10	17486
11, 12	24976	11, 12	17526
13, 14	25016	13, 14	17566
15, 16	25056	15, 16	17606
17, 18	25096	17, 18	17646

Table 5-1. T16 17/24 GHz BSS Uplink/Downlink Interconnectivity Plan

5.3 DBS Description of Frequencies and Beams

T16 will be capable of providing DBS services in the 17.3-17.8 GHz (Earth-to-space) and 12.2-12.7 GHz (space-to-Earth) DBS bands. The channel plan designed into the satellite conforms to that defined in Appendices 30/30A of the ITU Radio Regulations. The satellite will support 32 channels using both senses of polarization.

Receive spot beams directed towards DIRECTV's LABC and CRBC facilities (*i.e.,* beams Ku1 and Ku2 from Schedule S) will receive national programming that will be connected to both the CONUS plus Alaska transmit beam (*i.e.,* beams KURH and KULH) and the Hawaii and Puerto Rico transmit spot beams. Any DBS uplink channel, the technical details of which (*i.e.,* center frequency, polarization, bandwidth) are included in the accompanying Schedule S as channels K1-K32, can be received in either uplink spot beam. The corresponding Schedule S downlink channels K1-K32 are retransmitted in CONUS/Alaska fixed and Hawaii/Puerto Rico spot beams. Because of the national downlink coverage, each channel can be used only once.

5.4 TT&C Description of Frequencies and Beams

The transfer orbit and on-station TT&C functions for T16 will be provided at the edges of the 17.3-17.8 GHz and 12.2-12.7 GHz frequency bands allocated for DBS Ku-band operations.[12] On-station TT&C will be received and transmitted through dedicated telemetry and command horn antennas (one each for RHCP and LHCP for command and for telemetry) providing essentially global coverage.

[12] DIRECTV is not seeking authority to provide DBS service using the 12/17 GHz DBS frequency band at the nominal 103° W.L. orbital location, and its proposed limited use of the band for TT&C functions should not implicate the Commission's freeze on new DBS applications. *See Direct Broadcast Satellite (DBS) Service Auction Nullified: Commission Sets Forth Refund Procedures for Auction No. 52 Winning Bidders and Adopts a Freeze on All New DBS Service Applications*, Public Notice, 20 FCC Rcd 20618 (2005) (clarifying that "the freeze on DBS applications applies to any application for authority *to provide DBS service*") (emphasis added). To the extent the Commission determines the DBS application freeze applies, DIRECTV respectfully requests a waiver to provide limited transfer orbit and on-station TT&C functions for T16 using a small amount of the 17.3-17.8 GHz and 12.2-12.7 GHz frequency bands.

5.5 Communications Payload

5.5.1 Ka-band Uplink Transmissions

Ka-band uplink transmissions received by T16 are routed through wideband receive filters before low noise amplification and down-conversion and then through an arrangement of channel filtering. CONUS plus Alaska national channels are amplified by individual channel amplifiers with selectable fixed gain mode ("FGM")/automatic level control ("ALC") operating modes prior to final amplification in the TWTA. The filtered national channels for Hawaii and Puerto Rico are combined and routed to wideband amplifiers, also with selectable FGM/ALC operating modes, prior to final amplification in the TWTA. The normal mode of operation is ALC for all channels; this mode has a minimum input dynamic range of 19 dB and a commandable output power range of 13 dB with a maximum step size of 0.5 dB. The fixed gain mode of operation has 19 dB of gain step attenuation, settable in approximately 1 dB steps.

The maximum expected G/T performance for T16 for the Ka-band receive antennas directed towards the various uplink site locations is shown in the accompanying Schedule S. Note that this G/T value is for beam peak, and the beam pointing will be optimized to place each broadcast site at or near beam peak. Also note that this value of G/T will decrease, dB-for-dB, as the uplink location moves away from beam peak.

5.5.2 17/24 GHz BSS Uplink Transmissions

The T16 uplink channels received in the 24.75-25.15 GHz frequency band will be routed to the appropriate band-limiting input multiplexer comprising the receive channel filters and will be frequency translated to the desired output channel frequency by using a 7.45 GHz local oscillator. The filtered and frequency translated signals will be amplified by channel amplifiers with selectable fixed/ALC modes prior to final amplification in the

TWTA. The fixed gain mode will have at least 20 dB of gain adjustment with a step size of 1 dB. The ALC will hold the output level constant over an input dynamic range of at least 15 dB and will have a minimum output level adjustment of 10 dB in 0.5 dB increments.

The maximum gain of the T16 receive antenna will be 51.8 dBi, and the receive noise temperature will be approximately 700 Kelvin. The maximum expected G/T performance for T16 for the Reverse DBS receive antennas directed towards the various uplink site locations is shown in the accompanying Schedule S. The G/T will decrease, dB-for-dB, as the uplink location moves away from beam peak.

5.5.3 DBS Uplink Transmissions

DBS uplink transmissions received by T16 are routed through wideband receive filters before the satellite receiver and then through either individual channel filters for CONUS plus Alaska national channels, or through wideband transponder filters for the case of Hawaii and Puerto Rico national channels. Filtered signals are amplified by microwave power modules with selectable FGM/ALC operating modes prior to final amplification in the TWTA. The normal mode of operation for all channels is ALC; this mode has a minimum input dynamic range of 19 dB and a commandable output power range of 13 dB with a maximum step size of 0.5 dB. The fixed gain mode of operation has 19 dB of gain step attenuation, settable in approximately 1 dB steps.

The maximum expected G/T performance for T16 for the DBS receive antennas directed towards the various uplink site locations is shown in the accompanying Schedule S. Note that this G/T value is for beam peak, and the beam pointing will be optimized to place each broadcast site at or near beam peak. Also note that this value of G/T will decrease, dB-for-dB, as the uplink location moves away from beam peak.

5.5.4 Ka-band Downlink Transmissions

The Ka-band downlink transmissions will consist of a set of frequency division multiplexed digital signals carrying DIRECTV programming material. The individual channels used will depend upon the manner in which the operation of T16 is integrated with the operations of the other DIRECTV Ka-band satellites at the requested orbital location. Due to the national coverage nature of the Ka-band downlink beam, each channel can be transmitted only once. The resultant effective transmit power for Ka-band channels from T16 is shown in the accompanying Schedule S.

5.5.5 17/24 GHz BSS Downlink Transmissions

The 17/24 GHz BSS downlink transmissions will consist of a set of frequency division multiplexed digital signals carrying DIRECTV programming material. The individual channels used will depend upon the manner in which the operation of T16 is integrated with the operations of the other DIRECTV 17/24 GHz BSS satellites at the requested orbital location. Due to the national coverage nature of the 17/24 GHz BSS downlink beam, each channel can be transmitted only once. The resultant effective transmit power for 17/24 GHz BSS channels from T16 is shown in the accompanying Schedule S.

5.5.6 DBS Downlink Transmissions

The DBS downlink transmissions will consist of a set of frequency division multiplexed digital signals carrying DIRECTV programming material. The individual channels used will depend upon the manner in which the operation of T16 is integrated with the operations of the other DIRECTV DBS satellites at the requested orbital location. The channel plan for these signals is consistent with that defined in Appendices 30/30A of the ITU Radio Regulations. Due to the national coverage nature of the DBS

downlink beam, each channel can be transmitted only once. The resultant effective transmit power for DBS channels from T16 is shown in the accompanying Schedule S. Assuming it is authorized for such operations in the future, T16 will be operated in accordance with relevant U.S. ITU DBS satellite network filings at any assigned location.

5.6 TT&C Subsystem

The TT&C subsystem provides redundant telemetry, tracking, and control channels for the spacecraft. The principal functions of the subsystem are:

1. Reception of RF telecommands addressed to the spacecraft.
2. RF modulation and emission of telemetry data.
3. Reception of RF ranging tones, the demodulation and then RF modulation and emission with the telemetry downlink signal.

The subsystem is configurable to accommodate the unique requirements of pre-launch, orbit raising, and on-station synchronous orbit operations. The command and telemetry frequencies and polarization for T16, which fall at the edges of the 17.3-17.8 GHz and 12.2-12.7 GHz frequency bands allocated for DBS Ku-band operations, are as shown in the accompanying Schedule S. The telecommand and telemetry carriers are modulated with data to a width of approximately 800 kHz. The antenna patterns for the TT&C subsystem are discussed in Section 7.7.

6. Orbital Locations

The precise orbital location for T16 will be 102.70° W.L., as is also specified in the accompanying Schedule S. The T16 satellite will be collocated with the T10 and T12 satellites at the nominal 103° W.L. orbital location.[13]

[13] DIRECTV was recently granted special temporary authority to relocate T15 temporarily from nominal 103° W.L. to nominal 101° W.L. *See 30-Day STA Request to Relocate T15 (Call Sign S2930) to 101 WL*, File No. SAT-STA-20180817-00063 (stamp grant issued Aug. 28, 2018).

7. Predicted Spacecraft Antenna Gain Contours

7.1 Ka-Band Uplink Beams

The satellite will receive national Ka-band communications signals from the DIRECTV broadcast centers in Los Angeles, CA (LABC) and Castle Rock, CO (CRBC) using both RHCP and LHCP. Note that both of these facilities operate in conjunction with diversity sites in order to achieve the required uplink availability. The diversity site for LABC is located in Long Beach, CA, and for CRBC in Englewood, CO. The G/T and minimum saturation flux density are included in the accompanying Schedule S. The maximum saturation flux density level for the LABC uplink beam is -87.6 dBW/m^2 and for the CRBC uplink beam is -87.6 dBW/m^2. Both uplink beams will have a minimum cross-polarization isolation of 27 dB. GXTs for all beams are provided in the accompanying GIMS container database.

7.2 17/24 GHz BSS Uplink Beams

The satellite will receive 17/24 GHz BSS communications signals from the DIRECTV broadcast centers in Moxee, WA (NWUF) and New Hampton, NH (NEUF). It will be capable of receiving these signals across the frequency band 24.75-25.15 GHz using both LHCP and RHCP. The G/T and minimum saturation flux density are included in the accompanying Schedule S. The maximum saturation flux density level for the NWUF uplink beam is -87.6 dBW/m^2 and for the NEUF uplink beam is -87.6 dBW/m^2. Both uplink beams will have a minimum cross-polarization isolation of 27 dB. GXTs for all beams are provided in the accompanying GIMS container database.

7.3 DBS Uplink Beams

The satellite will receive Ku-DBS communications signals from the DIRECTV uplink facilities in Los Angeles, CA and Castlerock, CO using both RHCP and LHCP.

The G/T and minimum saturation flux density are included in the accompanying Schedule S. The maximum saturation flux density level for the LABC uplink beam is -83.8 dBW/m^2 and for the CRBC uplink beam is -83.8 dBW/m^2. Both uplink beams will have a minimum cross-polarization isolation of 27 dB. GXTs for all beams are provided in the accompanying GIMS container database.

7.4 Ka-band Downlink Beams

The Ka-band national coverage for T16 will include CONUS plus Alaska, Hawaii, and Puerto Rico using both RHCP and LHCP. The maximum EIRP for the downlink beams is included in the accompanying Schedule S. The maximum EIRP density for each of these beams is 46.0 dBW/MHz. All downlink beams will have a minimum cross-polarization isolation of 27 dB. GXTs for all beams are provided in the accompanying GIMS container database.

7.5 17/24 GHz BSS Downlink Beams

The 17/24 GHz BSS national coverage for T16 will include CONUS plus Alaska, Hawaii, and Puerto Rico using both RHCP and LHCP. The maximum EIRP for the downlink beams is included in the accompanying Schedule S. The maximum EIRP density for each of these beams is 47.15 dBW/MHz. All downlink beams will have a minimum cross-polarization isolation of 27 dB. GXTs for all beams are provided in the accompanying GIMS container database.

7.6 DBS Downlink Beams

The DBS national coverage for T16 will include CONUS plus Alaska, Hawaii, and Puerto Rico using both RHCP and LHCP. The maximum EIRP for the downlink beams is included in the accompanying Schedule S. The maximum EIRP density for these beams is 22.0 dBW/4 kHz for the CONUS plus Alaska beam, 19.0 dBW/4 kHz for

the Hawaii spot beam, and 19.0 dBW/4 kHz for the Puerto Rico spot beam. All downlink beams will have a minimum cross-polarization isolation of 27 dB. GXTs for all beams are provided in the accompanying GIMS container database.

7.7 TT&C Beams

Telecommand signals will be received through two hemi antennas (during transfer orbit and in case of emergency) or through one of two Ku-band horns (RHCP or LHCP) (when earth pointed on-station). For transfer and emergency phases, in order to give omni coverage, one hemi antenna is located on +Z and the other one on –Z side of the spacecraft. There is no switch implemented between the omni antennas and the command receivers, both reception paths being simultaneously available. During on-station operations, the telecommands are received through a Ku-band horn, the output of which is directed toward the command receivers. The command link beam peak flux density at command threshold is -95 dBW/m^2.

Telemetry signals will be sent either through a hemi antenna (during transfer orbit or in case of emergency) or through one of two Ku-band horns (RHCP or LHCP) (when earth pointed on-station). For transfer and emergency, as for command, in order to give omni coverage, one hemi antenna is located on +Z and the other on –Z side of the spacecraft. In nominal and on-station operation, the telemetry is output by one of the two transmitters and delivered to a Ku-band horn. The maximum EIRP of the telemetry signal is 19 dBW, and the maximum EIRP density is 27 dBW/MHz.

The coverage patterns for the on-station telecommand and telemetry horn antennas are included in the accompanying GIMS container database. The cross polarization performance of the telecommand horn is 25 dB and of the telemetry horn is 30 dB.

8. Service Description, Link Performance, and Earth Station Parameters

8.1 Service Description

As discussed more fully in Section I of this application, DIRECTV will use the T16 satellite to transmit HD digital video and audio entertainment and educational and informational programming to customers throughout the United States and Puerto Rico, who will receive this programming using small dish antennas.

8.2 Ka-band Link Performance

A representative link budget for the Ka-band payload is shown in Appendix A as Table A-1 and assumes a receive antenna size of 65 cm and also includes the interference contribution for adjacent satellite interference from neighboring Ka-band satellites nominally spaced two degrees away. Note that an availability of 99.7% has been assumed for this budget.

8.3 17/24 GHz BSS Link Performance

Representative communications link budgets for the 17/24 GHz BSS payload are shown in Appendix A as Tables A-2 to A-6, *i.e.*, one for a city in each of the CONUS downlink power flux density ("PFD") regions defined by the Commission's rules, and one each for Hawaii and Puerto Rico. These link budgets demonstrate adjacent satellite interference ("ASI") compatibility with 17/24 GHz BSS satellites spaced 4º and 8º away from the nominal 103º W.L. orbital location.

8.4 DBS Link Performance

A representative link budget for the DBS payload will be provided at such time as an operational location is requested and DIRECTV requests operating authority for that payload.

8.5 TT&C Link Performance

Representative link budgets for the telemetry and command links are shown in Appendix B as Tables B-1 and B-2, respectively.

8.6 Earth Station Parameters

There are essentially two types of earth stations that will be used with the T16 satellite – feeder-link earth stations and subscriber terminals. The feeder-link stations are relatively large transmit antennas, typically around 9 meters, that track the satellite and are used for transmitting national HD programming material from the DIRECTV broadcast sites to the satellite. The subscriber terminals are effectively 65 cm receive antennas that are installed at the customers' premises and have fixed pointing, which is optimized at installation. Somewhat larger antennas may have to be used in Alaska, Hawaii, and Puerto Rico.

9. Satellite Orbit Characteristics

The T16 satellite will be maintained in synchronous orbit at its nominal orbital location with a North-to-South drift tolerance of ±0.05 degrees and an East-to-West drift tolerance of ±0.025 degrees. The antenna axis attitude will be maintained so as to keep the beam pointing error to within ±0.1 degrees for the national beam.

10. Power Flux Density

10.1 Ka-band Power Flux Density

The national downlink beam of T16 will be operated so as to generate a maximum downlink EIRP of 59.5 dBW per 36 MHz channel and to thereby comply with the Ka-Band blanket licensing coordination threshold of -118 dBW/m^2/MHz. Operation with this EIRP complies with the Commission's requirements as is demonstrated by virtue of the fact that, for a 36 MHz digital carrier, a satellite downlink EIRP of 59.5 dBW results

in a maximum PFD of -118.5 dBW/m^2/MHz on the surface of the Earth (*i.e.*, 59.5 dBW – 162.4 dB-m^2 – 10*log (36) dB-MHz).[14] In all cases the upper bound on system and individual link availability is determined by -118 dBW/m^2/MHz, *i.e.*, the downlink PFD coordination threshold established in Section 25.138 of the Commission's rules.

The satellite will also comply with the downlink PFD limits established in Section 25.208 of the Commission's rules, which are as follows:

- -115 dB (W/m^2) in any 1 MHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;
- -115 + 0.5 (d-5) dB (W/m^2) in any 1 MHz band for angles of arrival d (in degrees) between 5 and 25 degrees above the horizontal plane; and
- -105 dB (W/m^2) in any 1 MHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.

The simple analysis above illustrates that the T16 operations will result in a PFD on the surface of the Earth that is within the Commission's requirements.

10.2 17/24 GHz BSS Power Flux Density

The allowable PFD levels in the 17.3-17.7 GHz band are defined in Section 25.208(w) of the Commission's rules on a regional basis for all conditions, including clear sky, and for all methods of modulation as:

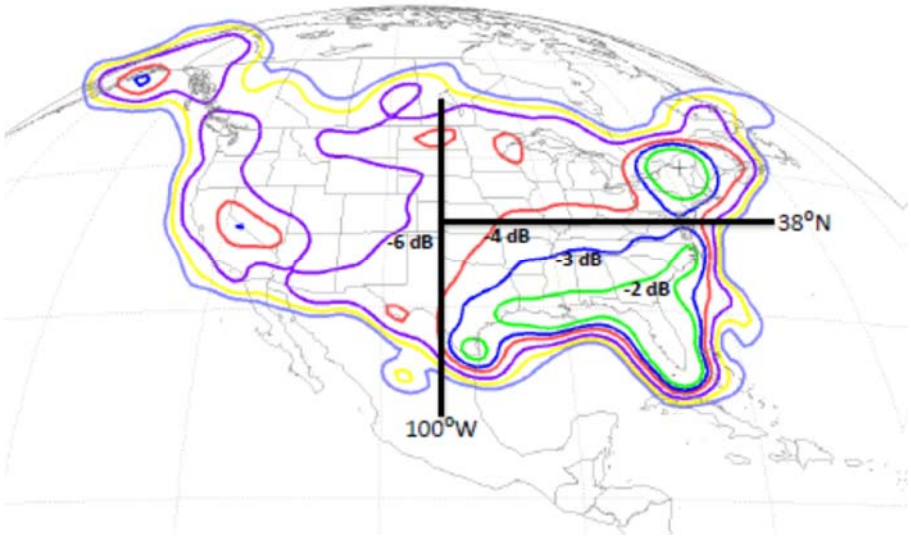
- In the region of the contiguous United States, located south of 38º North Latitude and east of 100º West Longitude: -115 dBW/m^2/MHz;

[14] Note that the value of 162.4 dB-m^2 for spreading loss is the value of such loss from the 103° W.L. location to the approximate beam peak location. Also note that all communications carriers in the Ka-band national downlink beam will have a bandwidth of 36 MHz.

- In the region of the contiguous United States, located north of 38º North Latitude and east of 100º West Longitude: -118 dBW/m^2/MHz;
- In the region of the contiguous United States, located west of 100º West Longitude: -121 dBW/m^2/MHz; and
- For all regions outside of the contiguous United States including Alaska and Hawaii: -115 dBW/m^2/MHz.

The maximum downlink EIRP for T16 in the Hawaii beam will be 61.9 dBW/36 MHz channel. DIRECTV calculates the maximum power flux density on the Earth's surface from this emission as: Max EIRP/channel minus spreading loss in direction of max gain minus bandwidth correction factor, or 61.9 dBW/36MHz – 162.4 (dB-m^2) – 10log(36) = -116.1 dBW/m^2/MHz.

As discussed in Section 7.5 above, the downlink antenna gain pattern for T16 is included in GXT format in the accompanying Schedule S and is also represented below for the CONUS+AK beam. Inspection of this pattern shows that (1) the antenna peak gain is north of 38º North latitude and east of 100º W.L., and the peak PFD density for this beam of -118.8 dBW/MHz complies with both Section 25.208(w)(1) and (w)(2); and (2) the antenna relative gain west of 100º W.L. is at least 4 dB below peak gain, which means that the peak PFD density in this region is below -122.8 dBW/MHz, making this beam compliant with Section 25.208(w)(3). As a result, the maximum PFD on the earth's surface complies with Section 25.208(w) in each of the applicable regions defined in the Commission's rules.



10.3 DBS Power Flux Density

There are no PFD limits associated with the DBS bands.

11. Arrangement for tracking, telemetry, and control

DIRECTV has contracted with Intelsat Satellite Operations to perform the TT&C operations for T16. The Intelsat control center is located in Long Beach, CA. The primary TT&C uplink will come from DIRECTV's Castle Rock Broadcast Center in Castle Rock, CO. The backup TT&C uplink will come from DIRECTV's Los Angeles Broadcast Center in Los Angeles, CA.

12. Milestones and Bond

DIRECTV requests grant of the T16 satellite application without milestones or a bond because T16 will operate using the same frequencies and coverage areas as currently licensed to DIRECTV at the nominal 103° W.L. orbital location, except for the sliver of TT&C frequencies in the Ku-DBS band for which a waiver is requested to the extent necessary.[15]

[15] *See* 47 C.F.R. §§ 25.164(a), 25.165(a), (e).

DIRECTV Licensed Frequencies at Nominal 103° W.L.

	T16	T10	T12	T15
space-to-Earth				
12.2-12.7 GHz	X[16]			
17.3-17.7 GHz	X		X	X
18.3-18.59 GHz	X	X	X	X
18.59-18.8 GHz		X	X	
19.7-20.2 GHz	X		X	X
Earth-to-space				
17.3-17.8 GHz	X[17]			
24.75-25.15 GHz	X		X	X
28.35-28.6 GHz	X	X	X	X
29.25-29.29 GHz	X	X	X	X
29.29-29.5 GHz		X	X	
29.50-30.0 GHz	X		X	X

13. Public Interest Considerations

See Section I above.

14. Interference Analysis

14.1 Ka-band Analysis

The link budget included in Appendix A demonstrates that the T16 satellite design described in this application will operate without exceeding the limits set for the Ka-band by the Commission's two-degree spacing policy and implementing rules. Accordingly, the proposed T16 satellite will remain in compliance with the relevant technical rules established by the Commission.

[16] At the nominal 103° W.L. orbital location, DIRECTV requests authority to operate only TT&C functions in the spacecraft's 12/17 GHz DBS payload.

[17] At the nominal 103° W.L. orbital location, DIRECTV requests authority to operate only TT&C functions in the spacecraft's 12/17 GHz DBS payload.

At Ka-band, in order to achieve maximum compatibility between diverse networks, the Commission established coordination thresholds for spacecraft downlink PFD in the *18 GHz Order*.[18] This operational threshold was the outcome of the blanket licensing parameters coordinated by industry for Ka-band earth terminals. This T16 proposal is fully compatible with this aspect of the *18 GHz Order*. For U.S. service, the system complies with the established -118 dBW/m^2/MHz PFD threshold, as well as the PFD limitations established in Section 25.208 of the Commission's rules.

An end-to-end link performance analysis, including both uplink and downlink, is presented in Appendix A. The analysis included the aggregate effects of interference from adjacent satellite networks in evaluating whether the system will operate at acceptable C/(N+I) thresholds.

To properly account for all interference from adjacent operating satellite systems, aggregate interference from earth terminals and satellites associated with pairs of satellites at 2, 4, 6, and 8 degrees of orbit separation were included. The budgets used a level of assumed interference that accounts for the maximum level permissible under the Commission's rules. The aggregate adjacent system interference that results from these assumptions is included in the link budget Table A-1.

14.2 17/24 GHz BSS Analysis

In order to achieve maximum compatibility between diverse networks, the Commission has established coordination thresholds for earth station off-axis EIRP density and spacecraft PFD in Sections 25.223 and 25.208, respectively. As such,

18 *Redesignation of the 17.7-19.7 GHz Frequency Band, Blanket Licensing of Satellite Earth Station in the 17.7-20.2 GHz and 27.5-30.0 GHz Frequency Bands, and the Allocation of Additional Spectrum in the 17.3-17.8 GHz and 24.75-25.25 GHz Frequency Bands for Broadcast Satellite-Service Use*, Report and Order, 15 FCC Rcd 13430 (2000) ("*18 GHz Order*").

DIRECTV has assumed for purposes of this application regional maximum downlink PFD values from neighboring systems consistent with Section 25.208(w), maximum feeder link earth station off-axis transmit power density consistent with Section 25.223, and receive earth station compliance with Section 25.224 (*i.e.*, Recommendation ITU-R BO.1213).

The interference analyses that are included in this application were performed in conjunction with the end-to-end link performance analyses. Abbreviated link budgets are presented in Tables A-2 through A-6 in Appendix A, *i.e.*, one budget for each of the CONUS PFD regions defined in Section 25.208(w) and one budget for each of Hawaii and Puerto Rico. In each case, the analysis includes the effects of adjacent satellite interference from satellites nominally spaced 3.75º, 4.25º, 7.75º and 8.25º away in evaluating whether the system accommodates the various data rates at acceptable C/(N+I) thresholds. Additionally, adjacent satellite interference was calculated assuming 0.5° mis-pointing of the receive antenna and 0.05° station-keeping of the interfering satellites. Tables A-2 to A-6 of Appendix A demonstrate that the T16 design described in this application is compatible with the aforementioned transmission parameters and interference environment. Accordingly, the proposed 17/24 GHz BSS payload would operate successfully in such an environment.

To properly account for interference from adjacent operating satellite systems, the uplink budgets include aggregate interference from earth terminals associated with satellites at 3.75º, 4.25º, 7.75º and 8.25º of orbit separation. On the uplink, the budgets include a level of interference that accounts for the maximum level of off-axis EIRP permissible under Section 25.223. On the downlink, the satellites at 3.75º, 4.25º, 7.75º

and 8.25º of orbit separation are each assumed to produce an interference level equivalent to the maximum PFD value permissible under Section 25.208(w) at that geographical location. In all cases it is shown that the system, as proposed, will be able to operate successfully in this interference environment. DIRECTV recognizes that it must accept any increased interference from compliant systems operating at adjacent orbital locations precisely 4º away from 103º W.L. that may result from operating T16 at a slight offset from nominal 103° W.L.

14.3 DBS Analysis

A representative link budget for DBS operation shall be provided at such time as DIRECTV requests authority for such operation.

15. 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. 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 102.70° 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 102.70° 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 two other systems have been licensed by the Commission for, and are currently operating within 0.2° of, the requested location for T16: T10 at 102.85° W.L. and T12 at 102.8º W.L. As the station keeping of each satellite will be maintained within ±0.025°, there will be no overlap of station keeping volumes of any of these satellites with each other, or with any other satellite.

With regard to ITU filings within ±0.2 degrees of the requested location for T16, the only satellite networks for which the ITU has published any information are USASAT-

70W and USABSN-12B. Both of these networks were submitted to the ITU by the United States on behalf of DIRECTV.

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,[19] 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

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

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

III. ITU COST RECOVERY

DIRECTV is aware that, as a result of the actions taken at the 1998 Plenipotentiary Conference, as modified by the ITU Council in 2005, processing fees are now charged by the ITU for satellite network filings. As a consequence, Commission applicants are responsible for any and all fees charged by the ITU. DIRECTV hereby states that it is aware of this requirement and accepts responsibility to pay any ITU cost recovery fees associated with this application. Invoices for such fees may be sent to the contact representative listed in the accompanying FCC Form 312.

IV. CONCLUSION

In summary, the satellite proposed in this application will provide DIRECTV with a highly capable spacecraft that will support a significant increase in the availability of high quality HD multichannel video programming for millions of Americans while at the same time providing in-orbit redundancy for DIRECTV's DBS capabilities. This new capability will advance the ongoing development of HD services, provide redundancy or replacement for DIRECTV's Ka-band, 17/24 GHz BSS band, and DBS operations and enhance DIRECTV's ability to offer a powerful alternative to incumbent cable operators. Due to the advanced design of the proposed satellite, DIRECTV will be able to provide these benefits without the allocation of any additional spectrum or orbital locations.

For these reasons, DIRECTV submits that the proposed satellite will serve the public interest and respectfully requests that the Commission expeditiously grant this application.

Respectfully submitted,

DIRECTV ENTERPRISES, LLC

By: */s/ Brian Regan*
Brian Regan
Vice President - Associate General Counsel

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/ Navid Motamed
Navid Motamed
Assistant Vice President – Satellite Systems Engineering

September 13, 2018
Date

APPENDIX A

T16 LINK BUDGET ANALYSIS

CONUS Ka-band	Clear Sky	Rain Dn
LABC Uplink		
Transmit power, dBW	2.6	8.6
Transmit losses, dB	-2.0	-2.0
Ground antenna gain, dB	66.7	66.7
Antenna pointing loss, dB	-0.5	-0.5
Free space loss, dB	-213.4	-213.4
Atmospheric loss, dB	-1.0	-1.0
Uplink rain loss, dB	0.0	-6.0
Satellite G/T, dB/K	21.0	21.0
Bandwidth, dB-Hz	-74.8	-74.8
Boltzmann's constant, dBW/Hz K	228.6	228.6
Uplink C/N (thermal) (dB)	**27.2**	**27.2**
Washington, DC		
Satellite EIRP, dBW/36 MHz	55.5	55.5
Free space loss, dB	-209.9	-209.9
Downlink rain loss, dB	N/A	-4.6
Atmospheric loss, dB	2.6	2.6
Rain temp increase, dB	0.0	-3.1
Rcv. antenna pointing loss, dB	-1.0	-1.0
Antenna wetting + noise increase, dB	0.0	-1.0
Ground G/T, dB/K	18.4	18.4
Bandwidth, dB-Hz	-74.8	-74.8
Boltzmann's constant, dBW/Hz K	228.6	228.6
Downlink C/N (thermal) (dB)	**19.4**	**15.3**
	Clear Sky	Rain Dn
Uplink C/N (thermal), dB	27.2	27.2
Downlink C/N (thermal), dB	19.4	15.3
Total inter and intra-system C/I, dB (incl. x-pol, ASI, ACI, ABI, TX E/S)	7.8	7.8
Total C/(N+I), dB	7.5	7.0
Required C/(N+I), dB (includes implementation margin)	4.7	4.7
Margin, dB	**2.8**	**2.3**

Table A-1. T16 Link Budget – Ka-band National Coverage

Reverse Band 102.70W	Miami	Clear Sky	Rain Up and Rain Dn
Uplink C/N (thermal), dB	Transmit power, dBW	2.2	7.2
Moxee, WA	Transmit losses, dB	1.2	1.2
	Ground antenna gain, dB	65.2	65.2
	Antenna pointing loss, dB	0.5	0.5
24.95 GHz	Free space loss, dB	211.5	211.5
	Atmospheric loss, dB	1.0	1.0
	Uplink rain loss, dB	0.0	5.0
	Satellite G/T, dB/K	21.4	21.4
	Bandwidth, dB-Hz	74.8	74.8
	Boltzmann's constant, dBW/Hz K	-228.6	-228.6
Uplink C/N (thermal)		28.4	28.4
	C/I (x-pol, NPR), dB	25.0	25.0
Total Uplink C/(N+I)		**23.4**	**23.4**
Downlink C/N (thermal),dB	Satellite EIRP, dBW/36 MHz	56.9	56.9
	Free space loss, dB	208.7	208.7
	Gaseous	0.4	0.4
	Cloud	0.6	0.6
	Scintillation	0.4	0.4
17.5 GHz	Downlink rain loss, dB	0.0	5.8
	Rain temp increase, dB	0.0	4.0
	Rain + Atmos Loss, dB	1.2	6.9
	Rcv. antenna pointing loss, dB	1.0	1.0
	Antenna wetting + noise increase, dB	0.0	1.0
	Ground G/T, dB/K	17.9	17.9
	Bandwidth, dB-Hz	74.8	74.8
	Boltzmann's constant, dBW/Hz K	-228.6	-228.6
Total Downlink C/N		**17.7**	**7.0**
Totals	Uplink C/N (thermal), dB	23.4	23.4
	Downlink C/N (thermal), dB	17.7	7.0
	x-pol interference, dB	20.0	20.0
	Aggregate C/I from ASI	16.6	16.6
	Aggregate C/I from TX E/S	29.6	29.6
	Adjacent Channel C/I, dB	25.0	25.0
	Co-frequency C/I, dB	99.0	99.0
	Total inter and intra-system C/I, dB (incl. x-pol, ASI, ACI, TX E/S)	**14.4**	**14.4**
	Total C/(N+I), dB	**12.4**	**6.2**
	Required C/(N+I), dB (includes implementation margin)	**4.7**	**4.7**
	Margin, dB	**7.7**	**1.5**

Table A-2. T16 Link Budget – Downlink to Miami

Reverse Band 102.70W	Chicago	Clear Sky	Rain Up and Rain Dn
Uplink C/N (thermal), dB	Transmit power, dBW	2.2	7.2
Moxee, WA	Transmit losses, dB	1.2	1.2
	Ground antenna gain, dB	65.2	65.2
	Antenna pointing loss, dB	0.5	0.5
24.95 GHz	Free space loss, dB	211.5	211.5
	Atmospheric loss, dB	1.0	1.0
	Uplink rain loss, dB	0.0	5.0
	Satellite G/T, dB/K	21.4	21.4
	Bandwidth, dB-Hz	74.8	74.8
	Boltzmann's constant, dBW/Hz K	-228.6	-228.6
Uplink C/N (thermal)		28.4	28.4
	C/I (x-pol, NPR), dB	25.0	25.0
Total Uplink C/(N+I)		**23.4**	**23.4**
Downlink C/N (thermal),dB	Satellite EIRP, dBW/36 MHz	54.9	54.9
Chicago	Free space loss, dB	208.8	208.8
	Gaseous	0.4	0.4
	Cloud	0.7	0.7
	Scintillation	0.5	0.5
17.5 GHz	Downlink rain loss, dB	0.0	2.9
	Rain temp increase, dB	0.0	3.3
	Rain + Atmos Loss, dB	1.3	4.0
	Rcv. antenna pointing loss, dB	1.0	1.0
	Antenna wetting + noise increase, dB	0.0	1.0
	Ground G/T, dB/K	17.9	17.9
	Bandwidth, dB-Hz	74.8	74.8
	Boltzmann's constant, dBW/Hz K	-228.6	-228.6
Total Downlink C/N		**15.6**	**8.5**
Totals	Uplink C/N (thermal), dB	23.4	23.4
	Downlink C/N (thermal), dB	15.6	8.5
	x-pol interference, dB	20.0	20.0
	Aggregate C/I from ASI	17.6	17.6
	Aggregate C/I from TX E/S	29.6	29.6
	Adjacent Channel C/I, dB	25.0	25.0
	Co-frequency C/I, dB	99.0	99.0
	Total inter and intra-system C/I, dB (incl. x-pol, ASI, ACI, TX E/S)	**15.0**	**15.0**
	Total C/(N+I), dB	**11.9**	**7.5**
	Required C/(N+I), dB (includes implementation margin)	**4.7**	**4.7**
	Margin, dB	**7.2**	**2.8**

Table A-3. T16 Link Budget – Downlink to Chicago

Reverse Band 102.70W	Los Angeles	Clear Sky	Rain Up and Rain Dn
Uplink C/N (thermal), dB	Transmit power, dBW	2.2	7.2
Moxee, WA	Transmit losses, dB	1.2	1.2
	Ground antenna gain, dB	65.2	65.2
	Antenna pointing loss, dB	0.5	0.5
24.95 GHz	Free space loss, dB	211.5	211.5
	Atmospheric loss, dB	1.0	1.0
	Uplink rain loss, dB	0.0	5.0
	Satellite G/T, dB/K	21.4	21.4
	Bandwidth, dB-Hz	74.8	74.8
	Boltzmann's constant, dBW/Hz K	-228.6	-228.6
Uplink C/N (thermal)		28.4	28.4
	C/I (x-pol, NPR), dB	25.0	25.0
Total Uplink C/(N+I)		**23.4**	**23.4**
Downlink C/N (thermal),dB	Satellite EIRP, dBW/36 MHz	52.9	52.9
Los Angeles	Free space loss, dB	208.8	208.8
	Gaseous	0.4	0.4
	Cloud	0.2	0.2
	Scintillation	0.3	0.3
17.5 GHz	Downlink rain loss, dB	0.0	1.6
	Rain temp increase, dB	0.0	2.1
	Rain + Atmos Loss, dB	0.8	2.2
	Rcv. antenna pointing loss, dB	1.0	1.0
	Antenna wetting + noise increase, dB	0.0	1.0
	Ground G/T, dB/K	17.9	17.9
	Bandwidth, dB-Hz	74.8	74.8
	Boltzmann's constant, dBW/Hz K	-228.6	-228.6
Total Downlink C/N		**14.1**	**9.5**
Totals	Uplink C/N (thermal), dB	23.4	23.4
	Downlink C/N (thermal), dB	14.1	9.5
	x-pol interference, dB	20.0	20.0
	Aggregate C/I from ASI	18.6	18.6
	Aggregate C/I from TX E/S	29.6	29.6
	Adjacent Channel C/I, dB	25.0	25.0
	Co-frequency C/I, dB	99.0	99.0
	Total inter and intra-system C/I, dB (incl. x-pol, ASI, ACI, TX E/S)	**15.5**	**15.5**
	Total C/(N+I), dB	**11.4**	**8.4**
	Required C/(N+I), dB (includes implementation margin)	**4.7**	**4.7**
	Margin, dB	**6.7**	**3.7**

Table A-4. T16 Link Budget – Downlink to Los Angeles

Reverse Band 102.70W	Honolulu	Clear Sky	Rain Up and Rain Dn
Uplink C/N (thermal), dB	Transmit power, dBW	2.2	7.2
Moxee, WA	Transmit losses, dB	1.2	1.2
	Ground antenna gain, dB	65.2	65.2
	Antenna pointing loss, dB	0.5	0.5
24.95 GHz	Free space loss, dB	211.5	211.5
	Atmospheric loss, dB	1.0	1.0
	Uplink rain loss, dB	0.0	5.0
	Satellite G/T, dB/K	21.4	21.4
	Bandwidth, dB-Hz	74.8	74.8
	Boltzmann's constant, dBW/Hz K	-228.6	-228.6
Uplink C/N (thermal)		28.4	28.4
	C/I (x-pol, NPR), dB	25.0	25.0
Total Uplink C/(N+I)		**23.4**	**23.4**
Downlink C/N (thermal),dB	Satellite EIRP, dBW/36 MHz	57.5	57.5
Honolulu	Free space loss, dB	209.3	209.3
	Gaseous	0.6	0.6
	Cloud	1.5	1.5
	Scintillation	0.9	0.9
17.5 GHz	Downlink rain loss, dB	0.0	7.3
	Rain temp increase, dB	0.0	4.7
	Rain + Atmos Loss, dB	2.3	9.4
	Rcv. antenna pointing loss, dB	1.0	1.0
	Antenna wetting + noise increase, dB	0.0	1.0
	Ground G/T, dB/K	23.2	23.2
	Bandwidth, dB-Hz	74.8	74.8
	Boltzmann's constant, dBW/Hz K	-228.6	-228.6
Total Downlink C/N		**21.9**	**9.1**
Totals	Uplink C/N (thermal), dB	23.4	23.4
	Downlink C/N (thermal), dB	21.9	9.1
	x-pol interference, dB	20.0	20.0
	Aggregate C/I from ASI	22.6	22.6
	Aggregate C/I from TX E/S	29.6	29.6
	Adjacent Channel C/I, dB	25.0	25.0
	Co-frequency C/I, dB	99.0	99.0
	Total inter and intra-system C/I, dB (incl. x-pol, ASI, ACI, TX E/S)	**17.0**	**17.0**
	Total C/(N+I), dB	**15.1**	**8.3**
	Required C/(N+I), dB (includes implementation margin)	**4.7**	**4.7**
	Margin, dB	**10.4**	**3.6**

Table A-5. T16 Link Budget – Downlink to Honolulu

Reverse Band 102.70W	San Juan PR	Clear Sky	Rain Up and Rain Dn
Uplink C/N (thermal), dB	Transmit power, dBW	2.2	7.2
Moxee, WA	Transmit losses, dB	1.2	1.2
	Ground antenna gain, dB	65.2	65.2
	Antenna pointing loss, dB	0.5	0.5
24.95 GHz	Free space loss, dB	211.5	211.5
	Atmospheric loss, dB	1.0	1.0
	Uplink rain loss, dB	0.0	5.0
	Satellite G/T, dB/K	21.4	21.4
	Bandwidth, dB-Hz	74.8	74.8
	Boltzmann's constant, dBW/Hz K	-228.6	-228.6
Uplink C/N (thermal)		28.4	28.4
	C/I (x-pol, NPR), dB	25.0	25.0
Total Uplink C/(N+I)		**23.4**	**23.4**
Downlink C/N (thermal),dB	Satellite EIRP, dBW/36 MHz	60.6	60.6
San Juan PR	Free space loss, dB	208.9	208.9
	Gaseous	0.2	0.2
	Cloud	0.2	0.2
	Scintillation	0.3	0.3
17.5 GHz	Downlink rain loss, dB	0.0	4.9
	Rain temp increase, dB	0.0	3.5
	Rain + Atmos Loss, dB	0.6	5.3
	Rcv. antenna pointing loss, dB	1.0	1.0
	Antenna wetting + noise increase, dB	0.0	1.0
	Ground G/T, dB/K	17.9	17.9
	Bandwidth, dB-Hz	74.8	74.8
	Boltzmann's constant, dBW/Hz K	-228.6	-228.6
Total Downlink C/N		**21.9**	**12.6**
Totals	Uplink C/N (thermal), dB	23.4	23.4
	Downlink C/N (thermal), dB	21.9	12.6
	x-pol interference, dB	20.0	20.0
	Aggregate C/I from ASI	20.3	20.3
	Aggregate C/I from TX E/S	29.6	29.6
	Adjacent Channel C/I, dB	25.0	25.0
	Co-frequency C/I, dB	99.0	99.0
	Total inter and intra-system C/I, dB (incl. x-pol, ASI, ACI, TX E/S)	**16.3**	**16.3**
	Total C/(N+I), dB	**14.6**	**10.8**
	Required C/(N+I), dB (includes implementation margin)	**4.7**	**4.7**
	Margin, dB	**9.9**	**6.1**

Table A-6. T16 Link Budget – Downlink to San Juan

APPENDIX B

TT&C LINK BUDGETS

Telemetry Link Analysis - On Station		
S/C altitude (km)	35786	35786
G/S elevation (deg)	44	45
S/C antenna	TM Horn	TM Horn
S/C coverage	Over G/S	Over G/S
Link Availability (%)	99.9	99.9
Ground Station	LABC	CRBC
TX Output power (W)	0.5	0.5
S/C EIRP (dBW)	12	12
G/T at ground station (dBK)	37.5	37.5
G/T degradation due to rain (dB)	3.1	2.6
Predetection C/No (dB-Hz)	69.5	69.0
Acquisition margin (dB)	28.2	28.5
TM margin (dB)	13.9	14.1

Table B-1. On-Station Telemetry Link Budget

Command Link Analysis - On Station		
S/C altitude (km)	35786	35786
G/S elevation (deg)	44	45
S/C antenna	TC Horn	TC Horn
S/C coverage	Over G/S	Over G/S
Link Availability (%)	99.9	99.9
Ground Station	LABC	CRBC
G/S EIRP (dBW)	88	88
Atmospheric losses (dB)	3.6	3.0
S/C flux density (dBW/m^2)	-78	-77.5
RX input power (dBW)	-121.2	-120.5
Predetection C/No (dB-Hz)	76	75.2
Receiver threshold (@1 kbps) (dB-Hz)	56.9	56.9
Acqu Command margin (dB)	18.4	19.1

Table B-2. On-Station Command Link Budget