ECHOSTAR-10

ATTACHMENT A

Technical Information to Supplement Schedule S

A.1 Scope

This attachment contains the following information:

(i) Information required by §25.114(d) that is not expected to be included in the associated Schedule S submission (See Sections A.2, A.3, A.4, A.8, A.9 and A.10 below);

(ii) Information required by §25.114(c) and other sections of the FCC §25 rules that cannot be entered into the Schedule S software used to prepare the associated Schedule S submission (See Sections A.5, A.6 and A.7);

(iii) Technical waiver requests, including necessary justification (See Section A.11);

(iv) Additional comments relating to the data provided in the associated Schedule S submission (see Section A.12).

A.2 General Description of Overall System Facilities, Operations and Services (§25.114(d)(1))

The ECHOSTAR-10 satellite will operate at the 110°W.L. orbital location and has the capability to provide BSS services to the USA, including Alaska and Hawaii, as well as to Puerto Rico and Cuba. The satellite operates in the 17.3-17.8 GHz BSS feeder uplink band (ITU Appendix 30A) and the 12.2-12.7 GHz BSS downlink band (ITU Appendix 30), using a subset of the channels licensed by the Commission to EchoStar at this orbital location.

Spot beams are used on both uplink and downlink to provide a high level of frequency reuse and satellite power efficiency, and to permit broadcasting of specific programming into restricted geographic areas. There are six separate uplink spot beams pointed towards six separate locations within CONUS, as well as four uplink spot beams pointed to geographic areas outside of CONUS (Alaska, Hawaii, Puerto Rico and Cuba).[1] There are 49 distinct downlink beams, consisting of 45 spot beams covering different parts of CONUS, and individual beams covering Alaska, Hawaii, Puerto Rico and Cuba. The assignment of uplink channels to the different uplink beams has been made in order to permit the ECHOSTAR-10 satellite to be collocated in the future at the 110°W.L. nominal orbital position with other existing EchoStar satellites that operate uplinks only from the Cheyenne and Gilbert feeder link earth stations.

Ten downlink channels and 27 uplink channels are used by the ECHOSTAR-10 satellite. Using 42 active TWTAs, each of 140 Watts saturated power capability, the satellite supports the simultaneous transmission of 123 independent signal transmission chains, each of nominally 24 MHz bandwidth.[2,3,4] Based on this, the satellite achieves an average spatial frequency reuse factor of 12.3 for the downlink frequencies and 4.55 for the uplink frequencies. This is in addition to the two-fold frequency reuse factor inherent in the use of dual orthogonal circular polarization as prescribed by the ITU Region 2 BSS Plan.

EchoStar will add four feeder link earth station facilities in CONUS to complement its existing uplink facilities in Cheyenne, WY and Gilbert, AZ. These will be located in the following U.S. cities: Mount Jackson (VA), Monee (IL), Spokane (WA) and New Braunfels (TX). These locations have been selected to achieve the spatial isolation necessary to permit the uplink

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[1] EchoStar is <u>not</u> requesting authority to operate the beam covering Cuba, and will not do so until and unless all required approvals for such operation by the U.S. Government, including the Commission, have been requested and obtained.

[2] Each channel is nominally 24 MHz bandwidth, with 29.16 MHz channel center frequency spacing, consistent with the ITU Appendix 30 and 30 A BSS Plans. However, note that the transponder useful bandwidth is actually greater than 24 MHz (approximately 26 MHz) which permits the transmission of signals with occupied bandwidth slightly in excess of 24 MHz. See also Section A.4.2.

[3] Nine of these signal transmission chains downlink the same signals into two separate spot beams, making a total of 132 beam-channel signal paths.

[4] The associated Schedule S shows 137 possible transponders, which includes five alternate signal connectivities for certain channels downlinking into the non-CONUS beams (see Section A.12.2).

frequency reuse. In addition there may be uplink earth stations outside of CONUS, in each of the other four uplink beams that serve Alaska, Hawaii, Puerto Rico and Cuba.[5,6]

Spacecraft TT&C functions will take place from EchoStar's primary TT&C earth station and satellite control facility located in Cheyenne, WY and the back-up facility located in Gilbert, AZ.

A.3 Predicted Space Station Antenna Gain Contours (§25.114(d)(3))

The ECHOSTAR-10 antenna gain contours for the receive and transmit beams, as required by §25.114(d)(3), are given in GXT format and embedded in the associated Schedule S submission.[7] Note that this consists of the following:

- Specific co-polar gain contours for all ten receive beams;
- Specific co-polar gain contours for all 49 transmit beams, including 45 that serve CONUS and the four non-CONUS beams (i.e., Alaska, Hawaii, Puerto Rico and Cuba).

The GXT data files that form part of the ITU submission for ECHOSTAR-10 are provided as a separate attachment to this application.

A.4 Services to be Provided (§25.114(d)(4))

The ECHOSTAR-10 high powered spot-beam satellite will provide a range of DBS services to millions of small and inexpensive subscriber receive-only earth terminals.

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5 EchoStar will apply for all necessary earth station licenses for U.S. feeder link earth stations in due course.

6 EchoStar's primary feeder link earth stations will be located in CONUS. However, the ECHOSTAR-10 satellite design also permits programming to be uplinked from the non-CONUS beams, rather than back-hauling the signals to the CONUS feeder link sites. Therefore, uplinks from outside CONUS may also be utilized in the future. In the case of the Cuba spot beam, this will not occur unless EchoStar requests and receives prior Commission and other approval.

7 All beams operate in both LHC and RHC polarization. Only one GXT file is provided for each beam and this applies to both senses of polarization.

There will be one wideband digitally modulated signal transmitted in each of the active transponders, supporting a range of information data rates depending on the order of the modulation (e.g., QPSK, 8PSK) and the type and degree of FEC coding used.

Representative link budgets, which include details of the transmission characteristics, performance objectives and earth station characteristics, are provided in the associated Schedule S submission, and further described in Section A.4.2 below.

A.4.1 Earth Stations

The subscriber receive-only earth stations to be used with the ECHOSTAR-10 satellite will have effective antenna diameters in the range 45 to 90 cm, depending on a variety of factors such as rain zone, availability requirements, location in CONUS, and the number of EchoStar satellites simultaneously being received. There will be millions of these types of terminals across the service areas. The feeder uplink earth stations (main and back-up) will typically use a 13 meter antenna, although possible future uplinks from the non-CONUS beams may use antennas as small as 6 meters.

A.4.2 Link Budgets

Three representative modulation/coding schemes are provided in the associated Schedule S submission, as follows:

a) QPSK, DVB-S rate 3/4 inner coding

b) QPSK, DVB-S rate 5/6 inner coding

c) 8PSK, Turbo rate 2/3 inner coding

Each of these schemes has its associated bandwidth and power efficiencies as given in the Schedule S.

Representative link budgets for all of the above schemes are provided as attachments embedded in the Schedule S. The following notes provide additional explanation of these link budgets:

- Each link budget table is for one of the three modulation/coding schemes listed above.[8]

- There are multiple columns in each table showing different example link budgets in the various downlink beams (three for CONUS and one for each of the four non-CONUS beams).

- Each column shows the link performance under both clear sky and rain-faded downlink conditions.

- The uplink is operated with both UPC (Uplink Power Control) at the feeder link earth station and satellite ALC (Automatic Level Control), so the effects of any uplink rain fade are minimized. Also, the link budgets are all shown for the case of an uplink from the Cheyenne feeder link earth station, as the results for the other possible uplink beams and uplink sites are approximately the same. The reason for this is that the satellite G/T is designed to be approximately 8 dB/K and the operating flux density (for the same transponder gain setting) is designed to be approximately -86 dBW/m^2 towards all the candidate uplink sites in the different satellite receive beams.

- Each satellite TWTA transmits several distinct RF channels and therefore always operates in a multi-carrier, linear, backed-off mode, and never at saturation. This allows some adjustment of beam downlink EIRP by varying the uplink drive level on a channel, although the maximum EIRP level for each downlink beam given in the associated Schedule S submission will not be exceeded. The link budgets therefore show representative EIRP levels as currently foreseen for the operation of the satellite in the various downlink beams operating in different rain climatic zones in CONUS, with examples of downlinks in the states of Florida, New York and California within CONUS. Similar examples are given for the non-CONUS downlink spot beams.

- The link budgets include a significant intra-system C/I allowance of between 11 and 14 dB for the CONUS downlinks, which reflects the relatively high levels of intra-system

[8] The QPSK emissions have an occupied bandwidth of 24.0 MHz. The 8PSK emission has an occupied bandwidth of 25.8 MHz, which can be accommodated within the useful bandwidth of the channel filters.

interference arising from the spatial frequency reuse as well as interference from other sources, including other adjacent DBS satellite networks. The exact C/I value varies from beam to beam and for the different locations within the service area of a beam.

- Subscriber earth terminals with effective antenna diameters in the range 45 cm (~18 inches) to 60 cm (~24 inches) are shown in the representative link budgets. In practice, terminals anywhere within this range, or larger (up to 90 cm effective antenna diameter), may be used.

A.5 TT&C Characteristics (§25.114(c)(4)(i) and §25.114(c)(9))

The information provided in this section complements that provided in the associated Schedule S submission.

The ECHOSTAR-10 TT&C sub-system provides for communications during pre-launch, transfer orbit and on-station operations, as well as during spacecraft emergencies. The TT&C sub-system will operate at the edges of the uplink and downlink frequency ranges during all phases of the mission.

During transfer orbit and on-station emergencies the TT&C signals will be received and transmitted by the satellite using a combination of antennas on the satellite that create a near omni-directional gain pattern. During normal on-station operation the TT&C signals will be received and transmitted via an Earth-coverage horn antenna on the Earth (+Z) face of the spacecraft.

A summary of the TT&C subsystem characteristics is given in Table A5-1.

Table A5-1: TT&C Performance Characteristics

Command Modulation	PCM/FSK
Command/Ranging Frequencies	17,304.0 MHz 17,306.0 MHz

Uplink Flux Density	Between -80 and -60 dBW/m^2
Satellite Receive Antenna Types	Pseudo-omni antenna during transfer orbit and on-station emergencies; Earth coverage horn antenna during on-normal on-station mode.
Polarization of Satellite Receive Antennas	HP for pseudo-omni antenna; VP for Earth-coverage horn antenna.
Peak Deviation (Command/Ranging)	± 400 kHz
Telemetry/Ranging Frequencies	12,201.0 MHz 12,696.5 MHz 12,699.5 MHz
Satellite Transmit Antenna Types	Pseudo-omni antenna during transfer orbit and on-station emergencies; Earth coverage horn antenna during on-normal on-station operations.
Polarization of Satellite Transmit Antennas	VP for all antennas
Maximum Downlink EIRP	13 dBW (pseudo-omni antenna); 27 dBW (Earth-coverage horn antenna).
Telemetry/Ranging Modulation Index:	
1 sub-carrier	1.0
2 sub-carriers	0.7
3 sub-carriers	0.6

A.6 Satellite Transponder Frequency Responses (§25.114(c)(4)(vii))

The predicted worst case receive and transmit channel filter response performance is given in Table A6-1 below. The receive response is measured from the satellite receive antenna up to the input of the TWTA. The transmit response is measured from the input of the TWTA to the satellite transmit antenna.

Table A.6-1 - Typical Receiver and Transmitter Filter Responses

Frequency offset from channel center	Gain relative to channel center frequency (dB)		Comments
	Receive	Transmit	
CF±5 MHz	0.55	0.73	In-Band

CF±7 MHz	0.80	0.94	Value does not exceed these p-p values
CF±9 MHz	1.11	1.35	
CF±11 MHz		2.73	
CF±12 MHz	1.84	3.56	
CF±13 MHz	2.47		
CF±18 MHz	-12.00	0.0	Out-of-Band Attenuation is not less than these values
CF±21 MHz	-33.00	-1.0	
CF±27 MHz	-38.00	-10.0	

A.7 Cessation of Emissions (§25.207)

Each active satellite transmission chain (channel amplifiers and associated TWTA) can be individually turned on and off by ground telecommand, thereby causing cessation of emissions from the satellite, as required.

A.8 Interference Analyses (§25.114(d)(13))

The analyses of the proposed ECHOSTAR-10 satellite network with respect to the limits in Annex 1 to Appendices 30 and 30A are given in Appendices 1 and 2 to this document. The results of these analyses are discussed below.

Appendix 1 shows that the proposed ECHOSTAR-10 satellite network meets the ITU criteria in Annex 1 to Appendix 30, and so no coordination is required, except for the following cases:

- The MSPACE analysis results with respect to non-U.S. networks are given in Section 2 and Annex 1 of Appendix 1. The only affected foreign administrations are Argentina, Canada, France, the United Kingdom, the Netherlands and Mexico. None of the OEPM degradations are more than 1.0 dB greater than the allowed 0.25 dB except for the United Kingdom and the Netherlands filings at 105.5°W and 114°W respectively. These two filings would be expected to produce such results due to their close orbital separation from the U.S. 110°W orbital location. Regarding the cases where the OEPM exceedence is less than 1 dB it is likely that the agreement of the affected Administrations can be achieved, if necessary, through coordination.

- Section 4 of Appendix 1 indicates a minor pfd exceedence of the Alaska beam over a small part of Russian territory. This is often a problem with U.S. DBS satellites due to the geometry of the look angles to Alaska. It is likely that the agreement of Russia can be obtained if necessary through coordination.

Appendix 2 shows that the proposed ECHOSTAR-10 satellite network meets all of the ITU criteria in Annex 1 to Appendix 30A.

The closest adjacent U.S. licensed DBS satellites to the 110°W.L. orbital position are 9° away at 119°W.L. and 101°W.L.. This wide orbital spacing ensures that interference into these networks will not be a problem. In this regard it should be noted that the highest spot beam peak EIRP of the ECHOSTAR-10 satellite is 63.9 dB, which is only 1.7 dB higher than the ECHOSTAR-8 satellite that is currently operational at the 110°W.L. orbital position.

A.9 ITU Filing for ECHOSTAR-10 (§25.114(d)(13))

All materials related to the ITU filing for ECHOSTAR-10 (to be filed as "USABSS-26" network name) are attached to this application. These consist of the following:

- SpaceCap database file (USABSS-26.mdb) containing the data required by the ITU as stated in Appendix 4 of the Radio Regulations.
- Contour data files in .gxt format for all transmit and receive beams to be filed, including both co-polar and cross-polar. These are combined into a single database file (BSS26GXT.mdb) that can be read by ITU software (e.g., GIMS and MSPACE).

- Diagrams of the gain towards the geostationary orbit in .gxt format for receive beams to be filed. These are combined into a single database file (BSS26GSO.mdb) that can be read by ITU software (e.g., GIMS).
- Description in WORD document format of the various service areas (BSS26_SA.doc).

A.10 Orbital Debris Mitigation Plan (§25.114(d)(14))

EchoStar has assessed and limited the amount of debris released during normal operations. The satellite was designed to minimize debris generated after separation from the launch vehicle and to cause no debris during normal on-station operations. All pyrotechnic devices onboard the satellite have been designed to retain all physical debris. With its satellite contractor, EchoStar assessed and limited the probability of the space station becoming a source of debris by collisions with small debris or meteoroids smaller than one centimeter in diameter that could cause loss of control and prevent post-mission disposal. The possibility of collisions with small debris and meteoroids was taken into account as part of the satellite design. EchoStar has taken steps to limit the effects of such collisions through the use of shielding, the placement of components, and the use of redundant systems. In addition, all sources of stored energy are located within the body of the spacecraft, thereby providing protection from small orbital debris.

EchoStar has assessed and limited the probability of accidental explosions during and after completion of mission operations. The satellite was designed to ensure that debris generation does not result from the conversion of energy sources on board the satellite into energy that fragments the satellite. The propulsion subsystem pressure vessels have been designed to provide high safety margins. EchoStar and its satellite manufacturer, Lockheed Martin, have limited the probability of accidental explosions during mission operations by means of a failure mode verification analysis. All pressures, including those of the batteries, will be monitored by telemetry. At end-of-life and once the satellite has been placed into its final disposal orbit, all on-board sources of stored energy will be depleted, the batteries will be discharged and all fuel line valves will be left opened.

In considering current and planned satellites that may have a station-keeping volume that overlaps the ECHOSTAR-10 satellite, EchoStar has reviewed the lists of FCC licensed satellite networks, as well as those that are currently under consideration by the FCC. In addition, non-USA networks for which a request for coordination has been submitted to the ITU in the vicinity of 110°W.L. have also been reviewed. Only those networks that either operate, or are planned to operate, and have an overlapping station-keeping volume with the ECHOSTAR-10 satellite, have been taken into account in the analysis. For purposes of calculating potential station-keeping volume overlap, US satellites have been assumed to have a maximum east-west excursion of ±0.05° from their nominal location, while non-US satellite networks have been assumed to have a maximum excursion of ±0.1° from their nominal location.

Currently there are four operational US licensed satellites within ±0.5° of 110°W.L. These are as follows:

- DIRECTV 6 satellite at 109.5°W.L., launched in 1997.
- ECHOSTAR 6 satellite at 110.2°W.L., launched in 2000.
- ECHOSTAR 8 satellite at 110.0°W.L., launched in 2002.
- DIRECTV 5 satellite at 109.8°W.L., launched in 2002.

None of these satellites in their current locations have overlapping station-keeping volumes with respect to the 110.0°W.L. orbital position.

When the ECHOSTAR-10 satellite is launched it will be located at 110.0°W.L.

The only non-US ITU filing with a station-keeping volume that would overlap that of ECHOSTAR-10 is a UK filed network on behalf of Intelsat (INTELSAT V-B 250E) at 110°W.L. We can find no evidence that this satellite is under construction or scheduled to be launched. EchoStar will continue to monitor this situation and contact Intelsat if plans for the INTELSAT V-B 250E satellite are progressed. EchoStar will ensure that all necessary physical coordination with Intelsat takes place to ensure there is no risk of collision between the proposed ECHOSTAR-10 and INTELSAT V-B 250E satellites.

EchoStar therefore concludes that physical coordination of the ECHOSTAR-10 satellite is currently required only with respect to the current operations of EchoStar and DIRECTV in the close proximity of the 110°W.L. orbital position. EchoStar already coordinates in this way with DIRECTV for the current fleets of satellites and will continue to do so with respect to the introduction of ECHOSTAR-10.

At the end of the operational life of the EchoStar-10 satellite, EchoStar will maneuver the satellite to a disposal orbit with a minimum perigee of 330 km above the normal GSO operational orbit, which is higher than the minimum derived from the calculation required in §25.283:

Solar array area = 74 m^2

Satellite body area (oriented for max antenna exposure) = 6 m^2

Uplink/Downlink antenna area = 20 m^2

Total Solar Pressure Area "A" = 100 m^2

"M" = Dry Mass of Satellite = 2165 kg

"C_R" = Solar Pressure Radiation Coefficient (worst case) = 2

Therefore the Minimum Disposal Orbit Perigee Altitude:

= 36,021 km + 1000 x C_R x A/m

= 36,021 km + 1000 x 2 x 100/2165

= 36,113.38 km

= 327 km above GSO (35,786 km)

Adequate margin has already been accounted for in the calculation of the designed disposal orbit of 330 km, which includes margin relative to the above calculation. This will require approximately 14 kg of propellant that will be reserved, taking account of all fuel measurement uncertainties, to perform the final orbit raising maneuvers.

A.11 Waivers Requested

A.11.1 Cross-Polar Isolation of the Satellite Antennas (§25.210(i) and §25.215)

Section S7 of the associated Schedule S submission states that the minimum cross-polar isolation is in the range 24.6 to 29.7 dB for the satellite receive antennas and in the range 28.3 to 30.0 dB for the satellite transmit antennas.[9] This is less than the 30 dB requirement stated in §25.210(i) (for the FSS) and §25.215 (for the BSS). However, this is not a problem for the following reasons:

(i) For the ECHOSTAR-10 receive antennas the non-compliance in cross-polar isolation only impacts the levels of potential interference from other feeder uplinks into the ECHOSTAR-10 uplinks. The non-compliance results in negligible levels of additional interference into ECHOSTAR-10 compared to the other link degradations, and this effect has already been factored into the link budgets given in the associated Schedule S submission.

(ii) The 1.7 dB shortfall in cross-polar isolation of the ECHOSTAR-10 transmit antennas creates an insignificant amount of additional self-interference into the ECHOSTAR-10 network, which has already been factored into the link budgets given in the associated Schedule S submission.

(iii) The 1.7 dB shortfall in cross-polar isolation of the ECHOSTAR-10 transmit antennas creates an insignificant amount of additional downlink interference to adjacent co-frequency DBS satellites operating 9° away in the geostationary orbit. This is because the overall interference isolation of adjacent satellites is dominated by the receive earth station antenna off-axis discrimination for co-polar signals, and the contribution from the cross-polar component is negligible. 28.3 dB cross-polar isolation will

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[9] Note that the worst-case cross-polar isolation for the any of the transmit antennas serving U.S. territory is 28.8 dB which is 0.5 dB higher than the minimum stated above.

increase the adjacent satellite interference by approximately 0.002 dB compared to the case where the cross-polar isolation is 30 dB.

(iv) At the 110°W.L. orbital position channels 28, 30 and 32 are licensed to DIRECTV. These operate cross-polar to the EchoStar channels (27, 29 and 31). Therefore the 1.7 dB shortfall in the cross-polar isolation of the ECHOSTAR-10 transmit antennas does have a minor impact on the cross-polar interference into these DIRECTV channels, but this is negligible as shown below.

The cross-polar interference from the same or collocated satellite is dependent on the combined cross-polar isolation factors of the satellite transmit and the earth station receive antennas. The latter is likely to be in the region of 25 dB (see ITU-R Rec. BO.1213). This factor therefore dominates the cross-polar interference. The 1.7 dB shortfall in the cross-polar isolation of the ECHOSTAR-10 transmit antennas will therefore result in a 0.47 dB reduction in the cross-polar interference received by DIRECTV, and still give a C/I level in excess of 23.3 dB. This is significantly higher than other likely link degradation effects, including other interference sources. Therefore we can conclude that the 1.7 dB shortfall has negligible effect in terms of additional interference into channels 28, 30 and 32 of the DIRECTV satellite at the 110°W.L. orbital position.

A.12 Additional Information Concerning Certain Data in the Associated Schedule S

A.12.1 Space Station Antenna Beam Characteristics (S7)

For all the communications downlink beams a value of 2.1 dB is assigned to parameter S7.k (Xmit Input Losses). This value, combined with the actual Peak Gain (S7.c) and the stated Xmit Effective Output Power (S7.l), gives the actual Xmit Max EIRP (S7.m). However, in practice the value of the S7k parameter will vary (typically over the range 1.6 to 2.6 dB) depending on the redundancy switching and beam configuration, and the value of 2.1 dB has been used as a mid-range value. This simplification by using a constant value of 2.1 dB does not in any way affect the accuracy of the important data, which is the maximum downlink EIRP per beam (S7.m).

This approach is further justified by the fact that each TWTA is shared between several transponders, and operates in a multi-carrier backed-off mode, so that the individual power that can be delivered to each spot beam (S7.l) is adjustable within certain bounds by means of varying the uplink drive level per carrier.

A.12.2 Space Station Transponders (S10)

137 separate communications transponders are shown in the Schedule S. All of these can be simultaneously operated with the following exceptions:

- Transponder ID 133 is an alternate configuration to transponder ID 011. They both use channel 26 to downlink in beam 46 (Alaska);
- Transponder IDs 134 and 135 are alternate configurations to transponder IDs 016 and 017. They both use channels 23 and 25, respectively, to downlink in beam 47 (Hawaii);
- Transponder ID 136 is an alternate configuration to transponder ID 013. They both use channel 29 to downlink in beam 48 (Puerto Rico);
- Transponder ID 137 is an alternate configuration to transponder ID 012. They both use channel 27 to downlink in beam 48 (Cuba).

Note that this results in a maximum of 132 simultaneously active transponders. Of these, nine transponders are transmitting the same signal to two downlink spot beams, leaving a total of 123 independent signal transmission chains.

CERTIFICATION OF PERSON RESPONSIBLE FOR PREPARING ENGINEERING INFORMATION

I hereby certify that I am the technically qualified person responsible for preparation of the engineering information contained in this application, that I am familiar with Part 25 of the Commission's rules, that I have either prepared or reviewed the engineering information submitted in this application and that it is complete and accurate to the best of my knowledge and belief.

_________/s/_________

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