ECHOSTAR-23

ATTACHMENT A

Technical Information to Supplement Schedule S

A.1 Scope

This attachment contains the information required by § 25.114(c) and other sections of Part 25 of the Commission's rules that cannot be entered into the Schedule S form.

A.2 General Description of Overall System Facilities, Operations and Services

The ECHOSTAR-23 satellite will operate at the 72.6° W.L. nominal orbital location and will provide Broadcasting-Satellite Service ("BSS") service to the contiguous United States ("CONUS"). Feeder link transmissions are received by a spot beam centered over EchoStar's feeder link earth station facilities located in Gilbert, AZ. The satellite will operate under two Canadian ITU networks filed at 72.7° W.L.: CAN-BSS3 and CAN-BSS6. Commission authorization is currently being sought to operate at a maximum downlink EIRP of 53 dBW. This level is in keeping with the downlink parameters of the Canadian ITU networks.

The ECHOSTAR-23 satellite operates within 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). The channel center frequencies are identical to those prescribed by the ITU's Region 2 BSS Plan. Full frequency re-use is achieved through the use of dual orthogonal polarizations. The bandwidth of each channel is 24 MHz.

Spacecraft Telemetry, Tracking and Control ("TT&C") functions will take place from FCC-authorized, fully redundant TT&C earth station and satellite control facilities located in Cheyenne,

WY and Gilbert, AZ. TT&C transmissions occur at the edges of the 17.3-17.8 GHz uplink band and 12.2-12.7 GHz downlink band.

A.3 Predicted Space Station Antenna Gain Contours

The ECHOSTAR-23 satellite's antenna gain contours for the receive and transmit beams are provided in GXT format and embedded in the associated Schedule S submission. The beams used for TT&C operations have gain contours that vary by less than 8 dB below peak across the surface of the visible Earth. Therefore, gain contours for these beams (beams CMDR, CMDL and TLM) have not been included in the associated Schedule S form.

A.4 TT&C Characteristics

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

The ECHOSTAR-23 TT&C sub-system provides for communications during on-station operations, as well as during spacecraft emergencies. For on-station emergencies the TT&C signals are received and transmitted by the satellite using a combination of wide-angle antennas on the satellite that create a near omni-directional gain pattern. For normal on-station operation, the TT&C signals are received and transmitted by the satellite using large-coverage horn antennas.

There are two primary command receivers: one operating at 17.791 GHz and the other at 17.305 GHz. In addition, there is one "flex" receiver that can be tuned in 500 kHz steps anywhere within the 17.300 - 17.310 GHz band by ground command. Telemetry operates either at 12.207 GHz or 12.208 GHz. There is also a "flex" transmitter that can be tuned in 500 kHz steps anywhere within the 12.200 - 12.210 GHz band by ground command.

A summary of the TT&C subsystem is given in Table A.4-1.

Table A.4-1: Summary of the TT&C Subsystem

Command/Ranging Frequencies	17,791 MHz (RHCP) 17,305 MHz (LHCP) 17,300 - 17,305 MHz (LHCP) 17,305 - 17,310 MHz (LHCP)
Uplink Flux Density (Threshold)	-93 dBW/m^2 (Command) -87 dBW/m^2 (Ranging)
Telemetry/Ranging Frequencies	12,207 MHz (LHCP) 12,208 MHz (LHCP) 12,200 - 12,205 MHz (LHCP) 12,205 - 12,210 MHz (LHCP)
Maximum Downlink EIRP	14.8 dBW

A.5 Orbital Debris Mitigation Plan

A.5.1 Spacecraft Hardware Design

Space Systems/Loral ("Loral") is the manufacturer of the ECHOSTAR-23 satellite. Loral has determined that no debris will be released by the spacecraft throughout its remaining lifetime.

To protect the spacecraft from small body collisions, including debris less than one centimeter in diameter, the design of the ECHOSTAR-23 spacecraft allows for individual faults without losing the entire spacecraft. All critical components are built within the structure and shielded from external influences. Items that cannot be built within the spacecraft nor shielded (such as antennas) are either redundant or are able to withstand impact. The ECHOSTAR-23 spacecraft can be controlled through both the large-coverage horn antenna and the wide-angle antennas. The likelihood of all antennas being damaged during a small body collision is minimal.

The ECHOSTAR-23 satellite has TT&C and propulsion subsystems that are necessary for end-of-life disposal. The spacecraft TT&C system is extremely rugged with regard to meteoroids smaller than 1 cm, by virtue of its redundancy, shielding, separation of components and physical characteristics. The command receivers and decoders and telemetry encoders and transmitters are

located within a shielded area are redundant and physically separated. A single main satellite thruster and shielded propellant tank provided the energy for orbit raising. Otherwise, there are no single points of failure in the system.

A.5.2 Accidental Explosion Assessment

Loral has reviewed failure modes for all equipment to assess the possibility of an accidental explosion onboard the spacecraft. In order to ensure that the spacecraft does not explode on orbit, the satellite controller will take specific precautions. All batteries and fuel tanks are monitored for pressure or temperature variations. Alarms in the Satellite Control Center ("SCC") inform controllers of any variations. Additionally, long term trending analysis is performed to monitor for any unexpected trends.

Operationally, batteries are operated utilizing the manufacturer's automatic recharging scheme. Doing so ensures that charging terminates normally without building up additional heat and pressure. As this process occurs wholly within the spacecraft, it also affords protection from command link failures.

In order to protect the propulsion system, fuel tanks will all be operated in a blow down mode. At the completion of orbit raising, the pressurant was isolated from the fuel system. This causes the pressure in the tanks to decrease over the life of the spacecraft. This also protects against a pressure valve failure that might otherwise cause the fuel tanks to become over pressurized.

In order to ensure that the spacecraft has no explosive risk after it has been successfully de-orbited, all stored energy onboard the spacecraft will be removed. Upon successful de-orbit of the spacecraft, all propulsion lines and latch valves will be vented and left open. All battery chargers will be turned off and batteries will be left in a permanent discharge state. These steps will ensure that no buildup of energy can occur resulting in an explosion in the years after the spacecraft is de-orbited.

A.5.3 Safe Flight Profiles

In considering current and planned satellites that may have a station-keeping volume that overlaps the ECHOSTAR-23 satellite, EchoStar has reviewed the lists of FCC-licensed satellite networks that are located within ±0.15 degrees of 72.6° W.L., as well as those that are currently under consideration by the FCC. In addition, submissions to the ITU for a network located within ±0.15 degrees of 72.6° W.L. have also been reviewed.

Telesat Canada operates the NIMIQ 5 satellite at 72.7° W.L. and with an east-west station-keeping tolerance of ±0.05°.[1]

There are no pending applications before the Commission for a satellite to be located at an orbital location in the immediate vicinity of 72.6° W.L. With respect to ITU networks, EchoStar is not aware of any satellite with an overlapping station-keeping volume with the ECHOSTAR-23 satellite that is the subject of an ITU filing and that is either in orbit or progressing towards launch.

Based on the preceding, EchoStar seeks to locate the ECHOSTAR-23 satellite at 72.6° W.L. and operated with an east-west station-keeping tolerance of ±0.05°. This eliminates the possibility of any station-keeping volume overlap with the NIMIQ 5 satellite. EchoStar concludes there is no requirement to physically coordinate the ECHOSTAR-23 satellite with another satellite operator at the present time.

A.5.4 Post Mission Disposal Plan

At the end of the operational life of the ECHOSTAR-23 satellite, EchoStar will maneuver the satellite to a disposal orbit with a minimum perigee of 340 km above the normal GSO operational

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[1] *See* SES-MFS-20090306-00253.

orbit. This proposed disposal orbit altitude exceeds the minimum required by §25.283, which is calculated below.

The input data required for the calculation is as follows:

Total Solar Pressure Area "A" = 121.1 m^2

"M" = Dry Mass of Satellite = 2613.2 kg

"C_R" = Solar Pressure Radiation Coefficient = 2

Using the formula given in §25.283, the Minimum Disposal Orbit Perigee Altitude is calculated as follows:

= 235 km + 1000 x C_R x A/m

= 235 km + 1000 x 2 x 121.1/2613.2

= 327.7 km above GSO (35,786 km)

Maneuvering the satellite to the disposal orbit will require 15.9 kg of propellant, and this quantity of fuel, taking account of all fuel measurement uncertainties, will be reserved to perform the final orbit raising maneuvers.

EchoStar will apply all available propellant accounting methodologies to track propellant usage. For the ECHOSTAR-23 satellite, these methodologies include the bookkeeping method, the pressure-volume-temperature ("PVT") method, and the propellant depletion gauge operations ("PDGO") method.

The bookkeeping method, whereby the estimated propellant used during a thruster-firing event is subtracted from the beginning of life propellant mass, will be applied after every thruster-firing event. The PVT method, which uses current state pressure and temperature telemetry received from the satellite to estimate the remaining propellant, will be applied once a month. The PDGO method uses propellant temperature measurements taken while tank heaters are activated to determine more accurately the amount of oxidizer and fuel in tanks at the end of mission life. The

PDGO method will be applied annually until propellant analysis shows 60 kg or less propellant remaining, after which the PDGO method will be applied after every north-south station-keeping maneuver. Combined, these methods will ensure the necessary amount of fuel is reserved to perform deorbit procedures as well as maximize fuel depletion when the ECHOSTAR-23 satellite reaches its disposal orbit.

.5.4.1 Interference Analyses

The analyses of the ECHOSTAR-23 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 analyses performed for the various Appendix 30/30A limits showed that no networks are affected except for four Region 2 BSS networks where the OEPM limits are exceeded.

The results of the MSPACE analysis for the ECHOSTAR-23 satellite network are contained in Annex 1 to Appendix 1. Four adjacent Region 2 BSS networks are deemed to be affected. Each of these networks is discussed below:

- Mexico's MEX01SUR network at 69.2° W.L. is deemed to be affected. This network is not operational.

- Mexico's MEX-TDH1 and QUESTZAT-77 networks at 77° W.L. are deemed to be affected. Quetzsat operates the QUETZSAT satellite under these two ITU networks. DISH leases all the satellite's capacity. EchoStar has determined that the interference caused to these DISH services by the ECHOSTAR-23 satellite is acceptable.

- Brazil's non-operational B-SAT-3B-1 network at 74° W.L. is deemed to be affected. This network needs to be coordinated with Mexico's two networks at 77° W.L. before it can be implemented.

Note that the ECHOSTAR-23 satellite will operate under Canada's 72.7° W.L. ITU filings and therefore ITU coordination is the responsibility of the Administration of Canada.

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.

Date: February 15, 2019

/s/ *Stephen D. McNeil*

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APPENDIX 1 TO ATTACHMENT A

Analysis of ANNEX 1 of Appendix 30

1 Limits for the interference into frequency assignments in conformity with the Regions 1 and 3 Plan or with the Regions 1 and 3 List or into new or modified assignments in the Regions 1 and 3 List

Does not apply to the Region 2 Plan.

2 Limits to the change in the overall equivalent protection margin for frequency assignments in conformity with the Region 2 plan

With respect to § 4.2.3 c) of Article 4, an administration in Region 2 is considered as being affected if the overall equivalent protection margin[28] corresponding to a test point of its entry in the Region 2 Plan, including the cumulative effect of any previous modification to that Plan or any previous agreement, falls more than 0.25 dB below 0 dB, or, if already negative, more than 0.25 dB below the value resulting from:

– *the Region 2 Plan as established by the 1983 Conference; or*

– *a modification of the assignment in accordance with this Appendix; or*

– *a new entry in the Region 2 Plan under Article 4; or*

– *any agreement reached in accordance with this Appendix.* *(WRC-03)*

An MSPACE analysis was performed utilizing the Region 2 BSS Plan as contained in IFIC 2886, and using the characteristics of the ECHOSTAR-23 satellite network as it is proposed to operate. The results of the analysis are shown in Annex 1 to this Appendix.

[28] For the definition of the overall equivalent protection margin, see § 1.11 of Annex 5.

3 Limits to the change in the power flux-density to protect the broadcasting-satellite service in Regions 1 and 2 in the band 12.2-12.5 GHz and in Region 3 in the band 12.5-12.7 GHz

With respect to § 4.2.3 a), 4.2.3 b) or 4.2.3 f) of Article 4, as appropriate, an administration in Region 1 or 3 is considered as being affected if the proposed modification to the Region 2 Plan would result in exceeding the following power flux-density values, at any test point in the service area of its overlapping frequency assignments:

-147 dB(W/(m^2 · 27 MHz))	for $0° \le \theta < 0.23°$
$-135.7 + 17.74 \log \theta$ dB(W/(m^2 · 27 MHz))	for $0.23° \le \theta < 2.0°$
$-136.7 + 1.66\ \theta^2$ dB(W/(m^2 · 27 MHz))	for $2.0° \le \theta < 3.59°$
$-129.2 + 25 \log \theta$ dB(W/(m^2 · 27 MHz))	for $3.59° \le \theta < 10.57°$
-103.6 dB(W/(m^2 · 27 MHz))	for $10.57° \le \theta$

where θ is the minimum geocentric orbital separation in degrees between the wanted and interfering space stations, taking into account the respective East-West station-keeping accuracies. *(WRC-03)*

The GIMS PFD tool was used to assess compliance with this Section. Using the antenna gain contours and proposed power level of the ECHOSTAR-23 satellite, the GIMS PFD tool showed that no administrations are affected. Therefore, the ECHOSTAR-23 satellite network is compliant with this Section.

4 Limits to the power flux-density to protect the terrestrial services of other administrations[29, 30, 31]

With respect to § 4.2.3 d) of Article 4, an administration in Region 1, 2 or 3 is considered as being affected if the consequence of the proposed modification to an existing assignment in the Region 2 Plan is to increase the power flux-density arriving on any part of the territory of that administration by more than 0.25 dB over that resulting from that frequency assignment in the Region 2 Plan at the time of entry into force of the Final Acts of the 1985 Conference. The same

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[29] See § 3.18 of Annex 5.

[30] In the band 12.5-12.7 GHz in Region 1, these limits are applicable only to the territory of administrations mentioned in Nos. **5.494** and **5.496**.

[31] See Resolution **34**.

administration is considered as not being affected if the value of the power flux-density anywhere in its territory does not exceed the limits expressed below.

With respect to § 4.1.1 d) or § 4.2.3 d) of Article 4, an administration in Region 1, 2 or 3 is considered as being affected if the proposed new assignment in the Regions 1 and 3 List, or if the proposed new frequency assignment in the Region 2 Plan, would result in exceeding a power flux-density, for any angle of arrival, at any point on its territory, of:

$$-148 \quad dB(W/(m^2 \cdot 4\ kHz)) \qquad for \quad \theta \leq 5°$$

$$-148 + 0.5\,(\theta - 5)\ dB(W(m^2 \cdot 4\ kHz)) \qquad for \quad 5° < \theta \leq 25°$$

$$-138 \quad dB(W/(m^2 \cdot 4\ kHz)) \qquad for \quad 25° < \theta \leq 90°$$

where θ represents the angle of arrival. *(WRC-03)*

The GIMS PFD tool was used to assess compliance with this Section. Using the antenna gain contours and proposed power levels of the ECHOSTAR-23 satellite, the GIMS PFD tool showed that no administrations are affected. Therefore, the ECHOSTAR-23 satellite network is compliant with this Section.

5 (Not used.)

6 Limits to the change in the power flux-density of assignments in the Regions 1 and 3 Plan or List to protect the fixed-satellite service (space-to-earth) in the band 11.7-12.2 GHz[32] in Region 2 or in the band 12.2-12.5 GHz in Region 3, and of assignments in the Region 2 plan to protect the fixed-satellite service (space-to-earth) in the band 12.5-12.7 GHz in Region 1 and in the band 12.2-12.7 GHz in Region 3

With respect to § 4.2.3 e), an administration is considered as being affected if the proposed modification to the Region 2 Plan would result in an increase in the power flux-density over any portion of the service area of its overlapping frequency assignments in the fixed-satellite service in Region 1 or 3 of 0.25 dB or more above that resulting from the frequency assignments in the Region 2 Plan at the time of entry into force of the Final Acts of the 1985 Conference.

With respect to § 4.1.1 e) or 4.2.3 e) of Article 4, an administration is considered as not being affected if the proposed new or modified assignment in the Regions 1 and 3 List, or if a proposed

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[32] Including assignments operating under No. **5.485**.

modification to the Region 2 Plan, gives a power flux-density anywhere over any portion of the service area of its overlapping frequency assignments in the fixed-satellite service in Region 1, 2 or 3 of less than:

-186.5 dB(W/(m^2 · 40 kHz))	for $0° \le \theta < 0.054°$
$-164.0 + 17.74 \log \theta$ dB(W/(m^2 · 40 kHz))	for $0.054° \le \theta < 2.0°$
$-165.0 + 1.66\ \theta^2$ dB(W/(m^2 · 40 kHz))	for $2.0° \le \theta < 3.59°$
$-157.5 + 25 \log \theta$ dB(W/(m^2 · 40 kHz))	for $3.59° \le \theta < 10.57°$
-131.9 dB(W/(m^2 · 40 kHz))	for $10.57° \le \theta$

where θ is the minimum geocentric orbital separation in degrees between the wanted and interfering space stations, taking into account the respective East-West station-keeping accuracies.

The ITU's GIBC software tool was used to assess compliance with this Section. The results show that no administrations are affected and therefore the ECHOSTAR-23 satellite network is compliant with this Section.

7 Limits to the change in equivalent noise temperature to protect the fixed-satellite service (earth-to-space) in Region 1 from modifications to the Region 2 plan in the band 12.5-12.7 GHz

With respect to § 4.2.3 e) of Article 4, an administration of Region 1 is considered as being affected if the proposed modification to the Region 2 Plan would result in:

- *the value of $\Delta T/T$ resulting from the proposed modification is greater than the value of $\Delta T/T$ resulting from the assignment in the Region 2 Plan as of the date of entry into force of the Final Acts of the 1985 Conference; and*
- *the value of $\Delta T/T$ resulting from the proposed modification exceeds 6%,*

using the method of Appendix 8 (Case II). *(WRC-03)*

From a review of the available ITU space network databases there are no assignments registered in the Earth-to-space direction in the frequency band 12.5-12.7 GHz. Therefore, no Region 1 space stations can be affected and hence the ECHOSTAR-23 satellite network is compliant with this Section.

Annex 1

ECHOSTAR-23 at 72.6° W.L. MSPACE Results

Admin	Orbital Position (°W)	Network	Max. OEPM Degradation (dB)
MEX	**69.2**	**MEX01SUR**	**0.779**
MEX	**77.0**	**MEX-TDH1**	**0.604**
MEX	**77.0**	**QUETZSAT-77**	**0.787**
B	**74.0**	**B-SAT-3B-1**	**6.624**

APPENDIX 2 TO ATTACHMENT A

Analysis of ANNEX 1 of Appendix 30A

1 (SUP - WRC-2000)

2 (SUP - WRC-2000)

3 **Limits to the change in the overall equivalent protection margin with respect to frequency assignments in conformity with the Region 2 feeder-link plan**[33] (WRC-2000)

With respect to the modification to the Region 2 feeder-link Plan and when it is necessary under this Appendix to seek the agreement of any other administration of Region 2, except in cases covered by Resolution 42 (Rev.WRC-03), an administration is considered as being affected if the overall equivalent protection margin[34] *corresponding to a test point of its entry in that Plan, including the cumulative effect of any previous modification to that Plan or any previous agreement, falls more than 0.25 dB below 0 dB, or, if already negative, more than 0.25 dB below the value resulting from:*

– *the feeder-link Plan as established by the 1983 Conference; or*

– *a modification of the assignment in accordance with this Appendix; or*

– *a new entry in the feeder-link Plan under Article 4; or*

– *any agreement reached in accordance with this Appendix except for Resolution 42 (Rev.WRC-03).* *(WRC-03)*

An MSPACE analysis was performed utilizing the Region 2 BSS Plan as contained in IFIC 2886, and using the characteristics of the ECHOSTAR-23 satellite network as it is proposed to operate. The results of the analysis are shown in Annex 1 to this Appendix.

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[33] With respect to § 3 the limit specified relates to the overall equivalent protection margin calculated in accordance with § 1.12 of Annex 3.

[34] For the definition of the overall equivalent protection margin, see § 1.11 of Annex 5 to Appendix **30**.

4 Limits to the interference into frequency assignments in conformity with the Regions 1 and 3 feeder-link Plan or with the Regions 1 and 3 feeder-link List or proposed new or modified assignments in the Regions 1 and 3 feeder-link list (WRC-03)

Does not apply to the Region 2 Plan.

5 Limits applicable to protect a frequency assignment in the bands 17.3-18.1 GHz (Regions 1 and 3) and 17.3-17.8 GHz (Region 2) to a receiving space station in the fixed-satellite service (earth-to-space)

An administration in Region 1 or 3 is considered as being affected by a proposed modification in Region 2, with respect to § 4.2.2 a) or 4.2.2 b) of Article 4, or an administration in Region 2 is considered as being affected by a proposed new or modified assignment in the Regions 1 and 3 feeder-link List, with respect to § 4.1.1 c) of Article 4, when the power flux-density arriving at the receiving space station of a broadcasting-satellite feeder-link would cause an increase in the noise temperature of the feeder-link space station which exceeds the threshold value of ΔT/T corresponding to 6%, where ΔT/T is calculated in accordance with the method given in Appendix 8, except that the maximum power densities per hertz averaged over the worst 1 MHz are replaced by power densities per hertz averaged over the necessary bandwidth of the feeder-link carriers. *(WRC-03)*

The analysis shows that there are no affected Region 1 or Region 3 networks. Therefore, the ECHOSTAR-23 satellite network is compliant with this Section.

6 Limits applicable to protect a frequency assignment in the band 17.8- 18.1 GHz (Region 2) to a receiving feeder-link space station in the fixed-satellite service (earth-to-space) (WRC-03)

Does not apply to the Region 2 Plan.