# Attachment A

# Technical Exhibit for "Telstar 12" Satellite at 109.2°WL

## A1. Introduction

This document is the technical attachment to the application of Skynet Satellite Corp. ("Skynet") for authority to relocate the *Telstar 12* satellite ("T12") to the 109.2° west longitude (WL) geostationary satellite orbit location. The technical information required by paragraph (d) of Section §25.114[1] of the FCC rules is provided in this document. The information specified in paragraph (c) of that section is provided in Schedule S.

## A2. §25.114(d)(1): General Description of the Overall System

The T12 satellite is currently deployed at 15° WL.[2] Now that the replacement satellite for T12, Telstar 12V, is operational at 15°WL[3] and customers have been transferred from T12 to T12V, Skynet is seeking permission to relocate T12 to 109.2°WL slot and operate it there. The T12 satellite network will consist of the geostationary satellite at 109.2° WL and associated earth station facilities. At the new orbital location, T12 will be capable of providing a range of fixed-satellite services (FSS) to the United States (including Hawaii) and countries in the Caribbean, Central America, and South America.

This satellite is designed to implement three regional beams. However, at 109.2W, not all beams will be used simultaneously. Rather, T12 will operate in one of two configurations. For both configurations, Skynet seeks authority to operate the beam as steerable.

Configuration 1 is shown in Figure 1, with the beams shown in their nominal location. Beam A is positioned over the southeastern USA, the Caribbean, and South America. Beam C is positioned over Hawaii. When Beam C is active, the signal transmitted to it is duplicated in Beam B. However, the duplicated signal will not be used to provide any service in Beam B. The extent of the steerable range requested for Beam A is indicated by the red bounding rectangle, and for Beam C the steerable range is indicated by the blue rectangle.

[1] 47 C.F.R. §25.114
[2] FCC file number SAT-MOD-19991213-00120
[3] FCC file number SAT-LOA-20141010-00107

Configuration 2 is shown in Figure 2. Beam B is shown in its nominal position over the United States and the Caribbean. Beams A and C are turned off. The extent of the Beam B steerable range requested is indicated by the red bounding box.

Beam A has 15 usable transponders with bandwidths of 54 MHz each. The uplink and downlink frequencies all fall within the Standard Ku band (respectively, 14.0-14.5 and 11.7-12.2 GHz). 14 of the 15 transponders operate in loop-back and one has its uplink in Beam C.

Beam B has 12 usable transponders with bandwidths of 54 MHz each. The uplink frequencies fall within both Standard and Extended-Ku (respectively, 14.0-14.5 and 13.75-14 GHz), while the downlink frequencies fall entirely within Extended-Ku bands (10.95-11.2 and 11.45-11.7 GHz). All 12 transponders operate in loop-back.

Beam C has one 54 MHz transponder. Its uplink is in Beam A. The uplink frequency falls in Standard-Ku band and the downlink in the Extended-Ku band.

**Figure 1: T12 Coverage Configuration 1: Beams A, B, and C indicated. The red rectangle around Beam A and the blue rectangle around Beam C indicate the extents of their steerable ranges**

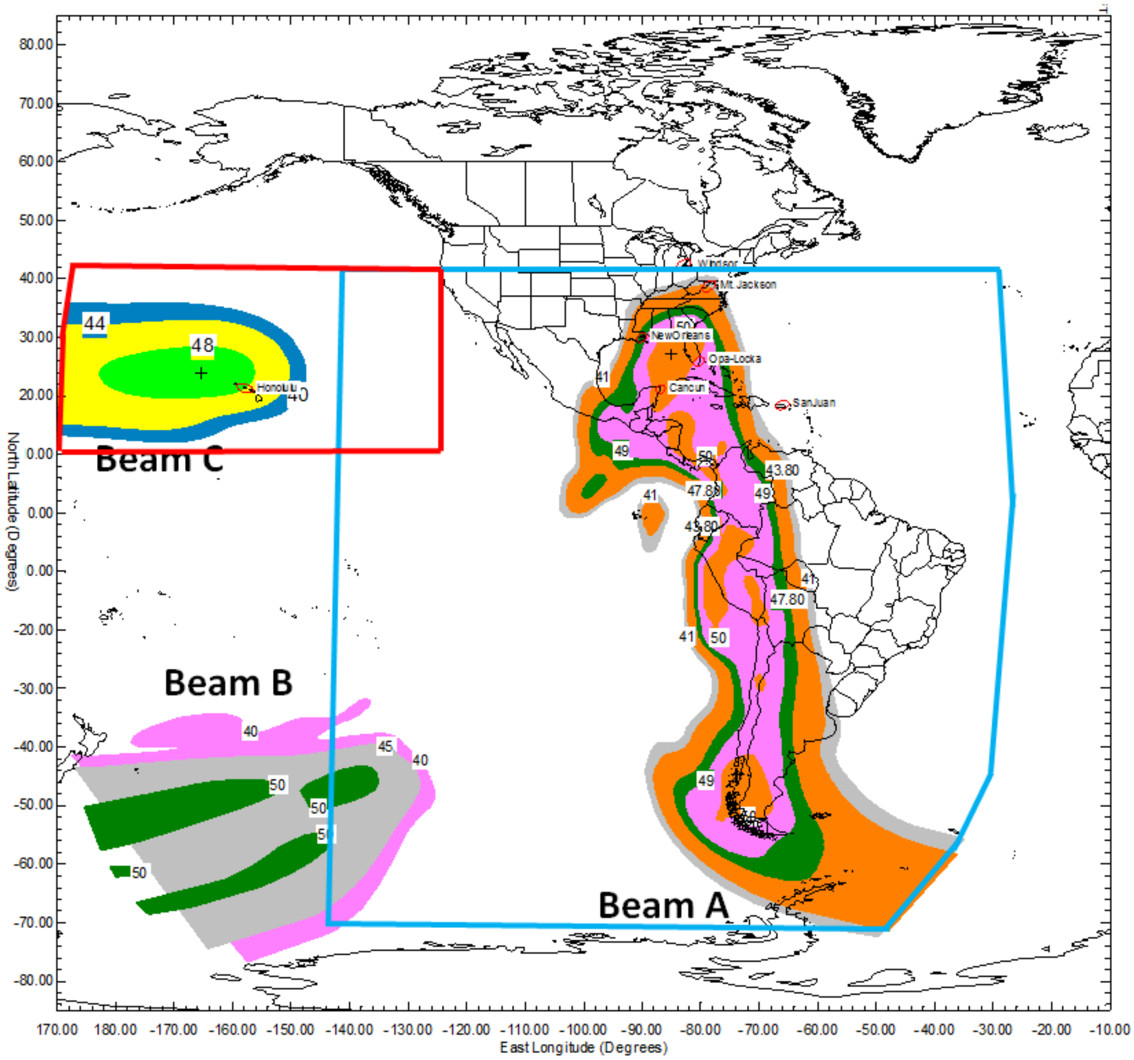
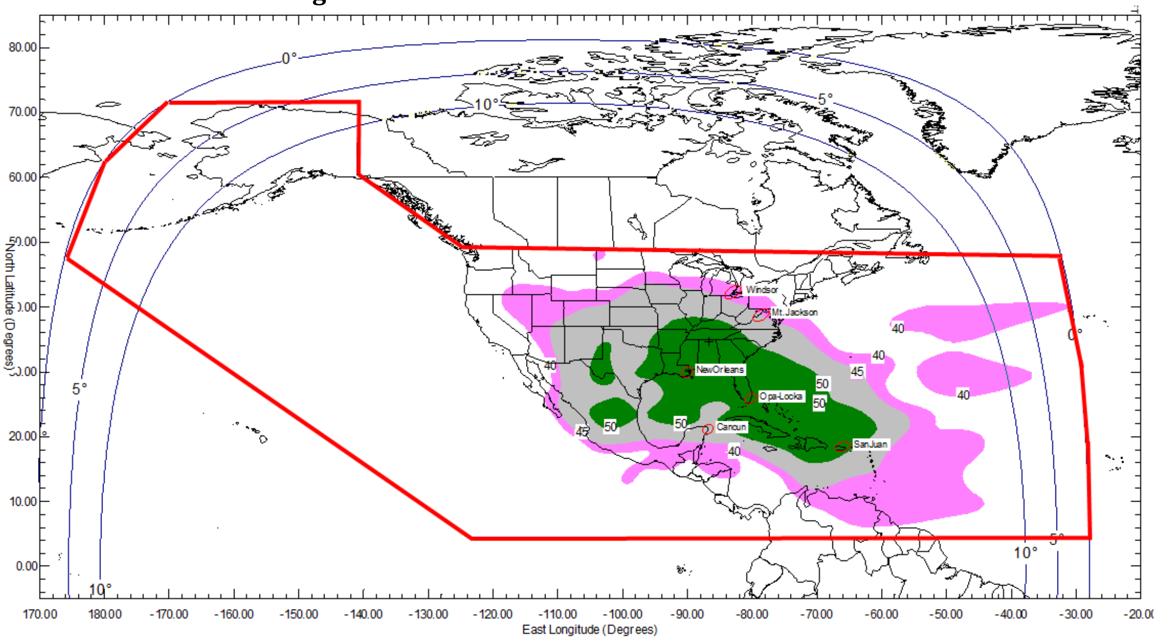


**Figure 2: T12 Coverage Configuration 2: only Beam B is active. The red rectangle indicates the extent of its steerable range**




The frequency bands that will be implemented on the T12 satellite are summarized in Table 1.

**Table 1: Frequency bands of T12**

| Lower Frequency Limit (GHz) | Upper Frequency Limit (GHz) | Downlink/Uplink | Beams Using the Band |
|---|---|---|---|
| 10.95 | 11.2 | Downlink | B |
| 11.45 | 11.7 | Downlink | B,C |
| 11.7 | 12.2 | Downlink | A |
| 13.75 | 14.0 | Uplink | B,C |
| 14.0 | 14.5 | Uplink | A,B,C |

Skynet seeks FCC authority to operate T12 in all of the frequency bands shown in Table 1. The downlink bands 10.95-11.2 GHz and 11.45–11.7 GHz will be used in the United States only for international links, i.e., for services between the United States and other countries.

As requested in §25.114(d)(1), an explanation of how the uplink frequency bands are connected to the downlink frequency bands is as follows: The uplink band 13.75-14.0 GHz is connected to the downlink band 10.95-11.2. The uplink band 14.0-14.5 GHz may be connected to the downlink bands 11.45-11.7 or 11.7-12.2 GHz. The strapping information has been provided in Schedule S, which has further details of how the uplink frequency bands are connected to the downlink frequency bands as well as the corresponding beams and the geographical coverage.

The polarization used for the Ku-band signals is linear. Frequency reuse will be exploited through the use of orthogonal polarization. All transponders will contain step attenuators which can be adjusted remotely by ground commands.

The satellite TT&C operations will be performed from the following address:

1305 Industrial Park Road, Mt. Jackson, VA 22842, USA
Phone: 540-477-5520

The Mt. Jackson TT&C location is usable only in part of the steerable range indicated in Figures 1 and 2. Should Skynet steer the beams to a position where TT&C operations must be performed from a different location, Skynet will notify the FCC as required by §25.172(b)[4] of the Commission's rules.

The TT&C frequencies and polarization plan are provided in Schedule S.

Satellite transmission on each transponder can be individually turned on and off by ground telecommand signals, enabling cessation of emissions from the satellite, as required by §25.207[5].

Skynet previously notified the Commission it was commencing inclined orbit operation of T12 at 15° WL.[6] Skynet will continue to operate T12 in an inclined orbit at 109.2°WL slot. The initial inclination will be 0.05°, with a rate of change of 0.88° per year. The expected end-of-life of the satellite, accounting for inclined orbit operation and the maneuvers specified under §25.283 of the Commission's rules: March 2029.

## A3. Space station antenna gain contours

The co-pol and cross-pol antenna gain contours, as well as the service areas for all the beams of the T12 satellite, have been provided in the GIMS database "GIMS_DB_T12.mdb", which is submitted separately. The gain values of the contours in the GIMS database are relative to the peak gain. The peak gain values and polarization information for each of the beams is shown in Table 2.

**Table 2: List of the satellite beams and their peak antenna gain values**

| Beam | Uplink/ Downlink | Co-pol Antenna Peak Gain (dBi) | Cross-pol Antenna Peak Gain (dBi) | Polarization |
|---|---|---|---|---|
| ATX | Downlink | 31.3 | 0.5 | H and V |
| BTX | Downlink | 34.5 | 2.0 | H and V |

[4] 47 C.F.R. §25.172(b)
[5] 47 C.F.R. §25.207
[6] *See* letter, dated April 19, 2016, from Joseph A. Godles, attorney for Skynet, to Marlene H. Dortch, Secretary, FCC.

| | | | | |
|---|---|---|---|---|
| CTX | Downlink | 39.8 | 1.5 | H |
| ARX | Uplink | 32.5 | 1.3 | H and V |
| BRX | Uplink | 31.9 | 0.3 | H and V |
| CRX | Uplink | 40.4 | 1.2 | V |

# A4. Description of the types of services to be provided, areas served, transmission characteristics, performance objectives, link noise budget, typical earth station parameters, and modulation parameters

The T12 satellite can provide a range of fixed satellite services (FSS) to the continental United States (including Hawaii) and countries in the Caribbean, Central America, and South America. The services that can be provided by T12 include VSAT services and point-to-point communication links.

When operating in Configuration 2, Skynet will comply with FCC regulations requiring that extended-Ku band frequencies[7] be used for international communications by linking all extended Ku-band earth station signals originating or terminating in the United States via T12 with a gateway located outside the United States. Likewise, in Configuration 1, all extended Ku-band beam C signals originating or terminating in Hawaii will be linked with a gateway located outside the United States.

Typical digital modulation and emission schemes that will be used, along with their performance objectives, are listed in Table 3.

**Table 3: Typical modulation/emission schemes and the corresponding performance objectives**

| Modulation | FEC Rate | Emission Designator | Emission BW (kHz) | Total C/N Objective (dB) |
|---|---|---|---|---|
| QPSK | 1/2 | 54M0G7W | 54000 | 1.0 |
| QPSK | 2/3 | 54M0G7W | 54000 | 3.3 |
| 8PSK | 2/3 | 54M0G7W | 54000 | 7.5 |
| 8PSK | 3/4 | 54M0G7W | 54000 | 8.5 |
| 16APSK | 3/4 | 54M0G7W | 54000 | 11.2 |
| 16APSK | 4/5 | 54M0G7W | 54000 | 11.9 |
| | | | | |
| QPSK | 1/2 | 1M12G7W | 1200 | 2.2 |
| QPSK | 2/3 | 1M12G7W | 1200 | 4.4 |
| 8PSK | 2/3 | 1M12G7W | 1200 | 8.4 |
| 8PSK | 3/4 | 1M12G7W | 1200 | 9.8 |

[7] 47 C.F.R. §2.106, footnote NG 52

| | | | | |
|---|---|---|---|---|
| 8PSK | 6/7 | 1M12G7W | 1200 | 12.3 |

A typical gateway earth station antenna diameter will be 4.6m, and a typical terminal earth station antenna diameter will be 2.2m. The earth station antennas will meet the antenna performance requirements specified in §25.209[8] of the Commission's rules, and the uplink transmit power will comply with the requirements of §25.204. [9]

Typical link budgets and overall performance analysis, including the analysis of the effects of each contributing noise and interference source, are provided in Table 4 and Table 5. Table 4 shows typical link budgets when both the gateway and the terminal operate at standard-Ku in Beam A under Configuration 1. Table 5 shows typical link budgets when the terminal and gateway operate in extended-Ku band in Beam B under Configuration 2.

[8] 47 C.F.R. §25.209
[9] 47 C.F.R. §25.204

**Table 4: Typical standard-Ku link budgets for Configuration 1: Gateway and terminal located in Beam A**

| | | |
|---|---|---|
| TX ES Location | Mt. Jackson, VA (38.7N,78.6W) | Cancun, Mexico (21.2N,86.5W) |
| RX ES Location | Cancun, Mexico (21.2N,86.5W) | Mt. Jackson, VA (38.7N,78.6W) |
| Emission BW (kHz) | 54000 | 1200 |
| Modulation type | 16APSK | 8PSK |
| Information rate (kbps) | 131,623 | 2250 |
| FEC Rate | 4/5 | 3/4 |
| Uplink Frequency (GHz) | 14.219 | 14.157 |
| Uplink ES antenna diameter (m) | 4.6 | 2.2 |
| Uplink ES antenna gain (dBi) | 54.5 | 48.4 |
| Uplink Antenna feed flange power (dBW) | 19.5 | 6.2 |
| Uplink ES to Satellite Distance (km) | 38,164 | 36,802 |
| Uplink Free-Space Loss (dB) | 207.1 | 206.8 |
| Satellite RX antenna gain towards the TX ES (dBi) | 23.3 | 26.9 |
| Satellite Rx system noise temperature (K) | 400 | 400 |
| Uplink Thermal C/N (dB) | 15.6 | 16.1 |
| Uplink C/I (ASI) (dB) | 30.6 | 24.6 |
| Uplink C/I (Xpol) (dB) | 27.3 | 26.2 |
| Uplink C/I (IM) (dB) | 43.4 | 42.3 |
| Uplink C/(N+I) (dB) | 15.2 | 15.2 |
| Downlink Frequency (GHz) | 11.919 | 11.857 |
| Satellite TX antenna gain towards the RX ES (dBi) | 30.5 | 27.5 |
| Downlink Antenna feed flange power (dBW) | 18.1 | -0.2 |
| Downlink ES to Satellite Distance (km) | 36,802 | 38,164 |
| Downlink Free-Space Loss (dB) | 205.3 | 205.6 |
| RX ES antenna diameter (m) | 2.2 | 4.6 |
| RX ES antenna gain (dBi) | 46.9 | 52.9 |
| RX ES system noise temperature (K) | 132.7 | 128.1 |
| Downlink Thermal C/N (dB) | 19.6 | 22.4 |
| Downlink C/I (ASI) (dB) | 23.0 | 29.0 |
| Downlink C/I (Xpol) (dB) | 29.1 | 27.4 |
| Downlink C/I (IM) (dB) | 100 | 16.2 |
| Downlink C/(N+I) (dB) | 17.7 | 14.0 |
| Overall Link C/(N+I) (dB) | 13.2 | 11.5 |
| Required C/(N+I) (dB) | 11.9 | 9.8 |
| Margin (dB) | 1.3 | 1.7 |

**Table 5: Typical Extended-Ku link budgets for Configuration 2: Gateway and terminal located in Beam B**

| | | |
|---|---|---|
| TX ES Location | Mt. Jackson, VA (38.7N,78.6W) | Cancun, Mexico (21.2N,86.5W) |
| RX ES Location | Cancun, Mexico (21.2N,86.5W) | Mt. Jackson, VA (38.7N,78.6W) |
| Emission BW (kHz) | 54000 | 1200 |
| Modulation type | 16APSK | 8PSK |
| Information rate (kbps) | 131,623 | 2250 |
| FEC Rate | 4/5 | 3/4 |
| Uplink Frequency (GHz) | 13.840 | 13.875 |
| Uplink ES antenna diameter (m) | 4.6 | 2.2 |
| Uplink ES antenna gain (dBi) | 54.2 | 48.2 |
| Uplink Antenna feed flange power (dBW) | 17.1 | 4.4 |
| Uplink ES to Satellite Distance (km) | 38,164 | 36,802 |
| Uplink Free-Space Loss (dB) | 206.9 | 206.6 |
| Satellite RX antenna gain towards the TX ES (dBi) | 26.4 | 27.4 |
| Satellite Rx system noise temperature (K) | 400 | 400 |
| Uplink Thermal C/N (dB) | 16.3 | 14.8 |
| Uplink C/I (ASI) (dB) | 30.6 | 24.6 |
| Uplink C/I (Xpol) (dB) | 24.3 | 25.0 |
| Uplink C/I (IM) (dB) | 41.3 | 42.1 |
| Uplink C/(N+I) (dB) | 15.5 | 14.0 |
| Downlink Frequency (GHz) | 11.013 | 11.075 |
| Satellite TX antenna gain towards the RX ES (dBi) | 33.0 | 27.2 |
| Downlink Antenna feed flange power (dBW) | 14.6 | -2.2 |
| Downlink ES to Satellite Distance (km) | 36,802 | 38,164 |
| Downlink Free-Space Loss (dB) | 204.6 | 205.0 |
| RX ES antenna diameter (m) | 2.2 | 4.6 |
| RX ES antenna gain (dBi) | 46.2 | 52.3 |
| RX ES system noise temperature (K) | 132.7 | 128.1 |
| Downlink Thermal C/N (dB) | 18.7 | 19.2 |
| Downlink C/I (ASI) (dB) | 23.0 | 29.0 |
| Downlink C/I (Xpol) (dB) | 28.5 | 27.4 |
| Downlink C/I (IM) (dB) | 100 | 16.2 |
| Downlink C/(N+I) (dB) | 17.0 | 14.1 |
| Overall Link C/(N+I) (dB) | 13.2 | 11.0 |
| Required C/(N+I) (dB) | 11.9 | 9.8 |
| Margin (dB) | 1.3 | 1.2 |

# A5. Power flux density compliance

T12's satellite antenna gain contours are being provided in a GIMS database file separately, and the peak EIRP levels are being provided in Schedule S. Using the GIMS software, it was verified that the PFD limits of §25.208[10] and §25.138[11] , as well as the PFD limits of the ITU Radio Regulations, are met in all the operating frequency bands. In order to demonstrate PFD compliance in this document, for each of the satellite downlink beams the maximum PFD at the beam peak and at angles of arrival of 0°, 5°, 10°, 15°, 20°, and 25° are shown in Table 6 to Table 7 . In the tables, θ denotes the angle of arrival. Below is a brief description of these tables:

- Table 6 shows the maximum PFD levels for the beams that operate in the frequency band 10.95-11.2 GHz and 11.45-11.7 GHz for several angles of arrival. Also shown in this table are the PFD limits of §25.208(b) and the ITU Radio Regulations.
- Table 7 shows the maximum PFD levels at the beam peak for the beams that operate in the frequency band 10.95-11.2 GHz and 11.45-11.7 GHz. Also shown in this table are the PFD limits of §25.208(b) and the ITU Radio Regulations.

**Table 6: Maximum PFD levels at several angles of arrival for the beams that operate in the frequency band 10.95-11.2 GHz and 11.45-11.7 GHz**

| Beam Name | Peak EIRP (dBW) | Transponder BW (MHz) | Peak EIRP over 4 kHz BW (dBW) | Maximum PFD ($dB(W/m^2/4kHz)$) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | θ =0° | θ =5° | θ =10° | θ =15° | θ =20° | θ =25° |
| BTX | 52.1 | 54 | 10.8 | -166.6 | -166.6 | -166.6 | -161.6 | -161.6 | -159.6 |
| CTX | 49.6 | 54 | 8.3 | -156.2 | -156.2 | -155.7 | -155.2 | -154.7 | -156.2 |
| Telemetry Emission | 13 | 0.85 | -10.3 | -176.3 | -176.3 | -176.3 | -176.3 | -174.3 | -174.3 |
| **PFD limit of §25.208(b) ($dB(W/m^2/4kHz)$)** | | | | **-150.0** | **-150.0** | **-147.5** | **-145.0** | **-142.5** | **-140.0** |
| **ITU Radio Regulations limit ($dB(W/m^2/4kHz)$)** | | | | **-150.0** | **-150.0** | **-147.5** | **-145.0** | **-142.5** | **-140.0** |

[10] 47 C.F.R. §25.208
[11] 47 C.F.R. §25.138

**Table 7: Maximum PFD at the beam peak for the beams that operate in the frequency band 10.95-11.2 GHz and 11.45-11.7 GHz**

| Beam Name | Peak EIRP (dBW) | Transponder BW (MHz) | Peak EIRP over 4 kHz BW (dBW) | Max PFD at the Beam Peak (dB(W/m$^2$/4kHz)) | θ at the Beam Peak (deg) | **PFD limit of §25.208(b) (dB(W/m$^2$/4kHz))** | **ITU Radio Regulations limit (dB(W/m$^2$/4kHz))** |
|---|---|---|---|---|---|---|---|
| BTX | 52.1 | 54 | 10.8 | -151.6 | 45.4 | **-140.0** | **-140.0** |
| CTX | 49.6 | 54 | 8.3 | -154.7 | 18.5 | **-143.3** | **-143.3** |
| Telemetry Emission | 13 | 0.85 | -10.3 | -172.3 | 75.1 | **-140.0** | **-140.0** |

# A6. §25.114(d)(6): Public interest considerations in support of grant

T12 operations at 109.2° WL will provide new capacity to support services in the Unites States, Caribbean, and Central and South America. Customers will benefit from rate competition and a greater diversity of possible services. Grant of this application will therefore be in the public interest.

# A7. §25.114(d)(7): Information specified in §25.140(a) (Interference analysis and the compatibility of the proposed system two degrees from any authorized space station)

In this section the information specified in §25.140(a)[12] is presented (as required by §25.114(d)(7)): the demonstration of the compatibility of the proposed space system two degrees from any authorized space stations.

There are currently four geostationary satellites within 2 degrees of 109.2° WL with frequency bands that overlap with T12. Three are collocated at 107.3° WL: Anik F1, Anik F1R, and Anik G1. In addition, Anik F2 is located at 111.1° WL. All four of these satellites are owned and operated by Telesat Canada, which is an affiliate of Skynet.

In this analysis, earth station (ES) antenna diameters of 2.2m (user terminals) and 4.6 m (gateways) are considered for the T12 satellite network and the adjacent satellites. Table 8 shows the uplink carrier to interference ratios (C/I) due to ASI and Table 9 shows the downlink C/I due to ASI. The details of the ASI calculations have been presented in Annex 1.

[12] 47 C.F.R. §25.140(a)

The ASI values presented in Table 8 and Table 9 were used in the link budget calculations in Table 4 and Table 5. Those calculations indicate that the required carrier to noise plus interference ratios C/(N+I) are met. This confirms that the T12 satellite network can perform efficiently with the presence of Anik F2 and Anik F1/F1R/G1 – each within 1.9° of T12. Similarly, it follows that the ASI from T12 into these adjacent satellite networks will be tolerable. Furthermore, since Skynet and its affiliates own and operate all the satellites mentioned, it can self-coordinate by adjusting uplink and downlink power levels if required.

**Table 8: Uplink aggregate ASI from adjacent satellites at ±1.9 degrees away in Standard and Extended Ku band**

| TX Earth Station Antenna Diameter (m) | Ku-band uplink C/I due to ASI (dB) |
|---|---|
| 2.2 | 24.6 |
| 4.6 | 30.6 |

**Table 9: Downlink aggregate ASI from adjacent satellites at ±1.9 degrees away in Standard and Extended Ku band**

| RX earth Station Antenna Diameter (m) | Ku-band downlink C/I due to ASI (dB) |
|---|---|
| 2.2 | 23.0 |
| 4.6 | 29.0 |

# A8. §25.114(d)(14): Description of the design and operational strategies that will be used to mitigate orbital debris

**§25.114(d)(14)(i), Debris Release Assessment**. The T12 satellite has been designed so that in the normal operation of the satellite no debris will be released by the spacecraft. Its hardware has been designed so that individual faults will not cause the loss of the entire spacecraft. All critical components (e.g., computers and control devices) have been built within the structure and shielded from external influences. Items that could neither be built within the spacecraft nor shielded (e.g., antennas) are able to withstand impact. The spacecraft can be controlled through both the normal payload antennas and wide angle antennas. The likelihood of both being damaged during a small body collision is minimal. The wide angle antennas on this spacecraft are open waveguides that point towards the earth (there is one set on each side of the spacecraft and either set could be used to successfully de-orbit the spacecraft). These wide angle antennas would continue to operate even if struck and bent.

**§25.114(d)(14)(ii), Accidental Explosion Assessment**. Skynet 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, Skynet takes specific precautions. All batteries and fuel tanks are monitored for pressure or temperature variations. Alarms in the Satellite Control Center inform controllers of any variations. Additionally, long-term trending analysis is performed to monitor for any unexpected trends.

The 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 (on the ground).

In order to ensure that the spacecraft has no explosive risk after it has been successfully de-orbited, stored energy sources onboard the spacecraft will be removed by venting excess propellant, and all propulsion lines and latch valves will be vented and left open. This includes all fuel and helium contained within the propulsion system.

**§25.114(d)(14)(iii), Assessment Regarding Collision with Larger Debris and Other Space Stations**. The Telstar 12 satellite has been operating at the 15° WL orbital location since 1999 and Skynet has continuously monitored and minimized the probability of the space station becoming a source of debris by collisions with large debris or other space stations. Skynet will use the same approach for T12 at its new 109.2° WL orbit location to minimize the probability of collisions with large debris.

In order to protect against collision with other orbiting objects, Telesat Canada has a contract with MIT/Lincoln Labs to provide notification and high-precision orbits for drifter objects when close approaches with our operational satellites are projected. Processing of the notifications is fully automated to ensure efficient response should avoidance maneuver(s) be required to eliminate any threat of collision with the drifter object. For nearby operational satellites Skynet coordinates with operators directly and/or by providing ephemerides to the Space Data Center and the Joint Space Operations Center (JSpOC). The JSpOC also provides notifications to Skynet for any object they see approaching a Skynet satellite.

To further limit future potential for collision, Skynet will continue to monitor new satellite launches to ensure that future satellites do not present a danger to T12. If a new satellite is located in the vicinity of T12, Skynet will coordinate station keeping activities with the satellite operator to avoid any risk of collision.

Combined, these systems constitute a best practice approach to collision avoidance.

**§25.114(d)(14)(iv), Post-Mission Disposal Plans**. At end-of-life, the T12 satellite will be removed from its geostationary orbit at 109.2° WL to an altitude with a perigee no less than 290.4 km above the standard geostationary orbit of 35786 km. This altitude is determined by using the FCC-recommended equation in section 25.283(a)[13] regarding end-of-life satellite disposal. The corresponding calculations for the T12 satellite are presented below:

Minimum De-orbit Altitude= 36021 km + (1000×CR×A/m) (Eq.1)
CR = solar pressure radiation coefficient of the spacecraft = 1.16
A/m = area to mass ratio, in square meters per kilogram, of the spacecraft = 0.04776
Result: (Eq.1) Minimum Deorbit Altitude = 36021 km + (1000×1.16×0.04776) = 36076.4 km which is 290.4 km above the geostationary orbit of 35786 km.

The propellant needed to achieve the minimum de-orbit altitude is based on the delta-V required. Based on an estimated end-of-life mass of 1600 kg, and the delta-V required, approximately 8.6 kg of propellant will be reserved to ensure that the minimum de-orbit altitude is obtained. Any remaining propellant will be consumed by further raising the orbit until combustion is no longer possible. The remaining species of propellant, either Oxidizer (N204) or Fuel (MMH), will be vented, placing the propulsion system on the spacecraft in “safe” mode.

Propellant tracking is accomplished using a bookkeeping method consistent with industry standards. Using this method, the ground control station tracks the number of jet seconds utilized for station keeping, momentum control and other attitude control events. The amount of fuel used is determined from the number of jet seconds. This process has been calibrated using data collected from thruster tests conducted on the ground and has been found to be accurate to within a few months of life on the spacecraft.

Propellant Gauging System (PGS) tests can be performed throughout the operational life. This test uses heaters and heat transfer curves to determine the actual fuel still aboard the spacecraft. As the amount of fuel in the tanks decreases, the accuracy of the test results increases. Therefore, operationally, the PGS tests will be performed as the satellite approaches its end of propellant life in order to verify bookkeeping results.

# A9. Request for waiver of Footnote NG52

Footnote NG52 of the U.S. Table of Allocations (formerly footnote NG103) limits operations in the 10.95-11.2 and 11.45-11.7 GHz bands that are included on T12 to international services.[14] Skynet respectfully requests a waiver of NG52.

[13] 47 C.F.R. §25.283(a)
[14] *See* 47 C.F.R. § 2.106, footnote NG52.

Grant of a waiver would be consistent with precedents in which the Commission has waived NG52/NG103 because: (1) the footnote is intended to prevent a proliferation of earth stations in the affected bands; and (2) only a limited number of earth stations in the affected bands have been proposed.[15] In this case, Skynet will operate only a single earth station in the affected bands.

## A10. Request for waiver of Section 25.114(c)(4)(vi)(A)

Section 25.114(c)(4)(vi)(A) of the Commission's rules in general requires applicants for space stations in geostationary orbit to provide predicted space station antenna gain contour(s) for each transmit and receive antenna beam. Skynet, however, is unable to provide antenna gain contours for T12's TT&C beams. Skynet does not have these patterns in its possession, and T12's manufacturer, Space Systems/Loral, could not locate copies, either, due to the age of the satellite. Accordingly, Skynet requests a waiver of Section 25.114(c)(4)(vi)(A).

Table 6 and Table 7provide upper bounds on the PFD of the Telemetry beam at its peak and various angles of arrival. As indicated, the values fall well below the limits of 25.208(b) in all cases.

[15] *See, e.g.*, *EchoStar KuX Corporation*, Order and Authorization, DA 04-3162 (Sept. 30, 2004), ¶¶ 14-17 (EchoStar granted a waiver of NG104 permitting it to operate a single TT&C station in the United States).

# Annex 1 to Attachment A

## Details of the methodology for the calculation of C/I due to adjacent satellite interference

In this annex, the details of the methodology for the calculation of the carrier to interference ratio (C/I) due to the adjacent satellite interference (ASI) are presented and it is shown how the uplink and downlink C/I values in Table 8 and Table 9 were calculated.

Anik F1R and F2, at standard Ku, and Anik G1, at extended-Ku, provide a DTH (Direct To Home) service exclusive to the Canada market. This service is vulnerable to ASI due to the small terminals used. Skynet has conducted analysis to ensure there is sufficient geographic separation between the nominal coverage of T12 in its two possible configurations, as indicated in Figure 1 and Figure 2, and the Canadian border, to ensure there is no impact on the DTH service. However, should Skynet elect to steer Beam B to provide coverage over Alaska in Configuration 2, there would be insufficient geographic isolation to prevent significant ASI if the seven transponders whose frequency bands overlap with the DTH service are used. Therefore, in this case Skynet would only operate the five transponders which will not interfere with the DTH service.

Anik F2 also provides FSS service in the United States, and Anik F1 and G1 provide FSS service in South America. Since these areas overlap with those proposed for T12, interference analysis is necessary. In these areas, the three adjacent satellites all operate at standard Ku. The following considers a 2.2m Ku-band earth station within the T12 satellite network, and calculates uplink and downlink C/I due to ASI from the adjacent satellites ±1.9° away from T12.

Table A1 shows the calculation details of the uplink ASI C/I due to an earth station in the United States transmitting to Anik F2, which is 1.9° away from T12. The on-bore uplink power density for the antenna is assumed to the same as that of an antenna transmitting to T12. The results are the same when considering an earth station in South America transmitting to Anik F1 or G1.

Table A2 shows the calculation of the aggregate uplink ASI due to an earth station in South America transmitting to Anik F1 or G1 simultaneously with an earth station in the United States transmitting to Anik F2 at the same frequency.

The calculation details for downlink C/I due to ASI from Anik F2 are shown in Table A3. The calculation of the maximum aggregate downlink ASI from Anik F1/G1 and F2 is shown in Table A4. Since the overlap of Anik F1/G1 and Anik F2's coverage falls in an area where each satellite's power is significantly lower than at its beam peak, the maximum aggregate downlink ASI is a loose upper bound on the actual value.

Calculations for the uplink and downlink ASI C/I for a 4.6 m antenna gateway follow analogously and are not shown.

**Table A1: Calculation of Standard Ku-band uplink ASI C/I due to an earth station transmitting to Anik F2 at 1.9° away**

| | | |
|---|---|---|
| T12 Orbital Location | Deg WL | 109.2 |
| Anik F2 Location at 1.9 degrees away | Deg WL | 111.1 |
| Station Keeping Tolerance | Deg | 0.05 |
| Minimum Geocentric Effective Separation | Deg | 1.9 |
| Topocentric Separation (θ) | Deg | 2.1 |
| | | |
| **Uplink ASI C/I Calculation** | | |
| Frequency | GHz | 14.25 |
| T12 TX Earth Station | | |
| Antenna Diameter | m | 2.2 |
| Antenna Gain | dBi | 48.5 |
| Anik F2 TX Earth Station | | |
| Antenna Off-axis gain toward T12 (29-25log(θ)) | dBi | 20.9 |
| C/I (Uplink ASI) | dB | 27.6 |

**Table A2: Aggregate Standard Ku-band band uplink ASI from Anik F2 and Anik F1/G1**

| | | |
|---|---|---|
| Uplink C/I due to ASI from Anik F2 | dB | 27.6 |
| Uplink C/I due to ASI from Anik F1/G1 | dB | 27.6 |
| **Aggregate Uplink C/I due to ASI** | **dB** | **24.6** |

**Table A3: Calculation of Standard Ku-band downlink ASI C/I for a 2.2 m earth station antenna due to ASI from Anik F2 at 1.9° away**

| | | |
|---|---|---|
| T12 Orbital Location | Deg WL | 109.2 |
| Anik F2 Location at 1.9 degrees away | Deg WL | 111.1 |
| Station Keeping Tolerance | Deg | 0.05 |
| Minimum Geocentric Effective Separation | Deg | 1.9 |
| Topocentric Separation (θ) | Deg | 2.1 |
| | | |
| **Downlink ASI C/I Calculation** | | |
| Frequency | GHz | 11.95 |
| T12 Receive Earth Station | | |
| Antenna Diameter | m | 2.2 |
| Antenna Gain | dBi | 46.9 |
| Antenna Off-axis gain toward Adjacent Satellite (29-25log(θ)) | dBi | 20.9 |
| C/I (Downlink ASI) | dB | 26.0 |

**Table A4: Aggregate Standard Ku-band downlink ASI from Anik F2 and Anik F1/G1**

| | | |
|---|---|---|
| Uplink C/I due to ASI from Anik F2 | dB | 26.0 |
| Uplink C/I due to ASI from Anik F1/G1 | dB | 26.0 |
| **Aggregate Uplink C/I due to ASI** | **dB** | **23.0** |

Anik F1 and F2 are also licensed to operate at Extended-Ku band, although they only utilize a small portion of the band for telemetry and command. Nevertheless, for the purpose of modeling the worst-case ASI that may arise in a future scenario, the link budgets in Section A4 assume the same ASI C/I values for both standard and extended-Ku band.

**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.

Richard Thommes
Communications Systems Engineer
1601 Telesat Court, Ottawa,
ON, Canada K1B5P4
Phone: 613-748-8700 Ext. 2307

May 13, 2016