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

In the Matter of	)	
TELESAT CANADA	)	Call Sign: S2976
Petition for Declaratory Ruling to Grant Access to the U.S. Market for Telesat's NGSO Constellation	)	File No. SAT-PDR-20161115-00108

COMMENTS OF SPACE EXPLORATION TECHNOLOGIES CORP.

Space Exploration Technologies Corp. ("SpaceX") hereby comments on the application filed by Telesat Canada for authority to serve the U.S. market with its non-geostationary satellite orbit ("NGSO") system providing Fixed-Satellite Service ("FSS") in the Ku and Ka bands. The proposed system would consist of at least 117 satellites in a combination of circular polar ort an altitude of 1,000 km, and inclined orbits at an altitude of 1,248 km.[1] Each satellite in the Telesat system can deploy user spot beams as small as 35 km in diameter and as large as 560 km in diameter, which are both steerable and shapeable.[2] The system also includes optical inter-satellite links ("ISLs") which will allow Telesat to route traffic through satellites in the same or adjacent orbital planes.

As proposed, the Telesat system includes many technical characteristics that may facilitate coordination and spectrum sharing with other NGSO systems. Small, agile beams

1 *See Petition for Declaratory Ruling to Grant Access to the U.S. Market for Telesat's NGSO Constellation*, IBFS File No. SAT-PDR-20161115-00108, Appendix A at 1 (Nov. 15, 2016). ("Telesat Petition")

2 *Id.*, Appendix A at 8.

help to enhance spectral efficiency through a high level of frequency reuse. In addition, small beams generally decrease the number of in-line events that a Telesat satellite is likely to experience with other systems, decreases the duration of those in-line events, and decreases the odds that a given satellite will experience in-line events with multiple operators at one time. ISLs offer additional flexibility to route traffic in ways that can avoid conflicts with other NGSO operations. Thus, the Telesat system will have the tools to operate efficiently and cooperatively with other NGSO systems.

SpaceX would note, however, that while Telesat has the capability to operate using narrow spot beams (35 km diameter), it can also use spot beams more than fifteen times larger (560 km diameter). Using such large beams would reduce spectral efficiency and complicate spectrum sharing with other NGSO systems. To the extent Telesat chooses to operate with these large beams, it would effectively shift to other operators the responsibility to shoulder either the burden of designing a highly flexible system capable of working around other NGSO systems (as SpaceX has done), or the burden of inefficiently splitting spectrum during a large portion of its satellites' time on orbit.

It is not clear what criteria Telesat will use in determining whether to deploy wide or narrow beams. SpaceX believes that the public interest would be better served by use of narrow beams, and that the Commission should therefore consider whether any grant of Telesat's application should be conditioned so as to encourage deployment of such beams rather than wider, less efficient beams.

In addition, Telesat proposes to use very high-EIRP earth station uplink beams, which are likely to cause interference to other LEO systems. For example, although both SpaceX and Telesat propose to operate at LEO altitudes, Telesat's uplink beams will transmit at EIRP levels much higher than SpaceX's. With such a large EIRP disparity, the Telesat uplink beam would likely degrade SpaceX's or any other LEO satellite's ability to receive any uplink signal in the affected band from *any* location on the Earth, whether or not it is near the transmitting Telesat earth station. This would essentially prevent a LEO satellite with steerable beams from using that steering capability to avoid an in-line event, forcing both operators to default to band segmentation.

To illustrate this point, we consider two in-line scenarios involving the NGSO systems proposed by Telesat and SpaceX, and use operational parameters from their respective applications to determine the impact (measured as ΔT/T) of these in-line events. In Scenario 1, the SpaceX satellite is in the main beam of the Telesat earth station uplink beam. In this scenario, SpaceX has the ability to redirect beams to serve areas unaffected by the in-line event. Tables 1 and 2 set forth the analysis of the impact on SpaceX in this scenario from 1-meter and 3.5-meter Telesat earth stations, where the SpaceX beams have been redirected to achieve 30 degrees of angular separation from the SpaceX satellite's point of view. As this analysis demonstrates, the uplink beam from a Telesat earth station would cause a dramatic increase in noise temperature relative to the desired signal at the receive antenna of SpaceX satellites, with ΔT/T of 26% and 377%, even assuming 30 degrees of angular separation.[3]

[3] For purposes of this analysis, SpaceX used a representative frequency (28 GHz) and representative orbital altitude for its system (1,110 km), and EIRP values for Telesat earth stations taken from Table 8, page 21 of Attachment A to the Telesat Petition. I/N is calculated using this equation (where k = Boltzmann constant):

$$\frac{I}{N} = EIRP - 10\log(4\pi d^2) - 10\log\left(\frac{4\pi}{\lambda^2}\right) + \frac{G}{T} - 10\log(k)$$

SpaceX SAT Rx antenna gain at nadir [dB]	41.00	
SpaceX SAT Rx antenna G/T at nadir [dB/K]	13.70	*see SpaceX FCC filing*
SpaceX SAT Rx antenna G/T at 30º [dB/K]	-32.23	*32-25log(φ) at 30° separation*
Telesat ES Tx power [dBW/Hz]	-67.00	*per Telesat (see Table 8, page 21)*
Telesat ES Gmax [dB]	47.10	*estimated for 1m antenna*
Telesat ES EIRP [dBW/Hz]	-19.90	
I/N [dB]	**-5.82**	*at 30° separation*
ΔT/T [%]	**26%**	*at 30° separation*

Table 1. Impact of 1 m Telesat Earth Station in Scenario 1

SpaceX SAT Rx antenna gain at nadir [dB]	41.00	
SpaceX SAT Rx antenna G/T at nadir [dB/K]	13.70	*see SpaceX FCC filing*
SpaceX SAT Rx antenna G/T at 30º [dB/K]	-32.23	*32-25log(φ) at 30° separation*
Telesat ES Tx power [dBW/Hz]	-67.00	*per Telesat (see Table 8, page 21)*
Telesat ES Gmax [dB]	58.68	*estimated for 3.5m antenna*
Telesat ES EIRP [dBW/Hz]	-8.32	
I/N [dB]	**5.76**	*at 30° separation*
ΔT/T [%]	**377%**	*at 30° separation*

Table 2. Impact of 3.5 m Telesat Earth Station in Scenario 1

In Scenario 2, the SpaceX and Telesat earth stations are essentially collocated while their satellites have an apparent angular separation of 10 degrees (*i.e.*, the edge of an in-line event). Here again, the analysis in Tables 3 and 4 (for 1m and 3.5m antennas, respectively) demonstrates that the high-EIRP transmissions from the Telesat earth station would cause a dramatic increase in interference, with ΔT/T of 100%.

SpaceX SAT Rx antenna G/T at nadir [dB/K]	13.70	*see SpaceX FCC filing*
Telesat ES Diameter D [m]	1.00	
Telesat ES Gmax [dB]	47.10	*estimated*
Telesat Gain @ 10° [dB]	7.00	*32-25log(φ), per Rec. ITU-R S.465-6*
Telesat ES Tx power [dBW/Hz]	-67.00	*per Telesat (see Table 8, page 21)*
Telesat ES EIRP @ 10° [dBW/Hz]	-60.00	
I/N [dB]	**0.01**	*at 10° separation*
ΔT/T [%]	**100%**	*at 10° separation*

Table 3. Impact of 1m Telesat Earth Station in Scenario 2

SpaceX SAT Rx antenna G/T at nadir [dB/K]	13.70	*see SpaceX FCC filing*
Telesat ES Diameter D [m]	3.50	
Telesat ES Gmax [dB]	58.68	*estimated*
Telesat Gain @ 10° [dB]	7.00	*32-25log(φ), per Rec. ITU-R S.465-6*
Telesat ES Tx power [dBW/Hz]	-67.00	*per Telesat (see Table 8, page 21)*
Telesat ES EIRP @ 10° [dBW/Hz]	-60.00	
I/N [dB]	**0.01**	*at 10° separation*
ΔT/T [%]	**100%**	*at 10° separation*

Table 4. Impact of 3.5m Telesat Earth Station in Scenario 2

In Scenario 1, interference is so strong that it would prevent the SpaceX satellite from using its steerable beams to service other users (even outside the area subject to the in-line event) using spectrum shared with Telesat, and thus essentially prevents SpaceX from using those frequencies anywhere during the in-line event. In Scenario 2, because SpaceX will experience an unacceptable level of interference without a separation angle much larger than 10 degrees, the operators would have to expand the in-line event zone which would negatively impact spectral efficiency and usable capacity for both systems.

Without effective coordination, this pervasive interference will significantly reduce the overall utility of NGSO operations throughout the band. The Commission is currently considering whether to adopt default limits for EIRP density of NGSO uplink transmissions in order to facilitate spectrum sharing among systems,[4] and SpaceX believes that such limits will be critical to equitable and efficient spectrum sharing among non-homogeneous NGSO systems. At a minimum, any grant of Telesat's application should be conditioned upon compliance with the outcome of that rulemaking proceeding. The Commission should also consider whether it would be appropriate to impose additional conditions to address this potential interference and enhance the potential for efficient spectrum sharing.

[4] *See Update to Parts 2 and 25 Concerning Non-Geostationary, Fixed-Satellite Service Systems and Related Matters*, 31 FCC Rcd. 13651, ¶¶ 28-30 (2016).

Respectfully submitted,

SPACE EXPLORATION TECHNOLOGIES CORP.

By: */s/ Tim Hughes*
Tim Hughes
Senior Vice President, Global Business and Government Affairs

Patricia Cooper
Vice President, Satellite Government Affairs
SPACE EXPLORATION TECHNOLOGIES CORP.
1030 15th Street, N.W.
Suite 220E
Washington, DC 20005
202-649-2700 tel
202-649-2701 fax

William M. Wiltshire
Paul Caritj
HARRIS, WILTSHIRE & GRANNIS LLP
1919 M Street, N.W.
Suite 800
Washington, DC 20036
202-730-1300 tel
202-730-1301 fax

Counsel to SpaceX

June 26, 2017

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 Comments,

(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 Comments, and it is complete and accurate to the best of my knowledge and belief.

Signed:

/s/ Mihai Albulet

Mihai Albulet, PhD
Principal RF Engineer
SPACE EXPLORATION TECHNOLOGIES CORP.

June 26, 2017

Date

CERTIFICATE OF SERVICE

I hereby certify that, on this 26th day of June, 2017, a copy of the foregoing Comments was served by electronic mail upon:

Henry Goldberg
Joseph A. Godles
Goldberg, Godles, Wiener & Wright, LLP
1229 Nineteenth Street, N.W.
Washington, DC 20036
JGodles@g2w2.com

/s/ *Sabrina McMillin*
Sabrina McMillin