

**TELESAT LOW EARTH ORBIT NON-GEOSTATIONARY SATELLITE SYSTEM
MINOR AMENDMENT
TECHNICAL EXHIBIT**

A.1 SCOPE AND PURPOSE

On November 3, 2017, the Commission granted Telesat’s petition (hereafter the “Grant”¹) for an NGSO LEO constellation of 117 satellites (hereafter the “Constellation”). On May 26, 2020, Telesat submitted an application² (hereafter the “May 2020 Application”) to modify the Grant in two phases: the first phase (“Phase 1”) would modify the constellation from 117 satellites to 298 satellites (the “Modified Constellation”); and the second phase (“Phase 2”) would add 1373 satellites to the Modified Constellation to bring the total to 1671 satellites (the “Final Constellation”). On May 31, 2022, pursuant to Section 1.65 of the Commission’s rules, Telesat provided notice that the number of satellites in Phase 1 is now planned to be 188 (the “Amended Modified Constellation”) instead of 298, and that the remaining 110 satellites would be added to Phase 2.

This minor amendment details the associated changes to the technical information, provided in the May 2020 Application as required by paragraph (d) of Section §25.114³ of the FCC rules, due to this change. Except as stated in this exhibit, the May 2020 Application is unchanged.

¹ Order and Declaratory Ruling, *Telesat Canada Petition for Declaratory Ruling to Grant Access to the U.S. Market for Telesat’s NGSO Constellation*, 32 FCC Rcd 9663 (2017).

² See IBFS File Nos. SAT-MPL-20200526-00053 and SAT-APL-20210104-00002. See also *Public Notice*, Satellite Policy Branch Information Space Station Applications Accepted for Filing, Report No. SAT-01632 (rel. May 13, 2022).

³ 47 C.F.R. §25.114.

A.2 OVERALL DESCRIPTION

The overall design concept and frequencies remain unchanged as compared to that provided in the May 2020 Application. Table A.2-1 details the orbital parameters of the Amended Modified and the Final constellations, and it illustrates the change in number of satellites due to the amendment from 298 to 188 satellites in Phase 1.

Table A.2-1 – Summary of Orbit Parameters

Parameter		(Telesat Grant) Constellation	Phase 1 <u>Amended</u> Modified Constellation	Phase 2 Final Constellation
Polar Sub- Constellation	Orbital planes	6	6	27
	Satellites per plane	12	13	13
	Inclination (deg)	99.5	98.98	98.98
	Altitude (km)	1000	1015	1015
	Total satellites	72	78	351
Inclined Sub- Constellation	Orbital planes	5	20 <u>10</u>	40
	Satellites per plane	9	11	33
	Inclination (deg)	37.4	50.88	50.88
	Altitude (km)	1248	1325	1325
	Total satellites	45	220 <u>110</u>	1320
Total satellites in constellation		117	298 <u>188</u>	1671

In Table A.2-1, note that there is no change to the Polar Sub-Constellation so that the associated number of satellites remains 78; the only change is with respect to the Inclined Sub-Constellation where the number of orbital planes is 10 instead of 20, so that the associated number of satellites is 110 instead of 220.

As was stated in the May 2020 Application, the Phase 1 satellites are a subset of the Phase 2 Final Constellation. With respect to the Right Ascension of the Ascending Node (“RAAN”) there is a change as compared to the May 2020 Application, which relates only to the Inclined Sub-Constellation: since there are now only 10 orbital planes rather than 20, the RAAN angles of the orbital planes are now equally spaced by 36 degrees between zero and 324 degrees (inclusive), rather than by 18 degrees between zero and 342 degrees (inclusive). The 11 satellites in each of the now 10 orbital planes of the Inclined Sub-constellation remain equally spaced by 32.7 degrees in true anomaly. The angles of the true anomaly of the first satellite in each of the 10 orbital planes of the Inclined Sub-constellation are now provided in Table A.2-2 below, as the formula provided in the May 2020 Application is not valid anymore due to the different spacing between the orbital planes.

Table A.2-2 – True anomaly of the first satellite in each orbital planes of the Inclined Sub-Constellation

Orbit #	1	2	3	4	5	6	7	8	9	10
True anomaly (deg)	0.0	26.2	19.6	13.1	6.5	32.7	26.2	19.6	13.1	6.5

As was noted in the May 2020 Application, IBFS allows only one Schedule S per application. With the May 2020 Application, the Final Constellation of 1671 satellites was set out in the Schedule S filed in IBFS (the “IBFS Schedule S”) and a version of Schedule S with only the 298 satellites of the Modified Constellation was provided as an attachment for reference (the “Reference Schedule S”). As the Final Constellation has not changed there is no change required to the IBFS Schedule S; however, following the earlier approach, we attach a Reference Schedule S for the 188 satellites of the Amended Modified Constellation.

Note that the technical information in the Reference Schedule S for the 188 satellites is the same as that previously provided in the Reference Schedule S for the 298 satellites except that for the former, every second orbit of the Inclined Sub-Constellation has been removed to reflect the change from 20 orbits to 10 orbits. When generating a Schedule S, the software automatically generates the row (index) order in the different tables. Therefore, in some tables of the Reference Schedule S for the 188-satellite constellation the row order is different as compared to the same tables in the Reference Schedule S for the 298-satellite constellation. Nevertheless, the information contained in those tables has not changed. Table A.2-3 provides a summary of the Reference Schedule S.

Table A.2-3 – Summary of Reference Schedule S (current amendment as compared to the May 2020 Application)

	May 2020 Application	Current Amendment
Total Number of Satellites in the active constellation	298	188
Polar Orbit plane ID	1, 2, 3, 4, 5, 6	1, 2, 3, 4, 5, 6
Inclined Orbit plane ID	The IDs in the columns below identify the corresponding orbital planes between the 298-satellite and the 188-satellite configurations. For example, plane ID n. 9 of the 298-satellite configuration is the same as plane ID n. 8 of the 188-satellite configuration, and so on.	
	7, 9, 11, 13, 15, 17, 19, 21, 23, 25	7, 8, 9, 10, 11, 12, 13, 14, 15, 16
Inclined Orbit plane ID no longer included due to reduction from 20 to 10 orbits	8, 10, 12, 14, 16, 18, 20, 22, 24, 26	N/A
Tables that have not changed in Schedule S		
Operating Frequency Bands	–	Row order (index) generated by the software may have changed but the information contained in those rows has not
Receiving Beams	–	
Receiving Channels	–	
Transmitting Beams	–	
Transmitting Channels	–	

A.3 SPACE STATION ANTENNA GAIN CONTOURS

The space station antenna gain information and the linkage between the beams in the GIMS database and the beams in Schedule S have not changed as compared to the May 2020 Application.

A.4 INTERFERENCE ANALYSIS

This section addresses compliance with Article **21** power flux-density (“PFD”) limits, Article **22** equivalent power flux-density (“EPFD”) limits, and the interference analysis with respect to other NGSO systems belonging to the first processing round.

A.4.1 Compliance with Article 21 PFD limits

In the May 2020 Application, an analysis for the Modified and Final Constellations was provided. For the latter, since the Final Constellation has not changed, the analysis in the May 2020 Application for the Final Constellation remains valid. For the former, the analysis for 188 satellites rather than 298 satellites is provided below. The applicable approach to calculate the limits (which are based on angle of arrival) is the same as indicated in the May 2020 Application and is repeated below in Table A.4.1-1 below for convenience.

Table A.4.1-1: Applicable PFD limits (reference bandwidth = 1 MHz)

Frequency Band (GHz)	Limit in dB(W/m ²) for angles of arrival (δ) above the horizontal plane		
	0°-5°	5°-25°	25°-90°
17.7-19.3	-115-X	$-115-X + ((10+X)/20)(\delta-5)$	-105

where the parameter X is a function of the number, n, of satellites:

$$X = 0 \quad \text{dB} \quad \text{for } n \leq 50$$

$$X = (5/119) (n - 50) \quad \text{dB} \quad \text{for } 50 < n \leq 288$$

$$X = (1/69) (n + 402) \quad \text{dB} \quad \text{for } n > 288$$

In the May 2020 Application, the value of n, the number of satellites, was 298 so using the relevant formula above for n = 298 gave a value of X = 10.14 dB. With this current (Amended Modified Constellation) application the relevant formula for n = 188 gives a value of X = 5.80 dB. There is no change to the maximum EIRP density as compared to the May 2020 Application (i.e. it remains -50 dB(W/Hz)). Taking into account these parameters, the PFD limit and the calculated PFD due to the Amended Modified Constellation, for various angle of arrival, is shown in Table A.4.1-2. In all cases, the calculated PFD is lower than the applicable PFD limit, and therefore, the Amended Modified Constellation is compliant with the limits stated in Section §25.208 of the Commission's rules.

Table A.4.1-2: Amended Modified Constellation PFD

Angle of Arrival (deg)	PFD limit for 188 satellites dB(W/m ² /MHz)	Calculated PFD for 188 satellite constellation dB(W/m ² /MHz)
5	-120.8	-131.2
10	-116.9	-129.9
15	-112.9	-128.7
20	-109.0	-127.6
25	-105	-126.8
90	-105	-121.1

A.4.2 Compliance with Article 22 EPFD limits

As stated in the May 2020 Application, Telesat will ensure compliance with the applicable EPFD limits set forth in Article **22** of the ITU Radio Regulations.⁴ The Commission's rules and the Grant oblige Telesat to receive from the ITU Radiocommunication Bureau, prior to initiation of service, a favorable or "qualified favorable" finding in accordance with Resolution **85 (WRC-03)**. As stated in the May 2020 Application, Telesat received from the ITU a favorable finding⁵ for the Constellation and expects to receive favorable findings for the Modified and Final Constellations. Telesat also expects to receive a favorable finding for the Amended Modified Constellation. In the May 2020 Application, although not required by the

⁴ 47 C.F.R. §25.146(a)(2)

⁵ See CR/C/3313 MOD-3, published in BR IFIC 2863

Commission's rules, Telesat provided a demonstration of compliance with the EPFD limits for the Modified Constellation. As the Amended Modified Constellation is for fewer satellites (188 instead of 298), and as the reduction in the number of satellites in Phase 1 will not worsen the EPFD statistics generated by the constellation during that phase, the demonstration of compliance with the EPFD limits remains valid and no further demonstration is required.

A.4.3 Interference analysis with respect to other NGSO systems

The analysis Telesat provided in the May 2020 Application demonstrated that the changes proposed for the Modified Constellation would improve the interference environment vis-a-vis other first round NGSO systems.⁶ The analysis showed that three factors account for this improvement. These three factors are associated as well with the Amended Modified Constellation. Accordingly, the Amended Modified Constellation also will improve the interference environment vis-a-vis other first round NGSO systems, and no additional interference analysis has been provided.

The three factors are as follows:

- There are more satellites to choose from than there were with the original Grant.⁷ The additional satellites enhance satellite diversity, making it

⁶ May 2020 Application, Technical Exhibit at Section A.4.3.

⁷ The system approved in the original Grant consisted of 117 satellites. The Amended Modified Constellation, although smaller than the Modified Constellation, consists of 188 satellites, *i.e.*, 71 more satellites than in the original Grant.

possible for terminals to select links that have less potential to cause or suffer interference.

- Only one co-frequency satellite will offer service towards a given location rather than the two co-frequency satellites associated with the original Grant, which will improve the interference environment with respect to other NGSO systems.
- The G/T for the satellites and earth station receivers is lower than envisioned in the original Grant, which will improve resilience to interference caused by other NGSO systems.

A.5 ITU FILINGS

As stated in the May 2020 Application, Telesat is licensed through the Canadian administration to the ITU networks COMMSTELLATION, CANSAT-LEO and TELSTAR-LEO. In August 2021, Telesat also submitted the ITU filing TELSTAR-LEO-2 through Canada.

A.6 COMPLIANCE WITH COVERAGE REQUIREMENTS

There is no change as compared to the May 2020 Application.

A.7 WAIVER REQUESTS

Telesat continues to request the following waivers it had sought in the May 2020 Application:

- A waiver, to the extent required, of Section 25.114 of the rules, permitting it to submit as an attachment, rather than uploading directly to IBFS, a Schedule S for the Amended Modified Constellation. (The Commission's IBFS filing system will accommodate only a single uploaded Schedule S with a modification filing, and Telesat already has uploaded a Schedule S for the Final Constellation.)
- A waiver, taking into account the significant backlog at the ITU Radiocommunication Bureau ("ITU BR") in assessing compliance of NGSO systems with applicable EPFD limits, permitting Telesat to commence operations if the ITU BR has not at the time completed its assessment as to whether Telesat should receive a favorable or "qualified favorable" finding from the ITU BR with respect to the compliance of the Amended Modified Constellation with the applicable limits set forth in Article 22 of the ITU Radio Regulations.
- Continuation of the waivers approved in the original Grant.

**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/ Mario Neri

Mario Neri, CEng.
Director, International Coordination
Telesat International Ltd.

June 16, 2022