FCC Form 312 **Exhibit 1**

Response to Questions 30-34: Alien Ownership

In response to Questions 30 and 31 of Form 312, Telesat Canada is organized under the laws of Canada.

Questions 32 and 33 of Form 312 ask whether the Applicant, Telesat Canada, is: (1) a corporation of which more than 20 percent of the capital stock is owned of record or voted by aliens or their representatives or by a foreign government or representative thereof or by any corporation organized under the laws of a foreign country; or (2) directly or indirectly controlled by a corporation of which more than 25 percent of the capital stock is owned of record or voted by aliens or their representatives or by a foreign government or representative thereof or by any corporation organized under the laws of a foreign country. These questions are intended to ascertain whether the applicant complies with Sections 310(b)(3) and 310(b)(4) of the Communications Act, which establish limits on foreign ownership of the licensees of broadcast, common carrier, aeronautical en route, and aeronautical fixed stations. Sections 310(b)(3) and 310(b)(4) are inapplicable to the proposed satellite constellation, because the satellite constellation is not an aeronautical en route or aeronautical fixed station and Telesat Canada does not propose to provide broadcast or common carrier service via the satellite constellation.

FCC Form 312 **Exhibit 2**

Response to Question 36: Licenses Revoked or Applications Denied

Neither Telesat Canada, which is the Applicant, nor Loral Space & Communications, Inc. ("Loral Space"), which is an indirect shareholder of Telesat Canada, has had any FCC station authorization or license revoked or had any application for an initial, modification or renewal of FCC station authorization, license, or construction permit denied by the Commission.

The following information involves entities owned by Loral Space:

In an order issued April 1, 2003, the International Bureau declared null and void authorizations held by Loral SpaceCom Corporation and Loral Space & Communications Corporation to construct, launch and operate geostationary Fixed Satellite Service Ka-band payloads at 89° WL, 81 ° W.L., 47° W.L., and 78° E.L.[1] The Bureau affirmed its earlier decision not to extend the construction milestones associated with these authorizations.[2]

In an order issued July 7, 2005, the International Bureau declared null and void, by its own terms, Loral SpaceCom Corporation's authorization to launch and operate a satellite at the 69° W.L. orbit location.[3]

In an order issued September 26, 2005, the International Bureau declared null and void, by its own terms, CyberStar Licensee, LLC's Ka-band system authorization to launch and operate satellites at the 93° WL and 115° W.L. orbital locations.[4]

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[1] *See Loral SpaceCom Corporation and Loral Space & Communications Corporation*, Memorandum Opinion, Order and Authorization, 18 FCC Rcd 6301 (2003).

[2] *See Loral Space & Communications Corporation*, Order, 16 FCC Rcd 11044 (2001).

[3] *See Loral SpaceCom Corporation (Debtor-in-Possession)*, Memorandum Opinion and Order, 20 FCC Rcd 12045 (2005).

[4] *See CyberStar Licensee, LLC*, Order, 20 FCC Rcd 15412 (2005).

Response to Question 40:
Officers, Directors, and Ten Percent or Greater Shareholders

The Applicant, Telesat Canada, is organized under the laws of Canada.

The officers and directors of Telesat Canada are:

Officers
Daniel S. Goldberg, President and CEO
Christopher S. DiFrancesco, Vice President, General Counsel & Secretary
Michel G. Cayouette, CFO and Treasurer

Directors

John P. Cashman	Daniel Garant
Clare R. Copeland	Michael Boychuk
Guthrie Stewart	Mark H. Rachesky
Richard Fadden	Colin D. Watson
Hank Intven	Michael Targoff

Address for all officers and directors:
Telesat
1601 Telesat Court
Ottawa ON K1B 5P4 Canada

Loral Space & Communications Inc. ("Loral"), through its wholly-owned subsidiary, Loral Holdings Corporation, a U.S. company, holds 62.70% of the equity of Telesat Canada. Loral, through its subsidiary previously mentioned, holds a 32.65% voting interest for all matters.

The Public Sector Pension Investment Board ("PSP"), through its wholly- owned subsidiary Red Isle Private Investments Inc., a Canadian company, holds 35.76% of the equity of Telesat Canada. PSP is a Canadian Crown corporation established by the Canadian Parliament pursuant to the Public Sector Pension Investment Board Act. PSP, through its subsidiary previously mentioned, holds a 67.35% voting interest for all matters except the election of the board of directors, and a 29.39% voting interest for the election of the board of directors.

Certain past and present employees of Telesat Canada hold combined 1.53% of the equity of Telesat Canada.

John P. Cashman, a citizen of Canada and Ireland, holds a 31.12% voting interest solely for the election of the board of directors of Telesat Canada.

Colin D. Watson, who is a Canadian citizen, holds a 6.83% voting interest solely for the election of the board of directors of Telesat Canada.

Shareholder	**Jurisdiction of Incorporation**	**Address**	**Participating Equity**	**Shares with voting rights for direct**	**Shares with voting rights on all other**
PSP	Created by Act of Canadian Parliament	1250 René Lévesque Blvd., West, Suite 900 Montréal QC H3B 4W8	35.76%	29.39%	67.35%
Loral	Delaware	Loral Space & Communications Inc. 888 Seventh Avenue, 40th Floor New York, NY 10106 USA	62.70%	32.65%	32.65%
Past and Present Employees of Telesat Canada		c/o 1601 Telesat Court Ottawa, ON Canada K1B 5P4	1.54%		
John P. Cashman		13 Admiral Road Toronto, ON M5R 2L4 Canada		31.12%	
Colin D. Watson		72 Chestnut Park Rd Toronto, ON M4W 1W8 Canada		6.83%	

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

In the Matter of	)	
	)	
Telesat Canada	)	File No. ________________
	)	
Petition for Declaratory Ruling to Grant Access to the U.S. Market for Telesat's V-Band NGSO Constellation	)	

PETITION FOR DECLARATORY RULING

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March 1, 2017

TABLE OF CONTENTS

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

In the Matter of	)	
	)	
Telesat Canada	)	File No. _________________
	)	
Petition for Declaratory Ruling to Grant Access to the U.S. Market for Telesat's V-Band NGSO Constellation	)))	

PETITION FOR DECLARATORY RULING

I. INTRODUCTION AND SUMMARY

Pursuant to Section 25.137 of the Commission's rules and the Commission's *Public Notice* initiating a processing round for additional non-geostationary-satellite orbit ("NGSO")-like satellite applications in bands that include the V-band,[1] Telesat Canada ("Telesat") hereby petitions for a declaratory ruling ("Petition") authorizing the NGSO low earth orbit ("LEO") constellation system (the "Telesat V-band LEO Constellation" or "V-band Constellation") to serve the U.S. market using V-band frequencies.

Telesat recently filed a Petition for Declaratory Ruling ("PDR") to authorize service in the United States from Telesat's new NGSO low earth orbit ("LEO") Ka-band

[1] *Cut-Off Established for Additional NGSO-Like Satellite Applications or Petitions for Operations in the 37.5-40.0 GHz, 40.0-42.0 GHz, 47.2-50.2 GHz and 50.4-51.4 GHz Bands*, Public Notice, DA 16-1244 (rel. Nov. 1, 2016) ("*V-Band Public Notice*").

constellation system (the "Ka-band LEO Constellation").[2] Telesat now seeks permission to serve the United States from a new NGSO low earth orbit constellation system using V-band frequencies.

As Telesat pointed out in its PDR for its Ka-band LEO Constellation, innovative and spectrally-efficient NGSO constellations can serve currently unserved and underserved areas as well as providing additional differentiated and competitive broadband offerings in areas now served by terrestrial means and GSO-based networks. The same is true for Telesat's technically advanced V-band Constellation.

Telesat's depth of experience, technical expertise, innovative ideas, significant financial resources, and its willingness to invest those resources in the future assure its successful deployment of a new NGSO constellation. The Telesat V-band LEO Constellation will provide significant benefits including:

- High speed – Gigabits-per-second (Gbps) links;
- High capacity – Terabits-per-second (Tbps) of total capacity;
- Significantly lower latency than GSO – equivalent to, and in some cases even lower than, terrestrial networks;
- Global broadband coverage, including coverage of unserved and underserved areas, giving the ability to connect any two points on the globe;

[2] Telesat Canada Petition for Declaratory Ruling to Grant Access to the U.S. Market for Telesat's NGSO Constellation, File No. SAT-LOI-20161115-00108 (filed Nov. 15, 2016) ("Telesat Ka-band LEO Constellation PDR").

- Highly secure – ability to avoid traversing any third-party networks, thereby minimizing risk to user information;
- High resiliency – no single point of failure;
- Seamless extension of today's advanced terrestrial telecom networks – provision of Carrier Ethernet service[3] which allows users to access the constellation data capacity as they would access any other network; and
- Efficiency - efficient use of spectrum and orbital resources.

Telesat has a long history of relying upon U.S. satellite manufacturers and launch service providers. These relationships have brought innovative communications services to customers around the world, and have created U.S. jobs and contributed to the competitiveness of U.S. industry. Telesat currently has three satellites under construction being built by U.S.-based manufacturer SSL. Two of those satellites are under contract to be launched by SpaceX, a U.S. company. Telesat's global GSO constellation consists of 15 satellites, 11 of which were built by U.S. manufacturers. Telesat's Ka-band and V-band constellations will require the manufacture of hundreds of advanced satellites. A project of this scope, coupled with the use of the latest technologies, has the potential to greatly benefit U.S. workers, U.S. industry and the U.S. technology base.

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[3] The technical specifications for Carrier Ethernet are developed by MEF, a global industry alliance comprising more than 220 organizations including telecommunications service providers, cable MSOs, network equipment/software manufacturers, semiconductors vendors and testing organizations. *See* *https://www.mef.net/about-us/mef-overview*.

Telesat's NGSO constellations were designed in part to meet the objectives of U.S. military officials for a more resilient space architecture in an increasingly congested, contested, and competitive space environment. Specifically, the Department of Defense is interested in more distributed space architectures to enhance network resiliency as well as networks with greater security features to mitigate cyberattacks.[4]

Telesat's highly distributed and resilient network architecture will advance these objectives. Specifically, each of the advanced satellites in Telesat's constellations will operate as a network node so that traffic will be automatically routed around a failure point, similar to a ground-based IP network. This is made possible due to the system's regenerative payload and inter-satellite links (ISLs). In addition, the constellations will include multiple spare satellites contributing to its robustness. Telesat's constellations also provides the ability to connect any two points on the globe without the need to transit terrestrial communications networks, significantly mitigating the risk of cyberattacks. Telesat's Ka-band and V-band constellations will provide a level of resiliency and security not possible with GSO, terrestrial networks or NGSO constellations not having these features.

The V-band LEO Constellation will follow closely the design of the Ka-band LEO Constellation. It is designed as a second-generation overlay and, as in the case of the

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[4] *See, e.g.,* Command, Air Force Space, *Resiliency and Disaggregated Space Architectures* (2013), at http://www. afspc. af. mil/shared/media/document/AFD-130821-034.Pdf, *copied at* https://www.telesat.com/sites/default/files/telesat/files/governance/resiliency.pdf.

Ka-band LEO Constellation, will have a minimum of 117 satellites plus spares and use two sets of orbits. The first, a Polar Orbit constellation at an inclination of 99.5°, consists of a minimum of 6 planes at 1000 km, with a minimum of 12 satellites in each plane. The second, an Inclined Orbit constellation at an inclination of 37.4°, consists of a minimum of 5 planes at 1248 km, with a minimum of 9 satellites in each plane.

In addition, subject to regulatory approval, capacity can be quickly and efficiently added to the system by simply adding satellites in each of the planes of the Inclined and/or Polar Orbits, and/or by adding additional planes.

In order to operate the V-band Constellation without causing harmful interference into other radio services or receiving harmful interference from them, Telesat will conduct frequency coordination with the relevant federal and non-federal radio services — including terrestrial services (fixed, mobile, and broadcasting), geostationary and non-geostationary satellite services (fixed-satellite, mobile-satellite, broadcasting-satellite, space-research, and earth exploration-satellite services), and radio astronomy services — in accordance with the relevant provisions of the FCC Rules and the ITU Radio Regulations.

Grant of Telesat's Petition is in the public interest. A grant will afford the public the benefits of access to an innovative and technologically advanced V-band NGSO broadband service. Further, a grant will enhance competition with existing and future GSO and NGSO systems, thereby expanding the options available to customers in the United States.

Telesat demonstrates below that it has the experience, technical qualifications and expertise necessary to design, develop, and successfully implement and commercialize its highly innovative, technologically advanced V-band Constellation for providing new and vastly needed broadband services to the public. Telesat also provides below a summary description of the Telesat V-band LEO Constellation, which is presented in detail in the associated Technical Exhibit and Schedule S submitted herewith.

Telesat further demonstrates that it is technically and legally qualified to serve the U.S. market via its V-band Constellation. This Petition, the Technical Exhibit, and Schedule S show compliance with the Commission's technical requirements, including appropriate protections for fixed-satellite services using GSO and NGSO satellites and for other services. Telesat's Form 312 submission in combination with this Petition shows its legal qualifications. Telesat also shows that serving the United States via its V-band Constellation is presumed to enhance competition because the authorizing country, Canada, is a member of the World Trade Organization. Telesat further shows that no national security, law enforcement, foreign policy, or trade concerns are implicated by the proposed use of the Telesat V-band Constellation to serve the United States. Accordingly, the Commission's requirements for U.S. market access are satisfied.

II. TELESAT'S EXPERIENCE AND TECHNICAL QUALIFICATIONS AND EXPERTISE ARE UNPARALLELED

As stated in Telesat's recently-filed Ka-band PDR,[5] development, implementation and operation of an NGSO constellation requires considerable know-how. That is as true for a V-band system as it is for a Ka-band system. Given the experience, technical qualifications and expertise, and financial strength of Telesat, the company's capabilities make it uniquely qualified to construct and operate an advanced NGSO V-band constellation (the "V-band LEO Constellation"). The details regarding Telesat's NGSO qualifications may be found in its Ka-band LEO Constellation PDR and are summarized below.

Telesat is headquartered in Ottawa, Canada, and was established in 1969 with an initial mandate to provide satellite services to all parts of Canada, especially to remote areas where terrestrial alternatives were unavailable or prohibitively expensive. Thus, providing service to unserved or underserved communities is part of Telesat's heritage, which it has fostered and enhanced since its inception. Telesat launched the world's first domestic commercial geostationary satellite in 1972 and, since that time, has evolved into an international, diversified, and end-to-end satellite services company, with an unparalleled reputation for innovation, technical and operational expertise and customer service.

In 2007, Telesat's operations were combined with the satellite operations of Loral Skynet, a U.S. company with a strong technical background tied to the achievements of

[5] Telesat Ka-band LEO Constellation PDR, *supra* note 2.

AT&T Skynet, Bell Labs and the Telstar program. As a result, Telesat greatly expanded its coverage and transitioned to a truly global operator with ties to four licensing administrations: Canada, U.S., Brazil and the United Kingdom. Telesat's subsidiary, Skynet Satellite Corporation, operates the Telstar 11N (37.55W), Telstar 12 VANTAGE (15W) and Telstar 12 (109.2W) satellites under license from the FCC. Telesat also has U.S. market access for its Canadian-licensed Nimiq-5 (72.7W), Anik-F1 (107.3W), Anik-F1R (107.3W), Anik-F2 (111.1W), and Anik-F3 (118.7W) satellites, and its Brazilian-licensed Estrela do Sul 2 also known as Telstar-14R (63W) and planned Telstar 19 VANTAGE (63W) satellites.

Telesat is one of the largest and most successful satellite operators in the world and a leading provider of voice, data, video and IP networking services to the private sector and governments. The company's advanced communications are delivered through its global fleet of 15 satellites, with an additional two GSO and two NGSO satellites under construction. Telesat also operates a robust global teleport and terrestrial infrastructure that is seamlessly integrated with its fleet. Through this combination of space and ground assets, Telesat's communications solutions support the demanding requirements of customers throughout the world.

Telesat also has experience in operating non-geostationary LEO satellites. Specifically, since 2007 Telesat has been operating Radarsat-2, a LEO satellite at an altitude of 798 km.

The company's engineers and support personnel monitor, control, operate, and maintain satellite networks 24 hours a day, seven days a week. Telesat is widely respected for its ability to design, provision, implement, and manage comprehensive, end-to-end, state-of-the-art satellite-based communication networks, including in harsh and remote environments, for governments and commercial satellite users around the world. Telesat's deep technical expertise and customer-oriented culture, as reflected in the company's Consulting Engineering Group and Research and Development Lab, provide Telesat with depth and breadth of engineering and development expertise.

In addition to serving commercial customers, Telesat has long provided advanced satellite solutions to support mission critical requirements of allied governments and their departments, including the U.S. Department of Defense (DoD) and other U.S. government agencies.

Telesat's main teleport supporting its international satellite fleet is located in Mount Jackson, Virginia. Using Mount Jackson, Telesat customers can implement satellite service from the U.S. to coverage areas including the Middle East and North Africa, the Americas and Europe, which are served by Telesat's Telstar 11N, Telstar 12 VANTAGE, Telstar 14R and other Telesat and third-party satellites.

GSO satellites like Telstar 12 VANTAGE that offer high throughput capabilities are expected to remain core to Telesat's mission. However, in keeping with Telesat's goal to implement new leaps in technology and capability, the company is looking to augment its GSO fleet as the satellite industry pursues more data-centric applications with price and performance standards comparable to or exceeding terrestrial technologies. Telesat is working on NGSO innovations that will revolutionize the satellite industry. Telesat's Ka-band and V-band LEO constellations will provide unserved and underserved communities with high speed, low latency broadband services and deliver competitive services to those that already have access to broadband.

III. DESCRIPTION OF THE V-BAND LEO CONSTELLATION

Telesat's second-generation V-band LEO Constellation will greatly augment the capacity of Telesat's first-generation Ka-band LEO Constellation, which will offer high-speed, high-capacity broadband connectivity. Performance will be equivalent or superior to terrestrial networks with respect to security, resiliency, and latency. The V-band LEO constellation will provide additional capacity to unserved and underserved communities, for both private sector and government users.

A. System Overview

The V-band LEO Constellation will follow closely the design of the Ka-band LEO Constellation, for which it will be a second-generation overlay. As in the case of the Ka-band LEO Constellation, the V-band LEO Constellation will have a minimum of 117 satellites plus spares and use two sets of orbits. The first, a Polar Orbit constellation at an inclination of 99.5°, consists of a minimum of 6 planes at 1000 km, with a minimum of 12 satellites in each plane. The second, an Inclined Orbit constellation at an inclination of 37.4°, consists of a minimum of 5 planes at 1248 km, with a minimum of 9 satellites in each plane. Polar Orbits provide global coverage, with a concentration of satellites in the polar regions. Inclined Orbits concentrate satellites over equatorial and mid-latitude areas where demand for communications services is greater than in the polar regions. By using two complementary orbits, the system achieves true global coverage while concentrating satellite resources on areas of demand, thereby making the system much more efficient.

Users will link directly to a Telesat NGSO satellite through a high-gain steerable spot beam. The user signal will then connect: directly to a terrestrial hub (gateway); directly to another user; or indirectly to a gateway or other user through an inter-satellite link ("ISL"). Telesat will be able to assign capacity dynamically to locations and routes with different levels of demand by varying the number and size of the satellite spot beams, as well as the amount of spectrum and power allocated to each beam, thereby achieving highly efficient use both of satellite resources and of scarce orbital spectrum. In addition to its spot beams, each satellite in the constellation will have a fixed wide-area receive beam covering the satellite's entire field of view. The wide-area beam will allow the satellite to detect a user request to initiate communication. These wide-area beams will enable the network to provide global coverage. Through the use of inter-satellite links, the system will deliver connectivity to remote locations, even when no single satellite has visibility to both user and gateway locations. Each satellite will incorporate inter-satellite communication capability. The inter-satellite links will provide customers with the ability to connect from any point to any point on the globe. Each satellite will also employ on-board processing and will effectively be a node in an IP network.

In addition, subject to regulatory approval, capacity can be quickly and efficiently added to the system by simply adding satellites in each of the planes of the

Inclined and/or Polar Orbits, and/or by adding additional planes. As the number of satellites increases, the operational elevation angles of the gateways and users increase, allowing for increased capacity and more efficient use of satellite and spectrum resources.

Thus, the system's design will maximize the functionality of services offered while providing these services cost effectively.

In order to operate the V-band LEO Constellation without causing harmful interference into other radio services or receiving harmful interference from them, Telesat will conduct frequency coordination with the relevant federal and non-federal radio services, including terrestrial services (fixed, mobile, and broadcasting), geostationary and non-geostationary satellite services (fixed-satellite, mobile-satellite, broadcasting-satellite, space-research, and earth exploration-satellite services), and radio astronomy services in accordance with the relevant provisions of the FCC Rules and the ITU Radio Regulations.

As demonstrated in Telesat's Petition for Declaratory Ruling for its Ka-band LEO Constellation,[6] minimum discrimination angles between GSO satellite networks and Telesat's Ka-band LEO Constellation satellite network were calculated to ensure compliance with the equivalent power flux density (epfd) limits defined for Ka-band by the ITU Radio Regulations. V-band epfd limits have not yet been defined in the ITU Radio Regulations or the FCC rules, but are under study within the ITU-R. Telesat will

[6] Telesat Ka-band LEO Constellation PDR, *supra* note 2.

participate in the ITU studies for the development of epfd limits for V-band. The V-band LEO Constellation satellite network will avoid interfering into GSO satellite networks in the same way that Telesat's Ka-band LEO Constellation will avoid interfering into GSO satellite networks, *i.e.*, by complying with minimum discrimination angles that would ensure no harmful interference. Telesat will also perform frequency coordination with GSO satellite operators to ensure the GSO satellite networks will not receive harmful interference from its V-band LEO Constellation.

The V-band LEO Constellation will employ on-board processing, including an IP router. As a result, the amount of bandwidth employed in the Earth-to-space and space-to-Earth directions does not need to be identical. Telesat proposes to operate its V-band LEO Constellation using 4.5 GHz of spectrum space-to-Earth and 4 GHz of spectrum Earth-to-space. The bands to be used are: 37.5 – 42.0 GHz in the space-to-Earth direction, and 47.2-50.2 GHz and 50.4-51.4 GHz in the Earth-to-space direction. This spectrum will be used for both gateway and user links to the extent permitted by the Commission's Rules.

The band 37.5 – 42.0 GHz is allocated both internationally and in the FCC Table of Frequency Allocations to the FSS on a primary basis.

Other services, notably the fixed service (FS), are co-primary in segments of the 37.5 – 42.0 GHz band. Power-flux density (PFD) limits apply both internationally and domestically. In the portion of the band 40.0 – 42.0 GHz, the international and domestic

PFD limits are the same.[7] In the 37.5 – 40.0 GHz band, however, the Commission's Rules[8] impose more stringent PFD limits than do those of the ITU Radio Regulations. As discussed in greater detail in Section A5 of the Technical Appendix, Telesat will comply with the PFD limits contained in Sections 25.208 (r), 25.208 (s) and 25.208 (t) of the Commission's Rules.

The band 47.2 – 50.2 GHz is allocated internationally and in the FCC Table of Allocations to the FSS on a primary basis, co-primary with both the fixed and mobile services. To the extent that there are any federal or non-federal terrestrial users in this band, Telesat will coordinate with co-primary services as required.

The band 50.4 – 51.4 GHz is allocated internationally and in the FCC Table to the FSS on a primary basis, co-primary with the fixed, mobile, and mobile-satellite services.[9] However, the band is not identified in Section 25.202(a)(1) of the Commission's rules as being available for FSS. Accordingly, Telesat seeks a waiver below[10] of Section 25.202(a)(1) to allow use of this band by the Telesat V-band LEO constellation in the Earth-to-space direction. Telesat notes that a Petition for Rulemaking has been filed seeking the initiation of a Commission proceeding to permit the use of FSS Earth-to-space in the 50.4-51.4 GHz band.[11]

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[7] See 47 C.F.R. §§ 25.208(s) and 25.208(t) and Table 21-4 of the ITU Radio Regulations.
[8] 47 C.F.R. § 25.208(r).
[9] The ITU allocation to the mobile-satellite service is on a secondary basis.
[10] Section IV.C.1 *infra*.
[11] The Boeing Co. Petition for Rulemaking, RM-11773 (filed June 22, 2016).

B. Space and Ground Segment

Each satellite in the constellation will be designed for maximum flexibility in terms of coverage, by means of shapeable and steerable beams and inter-satellite links, and in bandwidth and power assignment, by means of onboard processing. Specifically:

- **Direct Radiating Array (DRA)** – Will provide independent agile beams, each with steering and forming capabilities allowing beams to be generated where and when required, based on traffic demand;
- **On-board Processing** – Will perform signal regeneration (*i.e.*, demodulation and re-modulation) and routing of traffic, thereby improving link performance and increasing capacity compared with a simple channelizer or bent-pipe payload;
- **Optical Inter-Satellite Links (ISL)** – Multiple ISL beams on each satellite will connect to other satellites in the V-band LEO Constellation. The ISLs will be able to communicate with satellites within the same plane, within adjacent planes of the same orbit, and between the Polar Orbit and Inclined Orbit.

Satellite user and gateway beams will be formed using active array antennas with state-of-the-art beam-forming capability. The onboard processing and ISL capabilities will enable the constellation to route traffic flexibly and to make the most efficient use of gateways. The use of both polar and inclined NGSO orbits and satellites employing beam-forming technology connected through ISL links enable Telesat to perform continuous and seamless TT&C (telemetry, tracking and command) and collision-avoidance maneuvers.

A wide variety of user terminals, both electronically-steered and mechanically tracking, will access the V-band LEO Constellation. The system is capable of operating with both fixed terminals and mobile terminals. Since the FCC Rules do not authorize use of mobile terminals in the frequency bands that will be used in the V-band LEO Constellation, such terminals would be used in the U.S. only upon filing of the requisite waiver requests and their grant by the Commission. Telesat's system will provide a Carrier Ethernet Service, the *de facto* standard for networking.

C. Summary

Telesat's V-band NGSO design and combination of space and ground assets will support a network with a number of important advantages for the user community:

- **Truly Global Coverage** – Ability to provide service anywhere on the globe, even to locations where the serving satellite cannot simultaneously see a gateway;
- **Low Latency** – Equal or superior to the latency of terrestrial networks;
- **High Speed and Capacity** – The design provides Gbps links, and a total system capacity in the Tbps range;
- **High Level of Security** – Ability to directly connect locations, bypassing third-party networks, and providing a heightened level of service integrity;

- **Seamless Extension of Today's Advanced Terrestrial Telecom Networks** - The V-band LEO Constellation satellite network will provide a Carrier Ethernet service. With a standard network interface, users will access the constellation data capacity as they would access any other network;
- **Highly Resilient**
    - No single point of failure - The use of in-orbit spares, the combination of Polar Orbits and Inclined Orbits, and inter-satellite links, provide multiple routes for user traffic to ensure no single point failure, even in the case of a satellite anomaly;
    - Network Auto Recovery/Routing – Since each satellite, gateway and terminal acts as a node in an IP network, traffic is automatically routed around a failure point similar to what occurs in a terrestrial network;
- **Efficient and Scalable** – Scarce spectrum and spacecraft resources are focused where there is customer demand. Capacity can readily be increased by adding relatively few satellites targeted at areas of greatest need;
- **Can Operate with a Variety of User Terminals** –Both electronically steered and mechanically tracking terminals may be used.

IV. THE V-BAND LEO CONSTELLATION SATISFIES THE FCC'S REQUIREMENTS FOR SERVING THE UNITED STATES

The Commission has an established framework for considering requests for non-U.S. licensed space stations to access the U.S. market. In evaluating requests for such authority, the Commission considers the effect on competition in the United States, spectrum availability, eligibility and operational requirements, and concerns related to national security, law enforcement, foreign policy, and trade.[12]

Operators seeking U.S. market access for non-U.S. licensed space stations need to provide the same information concerning legal and technical qualifications as must be provided by applicants for space station licenses issued by the FCC.[13]

The proposed operation of the V-band LEO Constellation to serve the United States satisfies all of these tests.

A. Legal and Technical Qualifications

The information set forth in this legal narrative, the attached Technical Exhibit and the Schedule S that is filed herewith establish that the proposed operation of the V-band LEO Constellation is consistent with the Commission's legal and technical

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[12] *See Amendment of the Commission's Regulatory Policies to Allow Non-U.S. Licensed Space Stations to Provide Domestic and International Satellite Service in the United States*, 12 FCC Rcd 24094, ¶ 29 (1997))("*DISCO II Order*"), *on reconsideration,* 15 FCC Rcd 7207, ¶ 5 (1999). *See also* Section 25.137 of the Commission rules, 47 C.F.R. § 25.137.
[13] *See In the Matter of Amendment of the Commission's Space Station Licensing Rules and Policies; Mitigation of Orbital Debris,* First Report and Further Notice of Proposed Rulemaking in IB Docket No. 02-34, and First Report and Order in IB Docket No. 02-54, 18 FCC Rcd 10760, ¶ 288 (2003) *("Space Station Licensing Reform Order").* Some of the Commission's application policies for authorizing non-U.S. licensed space stations are codified in Section 25.137 of the Commission's rules, 47 C.F.R. § 25.137.

requirements, including those specified in Section 25.114 of the Commission's rules. In addition, Telesat makes specific note below of its compliance with other applicable parts of the Commission's rules.

1. Submission to ITU

With respect to the requirements of Section 25.137 for non-U.S.-licensed space stations, Telesat affirms that it has provided the Canadian licensing authority, Innovation, Science and Economic Development Canada ("ISED") (formerly Industry Canada), with documentation to initiate the coordination process for the V-band LEO Constellation, and that the documentation was received by ITU BR from ISED on February 16, 2017. Note that Telesat is not able to file an application for authorization with ISED at this time because of an ongoing moratorium on new commercial NGSO systems put in place by ISED.[14] Telesat will submit an application to ISED once the moratorium has been lifted.

2. Milestones

Pursuant to Sections 25.137(d)(1) and 25.164(b) of the Commission's rules, recipients of U.S. market access grants are subject to Commission rules that require NGSO system licensees to launch and operate their NGSO constellations within six years of grant. Telesat will demonstrate compliance with the FCC requirement by submitting Section 25.164(f) information as and when required.

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[14] Innovation, Science and Economic Development Canada, *Moratorium on Licensing of Satellite Spectrum Used by Commercial Non-Geostationary Satellite Orbit Systems*, *available at* http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11200.html.

Telesat requests that, if the Commission later decides to modify its milestone requirements — for example, by allowing for system expansion over time — the Commission should give Telesat (and other pending NGSO applicants) an opportunity to amend its application to take into account the changes in milestone requirements.

3. Posting of Bond

Pursuant to Sections 25.137(d)(4) and 25.165(a) of the Commission's rules, recipients of U.S. market access grants for non-U.S. licensed satellites that are not in orbit and operating are subject to the modified, escalating post-grant bond requirement. Telesat will post the required initial bond amount of $1 million within 30 days of grant of this Petition, as required by the Commission's rules. Telesat will also increase the bond amount as necessary in order to comply with the Commission's escalating bond requirements.[15]

4. Mitigation of Orbital Debris

Section 25.114(d) (14) of the Commission's rules requires applicants for space station licenses to provide a description of the design and operational strategies that will be used to mitigate orbital debris. In lieu of the particular showings required of applicants for U.S.-licensed space stations, Section 25.114(d)(14)(v) provides "[f]or non-U.S.-licensed space stations, the requirement to describe the design and operational

[15] *See* Public Notice, International Bureau Updates Procedures for Filing and Maintaining Surety Bonds Pursuant to Revised Milestone and Escalating Bond Requirements, DA 16-1157 Report No. SPB-266 (Oct. 7, 2016).

strategies to minimize orbital debris risk can be satisfied by demonstrating that debris mitigation plans for the space station(s) for which U.S. market access is requested are subject to direct and effective regulatory oversight by the national licensing authority."

Telesat is subject to the direct regulatory oversight of its Canadian licensing authority, ISED, with regard to issues of orbital debris mitigation plans for the satellites that will comprise the V-band LEO Constellation. Those regulations require that space debris mitigation measures be implemented in accordance with best industry practices so as to minimize adverse effects on the orbital environment.[16] It is anticipated that a license to be issued by ISED to Telesat for the V-band LEO Constellation will specify the same condition.[17] Accordingly, no separate showing relative to the mitigation of orbital debris should be required under the Commission's rules. Nevertheless, given the importance of the issue, Telesat makes a full orbital debris mitigation showing in Section A9 of the Technical Exhibit.

The sheer number of spacecraft proposed for operation by Telesat and other would-be NGSO LEO constellation operators requires coordination among operators to avoid physical collision, which Telesat is committed to do.

It is imperative that satellites be designed and operated with the technology, experience, and resources necessary to monitor, control, and take ongoing efforts to

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[16] Industry Canada RP-008 Issue 3, November 2013, "Policy Framework for Fixed-Satellite Service (FSS) and Broadcasting-Satellite Service (BSS), Section 3.2.6.

[17] As stated above, Telesat intends to submit an application to ISED for its V-band LEO Constellation once the present ISED moratorium on new commercial NGSO systems has been lifted.

avoid collisions in space. As demonstrated in Telesat's orbital debris mitigation showing, the operational and design features of the V-band LEO Constellation are geared toward mitigating the risk of orbital debris, including with maneuverability, shielding, and resiliency to protect against external influences that may be encountered and the ability to avoid collision with other spacecraft. Further, in addition to spacecraft design, as detailed in Section II, Telesat is uniquely qualified to operate and manage complex satellite systems, as a satellite operator for the past 45 years and as the world's leading satellite technical consultant and manager of satellite systems for other operators. Telesat has the ground resources around the world and extensive operational experience, both with GSO and NGSO satellites, which allow for greater confidence in its ability to prevent collisions or other events that might pose a risk.

B. Other Public Interest Factors

1. Effect on competition in the United States

The *DISCO II Order,* as implemented in Section 25.137(a) of the Commission's rules, establishes a presumption that granting applications to provide service in the United States via satellites licensed by countries that are members of the World Trade Organization ("WTO") will enhance competition and therefore is in the public interest.[18] All of the satellites that will comprise the V-band LEO Constellation will be operated under authority of Canada, which is a member of the WTO.

[18] *See In re Amendment of the Commission's Regulatory Policies to Allow Non-U.S. Licensed Space Stations to Provide Domestic and International Satellite Service in the United States*,

Telesat's Petition is limited to services covered by the WTO Basic Telecommunications Agreement. It does not seek authority to provide direct-to-home, Direct Broadcast Satellite, or Digital Audio Radio Service services in the United States. Accordingly, this Petition satisfies the requirements of Section 25.137, giving rise to a presumption that granting U.S. market entry to the V-band LEO Constellation is in the public interest.

2. Spectrum availability

The Commission considers under the "other public interest factors" element of *DISCO II* whether grant of an application would have an impact on spectrum availability.[19] In so doing, the Commission evaluates whether grant of access would create the potential for harmful interference with U.S.-licensed satellite and terrestrial systems. As demonstrated in the Technical Exhibit, the V-band LEO Constellation satisfies this aspect of *DISCO II*.

As shown therein, the V-band LEO Constellation architecture is based on highly flexible payload and antenna technologies. Each satellite will have the capability to steer and form independently a number of beams to focus on customer service areas where need exists. The ability to focus the beams in specific areas allows for a reduction in power for the same throughput or an increase in data rate. Beams are generated only when traffic is present,

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Report and Order, 12 FCC Rcd. 24094, 24112 (1997) ("*DISCO II Order*"). *See also* Estrela do Sul 1 Order, ¶ 5.

[19] *See DISCO II Order*, ¶¶ 146-182.

optimizing spectrum usage and on-board power management. The combination of Polar Orbits providing global coverage with Inclined Orbits providing increased capacity over mid-latitude regions allows users to have access to multiple LEO satellites within their field of view. The use of inter-satellite links provides further flexibility. These features promote an efficient use of the finite spectrum resource.

Interference management will be carried out through the operation of Telesat's Radio Resource Management ("RRM") system, which will manage the overall radio resource allocation of the entire constellation. The RRM will plan traffic connectivity, beam power, and satellite handovers.

3. National security, law enforcement, foreign policy, and trade issues

The Commission also considers under the "other public interest factors" element of *DISCO II* whether grant of an application would implicate national security, law enforcement, foreign policy, or trade concerns.[20] The Commission has found in similar circumstances involving affiliates of Telesat that using non-U.S. licensed satellites to serve the United States raises no national security, law enforcement, foreign policy, or trade concerns. The Commission made this finding, for example, in its grant of market

[20] *See DISCO II Order*, ¶¶ 146-182.

access to Telesat International Limited for the Telstar 19 VANTAGE spacecraft.[21] These findings apply with equal force to the V-band LEO Constellation.

C. Waiver Requests

The Commission may waive its rules upon a showing of "good cause"[22] and "where particular facts would make strict compliance inconsistent with the public interest."[23] The Commission has explained that a waiver may be granted when an applicant demonstrates that "any benefits achieved by its proposal are in the public interest and that a waiver would not compromise the fundamental policies served by the rule."[24]

Telesat respectfully requests waivers of the following rules. As discussed below, good cause exists to waive each rule and grant of a waiver would further the public interest while not compromising the underlying purpose of the rule.

1. Section 25.202(a)(1)

Telesat seeks to operate in the frequency bands identified in the November 1, 2016 *Public Notice*, *i.e.*, 37.5-42.0 GHz (space-to-Earth) and 47.2-50.2 GHz and 50.4-51.4

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[21] *See Telesat International Limited Application Petition for Declaratory Ruling* FCC File No. SAT-PPL-20110112-00012 (granted Aug 31, 2016). *See also Telesat Brasil Capacidade de Satelites Ltda. Application for Space Station Authorization, FCC File No. SAT-PPL-20110112-00012 (granted Apr. 4, 2011).Telesat Canada Petition for Declaratory Ruling for Inclusion of ANIK F3 on the Permitted Space Station List,* FCC File No. SAT-PPL-20160225-00020 (granted 18, 2007); *Loral Orion Services, Inc., Order,* 15 FCC Rcd. 12419 (IB 2000).
[22] 47 CFR § 1.3.
[23] *Northeast Cellular Tel. Co. v. FCC*, 897 F. 2d 1164, 1166 (D.C. Cir. 1990) (citing *WAIT Radio v. FCC*, 418 F.2d 1153, 1159 (D.C. Cir. 1969)).
[24] *Midwest Communications, Inc.*, 7 FCC Rcd 159, 160 (1991).

GHz (Earth-to-space). While these frequencies are allocated for FSS in the United States in the FCC's Table of Frequency Allocations in Section 2.106, the 50.4-51.4 GHz band is not identified as being available for FSS in Section 25.202(a)(1). Telesat respectfully requests a waiver of Section 25.202(a)(1) to permit NGSO uplinks in the 50.4-51.4 GHz band.

The FCC designated the 50.4-51.4 GHz band as primary for terrestrial wireless services almost two decades ago.[25] Since then, wireless services have been almost non-existent in the band and, at present, the FCC in the ongoing *Spectrum Frontiers* proceeding is considering allowing sharing between satellite and terrestrial operations.[26] Telesat will coordinate its proposed V-band NGSO system with and protect incumbent Federal users in adjacent bands from interference.[27]

In summary, permitting the requested satellite uplinks in the 50.4-51.4 GHz band will allow more efficient and productive use of spectrum while not causing harmful interference to other users of the band. Therefore, good cause exists to waive Section 25.202(a)(1) to permit the proposed NGSO uplinks in the 50.4-51.4 GHz band.

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[25] *Allocation and Designation of Spectrum for Fixed-Satellite Services in the 37.5-38.5 GHz, 40.5-41.5 GHz and 48.2-50.2 GHz Frequency Bands; Allocation of Spectrum to Upgrade Fixed and Mobile Allocations in the 40.5-42.5 GHz Frequency Band; Allocation of Spectrum in the 46.9-47.0 GHz Frequency Band for Wireless Services; and Allocation of Spectrum in the 37.0-38.0 GHz and 40.0-40.5 GHz for Government Operations*, Report and Order and Further Notice of Proposed Rulemaking, 13 FCC Rcd 24649, 24650 n. 3 (1998).

[26] *Use of Spectrum Bands Above 24 GHz For Mobile Radio Services; Establishing a More Flexible Framework to Facilitate Satellite Operations in the 27.5-28.35 GHz and 37.5-40 GHz Bands*; Report and Order and Further Notice of Proposed Rulemaking, at 142-145, ¶¶408-423 (rel. July 14, 2016).

[27] *See* Section III.A, *supra*; Section A7 of the Technical Appendix.

2. Section 25.156(d)(5)

Section 25.156(d)(5) states that:

> In cases where the Commission has not adopted frequency-band specific service rules, the Commission will not consider applications for NGSO-like satellite operation after it has granted an application for GSO-like operation in the same frequency band, and it will not consider applications for GSO-like operation after it has granted an application for NGSO-like operation in the same band, unless and until the Commission establishes NGSO/GSO sharing criteria for that frequency band.

Although the Commission has previously licensed GSO systems in portions of the V-band, these satellite systems were never built and the associated licenses have been surrendered. Thus, although the plain language of Section 25.156(d)(5) suggests that it will not consider NGSO applications because it has previously granted applications for GSO systems, the underlying purpose of the rule is not implicated in this case because the previously-licensed GSO systems were never built. Accordingly, to the extent that Section 25.156(d)(5) is deemed to apply, Telesat requests a waiver of this rule.

3. Section 25.157(e)

Section 25.157(e) of the Commission's rules establishes certain band segmentation procedures if there is not enough spectrum available to accommodate all qualified applicants in a processing round. However, this requirement is at odds with Commission policy with respect to NGSO systems in some bands, specifically the "avoidance of in-line interference events" approach adopted by the Commission in 2002 regarding Ku-band sharing[28] and in Section 25.261 of the rules regarding sharing in portions of the Ka-band.

Telesat submits that application of the Section 25.157(e) band segmentation rule in the context of the V-band NGSO processing round would frustrate the underlying purpose of the rule and not serve the public interest because band-splitting among multiple NSGO-like constellation applicants will provide too little spectrum to enable commercial viability for any of the applicants, resulting in no systems being launched. Accordingly, if deemed applicable, Telesat requests waiver of the band segmentation requirements of Section 25.157 of the Commission's rules.

*   *   *

[28] *Establishment of Policies and Service Rules for the Non-Geostationary Satellite Orbit, Fixed Satellite Service in the Ku-Band*, Report and Order and Further Notice of Proposed Rulemaking, FCC 02-123, 17 FCC Rcd 7841, 7843 (2002). This policy was more recently reaffirmed by the International Bureau. *See International Bureau Provides Guidance Concerning Avoidance of In-Line Interference Events Among Ku-Band NGSO FSS Systems*, DA 15-1197 (Oct. 20, 2015).

CONCLUSION

In view of the foregoing, grant of Telesat's application is in the public interest, and it is respectfully requested that the Commission grant the application expeditiously.

Respectfully submitted,

/s/

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March 1, 2017

Appendix A

Technical Exhibit for the V-band LEO Constellation Satellite Network

A1. Introduction

This document is the technical appendix to Telesat's Petition for a Declaratory Ruling for the V-band non-geostationary low-earth orbit (LEO) satellite network referred to as the V-band LEO Constellation. The technical information for the proposed system, as required by paragraph (d) of §25.114[1] of the FCC rules, is provided in this document. The information specified in paragraph (c) of that section has been provided in the Schedule S and is not repeated in this document. (Some clarifying remarks regarding the content of the Schedule S are contained in this document.)

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

The space segment of the V-band LEO Constellation satellite network will consist of a minimum of 117 operating satellites plus spare satellites to fulfill the reliability requirements. There will be a minimum of 6 circular orbits with an altitude of 1000 km and an inclination angle of 99.5° (these orbits are referred to as "Polar Orbits"). Each of the Polar Orbits will include a minimum of 12 operating satellites. There will also be a minimum of 5 circular orbits with an altitude of 1248 km and an inclination angle of 37.4° (these orbits are referred to as "Inclined Orbits"). Each of the Inclined Orbits will include a minimum of 9 operating satellites. Figure 1 shows the Polar Orbits and Figure 2 shows the Inclined Orbits. Polar Orbits provide coverage over all latitudes. Inclined Orbits concentrate satellites over equatorial and mid-latitude areas that are generally highly populated. The Inclined Orbits and Polar Orbits have been designed to work together and the V-band LEO Constellation satellite network takes advantage of the complementary nature of the two types of orbit.

The V-band LEO Constellation satellite network will have a global coverage and will provide a range of satellite services to the United States and elsewhere in the world. It will be an integrated system capable of providing layer-2 Carrier Ethernet connectivity from any point to any point with highly secure and resilient low-latency links. Flexible satellite and network technologies provide power and spectrum where and when needed. Each V-band LEO Constellation satellite will incorporate onboard processing and inter-satellite communication capabilities enabling the satellite network to connect any point on the Earth to any other point on the Earth without the need for the use of terrestrial infrastructure. Gateway earth stations will form part of the system to serve as interface points between the

[1] 47 C.F.R. §25.114

V-band LEO Constellation network and the terrestrial infrastructure. With these features, the constellation will offer mesh connectivity between users, VSAT network connectivity for enterprises, and consumer broadband services worldwide. It will provide broadband services to unserved and underserved communities.

Figure 1: The Polar Orbits

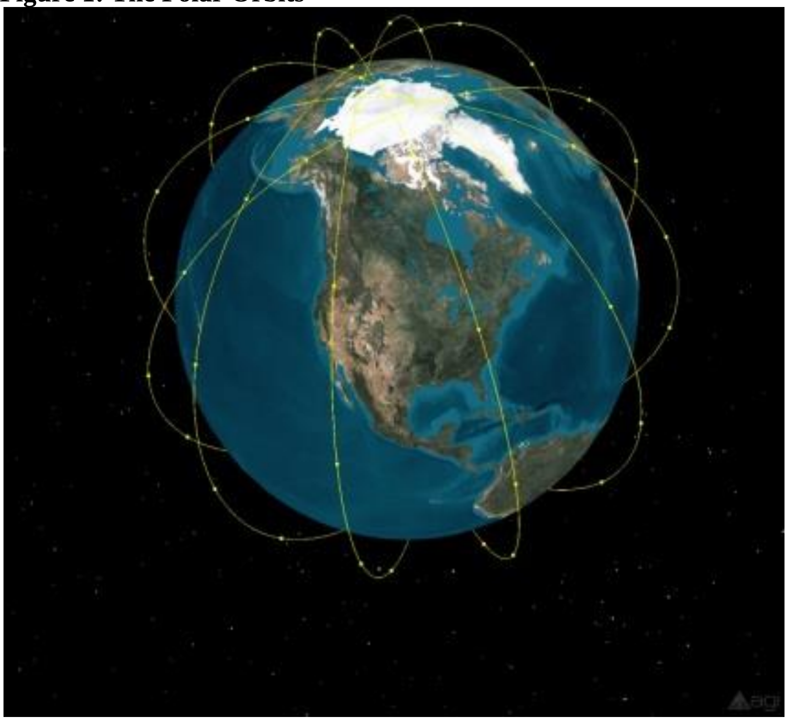
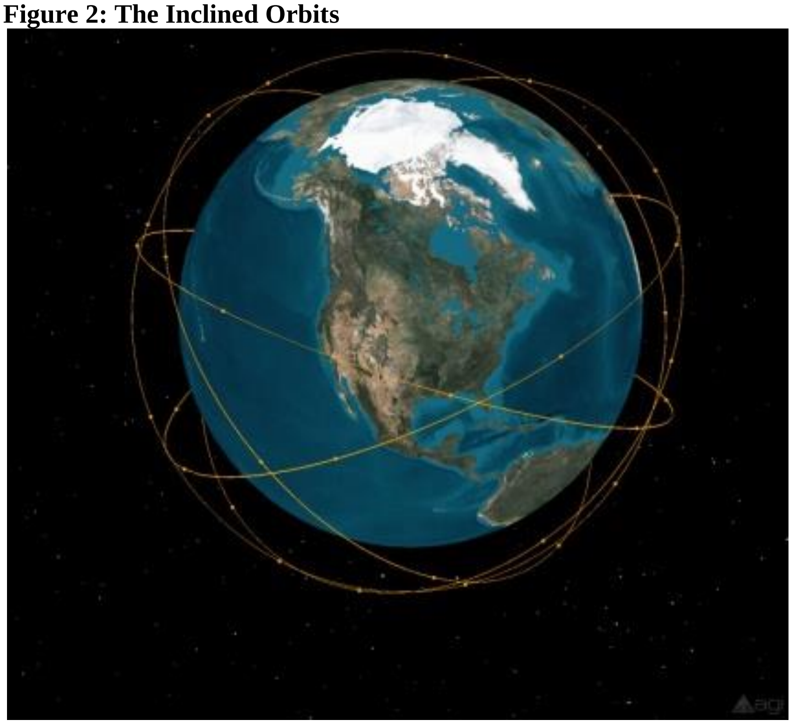


Figure 2: The Inclined Orbits



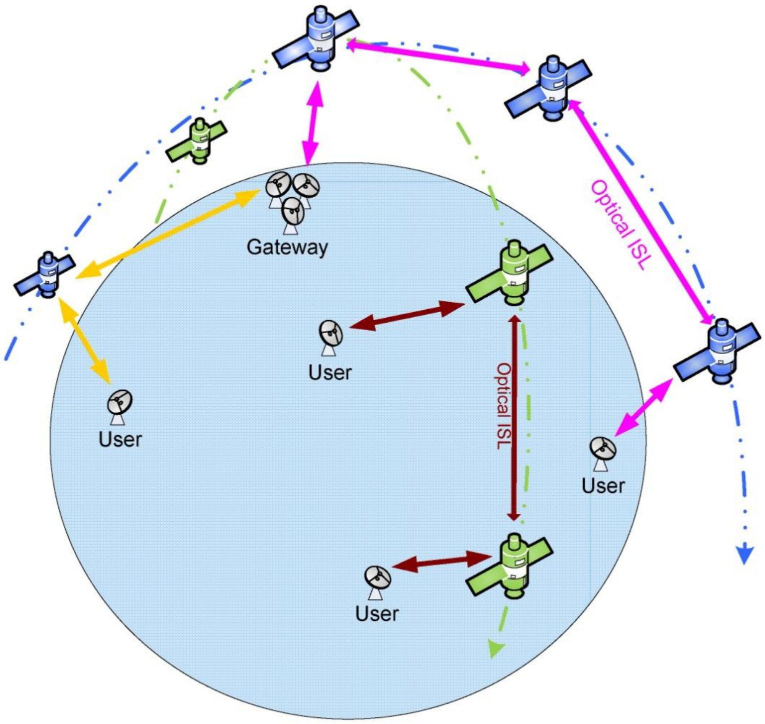
All the satellites of the V-band LEO Constellation satellite network will be identical. Each satellite will use Direct Radiating Array (DRA) antennas and beam forming to generate a minimum of 16 downlink beams and a minimum of 16 uplink beams. Each of the beams will be shapeable and steerable. Each satellite will also have a wide-area receive beam, which will allow the satellite to detect user requests to initiate communication. Each satellite will have optical terminals for inter-satellite links (ISL). These optical terminals will provide the capability of transmission within the same plane, within adjacent planes of the same orbit and between the Polar Orbits and Inclined Orbits.

Each satellite will employ a regenerative payload, including on-board processing and IP packet self-routing switching, to improve link performance. On the receive side, the on-board processor will perform analog-to-digital conversion (ADC), followed by digital beam forming, de-multiplexing, and demodulation. The processor will decode each packet header allowing the IP switch to provide routing of the information contained within the packet. On the transmit side, the on-board processor will perform modulation, multiplexing, digital beam forming, and digital-to-analog conversion (DAC). On-board regeneration of the signal will also permit separate optimization of the uplink and downlink, decoupling the uplink impairments from the downlink impairments in the link.

The system will use a network of gateway facilities enabling access to the constellation from a number of locations. From these gateway facilities, access to every satellite of the constellation will be possible at all times either directly or through other satellites via inter-satellite links. Selected gateways will also provide the necessary TT&C links to ensure redundant and reliable control of the constellation.

The network architecture is illustrated in Figure 3. The V-band LEO Constellation satellite network will provide Carrier Ethernet Service in a seamless extension of advanced terrestrial telecom networks. With a standard network interface, users will access the constellation data capacity as they would access any other network.

Figure 3: V-band LEO Constellation satellite network architecture



The V-band LEO Constellation satellite network will have an integrated control system comprised of a mission planning system and a network control system. The mission planning system will manage the satellite fleet health and orbits. The network control system will manage the payload resources and the operation of the network. The integrated control system will primarily be distributed among the satellites, gateways, and user terminals. However, Telesat's Satellite Control Centre (SCC) in Ottawa, Ontario, Canada, at the address below, will monitor and have ultimate control of the V-band LEO Constellation satellite network. The backup control facility will be located in Mt. Jackson, VA, USA.

Telesat
1601 Telesat Court,
Ottawa, ON, Canada K1B 5P4
Phone: 613-748-8700
SCC direct phone number: 613-747-3000
North American Toll Free: 1-888-662-8728 (option 3 – carrier access)
International: +1 519-371-5746 (option 3 – carrier access)
Email: tccsupport@telesat.com

One of the modules of the network control system will be the Radio Resource Management system (RRM) which will oversee the scheduling and maintenance of radio channels and will allocate satellite resources (power, bandwidth and beam size) to provide service. RRM will be responsible for radio resource allocation and control, such that the network quality of service (QoS) is optimized against bandwidth utilization. It will do so taking into account physical, operational, regulatory and coordination constraints.

A wide variety of user terminals, both electronically-steered and mechanically tracking, will access the V-band LEO Constellation. The system will be capable of operating with both fixed terminals and mobile terminals. Mobile terminals would be used in the U.S. only upon filing of an application for such terminals and its grant by the Commission.

The frequency bands of the V-band LEO Constellation satellite network are summarized in Table 1. In the FCC Table of Frequency Allocations[2] and other FCC documents there are restrictions for the use of some of the frequency band segments of Table 1 for fixed satellite service by a non-geostationary satellite network. These are described below.

Table 1: Frequency bands of the V-band LEO Constellation satellite network

Lower Frequency Limit (GHz)	Upper Frequency Limit (GHz)	Downlink/ Uplink
37.5	42	Downlink
47.2	50.2	Uplink
50.4	51.4	Uplink

37.5-40 GHz frequency band

According to footnote NG63 of the FCC Table of Frequency Allocations, in the band 37.5-40 GHz earth station operations in the fixed-satellite service (space-to-Earth) shall not claim protection from stations in the fixed and mobile services, except where individually licensed earth stations are authorized. §25.202[3] of the Commission's Rules states that use of the band 37.5-40 GHz by the fixed-satellite service is limited to individually licensed earth stations and that satellite earth station facilities in this band may not be ubiquitously deployed.

Telesat's use of the band 37.5-40 GHz for the V-band LEO Constellation in the U.S. will be in compliance with footnote NG63 and §25.202, as described above. In addition, recently the FCC allocated the frequency band 37.5-40 GHz to Upper Microwave Flexible Use Services (UMFUS) while still allowing fixed-satellite services to share this band with the UMFUS through several mechanisms. Telesat's use of the frequency band 37.5-40

[2] 47 C.F.R. §2.106
[3] 47 C.F.R. §25.202 (a) (1)

GHz in the U.S. will comply with the FCC mechanisms for sharing with the UMFUS[4], including §25.136[5].

50.4-51.4 GHz frequency band

The frequency band 50.4-51.4 GHz is allocated to fixed satellite service (Earth-to-space) in the FCC Table of Frequency Allocations. However, this frequency band does not appear in §25.202. Telesat seeks a waiver of §25.202 to allow use of this band. Telesat's operation of the V-band LEO Constellation will be in compliance with the footnote US156 of the FCC Table of Frequency Allocations which states that "In the bands 49.7-50.2 GHz and 50.4-50.9 GHz, for earth stations in the fixed-satellite service (Earth-to-space), the unwanted emissions power in the band 50.2-50.4 GHz shall not exceed -20 dBW/ 200 MHz (measured at the input of the antenna), except that the maximum unwanted emissions power may be increased to -10 dBW/200 MHz for earth stations having an antenna gain greater than or equal to 57 dBi. These limits apply under clear-sky conditions. During fading conditions, the limits may be exceeded by earth stations when using uplink power control."

§25.114(d)(1) of the Commission's Rules requires an explanation of how the uplink frequency bands are connected to the downlink frequency bands. The frequency bands of the V-band LEO Constellation satellites are listed in Table 1. As mentioned earlier, the V-band LEO Constellation satellites will use on-board processing and, as part of the on-board processing, any uplink frequency band segment will be able to be connected to any downlink frequency band segment. Each V-band LEO Constellation satellite will have an IP network router and optical inter-satellite link terminals so that any user or any gateway can be connected to any other user or gateway. Thus, any uplink frequency band received from any user or any gateway can be connected to any downlink frequency band and transmitted to any user or any gateway.

The polarization used for all signals will be circular. Frequency reuse will be exploited through the use of orthogonal polarization and geographical isolation of the beams.

A3. §25.114(c)(4)(vi): Space station antenna gain contours

The antenna gain contours of the V-band LEO Constellation satellites have been provided in a GIMS database attached to the Schedule S, as per FCC §25.114(c)(4)(vi). This section provides a clarification with respect to the patterns that have been provided.

The service area of the V-band LEO Constellation is the entire Earth. The satellites of the V-band LEO Constellation will be identical and each satellite will use Direct Radiating Array (DRA) antennas and beam forming to generate a minimum of 16 downlink spot

[4] *See In the Matter of Use of Spectrum Bands Above 24 GHz For Mobile Radio Services*, Report and Order and Further Notice of Proposed Rulemaking, 206 FCC Lexis 2470 (2016).
[5] 47 C.F.R. §25.136

beams and 16 uplink spot beams. Therefore, a minimum of 32 (uplink and downlink) spot beams will be available for each satellite and each of these beams can be used to communicate with a user or a gateway. The spot beams are capable of operating in both right hand circular polarization (RHCP) and left hand circular polarization (LHCP). The spot beams are shapeable and steerable. Each spot beam will be capable of being independently formed and steered. Since all the uplink and all the downlink spot beams will have the same capability (i.e., technically identical), in the Schedule S only one uplink spot beam and one downlink spot beam have been provided. It is noted that the Schedule S allows one beam ID for each continuous frequency band segment in each polarization. Table 2 provides a description of the beams specified in the Schedule S. The corresponding gain contours have been provided in the GIMS database attached to the Schedule S. Each satellite will also have a wide-area receive beam, which will allow the satellite to detect a user request to initiate communication. The corresponding gain contours have been provided in the GIMS database attached to the Schedule S.

Table 2: Description of the beam IDs in the Schedule S

Beam	Corresponding Beam IDs in the Schedule S	Notes
Uplink spot beam with RHCP polarization	F1P1, F2P1	Since the beam operates in two separate band segments (47.2-50.2 and 50.4-51.4 GHz), Schedule S mandates using two beam IDs (F1P1 for 47.2-50.2 and F2P1 for 50.4-51.4 GHz)
Uplink spot beam with LHCP polarization	F1P2, F2P2	Since the beam operates in two separate band segments (47.2-50.2 and 50.4-51.4 GHz), Schedule S mandates using two beam IDs (F1P2 for 47.2-50.2 and F2P2 for 50.4-51.4 GHz)
Downlink spot beam with RHCP polarization	M1P1	The downlink spot beam can operate in the entire downlink frequency band 37.5-42 GHz
Downlink spot beam with LHCP polarization	M1P2	The downlink spot beam can operate in the entire downlink frequency band 37.5-42 GHz
Wide-area uplink beam with RHCP polarization	J1P1, J2P1	Since the beam operates in two separate band segments (47.2-50.2 and 50.4-51.4 GHz), Schedule S mandates using two beam IDs (J1P1 47.2-50.2 and J2P1 for 50.4-51.4 GHz)
Wide-area uplink beam with LHCP polarization	J1P2, J2P2	Since the beam operates in two separate band segments (47.2-50.2 and 50.4-51.4 GHz), Schedule S mandates using two beam IDs (J1P2 for 47.2-50.2 and J2P2 for 50.4-51.4 GHz)

Table 3 shows how the gain contours of the GIMS database (attached to the Schedule S) are related to the satellite beams. The GIMS database includes the antenna gain contours when the peak antenna gain is pointed at nadir for one Polar Orbit satellite location and one Inclined Orbit satellite location. As required by §25.114(c)(4)(vi), since the satellite beams are steerable, the contours that would result from moving the beam peak around the limit of the effective beam peak area and the 0 dB relative antenna gain isoline have also been included in the GIMS database. Since the beams are also shapeable, in the downlink direction the gain contours for the beam configuration that results in the highest EIRP have been provided and in the uplink direction the gain contours of the configuration that results in the smallest gain-to-temperature ratio have been provided, as required by §25.114(c)(4)(vi).[6]

Table 3: Description of the beam names in the GIMS database

Orbit type	Beam type	Uplink/Downlink	Beam name in the GIMS database	Associated beams in the Schedule S
Polar	Spot	Uplink	SPTPOLRX	F1P1, F1P2, F2P1, F2P2
Inclined	Spot	Uplink	SPTINCRX	F1P1, F1P2, F2P1, F2P2
Polar	Wide-area	Uplink	WAPOLRX	J1P1, J1P2, J2P1, J2P2
Inclined	Wide-area	Uplink	WAINCRX	J1P1, J1P2, J2P1, J2P2
Polar	Spot	Downlink	SPTPOLTX	M1P1, M1P2
Inclined	Spot	Downlink	SPTINCTX	M1P1, M1P2

A4. §25.114(d)(6): Public interest considerations in support of grant

The V-band LEO Constellation NGSO satellite network will provide secure, high speed, and low latency communications in the United States as well as the rest of the globe. Due to its efficient design, the V-band LEO Constellation satellite network will provide extensive flexibility in satisfying customer requirements especially where other services such as GSO services and terrestrial services cannot. Therefore, the grant of this application will be in the public interest.

A more comprehensive discussion of public interest considerations has been provided in the legal narrative portion of this application.

[6] Peak antenna gain values have been provided in the Schedule S. For clarification, it is noted that when the uplink beam has the configuration with the smallest gain-to-temperature ratio, its peak antenna gain is equal to 20.6 dBi and when it has the configuration with the largest gain-to-temperature ratio, its peak antenna gain is equal to 46.2 dBi.

A5. §25.208: Compliance with power flux density limits at the Earth's surface to protect terrestrial services

In §25.208[7] of the FCC rules there are limits for the power flux density (PFD) generated by the downlink transmission of a satellite at the surface of the earth. These limits are for the protection of terrestrial services. The downlink frequency band of the V-band LEO Constellation satellites is 37.5-42 GHz and different portions of this band have different PFD limits specified in §25.208. The V-band LEO Constellation will meet all the PFD limits as demonstrated below.

<u>Frequency band 37.5-40 GHz</u>

§25.208 includes two sets of PFD limits for NGSO satellites in the band 37.5-40 GHz, one set under assumed free space conditions and one set under rain-fade conditions. Both sets of PFD limits have been listed in Table 4.The PFD limit is a function of the angle of arrival (δ) at the surface of the earth.

Table 4: PFD limits of §25.208 for an NGSO satellite in the band 37.5-40 GHz

Type of PFD limit	Frequency band	Limit in $dB(W/m^2)$ for angles of arrival (δ) above the horizontal plane			Reference bandwidth
		0°-5°	5°-25°	25°-90°	
Clear-sky	37.5-40 GHz	−132	$-132 + 0.75(\delta - 5)$	−117	1 MHz
Rain-fade	37.5-40 GHz	−120	$-120 + 0.75(\delta - 5)$	−105	1 MHz

The operation of the V-band LEO Constellation in the U.S. will be such that in the frequency band 37.5-40 GHz, under clear-sky conditions, the V-band LEO Constellation will have a peak downlink EIRP density of -57 dB(W/Hz). If there is rain-fade present the peak downlink EIRP will be increased to compensate for the rain fading, but the downlink EIRP density will not exceed -45 dB(W/Hz). Tables 5 to 8 demonstrate that the V-band LEO Constellation meets the PFD limits of §25.208 in the band 37.5-40 GHz.

[7] 47 C.F.R. §25.208

Table 5: Demonstration of PFD compliance in the band 37.5-40 GHz under clear sky for the Polar Orbit satellites

Peak downlink EIRP density [dB(W/Hz)]	-57						
Minimum satellite to earth distance [km]	1000						
Maximum Power Flux Density at the earth surface [dB(W/m²/MHz)]	-128.0						
Angle of arrival [deg]	0	5	10	15	20	25	90
Satellite antenna gain discrimination compared to boresight [dB]	-15	-10	-4	0	0	0	0
PFD at the angle of arrival [dB(W/m²/MHz)]	-143.0	-138.0	-132.0	-128.0	-128.0	-128.0	-128.0
PFD limit [dB(W/m²/MHz)]	-132	-132	-128.25	-124.5	-120.75	-117	-117

Table 6: Demonstration of PFD compliance in the band 37.5-40 GHz under clear sky for the Inclined Orbits satellites

Peak downlink EIRP density [dB(W/Hz)]	-57						
Minimum satellite to earth distance [km]	1248						
Maximum Power Flux Density at the earth surface [dB(W/m²/MHz)]	-129.9						
Angle of arrival [deg]	0	5	10	15	20	25	90
Satellite antenna gain discrimination compared to boresight [dB]	-15	-10	-2	0	0	0	0
PFD at the angle of arrival [dB(W/m²/MHz)]	-144.9	-139.9	-131.9	-129.9	-129.9	-129.9	-129.9
PFD limit [dB(W/m²/MHz)]	-132	-132	-128.25	-124.5	-120.75	-117	-117

Table 7: Demonstration of PFD compliance in the band 37.5-40 GHz under rain-fade conditions for the Polar Orbits satellites

Peak downlink EIRP density [dB(W/Hz)]	-45						
Minimum satellite to earth distance [km]	1000						
Maximum Power Flux Density at the earth surface [dB(W/m²/MHz)]	-116.0						
Angle of arrival [deg]	0	5	10	15	20	25	90
Satellite antenna gain discrimination compared to boresight [dB]	-15	-10	-4	0	0	0	0
PFD at the angle of arrival [dB(W/m²/MHz)]	-131.0	-126.0	-120.0	-116.0	-116.0	-116.0	-116.0
PFD limit [dB(W/m²/MHz)]	-120	-120	-116.25	-112.5	-108.75	-105	-105

Table 8: Demonstration of PFD compliance in the band 37.5-40 GHz under rain-fade conditions for the Inclined Orbits satellites

Peak downlink EIRP density [dB(W/Hz)]	-45						
Minimum satellite to earth distance [km]	1248						
Maximum Power Flux Density at the earth surface [dB(W/m²/MHz)]	-117.9						
Angle of arrival [deg]	0	5	10	15	20	25	90
Satellite antenna gain discrimination compared to boresight [dB]	-15	-10	-2	0	0	0	0
PFD at the angle of arrival [dB(W/m²/MHz)]	-132.9	-127.9	-119.9	-117.9	-117.9	-117.9	-117.9
PFD limit [dB(W/m²/MHz)]	-120	-120	-116.25	-112.5	-108.75	-105	-105

Frequency band 40-42 GHz

Table 9 shows the PFD limits of §25.208 for an NGSO satellite in the frequency band 40-42 GHz.

Table 9: PFD limits of §25.208 for an NGSO satellite in the band 40-42 GHz

Frequency band	Limit in dB(W/m²) for angles of arrival (δ) above the horizontal plane			Reference bandwidth
	0°-5°	5°-25°	25°-90°	
40-42 GHz	−115	$-115 + 0.5(\delta - 5)$	−105	1 MHz

In the frequency band 40-42 GHz the V-band LEO Constellation will have a peak downlink EIRP density of -42 dB(W/Hz). Tables 10 to 11 demonstrate that the V-band LEO Constellation meets the PFD limits of §25.208 in the band 40-42 GHz.

Table 10: Demonstration of PFD compliance in the band 40-42 GHz for the Polar Orbits satellites

Peak downlink EIRP density [dB(W/Hz)]	-42						
Minimum satellite to earth distance [km]	1000						
Maximum Power Flux Density at the earth surface [dB(W/m²/MHz)]	-113.0						
Angle of arrival [deg]	0	5	10	15	20	25	90
Satellite antenna gain discrimination compared to boresight [dB]	-15	-10	-4	0	0	0	0
PFD at the angle of arrival [dB(W/m²/MHz)]	-128.0	-123.0	-117.0	-113.0	-113.0	-113.0	-113.0
PFD limit [dB(W/m²/MHz)]	-115	-115	-112.5	-110	-107.5	-105	-105

Table 11: Demonstration of PFD compliance in the band 40-42 GHz for the Inclined Orbits satellites

Peak downlink EIRP density [dB(W/Hz)]	-42						
Minimum satellite to earth distance [km]	1248						
Maximum Power Flux Density at the earth surface [dB(W/m²/MHz)]	-114.9						
Angle of arrival [deg]	0	5	10	15	20	25	90
Satellite antenna gain discrimination compared to boresight [dB]	-15	-10	-2	0	0	0	0
PFD at the angle of arrival [dB(W/m²/MHz)]	-129.9	-124.9	-116.9	-114.9	-114.9	-114.9	-114.9
PFD limit [dB(W/m²/MHz)]	-115	-115	-112.5	-110	-107.5	-105	-105

A6. Link budgets

The V-band LEO Constellation will use on-board processing and therefore uplink and downlink link budgets are analyzed independently. In order to make efficient use of the spectrum, the V-band LEO Constellation will use adaptive modulation and coding based on the signal to noise plus interference ratio. Sample clear-sky uplink and downlink budgets for the V-band LEO Constellation have been provided in Table 12 and Table 13, respectively. No adjacent satellite interference (ASI) has been considered from other satellite networks in the sample link budgets. It should be noted that the link budgets of Table 12 and Table 13 represent sample link budgets and in practice the Radio Resource Management system will select the proper modulation and coding scheme for each of the downlink and uplink communication links based on the actual levels of the signal to noise plus interference ratio for the link.

Table 12: Sample clear-sky uplink link budgets

	Forward Link		Return Link	
Orbit type	Polar Orbit	Inclined Orbit	Polar Orbit	Inclined Orbit
TX Earth Station Location	Inuvik, NT, Canada (68.4N,133.7W)	Allan Park, ON, Canada (44.2N,80.9W)	Shishmaref, AK, USA (66.2N, 166.1W)	Bismarck, ND, USA (46.8N, 100.8W)
Emission Bandwidth [kHz]	10000	10000	10000	10000
Modulation	256APSK 3/4	256APSK 31/45	256APSK 31/45	64APSK 4/5
Information (bit) rate [kbps]	59008.55	54173.38	54173.4	47353.5
Frequency [GHz]	49	49	49	49
Earth Station antenna diameter [m]	1.8	1.8	0.6	0.6
Earth Station antenna gain [dBi]	57.1	57.1	47.5	47.5
Antenna feed flange power density [dB(W/Hz)]	-76.5	-76	-72	-69.5
Antenna feed flange power [dBW]	-6.5	-6	-2	0.5
Earth Station antenna elevation angle [deg]	36.8	25.5	40	23.7
Earth Station to Satellite Distance [km]	1505	2254	1429	2341
Free-Space Loss [dB]	189.8	193.3	189.3	193.6
Satellite RX antenna gain towards the TX Earth Station [dBi]	40	40	40	40
Satellite Rx system noise temperature [K]	1200	1200	1200	1200
Attenuation due to Atmospheric Gases [dB]	2.5	3.5	2.3	3.7
Noise temperature increase due to Atmospheric Gases [K]	127.1	160.0	120.6	167.2
Thermal C/N [dB]	25.7	21.6	21.3	17.9
C/I (Xpol) [dB]	25	25	25	25
C/I (IM) [dB]	25	25	25	25
C/(N+I) [dB]	20.4	18.8	18.6	16.5
Required C/(N+I) [dB]	19.6	18.1	18.1	15.9
Margin [dB]	0.9	0.7	0.5	0.6

Table 13: Sample clear-sky downlink link budgets

	Forward Link		Return Link	
Orbit type	Polar Orbit	Inclined Orbit	Polar Orbit	Inclined Orbit
RX Earth Station Location	Shishmaref, AK, USA (66.2N, 166.1W)	Bismarck, ND, USA (46.8N, 100.8W)	Inuvik, NT, Canada (68.4N,133.7W)	Allan Park, ON, Canada (44.2N,80.9W)
Emission Bandwidth [kHz]	10000	10000	10000	10000
Modulation	32APSK 3/4	16APSK 25/36	64APSK 5/6	64APSK 4/5
Information (bit) rate [kbps]	37033.0	27457.34	49337.0	47353.54
Frequency [GHz]	41	41	41	41
Downlink EIRP density [dB(W/Hz)]	-46	-45.5	-47	-45.5
Downlink EIRP [dBW]	24	24.5	23	24.5
Earth Station antenna elevation angle [deg]	40	23.7	36.8	25.5
Earth Station to Satellite Distance [km]	1429	2341	1505	2254
Free-Space Loss [dB]	187.8	192.1	188.2	191.8
RX Earth Station antenna diameter [m]	0.6	0.6	1.8	1.8
RX Earth Station antenna gain [dBi]	46.0	46.0	55.5	55.5
RX Earth Station system noise temperature [K]	300	300	300	300
Attenuation due to Atmospheric Gases [dB]	0.7	1.1	0.8	1.0
Noise temperature increase due to Atmospheric Gases [K]	43.2	65.9	46.1	62.0
Thermal C/N [dB]	14.7	10.3	22.8	20.3
C/I (Xpol) [dB]	25	25	25	25
C/I (IM) [dB]	20	20	20	20
C/(N+I) [dB]	13.3	9.7	17.3	16.5
Required C/(N+I) [dB]	12.7	9.3	16.6	15.9
Margin [dB]	0.6	0.4	0.8	0.6

A7. ITU filings and sharing with other services

The ITU filing administration for the V-band LEO Constellation is Canada. Telesat has created an Advance Publication Information (API) ITU filing for the V-band Constellation with the ITU satellite network name "CANSAT-LEO-V". This API was submitted to the ITU by the Canadian administration and was received by the ITU BR on February 16, 2017.

In order to operate the V-band LEO Constellation without causing harmful interference into other radio services or receiving harmful interference from them Telesat will conduct frequency coordination with the relevant federal and non-federal radio services, including terrestrial services (fixed, mobile, and broadcasting), geostationary and non-geostationary satellite services (fixed-satellite, mobile-satellite, broadcasting-satellite, space-research, and earth exploration-satellite services), and radio astronomy services in accordance with the relevant provisions of the FCC Rules and the ITU Radio Regulations.

As demonstrated in Telesat's Petition for Declaratory Ruling for its Ka-band LEO Constellation[8], minimum discrimination angles between GSO satellite networks and Telesat's Ka-band LEO Constellation satellite network were calculated to assure compliance with the equivalent power flux density (epfd) limits mandated for Ka-band by the ITU Radio Regulations. The V-band LEO Constellation satellite network will also use discrimination angles to avoid interfering into V-band GSO satellite networks in the same way that Telesat's Ka-band LEO Constellation avoids interfering into Ka-band GSO satellite networks, i.e., by complying with minimum discrimination angles that would assure no harmful interference. V-band epfd limits have not yet been defined by the ITU Radio Regulations or the FCC rules, but are under study in the ITU-R and Telesat will contribute to the ITU studies for the development of epfd limits for V-band. Pending the adoption of regulatory V-band epfd limits, Telesat will perform frequency coordination with GSO satellite operators to assure the GSO satellite networks will not receive harmful interference from the V-band LEO Constellation.

A8. Compliance with §25.202(g)

The frequency and bandwidth of the telemetry, tracking, and command (TT&C) signals of the V-band LEO Constellation have been listed in the Schedule S. The on-axis and off-axis EIRP density levels of TT&C signals will not be more than the on-axis and off-axis EIRP density levels of the signals of the service links, in both the uplink and downlink directions. The methodology that is used for protecting other services applies identically to both the user communication signals and the TT&C signals. Therefore, the interference from the TT&C signals into other services will be at the same level as, or less than, the

[8] Telesat Canada Petition for Declaratory Ruling to Grant Access to the U.S. Market for Telesat's NGSO Constellation, File No. SAT-LOI-20161115-00108 (filed Nov. 15, 2016).

interference from the communication traffic, and neither the TT&C nor the communication links will cause any harmful interference into other services. The TT&C signals of the V-band LEO Constellation also require no greater protection from interference than the communications traffic. The operation of all frequency bands of the V-band LEO Constellation satellite network, including the communication traffic and the TT&C, will be coordinated in accordance with applicable FCC and international requirements.

A9. §25.114(d)(14): Description of the design and operational strategies that will be used to mitigate orbital debris

Telesat has been operating GSO satellites for more than 40 years during which multiple generations of its satellites have been retired and duly disposed of in the appropriate (graveyard) orbit to avoid adding debris to the GSO orbit. Telesat also takes LEO orbital debris mitigation very seriously, as it plans to be a major operator of satellites in LEO orbits. Debris control and mitigation are stated requirements in our spacecraft design specifications. Telesat has always met the requirements of the relevant regulatory bodies and the V-band LEO Constellation will fully meet the FCC debris mitigation requirements as described below.

§25.114(d)(14)(i), Debris Release Assessment. The V-band LEO Constellation satellites will be designed so that during their normal operation they will release no debris. The appendage deployment release mechanisms will be designed so as to contain all debris within the mechanism. The materials on the outside will be chosen to be tolerant of radiation and thermal cycling/mechanical fatigue to ensure no release of extraneous material. Items that will not be built within the spacecraft nor shielded (e.g., antennas) will be able to withstand impacts by small debris and meteoroids. All critical components (e.g., computers and control devices) will be built within the structure and shielded from external influences to ensure the spacecraft remains in full control from the ground

§25.114(d)(14)(ii), Accidental Explosion Assessment. Telesat will review failure modes for all equipment to assess the possibility of an accidental explosion onboard the spacecraft.

In order to pre-empt accidental explosion in orbit, Telesat will take specific precautions. All pressure vessels (pressurized propellant tanks, heat pipes, Lithium ion batteries etc.) on board will have the appropriate structural margins to failure in accordance with the MIL-Spec requirements used in the industry. All batteries and fuel tanks will be monitored for pressure or temperature variations. The batteries will be operated utilizing a redundant automatic recharging scheme. Doing so will ensure that charging terminates normally without building up additional heat and pressure. Alarms in the Satellite Control Centre will inform controllers of any anomalous variations. Additionally, long-term trending analysis will be performed to monitor for any unexpected trends.

§25.114(d)(14)(iii), Assessment Regarding Collision with Larger Debris and Other Space Stations. Telesat has been operating geostationary satellites for many years and has been performing the station-keeping for its satellite fleet from its Satellite Control Centre in Ottawa, Ontario, Canada.

Telesat also has experience of operating non-geostationary LEO satellites. Specifically, since 2007 Telesat has been operating Radarsat-2 for MacDonald, Dettwiler and Associates Ltd. (MDA). Radarsat-2 is a LEO non-geostationary satellite at an altitude of 798 km.

Telesat will use its highly developed and tested station-keeping methodologies to maintain the orbital parameters of the V-band LEO Constellation satellites with a level of accuracy sufficient to avoid collision with other non-geostationary satellites.

In order to protect against collision with other orbiting objects, Telesat has been sharing ephemeris data with the Canadian Space Agency (CSA), the Joint Space Operations Center (JSpOC), MIT Lincoln Laboratory and the Space Data Center (SDC). The JSpOC and the CSA provide notifications to Telesat for any object they see approaching a Telesat satellite, together with assessments of whether avoidance maneuvers are required, and Telesat will maneuver its satellites accordingly.

In the case of the LEO satellite Radarsat-2, Telesat has been working with the Canadian Space Agency to use Probability of Collision (PoC) analysis to determine the need for collision avoidance maneuvers.

Telesat will coordinate with other non-geostationary satellite networks to minimize the risk of collision between Telesat V-band LEO Constellation satellites and any other NGSO satellite.

To further limit the potential for future collision, Telesat will continue to monitor new satellite launches to ensure that future satellites do not present a danger to the V-band LEO Constellation satellites.

All the satellites of the V-band LEO Constellation will have a propulsion system to maintain their orbit. The propulsion system on each satellite will also enable the satellite to make necessary maneuvers to avoid collision with any approaching object. Avoidance of other space objects will be achieved by the satellite firing its thrusters to adjust its position within its control box in order to avoid the other object. The clearance required between space objects is typically about 2 km, and this is significantly smaller than the allowable control box, so that the impact to the mission is minimal or non-existent.

For orbit insertion, the spacecraft will be phased into the final orbits after release from the launcher, with due regard to the debris environment in the transition orbits. The maneuvers will be planned after appropriate conjunction analyses to ensure safe delivery into the operational orbit. By design, Telesat LEO satellites in both the Polar Constellation and Inclined Constellation will have a minimum close approach of 10 km with other satellites. The orbits will be propagated a few days ahead and compared with the data from debris monitoring agencies so that appropriate collision avoidance maneuvers will be undertaken as necessary.

To ensure the effectiveness of collision avoidance measures, the spacecraft can be controlled through the normal payload antennas and wide angle antennas as well as through Inter-satellite Links. The likelihood of all of these receive paths being damaged is minimal. The wide-angle antennas on these spacecraft will be passive omni-directional antennas. (There will be one set on each side of the spacecraft and either set could be used to de-orbit the spacecraft.) These wide-angle antennas would continue to operate even if struck, ensuring control of the satellite.

The spacecraft will be designed with redundancy so that individual unit faults will not cause the loss of control of the spacecraft. On board fault protection will ensure the isolation of the affected unit(s) and the replacement with the back-up hardware/systems. As this process will occur within the spacecraft, it will also afford protection from command link failures (on the ground).

§25.114(d)(14)(iv), Post-Mission Disposal Plans. At the end of life, each satellite will be de-orbited by re-entering the satellite into the Earth’s atmosphere and burning.

The de-orbiting has two phases. In the first phase, the satellite will be moved from its operational orbit to a planned lower orbit, the “Decaying Lower Orbit”. The Decaying Lower Orbit will be an orbit with an apogee of less than 1000 km and a perigee of not more than 550 km. Once the satellite is moved to this lower orbit, all stored energy sources onboard the satellite will be removed by venting the remaining propellant and the remaining helium pressurant. 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. All momentum storage devices will be switched off. These steps will ensure that no buildup of energy can occur and eliminate the risk of explosion after the satellite has stopped operating. In the second phase, the satellite will be left in the Decaying Lower Orbit which, within 25 years, will result in the re-entry of the satellite into the Earth’s atmosphere and burning of the satellite. (The design will be consistent with the requirement 4.7.-1 of NASA-STD 8719.14- Process for Limiting Orbit Debris.) Sufficient (worst case 3 sigma) propellant will be budgeted for the de-orbit maneuvers to insert the spacecraft into the Decaying Lower Orbit, which will ensure re-entry into the Earth’s atmosphere and burning up of the satellite.

One of the critical requirements for the satellite design will be to ensure that the materials, processes and assemblies are selected, designed, and integrated such that the probability of survival of spacecraft components through the re-entry into the Earth’s atmosphere is extremely limited. The design will be assessed using NASA DAS (Debris Assessment

Software) and modified as required to ensure that the human casualty risk resulting from the de-orbiting of the satellites is less than 1 in 10,000, in accordance with the applicable guidelines.

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.

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1 March 2017