Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
Space Norway AS	)	File No. SAT-PDR-20161115-00111
Petition for a Declaratory Ruling Granting Access to the U.S. Market for the Arctic Satellite Broadband Mission	)	

RESPONSE OF SPACE NORWAY AS TO COMMENTS AND OPPOSITION TO PETITIONS TO DENY

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SUMMARY

Space Norway AS ("Space Norway") hereby submits its response to certain comments, and its opposition to certain petitions to deny, relating to Space Norway's Petition for Declaratory Ruling (the "Space Norway PDR"), requesting authorization for Space Norway's highly elliptical orbit ("HEO"), non-geostationary orbit ("NGSO") satellite system, the Arctic Satellite Broadband Mission (the "ASBM"), to access the U.S. market. Herein, Space Norway addresses, among other issues, a framework for spectrum sharing among HEO and other NGSO systems; the relevance of International Telecommunication Union ("ITU") date priority; the longstanding principles under which HEO systems, such as the ASBM, should appropriately receive interference protection from large, more bandwidth-intensive, global NGSO constellations; in-line interference events; and the NGSO Notice of Proposed Rulemaking (the "NPRM"). For the reasons discussed below, the Federal Communications Commission ("FCC" or the "Commission") should promptly grant the Space Norway PDR.

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I. INTRODUCTION

Pursuant to Section 25.154(c) of the Commission's Rules,[1] Space Norway hereby submits its response to the comments, and its opposition to the petitions to deny or impose conditions, filed by Hughes Network Systems, LLC ("Hughes"), SES S.A. and its subsidiary O3b Limited ("SES/O3b"), Space Exploration Technologies Corp. ("SpaceX"), Spire Global, Inc. ("Spire"), Telesat Canada ("Telesat"), and ViaSat, Inc. ("ViaSat"). These comments and petitions were filed in response to the FCC Public Notice accepting for filing the Space Norway PDR.[2]

[1] 47 C.F.R. § 25.154(c).

[2] FCC Public Notice, DA 17-524 (Satellite Policy Branch, May 26, 2017).

II. DISCUSSION

a. ITU coordination and overlapping frequency bands

In a petition to deny, Telesat opposes the Space Norway PDR, because, Telesat claims, the ASBM would interfere with some of the frequency bands in which Telesat is authorized to operate a non-geostationary orbit ("NGSO") system by the Canadian Government. Additionally, Telesat argues that the ITU filings made by Canada and associated with Telesat's proposed NGSO system have date priority over the ITU filings made by Norway that are associated with the ASBM.

Telesat's arguments about its alleged ITU date priority reflect a fundamental misunderstanding of both the FCC Rules and the Radio Regulations of the ITU (the "RR") and their underlying purpose. Both the FCC and the ITU are focused, in their promulgation and implementation of rules relating to satellite system coordination, on ensuring that the most efficient use possible is made of radio spectrum, in order to assure the best possible service to the public.

The FCC Rules,[3] as well as the new rules proposed by the Commission in the recent NPRM relating to NGSO systems,[4] treat all qualified applicants in an NGSO processing round, such as the current processing round,[5] on equal terms, without regard to date priority. The Rules and the proposed rules make clear that those authorized in a processing round to access the U.S. market from NGSO must seek to coordinate their systems with one another to avoid harmful interference, and if they cannot, then each authorized petitioner or applicant

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3 *See* 47 CFR § 25.261.

4 *Update to Parts 2 and 25 Concerning Non-Geostationary, Fixed-Satellite Service Systems and Related Matters,* Notice of Proposed Rulemaking, at 6-7, 31 FCC Rcd 13651 (2016).

5 *See* FCC Public Notice, DA 16-804, 31 FCC Rcd. 7666 (Int'l Bureau, July 15, 2016).

will have to operate from a limited amount of "home base" spectrum during instances of in-line interference.[6]

The ITU RR similarly require that nations with proposed satellite systems that might conflict in terms of their frequency use seek to coordinate to avoid harmful interference, and indeed the ITU is explicit in stating that "the coordination process is a two way process."[7] The RR effectively leave it to the Administrations that are the ITU members to find a way to coexist, and Canada and Norway (and their associated operators, Telesat and Space Norway, respectively) have not yet begun any discussions about coordinating their respective NGSO systems.[8] Accordingly, it is premature to conclude that Canada's alleged ITU date priority should have any impact on the Space Norway ASBM,[9] and in any event the argument about ITU date priority is not relevant for present purposes under the FCC Rules.

b. Protection of HEO systems such as the ASBM

Telesat in its petition to deny also argues that the Space Norway PDR does not address the interference that the ASBM would cause to other NGSO systems, and contends that there is no basis for Space Norway's proposal that low Earth orbit ("LEO") and "medium

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6 *See* 47 CFR § 25.261(c), (d). *See also* NPRM at para. 22.

7 Rules of Procedure for the Radio Regulations, § 9.6(1)(c) (ITU, 2017). Section 9.6(1)(d) of the ITU Rules of Procedure also states that, "in the application of Article 9 no administration obtains any particular priority as a result of being the first to start either the advance publication phase . . . or the request for coordination procedure . . . ."

8 Space Norway has tried to begin frequency coordination discussions with Telesat, but has found the latter to be unresponsive. Apparently Telesat prefers to argue to the FCC about date priority, rather than to make a genuine effort at spectrum sharing through coordination.

9 The government of Canada has long had an interest in assuring telecommunications services for its remote regions in the Arctic. *See, e.g., Telecom Regulatory Policy CRTC 2016-496*, *Modern telecommunications services – The path forward for Canada's digital economy*, File No. 8663-C12-201503186 (Dec. 21, 2016), available at http://www.crtc.gc.ca/eng/archive/2016/2016-496.pdf. There is every reason to believe that Canada would welcome having ASBM service and would, therefore, seek to ensure successful coordination between the ASBM and any Canadian-authorized NGSO system.

Earth orbit ("MEO") systems be required to protect certain HEO systems, such as the ASBM, from harmful interference. SpaceX in its comments similarly argues that the Commission should not reward an allegedly inflexible system design with the interference protection that Space Norway has requested.

The ASBM is unique among the systems proposed by NGSO applicants/petitioners in the processing round, because Space Norway does not intend to deploy a large constellation with global coverage and significant spectrum requirements. The ASBM would have a limited pan-Arctic coverage area, targeting geographic areas with low population density that, at present, are underserved or not served at all by broadband systems, thereby effectively precluding these areas from realizing today the benefits of the increasingly essential digital economy. In addition to providing broadband access to those living in the Arctic, including residents of the State of Alaska, the ASBM would provide services to local governments, search and rescue agencies, and environmental protection agencies. As the polar ice recedes and maritime traffic increases, the two latter functions become increasingly important.

The ASBM would be able to provide continuous coverage throughout the Arctic through only two satellites (based on a standard geostationary orbit ("GSO") satellite bus design), deployed in a single orbital plane by a single launch vehicle, with just one active satellite at any one time (except for a brief handover). By contrast, the larger proposed NGSO LEO constellations with polar orbiting planes would need to deploy a significant proportion of their planned satellites before they could offer continuous service, and for a system like the one proposed by SpaceX,[10] would not deploy the orbital planes covering the Arctic until a later stage.

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[10] *Space Exploration Holdings, LLC, For Approval for Orbital Deployment and Operating Authority for the SpaceX NGSO Satellite System*, IBFS File No. SAT-LOA-20161115-00118 (filed Nov. 15, 2016) (the "SpaceX Application").

The HEO orbit in which the ASBM will operate should make it relatively easy to ensure compatibility with GSO networks, due to the significant minimum separation angle of 35.4°.[11] There would be no need for the ASBM to implement any special techniques to protect GSO networks. Additionally, the combination of a comparable orbital height between GSO and HEO (less than 1.7 dB difference in free space loss), and the rather slow movement that the ASBM satellite will appear to make across the sky (from the perspective of a user on Earth) during its active phase, would enable the ASBM satellite to operate with GSO user terminals with steerable antennas.[12] These factors would also allow aircraft flying over the North Pole on their routes between the United States and Asia to reuse their GSO user terminals with the ASBM system.

The ASBM's unique combination of inclination and apogee height would result in a coverage area, beam sizes, and spectral efficiencies comparable to that of a GSO system, but in a geographic area where GSO coverage is either limited or completely absent. These aspects of ASBM would represent significant value to end-users. The ASBM would also be very similar to a GSO networks in terms of interference as seen from another NGSO satellite in a lower orbit. As Space Norway indicated in comments with respect to both the NPRM and the applications/petitions filed by others in the current NGSO processing round, the ASBM has more in common with a GSO-type system than with other NGSO systems, and can co-exist with other lower orbit NGSO systems in the same manner as can GSO systems, with the same protection levels and mechanisms. [13]

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[11] *See Space Norway AS, Petition for a Declaratory Ruling Granting Access to the U.S. Market for the Arctic Satellite Broadband Mission*, *Annex 2*, at 1, IBFS File No. SAT-PDR-20161115-00111 (filed Nov. 15, 2016).

[12] Doppler compensation would be required at the gateway.

[13] *See Comments of Space Norway AS,* IB Docket 16-408, at 10-11 (filed Feb. 27, 2017). *See, e.g., Comments of Space Norway AS,* In the Matter of Telesat Canada -- Petition for Declaratory Ruling, at 2, File No. SAT-PDR-20161115-00108 (filed June 26, 2017). In the latter document, Space Norway summarized as follows: "The ASBM would be more

Space Norway does not agree with statements in Telesat's petition to deny[14] and in SpaceX's comments[15] to the effect that there is no basis for giving systems such as the ASBM special treatment. To the contrary, fundamental principles long recognized by both the ITU and the FCC require providing small, less bandwidth-intensive, regional systems some level of protection from large, more bandwidth-intensive, global NGSO constellations. These principles include equitable spectrum access, making efficient use (and reuse) of scarce spectrum, ensuring access to the Internet in remote and unserved areas, promoting more telecommunications competition, and attaching importance to telecommunications associated with vital public safety functions, all of which militate here in favor of finding a solution to accommodate the ASBM. More specifically:

- The combination of satellite orbit and satellite design makes the ASBM in HEO the most cost-effective way to provide continuous and reliable broadband coverage in the Arctic, and this system will be deployed for Arctic service long before any of the larger global NGSO constellations are able to provide such service;

- The proposed treatment of the ASBM as a "quasi-GSO" system would not deny other NGSO constellations access to spectrum; it actually would promote sharing

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similar to a GSO system than to other NGSO constellations because of various factors. Specifically, the ASBM: (i) would have a single active satellite that is quasi-stationary in its active phase (dwells around its apogee for eight hours); (ii) would be similar to a GSO satellite from a LEO/MEO interference perspective; (iii) would have a wide coverage area comparable to a GSO satellite; (iv) is inherently compatible with GSO networks through its orbital inclination and coverage area; (v) would be compatible with GSO user terminals; and (vi) would require the same type and level of protection as afforded to GSO user terminals. In addition, the ASBM would provide 'quasi-GSO' coverage at northern latitudes, including providing vital communications services for unserved and underserved remote areas of the Arctic (including those in Alaska)." *Id.*

[14] *Petition to Deny*, In the Matter of Space Norway AS – Petition for a Declaratory Ruling Granting Access to the U.S. Market for the Arctic Satellite Broadband Mission, at 2, File No. SAT-PDR-20161115-00111 (filed June 26, 2017).

[15] *Comments of Space Exploration Technologies Corp.*, In the Matter of Space Norway AS – Petition for a Declaratory Ruling Granting Access to the U.S. Market for the Arctic Satellite Broadband Mission, at 2-3, File No. SAT-PDR-20161115-00111 (filed June 26, 2017).

among different types of NGSO systems by assuring access to more spectrum for all authorized participants in the processing round;

- If other NGSO constellations were later deployed with continuous coverage of the Arctic, Space Norway would be there to ensure competition, which would lead to better and less expensive services, to the benefit of broadband and other users in the Arctic region;

- The ASBM would only require access to limited band segments in Ku- and Ka-band (250 MHz in Ku-band and 500 MHz in Ka-band for communication with user terminals); and

- Granting ASBM interference protection through EPFD limits (the same limits that NGSOs have to observe vis-à-vis GSO systems) would promote diversity in NGSO constellation designs.

c. In-line interference events

SpaceX argues that, due to Space Norway's very large spot sizes, there will virtually always be in-line interference events between the ASBM and LEO satellites, and that in-line interference events involving three or more satellite operators may not be uncommon. In this regard, SpaceX states that the ASBM does not provide any significant degree of satellite diversity to avoid in-line interference events, and reproaches Space Norway for expecting other satellite operators to shoulder the burden of avoiding these in-line interference events or being forced to divide the available spectrum, absent an alternative agreement.

The differences between a two-satellite HEO system and a LEO system with hundreds, or even thousands, of satellites are obvious, but the situation is similar to the one that would exist between GSO satellites and large LEO constellations. As noted above, it is reasonable – and consistent with longstanding FCC and ITU principles – for the FCC to require that large, very spectrum-intensive, global constellations carry the burden of in-line interference avoidance with small, less spectrum-intensive, regional systems. By the FCC taking this approach, spectrum sharing among the ASBM and other NGSO systems would be possible, and both types of systems could continue to operate across the full amount of spectrum allocated to them. LEO systems with polar orbiting satellites would in fact have more satellites in the polar regions with which to implement satellite diversity in areas where

in-line interference could occur with the ASBM, as compared to what these LEO systems would have around the Equator with respect to GSO. The limited amount of users in the Arctic, combined with more available satellites, should mean that, for a LEO system, the impact of sharing with a HEO system such as the ASBM should be smaller than what is required for the LEO system's sharing with a GSO system.

SpaceX specifically points to the ASBM uplinks as a source of significant interference, and claims that there will be a 30-50 dB difference in EIRP between the ASBM and SpaceX.[16] If typical operational parameters for the ASBM system are used as a basis and we compare the extremes in the ITU filing STEAM-1, however, that difference would in fact be in the range of 1-43 dB.[17]

In sections A.8.1.1 to A.8.1.3 in the technical attachment to the SpaceX Application, SpaceX elaborates on how it proposes to comply with EPFD limits and co-exist with GSO networks. SpaceX claims that it would be able to co-exist by maintaining a separation angle of 22°, together with beamforming and sidelobe nulling, while still providing continuous coverage through the use of satellite diversity and inter-satellite links. If the same separation angle of 22°were to be applied to the ASBM, together with beamforming that shifts the coverage area by 3° in a direction opposite of in-line, sufficient isolation between the SpaceX

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[16] *Id.* at 6.

[17] The calculations underlying this statement are as follows:

SpaceX (low):

PFD: -84.5 dBW/Hz; Terminal gain: 27.0 dB; EIRP: -57.5 dBW/Hz; Delta: 42,9 dB

SpaceX (high):

PFD: -69.6 dBW/Hz; Terminal gain: 53.9 dB; EIRP: -15.7 dBW/Hz; Delta: 1.1 dB

ASBM:

PFD: -57.8 dBW/Hz; Terminal gain: 42.8 dB; EIRP: -14.6 dBW/Hz

Therefore, ASBM user terminals would transmit with an EIRP level that is 20.4 dB higher than SpaceX user terminals.

system and the ASBM would be achieved to enable the avoidance of in-line interference events. This 22° separation, together with a 3° shift, would allow the systems to co-exist with sufficient margin, as confirmed in the table below.

	Ku-band	Ka-band
SpaceX SAT Rx antenna gain at nadir [dB]	37	41
SpaceX SAT Rx antenna G/T at nadir [dB/K]	9.8	13.7
SpaceX SAT Rx antenna G/T at 3° [dB/K]	-7.13	-7.23
Space Norway user terminal EIRP [dBW/40 kHz]	-11.78	-13.58
Space Norway user terminal EIRP [dBW/Hz]	-57.8	-59.6
Space Norway user terminal EIRP at 22° [dBW/40 kHz]	-13.34	-15.14
Space Norway user terminal EIRP at 22° [dBW/Hz]	-59.36	-61.16
I/N [dB]	-14.21	-16.14
$\Delta T/T$ [%]	3.79	2.43

Note: The values for the SpaceX system are based on those SpaceX used in its comments on the Space Norway PDR.. All off-axis antenna diagrams have been based on $32-25\log(\phi)$ from Recommendation ITU-R S.465-6. The ASBM user terminal is assumed to have an elevation angle of 90° in these calculations.

The separation angle could be further reduced, depending on what level of protection the SpaceX system were to require. For example, I/N = -12 dB would result in an 18° separation angle, and I/N = -6 dB would result in 11° in Ku-band. Based on these results, Space Norway believes that the techniques SpaceX would apply toward GSO networks could be readily applied toward the ASBM. Additionally, user density in the Arctic is relatively low compared to the latitudes around the Equator and is expected to remain so in the foreseeable future. Any capacity reduction that the SpaceX system would suffer due to in-line avoidance with ASBM should therefore not cause any meaningful impact on the user experience for SpaceX users.

Finally, SpaceX brings up the question of its gateways' compatibility with Space Norway's gateway station. The ASBM will have just a single gateway location (this single gateway will be located in Norway), and, because access to ground infrastructure (such as power and fiber connections) is limited in the Arctic, it is likely that SpaceX would not have many locations from which to choose within the ASBM coverage area. Also, the SpaceX system architecture, utilizing intersatellite links, should give SpaceX a high degree of flexibility in terms of both the number of gateways required in a particular geographic area and their specific locations. Therefore, Space Norway and SpaceX should be able to coordinate their gateway operations through traditional means.

d. Conditions of grant and outcome of NGSO rulemaking

Space Norway fully agrees with Telesat, SpaceX, ViaSat, SES/O3b and Spire that any grant of market access should be conditioned upon compliance with the outcome of the currently pending NGSO NPRM.

Additionally, ViaSat, Hughes, and SES/O3b ask the Commission to impose conditions to any grants of authority in this processing round that would ensure that GSO networks are protected from aggregate interference from numerous NGSO constellations. It

is proposed that conditions must be set to ensure compliance with any relevant EPFD limits, whether they be single-entry or aggregate, and so that the systems must comply with any future revisions of EPFD limits to take into account more and larger constellations. SES/O3b and ViaSat also propose that the Commission intervene and enforce its Rules as necessary in instances where harmful interference is inflicted on GSO networks. ViaSat suggests that NGSO operators might be held jointly and severally responsible for aggregate interference effects.

While Space Norway agrees with the basic thrust of these proposals, it has concerns regarding how identification of which NGSO system(s) are the root cause of the aggregate interference effects would work, and how a requirement of reduced power levels would be implemented where multiple systems are blamed. Space Norway believes that the mechanisms established in ITU Resolution 76 (Rev. WRC-15) should be sufficient to address the concerns on how to handle any eventual cases of aggregate interference.

ViaSat also argued that Space Norway did not specify the minimum separation angle to the GSO arc at which the ASBM would operate. In this regard, ViaSat requested that the Commission require Space Norway to provide this information, so that ViaSat may evaluate whether Space Norway's proposed operations, once implemented, would provide adequate protection to ViaSat's GSO operations. However, Annex 2 of the Space Norway PDR specifically stated that the minimum separation angle between the ASBM and any GSO satellite from any location on the surface of the Earth would be 35.4°.[18] This large minimum separation angle would undoubtedly protect ViaSat's existing and future GSO networks from any harmful interference.

SpaceX requested that Space Norway's grant of authority be conditioned on Space Norway's complying with any rule concerning the adoption of default limits for EIRP density

[18] *Space Norway AS, Petition for a Declaratory Ruling,* note 11, *supra*.

of NGSO uplink transmissions that the Commission might adopt through the NGSO NPRM. Space Norway agrees that EIRP density limits should be adopted, and that they will be helpful regarding coordination between NGSO systems. Space Norway supported adoption of the Commission's proposal to implement GSO FSS EIRP limits in Space Norway's comments to the NPRM.[19]

Finally, Spire requested that the Commission condition Space Norway's grant of authority on Space Norway (i) providing additional information regarding its post-mission disposal plans and a revised orbital debris plan once it finalizes its satellite designs, and (ii) modifying its operations in compliance with any orbital debris mitigation rules or policies that the Commission might adopt in the future. Space Norway has already, in response to an FCC request, supplemented its PDR with additional information about orbital debris mitigation,[20] and it does not object to providing additional information, when appropriately requested by the Commission.

III. CONCLUSION

To promote spectrum sharing, diversity in design, and competition, the FCC should condition grants of authority or make appropriate rules in the NGSO rulemaking process that facilitate co-existence between small, less bandwidth-intensive, regional systems and large, highly bandwidth-intensive, global NGSO systems. Large global NGSO constellations using the majority of available FSS spectrum worldwide should be mandated to implement spectrum sharing mechanisms among themselves and to facilitate access for smaller regional

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19 *See Comments of Space Norway AS,* note 13, *supra*, at 13.

20 Letter from Phillip L. Spector, Attorney for Space Norway AS, to Dr. Jose Albuquerque, Chief, FCC Int'l Bur. Satellite Div., IBFS File No. SAT-PDR-20161115-00111 (filed Mar. 29, 2017).

systems using limited amounts of available spectrum. For these reasons and those discussed above, the Commission should promptly grant the Space Norway PDR.

Respectfully submitted,

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CERTIFICATE OF SERVICE

I, Jostein Rønneberg, hereby certify that on this 7th day of July, 2017, I caused to be served a true copy of the foregoing "Response of Space Norway AS to Comments and Opposition to Petitions to Deny," by electronic mail upon the following:

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