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May 5, 2017

Federal Communications Commission
International Bureau, Satellite Division
445 12th Street S.W.
Washington, D.C. 20554
Attn: Dr. Jose Albuquerque, Chief

RE: Space Norway AS, IBFS File No. SAT-LOI-20161115-00111 (Call Sign S2978)

Dear Dr. Albuquerque:

Space Norway AS ("Space Norway"), by its attorneys, submits this letter in response to the letter sent by you to Space Norway, dated March 10, 2017 (the "FCC Letter"). The FCC Letter related to the above-referenced petition (the "Petition") to provide service to the United States market via Space Norway's non-geostationary satellite orbit ("NGSO") system, the Arctic Satellite Broadband Mission (the "ASBM"), which will comprise two satellites in highly elliptical orbits.

The FCC Letter asked Space Norway to provide the Federal Communications Commission (the "FCC") with some additional information to aid the FCC's evaluation of Space Norway's Petition. The deadline for submitting this additional information was April 11, 2017. On March 29, 2017, Space Norway sent a letter to the FCC requesting that the

deadline to respond to the FCC Letter be extended to May 11, 2017 ("Space Norway's Letter"). The FCC granted Space Norway's request on April 6, 2017.

As mentioned in Space Norway's Letter, Space Norway is currently in negotiations with several satellite manufacturers and has not yet selected which satellite manufacturer will assist Space Norway in the design, development, and manufacture of the ASBM. In preparing this response, Space Norway relied on information provided by certain satellite manufacturers. Although Space Norway cannot at this time provide definitive responses to all of the questions regarding space orbital debris mitigation included in the FCC Letter because the ASBM satellites have yet to be designed, Space Norway will ensure that the satellite manufacturer it chooses for the ASBM complies with all of the FCC's requirements pertaining to space orbital debris mitigation.

1. *FCC: A statement concerning assessment and limitation of the amount of debris released during normal operations, and assessment and limitation of the probability of the satellites becoming a source of debris by collisions with small debris and meteoroids that could cause loss of control and prevent post-mission disposal.*

   During nominal operations and post-mission disposal, preliminary assessments show that no debris will be released from the ASBM satellites. Throughout the design process, Space Norway will take measures towards limiting damage caused by collisions with small debris or meteoroids. By applying the procedures included in the European Space Agency ("ESA") Space Debris Mitigation Compliance Verification Guidelines,[1] the probability of damage or failure will be analyzed for all critical components. This analysis will take into account components critical to the surface and their placement. Furthermore, if such analysis demonstrates that additional shielding is required, Space Norway will change the placement of components or add additional shielding. This process, together with redundancy in the overall design, will ensure that no loss of post-mission disposal functionality or of control of the ASBM satellites occurs.

2. *FCC: A statement concerning assessment and limitation of the probability of accidental explosions during and after completion of mission operations. This statement must include a demonstration that debris generation will not result from the conversion of energy sources on board the spacecraft into energy that fragments the spacecraft. Energy sources include chemical, pressure, and kinetic energy.*

   All pressurized vessels and components with stored energy will go through acceptance tests with sufficient safety margins. Batteries and pressurized vessels will be monitored throughout the lifetime of the ASBM satellites and have a "leak-before-break" design that will help minimize the risk of accidental explosions. During post-mission disposal, batteries will be discharged and their charging disconnected, and reaction wheels spun down. Xenon propellant tanks cannot be purged, but with ample margin from maximum operating pressure and burst pressure, coupled with a "leak-before-break" design, the probability of an accidental explosion during and after completion of nominal mission operations will be minimized. These measures will,

[1] ESA Space Debris Mitigation Compliance Verification Guidelines - ESSB-HB-U-002, *available at* http://www.iadc-online.org/References/Docu/ESSB-HB-U-002-Issue1(19February2015).pdf.

with a very high degree of probability, ensure that the ASBM satellites are able go through nominal operations and post-mission disposal phases without becoming a source of space debris.

3. *FCC: The accuracy – if any – with which the parameters of satellite orbits will be maintained, including apogee, perigee, inclination, and the right ascension of the ascending node(s). In the event that the system is not able to maintain orbital parameters, i.e., it lacks a propulsion system for orbital maintenance, that fact should be included in the debris mitigation disclosure. Such systems must also indicate the anticipated evolution over time of the orbit of the proposed satellites.*

   The ASBM is designed to have a repeating ground track, which will be achieved through an orbit maintenance strategy that keeps the apogee and perigee altitudes stable through periodic use of an on-board propulsion system. Other orbital parameters, such as the right ascension of the ascending node, the argument of the perigee, and inclination, will not require active corrections.

   As the ASBM satellites will undergo a de-orbit maneuver at the end of their mission life that will lead to re-entry in the Earth's atmosphere (see next section for further details),[2] these satellites will necessarily intersect with the MEO and LEO regions without any active propulsion system. By taking measures to protect the ASBM satellites from accidental break-ups, however, these satellites will stay intact until re-entry. The ASBM satellites will therefore be relatively easy to track and avoid, if so required. The ascending and descending nodes of the ASBM satellites will never intersect with LEO- and GEO-protected regions.

4. *FCC: A casualty risk assessment including an estimate of the number, dimensions, weight and the kinetic energy of any surviving components/fragments that may reach the surface of the Earth, as well as an estimate of the resulting probability of human casualty. In the event there are surviving fragments, please provide the projected geographic area of the debris field, and any measures taken to forewarn people who are likely to be in the geographic region during the time period of the re-entry.*

   The ASBM satellites will carry sufficient fuel to perform end-of-life disposal through re-entry into the Earth's atmosphere in a semi-controlled manner. A de-orbit maneuver will lead to a gradual decay of the perigee altitude until re-entry occurs. This maneuver will be designed to ensure that the point of re-entry (i.e., the perigee) is located south of the 60th parallel south. In this region of the world, re-entering satellites will pose a negligible threat to human life because there are no permanent settlements and the population density is very low. Nevertheless, Space Norway will use NASA's Debris Assessment Software to assess re-entry material and casualty risk; a detailed analysis on surviving components and their energy cannot be completed at

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[2] The FCC's rules allow NGSO satellite operators to utilize atmospheric re-entry in connection with post-mission disposal of space stations so long as any such NGSO satellite operator provides the FCC with a casualty risk assessment, which includes "an estimate as to whether portions of the spacecraft will survive re-entry and reach the surface of the Earth, as well as an estimate of the resulting probability of human casualty." *See* 47 C.F.R. § 25.114(d)(14)(iv). Space Norway has provided this statement in its response to item #4.

this time because Space Norway is in the very early stages of designing its satellites. Moreover, Space Norway will notify the relevant authorities in due time before re-entry so that proper notification can be given to those vessels and personnel that may be in the affected region.

5. *FCC: Identify the administration that will register the Space Norway satellites pursuant to the United Nations Convention on Registration of Objects Launched into Outer Space.*[3]

   The ASBM satellites will be registered in the Norwegian space object register, which is maintained by the Norwegian Space Centre, and registration information will be transmitted to the United Nations Secretary-General through the Permanent Mission of Norway to the United Nations in Vienna, Austria.

Space Norway remains at the FCC's disposal to answer any further inquiries regarding the ASBM system that will aid in the evaluation of Space Norway's Petition.

Very truly yours,

/s/

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Phillip L. Spector
Lafayette Greenfield
Attorneys for Space Norway AS

cc: Stephen Duall
Kathryn Medley
Satellite Division, FCC

[3] Convention on Registration of Objects Launched into Outer Space, Nov. 12, 1974, 28 U.S.T. 695, 1023 U.N.T.S. 15, *available at* http://www.unoosa.org/oosa/en/spaceobjectregister/index.html.