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July 30, 2015

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VIA ELECTRONIC FILING

Marlene H. Dortch, Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Re: Iridium Constellation LLC; Application for Modification of NGSO Mobile Satellite Service System Authorization (S2110) To Launch and Operate Replacement Satellites; Call Sign S2110;
File No. SAT-MOD-20131227-00148

Dear Ms. Dortch:

Iridium Constellation LLC ("Iridium"), by its counsel, hereby responds to the International Bureau's June 10, 2015 request for additional information related to the orbital debris mitigation plan submitted in conjunction with the above-captioned application seeking authority to launch and operate Iridium's second generation satellite system, Iridium NEXT. Attached to this letter are complete responses to the Commission's questions. With these responses, Iridium respectfully requests that the commission approve Iridium's orbital debris mitigation plan for Iridium NEXT.

Please contact the undersigned with any additional questions.

Respectfully Submitted,

/s/ Jennifer D. Hindin

Jennifer D. Hindin

cc: Jose P. Albuquerque, Chief, Satellite Division, International Bureau
Daryl T. Hunter, Senior Director, Regulatory Affairs, Chris Hofer Director, Regulatory Affairs, VIASAT, INC.
John P. Janka, Elizabeth R. Park, Latham & Watkins LLP
Nancy J. Eskenazi, Daniel C.H. Mah, SES Americom, Inc.
Christopher J. Murphy, Vice President, Government Affairs, Inmarsat, Inc.
Karis A. Hastings, SatCom Law LLC

Attachment

IRIDIUM RESPONSES TO FCC QUESTIONS OF JUNE 10, 2015

The Federal Communications Commission's ("FCC") June 10, 2015 letter poses a number of questions related to end of life disposal of the Iridium NEXT satellites and mitigation of orbital debris. Questions and responses follow, including description of specialized modeling tools, NEXT system characteristics, and environmental assumptions.

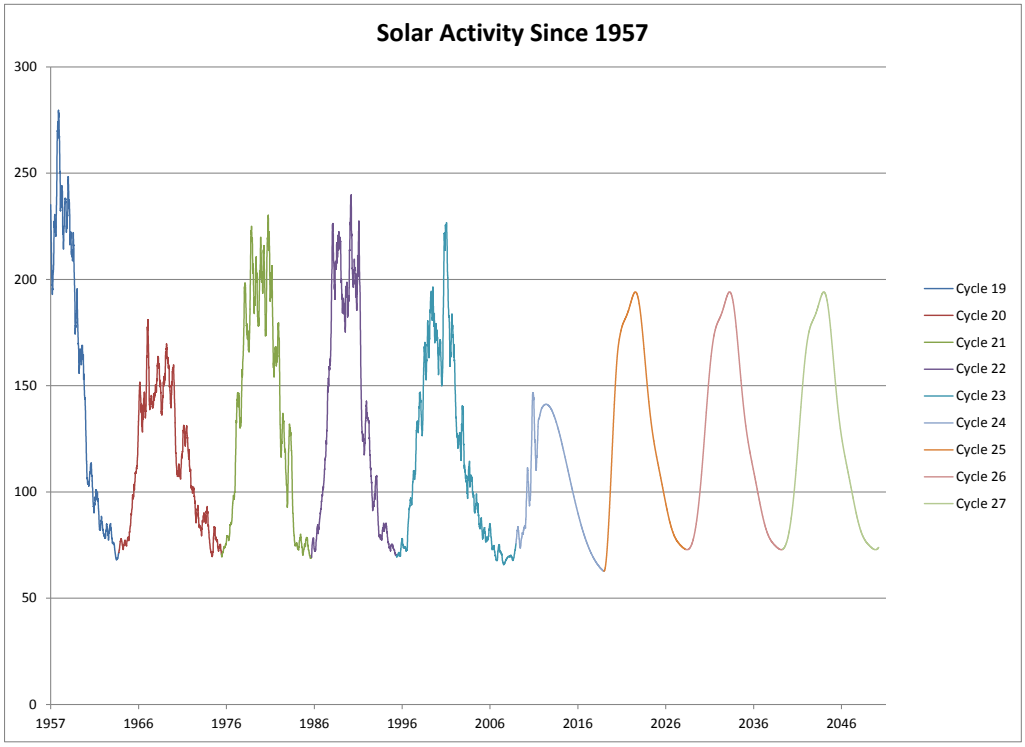
1. **Iridium proposes to relocate second-generation satellites at end of life to a disposal orbit with an apogee altitude of 750 km and a perigee altitude of 500 km. For this disposal orbit and for alternative disposal orbits with the same apogee altitude and perigee altitudes of 450 km, 400 km, 350 km, 300 km, and 250 km, state:**

    a. **The predicted amount of time the satellite will remain in orbit following placement into the disposal orbit;**

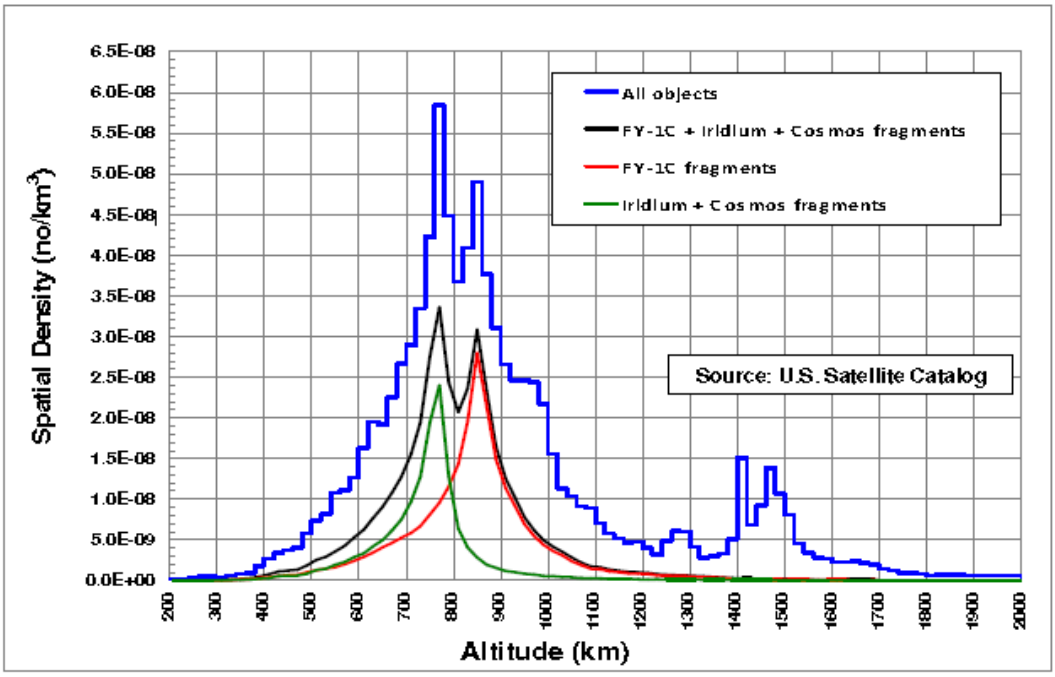
    b. **the probability of accidental collision with space objects larger than 10 cm in diameter during that time period; and**

    c. **the effect, if any, on duration of the communications mission or on the satellite's mission capabilities in the event perigee altitudes of the disposal orbits are reduced below the proposed 500 km.**

The Iridium NEXT satellite lifetime was modeled using STELA v2.4.2, available at no charge from CNES at https://logiciels.cnes.fr/content/stela?language=en. Satellite dry mass is 678 kg, drag area 3.4 m^2. This drag area is the minimum cross section found when the solar arrays are positioned to maximize the minimum drag surface. The target disposal orbit is 750 km x 480 km, which results in a predicted orbital life of less than 25 years. These values have changed slightly since the December 2013 filing as analyses have been updated as the design matures. The disposal year was taken to be 2025, this representing a worst case value for predicted atmospheric density. Atmospheric density is variable, and driven by the Sun's 12 year activity cycle (see figure).

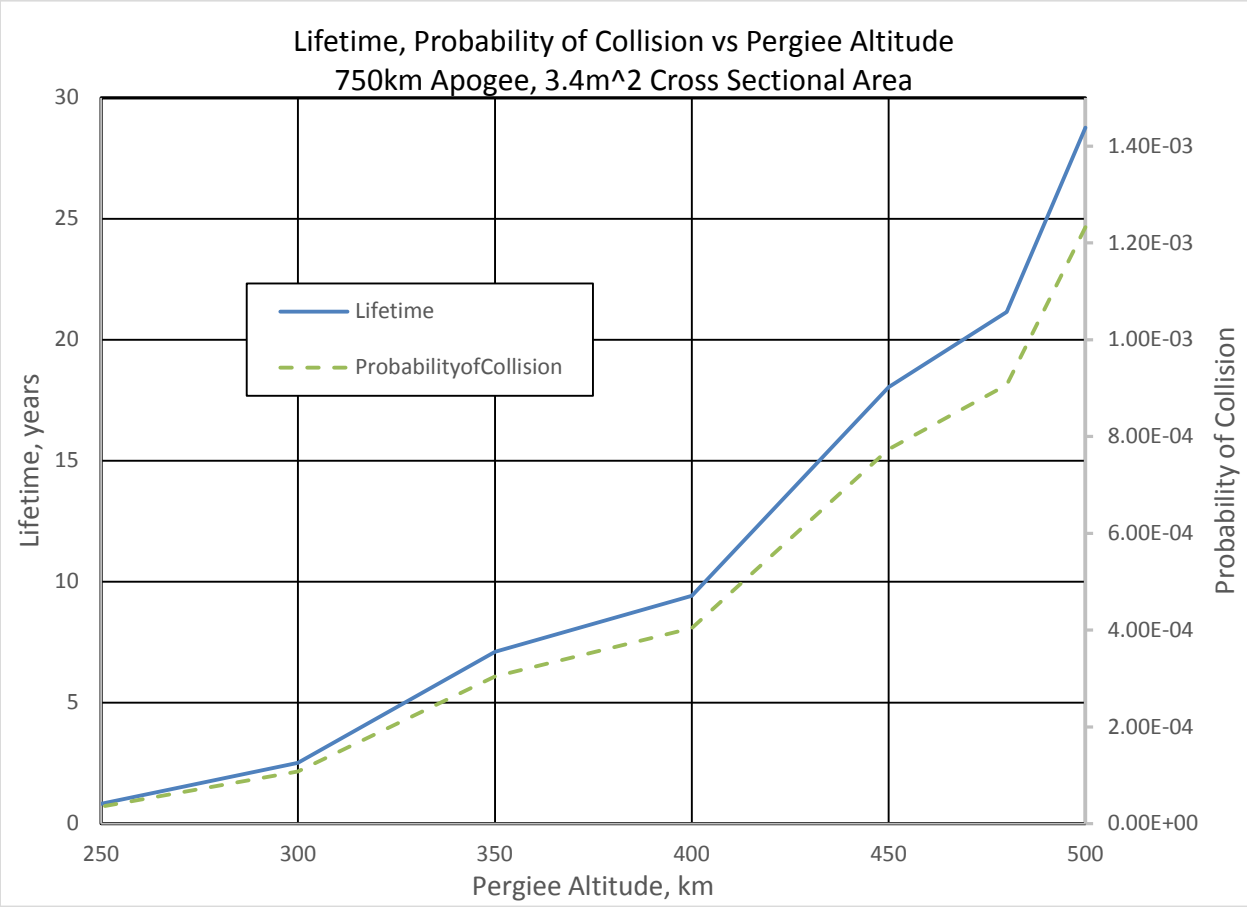


For simplicity, the approximate spatial density of orbital debris near 750 km was used, a value of $4x10^{-8}$ objects (of a size 10 cm or greater) per cubic kilometer (ref www.unoosa.org/pdf/pres/stsc2013/tech-17E.pdf). This will provide a conservative result, as object density drops rapidly with altitude (see figure).



Calculation of collision probability was performed using the relationship suggested in https://www.faa.gov/about/office_org/headquarters_offices/ast/media/poisson.pdf.

With assumptions outlined above, and using the tool identified, this figure shows the estimated post-disposal lifetime and probability of debris collision during that lifetime.



Requiring a lower perigee altitude would consume the limited end-of-life fuel margin budgeted for the Iridium NEXT satellites and would reduce the operational lifetime of the system. The propellant budget for Iridium NEXT currently maintains a 3 percent end of life margin, calculated based upon the FCC's guidance for NGSO systems, which endorses a 25 year deorbit timeframe. Propellant carried on the Iridium NEXT satellites is used for orbit raising (insertion to mission orbit), orbit maintenance and station keeping, orbital maneuvers during the course of the mission (such as those required in coordination with JSPOC to avoid collisions and any plane change or other maneuvers required to ensure continuity of service coverage), and end of life disposal. The 3 percent margin is estimated reserve propellant, which, if not applied to other operations, could support lowering perigee to approximately 440 km. However, should the 3 percent propellant margin be required to support any of these other activities during the mission, it will be applied accordingly. Were the FCC to mandate a lower perigee altitude, it would shorten the operational lifetime of the Iridium NEXT constellation, as vehicles needing to use the margin fuel for other activities would have to deorbit sooner than they otherwise would, to meet

the non-conforming deorbit requirement. As stated in the Iridium NEXT Orbital Debris Mitigation plan, any portion of the fuel margin remaining on a spacecraft at the end of the mission will be used to lower perigee altitude further and decrease the deorbit lifetime.

2. **For the cases of a failed second-generation satellite in the 625 km circular insertion orbit or in the 778 km circular mission orbit, state the predicted amount of time the satellite will remain in orbit and the probability during that time of accidental collision with space objects larger than 10 cm in diameter.**

The estimated lifetime of a failed satellite in the 625km circular insertion orbit is 12.3 years, with a $7x10^{-4}$ probability of collision with debris. This assumes an object density of $2x10^{-8}$ at 625 km.

The estimated lifetime of a failed satellite in the 778 km circular mission orbit is on the order of 100 years, with a $1.4x10^{-2}$ probability of collision with debris.

3. **The application Schedule S indicates that the probability of survival to end of life of a second-generation spacecraft is 0.92 for the satellite bus. Please provide the basis for this estimate. Is 0.08 the expected catastrophic failure rate for operational satellites? Does the 0.92 probability of success also include the disposal operations specified in the application? If not, please provide the probability of success of the disposal plan and the basis for the estimate.**

The 0.92 probability of survival at 12.5 years was analytically determined by Thales Alenia Space using standard aerospace reliability modeling methods. This corresponds to the probability of successfully completing the 12.5 year mission life of the spacecraft, lowering a fully-functioning spacecraft to disposal orbit, and conducting other disposal operations.

4. **An affiliate of Iridium currently maintains an insurance policy to cover the de-orbiting of the Iridium first-generation constellation, with the U.S. government as a named beneficiary. Will an insurance policy be procured to cover de-orbiting of the second-generation satellites? If so, will the policy include the U.S. government as a beneficiary? Will the second-generation satellites be covered by an insurance policy for third party liability for events occurring throughout the period during which a satellite remains in orbit?**

Iridium does not plan to acquire insurance to cover de-orbiting of the second-generation satellites. The terms of Iridium's financing arrangements require the company to procure insurance covering launch of the satellites and the first year of operations, at a substantial cost to Iridium. It is not a standard industry practice to purchase insurance covering end-of-life disposal in the United States or anywhere in the world. Requiring Iridium to absorb the ongoing cost of maintaining such a policy would be a very significant expense, put Iridium at a competitive disadvantage in the MSS marketplace, and be fundamentally unfair.

The FCC expressly declined to adopt a de-orbit insurance requirement in the 2004 Orbital Debris Mitigation Order, deciding instead to consider the decision to acquire insurance as one of the myriad factors to be considered in its public interest analysis regarding an orbital debris mitigation plan. Iridium is not aware of any other NGSO system operating in the United States

that carries such insurance. Iridium does not believe this insurance was required or procured by Orbcomm, for its recent U.S.-licensed replacement MSS constellation. Iridium also does not believe similar insurance was procured by Globalstar, Planet Labs, or Skybox for their respective systems. Acquiring this insurance could put Iridium at a significant competitive disadvantage in the U.S. market.

It is true that Iridium carries such insurance on its first-generation MSS constellation, but the origination of that insurance is a historical anomaly resulting from an agreement among Iridium's predecessor's former parent company (Motorola), Iridium, and the U.S. Government. When Iridium Satellite purchased the assets of Iridium LLC out of bankruptcy, Boeing, Motorola and the U.S. government required specified de-orbit rights as a way to control potential liability risk arising from future operation of the Iridium constellation, and to provide for the U.S. government's obligation to indemnify Motorola. As a result, Iridium Satellite, Boeing, Motorola and the U.S. government entered into an Indemnification Agreement, which, *inter alia*, gave the U.S. government the right to require de-orbit of the Iridium constellation should Iridium Satellite fail to maintain certain insurance coverage. This insurance would not have been purchased absent this Indemnification Agreement, and was not imposed as a requirement for the initial authorization of Iridium's current satellite constellation. Analogous factual circumstances do not exist in this instance: there has been no new Indemnification Agreement negotiated, and no new deorbit insurance is planned.

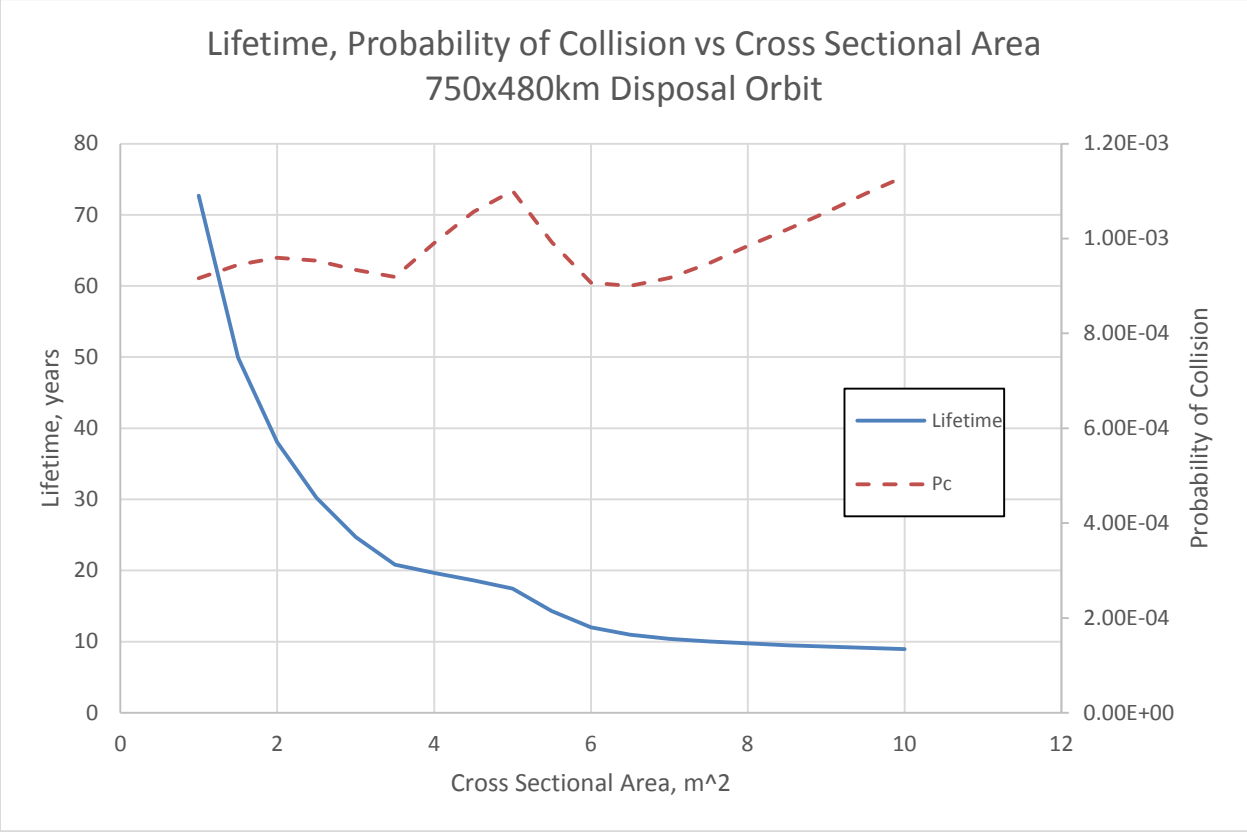
5. **The application states that a casualty risk assessment was conducted using the National Aeronautics and Space Administration Debris Assessment Software (DAS). What was the casualty risk output in DAS from this assessment? When Iridium second-generation mission information is entered into DAS, does the software indicate that the mission is compliant with each of the relevant items in the "Requirement Assessments" window? If not, please specifically identify any such items.**

As was stated in the application, DAS was run by Thales Alenia Space for Iridium NEXT. Iridium did not observe this analysis at run time, and cannot speak to what was displayed in the "Requirements Assessment" window. However, the analysis report provided by Thales Alenia Space concludes that the raw casualty risk (not accounting for the effects of sheltering) is 2.44×10^{-4}, or 1:4098. While this does exceed the 1:10000 guideline, it should be recalled that DAS "is intended to be a 'first-cut' assessment tool" (DAS v2.0 users guide p35) that provides conservative results that may require additional analysis. In the case of Iridium NEXT, incorporation of the reasonable sheltering assumptions set forth in NASA Technical Standard, NASA-STD-8719.14A, demonstrates compliance with the 1:10000 guideline, as was stated in the application.

6. **Iridium states that "[a]s part of the de-orbit process, the satellite's solar arrays will be positioned to maximize the minimum drag surface for atmospheric re-entry." Please provide further explanation. Will this disposal configuration minimize collision risk, remaining orbital lifetime, or both?**

This disposal configuration minimizes orbital lifetime, and consequently collision risk. A sensitivity study of cross sectional area as compared to orbital lifetime and collision risk was

performed using the same assumptions as outlined above. The results can be seen in the following figure:



As can be clearly seen, increasing cross sectional area dramatically decreases orbit lifetime until the area reaches roughly 6 m^2 (note this assumes a common mass of 678 kg in all cases), but does not strongly effect the probability of collision. This is due to the fact that the probability of collision is a function of cross sectional area and time, not cross sectional area alone.