Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Application of The Boeing Company	)	Call Sign E140097
for Authority to Operate Up to 100	)	File No. SES-LIC-20140922-00748
Earth Stations Aboard Aircraft ("ESAA")	)	

APPLICATION SUPPLEMENT AND
REQUEST FOR WAIVER

In connection with the above-captioned application and pursuant to Section 1.3 of the Commission's rules,[1] Boeing hereby requests partial waiver of Section 25.283(c)[2] of the Commission's rules to the extent the rule requires satellite Eutelsat 36B ("E36B") to vent all remaining helium pressurant from the spacecraft at end-of-life. Section 1.3 of the Commission's rules provides that any Commission rule may be waived for "good cause" shown. For the reasons stated below, Boeing's waiver request is supported by good cause.

I. REQUEST FOR PARTIAL WAIVER OF END OF LIFE VENTING REQUIREMENT

Section 25.283(c) requires that after the completion of a satellite mission "all stored energy sources on board the satellite are discharged, by venting excess propellant, discharging batteries, relieving pressure vessels, and other appropriate measures." The E36B satellite uses a Thales Alenia Space Spacebus 4000, a widely used spacecraft bus.[3] This spacecraft bus propulsion system design, like many others, dictates that the propellant and pressurant tanks be

[1] 47 C.F.R § 1.3.

[2] 47 C.F.R. § 25.283(b).

[3] *See* Thales Alenia Space: Spacebus-3000/4000 C-Class (available at http://space.skyrocket.de/doc_sat/aeosp_spacebus-c-class.htm).

isolated from each other when the satellite reaches geostationary orbit. Once the propellant and pressurant tanks have been isolated from each other, the remaining helium in the pressurant tank cannot be vented, as the exit from the tank is closed by the action of firing a pyro-valve and this operation cannot be reversed. Therefore, as a result of the design of the spacecraft bus, Eutelsat cannot vent all remaining pressurant from E36B at end-of-life.

Multiple factors, however, ensure that E36B's design is consistent with a safe flight profile and will not pose a risk of creating orbital debris. As explained in the E36B Space Debris Mitigation Plan,[4] the remaining helium in the two pressurant tanks will be *de minimis*, containing less than 1.1 kg of helium in each 90 liter tank. The isolated helium pressurant tank will have remaining pressure of only 79 bars at end of life, which is far below the burst pressure of the tanks.[5] The pressurant tanks have been designed, manufactured, and validated according to MIL-STD-1522 with a break-up security coefficient of 1.5 for the whole mission, *i.e.* including full-load and maximum-pressure conditions.[6] Clearly, the security coefficient is much higher than this (probably orders of magnitude higher) for residual pressurant at end of life. Accordingly, the need for safety has been appropriately addressed.

Boeing notes that the Commission has granted a waiver in analogous circumstances, such as for Anik F3 and AMAZONAS-3.[7] Boeing respectfully submits that a similar waiver is justified here.

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[4] Included as a supplement to the above-captioned application and attached here.

[5] *Eutelsat 36B Space Debris Mitigation Plan* at 6.

[6] *Id*. at 7.

[7] *See, e.g.,* Telesat Canada Petition for Partial Waiver of Section 25.283(c); File No. SAT-APL-20111117-00222 (granted April 11, 2012); Hispamar Satélites, S.A. Petition for Declaratory Ruling to Add Amazonas-3 Satellite to the Permitted Space Station List, File No. SAT-PPL-

II. GRANT OF THIS WAIVER WILL SERVE THE PUBLIC INTEREST

Grant of this application will serve the public interest by helping Boeing to serve the needs of the United States Air Force Air Mobility Command to support the operation of critically-important VIP/SAM (Very Important Personnel/Special Air Mission) aircraft used to transport senior leadership of the U.S. Government and the Department of Defense. Boeing therefore respectfully requests that the Commission grant the requested waiver.

Sincerely,

Bruce A. Olcott

December 15, 2014

20121018-00183 (Granted Mar. 14, 2013) (granting Permitted List status to Amazonas-3, which will retain a de minimis quantity of helium pressurant at end of life).

Eutelsat 36B Space Debris Mitigation Plan (prepared for the Federal Communications Commission)

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1. Introduction

This document describes the space debris mitigation plan that Eutelsat shall apply to the **Eutelsat 36B ("E36B")** space station.

E36B is based on the Thales Alenia Space Spacebus 4000 bus and it was manufactured according to European standards and specifications. The satellite is 3-axis stabilized and uses bi-propellant chemical propulsion for attitude and on-station control.

E36B was launched in 2009 and the end of its operational life is not expected to be before mid 2026.

2. Related documents

2.1. Applicable Documents

1. EUTELSAT Space Debris Mitigation Plan. Issue 1.3. EUT_CTL_SAT_QMS_PLN_00021, 26 July 2010.
2. FCC. Orbital Debris Mitigation Standard Practices. FCC 04-130. June 21, 2004.

2.2. Reference Documents

1. European Code of Conduct for Space Debris Mitigation. Issue 1.0. 28 June 2004.
2. IADC Space Debris Mitigation Guidelines. IADC-02-01. Revision 1. September 2007.
3. Space Product Assurance. Safety. ECSS-Q-40A. 19 April 1996.
4. Orbital Debris Mitigation Standard Practices. FCC 04-130. 21 June 2004.
5. NASA Safety Standard. Guidelines and Assessment Procedures for limiting Orbital Debris. NSS 1740.14. Aug 1995.
6. ITU Environment Protection of the Geostationary Orbit. S.1003. 1993.
7. UNCOPUOS. Technical Report on Space Debris. 1999.

3. Eutelsat 36B operations

- Eutelsat operates in order to control and limit the amount of debris released in a planned manner during normal operations, and assesses and limits the probability of the space station becoming a source of debris by collisions with small debris or meteoroids that could cause loss of control and prevent post-mission disposal.
- Eutelsat has assessed the amount of debris released in a planned manner and no intentional debris will be released during normal operations of the E36B spacecraft. A safe operational configuration of the satellite system is ensured thanks to the hardware design and operational procedures

- Eutelsat minimizes the probability of the satellite becoming a source of debris by collisions with large debris or other operational satellites. Eutelsat assessed for E36B whether there were any known satellites located at the requested orbital location or might overlap.
- E36B is controlled within its ITU allocated orbit control window (35.9°E +/- 0.1°) by standard routine periodic orbit correction maneuvers. In case of anticipated violation of the window, correction maneuvers would be implemented to avoid such violation.
- Eutelsat has assessed the probability of accidental explosions during and after completion of mission operations. Thanks to design safety margins and enough safety barriers, the probability of occurrence of accidental explosion of the E36B satellite is negligible.
- Satellite design is such that high levels of thruster activity and orbit perturbation do not result when foreseeable on-board events occur.

4. Eutelsat 36B End-of-Life Disposal

The post-mission disposal activities have been planned as follows:

1. The orbit of the satellite will be raised by 300 km in order to ensure that the spacecraft will not re-enter into the GEO protected region (GEO height +/- 200 km) in the long term. A mass of 13.7 kg of propellant have been allocated and reserved with a confidence level of 99% to carry-out the post-mission disposal maneuvers. The FCC will be informed of any significant change to the above quantity of propellant.

   The minimum perigee height to avoid re-entering into the GEO protected region can be computed using the IADC formula applied to this satellite:

   $$\ddot{A}H\ (km) = 235 + 1000.(A/m)eff = 272\ km$$

   where the final term is the effective area/mass ratio of the satellite. Therefore, the planned 300 km above GEO height is sufficient to satisfy the 272 km requirement.

   During the satellite lifetime, Eutelsat determine the remaining propellant tanks.

2. As part of the end of life (EOL) activities, E36B energy sources will be rendered inactive, such that debris generation will not result from the conversion of energy sources on board the spacecraft into energy that fragments the satellite. For E36B, this involves the following:

A. Depleting the chemical propulsion system, and where possible leaving open fuel lines and valves. Eutelsat 36B satellite includes two (2) interconnected helium tanks. Before switch-off of the E36B satellite, thrusters will be fired as much as possible to deplete the propellant and depressurize the tanks. The Orbital Debris Plan for E36B satellite states that “where possible” fuel lines and valves will be left open.

The following table shows the characteristics of the pressurant tank, propellant tanks and propellant lines at EOL. It shall be noted that during the passivation the four propellant tanks will be depressurized as much as possible.

Element	Total Volume (l)	Material contained at EOL	Predicted mass of material at EOL (kg)
MON-1 Propellant tank	1391	MON-1 He	9.5 2.7
MMH propellant tank	1391	MMH He	2.2 2.8
MON-1 lines MMH lines	0.65 0.65	MON-1 MMH	1.0 0.6
Pressurant tank 1	90	He	1.1
Pressurant tank 2	90	He	1.1

Eutelsat employs a combination of methods, including bookkeeping and PVT measurements and, where possible, measurements of tanks thermal inertia, to calculate the predicted EOL mass values. The figures in the last column of the Table can be considered as worst-case post-passivation remaining mass for MON and MMH after final shutdown of the satellite. They correspond to the static residuals of MON and MMH at the end-of-life. The helium pass in the pressurant tanks corresponds to the value measured at the end of launch and early orbit phase (“LEOP”). The pressurant tank is isolated just after the completion of LEOP operations and cannot be passivated as part of the EOL operations.

The residual pressure statement (less than 1 bar) corresponds to temperatures between 20° C and 30° C. The predicted pressures at end-of-life for the remaining materials are as follows: 13.2 bars before passivation for MON-1 propellant tank; 12.7 bars before passivation for MMH propellant tank; and 79 bars for pressurant tank 1 and 2. The EOL values given for masses and pressures and temperatures are when the satellite is taken out of service. Then, Eutelsat starts the orbit raise activity and finishes the passivation exercise by emptying the fuel and oxidizer tanks as far as possible. During the satellite life, Eutelsat performs gauging activities to monitor the remaining liquid quantities to determine the remaining masses in the tanks.

The passivation exercise is not a closed system due to the fact that matter is expelled. Eutelsat expels the remaining liquid as it evaporates at lower pressures, then expels as much pressurant as possible to lower the tank pressures down to 1 bar or below. All the tanks have been designed, manufactured, and validated according to the MIL-STD-1522 standard with a break-up security coefficient of 1.5 for the whole mission; *i.e.*, including full-load and maximum-pressure conditions. Clearly, the security coefficient is much higher than this (probably in orders of magnitude) for depleted conditions where the pressure is around 1 bar, but no analysis exists to provide the actual value.

The design of the Eutelsat 36B spacecraft, fully consistent with EOL passivation requirements as existed at the time of construction, does not allow passive venting once the spacecraft has been switched-off. The thruster propellant flow control valves for the MMH and MON1 tanks are left closed after switching off the spacecraft because power is needed to open them. Therefore, none of the elements that appear on the previous Table can be vented over time once the spacecraft has been switched-off. Nevertheless, as part of the passivation of the spacecraft during the EOL operations, Eutelsat always makes best efforts to vent the propellant remaining in the propellant tanks and lines as much as possible.

Additionally, it should be noted that the Lithium-Ion batteries mounted on this satellite cannot be depressurized. Nevertheless, they have been designed with a security coefficient greater than 3 and the batteries are “leak before burst” designed. The heatpipes, which use ammonia as working fluid, cannot be depressurized either. They have been designed with a security coefficient greater than 4, the risk of break-up is considered negligible.

B. Leaving all batteries in a state of permanent discharge by isolation of the battery charge circuits and leaving certain loads connected to the batteries.

3. The satellite tracking, TM and TC usage are planned so as to avoid electrical interference to other satellites and coordinated with any potential affected satellite networks.

4. During the orbit raising maneuvers the tracking, TM and TC frequencies will be limited to those where the satellite is authorized to operate.

5. Notifications

EUTELSAT undertakes to provide the relevant bodies as required (UNCOPUOS, FCC, ITU, French ANFR, etc) with all appropriate notifications as required by law or regulations for Eutelsat satellites including but not limited to those concerning initial entry of service, location, relocations, inclined orbit operations and re-orbiting operations.