BSSI/Morelos Space Debris Mitigation Plan

(Prepared in support of Hughes Network Systems' application to the Federal Communications Commission for a license)

Contents

1. Introduction

This document describes the space debris mitigation plan for the Morelos-3 (Centenario) satellite to show compliance with the FCC's rules on orbital debris.[1] The Morelos-3 satellite is based on the Boeing 702HP bus. The satellite is 3-axis stabilized and uses bi-propellant chemical propulsion for attitude and on-station control. Morelos-3 is scheduled to launch in October 2015 and was designed for a 15-year service life.

2. Applicable Documents

1. NASA Technical Memorandum-4527, Natural Orbital Environment Guidelines for use in Aerospace Vehicle Development, Marshall Space Flight Center, June 1994
2. IADC Space Debris Mitigation Guidelines. IADC-02-01. Revision 1. September 2007

3. Morelos-3 Design

The satellite is designed to ensure that debris generation will not result from the conversion of energy sources on board the satellite into energy that fragments the satellite. The propulsion subsystem pressure vessels are designed with high safety margins.

Boeing has completed the assessment of the launch, orbit raising, deployment and normal operations of the mission and determined that the probability of the satellite (units/subsystems) becoming a source of debris caused by the micrometeoroid and orbital debris environment is limited/negligible and meets or exceeds their respective failure specification.

The impacts of micrometeoroid and orbital debris on the spacecraft have been analyzed. The analysis includes the impact of debris of all components not blanketed or protected by the spacecraft structure, including the T&C antenna assemblies. The environments considered were the Grun micrometeoroid model, as described in NASA TM-4527, plus man-made orbital debris during transfer through low-Earth orbit.

The Morelos-3 design meets micrometeoroid and orbital debris requirements.

In addition, the propulsion system of the Morelos-3 spacecraft is designed to mitigate explosions as it has been assessed for loaded and pressurized on-orbit conditions.

All tanks are designed to a minimum burst factor of safety of 1.25 x MEOP (Maximum Expected Operating Pressure).

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[1] *See* 47 C.F.R §§ 25.114(d)(14), 25.283, 5.64 (special provisions for experimental authorizations for satellite systems).

The explosive material in the valves is contained within a hermetically sealed capsule within the valve body, which is also hermetically sealed.

After the propellant is loaded onto the spacecraft, and throughout the entire on-orbit service life of the mission, propellant compatibility with wetted materials has been assessed.

4. Morelos-3 Operations

The Morelos-3 customer-designated orbital location is 113.1 degrees W.L. Morelos-3 is designed to be operated in an inclined orbit with a requirement to maintain the designated longitude within +/- 0.05 degrees of the required orbital location whenever the satellite's inclination is within +/- 0.05 degrees in latitude from the equator. The nearest known or planned geostationary satellite (satellite operating at zero degree inclination) is Eutelsat at 113.0 degree W.L-1.

By locating the Morelos-3 satellite at 113.1° W.L. and maintaining an east-west station-keeping tolerance of ±0.05 degrees when the spacecraft's inclination is within +/- 0.05° in latitude of the equator, there should be no overlap of station-keeping volume with Eutelsat at 113.0 degree W.L-1, provided Eutelsat maintains its east-west station keeping of+/- 0.05 degrees per publicly available information.

There are no pending applications before the Commission for an additional satellite to be located at an orbital location in the immediate vicinity of 113.1° W.L.

With regard to ITU filings within ±0.15 degrees of 113° W.L., the ITU has published requests for coordination for the following non-Mexican FSS networks:

- CAN-BSS53 (113W)
- CANSAT(113W)-XKA
- GIBSAT-113W
- GIBSAT-G12-1
- UK-KA-9
- RAGGIANA-19
- RAGGIANA-6
- INTERSPUTNIK-113W

There is no evidence publicly available that any of these networks are under construction.

5. Morelos-3 End of Life Disposal

The Morelos-3 spacecraft will be delivered to Boeing's customer, The Ministry of Communications and Transportation on behalf of the Mexican Government, as will the procedure for end of life disposal. The procedure includes the following:

- The batteries will be discharged upon completing their authorized mission.
- The end of life shutdown Recommended Operating Procedures (ROPs) consist of an orderly process of turning off the payload, relocating to the final orbit (de-orbit), depleting remaining propellant, and shutting down the spacecraft. The satellite is not designed to re-enter the earth as it is designed to be deorbited at the end of life.
- Barring catastrophic failure of satellite components, at the end of its useful life, the Morelos-3 spacecraft is designed to provide relocation to an orbit with a minimum perigee height to avoid re-entering into the GEO protected region. This minimum height is computed using the IADC formula applied to this satellite:

  $$\Delta H \text{ (km)} = 235 + 1000*(C/R * A/m) = 279 \text{ km above GEO}$$

  Where:

  - CR = 1.175, is the solar pressure radiation coefficient of the spacecraft,
  - A/m = 116.5 m^2, is the Area to mass ratio, in square meters per kilogram.
- The propellant budget includes a propellant allocation to de-orbit the satellite 300 km from the geosynchronous altitude
- The Morelos-specific Recommended Operating Procedures (ROPs) document the procedure for de-orbiting the spacecraft to the required altitude and configuring the spacecraft after the maneuvers.