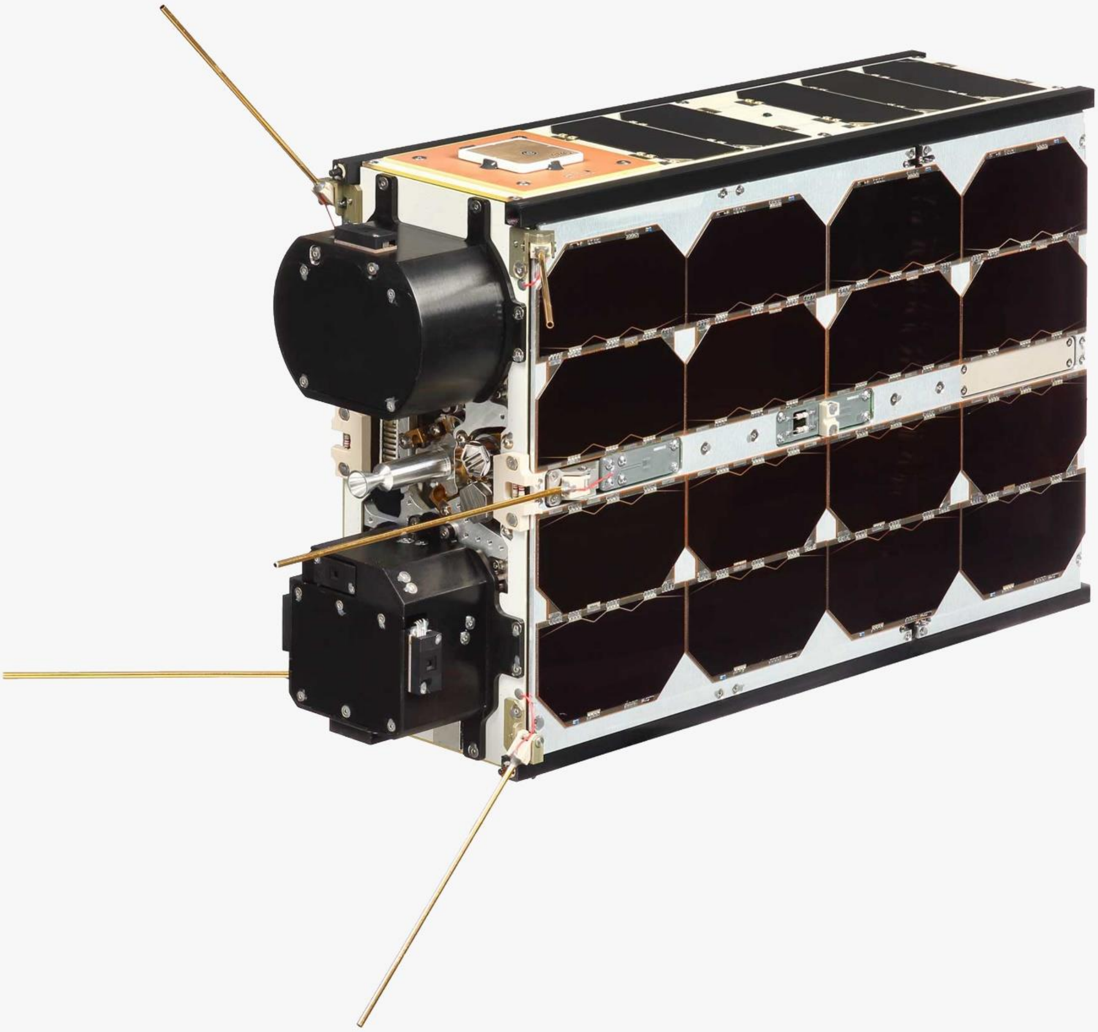

BW 1 Space Debris Mitigation Document

Technical Information Summary

NA-M6P-GO-R26

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1 Introduction

This document aims to describe the measures, verification methods and possible implementations to be taken in order to reduce the probability of fragmentation events and collisions, and minimize the probability of hazard occurrence in orbit and in case of re-entry as described in ECSS-Q-40B document for the BW 1 platform. This document was prepared by NanoAvionics by following ESA Space Debris Compliance Verification Guidelines.

2 Scope of the Document

This document provides information on how the ESA Space Debris Requirements are met by BW 1 satellite.

3 Reference Documents

1. *Launch Information PSLV*
2. *ESA Space Debris Mitigation Compliance Verification Guidelines*

4 BW 1 Platform Summary

The mission of BW 1 platform is to safely and cost efficiently launch the satellite into its orbit and to operate there with integrated customers payload.

Standard configuration of the platform hardware layout allows the maximization of volume available for the payload and ensures robust power properties and thermal control for sensitive payloads, such as measurement and remote sensing instruments. To ensure the practical reliability of the platform, radiation-resistant components and design implementations are involved to support critical systems such as the Flight Computer, Payload Controller, Electric Power System and Communication System.

The BW 1 platform is split into following subsystems:

- **Electrical Power Supply (EPS)**: the system that delivers the power to all other subsystems as regulated power on individual channels. These channels are also monitored and turned on/off by the EPS. The EPS also controls the satellite operational modes.
- **Communications (COM)**: the COM subsystem takes care of communication with earth over UHF-based radio link. The system is able to send and receive telemetry data and establish a two way communication with the ground station
- **Flight Computer (FC)**: this system is responsible for system level services such as mission planning, telemetry logging, power management and payload control. Additionally it provides power and data interface to other subsystems, as well as performs automatic or manual thermal control.
- **Payload Controller (PC)**: provides an interface with the other subsystems and allows to monitor and control the payload.
- **Structure**: responsible for the overall structure of the platform. This includes subsystem placement and fastening, deployables and material selection.
- **Solar Panels (SP)**: the solar panels are used to charge the batteries, which helps to ensure safe operating conditions even in the eclipse.
- **Attitude Determination and Control Subsystem (ADCS)**: this system is responsible for detumbling the satellite as well as provides accuracy and stability of the satellite, payload and antennas. This is done by the use of various sensors and actuators.
- **S-Band**: is also used for communication.

5 Procured Launch Service Description

NanoAvionics will use the offer for a piggyback-launch opportunity to Low Earth Orbit (LEO) with the Indian Polar Satellite Launch Vehicle (PSLV) as a main option due to its favorable conditions. All the technical information about the launch vehicle can be found in *Launch Information PSLV* document.

6 Space Debris Requirements

The space debris requirements will be met by verification methods, which include test, analysis, review-of-design and inspection. Debris Assessment Software (DAS) was used in order to analyse the change in the satellites orbit due to natural decay as well as to see if the orbit debris requirements are met. Atmospheric drag, solar and lunar gravity, solar radiation pressure, and Earth's gravity field with Zonal harmonics (J2, J3 and J4) are the perturbations included in the DAS orbit propagator. The atmospheric model used in DAS was the Jachia 1976 Standard Model. The coefficient of drag is assumed to be 2.2 and coefficient of reflectivity is assumed to be 1.25.

7 Space Debris Mitigation Implementation and Verification

7.1 Space System Mission-Related Objects (MROs)

The requirement aims at limiting the spacecraft Mission-Related Objects (MROs), larger than 1 mm, which can be intentionally separated or unintentionally released during the launch and operational phases. The requirement aims as well at limiting the risk of collision of MROs with the parent space system or any other operating space system since most of these mission-related objects are released with low relative velocity and, therefore, remain in close proximity to the operational orbit of the parent body.

7.1.1 Mitigation Measures

The BW 1 was designed such that there are no unintentional MROs released. This was done by choosing materials and system technologies that are able to withstand the environmental degradation, before atmospheric re-entry.

7.2 Space System Fragmentation and Explosion Risk

This section covers all potential causes of break-up during deployment and mission operations.

7.2.1 Mitigation Measure

To minimize and eliminate the presence of MROs in LEO the BW 1 was designed in such a way that no MROs are released during the satellite deployment or mission operations.

7.3 Space System Small Particles Release

The requirement aims at preventing the release of randomly dispersed small particles (> 1 mm) in Earth orbit. These particles, although small, can damage operational space systems.

7.3.1 Mitigation Measures

The BW 1 satellite has four burn out wires used in its design:

1. Latcher burnout wire
2. Two splitter burnout wires
3. 5th antenna burnout wire

To eliminate the release of small particles, the wires are secured in such a way, that when they are burned, they are not released to the outer space or to the inside the system, rather the wires are tied down to the subsystems to ensure that they are not released.

7.4 Space System On-Orbit Collision Risk Assessment

NASA DAS software was used in order to assess on-orbit collision risk. For each spacecraft and launch vehicle orbital stage in or passing through LEO, the program or project shall demonstrate that, during the orbital lifetime of each spacecraft and orbital stage, the probability of accidental collision with space objects larger than 10 cm in diameter is less than 0.001.

DAS software showed that for the BW 1 satellite, this probability is less than 0.001.

7.5 Space System Disposal

The BW 1 satellite will naturally decay to the Earth's atmosphere within 25 years. This analysis was carried out using DAS software with the following parameters:

- Orbit altitude: 505 km
- Inclination: 97.42 degrees
- Area-to-Mass ratio: 0.0039
- Launch date: 1st of April 2019

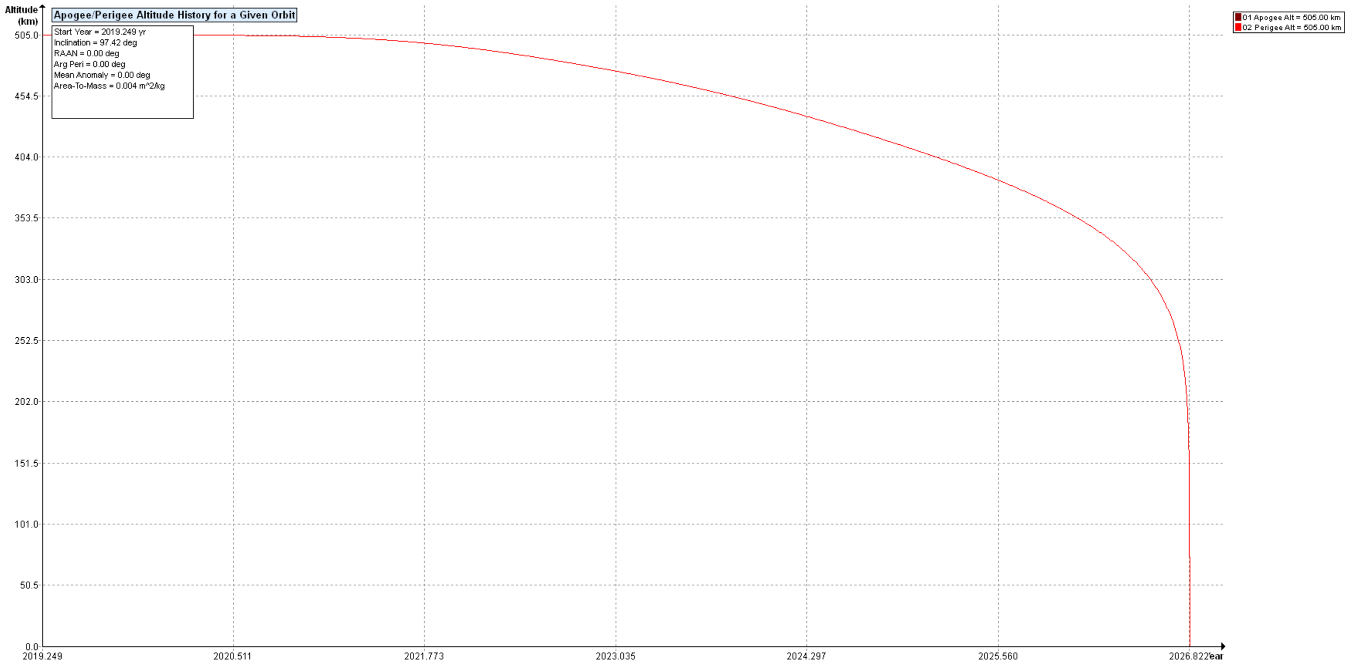

Figure 1. Apogee/Perigee Altitude History for a BW 1 Orbit

The analysis showed that the lifetime of the BW 1 mission is 7.9 years, hence the satellite will de-orbit naturally.

7.6 Space System Passivation

The requirement aims at preventing accidental break-ups of the space system in Earth orbit after the completion of its mission operations and post-mission disposal by depleting energy or making safe all on-board sources of energy.

7.6.1 Mitigation Measure

Mitigation measure to minimize risk related to store energy after the disposal phase are summarized in Annex E, *ESA Space Debris Mitigation Compliance Verification Guidelines* document.

7.7 Space System Re-Entry

This requirement addresses with a maximum risk figure each spacecraft, launch vehicle stage, and MRO, which can re-enter in controlled or uncontrolled way, the casualty risk shall not exceed 1 in 10000 for any re-entry event (controlled or uncontrolled).

7.7.1 Mitigation Measure

The BW 1 was designed to ensure that all the components and materials can demise during re-entry. What is more an analysis was carried out on DAS software which confirmed that the risk does not exceed 1 in 10000.

7.8 Space System Hazardous Materials

BW 1 contains no hazardous materials.