Axelspace Green Spacecraft Standard 1.0

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Revision history

Date	Revision	Updates
2023-06-05	1.0	Initial release

1. Introduction

With the increasing utilization of space through satellite constellations, it is predicted that a wide variety of satellites will be mass-produced and launched more frequently worldwide in the future. Under these circumstances, as a company involved in spacecraft development, manufacturing, and operation, Axelspace believes the following two sustainability initiatives are crucial to undertake.

For Sustainable Earth

Although little attention has been paid to the space sector in the past, with the advent of the era of satellite mass production, it is necessary to work on reducing the burden on the global environment during the satellite development, manufacturing, and testing phases on the ground, just as in other industries. Axelspace has developed guidelines for sustainable manufacturing practices during the development, manufacturing, and testing phases on the ground through discussions with partner companies in the Spacecraft Manufacturing Alliance who have expertise in manufacturing sustainability in other industry sectors.

For Sustainable Space

In addition to the accumulation of space debris since the dawn of space exploration, there are concerns about the further deterioration of the orbital environment, including the increased risk of collisions due to orbital congestion caused by the emergence of mega-constellations. Guidelines for debris mitigation have been established by the United Nations Office for Outer Space Affairs, IADC, and ISO, but it is up to satellite developers and operators to determine how to achieve the established goals. Under these circumstances, Axelspace endorsed the Space Sustainability Rating (SSR) initiative, in which the Space Center (eSpace) of the Swiss Federal Institute of Technology Lausanne (EPFL) serves as the operating agency to quantify and rate the impact of satellite operators' missions on the space environment. We participated in the SSR beta test program to provide feedback to the rating system from the perspective of satellite developers and operators, and developed guidelines for space sustainable design and operation.

This Green Spacecraft Standard establishes best practices that satellite developers and operators can implement specifically for sustainability of both the terrestrial and space environments throughout

the entire life cycle of a spacecraft, from ground-based design and development to in-orbit disposal. This standard will be updated from time to time to reflect the space community's rule making, research results, and technological innovations.

1.1. Acronyms

Acronyms	Stands for	Meaning
COLA	Collision Avoidance	Operation to avoid collision with space debris or other active spacecrafts.
IADC	Inter-Agency Space Debris Coordination Committee	Committee of space debris experts from national space agencies around the world.
ISO	International Organization for Standardization	International organization for making industrial standards.
PMD	Post-Mission Disposal	De-orbiting operation after mission completion to dispose spacecrafts by atmospheric reentry or moving to graveyard orbit.
SSA	Space Situational Awareness	Activities to monitor orbital environment such as detection of space objects, orbit determination, maintaining a space object database, and collision risk evaluation.
SSR	Space Sustainability Rating	Rating system proposed by World Economic Forum to assess spacecraft developers and operators in terms of space sustainability.
UNOOSA	United Nations Office for Outer Space Affairs	UNOOSA manages international cooperation for peaceful space utilization.

2. For Sustainable Earth

Axelspace and the Spacecraft Manufacturing Alliance's initiative to work towards global environmental sustainability during the development, manufacturing, and testing phases of spacecrafts is established in the Green Spacecraft Manufacturing Guidelines. This chapter describes the abstract of the guidelines.

2.1. Green Procurement

Regarding the procurement of products, semi-processed products, parts, raw materials, auxiliary materials, packaging materials, packing materials, etc. for satellite development, manufacturing, and testing, we will:

- Select items that have minimal environmental impact and do not contain prohibited hazardous chemicals
- Select supplier companies that are committed to environmental protection and chemical substance management

2.2. Green Manufacturing & Testing

To reduce the environmental impact of the satellite manufacturing process including procurement operations, delivery and inspection of procured products, satellite assembly, (environmental) testing of the satellite, and various supporting processes, we will implement the following initiatives:

- Promote paperless practices
- Reduce power consumption during the manufacturing process
- Recycle materials during processing (metal materials, waste oil, etc.)
- Automate and streamline testing and inspection processes

2.3. Green Transportation

To reduce the use of accompanying materials and minimize waste during transportation within the development, manufacturing, and testing processes, we will implement the following initiatives:

- Standardize and reuse shipping containers
- Reduce and reuse accompanying materials during transportation
- Make efforts to reduce CO_2 emissions during transportation
- Reduce the use of GSE (Ground Support Equipment)

3. For Sustainable Space

As a result of humanity's past space activities, the presence of space debris, including objects like used rockets and satellites left in orbit, has become an extremely serious problem for the development and sustainability of the space business.

Axelspace's satellites are designed and operated with careful consideration for the orbital debris environment throughout their life cycle in space, from orbital deployment to disposal after operation.

3.1. Prevention of Debris Release

In the past, when the debris problem was not as apparent as it is today, there were instances where unnecessary objects such as protective covers for sensors and separation/deployment mechanisms were detached from satellites as debris. It is necessary to design satellites in a way that prevents the release of such objects as debris.

GS-STD-SS-01: Design the satellite in a way that prevents the release of debris objects (defined internationally as 1 mm or larger) from the satellite.

3.2. Post Mission Disposal (PMD)

If a satellite remains in orbit after it has been decommissioned, it will become debris and pose a collision risk to other satellites. In order to maintain a sustainable orbital environment for shared use by satellite operators, it is crucial to dispose of post-mission satellites in a timely and reliable manner.

GS-STD-SS-02: Orbit planning shall be performed so that a natural fall (atmospheric re-entry) occurs within 25 years from decommissioning.

GS-STD-SS-03: Equip the satellite with devices such as Drag Sail to achieve rapid deorbiting, reducing the deorbit time to within 5 years during disposal operations.

GS-STD-SS-04: To ensure that PMD is properly executed, prepare a disposal operation plan that specifies satellite telemetry to be monitored for PMD, criteria for suspending mission operations and shifting to PMD, criteria for extending the mission operation period, and procedures for implementing PMD.

3.3. Orbital Collision Avoidance (COLA: COLlision Avoidance) With Debris and Other Satellites

When a satellite collides with orbital debris or other operational satellites, it not only results in the loss of satellite functionality but also generates a large amount of debris, leading to further collision risks. To avoid this, it is necessary to detect the risk of approaching debris or other satellites and perform appropriate collision avoidance operations.

GS-STD-SS-05: For accurate collision risk assessment, maintain and update orbit determination information based on the satellite's positional data throughout the operational phase, ensuring higher precision than NORAD TLE.

GS-STD-SS-06: Establish a collision avoidance operation plan that defines the procedures to screen, evaluate, and perform collision avoidance maneuvers in response to collision risk alerts.

GS-STD-SS-07: Using the latest orbital object distribution model, estimate the frequency of collision avoidance maneuvers during the operational and PMD phases and incorporate them into the satellite propulsion system requirement specifications.

GS-STD-SS-08: Confirm that maneuver plans (not limited to collision avoidance operations) of our managed satellites do not create a collision risk with debris or other satellites (Perform COLA analysis).

3.4. Collaboration With SSA Agencies and Other Satellite Operators

For collision risk assessment and appropriate collision avoidance operations, it is important to cooperate and collaborate with SSA agencies (e.g. Space Track) and other satellite operators with whom there is a collision risk.

GS-STD-SS-09: Establish a communication protocol and provide our contact information to SSA agencies like Space Track so that other satellite operators at risk of collision with our managed satellites can contact us.

GS-STD-SS-10: Disclose to SSA agencies and other operators Ephemeris information and maneuver plans of our managed satellites up to 7 days ahead based on high-precision orbit determination.

GS-STD-SS-11: Provide SSA agencies with the necessary satellite information (mass, size, presence of orbit control capability, operational status, etc.) to assess collision risk.

3.5. Orbital Object Detection, Identification, and Tracking

The number of satellites launched into orbit on a single launch vehicle has increased significantly from previous years through methods like piggybacking, ridesharing, etc., making it more important than ever for SSA agencies to quickly identify which satellite corresponds to detected objects in orbit.

GS-STD-SS-12: Notify SSA agencies in advance about satellites scheduled for deployment and provide their orbital information prior to launch.

GS-STD-SS-13: During initial operations, we shall promptly notify the SSA agencies as soon as we are able to identify the COSPAR ID of our satellites.

3.6. Third Party Review

Ensure transparency of the above efforts for orbital sustainability by obtaining an objective evaluation of their effectiveness by a third party.

GS-STD-SS-14: Receive an evaluation of our orbital sustainability efforts by an external organization such as SSR.