In collaboration with the
European Space Agency

WORLD ECONOMIC FORUM

Space Industry Debris Mitigation Recommendations

Future of Space Network - Sustainable Space Initiative, Centre for the Fourth Industrial Revolution

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Coordination and sustainable behaviour by stakeholders in the space industry is necessary for achieving a safe, inclusive and beneficial space environment for life on Earth. Through these recommendations, we advance the targets that we believe all space actors should collectively adhere to and promote. We believe this type of responsible behaviour is now critical to drive productivity in space while maintaining a high standard of sustainability and safety in the entire orbital region.

The challenge

Human-made space debris, lack of collision avoidance mechanisms, and insufficient coordination and data sharing between operators are just a few of the many factors that pose a threat to the evolving orbital regime and hence the entire space sector. Forecasts show that the space economy could reach $1 trillion per year by the next decade. However, in order to sustain this growth and enable a healthy environment in space and on Earth, it is critical that we address the growing risks associated with orbital debris and ensure an environment that will continue to encourage and support the tremendous innovation in space.

Space is critical for our modern way of life – internet connectivity, global positioning, financial transactions and satellite imagery are just a few examples of the ubiquitous applications of space technology. It is also an important tool for environmental monitoring, which is of vital necessity now more than ever, and we therefore need to protect this domain for the benefit of all humankind.

The solution

International regulatory frameworks relating to sustainability in space are generally voluntary and are mostly used as a reference point for space actors actively seeking to adhere to the latest standards of recommended behaviour in space. Examples of these include, but are not limited to, the Inter-Agency Space Debris Coordination Committee's Guidelines (2019 and its supplements), the United Nations Guidelines for the Long-term Sustainability of Outer Space Activities and the ISO 24113:2023. More recently, private actors have led the charge in the development of some candidate best practices to support the long-term sustainability of the space environment, recognizing the need for well-understood operational norms, safety standards and responsible behaviours that allow all operators to prosper. The goal of these Space Industry Debris Mitigation Recommendations is to complement existing best practices and recommendations to set an ambitious but realistic target for behaviour in orbit by a group of progressive industry actors who are focused on sustainable development of the sector. Discrepancies with existing or suggested practices stem from this document's focus on targets for behaviour and goals to which the community should aspire. These recommendations will also help support the creation of a level playing field in the sector, which all industry actors regard as a necessary condition for its continued development.

As signatories to this document, we believe in setting ambitious yet sensible best practices to mitigate the risks posed to the orbital regime, particularly in the Low Earth Orbit.[1] There is a need to identify and refrain from activity that negatively impacts the Earth's orbits in the short and long term; we must take better care of our space assets, particularly when they approach the end of life and need to be responsibly disposed of. We must better communicate and share data about our missions to ensure transparency in operations, and finally, there is a need for Active Debris Removal (ADR) solutions to address the population of larger debris already in orbit.

We therefore commit to working with governments, civil society, commercial partners and industry peers to substantially reduce any unsustainable activity, such as new debris creation. We also call for new collaborations for transparency between operators.

The development of technologies and practices for each mission is a crucial step in the direction of sustainability and growth, specifically regarding mission disposal at end of life,

for removing existing debris already in orbit, and more. More sustainable practices such as these will also help create new business opportunities and develop entire markets. These are necessary steps in ensuring more responsible operations in space, which we all share. We encourage entities across the space sector to join us in this mission, to work together to inform and support the creation of practical regulations for the sustainable use of space.

The following recommendations have been carefully and thoughtfully assembled through various in-depth discussions with space actors:[2]

1 Post-mission disposal (PMD)

a. All spacecraft operators in LEO should strive for a PMD process that maintains a success rate of **95-99%** or above.[3]

b. All spacecraft operators should strive for a target of **five years** or below after end of life for removal of spacecraft from LEO.

c. Recognizing existing missions and long development plans, the above targets should be applied progressively to new missions from **2023** with the aim of putting them into full effect by **2025**.

d. In case of inability to maintain control during a spacecraft's PMD de-orbit process, other proven, reliable and cost-effective technologies should be considered.[4] This is particularly critical for missions operating at and above **375km** altitude.[5]

e. Spacecraft designs could consider applying additional technologies and measures to facilitate emergency disposal.

2 Collision avoidance, manoeuvrability and propulsion

a. All spacecraft operators should strive to limit their satellites' collision probability with other satellites and trackable space debris through the application of appropriate means in an effective and timely way. They should strive to maintain the ability of their spacecraft to perform timely collision avoidance manoeuvres or limit collision probability at all times while operating above **375km**.

b. Active manoeuvrability or the ability to actively manage an orbit should exist on missions with an altitude of **375km** or higher. As a principle, propulsion is encouraged, though other effective methods to manoeuvre smaller spacecraft or reduce collision probability at lower altitudes may be more appropriate to ensure timely collision probability reduction.

c. Operators will ensure they possess the capability of collision avoidance throughout the entirety of their mission lifetime (including de-orbit).

3 Data sharing and traffic management in orbit

a. All spacecraft operators must answer all reasonable and legitimate requests for space traffic management coordination, with other operators or established entities, in a timely manner.

b. All spacecraft operators should seek to proactively coordinate with other operators and established entities to facilitate operational coordination agreements and space situational awareness information-sharing. Such information should include, at a minimum, operator points-of-contact, ephemerides, ability to manoeuvre, and manoeuvre plans.

c. Operators must make data generally available and provide its appropriate and timely communication (as per 3b), in recognized and standard formats. This is important even if there is no ability to manoeuvre.

d. Operators should consider applicability and relevance of an autonomously operating system for their constellation, with the capacity to inform other missions with the appropriate data and some type of clearance. Efforts should be made to ensure, if such systems are implemented, that they are interoperable and are able to effectively communicate the required data with one another.

4 Financial measures

a. Third-party liability insurance organizations should consider incentives for sustainable missions, and appropriate safety measures should be implemented to allow for a healthy standard.

   i. Space Sustainability Rating (SSR)[6] is one example of a metric to take into consideration.

b. Appropriate financial measures including insurance mechanisms, cost-sharing schemes and others should be considered.

c. Financial measures should not impose an unreasonable burden on space operators and should not disrupt competition in the commercial space sector. Such measures should have the primary goal of incentivizing operators to avoid the creation of hazardous space debris.

Longer-term goals and requests of policy-makers

5 Environmental capacity

a. Industry actors encourage the further study of the environmental capacity topic, so as to ensure that the overall population of objects in orbit – active and inactive – its evolution, and the interaction between objects, are well understood; this is especially true as this population will continue to increase along with improved space situational awareness capabilities.

6 Responsibilities of governments

a. While the primary focus of this document is on outlining recommendations that the industry can subscribe to in order to maintain space sustainability, governments can also play a key role in sustainable space operations by enabling and leading by example. Some actions governments can undertake on this front include:

   i. By **2025**, governments should require that for missions launched as of **2030**, end of life equipment (including upper rocket stages) re-enter or be removed from LEO within **five years** or less; if objects become unresponsive or un-manoeuvrable and are not estimated to re-enter within **five years**, ADR services or alternative backup means of controlled post-mission disposal should be used, once adequately demonstrated to be practical and commercially affordable.

b. While ADR solutions and other backup means of ensuring successful PMD could play a role in enabling sustainable space operations, such systems have only initially begun to be demonstrated in space, and need to be proven effective, cost-effective, safe and secure. In order to continue exploring the development of ADR and other alternative backup methods to mitigate and remediate space debris, governments should continue to support the development of these technologies, with a focus on maturation, on both technical and financial bases.

c. Continued investments should be made into development of automated Space Situational Awareness.

d. Governments should encourage and incentivize further data sharing and coordination efforts for all spacecraft operators in orbit, including LEO, middle Earth orbit (MEO) and geostationary Earth orbit (GEO).

e. Governments should aim to coordinate, harmonize and publicly share their space legislation and regulation to support the creation of a level playing field.

f. Governments should encourage and incentivize the development and adoption of international standards.

Signatories

The undersigned space sector stakeholders endorse, promote and will strive to adhere to these “Space Industry Debris Mitigation Recommendations” published by the World Economic Forum.

- AIRBUS
- Akash Systems
- Astra
- Astranis
- Astroscale
- Avanti Communications
- Axiom Space
- ClearSpace
- D-Orbit
- EchoStar
- Exolaunch
- GHGSat
- GMV
- Honeywell
- Hydrosat
- NorthStar Earth & Space
- OneWeb
- OHB
- Planet
- SatSure
- SES
- Slingshot Aerospace
- Spire Global
- Thales Alenia Space
- The Aerospace Corporation
- The Exploration Company
- Voyager Space

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Endnotes

1. Low Earth Orbit (LEO) is categorized as being below 2000 km in altitude above Earth.
2. This statement uses ISO terminology. For any technical definitions, see https://www.iso.org/ics/49.140/x/.
3. For larger constellation LEO satellite systems, the PMD goal should be close to 99% or above.
4. As such systems and services become practical and affordable (e.g. ADR), all spacecraft operators should strive to implement backup means of performing disposal manoeuvres and maintaining collision avoidance capabilities during disposal, particularly if the primary spacecraft has failed. In some cases, a natural passive de-orbit of a stable object may be appropriate without any intervention but should be accompanied by full transparency and communication with the other operators concerned.
5. The 375km altitude was selected as below this, there are currently no planned human spaceflight facilities or major LEO satellite constellations.
6. The Space Sustainability Rating (SSR) provides a rating system informed by transparent, data-based assessments of the level of sustainability of space missions and operations: https://spacesustainabilityrating.org/.