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## Industry Implementation of the Long-Term Sustainability Guidelines: An Astroscale Perspective

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### Abstract

In 2010, the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) established a Long-term Sustainability (LTS) Working Group (WG) dedicated to developing a set of voluntary practices that members could adopt. The LTS WG deliberated for 8 years, developing 21 Guidelines and a preamble text. These guidelines are not only useful for state actors, but also for private industry as space congestion and orbital debris issues continue to grow, and as space operations become more complex. Indeed, the space industry has a responsibility to be engaged in the development of norms of behaviour in space. Industry implementation of the LTS guidelines, as well as developing and adhering to industry norms and standards will be necessary in order to grow successful businesses in space. Astroscale is involved in several efforts to set standards and norms but is also incorporating and implementing the LTS WG guidelines where applicable. This paper will highlight which LTS guidelines are most relevant for Astroscale's End of Life (EOL) and Active Debris Removal (ADR) services and provide concrete examples and plans for implementation. Finally, the paper will discuss additional industry guidelines on topics that were not covered by the LTS WG but are being deliberated through formal or informal and ad hoc groups.

This paper will provide an overview of the factors that will lead to the creation of a market for orbital debris removal in LEO – technology, regulations and business case – while highlighting the role that Astroscale is playing in each area.

Keywords: active debris removal, end-of-life, in-orbit servicing, space traffic management, policy

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### 1. Introduction

Never before have space activities benefited so many here on Earth. Growing access to broadband communications, widespread understanding of the planet's resources, and earlier warning of natural disasters are just a few examples of how satellites support a modern society. To emphasize this point, the United Nations Office of Outer Space Affairs (UN OOSA) has outlined how each of the 17 UN Sustainable Development Goals are supported through space activities [1]. Space has also become widely accessible. To date, over 60 nations have developed or operated space hardware. Approximately 2,000 operational satellites orbit the planet at this moment and an order of magnitude more are planned to launch in the next ten years.

Yet, there is a downside to this growth. Hundreds of thousands of pieces of debris greater than 1 cm have been generated over the past six decades of spaceflight and congestion of the orbits is becoming a significant concern. This issue is exacerbated by the fact that there are no internationally agreed upon rules on how to operate in a congested orbit, let alone how to reach out to another satellite operator to communicate an impending conjunction. The significance of the 21 Long-term Sustainability (LTS) voluntary guidelines, agreed to by the United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS) membership in June of 2018, is that they are a positive step forward to developing a global common understanding on what constitutes good orbital behavior [2].

While the 21 LTS guidelines are addressed to the member States for implementation, it is also incumbent upon private space operators to be good stewards of the space environment. In fact, the majority of active satellites in orbit today are operated by private space actors: academia, non-governmental organizations, and commercial entities [see figure 1]. This trend will continue over the next decade with thousands of satellites planned for launch. Investment in commercial space activities has also reached a record high in 2018, at \$3.2 Billion USD, meaning this trend of increasing space activity will continue [3]. The future makeup of earth's orbits will become commercial in nature, and therefore the commercial space community needs to support the forging of responsible behavior in space. States may choose to implement the 21 LTS guidelines through domestic legislation, policy, and regulation. However, private operators, as significant stakeholders in the long-term sustainability of space, can play a constructive role in developing best practices and norms that support the guidelines.

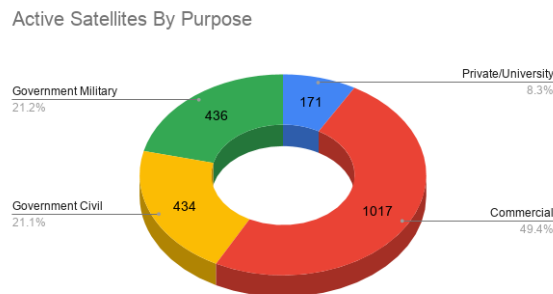


Figure 1: Active Satellites by Purpose as of May 2019  
Source: Union of Concerned Scientists

This paper will review the 21 LTS guidelines through a lens of a private satellite operator, Astroscale, outlining how the company views the guidelines aligning with its efforts to create a sustainable space environment through end-of-life services and active debris removal. Astroscale is also participating in several standards and best practices organizations which add definition to what it means to be a responsible space actor. These industry practices and standards groups similarly provide a method with which industry can implement the guidelines.

## 2. Industry Best Practices and Standards Groups

Astroscale supports the development of best practices and standards to ensure the long-term sustainability of space. This is currently being done through formal and informal dialogues. While there are several informal or ad hoc industry groups that can

be characterized as addressing elements of the 21 LTS guidelines, we will be focusing on two specific entities: Consortium for the Execution of Rendezvous and Servicing Operations (CONFERS) and the Space Safety Coalition (SSC). Voluntary practices stemming from these two groups can be shown to have similarities with specific LTS guidelines. A comparison of these practices with the 21 LTS guidelines will be discussed in Section 4.

### 2.1 CONFERS Guiding Principles and Recommended Design and Operational Practices

CONFERS is an industry-led initiative seeking to establish best practices and operations standards for rendezvous and proximity operations (RPO) and On-Orbit Servicing (OOS). While aimed at industry best practices, there is government, academic, and non-governmental organization representation through observer status. Astroscale is an executive member, having worked with other members to develop a set of Guiding Principles in 2018 and Recommended Design and Operational Practices in 2019 [4, 5]. Both documents are intended to be updated in order to reflect the changing nature of On-Orbit Servicing operations.

The key elements of the CONFERS Guiding Principles are:

- Consensual operations
- Compliance with relevant laws and regulations
- Responsible operations
- Transparent operations

The key elements of the CONFERS Recommended Design and Operational Practices are:

- Designing for mission success
- Designing satellites to facilitate safe and effective satellite servicing
- Designing servicing operations to minimize the risk and consequences of mishaps
- Avoiding physical or electro-magnetic interference during all phases of operations
- Sharing information on resolution of spacecraft anomalies/failures and related root cause analysis
- Promoting the long-term sustainability of space activities

### 2.2 Space Safety Coalition

SSC is an ad hoc coalition of companies, organizations, and other government and industry stakeholders that actively promote responsible space safety through the adoption of relevant international

standards, guidelines and practices, and the development of more effective space safety guidelines and best practices. Astroscale has endorsed SSC's recent Best Practices for the Sustainability of Space Operations that are meant to specifically address the UN COPUOS 21 LTS guidelines [6].

The key elements of the SSC Best Practices for the Sustainability of Space Operations are:

- Encouraging information relevant to safety-of-flight and collision avoidance
- Consider the sustainability of the space environment when selecting launch service providers
- Making safety a priority when designing architectures and operations concepts
- Designing spacecraft that adhere to specific operations practices
- Adopting space operations concepts that enhance the sustainability of the space environment

### 3. LTS Guideline Objectives

Before evaluating individual guidelines as they are reflected in private space activities, three objectives of the 21 LTS guidelines stand out as uniquely aligned with Astroscale's mission.

First and foremost, one objective of the guidelines is to ensure and enhance the long-term sustainability of outer space activities. Astroscale is fundamentally aligned with this objective in that its own mission is to "secure long-term spaceflight safety and orbital sustainability for the benefit of future generations" [7].

Another COPUOS LTS objective is to promote international cooperation and understanding to address natural and man-made hazards that could compromise operations. Educating governments, industry, and the public is a key component of Astroscale's outreach. Besides the dozens of events that Astroscale employees participate in each year, the company had a presence at the 2019 G20 Summit in Osaka, Japan, a first for a private company focused on space sustainability. The company's founder, Nobu Okada, also provided a technical presentation in June 2019 during the UN COPUOS plenary. By having a multinational presence through its Japan, United Kingdom, United States, and Singapore offices, Astroscale can more effectively communicate the issue of space debris with policy leaders and private space actors around the world.

Finally, the LTS objective of developing national and international practices and safety frameworks is precisely why Astroscale has put an emphasis on policy, regulation, best standards and practices. Each

of these pathways can advance norms of behavior in space, creating a more sustainable environment.

### 4. Evaluating Private Space Actor Implementation of the LTS Guidelines

While the voluntary guidelines are intended for member States, private space actors can still play a role in their implementation. Here, we assess the guidelines where commercial actors are playing an active role, demonstrating leadership in creating standards and practices for the long-term sustainability of space. Where applicable, Astroscale's current efforts will be highlighted.

Of the 21 LTS guidelines, at least six can be directly attributed to the commercial space community. In fact, some guidelines are currently in practice by the commercial sector or have been identified in industry standards and best practices. It is important to note that the guidelines selected are not the only ones that are implementable by private space actors. Besides the guidelines being evaluated here, there are several more where commercial space actors can support government's role to implement. Here, we discuss those guidelines that can be implemented quickly and align with industry-led practices and standards.

#### 4.1 Better Communication and Transparency

The following guidelines reflect an interest in more transparency with the purpose of avoiding misperceptions, building trust and making it easier to communicate, particularly to avoid conjunctions or collisions. The commercial space community, including Astroscale, is very active in developing practices that enhance communication across satellite operators.

##### B1: Provide updated contact information and share information on space objects and orbital events

The key elements of this guideline are to provide contact information of entities authorized to engage in exchanges with respect to on-orbit spacecraft operations, conjunction assessments and the monitoring of objects and events in outer space, ensuring the appropriate means to enable timely coordination, and ensure standardization in formatting. As a private entity-led example of information sharing, the Space Data Association (SDA) has been providing contact support and information regarding space objects and orbital events since 2009 [8].

CONFERS members additionally support the sharing of key orbital information through a guiding

principle of transparency in operations. From the CONFERS Guiding Principles, “The parties conducting the servicing operation will ensure sufficient communication and coordination with entities that could reasonably be affected by the servicing operation to support safety and avoid harmful interference”. Members will also ensure “timely public notification of anomalies or mishaps that could have an adverse impact on other entities or the space environment.”

The SSC similarly recommends data sharing amongst orbital operators. Specifically, the SSC Best Practices for Sustainability of Space Operations calls on operators to share points-of-contact, ephemerides, their ability to maneuver, and maneuver plans. SSC recommends operator-to-operator coordination, using space situational awareness or space traffic management entities.

Astroscale agrees that information sharing and transparency is essential to the understanding of orbital activities and prevention of collision. Astroscale will be receiving SSA information from ESA entities and is open to providing ephemeris to stakeholders in order to reduce the uncertainty of positional information. Astroscale will also proactively supply contact information to neighbors in similar orbits. Finally, Astroscale will be providing publicly available information on the mission, including that of planned maneuvers.

**B2: Improve accuracy of orbital data on space objects and enhance the practice and utility of sharing orbital information on space objects**

This guideline encourages States and International Intergovernmental Organizations to improve the accuracy of orbital data by using, for example, geographic distribution of sensor networks, on-orbit tracking aids, and a variety of sources of information. The commercial space community can and is playing a role in improving the accuracy of orbital data, and can help ensure the application of standard formatting of orbital information.

Private SSA capability, from academia or commercial sources, can also provide a rich set of data that is geographically and technically diverse. Like other aspects of data-sharing between multiple actors, the logistics of integration and validation of data present organizational, financial, and operational challenges. But the communal investment and risk-sharing enacted in collaborative SSA models allow for greater transparency between actors with regards to the processes and analysis informing their conjunction warning models and standards for risk thresholds. This in turn can build overall trust and expectations for increasing the “normalcy” of operations.

**C2: Share experience related to the long-term sustainability of outer space activities and develop new procedures, as appropriate, for information exchange**

This guideline encourages involvement of non-governmental entities in sharing experiences and expertise in space activities that contribute to the long-term sustainability of space. The CONFERS operating practices document serves as an example of sharing experiences of anomalies in order to reinforce safe practices for on-orbit servicing. Anomaly sharing is common in the aviation industry, which has led it to be the safest mode of transportation available. Specifically, the CONFERS practices call for:

- Developing and sharing best practices for the anomaly attribution processes within the servicing community
- Participating in the development of anomaly resolution standards and sharing frameworks
- Where possible, sharing information within the satellite servicing community on specific examples of anomaly resolution and attribution that could impact the community as a whole

Astroscale’s mission in 2020, End-of-Life Services by Astroscale Demonstration (ELSA-d) [14 – 16], will be the first end-to-end demonstration including elements of rendezvous, proximity operations, guidance and navigation, attachment, and de-orbiting. This will provide an opportunity to share lessons learned with CONFERS membership. Astroscale will also be sharing relevant information of the demonstration mission with the international community in order to provide input into on-going dialogue of active debris removal as a key component of long-term sustainability of space.

**C4: Raise awareness of space activities**

The commercial space community is eager to increase awareness of the innovative technologies and activities occurring in space as well as end user benefits. Astroscale is an active participant in many fora and groups around the world that promote the education of the value of space activities and in particular, on-orbit servicing, debris removal and the long-term sustainability of space.

Below is just a sampling of the more than 60 outreach opportunities to date in 2019 alone in which Astroscale had an opportunity to share how it is contributing to the long-term sustainability of space through debris removal:

- The inaugural Summit for Space Sustainability, sponsored by the Secure World Foundation, was held in June 2019. Astroscale was featured prominently on the Space Traffic Management panel, offering both policy and industry practices recommendations that will support spaceflight safety.
- The second annual Global Satellite Servicing Forum (GSSF) was held in October 2019 in Washington, DC, where Astroscale provided insights into the business imperative of debris removal activities and how the commercial community can provide a positive impact in mitigating space debris.
- The UK Space Conference in Cardiff, Wales in October 2019 had several examples of Astroscale outreach as employees provided insights regarding on-orbit servicing, orbital sustainability, and investment interests in new space activities.
- An abundance of outreach is performed in Japan regarding the topic of space sustainability. Astroscale was a participant in NHK World, Japan's only public broadcaster, and awarded as first prize for the Start-up of the Year in 2019 by Forbes Japan. Supporting diversity in the space industry is also championed by Astroscale, having participated in the International Conference for Women in Business.

Astroscale recognizes that Governments have similarly supported outreach of commercial entities to the public and stakeholders on maintaining space as a safe environment within which to operate. Astroscale's founder and CEO Nobu Okada was invited by the Government of Japan to provide a technical presentation of debris removal activities during the UN COPUOS plenary in June 2019. Discussing non-governmental and commercial activities in space at COPUOS meetings helps reinforce the efforts that industry is taking towards peaceful uses of outer space. The U.S. Government similarly invited Astroscale U.S. President and Managing Director, Ron Lopez, to address the Space Enterprise Forum, co-hosted by the Department of State and Department of Commerce in July 2019. The event reinforced the message that a growing global space economy is anchored by space sustainability, permissive regulation, and commercial innovation.

#### 4.2 Behavior and Technology

The following guidelines focus on technologies and behaviors of space operators for the purpose of creating a safe space flight environment. Due to

industry efforts in the development of best practices and standards for long-term sustainability, there are now concrete examples of the following guidelines being implemented by commercial space operators. Additionally, the recent Notice of Proposed Rulemaking by the U.S. Federal Communication Commission (FCC) on Orbital Debris Mitigation and the Request for Information by the U.S. Department of Commerce have revealed industry preferences with regards to the technologies and behaviors required to maintain a safe orbital environment [9, 10].

#### B8: Design and operation of space objects regardless of their physical and operational characteristics

This guideline encourages the trackability of space objects as well as consideration of end-of-life disposal according to international or national debris mitigation guidelines.

Here, Astroscale has been vocal in recommending specifics for trackability, identification, and end-of-life procedures. Astroscale, along with seven other space companies, made recommendations to the Federal Communication Commission (FCC) regarding orbital debris mitigation regulation in April 2019. Within, the Global NewSpace Operators recommended that satellite operators express to regulators how their systems may be tracked and provide unique identification of their spacecraft [9]. The Global Newspace Operators also suggested that satellite operators achieve a minimum of 95% post-mission disposal reliability for large constellations, a level that may be able to stave off an out-of-control risk profile of orbits littered with debris.

The SSC Best Practices echo these recommendations. Within, the practices state that, "Spacecraft should be designed to be reliably trackable from the ground using passive tracking means". The practices also mention, "Spacecraft with limited observability should include features that enhance visibility". The document continues in its best practices that operators "consider including technologies and features that facilitate capture and deorbit in the event that the spacecraft becomes derelict". Astroscale endorses and recommends operators employing back-up deorbit mechanisms in the event a satellite goes defunct in orbit.

#### D2: Investigate and consider new measures to manage the space debris population in the long term

This guideline encourages the development of new measures including technological solutions to manage space debris including extension of lifetime, prevention of collision, passivation techniques, and post-mission disposal.



The SSC outlines several practices with which to address this guideline including consideration of constellation architectures using radial separation, automation in maintaining collision risk, and extending the time available to avoid collision with defunct spacecraft are recommended.

Astroscale's comment into the Department of Commerce Request for Information regarding SSA and STM also discusses recommendations for government to address management of space debris [10]. Within, Astroscale argues that a post-mission lifetime of 25 years is no longer sustainable given the number of satellites expected to reach orbit in the next decade. Additionally, deployable backup deorbit systems and debris removal technologies are encouraged for inclusion in debris mitigation strategies.

## 5. Summary

The commercial space industry are stakeholders in ensuring the long-term sustainability of space to enable growth in the sector and continue to bring an abundance of benefits to society. The Long-term Sustainability voluntary guidelines, agreed to by the United Nations Committee on the Peaceful Uses of Outer Space, are a strong step forward in reaching common global understanding of what is needed to sustain the space environment, contain items that can be implemented by commercial actors or where commercial actors are already adhering to these guidelines. Additionally, through collaborative fora such as CONFERS and the SSC, Astroscale has been a leader in the establishment and implementation of standards and best practices for the safety and sustainability of commercial operations in space. A primary task of these collaborative fora has been the industry implementation of the 21 LTS Guidelines.

Astroscale has worked to implement, incentivize, and normalize the guidelines that consider enhanced communication and behavior or design features such as: improving the accuracy of orbital data on space objects and enhancing the practice and utility of sharing orbital information on space objects, sharing experience related to the long-term sustainability of outer space activities, developing new procedures, as appropriate, for information exchange, raising awareness of space activities, and investigating new measures to manage the space debris population in the long term. Within fora such as CONFERS and SSC as well as through direct communication with governments to keep them aware of state of the industry through public comments, Astroscale has participated in the development of best practices and has taken an active role in demonstrating leadership in

creating commercial standards for the long-term sustainability of the outer space environment.

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