UNITED NATIONS
Office for Outer Space Affairs

Promoting Space Sustainability

[On-orbit servicing]

[Astroscale]

[11 Jun 2021]

Implementation of the Guidelines for the Long-term Sustainability (LTS) of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space

Operational Case Studies

[Operational case studies are drafted by the submitting entity in their own words using the following template. Please avoid using national jargon and spell out acronyms to assist readers from other jurisdictions. All case studies will be made publicly available to facilitate peer-to-peer exchange, share experiences and raise awareness.]

I. Short description of the outer space activity [*1000-word max.*]

[Include any relevant background or technical information that may be helpful.]

Astroscale is the first private company with a vision to secure the safe and sustainable development of space for the benefit of future generations, and the only company dedicated to on-orbit servicing across all orbits – from low Earth orbit (LEO) to the geostationary orbit (GEO).

Founded in 2013, Astroscale is developing innovative and scalable solutions across the spectrum of on-orbit servicing missions, including Life Extension, *In situ* Space Situational Awareness, End-of-Life services, and Active Debris Removal, to create sustainable space systems and mitigate the growing and hazardous build-up of debris in space. Astroscale is also defining business cases and working with government and commercial stakeholders to develop norms, regulations, and incentives for the responsible use of space. Headquartered in Japan, Astroscale has an international presence with subsidiaries in the United Kingdom, the United States, Israel, and Singapore. Astroscale is a rapidly expanding venture company, working to advance safe and sustainable growth in space and solve a growing environmental concern.

Astroscale is actively progressing the following space projects in this domain.

a) The ELSA-d (End-of-Life Services by Astroscale-demonstration) satellite system, which launched in March 2021, is the world's first commercial space mission to demonstrate the core technologies and capabilities necessary for space debris docking and removal. ELSA-d consists of two spacecraft: a servicer satellite (~175kg) and a client satellite (~17kg), launched stacked together. The servicer satellite has been developed to safely remove debris objects from orbit, equipped with proximity rendezvous technologies and a magnetic docking mechanism. The client satellite is

a piece of replica debris, fitted with a ferromagnetic plate that enables docking with the servicer.

Overall, the Concept of Operations (ConOps) for ELSA-d is designed so that each demonstration of rendezvous and proximity operations can be tested in a step-by-step manner, with each phase gradually increasing in complexity. For example, before a demonstration of tumbling docking is attempted, a non-tumbling docking will be attempted, which requires the client to hold a set orientation.

Decreased launch and satellite development costs, an increasing global dependence on data from space, and the rise of large commercial satellite constellations have led to a rapidly increasing population of objects in LEO. This growing use of space brings significant benefits to society, but also greatly increases the threat of collision or break-up. This growing potential for additional debris creation endangers current and future satellite missions and puts society's reliance on data from space at risk. ELSA-d will demonstrate a valuable service by safely demonstrating capabilities needed to remove defunct satellites from orbit to maintain the viability of LEO.

b) ELSA-M is Astroscale's next generation servicer, evolving heritage from the ELSA-d programme and designed for removal of commercial constellation LEO satellites. ELSA-M has been in development for over three years working jointly with OneWeb and the European Space Agency (ESA), and funded under ESA-OneWeb Project Sunrise. ELSA-M (where "M" stands for multi-client) enables multiple space debris assets to be removed sequentially – it is a key driver of space sustainability, as it enables space to be cleaned up more efficiently than single removal vehicles, and it specifically addresses the large number of constellation satellites being launched in the upcoming years, of which there will be failures or the inability to de-orbit. ELSA-M also has electric propulsion to enable more efficient orbital transfers and will have advanced collision avoidance capabilities on-board – an important part of space traffic management that ensures satellites can operate sustainably in this more congested future environment. The first ELSA-M space mission is presently planned to be launched by 2024

c) The Japan Aerospace Exploration Agency's (JAXA) Commercial Removal of Debris Demonstration (CRD2) project, Phase 1, is the first of an anticipated two-phase mission to perform the world's first removal of a multi-ton debris object. For the first phase, JAXA has selected Astroscale to send its Active Debris Removal by Astroscale (ADRAS-J) spacecraft into orbit to inspect a discarded Japanese rocket upper stage. This step paves the way for a subsequent debris-removal mission to remove the rocket upper stage. This first phase is presently planned to be demonstrated in 2023 and will focus on data acquisition on an upper stage Japanese rocket body. Astroscale will be responsible for the manufacturing, launch and operations of the satellite that will characterize the rocket body, acquiring and delivering movement observational data to better understand the debris environment. JAXA has announced plans for the second phase, but no proposal has yet been released.

d) Geostationary-orbit (GEO) satellites are a critical part of the telecommunications, navigation, and national security space infrastructure. However, the cost to deploy a single GEO satellite can reach over US$1 billion, underscoring the value of capabilities to inspect, rendezvous with, and extend the lifetimes of such satellites rather than incur the high costs of replacing them. On-orbit servicing presents a robust and compelling set of value propositions to GEO satellite operators, with independent valuations estimating that life extension and other on-orbit satellite services will generate more than $4 billion in revenues by 2028. As GEO satellite operators face an increasingly competitive environment and evolving end-user demands, solving the challenge of optimizing asset & fleet utilization is more critical than ever. Yet the solutions in use today remain limited. Astroscale's LEXI – Life Extension Services In-orbit – is a robust and cost-effective solution that opens a range of new choices and enhanced flexibility for fleet management. Astroscale plans to deploy its first LEXI servicer at the end of 2023 for a GEO satellite operator customer.

II. Connection with the LTS Guidelines [*500-word max.*]

[Please indicate any relevant links between the activity above and the LTS Guidelines or portions of the preamble.]

Astroscale's global vision is deeply integrated with the aims of the Long-Term Sustainability (LTS) guidelines, and indeed the objectives of the UN Working Group on the Long-term Sustainability of Outer Space Activities itself. In Astroscale's efforts to secure safe and sustainable development of space for the benefit of future generations, the company is developing the technological capabilities, business cases, policy environment, and shared standards to enable space operators to integrate sustainable practices into their activities. In this way, our work acts in tandem with the LTS guidelines towards a common goal.

Several of Astroscale's actions across the design, planning, construction, and operation of ELSA-d incorporate recommended practices within the LTS guidelines. In particular, Astroscale has implemented a range of elements within Section B, Safety of Space Operations, regarding the exchange of information on space objects, the performance of conjunction assessments, and the control of risks associated with re-entry.

Astroscale is also an industry leader in elements of Guideline D.2, through cooperation with relevant governments and space agencies and participation in industry standards organizations such as the Consortium for the Execution of Rendezvous and Servicing Operations (CONFERS), among others. Astroscale is consistently working to investigate and consider new measures to manage the space debris population, developing necessary technologies for Active Debris Removal as well as policy and legal standards for debris mitigation and remediation.

Astroscale supports that all spacefaring States as a minimum implement the LTS Guidelines as soon as possible. However, more work is needed to mitigate the rapidly increasing levels of pollution of the space environment posed in the short to medium term by an ever-increasing population of space debris. Astroscale encourages States to take proactive regulatory, policy, and space licensing actions intended to ensure government and commercial space operators fulfill their responsibilities to avoid further pollution of the space environment and to take steps to rapidly remediate or remove debris created by their activities.

Astroscale has made proposals in various national fora with regards to the technologies, standards, operator best practices, and regulations necessary for the cultivation and establishment of a safe orbital environment. Astroscale has proposed that:

- National regulators, when conducting assessments of licence requests from satellite operators for LEO satellite systems containing multiple satellites, should consider the full impact of such systems on the orbital environment by calculating the aggregate Probability of collision (Pc) risk posed by the entire system.
- LEO satellites typically operated above 400 km altitude should be capable of maneuvering to avoid collisions with other operating or derelict LEO satellites or other detectable space debris.
- LEO satellites should be designed and operated such that at the end of their in-service lives, they can be safely deorbited within 5 years.
- LEO satellites should be future proofed by being equipped with docking mechanisms to enable active removal or repair should the satellite fail, be incapable of collision avoidance maneuvers (CAMs), or otherwise pose a hazard.

III. Lessons learned [*500-word max.*]

[Please share any information or observations that may assist others in their space activities.]

One of the most important lessons learned for space operators is to share information. Transparency and information sharing on space activities and operations are important measures that space operators can voluntarily take.

- Astroscale shares information on its space activities, including ELSA-d, through its website (https://astroscale.com), social media (Twitter @Astroscale_HQ), and workshops or events. The location of ELSA-d is shown on the company website so that anyone can track its orbital positions based on the latest NORAD TLE data. https://astroscale.com/elsa-d/ **(Guideline B.1)**
- Astroscale shares orbital information of the ELSA-d spacecraft with major Space Situational Awareness service providers such as ESA and the US Space Command18th Space Control Squadron.
- Astroscale also generally adheres to the existing space debris mitigation guidelines. **(Guideline B.2, B.4 and B.8)**

Private space operators also have a significant and growing role in influencing best practices that will mitigate debris. They and the public, who benefit greatly from space services, have the opportunity to advocate for a safe and sustainable space environment in which to successfully operate. Therefore, the lesson learned here is to get involved. Astroscale works to raise awareness of the need to ensure the sustainability of outer space activities through membership in industry groups such as CONFERS, the Space Safety Coalition, EMEA Satellite Operations Association, and by participating in global multi-stakeholder fora such as the World Economic Forum and the Paris Peace Forum, in addition to robust public campaigns. Astroscale has also contributed on these matters in multiple national level consultations (e.g. in Japan, the US, and the UK). **(Guideline C.4)**

Finally, on-orbit services and their demonstrations, such as ELSA-d, can result in unique licensing and oversight by domestic bodies. In the case of ELSA-d, it will be registered from Japan and is mission licensed through the United Kingdom. Third-party ground system licenses supporting ELSA-d are granted from several domestic regulatory bodies around the world, with one dedicated ground station being licensed by Japan. Astroscale encourages state-to-state collaboration to bring certainty to licensing of novel yet important missions that will be instrumental in spaceflight safety and sustainability.