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Authorization and Continuous Supervision of Astroscale's De-Orbit Activities: A Review of the Regulatory Environment for End of Life (EOL) and Active Debris Removal (ADR) Services

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Abstract

Astroscale is one of the few companies in the world proposing an end-to-end solution for the removal of orbital debris through the provision of End of Life (EOL) and Active Debris Removal (ADR) services. The company is working on the difficult technical aspects of the space and ground segments of the mission at offices in Japan and the UK. However, a sustainable business case requires much more than just technical success. A regulatory framework is required by the licensing State to support the authorization and continuous supervision of de-orbiting activities as outlined in Article VI of the Outer Space Treaty; insurance is needed for the launch, on-orbit activities and third-party liability; and universally accepted norms, standards and policies are necessary in order to sustain a business.

Regarding regulatory aspects, Astroscale's first technology demonstration mission, ELSA-d (End-of- Life Services by Astroscale Demonstration), will get authorization and oversight from two States: spectrum licensing is being sought through Japan, while mission authorization is through the United Kingdom. Spectrum licensing is a common activity with a predictable outcome but obtaining a mission license for a debris removal mission is unique and will open a path for future end-of-life services that will support the long-term sustainability of space. In addition to obtaining licenses, Astroscale is pursuing insurance, again something that has rarely been done for a mission of such complexity as ELSA-d. Finally, Astroscale is working with multiple national policy makers and international organizations to help establish the standards that will contribute to future sustainability of space.

This paper will outline the pathway Astroscale is taking to prepare for authorization, acquiring insurance and work with industry and government representatives to ensure missions are conducted with safety, transparency, and the public interest in mind.

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

1. Introduction

States that are signatories of the Outer Space Treaty of 1967 have an obligation to authorize and provide continuous oversight of non-governmental space activities [1]. How this is implemented varies from state to state. Often, domestic regulation embodies the tools to conduct this authorization and continuing supervision, outlining requirements towards a license approval for a variety of space activities. Through proper licensing, the state can adhere to its international treaty obligations and the non-

governmental private space operator is adhering to the domestic regulatory minimums required to operate a space object in the public interest.

Beyond regulatory minimums, the space operator may implement industry standards and best practices that further enhance safety of operations. This is an area of growing interest in the space community as orbits are becoming more congested with space activity and the consequences of a malfunction or collision present economic and sustainability issues.

Astroscale's first demonstration mission on end-of-life rendezvous, docking and deorbit services are

planned for 2020 and as a private entity, must be authorized and supervised by the appropriate State party to the Outer Space Treaty. The ELSA-d mission consists of a servicer and client satellite, which will be launched together, detached in orbit, and then deorbit together. Because the elements of the ELSA-d mission are multinational in nature, so are the required authorization and continuous supervision requirements [2].

This paper will outline the pathway Astroscale is taking to prepare for authorization and working with industry and government representatives to ensure missions are conducted with safety, transparency, and the public interest in mind.

1.1 Paper Structure

This paper will provide a summary of Astroscale and the ELSA-d mission. It will then describe jurisdictional aspects of the mission and required licensing. Finally, the paper will identify best practice efforts that enhance the safety of the mission beyond minimum regulatory requirements.

2. Astroscale Summary

Founded in 2013, Astroscale's mission is to secure long-term spaceflight safety by becoming a provider of reliable and cost-efficient spacecraft retrieval. The company currently consists of approximately 90 people, 75% of whom are engineers, located in offices in Singapore, Japan, UK and USA.

In addition to developing the technology for debris capture and removal, Astroscale is deeply involved in the global conversation on policy, standards, and best practices. From the technology side, Astroscale plans to help in the removal of orbital debris through the provision of two services: end-of-life (EOL) targeting the LEO constellations, and active debris removal (ADR) targeting existing larger space debris:

EOL

To provide this service, satellites will be prepared with a docking mechanism before launch that will allow for eventual removal from orbit. This "semi-cooperative" solution allows for a simpler capture mechanism and will ensure that all satellites have a means of de-orbiting by a third party, improving long-term orbital sustainability and safety of future satellite operations. The primary customers for this service will be the commercial satellite operators.

ADR

Removing debris that is currently in orbit requires a "non-cooperative" solution as this debris was not prepared for deorbit before launch. Astroscale will partner with national space agencies and international organizations to research and develop missions that incorporate innovative solutions for capture and removal of environmental critical debris, such as rocket upper stages and defunct satellites that are already in orbit. The primary customers for this service will be Space Agencies.

For both business lines, Astroscale is focused on providing an end-to-end service, addressing mission licensing, spectrum acquisition, insurance and operations for debris removal.

2.1 ELSA-d Technology Demonstration Mission

Astroscale is planning to launch its first semi-cooperative spacecraft retrieval mission, ELSA-d, in 2020. This ground-breaking mission, will be a technology and capability demonstrator for future services. It will consist of two satellites, a servicer satellite and a client satellite, launched together. The servicer satellite is equipped with proximity rendezvous technologies and a magnetic capture mechanism, whereas the client has a docking plate which enables it to be captured magnetically. Through a series of release and capture activities, ELSA-d will demonstrate a range of key technologies proving capabilities for a full customer mission, including: client search; client inspection; client approach and rendezvous; and client capture [3].

3. Licensing of the ELSA-d mission

Perhaps the four most influential items to consider when seeking space activity authorization are: ownership, command and control, radio frequency uplink and downlink location, and launch location. The answers to these items will determine which state has jurisdiction over various elements of the mission. Licensed private space activities typically include communications, remote sensing, or launch and re-entry. However, new private space activities are emerging such as on-orbit servicing, for which debris removal services are a sub-element. Seeking licensing authority for such novel activities can be complex and uncertain, and therefore requiring more time and resources. An all-encompassing mission license option can alleviate some of this uncertainty.

Multiple State jurisdiction and new and novel space activities are growing in number. It is essential that non-governmental entities to conduct the proper research and dialogue with stakeholders well in

advance of launching their space system in order to fully understand what authorizations are needed and from whom. Astroscale has had dialogue with a wide variety of stakeholders in preparation for the submission of license applications. The next section describes who the primary stakeholders are and the requirements for acquiring licenses for ELSA-d's end-of-life demonstration.

3.1 Mission Licensing and Insurance

For the ELSA-d mission, both the servicer and client satellites will be commanded and controlled from the In-Orbit Servicing Center in Harwell, UK. Thus, the ELSA-d mission requires a UK Outer Space Act license to operate, named "mission authorization license" throughout this paper. Astroscale Ltd, located in Harwell, UK, is in the process of seeking this mission authorization license from the UK Space Agency for the ELSA-d mission.

The application for a UK mission authorization license must be submitted a minimum of six months prior to carrying out the space activity, while there may be circumstances where this timeline can be shortened. The license includes an insurance requirement against third-party liability (TPL) and indemnification of the UK Government for claims made against the government which arise from the mission [4]. The UK is unique in its requirement for TPL insurance in order to obtain a mission authorization license. The insured amount was updated in 2018 to a level of 60 million euros or higher, per occurrence [5]. For small satellites deployed under the altitude of the International Space Station, the TPL requirement may be waived.

Currently, only 5% of low-Earth orbiting satellites possess insurance and as a company that is vocal in debris mitigation discussions, Astroscale asserts there is a need for satellite operators in low-Earth orbit to obtain TPL insurance in order to put a value on the risks associated with spaceflight [6]. Therefore, where there are higher risks in orbit, which may lead to collisions, insurers can appropriately price premiums that will incentivize satellite operators to establish safer practices in order to reduce the risk. Additionally, new insurance products that cover new activities, such as end-of-life services, need to be developed to meet the need for a more complex space environment.

Other key elements of the mission authorization license include the prevention of contamination of outer space and adverse changes in the environment of the Earth as well as disposal of the licensed space object appropriately at the end of the licensed activity. The licensee would need to inform the UK Space Agency of the disposal and termination of the activity. Astroscale agrees that a robust orbital debris mitigation plan should be established by each satellite operator

and that consistent communication with regulators regarding disposal is a necessary step for proper oversight.

It is important to note that the UK is switching to a new traffic light system as a preliminary indicator of licensing difficulty. The Red/Amber/Green rating helps determine, early on in the process, the likelihood of application approval. The intention here is to provide early information on the timing and difficulty of approving the application for mission license. This helps facilitate discussions with the UK Government, signaling the level of information and dialogue required of the applicant in order to have the license request approved.

3.2 Radio Frequency Licensing

Radio frequency coordination for the ELSA-d mission is in process with required information having been delivered to the International Telecommunication Union (ITU) via the Ministry of Internal Affairs and Communications (MIC) on May 28, 2019 [7].

Ground station access at locations around the world is required in order to be able to send or receive signals during operations. Separate from UK command and control operations, these ground stations will collect valuable information on telemetry of the satellites during the demonstration.

Astroscale owns and operates a ground station in Totsuka, Japan. The ground station license for Totsuka is underway through MIC as is a space station radio frequency license for both the ELSA-d servicer and client satellites. For the remainder of ground stations required around the world, contracted third-party providers outside of Japan are responsible for seeking national license authorization to communicate with the servicer and client spacecraft.

3.3 Launch Licensing

Astroscale Japan Inc. has contracted Glavkosmos/GK Launch Services to launch ELSA-d via a Soyuz-2 from the Baikonur Cosmodrome in 2020. The UK Mission License process will include authorization for Astroscale to have ELSA-d launched from Baikonur.

4. Best Practices and Standards

Astroscale ensures it is at the forefront of global discussions in driving more advanced norms and standards and defining "best practices" for the sustainability of space. While industry standards and best practices are not regulations, in order to address the urgent need for an updated spaceflight safety regime, Astroscale supports the development of best

practices, standards, and voluntary guidelines above and beyond the minimum regulatory requirements [8]. This is currently being done through the following formal or informal dialogues.

4.1 *The Consortium for the Execution of Rendezvous and Servicing Operations (CONFERS)*

CONFERS is an industry-led initiative seeking to establish best practices and operations standards for rendez-vous 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. CONFERS has several countries represented through industry membership. 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 [9, 10]. Both documents are intended to be updated in order to reflect the changing nature of On-Orbit Servicing operations.

4.2 *Space Safety Coalition (SSC)*

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 encourages information exchange, selecting launch service providers with spaceflight safety in mind, considering design concepts that enhance safety, and encouraging operational practices that support space sustainability [11].

4.3 *World Economic Forum Space Sustainability Rating*

Astroscale's founder and CEO, Nobu Okada, is a member of the World Economic Forum (WEF) Global Future Council on Space Technologies. WEF has initiated a Space Sustainability Rating (SSR) project for which council members help steer. As the SSR is developed, Astroscale will be providing input to help assess what elements of a space operation should be considered for greatest affect towards space sustainability.

4.4 *Ad Hoc NewSpace Operators*

In April of 2019, Astroscale, along with seven other space companies, submitted comments to the

United States Federal Communication Commission (FCC)'s Notice of Proposed Rulemaking regarding mitigation of orbital debris [12]. The group labeled themselves Global NewSpace Operators to provide inputs on changes needed towards debris mitigation for operators. The comments addressed measures to update debris mitigation plans of operators seeking an FCC license or U.S. market access.

4.5 *ISO 24113:2019*

Standards are voluntary practices for space operators that provide an additional level of safety above and beyond regulatory requirements. As a recent example, the Technical Committee ISO/TC 20, Aircraft and space vehicles, Subcommittee SC 14, Space Systems and Operations recently updated the ISO standard for orbital debris (24113) in July 2019.

5. Summary

Astroscale's ELSA-d mission, set to launch in 2020, will in many ways be a unique mission to authorize and conduct continuous supervision over. This is due to the nature of the novel mission (end-of-life services demonstration with a servicing and client spacecraft), the multi-national authorities that are involved (UK and Japan, and third-party contractors situated globally), and the global communications needs for commanding the servicer and client spacecraft. Knowing the complexities of the mission, Astroscale has sought out government stakeholder dialogue to create as smooth licensing process as is possible.

Above and beyond the regulatory requirements for licensing the mission and its communications, there are standards and practices that enhance the safety of space operations. Many of these practices have evolved through ad hoc or formalized industry groups, where Astroscale has been a leading participant. By adhering to guidelines, practices, and standards in the ELSA-d mission, spaceflight safety can be enhanced and additional information can be provided to regulators with which to make a license determination with the public interest in mind.

For both EOL services and ADR, Astroscale is focused on providing an end-to-end service, addressing mission licensing, spectrum acquisition, insurance and operations for debris removal. With the launch of its first semi-cooperative spacecraft retrieval mission, ELSA-d, in 2020, Astroscale will demonstrate a full range of key technologies proving capabilities for a customer debris removal mission, including client search, inspection, approach and rendezvous, and capture. As a multinational company, in the course of its mission planning for ELSA-d,

Astroscale has also provided insights and feedback to regulatory and licensing authorities, such as the Federal Communication Commission (FCC) and a wide variety of other stakeholders regarding the still complex process of procuring necessary licenses for such emerging activities, particularly those that fall under multiple State jurisdictions. Astroscale has been an industry leader in the formation of industry best practices for the emerging field of on-orbit satellite servicing, active debris removal, and other applications for rendezvous and proximity operations on-orbit, through fora such as the Consortium for the Execution of Rendezvous and Servicing Operations (CONFERS) and the Space Safety Coalition (SSC). As regulatory frameworks and schemes for continuing supervision of de-orbiting services continue to develop in accordance with Article VI of the Outer Space Treaty, Astroscale will continue to work with relevant stakeholders in industry and government to ensure missions are conducted with safety, transparency, the public interest, and the sustainability of outer space in mind.

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