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On-Orbit Servicing: Repairing, Refuelling And Recycling The Legal Framework

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Abstract
On-orbit Servicing (OOS) will revolutionize the satellite industry, by offering tools that enable life-extension and debris remediation. However, the advanced technology heightens the risk of liability for damages and the overall perceived security in space. In addition, international OOS missions challenges the traditional concepts of ownership, responsibility and liability in the international space Treaties. Whilst OOS is not prohibited under the current legal framework, it is clear that the legal framework needs to be supplemented in order to address the new challenges. Based on the findings of the regulatory landscape, the paper offers various suggestions as to how the legal and political challenges can be addressed. These suggestions include meeting security concerns through a greater sense of transparency and trust, enabled by more information on the locations of the satellites as well as traffic rules for their movement. In addition to creating transparency, such rules for behaviour can also serve as evidence during a potential liability case, proving that the servicer acted with the right amount of care. This approach focuses on flexible and pragmatic solutions. National space law is seen as the entry point for many of these solutions, through an OOS license. In order to create harmonisation, UN resolutions can make recommendations on State practice. Despite their non-binding character, these resolutions have traditionally been used to supplement the interpretation and development of international space law. OOS can drive change in space activities, not only for the commercial use of space but also for the sustainable use, and it is therefore important that these regulatory challenges are met.

Keywords: On-Orbit Servicing, Space Law, Space Situational Awareness, On-Orbit Operational Regulation

1. Introduction

When something is broken you don't throw it away, you will try to fix it. This is especially true if that item is very valuable. However, once a satellite is launched into outer space it is difficult to repair it. A broken satellite could not only be useless but might also pose a potential danger to other satellites if it turns into debris heightening the risk of collision.

On-Orbit Servicing (OOS) seeks to remedy the amount of debris, as well as upgrade functional satellites with new technology.

Whilst OOS is not novel, it is new as a service. OOS includes a satellite servicer (hereinafter called the 'servicer') that performs one or several operations on the client satellite (hereinafter called the 'client'), be it for instance repair or refuelling.

OOS "has the potential to profoundly impact the traditional way of performing spaceflight – both from a technical and regulatory point of view ". [1] However, before OOS really can make it big, there are several challenges that need to be solved, as international OOS operations, where the client and servicer are from different States, raises significant legal, political and security concerns. A technically feasible solution might not be a politically feasible solution.

2. About On-Orbit Servicing

The purpose of OOS is to "reduce, reuse and recycle" [2] and thus, cater not only to the operator's business concern, but also to the increasing international concern over space debris and crowded orbits. In addition, OOS can contribute to facilitate space exploration, as its functions can be used for in-orbit assembling of space objects. [3]

2.1. Mission types

Each OOS mission type differentiates in technology and techniques to achieve the mission goal. The list is non-exhaustive.

2.1.1. Repairing

Repairing a satellites hardware requires mechanical intervention, e.g. by a spacecraft equipped with a robotic arm to assist in repairing a satellite after launch.

2.1.2. Life extension

Refuelling can extend the life of a spacecraft, and is considered by some as the greatest potential for the commercial viability of OOS missions.[4] The problem with refuelling is that the satellites currently in orbit are not designed for on orbit access to their tanks, making refuelling missions in the near future complex.

2.1.3 Upgrade

By docking to the client, the servicer can install a payload upgrade, which can improve the operational capacity of a satellite as well as changing the satellites mission.

2.1.4. Active debris removal, deorbit or recycling

Active debris removal is viewed as a method for making outer space activities more sustainable by decreasing risks of collision of spacecraft in Earth's orbit. A common failure is satellites being launched into the wrong orbit. Repositioning the space object can serve as a way to rescue these satellites.[5]

2.2. OOS companies

There are examples of early governmental OOS operations, such as the repairs performed on the Hubble Space Telescope or the Canadarm currently attached to the International Space Station (ISS). Current missions include government owned initiatives such as NASA's Restore-L refuelling mission, contracted to SSL, or the European Space Agency's (ESA) e.Deorbit, a space vehicle that aims at capturing derelict satellites to return them to Earth's atmosphere. The i-BOOS (intelligent Building Blocks for On-Orbit Servicing and Assembly) is an initiative by the German Government and its space Agency, which developed into a fully commercial company in 2017. Other commercial companies include Astroscale, a space debris removal company, and OrbitFab, a refuelling company.

3. Liability, Registration and Ownership

The main pillar of law governing activities in outer space is the "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Outer Celestial Bodies", also known as the Outer Space Treaty (OST).[6] The OST is supplemented by four other treaties: Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space also known as the Rescue and Return Agreement (ARRA)[7], Convention on International Liability for Damage Caused by Space Objects also known as the Liability Convention (LIAB)[8], Convention on Registration of Objects Launched into Outer Space also known as Registration Convention (REG)[9], and Agreement Governing the Activities of States on the Moon and Other Celestial Bodies also known as the Moon agreement (MOON).[10]

This chapter will outline the legal challenges that arise due to the insufficiency of these space law treaties to address the specific needs of OOS. As will be demonstrated, OOS is located in a legal grey area, where it is not strictly forbidden, and challenges some space law principles as it is not specifically addressed in the current framework.

In order to assess the legal pre-conditions and consequences of OOS operations, different entities can carry different rights and obligations simultaneously:

- Launching State: State which launches or procures the launching of a space object or a State from whose territory or facility the space object is launched. [11]
- Registering State: Upon registration the State retains jurisdiction and control over the satellite (limited to Launching States).[12]
- Owner of the satellite: governmental or commercial entity that has the full and disposable right over the space object.
- Licensor: if the OOS is performed by a non-governmental commercial entity, its national space law might require it to be licensed.

3.1. Challenges

3.1.1. Challenges regarding Liability

Pursuant to the LIAB article II and III, it is the Launching State that is liable for damages caused by a space object. When the damage occurs in space fault liability applies, whereas damages on Earth or Aircraft in flight are based on absolute liability. [13]

As can be seen from the definition above, the term 'Launching State' is quite broad. That means, if State A builds a satellite, has it launched from State B, on a rocket procured by State C, all of these States are jointly liable to a State who has suffered damage caused by that satellite. Should an accident occur where this satellite is the client being serviced by a satellite from State D as the servicer, the States (A-C) would only be liable to the extent of their fault under article III of LIAB. If the accident is caused by the client to another State E after the servicing, the client will only be liable to the extent it was at fault. D will be liable to the extent their fault can be proved. If the faulty repair does not show until after a while after the servicing, D's fault might be difficult to prove. If D causes E to fall to Earth and cause damage, E will be liable even without fault due to the strict liability meant to protect victims with no involvement in space activities under article II of the LIAB.

Due to the close interactions between the servicer and client required by the OOS mission, the risk of collision in space is high. Even higher risks are connected to missions that includes docking, where the servicer links itself to the clients docking port or ring adapter.[14] Proving faulty behaviour in space can be difficult due to the limitations in monitoring space activities. In the context of space law, Smith and Kerrest define fault as the failure to use such care as a responsible prudent and careful person would under those circumstances. [15] The judge might look at other relevant sources or expert opinions, that can serve as an indication that States have paid 'due regard' in line with the requirement of Article IX OST. [16] Specific OOS guidelines could be helpful to assess whether the behaviour was conducted in fault.

The challenges of proving fault, or risking becoming strict liable for damages on Earth, means it is important that questions of liability are properly addressed between the client and the servicer before servicing takes place. When the servicer and client have different launching States, this agreement must take place at State level through bilateral agreements, where right to recourse need to be addressed.

3.1.2 Challenges regarding ownership, registration, jurisdiction and control

The registering State of a space object retains jurisdiction and control over that object pursuant to article VIII OST. Only a launching State of the space object can register it.[17]

Because of the registering State's prerogative to exercise jurisdiction and control, States are required to obtain prior consent before intercepting another object. States are direct subjects in OST, meaning that the non-governmental OOS operator has to go through their State to obtain prior consent from the client's registering State before the operation can take place. This will cause an administrative burden on the national offices in charge of authorising OOS.

In order to be able to register in accordance with the REG, the State needs to fit the description of being a launching State. This requirement remains even when the ownership of the space object changes. That can cause issues, because the new owner might not fit in under the otherwise quite broad description of a launching State, if it for example did not have any involvement with the space activity whilst it was still on Earth.

The question of transfer of ownership may be relevant for OOS missions. An OOS mission can improve a space object by, for example, repairing or upgrading it. States or private entities that want to save money for the launch of an object, may wish to buy a satellite already in orbit and thus will need to be able to have the ownership transferred. Another aspect challenging the ownership question is when the OOS mission entails on orbit recycling. A 'new' spacecraft may be created of recycled pieces of space objects. However, as will be demonstrated below, a space object does not change legal status, despite being non-functional, and the launching State of the recycled parts of the space object will therefore continue to retain their obligations under the international space treaties.

If in the example above, State A owns the satellite and wants to sell its serviced satellite to State F, then this State will not be able to register as it did not have any involvement in the launch.

If the transferee (F) cannot become the registering State, it will affect many of its rights and obligations under the OST. First of all, the transferee will not be able to exercise jurisdiction and control, which will remain with the previous owner (A).

Despite not being addressed in REG, there are State practice supporting that a non-launching State can become the state of registry. This includes the Swedish state-owned company Nordic Satellite AB who in 1996 purchased a satellite of the United Kingdom. [18] UN resolution 59/115 recommends member States to submit information about their current practices regarding on-orbit transfer of ownership of space objects. [19] If the recommendation is followed, it could enable States to align their procedures and create more transparency.

Therefore should the OOS mission lead to a change of ownership, there needs to be a proper agreement in place ensuring that the owner also has all the other rights and obligations stemming from the OST and conferred to them through other means than registration.

3.2 Suggested solutions

The legal aspects of OOS require covering the grey area in which OOS currently stands within the OST. If the last 50 years of international space law have taught us anything it is that the challenges in space law are not easily solved through treaty making. Neither does it seem practicable feasible to amend the treaty, as demonstrated by the unwillingness of States to amend the Space Treaty in any way.[20] The fact that COPUOS only acts on the basis of consensus "is at the same time its strongest aspect and its weakest." [21] An alternative and pragmatic way is to elaborate the rights and obligations stemming from the treaties through national space law, which might require support from technical guidelines.

This can be implemented through:

1. Non-legally binding instruments in the form of Guidelines for OOS operations and design to support safe operations and increase transparency;
2. Implement these guidelines into national licenses for OOS operations to make them legally binding;

3. Contractually allocate risks related to liability, export control, insurance requirements.

3.2.1. OOS guidelines

By creating On-Orbit Operational Regulation and guidelines of the design of the servicer, it will be easier to prove faulty behaviour in space. International collaboration is necessary to create harmonised rules but due to the difficulties in creating new treaties this paper chooses to look at soft law regulations as a first step towards On-Orbit Operational Regulation and design guidelines. Soft law can meet several of the challenges related to regulation of OOS, as it can foster trust and transparency through measures of Transparency and Confidence Building Measures (TCBM.) This includes clear codes of conduct, which can manifest themselves in standards.

Despite lacking the necessary normative content to create rights and obligations that are enforceable, soft law is considered to be an important alternative way of cooperating internationally. [22] Soft law has the advantage of being flexible enough to adapt to the development of technical knowledge, which may be difficult to predict. [23] The problems related to amending or adopting new international treaties has led to the UN adopting guidelines to reflect the norms and standards within a given area. This includes the guidelines developed by the Inter-Agency Space Debris Coordination Committee (IADC), which eventually served as the baseline for the development of the UN Space Debris Mitigation Guidelines.[24] Whilst this does not make the guidelines legally binding, the UN guidelines have been declared to reflect existing practice between States. [25] The UN Committee for the Peaceful Uses of the Outer Space (COPUOS) has recently approved the Long Term Sustainability (LTS) guidelines and they are set to be endorsed at the UN General Assembly at the end of the year.[26]

OOS could benefit from the same path as the IADC by developing standards that reflect industry and government endorsed practice outside the traditional forums. "Consortium for the Execution of Rendezvous and Servicing Operations" (CONFERS) is an industry led initiative that sets out "to leverage best practices from government and industry to research, develop, and publish non-binding, consensus-derived technical and operations standards for OOS and RPO". [27] The project is funded by DARPA, which has a long history of developing cooperative OOS technologies, led by Secure World Foundation, and aims at transitioning fully into a private-sector operation over a period of years. [28] This cooperation is evidence that non-state entities can also take part in the creation of soft law. The discussions for the LTS included commercial companies, in an acknowledgement of the growing importance of the role of these players in the space industry.[29] A bottom-up approach ensures that the standards reflect the needs of the industry. Therefore, whilst there is a risk of being influenced by self-interest, it is desirable to have their technical knowledge included. [30] In order to get the best chance of being adopted by the international community, the standards should seek to be developed in cooperation with the broadest range of both industry and States interested in their development.

CONFERS has developed these guidelines [31] for the behaviour of Rendezvous and Proximity (RPO) and OOS that can be summed up as the following:

- Consensual operations, between client and servicer
- Compliance with Relevant Laws and Regulations
- Responsible Operations: designing the spacecraft according to generally accepted engineering practices, effective communication between the servicer and client, mitigating debris, insurance, best practices and standards
- Transparent Operations: notification to the relevant State(s) of the OOS operation, avoiding harmful interference, development of a protocol between servicer and client regarding notification of anomalies or mishaps that can impact the activity or the space environment, sharing lessons learned.

The implementation of these guidelines are partly elaborated in the "CONFERS Recommended Design and Operational Practices". [32] The document includes practices that are based on lessons learned from previous OOS missions. The guidelines directly address the relationship between the servicer and the client, and can be agreed upon in a contractual relationship between the parties. This will be elaborated in below in Chapter 3.2.3.

ESA is also currently working on requirements/ standards for Safe RPO, which have yet to be published.[33] Collaboration between the two should be encouraged.

Guidelines on operations and design would require voluntary adherence. The World Economic Forum has announced a Consortium to develop a "space sustainability" rating system. The consortium consists of companies, universities and agencies who will collect different methods of measuring space sustainability. The rating system depends on satellite operators' voluntary submission. Operators can be incentivized to such submission with a wish to "demonstrate their desire to be good stewards of space amid concerns about the growing population of orbital debris".[34] In the future, this could include adherence to OOS guidelines.

Due to the rigid opportunities for regulating OOS within the traditional loop legal system, soft law in the form of guidelines seems the most adaptable solution. OOS guidelines can take leverage of the path already taken by previous guidelines relating to debris mitigation and LTS to be endorsed at a global scale when they have matured sufficiently. With CONFERS already taking the lead, the perspective of both industry and government is guaranteed.

3.2.2. National implementation of OOS license

On-Orbit Operational and design guidelines can become legally binding through national space legislation, for example as a compliance requirement in a license for a space activity.

A registering and launching state is not only responsible but also liable for the space object and thus has an incentive to regulate space activities. National space legislation therefore typically ensures that the national activities are regulated and licensed in accordance with the obligations of the treaties. [35] The procedure for the development of national laws is generally less rigid and faster than in international law. This enables the acceleration and growth of such activities not directly regulated by international law. Furthermore, if enough States have adopted the same provisions in their national space legislation, over a certain amount of time, such provisions may evolve into customary international law. [36]

Some of the national space legislations differentiate between different kinds of authorisation, being either licences or permits, or between different kinds of rockets. [37] By doing so, national space legislation breaks "down the generic term 'space activity' into a multitude of sub-categories which may entail different legal consequences." [38] Thus a State could create a specific OOS license. This allows the license to address the specific challenges of OOS, such as requiring adherence to certain RPO and OOS standards. Such standards can relate to technical requirements of the servicer, as well as overarching principles for OOS operations.

A national space license can also protect the sensitive images taken during the OOS. As will be outlined in Chapter 4.1.1., such protection might be necessary due to the close interaction between the client and the servicer during RPO. Such protection can be achieved by including a specific requirement in the license that, for example, the images captured by the servicer could go through the filer of a national agency in order to single out sensitive elements related to national security.[39] That agency can also ensure that the OOS providers are complying with export control laws, a challenge that will addressed under Chapter 4.1.2. The disadvantage of implementing OOS requirements nationally is that it enhances the risk of creating a 'flag of convenience', whereby the companies chooses the state with the most beneficial regulation.[40] If the technical basis for the license is the same, e.g. UN approval guidelines, this risk will be mitigated. If a broad agreement at the UN cannot be achieved, States can bi-laterally create clauses in their space legislation regarding mutual recognition of a license that adheres to certain standards. Coming back to the example in Chapter 3.1.1., if the commercial servicer from State D has obtained a national license, State A could be required to give their consent if a mutual recognition clause were in place. This could potentially ease the administrative burden of the national space office from obtaining consent from the servicer state before issuing the authorisation.

The licensing rules can address the challenges related to sustainability of Earth's orbit, see Chapter 5.1., by including an assured removal clause hereby requiring companies to have the capability to safely de-orbit their space object, or contract to have their space object removed at the end of their life.[41]

3.2.3. Contractually

Some aspects of OOS will be best addressed in contracts as far as private actors are involved. In this regard the servicer and client need to ensure that the special need of the industry are met. This includes ensuring that the right export control permissions are in place, and information to be provided by the client to the servicer and disclosure hereof. The contract may reference to the CONFERS Recommended Design and Operational Practices as outlined above in order to ensure that the OOS operation is performed in line with industry accepted practices. Acceptance and rejection of the servicing needs to be addressed in order to address when the responsibility for the mission transfers from one party to the other. Finally it is important to address potential liability be it second or third party. Liability concerns can be met through cross-waiver of liability for non-international operators, as the parties will be able to cover their own risk through insurance.

3.2.4. Insurance

Insurance companies can contribute to the adherence of guidelines on OOS operations and design by forcing adherence to certain guidelines in exchange for lower price on the insurance. However, as there are not currently many insurance companies that cover space activities, these companies lack the possibility of having flexible pricing to incentivise such behaviour.[42]

Alternatively, insurance could contribute to the development of future satellites being designed for servicing missions, by offering OOS insurance for future damages to the satellite.

4. Security

OOS poses political obstacles because the satellites retain technology that may be perceived as a threat to foreign states. This includes RPO capabilities that enable the servicer to go close to and dock on the servicer. There are even examples of OOS missions that have the objective to remove debris through harpoons or net.[43] Without knowledge of the OOS missions intentions this can be perceived as an armament by other States.

4.1. Challenges

4.1.1. Perceived threat

The OST was written with two distinctive goals in mind. It voices the fundamental guiding principles for States to carry on their activities for the peaceful exploration and use of outer space. Furthermore, OST serves as an arms control treaty, laying down certain boundaries to the military uses of outer space. Pursuant to article IV OST, States are prohibited from placing weapons of mass destruction or nuclear weapons in outer space, and requires the Moon and other celestial bodies to be used for exclusively peaceful purposes. Space has been used for military purposes from the beginning of space exploration, but the use of military satellites has increased in recent time, as they are becoming crucial components of national security strategies.

Depending on the applications, the OOS mission has several phases. The most typical mission type includes a servicer approaching a client, performing rendezvous and capturing it.[44] In this approach, the servicer's camera will inspect the client for damages. In order to be able to perform the complex and precise task, the client will have to share substantial information about itself. The servicer will also have to disseminate information about its mission to reassure other States. In addition, as pointed out by J. Alver et al., whilst there are technological advantages to creating OOS technology that works on a non-cooperative satellite, this also heightens the risk of misuse. [45]

The capabilities of OOS has been compared to a 'space weapon' and it thus requires a high level of transparency about the objective of the mission. [46] If this need for transparency is not met, space security experts have warned that OOS "could accelerate global proliferation of co-orbital anti-satellite weapons". [47] In itself OOS is not prohibited by the security restrictions in OST, but the line between civilian and military purposes may be further blurred in State-led OOS operations. Transparency in OOS missions is therefore vital.

4.1.2. Export Control and protection of IPR

Due to the security and economic interests of States, many space faring nations have established national export and control regulations.[48] These rules entail heavy restrictions on the transfer of jurisdiction and control over their space objects to foreign countries or entities.

An OOS mission requires that the parties share some information beforehand, so that the servicer is able to recognise the object and to dock. This information may be restricted not only for national security reasons, but also through rules on intellectual property rights (IPR). IPR protects the commercial value of the patented technology, and it is therefore important, that OOS operations ensure protection of the clients IPR in order to attract the private sector to the OOS market. In addition to the information required beforehand, the servicer will also obtain images of the client satellite in orbit. These images are necessary for the servicer to conduct its operation to approach, refuel, repair and other activities involving rendezvous and proximity (RPO). As these pictures carry sensitive information, their distribution is restricted by International Traffic in Arms Regulations (ITAR). The U.S. ITAR regime best exemplifies such legal and regulatory restrictions. The purpose of the regulation is to protect the State from sharing information stemming from their satellite parts that could potentially reduce or hinder U.S. military activities, plans, operations or strategies. "Export" also includes the transfer of jurisdiction and control, of technical data, and performing defense services on behalf of, or for the benefit of non-US entities. [49] Consequently, technical data is not allowed to be transferred without a prior approval by the U.S. State Department. Currently, there are a limited number of ITAR-free objects in space. [50] OOS operations fall under the definition of 'export', even if the transfer of jurisdiction and ownership only takes place for a limited amount of time.[51]

These rules therefore pose a serious limitation of market opportunity, and reduce the available market for OOS beyond the a State's own military. Even if the export regulation does not create a direct barrier, it does create a hurdle for companies undertaking OOS activities.[52]

4.2. Suggested Solutions

The challenges relating to security need to be addressed by the creation of transparency and trust. The solutions suggested under Chapter 3.2. regarding On-Orbit Operational Regulation will be a step towards creating more transparency over a servicer's conduct in space. Such regulation can benefit from international Space Traffic Management. In addition a servicer's conduct can be monitored through increased Space Situational Awareness (SSA), which will create transparency in the event of an accident and could avoid escalatory military cycles caused by the perceived security threat posed by OOS.

4.2.1. SSA and STM

The term SSA is broad but this paper will use the understanding defined by The Space Foundation as "the ability to view, understand and predict the physical location of natural and manmade objects around the Earth, with the objective of avoiding collisions."[53] STM is part of SSA, which "means the set of technical and regulatory provisions for promoting safe access into outer space, operations in outer space, and return from outer space to Earth free from physical or radio-frequency interference." [54]

Increasing information about SSA and creating STM will contribute to making space more sustainable. It is fundamental to avoid collisions through transparency which in turn could contribute to reducing tensions between States. It also directly works as a tool to understand the space capabilities and intent of possible threats. [55]

The concept of STM is based on "covering access to, operations in, and return from outer space". [56] This approach distinguishes between three STM phases, (i) the launching phase; (ii) the in-orbit operation phase and (iii) the re-entry phase. [57] Phase (ii) is of specific interest for OOS operations. The in-orbit operations phase is challenged by the threat of potential collisions by debris. Therefore, it is necessary to have collision warning and avoidance mechanisms, which can be achieved by STM. [58] This can be step as a step further them the On-Orbit Operational guidelines. Furthermore, OOS in itself increases the need for STM, due to the growth of conducted manoeuvres and the increased lifespan. [59]

STM and SSA both require the geo-political willingness of States to collect and share their data. Therefore, whilst SSA and STM will create more transparency, this is ironically one of their biggest challenges.[60] It is necessary to create a trustworthy system of data distribution.

SSA was traditionally a capability developed for military, however with Space Policy Directive 3, National Space Traffic Management Policy, the US changed the department responsible for collecting and sharing SSA from Defence to Commerce. This has the effect that "the data will no longer be behind a military firewall and it has a commercial focus" [61] which could pave the way for more international collaboration.

The EU has also recently promoted a new initiative set to promote the need for sustainable space operations "Safety, Security and Sustainability of Outer Space (3SOS)". The European initiative does not want to push new regulation on satellite operators but points towards the need for a fully international approach in order to avoid putting companies in EU countries at a competitive disadvantage. [62] This underlines the need for an international agreement on STM.

Whilst a new international treaty could be a good solution to achieving harmonised rules, it is not a realistic solution. Achieving international collaboration on how to share potentially sensitive data be even more difficult with the increased focus on military operations in space. For example, the US has re-launched their Space Command within the Air Force, France has launched a new Space Command, and Japan has recently stated that they "may evolve into 'air and space' defense force". [63] The new EU Commissioner for Space, Sylvie Gouland, has been asked by the EU President Ursula von der Leyen to improve the crucial link between space and defence and security. [64] Meanwhile the US, China and recently India have done ASAT testing, showing how countries are strengthening their capabilities to attack other satellites.

In order to create a trustworthy system of data distribution, the information could be labelled after its confidentiality to ensure the protection of data. An information sharing platform could take inspiration from the European SSA system. In this study by ESA, users of the information are differentiated between i) civil institutional users, ii) military users and iii) commercial users.[65] Access to the data is granted depending on the need and "rights" of the users. The number of functional military space objects compared to non-military functional and non-functional space objects is small, and it does not therefore impede the functionality of SSA if no military information is contained. [66] As for STM, initiatives in the US and EU show that the topic is being discussed but it is clear that global collaboration is necessary.

A SSA and STM system would create more transparency for OOS missions. Transparency for space activities has the potential to deescalate tensions between states, potentially even more heightened due to the surveillance capabilities of OOS. A well-defined STM rule set and the potential to monitor activities could help ease difficulties of establishing fault in the event of an accident.

5. Environment

5.1. Space Debris

The UN report 'Towards Long-Term Sustainability Of Space Activities: Overcoming The Challenges Of Space Debris' states that even without new objects launched into space, "space debris will result in eight to nine more collisions in LEO by 2050". [67] In order to create a more sustainable space environment, focus on debris mitigation is not sufficient but will have to be supplemented by debris remediation. As mentioned above, ADR is one of the OOS mission types.

Because a space object does not lose its legal status even after it has become debris, it is the registering State that will continue to bear international responsibility for the space object in accordance with article VIII OST, even after the end of its functional period. Likewise, the launching State(s) will continue to be liable for the damages the debris may cause in accordance with Article VII OST. In addition, it is not clear whether States are responsible under Article VI OST for creating space debris or for not cleaning space debris up.[68] If such debris is expected to cause harmful interference, consultations are required under Article IX OST, which also requires States to pay 'due regard' to the corresponding interests of other States.

Being able to remove abandoned space objects without prior consent would make the clean-up of space easier, as is seen in traditional maritime salvage laws. [69] If a damages caused by the space debris the launching State might risk becoming liable despite having 'abandoned' it. [70] However, should an accident occur during an ADR mission, the servicer might end up becoming liable for the damage, since it is the entity that triggered the accident by performing the debris removal. Without a direct obligation to remove debris, it is difficult to create a business plan for commercial ADR or an incentive for governments to fund ADR. In addition potential liability claims need to be addressed before removal.

5.2. Suggested solutions

<u>5.2.1. Incentive for Active Debris Removal</u>

A sustainable business case for ADR is key for providing a safe space environment. Whilst space debris is a global threat, there has yet to be a global response to its remediation.

If a claim for liability involving space debris should occur in the future, this could be the catalyst for States to start cleaning up their debris in order to avoid potential liability claims. However, because most debris owners remain unidentified, the response will likely have to come voluntarily and through international collaboration. A global response could be through the creation of an economic fund to finance future missions, based on funds from international taxation of space activities.

Currently ADR companies, such as Astroscale, are relying on investments from big tech powers but say that for the long term business case it is important that regulations are being put in place.[71] In the meantime Astroscale has partnered up with University of South Hampton to identify the collision risk of satellites in orbit, in order to quantify the financial value of debris removal to satellite operators. [72] The driver for a business case could thus be the commercial value in the threat of not taking actions now. With time, the urgency of this threat will hopefully provide the incentive necessary for States to agree on a regulated debris removal requirement and/or an international tax.

Governments are already taking some actions toward debris removal, by funding ADR concepts. RemoveDEBRIS is a program consortium with for example Airbus, Ariane GmBH and University of Surrey, UK, and is funded by the EU. [73] Restore-L is a NASA mission and e-deorbit is funded by ESA. However, whilst funding is a step in the right direction, governments will also to be a commercial customer for ADR in the future. This is currently being done by the life extending MEV-1 by SpaceLogistics, a subsidiary of Northrop Grumman, with governments as the customer. [74]

Another way governments can contribute to the OOS industry is by planning servicing missions into the future design of government satellites.

5. Summary of challenges and way forward

OOS missions face various legal and political challenges including insufficiency of the space law treaties to address the specific needs of OOS, perceived level of threats as well as a business case for ADR, without a specific obligation to remove debris.

In order to create the necessary transparency in the event of an accident and to avoid the escalatory military cycle caused by the perceived security threat the following possible solutions were found:

- Enhanced SSA and the creation of a STM system to monitor the activities and international STM

- Creation and implementation on On-orbit Operational Regulation and Design Guidelines

In order to create the most geographical spread coverage of SSA and the most harmonised regulation, an international agreement between States is necessary to achieve the first point. However, with the geopolitical landscape of today and the few developments within space treaty making for the last 50 years in mind, the feasibility of cooperation between States whereby they agree on and bind themselves to share possible sensitive information as well as agree on STM seem unlikely. In the meantime, commercial SSA providers can support the tracking of space objects in orbit and bi-lateral agreements regarding sharing of governmental SSA should be encouraged.

Governments and insurance companies has been identified as the main path of implementation of the second point regarding On-orbit Operational Regulation and Design Guidelines. In order for the implementation to be sufficiently harmonised guidelines like CONFERS should push to take the path of IADC guidelines to be endorsed by the UN.

Governments have been identified as being able to independently contribute to the solutions of the challenges related to OOS through

- Creation of OOS license
- Supporting ADR through funding economically and as a commercial customer
- Planning OOS requirements into future satellite design

Insurance companies can contribute by

- Incentivising compliance to certain standards
- Offering OOS insurance

Commercial servicer and client must

- Address the legal loop holes contractually
- Cover risks during the OOS mission through insurance

6. Conclusion

This paper has outlined the legal and political challenges related to international OOS and offered some pragmatic ways to meet them. The pragmatic results are achieved through a bottom-up approach from both industry and governments, with the goal of eventually developing into a more harmonised international framework that can address the needs of the novel service-industry of OOS.

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