On-Orbit Servicing: Repairing, Refuelling and Recycling the Legal Framework

*Thea Flem Dethlefsen**

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 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 for example more information on the locations of the satellites, and rules for OOS behaviour.

1. Introduction

When a valuable items breaks, a natural remedy will be to try and fix it. 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.

* LLM (Adv.) candidate in Air and Space Law, International Institute of Air and Space Law, Leiden University.

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]

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

1 K.U. Schrogl, *Space Traffic Management – Towards A Roadmap For Implementation,* first ed., Paris, International Academy of Astronautics, 2018, p. 48.
2 A. Soucek, On-Orbit Servicing: Legal Perspectives, European Space Policy Institute (2018).
3 A. Long, M. Richards, D. Hastings, 'On-Orbit Servicing: A New Value Proposition For Satellite Design And Operation', *Journal of Spacecraft and Rockets* vol. 44, 2007, p. 965.
4 A. Graham, J. Kingston, 'Assessment of The Commercial Viability Of Selected Options For On-Orbit Servicing (OOS)', *Acta Astronautica*, vol. 117, 2015, p. 43.

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]

3. Liability, Registration and Ownership

The main pillar of law governing activities in outer space is the Outer Space Treaty (OST).[6] which is supplemented by four other treaties, including amongst others the Liability Convention (LIAB),[7] and the Registration Convention (REG).[8]

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.[9]

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 to a client satellite being serviced by a satellite from State D, 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.

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.[10] The judge might look at other relevant sources or expert opinions, that can serve as an indication that

5 A. Ellery, J. Kreisel, B. Sommer, 'The Case For Robotic On-Orbit Servicing Of Spacecraft: Spacecraft Reliability Is A Myth', *Acta Astronautica,* vol. 63, 2008, p. 635.

6 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and other Celestial Bodies, of 27 January 1967, 610 UNTS 8843.

7 Convention on International Liability for Damage Caused by Space Objects, of 29 November 1971, 961 UNTS 13810.

8 Convention on Registration of Objects Launched into Outer Space, of 12 November 1974, 1023 UNTS 15020.

9 LIAB Article II and III.

10 L.J. Smith and A. Kerrest, 'Article III LIAB', *in* S. Hobe et al (ed), *Cologne Commentary on Space Law Volume II*, Cologne, Carl Heymanns Verlag, 2009, p. 133.

States have paid 'due regard' in line with Article IX OST.[11] Specific OOS guidelines could be helpful to assess faulty behaviour.

The challenges of proving fault, 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 because it does not flow from the treaties themselves.

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.[12]

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.

Only launching States can be the registering State which can cause a challenge in situations where the OOS mission leads to a change of ownership in orbit. This can be the case when a serviced satellite is sold or with in orbit-assembly of recycled parts.

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 is 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.[13]

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.

11 Smith, Kerrest, 2009, p. 133.
12 REG Article I (c).
13 UN Register on Objects Launched into Outer Space, ST/SG/SER.R/219 and ST/SG/SER.R/352.

3.2. Suggested solutions

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.
Instead this section looks at soft law (guidelines) that can be implemented through national space legislation (special OOS license) and leaves the parties to address the rest of the risks contractually.

3.2.1. OOS guidelines

Creating On-Orbit Operational Regulation and guidelines of the design of the servicer will ease the burden of proving faulty behaviour in space.
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.[14] Soft law has the advantage of being flexible enough to adapt to the development of technical knowledge, which may be difficult to predict.[15] An example of this is 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.[16]
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".[17] The project is funded by DARPA, led by Secure World Foundation, and aims at transitioning fully into a private-sector operation over time.[18] Whilst there is a risk of being influenced by self-interest, it is desirable to have their technical knowledge included.

14 F. Francioni, International ''Soft Law': A Contemporary Assessment' *in* V. Lowe and M. Fitzmaurice (ed), *Fifty Years of the International Court of Justice, Essays in Honour of Sir Robert Jennings*, Cambridge, Cambridge University Press, 1996, p. 168.
15 I. Marboe, *Soft Law In Outer Space The Function Of Non-Binding Norms*, first edition, Wien Köln Graz, Boehlau Verlag, 2012, p. 6.
16 United Nations Office For Outer Space Affairs, 'Space Debris Mitigation Guidelines Of The Committee On The Peaceful Uses Of Outer Space' (2010), p. 5-6.
17 Secure World Foundation, CONFERS - Fostering Standards To Enable Commercial Satellite Servicing, 2018 https://swfound.org/media/206094/confers_onepager_jan 2018.pdf.
18 I. Christensen, Norms And Standards To Enable Emerging Industry Segments: Satellite Servicing, presentation at the Global Space and Technology Convention, 2018 https://www.satelliteconfers.org/wp-content/uploads/2018/03/2018-01-22-28968-GSTC-CONFERS-Deck-Final.pdf.

CONFERS has developed these guidelines[19] 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".[20] 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.[21] Collaboration between the two should be encouraged.

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.[22] The procedure for the development of national laws is generally less rigid and faster than in international law. If enough States have adopted the same provisions in

19 Guiding Principles for Commercial Rendezvous and Proximity Operations (RPO) and On-Orbit Servicing (OOS) https://www.satelliteconfers.org/wp-content/uploads/2018/11/CONFERS-Guiding-Principles_7Nov18.pdf.

20 CONFERS Recommended Design and Operational Practices https://www.satelliteconfers.org/wp-content/uploads/2019/02/CONFERS-Operating-Practices-Approved-1-Feb-2019-003.pdf.

21 Writing the rules on close-proximity orbital operations, ESA Cleanspace http://blogs.esa.int/cleanspace/2019/07/08/writing-the-rules-on-close-proximity-orbital-operations/.

22 M. Gerhard, 'National Space Legislation – Perspectives for Regulating Private Space Activities', *in* M. Benko and KU Schrogl (ed), *Space Law: Current problems and perspectives for future regulation*, Utrecht, Eleven Publisher, 2005, pp. 75-76.

their national space legislation, over a certain amount of time, such provisions may evolve into customary international law.[23]

Some of the national space legislations differentiate between different kinds of authorisation, either licences or permits, or between different kinds of rockets.[24] 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."[25] 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.

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.[26] 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. If the technical basis for the license is the same, e.g. UN approved guidelines, this risk will be mitigated.

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.[27]

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 to ensure that the OOS

23 M. Ferrazzani, 'Soft Law in Space Activities', *in* G. Lafferanderie and D. Crowther (ed), *Outlook on Space Law over the Next 30 Years*, The Hague, Kluwer Law International, 1997, p. 429.

24 Schrogl, 2018, p. 55; i.e. 51 U.S. Code § 50906 regarding experimental permits.

25 *Ibid.*

26 D. Belcher et al, Analysis Of United States Policy And Legal Impediments To On-Orbit Satellite Servicing Activities, paper presented at the International Astronautical Congress (2014), p. 6.

27 UNCOPUOS, 'Active Debris Removal – An Essential Mechanism for Ensuring the Safety and Sustainability of Outer Space, A Report of the International Interdisciplinary Congress on Space Debris Remediation and On-Orbit Satellite Servicing', 2012, UN Doc A/AC.105/C.1/2012/CRP.16, pp. 44-45.

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.[28]

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.

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.

In a typical OOS mission, the servicer will use RPO capabilities that enable it to go close to and dock on the client. There are even examples of OOS

28 V. Samson, J. Wolny, I. Christensen, Can the Space Insurance Indsutry Help Incentivize the Responsible Use of Space? Paper presented at the International Astronautical Congress (2018), p. 4.

missions that have the objective to remove debris through harpoons or net.[29] Without knowledge of the OOS missions intentions this can be perceived as an armament by other States.

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.[30] 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".[31] Transparency in OOS missions is therefore vital.

4.1.2. <u>Export Control</u>

Due to the security and economic interests of States, many space faring nations have established national export and control regulations.[32] 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.. 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 RPO. As these pictures carry sensitive information, their distribution is restricted by International Traffic in Arms Regulations (ITAR). In example the U.S. ITAR regime has as its purpose to protect the State from sharing information stemming from their satellite parts that could potentially damage U.S. military activities. This export control includes the transfer of jurisdiction and control, of technical data., and Consequently, technical data is not allowed to be transferred without a prior approval by the U.S. State Department. 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.[33]

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

29 e.g. RemoveDEBRIS: https://www.airbus.com/newsroom/press-releases/en/2018/06/RemoveDEBRIS-spacecraft-launched-from-ISS-with-Airbus-space-debris-capture-removal-technology.html or e.deorbit: https://m.esa.int/Our_Activities/Space_Safety/Clean_Space/ESA_s_e.Deorbit_debris_removal_mission_reborn_as_servicing_vehicle.

30 A. Krolikowski, and E. David, 'Commercial On-Orbit Satellite Servicing: National and International Policy Considerations Raised by Industry Proposals', *New Space*, vol. 1, 2013, p. 34.

31 *Ibid.*

32 Y. Nyampong, Legal And Regulatory Challenges To Active Debris Removal And On-Orbit Satellite Servicing Activities, Presentation at SWF/ SSTA Conference in Singapore, 2013 https://swfound.org/media/101969/yaw-legal_regulatory_challenges.pdf.

33 UNCOPUOS 2012, p. 34.

if the export regulation does not create a direct barrier, it does create a hurdle for companies undertaking OOS activities.[34]

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).

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."[35] SSA is part of STM, 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."[36]

The concept of STM is based on "covering access to, operations in, and return from outer space".[37]This approach distinguishes between three STM phases, (i) the launching phase; (ii) the in-orbit operation phase and (iii) the re-entry phase.[38] Phase (ii) is of specific interest for OOS operations. This phase is challenged by the threat of potential collisions by debris, making it necessary to have collision warning and avoidance mechanisms. This which can be achieved by STM.[39] OOS in itself also increases the need for STM, due to the growth of conducted manoeuvres.

STM and SSA both require the geo-political willingness of States to collect and share their data. Whilst SSA and STM will create more transparency, this

34 R. Jakhu, Y. Nyampong, T. Sgobba, 'Regulatory Framework And Organization For Space Debris Removal And On Orbit Servicing Of Satellites', *Journal of Space Safety Engineering*, vol. 4, 2017, p. 131.

35 Space Foundation https://www.spacefoundation.org/what-we-do/government-and-policy/intro-to-space-activities/.

36 Schrogl 2012, p. 17.

37 *Ibid*, p. 4.

38 Y. Henri, Frequency Management And Space Traffic Management, presentation at International Telecommunication Union Space Law Symposium, United Nations Committee on the Peaceful Uses of Outer Space, 2015 http://www.unoosa.org/pdf/pres/lsc2015/symp-04.pdf.

39 Schrogl 2012, p. 10.

is ironically one of their biggest challenges.[40] 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"[41] 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.[42] This underlines the need for an international agreement on STM.

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.[43] 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.[44]

5. Environment

5.1. Space Debris

A UN report on Long-Term Sustainability Of Space Activities states that even without new objects launched into space, "space debris will result in eight to

40 V. Samson, SSA and STM: Current Status And Possible Improvements, presentation at Embry-Riddle Aeronautical University, 2015 https://swfound.org/media/205317/victoria-samson_the-evolving-landscape-of-stm_erau_nov-13-2015.pdf.

41 A. Stickings, 'The Future of EU–US Cooperation in Space Traffic Management and Space Situational Awareness', *Chatham House*, 2019, p. 10.

42 J. Foust, EU agency starts space sustainability initiative, 15 September 2019 https://spacenews.com/eu-agency-starts-space-sustainability-initiative/.

43 Foundation pour la Recherche Stratégique, 'Study On Suitable Governance And Data Policy Models For A European Space Situational Awareness (SSA) System', Contract 21443/08/F/MOS European Space Agency, 2008, p. 3.

44 S. Kaiser, 'Legal And Policy Aspects Of Space Situational Awareness', *Space Policy*, vol. 31, 2015, p. 9.

nine more collisions in LEO by 2050".[45] 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.[46]

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.[47] If a damages is caused by the space debris the launching State might risk becoming liable despite having 'abandoned' it.[48] 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

5.2.1. Incentive for Active Debris Removal

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.

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.[49] 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

45 UNCOPUOS, 'Towards Long-Term Sustainability Of Space Activities: Overcoming The Challenges Of Space Debris' (United Nations 2011) A/AC.105/C.1?2-11/CRP.14.

46 C. Bonnal, D. McKnight, 'IAA Situation Report On Space Debris – 2016', *International Academy of Astronautics*, 2017, p. 135.

47 Jakhu, Nyampong, Sgobba, 2017, p. 131.

48 *Ibid*.

49 C. Henry, Q&A | Astroscale's Chris Blackerby aims to turn a profit by cleaning up space, 14 September 2017, https://spacenews.com/qa-astroscales-chris-blackerby-on-turning-a-profit-by-cleaning-up-space2/.

of debris removal to satellite operators.[50] 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.[51] 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.[52]

6. 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.

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

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

Insurance companies can contribute by

- Incentivising compliance to certain standards

50 A. Nyirady Astroscale, University of Southampton Work on Space Debris Removal, 30 September 2019,https://www.satellitetoday.com/innovation/2019/09/30/astroscale-university-of-southampton-work-on-space-debris-removal/.

51 Airbus RemoveDEBRIS https://www.airbus.com/space/space-infrastructures/removedebris.html.

52 T. Hitchens, DARPA In Talks With New Robot Sat Servicing Company, 3 October 2019, https://breakingdefense.com/2019/10/darpa-in-talks-with-new-robot-sat-servicing-company/.

- Offering OOS insurance

Commercial servicer and client must

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

7. 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.