

# The Importance of an International Funding Mechanism for Active Debris Removal in LEO

*Claudiu Mihai Taiatu\**

## Abstract

The proliferation of space debris and the imminent deployment of large constellations of satellites in LEO could negatively impact the long-term sustainability of outer space activities. A potential solution to clean up space and maintain a sustainable space environment is Active Debris Removal (ADR). The ADR is a potential revenue earning activity, but such activity needs a legal framework that will dissolve the existing concerns. Space law is fundamental for supporting a potential business case for commercial ADR missions. This paper will bring into discussion an international mechanism addressing the financial means for commercial ADR activity with a focus on LEO. By doing so, this paper will address the advent of ADR as lucrative activity and will analyze the proposal to finance an international fund by the launching states and ADR operators in a “Pay or play” fashion.

In particular, this paper will analyze the need of an international funding mechanism for space debris removal and analyze the liability issues affecting the launching state and indirectly the private company with ADR capabilities. This paper aims to answer why private companies should contribute to an international fund for space debris removal depending on the Post-Mission Disposal capabilities of the satellites deployed in orbit and/or ADR solutions identified in case the satellites fail to answer the control commands. Further, this paper will analyze the prospects to manage the activity for ADR by accessing this fund.

*“There has never been a more critical time to work together to address the problem of space debris”*

(Holger Krag, 2019)

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\* LLM (Adv.) in Air and Space Law, International Institute of Air and Space Law, Leiden University, c.taiatu@yahoo.com.

## 1. Introduction

Space private companies are months away from starting a regular, monthly-based, launching campaign of hundreds up to thousands of small satellites in Low Earth Orbit (LEO).<sup>1</sup> Large constellations of satellites raise serious questions in the space community towards the creation of space debris.<sup>2</sup> It is subject of debate how would the LEO satellite operators solve in practice the post mission disposal (PMD) procedures, the removal from orbit of the failed satellites (statistically such risk exists) and/or the risk of in orbit collisions.<sup>3</sup> Would the satellite operators really adhere to stricter rules for PMD and if so, which is the reason behind such effort? Are the satellite operators willing to deorbit the failed satellites and if so, are the satellite operators prepared financially? Or are these only sweet promises aimed to facilitate the licensing of a new space activity?

One of the most important questions in relation to large constellations of satellites, is how would the satellite operators pay for the Active Debris Removal (ADR) of failed satellites.<sup>4</sup> For the satellite operators, ADR is a nonprofit activity, satellite operators will not gain money, they don't have a financial motivation to do it. In fact, if the satellite operators would decide to buy such service, ADR would be regarded as a potential cost for the satellite operators in LEO. The cost for an ADR mission was not made publicly by any operator and a mission for ADR was never completed for satellites in LEO. The only available information is regarding the ESA satellite Envisat which proves how costly is an ADR operation.<sup>5</sup> Another question is how to make a business prediction for ADR missions for LEO commercial satellites based on uncertain or even lack of any data regarding cost of ADR missions?

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1 A. Nyirady, J. Hill, M. Holmes, "Constellations Combined: Iridium and OneWeb Join Forces on New LEO Service", 17 September 2019, <https://www.satellitetoday.com/telecom/2019/09/17/constellations-combined-iridium-and-oneweb-join-forces-on-new-leo-service/>, (accessed 1.10.2019).

See also: E. Kelly, "Space X targeting faster deployment of Starlink internet-beaming satellites", 18 September 2019, <https://eu.floridatoday.com/story/tech/science/space/2019/09/18/spacex-targeting-faster-deployment-starlink-internet-satellites/2361136001/>, (accessed 1.10.2019).

2 H. Krag, "Challenges Posed by Large Constellations", 11 June 2019, [http://www.unoosa.org/documents/pdf/copuos/2019/Topic\\_2\\_Holger\\_Krag\\_Challenges\\_posed\\_by\\_large\\_constellations\\_20190611.pdf](http://www.unoosa.org/documents/pdf/copuos/2019/Topic_2_Holger_Krag_Challenges_posed_by_large_constellations_20190611.pdf), (accessed 16.09.2019).

3 ESA blog, "ESA spacecraft dodges large constellation", 03 September 2019, [https://www.esa.int/Our\\_Activities/Space\\_Safety/ESA\\_spacecraft\\_dodges\\_large\\_constellation](https://www.esa.int/Our_Activities/Space_Safety/ESA_spacecraft_dodges_large_constellation), (accessed 16.09.2019).

4 V. Degrange, "Active Debris Removal: A Joint Task and Obligation to Cooperate for the Benefit of Mankind", in A. Froehlich (Ed.), *Space Security and Legal Aspects of Active Debris Removal*, Springer Nature Switzerland, 2019, pp. 1-17.

5 ESA, "From ADR to IOS: The Legacy of E. Deorbit, Part Four", 01 February 2019, <http://blogs.esa.int/cleanspace/2019/02/01/from-adr-to-ios-the-legacy-of-e-deorbit-part-four/>, (accessed 16 September 2019).

The potential return on investment (ROI) for satellite operators in contracting ADR operators should be based on other types of benefits such as focusing on avoiding collisions, minimizing collision alerts and paying lower insurance premiums. The funding mechanism for ADR poses many questions and some of them will be underlined by this research.

## 2. The Space Industry

### 2.1. Large Constellations Satellite Operator's Perspective

LEO is known as one of the most congested regions in earth orbit and hence the risk in LEO is greater for the proliferation of space debris. In-orbit operations for the large constellations of satellites in LEO would need to be managed responsibly in order to avoid collisions. The deployment and operation of large constellation satellites includes two phases of in-orbit operations supervised by the Satellite Operations Centre (SOC). The first phase of the space segment is the launch and early ops (LEOP) which would prepare the satellites to be deployed from the dispenser, to point their antennas to Earth and contact the ground control. The LEOP mission director will make sure the satellites are safe and healthy. The second phase is the in-orbit testing (IOT) which implies that LEOP phase was successful, that satellites were contacted and can be controlled from the ground. During the IOT phase, the satellites will start raising orbit.

OneWeb, SpaceX, Telesat and Amazon are some of the large constellations satellite operators planning to deploy satellites in LEO. It is reasonable to underline that the procedure of deploying the satellites in orbit could not be guaranteed as an error-free procedure. Despite the great efforts made by the satellite operator, it may be impossible to guarantee that all the satellites will work as planned. It would be recommendable the rate of failure not to exceed 1% but an error could happen any time and the satellite operators should be prepared to act quickly and responsibly. According to the Space Safety Coalition (SSC) "Best Practices for the Sustainability of Space Operations", operators of spacecraft that use chemical or electric propulsion to deorbit, should strive to complete the deorbit phase within 5 years of end-of-mission.<sup>6</sup> The SSC Best Practices are applicable to large constellations using electric propulsion, representing an initiative from the satellite industry to develop a practice above the current guidelines. The solution of deorbiting within 5 years after the end of mission, instead of 25 years as proposed by the IADC Guidelines is both supported by SpaceX and OneWeb.<sup>7</sup>

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6 Space Safety Coalition, "Best Practices for the Sustainability of Space Operations", Article 5 (h), 16 September 2019, [https://spacesafety.org/wp-content/uploads/2019/09/Endorsement-of-Best-Practices-for-Sustainability\\_v22.pdf](https://spacesafety.org/wp-content/uploads/2019/09/Endorsement-of-Best-Practices-for-Sustainability_v22.pdf), (accessed 4.10.2019).

7 Federal Communication Commission, DA 19-342, Paragraph 21, 26 April 2019, <https://docs.fcc.gov/public/attachments/DA-19-342A1.pdf>, (accessed 6.10.2019).

### 2.2. Active Debris Removal Operator's Perspective

ADR was identified by ESA as a strategic goal.<sup>8</sup> It was underlined that such technology would be necessary to stabilize the growth of space debris, in particular, to compensate the non-compliance for post-mission disposal. ADR could be successfully used to de-orbit failed satellites and would be most effective when satellites are physically intact. However, as efficient the ADR technology would be, it could be useful only with an efficient framework for the management of ADR activities which currently does not exist.<sup>9</sup> ADR entails economic, policy and legal concerns, necessitating a multidisciplinary approach.<sup>10</sup>

Liability is a main challenge for ADR operators. According to Article VII of the 1967 Outer Space Treaty (OST), complemented by the provisions of Article III of the Liability Convention establishes a fault-based liability for damage occurring in outer space. None of these provisions take into consideration a space debris removal mission.<sup>11</sup> In this situation, it can be concluded that the ADR operators would be currently treated without the consideration of the risk of their activity to remove the debris. It could be reasonably raised the question if the ADR operators should be in position to risk their entire business for a failed ADR mission. Jurisdiction and control of the space object stated by Article VIII OST is another main challenge for ADR missions. No entity is entitled to take control, even for ADR purposes, without the prior consent from the State of registry, which has the exclusive rights to supervise the in-orbit activities of that object, both governmental/or privately owned and/or operated.

### 2.3. Active Debris Removal vs. End-of-Life Services

ADR is not a revenue earning activity. This could be explained by the fact that ADR would only be necessary for failed satellites or for satellites that are already decommissioned and no longer provide services. Many of the ADR systems proposed are at conceptual/experimentation phase and reasonably require more development until being considered as commercially viable

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8 ESA, "Active Debris Removal", 14 April 2017, [https://www.esa.int/Our\\_Activities/Space\\_Safety/Space\\_Debris/Active\\_debris\\_removal](https://www.esa.int/Our_Activities/Space_Safety/Space_Debris/Active_debris_removal), (accessed 1.10.2019).

9 N. Okada, "Commercial Space Debris Removal Solutions", UNISPACE +50 Space and Industry, 18 June 2018, [http://www.unoosa.org/documents/pdf/unispace/plus50/Presentations\\_SYMPOSIUM/Okada\\_Astroscale.pdf](http://www.unoosa.org/documents/pdf/unispace/plus50/Presentations_SYMPOSIUM/Okada_Astroscale.pdf), (accessed 1.10.2019).

10 V. Nardone, "Dispute Resolution in the Context of ADR: A public International Law Perspective", in A. Froehlich (Ed.), *Space Security and Legal Aspects of Active Debris Removal*, Springer, 2019, pp. 17-31.

11 M. Frigoli, "Between Active Debris Removal and Space-Based Weapons: A Comprehensive Legal Approach", in A. Froehlich (Ed.), *Space Security and Legal Aspects of Active Debris Removal*, Springer, 2019, pp. 49-71.

platform. ADR systems could be classified into collective, laser-based, ion-beam shepherd-based, tether-based, sail-based, unconventional, and dynamical systems-based methods.<sup>12</sup> In fact, ADR could be referred to as a faster or as a back-up method for Post Mission Disposal, as an alternative to the natural decay of space debris caused by the atmospheric drag, which depending on the orbit, may remain in orbit for few centuries.<sup>13</sup> ADR is a cost with an indirect revenue earning. It is technically difficult and financially expensive to eliminate old spacecraft, especially if the satellite or rocket was not designed for disposal.<sup>14</sup> However, for the future generations of spacecraft, solutions should be integrated by design in order to bring the price down for future ADR missions.

The first commercial space debris removal company is Astroscale, founded in 2013. Astroscale makes a difference between ADR and End-of-Life (EOL) services. Basically, Astroscale understands to develop its services under the concept of EOL service missions in order to avoid the regulatory issues faced by ADR missions to remove existing debris, including international liability and cost-sharing. Astroscale will focus on retrieving satellites under the framework of an agreement/a business contract with the large constellation satellite operator that requests this service. The ADR operator would also need a license issued by the licensing authority of the launching state where the company is incorporated.<sup>15</sup> The approach of Astroscale for EOL is important from a business perspective. The large constellation satellite operators have the option to dispose of the satellites within five years of the end of its mission, and once they will request this service, the ADR operator will need to follow a business model and a legal framework.

### 3. The Way Forward

#### 3.1. The Funding Mechanism for Active Debris Removal in Low Earth Orbit

The avoidance of space debris and solutions for financing the activity of ADR in LEO may be summarized in 3 main steps, also highlighted by the Director

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12 C. P. Mark, S. Kamath, "Review of Active Space Debris Removal Methods", Elsevier Space Policy, Volume 47, pp. 194-206, February 2019, <https://doi.org/10.1016/j.spacepol.2018.12.005>, (accessed 2.10.2019).

13 D. Wood, "Recognizing Sustainable Behaviour", 6 May 2019, [https://m.esa.int/Our\\_Activities/Space\\_Safety/Space\\_Debris/Recognising\\_sustainable\\_behaviour](https://m.esa.int/Our_Activities/Space_Safety/Space_Debris/Recognising_sustainable_behaviour), (accessed 3.10.2019).

14 The Aerospace Corporation, "Space Debris and Space Traffic Management", 14 November 2018, <https://aerospace.org/article/space-debris-and-space-traffic-management>, (accessed 3.10.2019).

15 M. Okada, A. Okamoto, K. Fujimoto, M. Ito, "Maximizing Post Mission Disposal of Mega Constellations Satellites Reaching End of Operational Lifetime", April 2017, <https://pdfs.semanticscholar.org/0edf/cda2a7da4b880d81201a08bc7b24f5da916d.pdf>, (accessed 2.10.2019).

General of European Space Agency at the European Space Policy Institute (ESPI) Autumn Conference in 2019 in Vienna:

- 1) It should exist a redundant (independent system) on board.  
Such system will assure the capability of the satellites to deorbit automatically in case a satellite fails during the injection stage to orbit. This solution will assure a level of autonomy in case the satellite system fails. However, the main system will deorbit the satellite in case the redundant system fails.
- 2) The satellite operator should contract an ADR company. In case all the satellite systems fail, both the redundant (independent) and the satellite build, then an ADR company will have the permission to operate and deorbit the satellite. Contracting an ADR operator may be left to the satellite operator.
- 3) Deposit at trustful organization, in case the satellite is not deorbited by the satellite operator, the organization makes the deal with the ADR operator. Open an escrow account.

Dr. Mejía-Kaiser published several studies in relation to a mechanism for removing space debris.<sup>16</sup> In 2010, the author proposed a “self-enforcing mechanism, where third parties perform space debris removal, with the incentive of the payment by insurance”.<sup>17</sup> Among the elements discussed in Dr. Mejía-Kaiser research it was highlighted the need for an external removal arrangement in case of spacecraft malfunctioning, funded by the insurance underwriters or other financial sponsors.<sup>18</sup> In 2019, Dr. Mejía-Kaiser published an updated research about the removal of space debris. When referring to legal issues, the author underlined that “there are no legal obstacles for the execution of active space debris removal of own space objects”.<sup>19</sup> While the idea of an international funding mechanism is not new,<sup>20</sup> the funding mechanism for LEO developed in my paper implies an access fee imposed directly to large satellite constellation operators for the purpose of an ADR fund. As it will be further explained, this could be made by depositing the money in an escrow account and provide a pre-

16 M. Mejía-Kaiser, Social Sciences Research Network, 2019, [https://papers.ssrn.com/sol3/cf\\_dev/AbsByAuth.cfm?per\\_id=3412227](https://papers.ssrn.com/sol3/cf_dev/AbsByAuth.cfm?per_id=3412227), (accessed 21.11.2019).

17 M. Mejía-Kaiser, “Removal of Hazardous Space Debris”, in J. Pelton, R. Jakhu (Eds.), *Space Safety Regulations and Standards*, Elsevier/Butterworth, 2010, Chapter 27, pp. 371-382.

18 Ibid. *supra* note 17, M. Mejía-Kaiser, 2010.

19 M. Mejía-Kaiser, “Out into the Dark: Removing Space Debris from the Geostationary Orbit”, in IISL, *Proceedings of the IISL Colloquium on the Law of Outer Space*, Eleven Publishing, Washington, D.C., U.S.A., IAC-19.E7.7.2., 2019, <https://iafastro.directory/iac/paper/id/54110/summary/> and [https://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=3482010](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3482010), (accessed 21.11.2019).

20 Ibid. *supra* note 17, M. Mejía-Kaiser, 2010.

authorization to deorbit the satellite, given to an international organization and/or to a space agency.

To fund the activity of space debris removal, the large constellation satellite operators may be subject to an access fee, its level depending on the compliance with ADR solutions. Once the international space community would agree on the opportunity to implement a funding mechanism for ADR applicable to large constellations of satellites, it is important to identify what elements will set the level of contribution for the satellite operators. The funding mechanism should give the satellite operators the freedom to choose their ADR providers. In case of non-compliance by the large constellation satellite operators, it is crucial to split responsibility and thus, it could be reasonably highlighted a remedy which would include pre-approval to contract an ADR operator and the power to dispose of the funds, given to an international organization. The funding mechanism could be supported at international level, especially if an organization will oversee the ADR activities.<sup>21</sup>

The funding mechanism implies the private companies to contribute. However, the mechanism will imply the involvement of an international organization to supervise ADR mission, national licensing authorities to impose the obligation for funding, space insurers to adapt their fees on insurance premium depending on the compliance with ADR solutions and space agencies to support through PPP the implementation of the technology and enable a business model for ADR operators. Currently, the satellite operators have no obligation to contract an ADR operator. If the satellite operator will however contract the ADR operator, he will directly negotiate the conditions, including fees. Also, there are currently no examples of ADR missions deorbiting failed satellites in LEO. It should be underlined that it would be very difficult to determine the access fee based on an estimation of costs for ADR missions without a rating system to analyze the performance and assess the capabilities of the satellites for space sustainability. Also, without a space traffic footprint to assess how crowded the area and who operates there, it will be difficult to assess the risk and establish an access fee.

### **3.2. Access and Use of the Active Debris Removal Fund**

Subject to the analysis for establishing the ADR fund, it has to be clarified who has the right to access it. Could the satellite operators access the ADR fund to contract ADR services? Would this be possible only on an exceptional basis? or such fund could only be used and accessed by an organization in case of non-compliance of the satellite operators? Which is the legal content for the non-compliance of the satellite operators? Could be considered as a non-compliance the fact that a satellite operator did not

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21 Z. Tian, "Proposal for an International Agreement on Active Debris Removal", in A. Froehlich (Ed.), *Space Security and Legal Aspects of Active Debris Removal*, Springer, 2019, pp. 107-131.

contract the ADR services from their own funds in a given period? These questions should be answered by underlining in what conditions the satellite operator has the option to choose the ADR operator. Also, it is necessary to clarify if the pre-approval to use the funds and contract an ADR operator implies to indicate the exact ADR operator or this should remain at the sole decision of that organization.

If such a fund would have existed today and an international organization would have the power to contract an ADR operator in behalf of the satellite operator who did not comply with this obligation, then the question that would be raised would be if the ADR operator could be from another country, or would the ADR operator need to have the same nationality with the satellite.

Also, it has to be decided if this fund will be managed by the national authorities or should be managed internationally. If the ADR fund will be managed by an international organization, it will be necessary to set criteria to assure an equitable basis to access and use this fund. If accessing the fund internationally, the problem may be raised by the large constellation satellite operators if some countries will access more money than others. For example, if OneWeb and SpaceX both contribute to this fund but only one of them would use the fund, then the other satellite operator would raise the problem of funding the ADR mission for the other company from its own funds. Also, if more satellites will be deployed in orbit, it would mean that one satellite operator will contribute more to the fund and if so, should this fund only be accessed for that constellation or should be a common fund. Therefore, it is very important to establish the conditions and/or criteria the funds could be accessed and distributed towards the ADR missions. It is also necessary to establish the legal basis of the selection of the ADR operators, whether pre-approved or on the basis of a competitive selection.

### **3.3. International Organization for Oversight of Removal Activities**

The creation of an international organization tasked with the supervision of ADR missions could strengthen international cooperation and assure a high degree of transparency in the selection of ADR operators, distribution of funds and scope of the mission.

In 2010, Dr. Mejía-Kaiser proposed an International Technical Institution. This international organization should “inform the State of registry and the owner and/or operator about the hazardous nature of its object” and then “request the owner and/or operator for the removal of a space debris object, and inform the State of registry on that request”. Upon such notification and in the case the space debris owner would not remove the space debris until the deadline set for its removal “third parties can perform the removal of the hazardous space debris without the prior consent of the owner and/or operator and State of registry (...)”.<sup>22</sup> While the idea of an international

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22 Ibid. *supra* note 17, M. Mejía-Kaiser, 2010.



organization to supervise/coordinate ADR was previously proposed, additional questions arise in relation with the new approach for the funding mechanism, when a deposit and prior authorization is requested to large constellations of satellite operators. This organization should be pre-authorized by the satellite operator and by the licensing state for the removal of failed satellites. It is important to clarify the procedure followed by the international organization to contract an ADR mission in case of non-compliance by the satellite operator.

Would it be necessary to have a consensus among the stakeholders in regards of the funds distributed, the urgency of the ADR mission (if more missions would be necessary) and the selection of the ADR operator? Similar to the insurance market, someone would have to decide the amount of money and which company may be selected to operate the mission, proportionally with the damage and award the satellite operators that comply (provide incentives). Another important element to be decided in the agreement with the ADR operator, would be regarding liability which is essentially a significant concern for the satellite operator, the ADR operator and the third party.

It is important to develop an “ecosystem” within the space industry that supports sustainability, creating business opportunities in order to become attractive.<sup>23</sup> The large constellation satellite operators are aware that the reliability of their satellites impacts the sustainability of outer space and should prepare solutions to deorbit the failed satellites. As OneWeb representative points out “Once it fails in orbit, it becomes everybody’s else’s problem (...)”.<sup>24</sup> The international organization could be part of this ecosystem, on one hand supporting space sustainability and supervising the satellites to be deorbited and on the other hand, support the private ADR operators to accomplish the ADR mission.

#### **3.4. Licensing Process**

The licensing process is part of national space law and a State can impose conditions for the satellite operators. Article VI OST imposes duties as to licensing and supervision.<sup>25</sup> “States have taken upon themselves the explicit obligation that such activity will require their authorization and continuing supervision” so that they could bear direct responsibility for any such activity.<sup>26</sup> Licensing can be requested per launch of a single space object (not recommended for large constellations of satellites, as the cost may become

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23 J. Foust, “Can satellite megaconstellations be responsible users of space?”, 3 September 2019, <https://spacenews.com/can-satellite-megaconstellations-be-responsible-users-of-space/>, (accessed 4.10.2019).

24 Ibid. *supra* note 23, J. Foust, 2019.

25 F. Lyall, P.B. Larsen, *Space Law: A treatise*, 2nd Edition, Routledge, 2017, pp. 49-75.

26 M. Lachs, *The Law of Outer Space, An Experience in Contemporary Law-Making, Reissued on the Occasion of the 50th Anniversary of the International Institute of Space Law*, Martinus Nijhoff Publishers, 2010, p. 114.

prohibitive) or it can be a launch license issued to a satellite operator including a number of launches on a certain period under certain specifications (recommended for large constellations of satellites where satellites are mass produced and share the same platform and specifications). In this context, the licensing authority could impose an obligation to satellite operators to adhere to a funding mechanism for ADR and contribute with a fee in an escrow account.<sup>27</sup>

### **3.5. Space Insurance Market**

Against potential liability from in orbit collision, the licensing authorities may impose the obligation to satellite operators to provide insurance. Currently, the space insurers require different costs on insurance depending on the reliability of the rocket systems. It could be underlined that currently no similar system exists for the satellites. It is reasonable to consider that the large constellation satellite operators would support the development of a rating system for the satellites depending on the compliance with ADR solution. The rating system of the satellites will represent a criterion for the space insurers to set the insurance premiums. Depending on the solutions for ADR mitigation and remediation proven by the satellite operator, the insurers may impose a different cost for insurance premiums. The insurance market will be positively impacted by the successful development of such rating which will allow the space insurers to quantify the risk of collisions and foresee the estimated annual costs with the insured events.

### **3.6. Space Sustainability Rating**

The World Economic Forum (WEF) Global Future Council on Space Technologies developed the concept of Space Sustainability Rating (SSR).<sup>28</sup> Currently the satellites are not categorized by their impact on space sustainability. There is no standard information that could be compared to assess each satellite. Satellites are usually individual design, according to the specifications of the satellite operator. So far, most satellite operators were the Governments who operated spacecrafts in orbit, and they did not need a space sustainability rating, it was the beginning of space age. However, such rating will be useful for future missions. The scope of the SSR could be reasonably underlined as to encouraging and rewarding, spotlight those missions that contribute positively to the space environment. The SSR is therefore a procedure, meaning they will be designed to de-orbit at the End of Life or with standard fixture to help ADR companies. The need of a “new

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27 C. Banton, “Escrow”, 19 April 2019, <https://www.investopedia.com/terms/e/escrow.asp>, (accessed 4.10.2019).

28 World Economic Forum, “Global Future Council on Space Technologies”, 2019, <https://www.weforum.org/communities/the-future-of-space-technologies>, (accessed 13.09.2019).

global governance framework and new metrics for measuring the Space economy” was underlined by WEF.

### 3.7. Best Case Scenario

The best case scenario in relation to ADR would be if all space actors involved in LEO would agree that ADR is fundamental for sustainable space and would agree contributing towards an international fund that would be accessible in case of non-compliance of the satellite operator with the (voluntarily) obligation to de-orbit the satellites at end-of-life or in case of failure. This would be the only way to finance the operation of cleaning space in case of failed satellites that would endanger the already congested traffic in LEO. The best-case scenario would mean that an international funding mechanism would be agreed to finance ADR.

### 3.8. German Recycling Law as a Model for the Funding Mechanism

The German recycling law is a relevant model for the ADR funding mechanism. The German new Packaging Act (VerpackG) introduced a stricter policy and new rules for packaging producers who sell their goods in Germany. The Central Packaging Registry was established as an organizational and control authority for legally compliant distribution of packaging and recycling.<sup>29</sup> From 1 January 2019, retailers and manufacturers are obliged to register with the Central Registry *before* placing packaging with mandatory system participation on the market.<sup>30</sup> The law also obliges the “first distributor” of sales packaging to be responsible for its disposal and/or recycling.<sup>31</sup> The German Central Authority was set up to increase the transparency of the overall system and to support the enforcement authorities. The same role of enforcement could be attributed to the ADR international organization to contract an ADR operator for deorbiting the failed satellites and to supervise the compliance of the satellite operators for the ADR missions in accordance with the ADR funding mechanism.

## 4. Conclusions

This paper underlined the importance and analyzed the elements of a proposed funding mechanism for ADR in LEO, highlighting the multidisciplinary challenges for ADR in relation with the large constellation

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29 H. Schmitz, “The New German Packaging Act as of 1st January 2019, The Most Important Facts and Changes for Manufacturers and Distributors”, January 2019, <https://www.gruener-punkt.de/en/services/packaging/german-packaging-act.html>, (accessed 3.10.2019).

30 Lizenzero, “The New German Packaging Act: What you Need to Know”, 1 January 2019, [https://www.lizenzero.de/media/pdf/3a/87/c8/190205-ISD-Lizenzero-Whitepaper-DINA4\\_werblich\\_ENG\\_A.pdf](https://www.lizenzero.de/media/pdf/3a/87/c8/190205-ISD-Lizenzero-Whitepaper-DINA4_werblich_ENG_A.pdf), (accessed 3.10.2019).

31 Ibid. *supra* note 30, Lizenzero, 2019.

satellite operators and ADR operators and the perspective of a future ADR business model in LEO.

The satellite operators understand their responsibility to avoid creating space debris and collisions and intend to deorbit their satellites within 5 years after the end-of-mission on the basis of the Space Safety Coalition “Best Practices for the Sustainability of Space Operations”.

Because ADR is not a revenue earning activity, the analysis showed that is necessary for the large constellations satellite operators to consider additional precaution measures to guarantee that ADR will happen. Participating in an international funding mechanism for ADR would allow an international organization to take the lead and access the fund in case of non-compliance. The funding mechanism implies an access fee imposed to large satellite constellation operators for the purpose of an ADR fund. The level of this fee would depend on the level of compliance with ADR solutions. If the large constellations satellite operators demonstrate they have a low risk to produce a collision, they should benefit from lower insurance premiums and/or a more light-handed licensing approach.

The findings of this paper support the establishment of an international organization that will contract an ADR operator and access the fund in case the satellite operator would not comply with ADR. The access fee could be imposed by the national licensing authority/space agencies as a condition for issuing the license. The satellite operator would deposit the money in an escrow account and provide a pre-authorization to deorbit the satellite. Among the relevant aspects of this topic that remain to be clarified, include: (i) who will access the ADR fund; (ii) who will determine the amount of money and (iii) how will the ADR operator be selected.

This paper highlighted the importance for creating the ADR funding mechanism due to the risk of failures and collisions during the large constellations satellite missions. From a legal perspective, the challenge is to find solutions to reduce space debris while implementing a funding mechanism for ADR.

Overall, this paper should be regarded as an effort in underlining the importance of moving forward sustainably and create a new business incentive for the removal of satellites from orbit especially designed for large constellations of satellites in LEO.