ARTICLE IN PRESS
JID: JSSE [m5G;November 7, 2017;1:7]
Journal of Space Safety Engineering 000 (2017) 1–9
Contents lists available at ScienceDirect
Journal of Space Safety Engineering
journal homepage: www.elsevier.com/locate/jsse

Regulatory framework and organization for space debris removal and on orbit servicing of satellites

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ARTICLE INFO

Article history:
Received 28 September 2017
Revised 19 October 2017
Accepted 24 October 2017
Available online xxx

ABSTRACT

The challenges posed by increasing space debris are becoming so severe that sustainable use of space will be seriously jeopardised. Technical means for mitigation of debris in orbit can be expected to minimize the production of *new* pieces of debris. However, mitigation efforts must be accompanied by active debris removal (ADR) of *existing* pieces of debris from space in order to effectively protect the space environment. Additionally, on-orbit servicing (OOS) of satellites may also help in reducing pieces of space debris. However, both ADR and OOS cannot be effectively undertaken due to the existing complex legal problems, primarily at international level. One way of resolving these legal problems is to establish an international regulatory framework as well as an intergovernmental organization that will conduct ADR and OOS activities. This brief paper, discusses a proposal for an integrated development of operational, institutional and international regulatory framework and the creation of an intergovernmental organization (based on the models of earlier international satellite organizations like INTELSAT and INMARSAT) for carrying out active space debris removal and on-orbit servicing of satellites.

1. Introduction

The problem of space debris has reached a ‘tipping point’.[1] Future scenarios painted by several authoritative studies indicate that, if no action is taken to remove several of the existing debris (at least the big pieces) from orbit, the situation will become so severe that sustainable use of space, especially in Low Earth Orbit (LEO), will be seriously jeopardised.[2] Particularly, with the growing trend towards orbiting small satellite constellation(s) consisting of few hundreds to thousands of satellites may aggravate the situation, particularly in the low earth orbit, and this race towards creating mega satellite constellation is of utmost concern.[3] (For more details see generally, the Global Space Governance: An International Study)

As a result of little over 5000 space missions undertaken since 1957, it is estimated that, currently, there are in orbit more than 21,000 human-made objects larger than 10 cm in diameter, about 600,000 objects measuring between 1 and 10 cm in diameter, and many hundreds of millions between 1 mm and 1 cm. Over 95% of the about 16,000 catalogued objects larger than 10 cm are non-functional objects (i.e., pieces of space debris). A fairly large proportion of space debris is concentrated in Low Earth Orbit (LEO) below 2000 km and in the Geostationary Orbit (GEO) at an altitude of 36,000 km above the Earth’s equator.[4]

There are various sources of space debris. The principal one, which accounts for up to 57% of the total junk in space, is the break-up of spacecraft and rocket bodies.[5] This is because of the explosion of leftover fuel or other reactive chemicals in rocket en-

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1 [13].

2 “As NASA and other organizations that operate in space have come to realize, if the amount of orbital debris in LEO is not curtailed, it could limit - or potentially eliminate - space exploration.” stated in, NASA, Orbital Debris Management & Risk Mitigation, online: <https://www.nasa.gov/pdf/692076main_Orbital_Debris_Management_and_Risk_Mitigation.pdf⟩ at 26.

3 Ram S. Jakhu & Joseph N. Pelton eds, “Small Satellites and Large Commercial Satellite Constellations” in Global Space Governance: An International Study (Switzerland: Springer, 2017) at 369-373; See generally, IADC, Statement on Large Constellations of Satellites in Low Earth Orbit, (IADC: February, 2016) online: < http://www.iadc-online.org/Documents/IADC-15-03%20Megaconstellation%20Statement.pdf⟩.

4 This data is rough and broad approximation gathered from various sources, including: NASA, “Space Debris and Human Spacecraft” (updated 4th August 2017) available at https://www.nasa.gov/mission_pages/station/news/orbital_debris.html; ESA, “Call for a Sustainable Future in Space”, (21 April 2017), available at http://m.esa.int/Our_Activities/Operations/Space_Debris/Call_for_a_sustainable_future_in_space -

5 [16], a paper presented at the International Interdisciplinary Congress on Space Debris Remediation, held on 11 and 12 November 2011, at McGill University, Montreal, Canada.

https://doi.org/10.1016/j.jsse.2017.10.002
2468-8967/

Please cite this article as: R.S. Jakhu et al., Regulatory framework and organization for space debris removal and on orbit servicing of satellites, Journal of Space Safety Engineering (2017), https://doi.org/10.1016/j.jsse.2017.10.002

gines and fuel tanks used for launches. In addition, mission-related debris and rocket bodies that remain in orbit together account for 22%, and inoperable or non-functional satellites account for another 15%.[6]

Space debris is expected to continue to grow, even without additional launches. According to a Study, "even without any new launches, the growth in the amount of space debris will result in eight to nine more collisions in LEO by 2050, with half of those being of the same catastrophic nature as the Iridium-Cosmos collision which occurred in 2009." [7] According to Eugene Levin, as the space debris situation deteriorates, a collision like Cosmos-Iridium is bound to happen and "we may witness another catastrophic collision in this decade." [8]Space debris seriously threatens the sustainability of space utilization since it is considered to be an emerging navigation hazard to functional or operating satellites, especially after the collision of the Iridium 33 operational satellite with the Cosmos 2251 non-functional space object in February 2009.[9] The number of warnings of conjunction assessments as well as of collision avoidance manoeuvres has been increasing significantly. Pieces of space debris that survive re-entry into the atmosphere fall back onto the surface of the Earth. They could cause injury or death as well as damage to property and the environment. It is interesting to recall the 1978 crashing of the Soviet satellite COSMOS 954 which scattered radioactive debris over a large area of Canadian territory.[10]

It is therefore imperative that debris in orbit must be mitigated. For this purpose, various techniques, standards, procedures, guidelines and recommendations are being adopted and applied both at national and international levels. Most visible efforts in this regard can be viewed as coming from the Inter-Agency Space Debris Coordination Committee (IADC), which is an international forum or platform for governmental bodies created for the purpose of coordination in mitigation activities with regard to man-made space debris.[11] Such national and international efforts can be expected to minimize the production of *new* pieces of debris, if fully, strictly and universally complied with. However, it is generally believed that mitigation efforts must be accompanied by active debris removal (ADR) of *existing* pieces of debris from space in order to effectively protect the space environment. A recent In addition, on-orbit servicing (OOS) of satellites may also serve as an important tool for reduction of pieces of debris as non-functional satellites may be refueled or serviced while in orbit in order to bring them back into operation.

Various options are being discussed and developed for undertaking active debris removal and on- orbit servicing of satellites.[12] Interesting study with regard to success rate of ADR has been carried out at the Southampton University, which contends that the ubiquitous assumption of ADR missions being always successful is unrealistic and further suggests that ADR missions being complex, may at times fail and themselves result in creation of debris. This study concludes that successful efforts towards removal of debris, particularly in the LEO, requires that ADR research must count in the failure rate of the ADR missions.[13] While it may take considerable time for ADR technologies to mature to a point where ADR missions are robust and highly accurate with high success rates and thus, the adoption and use of these technical solutions will depend upon their technical feasibility and economic viability. However, most importantly, such technical solutions must be compatible with the existing international regulatory regime. There are complex and challenging legal issues, primarily at the international level, that relate to active space debris removal and on orbit servicing of a space object (i.e., a functional or non-functional satellite) that is owned and/or controlled by a foreign State or its private entity. In this paper, we will address some of the most important issues with a view to underlining the importance of resolving them *a priori* to pave the way for any technical means to be used for ADR and OOS. One way of resolving international legal problems is to establish an international regulatory framework as well as an international/intergovernmental organization that will undertake the development or procurement of the required technology and eventually conduct ADR and OOS activities.

The object of this brief paper is to put forward a proposal that aims at: (1) the development of an international regulatory framework for active debris removal and on-orbit servicing of satellites; and, (2) the establishment of an international/intergovernmental organization to conduct ADR and OOS of satellites.

Before we address the question related to the international regulatory framework and organization, it will be helpful to understand some important terms used in this paper. The term ADR is used here to include rendezvousing, capturing, stabilizing, towing, transferring to a disposal/graveyard orbit or relocating, and deorbiting through orbital maneuvers for active or passive re-entry into the Earth's atmosphere. OOS indicates capability of refueling, repairing, or upgrading satellites that have become non-functional while in space. A NASA Report on OOS concludes that "On-orbit repair and refurbishment have matured to the point where they can be applied to fairly complex satellite systems. … On-orbit repair and refurbishment directly improves overall mission reliability and helps to ensure mission success." [14] In addition, OOS extends the lives of defunct (non-functional) satellites, thus reducing the number of pieces of space debris and consequently avoiding the creation of new space debris that might result from collisions among non-functional satellites. Thus, OOS is a means of space debris mitigation and remediation.[15]

2. Rationale for an international regulatory framework and organization

There are major legal, political and financial challenges that presently prevent or pose difficulty to (or may in the future hinder) the conduct of active debris removal and on-orbit servicing activities.

At the outset, the following three important basic factors, also international legal realities, must be kept in mind with respect to ADR and/or OOS: First, the term "space object" includes satellites, component parts of a space object, launch vehicle and parts

6 Ibid.

7 Cf. Towards Long-term Sustainability of Space Activities: Overcoming the Challenges of Space Debris- A Report of the International Interdisciplinary Congress on Space *Debris* [12]; UN Document, A/AC.105/C.1/2011/CRP.14.

8 [17], at McGill University, Montreal, Canada. Levin refers to: D.J. Kessler, N.L. Johnson, J.-C. Liou, M. Matney, The Kessler Syndrome: implications to future space operations, AAS 10-016, Advances in the Astronautical Sciences, vol. 137, American Astronautical Society, 2010, pp. 47–62.

9 Ram Jakhu, "Iridium-Cosmos Collision and its implications for Space Operations" in Kai-Uwe Schrogl, et al (eds.) Yearbook on Space Policy: 2008/2009, Springer, WienNewYork, 2010, pp. 254-275.

10 Ibid.

11 IADC, Terms of Reference of the Inter-Agency Space Debris Coordination Committee, online: < http://www.iadc-online.org/Documents/IADC_TOR_rev_11.3_public.pdf⟩.

12 Ram S. Jakhu & Joseph N. Pelton eds, "On-Orbit Servicing, Active Debris Removal, and Related Activities" in Global Space Governance: An International Study (Switzerland: Springer, 2017) at 335-340.

13 See generally, Adam E. White & Hugh G. Lewis, "The Many Futures of Active Debris Removal" (2014) 95 Acta Astonautica 189 at 189-197, online: <https://eprints.soton.ac.uk/360565/⟩; Hugh G. Lewis & Aleksander Lidtke, "Active Debris Removal: Consequences of Mission Failure" (2014) A6 International Astronomical Conference 58, online: <https://www.southampton.ac.uk/~hglewis/presentations/ADR-FAILURE-POSTER.pptx⟩.

14 NASA, On-Orbit Satellite Servicing Study Project Report, October 2010, p.6

15 Ibid, p. 35.

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