"Leviathan Lite" - Towards a Global Stewardship Organization for Space Domain Awareness, Conduct, And Remediation

*Harrison E. Kearby, John M. Horack, Elizabeth K. Newton**

Abstract

This paper examines the dimensions, legal and policy implications, and ramifications of a proposed International Space Situational Awareness Organization (ISSAO), whose charter would be to provide leadership for international and collaborative stewardship of the space environment in LEO and beyond. As ever more satellites, rockets, and space stations are launched into space, the need for debris tracking, debris remediation, orbital traffic deconfliction, and definitions of 'best practices in care-taking the space environment' grow. Current organizations and programs are successful, at least to some extent, in educating the world on the potential dangers of space debris, and the importance of space situational awareness, yet they have little legal or political standing to provide enforcement, compliance, or remediation. Many global discussions related to space situational domain awareness have called for a cooperative international effort to create guidelines, if not charter an organization tasked with the stewardship of the space environment. Here, we examine important precedents set forth in international law and cooperation, and apply these to a proposed comprehensive body to steward space situational awareness and debris mitigation. We elucidate the requirements, enforceable powers, and probable limits of such an organization as well as important questions to be answered prior to establishment of such a body.

Keywords: Satellite Regulation, Space Traffic Management, Social Contract

* Harrison E. Kearby, Department of Mechanical and Aerospace Engineering, John Glenn College of Public Affairs, The Ohio State University. John M. Horack, Department of Mechanical and Aerospace Engineering, The Ohio State University. Elizabeth K. Newton, John Glenn College of Public Affairs, The Ohio State University.

Acronyms/Abbreviations

Geostationary Earth Orbit (GEO)
Hartford Steam Boiler Inspection and Insurance Company (HSB)
International Space Situational Awareness Organization (ISSAO)
ISS Intergovernmental Agreement (IGA)
Low Earth Orbit (LEO)
Outer Space Treaty (OST)
Space Situational Awareness (SSA)
Space Traffic Management (STM)
Secure World Foundation (SWF)
UN Committee of Peaceful Uses of Outer Space (UNCOPUOS)
Underwriters Laboratories (UL)

1. Introduction

In 2007 and 2009, two major events, the Chinese Anti-Satellite missile test and the Iridium collision, respectively, opened the world's eyes to the issue of space debris and space traffic management. Before these two events, an estimated 5,000 pieces of fragmentation debris were in orbit. These two events doubled, however, the amount of debris to almost 11,000 fragments. The problem is only expected to worsen since, in an outcome named the Kessler effect, orbital debris causes further collisions, resulting in an exponential growth in debris over years.[1] As Earth's orbit is a "good" shared among the world's nations without ownership, it is subject to the "tragedy of the commons;" that is, individual nations are not incentivized to act with a long-term view of developing and utilizing space in a sustainable way for all nations because it is easier and less costly to NOT follow best-practices in the short term.[2]

In recent years, several large satellite constellations have been proposed by private companies such as OneWeb, SpaceX, and Boeing, ranging from hundreds to a few thousand satellites.[3] A 2016 study of these proposed satellite constellations predicted that one collision would occur each year involving objects larger than 10 cm.[4] Given the number of proposed

1 D. Kessler, The Kessler Syndrome, 8 March 2009, www.meteor.uwo.ca/kessler/KesSym.html, (accessed 14.06.18)
2 G. Hardin, The Tragedy of the Commons, *Space*, 162:1243-1248, 1968
3 C. Henry, OneWeb asks FCC to authorize 1,200 more satellites, 20 March 2018 spacenews.com/oneweb-asks-fcc-to-authorize-1200-more-satellites/, (accessed 14.09.18)
4 G. Peterson, M. Sorge, A. Jenkin, J. McVey, Implications Of Proposed Small Satellite Constellations On Space Traffic Management And Long-term Debris Growth In Near-Earth Environment, IAC 16-A6.7.8, 67th International Astronautical Congress, Guadalajara, Mexico, 2016

constellations and the predicted collision rate, Earth orbit would quickly become unusable. However, the study also suggested that active collision avoidance during the mission and during disposal could prevent this destruction.

Several obstacles to the sustainable development and use of space have been previously identified: [5]

- Lack of transparency
- Lack of willingness to cooperate
- Legal framework was developed in the 1960's and has not been updated since
- Nearly all legal frameworks are non-binding soft law without enforcement mechanisms for implementation and compliance.

In the 1980's nations around the world worked together to ban chlorofluorocarbons from depleting the ozone layer though coordinated international action. Since the dawn of the space age, some experts have proposed that a similar approach be made to Space Traffic Management (STM) and debris mitigation.[6] This paper makes the case for a private International Space Situational Awareness Organization (ISSAO) that would oversee and enforce generally accepted Space Situational Awareness (SSA) and STM practices, thereby averting the tragedy of the commons.

2. The Basis for an ISSAO

The following requirements have been articulated by the international community for establishing a Space Situational Awareness Regime:

- Observing and cataloging space objects[7]
- Standardizing space operational activity, especially pertaining to debris[8]
- Sharing (appropriately) technological developments for preventing space debris
- Enforcing operational procedures in space
- Maintaining global transparency[7]

5 O. Stelmakh, Global Space Governance For Ensuring Responsible Use Of Outer Space, Its Sustainability And Environmental Security: Legal Perspective, IAC 15 E7.7-B3.8, International Astronautical Congress, Jerusalem, Israel, 2015, 12 – 16 October.

6 J. Dunstan, "Space Trash": Lessons Learned (and Ignored) from Space Law and Government, Journal of Space Law, 39 (2013) 23 - 76

7 Written Congressional Testimony by Dr Moriba Jah, 13 July 2017, sites.utexas.edu/moriba/2017/07/15/written-congressional-testimony-by-dr-moriba-jah/, (accessed 07.06.18).

8 P. Anz-Meador, Orbital Debris Quarterly News, Vol. 2 No. 3, NASA Orbital Debris Program, 2018

As described below, several international agreements and organizations offer a foundation and experience-base on which to build a future ISSAO.

The cornerstone of all space law is the Outer Space Treaty (OST), often referred to as the Magna Carta of space law. Article IX of the treaty states that space activities must be conducted "with due regard to the corresponding interests of all other States." The OST was written in the spirit of international cooperation and is manifest in the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS).[9] Its working group on the Long-term Sustainability of Outer Space Activities has, since 2010, been developing general policy guidelines for sustainable space development.[10] They also have been studying the feasibility of an international regime for space traffic management and space operations safety.[11] However, these guidelines and recommendations have yet to be presented to the United Nations General Assembly. Dialogue through UNCOPUOS is an important step to building up global transparency through space activities and will likely be the core of future ISSAO development.

Inter-Agency Debris Coordination Committee (IADC) is an international working group of space agencies that are sharing research, reviewing activity, and identifying best practices for debris mitigation. The IADC is recognized as the international scientific authority on space debris and has developed technical guidelines now adopted by both NASA and the European Space Agency (ESA).[12] Though not a part of the UN, the IADC has presented before the Scientific and Technical subcommittee of the UNCOPUOS – a "tradition" that began in 1997.[13] Unlike the Long-term Sustainability group, IADC's guidelines are technical in nature. However, the IADC's guidelines were used as the foundation for the UNCOPUOS' space debris mitigation guidelines.[13] Thus, the IADC has sufficient standing to propose international guidelines but no legal clout to enforce them. A recent study of guideline adherence by the IADC found a satisfactory trend of mitigation in geostationary orbit but not in low Earth orbit.[12] The IADC has already developed the standards for debris mitigation and the challenge becomes standardizing this code of conduct internationally. A future ISSAO could build on this work by providing global enforcement for these standards.

9 I.M. Vasilogeorgi, International Regulation of Aerospace Vehicles: At The Crossroads of Regenesis And Redefinition, McGill University, 2017

10 United Nations Office for Outer Space Affairs, Long-term Sustainability of Outer Space Activities, www.unoosa.org/oosa/en/ourwork/topics/long-term-sustainability-of-outer-space-activities.html (accessed 02.07.18)

11 A/71/20, Report of the Committee on the Peaceful Uses of Outer Space, Fifty-ninth session, (8-17 June 2016

12 M. Ohnishi, IADC - An overview of IADC's annual activities, 55th Session of the Scientific and Technical Subcommittee UNCOPUOS, 2018, 29 January – 9 February

13 N. Johnson, Origin of the Inter-Agency Space Debris Coordination Committee, ARES Biennial Report 2012, Nasa Technical Report, 2014. pp 70-72

A third organization involved in advocating for debris mitigation guidelines is the Secure World Foundation (SWF), a U.S. nonprofit policy organization with observer status in UNCOPUOS.[14] SWF generates research and analysis for STM actors in order to foster dialogue among stakeholders and promotes policy positions that support sustainable space activity. SWF has no powers of enforcement.

Beyond the precedent of actors working towards SSA and STM solutions, several international agreements also give an example how nations can work together in the SSA context. The international effort to plan and build the International Space Station (ISS) provides a basis on which to address several issues that are likely to confront an ISSAO. The ISS Intergovernmental Agreement (IGA) enabled the most expensive scientific program developed by humanity.[15] So, it sets an example for long term partnership scientifically, legally, and financially, addressing liability, privacy, and intellectual property.[16] Each partner has legal jurisdiction over its components but also embraces a form of joint governance in some areas. The IGA has been flexible enough to adapt to legal challenges presented over the ISS' lifetime without requiring amendment.[15] To satisfy one of the previously mentioned requirements, the IGA sets precedent as to how the sharing of technological developments can occur. The establishment of an ISSAO would again require a long-term and complex partnership that would address the scientific, legal, and financial challenges presented when managing space traffic or remediating debris.

A recent promising development for STM and SSA is US Space Policy Directive 3, which re-committed the US to improving guidelines for debris mitigation and satellite design.[17] The US government is developing an open, publicly available source repository of SSA data managed by the Department of Commerce. The responsibility for warning satellite operators about potential collisions will transition to Department of Commerce from the Department of Defense. This model of an open and publically available database would provide a precedent for future nations to not only share the

14 Secure World Foundation, Space Sustainability, 23 December 2013, swfound.org/our-focus/space-sustainability/ (accessed 04.06.18)

15 S. Thompson-King, R. Frank, International Cooperation Mechanisms Used by The United States In The Peaceful Exploration And Use Of Outer Space, IAC 15-E7.7-B3.8.3, International Astronautical Congress, Jerusalem, Israel, 2015, 12 – 16 October.

16 European Space Agency, International Space Station Legal Framework, 19 November 2017, www.esa.int/Our_Activities/Human_Spaceflight/International_Space_Station/International_Space_Station_legal_framework, (accessed 11.06.18)

17 Space Policy Directive-3, National Space Traffic Management Policy, 18 June 2018, www.whitehouse.gov/presidential-actions/space-policy-directive-3-national-space-traffic-management-policy/, (accessed 14.07.17)

tasks of observing and cataloguing space objects, but also a method of determining if guideline compliance has been met.

Another point of reference for an ISSAO is the Law of the Sea (UNCLOS), the most ambitious and comprehensive international attempt to steward the world's oceans.[18] There is no enforcement body, but the International Maritime Organization (IMO) and several international groups attempt to handle some level of governance. The IMO was established as an international coordinating body for shipping and other maritime activities and it developed agreements for preventing pollution on the seas, namely the International Convention for the Prevention of Pollution from Ships, established in 1973. These measures deal with oil spills, dumping, and emissions on an international level. The IMO also deals with safety on the high seas as well. Member nations enforce IMO conventions and are subject to Member Audit Schemes. Member states must submit to audits that evaluate compliance with standards and best practices.

The following table highlights the relevant attributes from the discussions above.

Organization or Event	Relevant Attributes
OST	Spirit of international cooperation; space activity conducted with regard to other states; promotes international transparency
UNCOPUOS Long-term Sustainability WG	Forum for dialogue about SSA and STM that builds transparency
IADC	Forum for sharing technological developments for debris mitigation
SWF	Generates and promotes research and analysis for space sustainability
ISS IGA	Legal precedent for the division of intellectual property; shared governance over a complex technical and political project
US Space Policy Directive 3	Precedent for open sharing of national SSA data; national commitment to developing technology for debris mitigation
UNCLOS and IMO	Shard governance of international treaties on safety and pollution by an international organization

18 T. Munoz, International Maritime Organization: Guardian of the Seas, 18 May 2015, www.maritime-executive.com/magazine/international-maritime-organization#gs.1oY9d6c (accessed 04.07.18)

3. Examination of Hobbes' Leviathan

When Garret Hardin popularized the idea of the tragedy of the commons in 1968, two solutions were suggested to solve the issue.[2] The first was the creation of a single 'Leviathan' state strong enough to oversee and manage the resource. The second was the privatization of the resource.[19] In the 1990's, Elinor Ostrom proposed a third solution where resource appropriators develop their own governance model to manage the resource.[20] This solution prescribed eight principles that are common to successfully managed pooled resources. Prior discussions have linked these principles to the challenges presented by STM and SSA so Ostrom's principles are outside the scope of this work.[21] However, the following sections seeks to examine the rights of a sovereign as described in Thomas Hobbes' *Leviathan*.

In Western political philosophy, the cornerstone of a government's legitimacy is the social contract. In *Leviathan* the natural state of man outside any community is anarchy and so a strong government is required to secure the greatest good.[22] Individuals cede certain freedoms to the governing Leviathan in order to enjoy the relative safety of a governed community.

In what fashion could a Leviathan model avert a tragedy of the space commons? The Hobbes' work discusses the relationship between people and their governing power, not the relationship between nations. While this concept was developed in a different context, however, several important pieces of the Leviathan framework may be applied when developing an ISSAO.

The elements below are drawn from the relevant principle rights of the sovereign described by Hobbes in Section XVIII of *Leviathan,* with his number in parenthesis.

- (#3) Majority has consented to the commonwealth and the minority have agreed to abide and assent.
- (#7) Legislate rules of law and property
- (#8) Judicature
- (#10) Choose officers and staff
- (#11) Reward with incentives and punish with corporal/pecuniary punishments or ignominy
- (#12) Establish laws of honor and a scale of worth.

19 B. Weeden, Policy Aspects of Space Debris and Space Sustainability, Stardust Global Virtual Workshop, January 19-22, 2016

20 E. Ostrom, Governing The Commons, Cambridge University Press, Cambridge, 1990.

21 B. Weeden, T. Chow, Taking a common-pool resources approach to space sustainability: A framework and potential policies, *Space Policy,* 28.3: 166-172

22 T. Hobbes, Leviathan, 1668

Extrapolating from the third principle, an ISSAO should be a product of a majority of nations, not just the major actors. Currently, three of the leading solutions for global STM involve pooling SSA resources from existing programs or the creating an ISSAO under the supervision of the UN.[23] As the majority of SSA assets belong to the major spacefaring nations such as the US, Russia, and ESA, the pooling of tracking resources and mitigation technologies would be the product of these nations. However, a UN organization would be a product of the majority of nations. This would not only lead to the neutrality and impartiality of the organization, but would also allow emerging actors to participate.[23] Generally, the strongest factor limiting an ISSAO is the willingness of actors to give up their rights in exchange for mutual benefits, thus entering a global social contract.

The responsibilities and enforceable powers of this organization are also limited to what is technically feasible. Currently, an ISSAO can only be expected to monitor traffic near Earth, though it would be reasonable to see this jurisdiction extend to the moon or Mars given sufficient economic activity present in orbit around those bodies.

International convention and private regulators and insurers offer a unique solution to address the power (#11) of the sovereign to incentivize or punish. Under the Liability Convention of 1972, spacefaring nations are liable for their space objects throughout the existence of the object.[24] However, nations have not yet been prosecuted for creating space debris, nor has the Liability Convention even been invoked. The international outcry from the 2007 Chinese ASAT test did lead to China changing its approach and testing in a fashion that did not generate debris from 2010 to 2014.[25] Clearly international norms and pressure can have an effect.

Private actors such as insurers can also play an important role in addressing behavior, as illustrated by the Hartford Steam Boiler Inspection and Insurance Company (HSB) in the US during the 1860's.[26] Steam boilers in that era were extremely dangerous and frequently exploded. In fact, the worst disaster in United States maritime history occurred due to boiler failure. In 1865, a boiler aboard the steamboat *Sultana* exploded and killed

23 S. Plattard, Could Introduction Of Space Payload Management Be The Next Step To Space Traffic Management?, IAC 15-A6.8.5, International Astronautical Congress, Jerusalem, Israel, 2015, 12 – 16 October.

24 Convention on International Liability for Damage Caused by Space Objects (Liability Convention), London/Moscow/Washington, adopted 29 November 1971, opened for signature 29 March 1972, entered into force 1 September 1972, Art. II - III.

25 M. Gruss, U.S. Official: China Turned to Debris-free ASAT Tests Following 2007 Outcry, 11 January 2016, spacenews.com/u-s-official-china-turned-to-debris-free-asat-tests-following-2007-outcry/ (accessed 06.11.18)

26 A. Harrington, Debris Mitigation As An Insurance Imperative, IAC 15-A6.8.1, International Astronautical Congress, Jerusalem, Israel, 2015, 12 – 16 October.

over 1,800 people.[27] The explosion was due to a hasty boiler repair, and the tragedy could have been avoided if the ship's captain had waited for replacement parts. A year later, the Hartford Steam Boiler Inspection and Insurance company was founded. After an inspection, the insured boiler would be assigned a risk rating which determined premium costs. Following the HSB's inspection suggestions would lead to decreased insurance premiums for the insured. HSB developed boiler standards well ahead of the US government while providing the majority of inspections throughout the US. This company's work has also been integrated into national law.[28] Currently, the US accepts inspections by either a government inspector or an insurance inspector for boiler certifications. This led to a profitable business model that continues today.

A second historical example of private regulation is Underwriters Laboratories (UL). Founded in 1894, UL was created to determine risks associated with electronics in order to promote safe living and working environments.[29] During the time UL was founded, electric fires were common. The business worked to develop technical standards for products and materials that would reduce the risk of electrical fires. UL tests products and materials from most industries, ranging from consumer goods to building materials. Products that pass inspection receive a special label denoting that it meets standards. The leading causes of product rejection by UL during its early years are similar to the causes of today: poor design, low quality electrical parts, and shoddy workmanship. However, UL also works with products beyond electronics: the company's airworthiness program set the standards used for the US Air Commerce Act which ultimately led to the creation of the Federal Aviation Administration. Similar to the HSB, the UL standards and procedures have also been integrated into national law and similarly, businesses can either go to the U.S. government or to UL for required testing and certification.[30]

These precedents show that private regulators or insurers could take a leading role in STM enforcement. Space insurance brokers and providers could effectively shape the incentives for private actors to comply with proposed guidelines from organizations such as the IADC or SWF. Though insurance has been previously refuted as a means for ensuring compliance,

27 D. Sniderman, The Greatest Disaster in U.S. History, March 2011, www.asme.org/engineering-topics/articles/boilers/the-greatest-maritime-disaster-in-u-s-history (accessed 02.08.18)

28 Hartford Steam Boiler Insurance and Inspection Company, Jurisdictional Inspection Services, https://www.munichre.com/HSB/jurisdictional-inspection/index.html, (accessed 26.09.18)

29 Underwriter's Laboratory, About Us – History, 2018, www.ul.com/aboutul/history/, (accessed 03.08.18)

30 Nationally Recognized Testing Laboratories - Underwriters Laboratories Inc, https://www.osha.gov/dts/otpca/nrtl/ul.html, United States Occupational Safety and Health Administration, (accessed 26.09.18)

future solutions can still look to insurance as a solution.[19] Previously, insurance has been dismissed because a majority of space objects were owned and operated by sovereign nations. Nations are self-insurers for their own satellites and accept the financial risks of operation. As stated in the introduction, several large privately owned satellite constellations have been proposed for the near future. This shift from the majority of satellites providing public benefits to private commercial value will likely increase the demand for satellite insurance coverage in LEO. Given the 2016 study on the likelihood of collisions due to these constellations and the demand for insurance in LEO increases, a private insurer or regulator would have the power to incentivize actors to follow STM and debris mitigation standards.[4]

A proposed 'Leviathan Lite Inspection and Insurance Company' (LL) could be formed to fulfill the requirements previous set for an ISSAO. For this discussion, the LL is a for-profit commercial entity like HSB, though it could also be a non-profit like UL. This organization would provide insurance for satellite owners, but would require inspections to ensure that technical guidelines for debris mitigation have been met.

Failure to comply with mitigation guidelines, space codes of conduct for mission execution, end-of-life procedures, and collisional breakups would result in increased premiums or the denial of insurance coverage in the future. International insurers could also have jurisdiction beyond national borders which would dissuade actors from moving between nations to avoid liability.[31] Potentially if the regulator is coordinated with its respective national government similar to the HSB, a private regulator could provide faster and less expensive means for launch licenses, similar to the current practices of the HSB or UL. Conversely, if the client were to fail an inspection, the regulator could also prevent the client from obtaining a launch license until regulations were satisfied. This new regime would also allow research groups to receive more funding for SSA and debris mitigation technologies as insurers would have a financial incentive for this development, as previously seen in the HSB case study. With this level of enforcement, one would ask why an ISSAO would be needed if the insurer could enforce STM practices. In order to make recommendations about maneuvers to avoid collisions and determine risk for flight trajectories, accurate SSA data is needed, thus allowing the ISSAO to exchange data and best practices in return for guideline compliance.[26]

This potential regime of private regulation also meet the rights and requirements of a space sovereign as mentioned earlier. By its nature, a regulatory group develops guidelines to be met and then test or inspect to make sure the guidelines are met. This nature covers rights (#7) and (#8) from above: the sovereign should legislate and judge the rules. Right (#10) is

31 M. Macauley, The Economics of Space Debris: Estimating the Costs and Benefits of Debris Mitigation, *Acta Astronautica*, 115:10-164, 2015.

also met as a private business is relatively free to choose its employees and staff when compared to democratic governing agencies. Finally, Rights (#11) and (#12) are the core of the proposed solution. A private regulator has the financial means to coerce their clients into behavior aligning with defined standards.

However, this proposed regime would benefit from improved conventions for determining liability in orbit. Insurers have high interests in their client's liability. However, liability in space is fault-based as according to the Liability Convention, a state is "liable only if the damage is due to its fault or the fault of persons for whom it is responsible." However, the Liability Convention does not give new legal criteria for "fault" in space, thus fault is based on negligent behavior and on the basis of duty of care. This means that the burden of proof is upon the state making the liability claim.[32] In the case of the 2009 Iridium-Cosmos collision, the US had both tracking capabilities to predict the path of the Iridium satellite as well as maneuvering capabilities to avoid the collision. However, the abandonment of satellites in orbit has not yet been legally recognized as negligent behavior so the US had weak grounds for pursing Russia. As the Russian Cosmos satellite was inactive, there was no value lost for them in the collision, thus they too had weak grounds for pursuing the US for any liabilities as well.

Traditionally in space law, debris has not been considered as a liability, only space vehicles.[6] Liability for both stemming from both debris and collisions needs to be better defined though this proposed framework. It may work fine without establishing in-space liability as following the current mitigation guidelines would reduce risks on the insured objects, let alone any other objects. This new organization would benefit from both a legal definition of space debris as well as a definition of fault specific to the space.

4. Conclusion

Ultimately, space traffic management and space debris are global problems requiring global solutions. The method of guideline adherence through satellite insurance and private regulation has the possibility to better ensure operator compliance as opposed to the current practice of voluntarily following guidelines. The proposed practices are also not as politically strong or negatively consequential as sanctions or national shaming. It also avoids the political walls presented by sovereignty erosion from submitting to hard power.

32 R. Jakhu , "Iridium-Cosmos Collision and its implications for space operations", ESPI Yearbook on Space Policy. 2008/2009: Setting New Trends. Wien: Springer Wien, NewYork: 2010. pp 254-275.

The following challenges also still need to be answered as to whether a LL could provide a solution or if a solution should be found elsewhere:[33]

- The Registration Convention only requires notification after an object is in orbit, not before launch.
- No "right of way" for traffic and activity
- No traffic separation
- No "zoning" of space activity
- No communication rules
- Enforcement over harmful RF interference[33]

For the future, a further examination of businesses like the LL should be made to determine whether it is reasonable or profitable that private regulators or space insurers could bear these new responsibilities. Engaging in dialogue with current and potential insurers and regulators is key as they are the primary stakeholders in this situation.

33 J. Rendleman, B. Green, Space Traffic Management Regime Needs And Organizational Options, IAC 15-E7.4.3, International Astronautical Congress, Jerusalem, Israel, 2015, 12 – 16 October.