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DEBRIS MITIGATION AS AN INSURANCE IMPERATIVE

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The hazards presented by space debris are well known, and debris mitigation has been one of the key topics in space sustainability. There is currently not political will, however, to create a binding regime for debris mitigation standards at the international level. While the IADC debris mitigation guidelines are an important step toward sustainable use of space, soft law guidelines will be insufficient to protect the international community's Outer Space Treaty-given right to use and explore outer space freely.

One possible avenue for the implementation of more stringent debris mitigation requirements is through insurance providers. Insurance is the third highest cost in launching a space object (with the first two being research and development of the satellite itself and launch). It is in the best interests of both the insurers and insureds to mitigate the risk of collision with space debris. The more debris, the more likely for a collision to occur, the more likely an insurance claim will be paid, and the higher insurance premiums will rise. This presentation and paper ask and answer the question "what can insurance providers do to raise the bar in debris mitigation standards?"

The historical example provided by the Hartford Steam Boiler Inspection and Insurance Company is used as a case study in an insurance provider leading the way in terms of safe operating practices. Prior to the implementation of HSB's safe operating requirements, which were both more stringent than government regulations and enforced by inspection, the operation of steam boilers was a much more dangerous activity. Through innovative standard setting, HSB was able to simultaneously reduce the number and severity of claims paid, reduce insurance premiums, and ensure safer operation of steam boilers. They have also used this model in providing insurance for nuclear power plants.

In a space context, insurers can set debris mitigation standards that are internationally uniform and encourage sustainable use of space, either by requiring implementation of these standards to acquire insurance, or by offering a discounted premium based on the level of compliance.

I. INTRODUCTION AND CONTEXT

As more public and private entities have begun launching and utilizing satellites, the problem of space debris has started to move toward the forefront of public consciousness about space. Many people have heard of the Kessler Syndrome that predicts a point of cascading exponential increase in space debris as debris collides, resulting in unusable Earth orbits.[*] As technology improves, it has become progressively easier and less expensive to launch satellites into orbit. Nanosats and smallsats are substantially cheaper to launch than their larger counterparts, and can be used for a variety of operations. In fact, some entities are pursuing a strategy of introducing "swarms" of small satellites for global coverage in lower Earth orbits.

Though the Outer Space Treaty[†] does contain some provisions that are relevant to the issue at hand and the Liability Convention establishes more detailed liability provisions for

[*] "The Kessler Effect and How To Stop It" (13 November 2012) online: *ESA,* (http://www.esa.int/Our_Activities/Space_Engineering_Technology/The_Kessler_Effect_and_how_to_stop_it).

[†] *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*, 27 January 1967, 610 UNTS 205.

damage caused by space objects[‡] (including space debris, at least space debris that can be identified), there is no international law that binds States regarding the specific issue of debris mitigation or remediation. The relevant provisions of the Outer Space Treaty follow for context.

Under Article I of the Outer Space Treaty, the exploration and use of outer space is to be carried out *for the benefit and in the interests of all countries*. Article IX of the Outer Space Treaty states that activities in outer space are to be guided by the principle of *cooperation and mutual assistance* and should be conducted with *due regard* to the to the corresponding interests of other States. It also provides a mechanism for consultations in the event that one State's activities may harmfully interfere with one (or more) other State's activities. In this light, creation of an unreasonable amount of space debris that could contribute to making outer space more difficult if not eventually impossible to use and explore would clearly run contrary to these principles.

Article VI of this Treaty also establishes that States are responsible for providing authorization and continuing supervision for their nationals' activities in space to ensure conformity with the provisions of the Treaty. Therefore, these principles can be extended to all actors in space who are States Parties or nationals of any State Party to this Treaty. Article VII, which is subsequently elaborated by the Liability Convention, establishes the ongoing liability of the Launching State(s) for damage caused by their space objects (which we will see in the next section includes space debris).

As private entities and some governments are taking on insurance for their satellites, the space debris question is gaining relevance for the insurers providing coverage. Increasing orbital debris will create increasing danger of full or partial loss of an insured satellite. It is worth considering what insurers can do to promote a safer space environment both for their own benefit and the direct benefit of space users.

[‡] *Convention on International Liability for Damage Caused by Space Objects*, 29 March 1972, 961 UNTS 187.

II. WHAT IS SPACE DEBRIS?

The definition of the term "space object" is critical to understanding the mechanisms governing space debris, particularly given that rules regarding State jurisdiction, registration and liability function primarily by reference to this term.[§] Though the Outer Space Treaty uses the term "space object," it does not define it. The Liability Convention is, from a temporal perspective, the first of the space conventions to provide a definition of the term "space object," though the definition is self-referential. Here, the term is defined to include "component parts of a space object as well as its launch vehicle and parts thereof."[**] The Registration Convention utilizes an identical definition.[††]

Following the rule *definition fiat per genus proximum et differentiam specificam*, 'object' is the general term which is modified by 'space;'[‡‡] and in the context of the space treaties, must also be modified by and include 'its component parts.'[§§]With regard to stray items in space, the treaties consistently include component parts as space objects.[***] Therefore, the term "space object" automatically includes component parts unless contextually indicated otherwise.[†††] Likewise, payload is "property on board" a space object "forming part of that space object and would not be an independent space object. This would in fact apply to all items of property on board."[‡‡‡]

[§] Bin Cheng, *Studies in International Space Law* (Oxford: Clarendon Press, 1997) at 463.

[**] *Liability Convention, supra*, art I(d).

[††] *Convention on Registration of Objects Launched into Outer Space*, 14 January 1975, 1023 UNTS 15.

[‡‡] Gyula Gal, "Space Objects – 'While in Outer Space'" in *Proceedings of the International Institute of Space Law* (Reston: American Institute of Aeronautics and Astronautics, 1995) 84 at 84.

[§§] Csabafi, Imre Anthony, *The Concept of State Jurisdiction in International Space Law* (Leiden: Martinus Nijhoff Publishers, 1971) at 11.

[***] Cheng, *Studies*, *supra* at 500

[†††] *Ibid*.

[‡‡‡] *Ibid* at 501-502.

The term space object can be abstruse and lead to misinformed interpretations.[§§§] Despite the attempt at providing a definition of the term, the Liability and Registration Conventions merely provide some insight as to what can be included in the definition, but not what should or could be excluded.

"Does a space object ever cease to be a space object, and if so, when?...One can probably say that they do not cease to be such until perhaps they have been dismantled or otherwise disposed of[;]"[****] in other words, "[t]here is no apparent time limit."[††††] The status of an object as a space object is not affected by its presence in outer space, on a celestial body, or upon return to Earth, as stated in the Outer Space Treaty;[‡‡‡‡] and at this point these principles can be considered to be declaratory of the rule existing in general international law.[§§§§]

The definition of the term space object "does not make the distinction between functional objects and non-functional objects (debris)."[*****] Given the emphasis that is placed on space debris in the current dialogue on the state of the space environment, it is important to understand the meaning of "space debris."

In endeavoring to arrive at a working description of 'debris' one can look at the place or places where it is found, the circumstances under which it came to be situated there, the intent of the launching authority which placed the unitary space object initially into orbit, the physical characteristics of the debris, the adversity resulting to functioning space objects and to the community at large from the presence of the debris, and the range of responses available to the launching authority and to other concerned international legal persons, including other States and international intergovernmental organizations, both universal and regional, as well as consortia of States which anticipate detriment as a result of the existence of the debris.[†††††]

"[T]here is no reason to think that non-functional space objects are no longer space objects. The definition of space object is not related to the object's use or usefulness[,]"[‡‡‡‡‡] however, a "space object can become debris in the event that it becomes non-functional, or is abandoned by the launching authority, or both."[§§§§§] Therefore, an object can be both a space object and a piece of space debris simultaneously; these definitions are not mutually exclusive. In fact, for liability to be maintained by the Launching State(s), an article of space debris must inherently also be a space object.[******]

Professors Francis Lyall and Paul Larsen likewise maintain that the inclusion of "component parts" and the "launch vehicle and parts thereof" in the provided definitions of space object mean that debris is included within the meaning of the term "space object."[††††††] There is nothing to suggest that objects such as paint flakes or pieces of fuel tanks would be treated any differently under the space law regime than fully in tact space objects.[‡‡‡‡‡‡] From a liability perspective, it would be desirable to include all manners of debris in an expansive interpretation of space object and its component parts.[§§§§§§] The problem, of course, would come in terms of identifying the origin of the paint flake or bolt that has caused damage to another satellite.

Many definitions suggest that control is a significant factor in determining whether or not

[§§§] E.R.C. van Bogaert, *Aspects of Space Law* (London: Kluwer Law and Taxation Publishers, 1986) at 118.

[****] Cheng, *Studies*, *supra* at 504.

[††††] *Ibid* at 505.

[‡‡‡‡] *Outer Space Treaty, supra*, art VIII.

[§§§§] Cheng, *Studies*, *supra* at 466.

[*****] Aldo Armando Cocca, "Convention on Registration of Objects Launched into Space" in Nandasiri Jasentuliyana & Roy S.K. Lee, eds, *Manual on Space Law Volume I* (Dobbs Ferry: Oceana Publications, 1979) 173 at 180.

[†††††] Carl Q. Christol, *Space Law: Past, Present, and Future* (Deventer: Kluwer Law and Taxation Publishers, 1991) at 250.

[‡‡‡‡‡] Cheng, *Studies*, *supra* at 506.

[§§§§§] Christol, *Space Law*, *supra* at 51.

[******] *Liability Convention, supra*, 3.

[††††††] Francis Lyall, & Paul B. Larsen, *Space Law: A Treatise* (Burlington: Ashgate Publishing Company, 2009) at 86.

[‡‡‡‡‡‡] Cheng, *Studies*, *supra* at 506.

[§§§§§§] Lawrence D. Roberts, "Addressing the Problem of Orbital Space Debris: Combining International Regulatory and Liability Regimes" (1992) 15 BC Int'l & Comp L Rev 51 at 64.

an object can be categorized as space debris;[*******] some other key terms used in the discussion of space debris are: hazardous, dangerous, destructive and unsafe.[†††††††] The functionality (or lack thereof) of a space object, as we have seen, is another important factor used by authors in determining whether an item can be qualified as space debris. One example is as follows: "any man-made Earth-orbiting object which is non-functional with no reasonable expectation of assuming or resuming its intended function or any other function for which it is or can be expected to be authorized, including fragments and parts thereof."[‡‡‡‡‡‡‡]

Though one author defines space debris as "natural or human made particles that circle the Earth[,]" using 'orbital debris' as an interchangeable term,[§§§§§§§] this is not a comprehensive approach. For the liability regime to function properly, articles of space debris, like space objects, should not be affected by their presence on a celestial body, nor should their status be altered by their return to Earth. The UN COPUOS Space Debris Mitigation Guidelines likewise define space debris as "all man-made objects, including fragments and elements thereof, in Earth orbit or re-entering the atmosphere that are non-functional."[********] While the limitation of the definition of debris to Earth orbit and re-entry is sensible for the purposes of these mitigation guidelines, a definition that is viable in the long-term, as exploration and use of celestial bodies is likely to continue, should have the scope to include objects on celestial bodies or in space beyond Earth orbit.

For the purpose of this article, including for insurance purposes, the following definition can be used: *any space object, including parts of a space object, which is non-functional that could pose a threat to the continued safe navigation and use of outer space or a celestial body*. It is useful to note that as technology improves, it may be possible for a once non-functional object to be repaired or refueled, causing it to cease being debris.

III. WHY IS SPACE DEBRIS A PROBLEM?

Space debris orbits the Earth with a very high velocity, meaning that it can have substantial destructive kinetic energy if it collides with another space object.[††††††††] More than 20,000 pieces of debris bigger than a softball orbit in low Earth orbit at speeds up to 17,500 miles per hour. There are millions of pieces of debris so small they cannot be tracked or accurately counted, and among those there are 500,000 pieces that are marble sized or larger.[‡‡‡‡‡‡‡‡] At high velocities, even tiny paint flecks can cause substantial damage. Several space shuttle windows have had to be replaced due to damage caused by such paint flecks.

The ability to detect debris in the extremely valuable but remote geostationary orbit is even more limited – objects can only be tracked that are at least nearly a meter large. This is particularly relevant as 95% of insured satellites are located in geostationary orbit.[§§§§§§§§] As an additional threat, large debris such as non-functional satellites can drift and block the

[*******] Christopher D. Williams, "Space: The Cluttered Frontier" (1995) 60 J Air L & Com 1139, 1151.

[†††††††] James D. Rendleman, "Non-cooperative Space Debris Mitigation" in Proceedings of the International Institute of Space Law (Corrine M. Jorgenson ed., 2010) 299.

[‡‡‡‡‡‡‡] Vladimir Kopal, "Some Remarks on Issues Relating to Legal Definitions of 'Space Object', 'Space Debris' and 'Astronaut'" in *Proceedings of the International Institute of Space Law* (Reston: American Institute of Aeronautics and Astronautics, 1995) 99 at 103.

[§§§§§§§] Robert C. Bird, "Procedural Challenges to Environmental Regulation of Space Debris" (2003) 40 Am Bus LJ 635, at 637.

[********] *Official Records of the General Assembly, Sixty-second Session, Supplement No. 20* (A/62/20), Annex.

[††††††††] Molly K. Macauley, "The economics of space debris: Estimating the costs and benefits of debris mitigation" (2015) 115 Acta Astronautica 160 at 160.

[‡‡‡‡‡‡‡‡] Mark Garcia, "Space Debris and Human Spacecraft" (23 September 2013) online: *NASA,* http://www.nasa.gov/mission_pages/station/news/orbital_debris.html.

[§§§§§§§§] Hanspeter Schaub et al., "Cost and risk assessment for spacecraft operation decisions caused by the space debris environment " (2015) 113 Acta Astronautica 66 at 68.

radiofrequency communications of active satellites, rendering them partially or totally non-functional.[*********] “As of February 2014, the GEO regime contains approximately 1145 large-scale, unclassified, and trackable objects larger than 0.8–1.0 m in effective diameter, 760 of which are uncontrolled derelict objects that actively contribute to longitude-dependent congestion levels across the GEO ring. In addition to this large-scale, catalogued debris population, significant populations of uncatalogued objects at sizes as small as 10–15 cm have been detected in GEO optical observation campaigns, and are hypothesized to be indicative of undetected fragmentation events in this regime.”[†††††††††] This situation substantially increases the danger in this high-value orbit and therefore difficulty in providing accurate actuarial calculations for the dangers there.

IV. DEVELOPMENT OF INTERNATIONAL STANDARDS

At an organizational level, NASA was the pioneer of orbital debris mitigation policies and guidelines in the 1990s. In 1993, the NASA Management Instruction “Policy for Limiting Orbital Debris Generation” was established. Subsequently, in 1995 the NASA Safety Standard “Guidelines and Assessment Procedures for Limiting Orbital Debris” were created as the first detailed mitigation guidelines to be used for NASA missions. In 2001, the U.S. Government established the Orbital Debris Mitigation Standard Practices. The National Space Policies of 2006 and 2010 have both directed implementation of these Practices.[‡‡‡‡‡‡‡‡‡]

As space debris became a hot issue from the 1990s and 2000s, international efforts were organized to address the problem. Though no binding standards have been adopted, non-binding guidelines exist to help space actors determine appropriate levels of debris mitigation. The Inter-Agency Space Debris Coordination Committee (IADC) is an international body made up of national and multinational space agencies to coordinate space debris-related activities. They meet annually in order to work on that year’s Action Items. The IADC Space Debris Mitigation Guidelines were accepted in 2002. A similar set of debris mitigation guidelines based on the IADC guidelines were adopted by COPUOS and subsequently the UN General Assembly in 2007. Though adherence to the IADC guidelines is voluntary, participating States have used these standards in developing domestic standards and nationally binding laws and regulations.[§§§§§§§§§]

As described in the Introduction to the IADC guidelines, the key common principles espoused in debris mitigation standards, guidelines, and handbooks to this point are:

(1) Preventing on-orbit break-ups;
(2) Removing spacecraft and orbital stages that have reached the end of their mission operations from the useful densely populated orbit regions; and
(3) Limiting the objects released during normal operations.

This document likewise recommends that every project have a feasible Space Debris Mitigation Plan established.[**********] The IADC guidelines recommend specific parameters for a graveyard orbit for geostationary satellites.[††††††††††] With regard to low Earth orbit satellites, the IADC (following substantial scientific study) have recommended that 25 years after the completion of operations is a “reasonable and appropriate

[*********] *International Telecommunication Union Radiocommunication Sector,* “Environmental protection of the geostationary-satellite orbit” (2010) Recommendation ITU-R S.1003-2 at 3-4.

[†††††††††] Schaub, *supra* at 68

[‡‡‡‡‡‡‡‡‡] J.-C. Liou and David Jarkey, “Orbital Debris Mitigation Policy and Unique Challenges for Small Satellites” *NASA Orbital Debris Program Office,* Small Satellite Conference, Logan, Utah, 10 August 2015 at 4.

[§§§§§§§§§] James D. Rendleman & Sarah M. Mountin, “*Responsible SSA Cooperation To Mitigate On-orbit Space Debris Risks*” (2015) Recent Advances in Space Technologies (10.1109/RAST.2015.7208459) at 2.

[**********] IADC Space Debris Mitigation Guidelines, IADC-02-01 (Revision 1, 2007) at 7.

[††††††††††] *Ibid* at 9.

lifetime limit."[‡‡‡‡‡‡‡‡‡‡]As you may have noticed, the key word here is "recommends" – given that the IADC is not in a position to create binding requirements.

The International Telecommunication Union (ITU) has also made a series of recommendations regarding debris mitigation. Their four key principles are as follows:

> (1) that as little debris as possible should be released into the GSO region during the placement of a satellite in orbit;
> (2) that every reasonable effort should be made to shorten the lifetime of debris in elliptical transfer orbits with the apogees at or near GSO altitude;
> (3) that before complete exhaustion of its propellant, a geostationary satellite at the end of its life should be removed from the GSO region such that under the influence of perturbing forces on its trajectory, it would subsequently remain in an orbit with a perigee no less than 200 km above the geostationary altitude;
> (4) that the transfer to the graveyard orbit removal should be carried out with particular caution in order to avoid RF interference with active satellites.[§§§§§§§§§§]

Despite these various efforts, post-mission disposal rates have fallen short of desired results.[***********] Additionally, low Earth orbit satellites with a perigee higher than 700km are unlikely to deorbit naturally within the prescribed 25-year timeframe, thus smallsats in these orbits are particularly problematic.[†††††††††††]From an insurance perspective, even fragments of those satellites that de-orbit and therefore do not wind up as space debris can re-enter the atmosphere and cause casualties (and, of course, liability) to third parties. In particular, tungsten, titanium, stainless steel, beryllium, and carbon-carbon components may not reach melting point during descent and can cause such difficulties.[‡‡‡‡‡‡‡‡‡‡‡]

V. HOW CAN INSURANCE PROVIDERS RAISE THE BAR?

There are a number of ways in which insurers can promote space debris mitigation. These strategies include repurposing solutions that have been proposed for other actors. For example, one author has suggested that "a tax or fee levied on both operators of both launch vehicles and spacecraft to account for their impact on elevating collision risks for (current and future) space fleets" would be one option.[§§§§§§§§§§§] Instead of a tax levied by a governmental authority that would likely create a forum shopping race to the bottom for space debris regulation, an insurer or group of insurers could either offer discounts for meeting more stringent debris mitigation requirements, or could require additional premium from those entities not undertaking a sufficiently robust debris mitigation plan. Unlike nationally imposed regimes, insurers can implement their policies across international boundaries, reducing "possibilities of debris "leakage" if operators of spacecraft divert their launch and mission control activities to countries without corrective taxes."[************] (Macauley, 161)

Critical elements of debris management are collisional breakup debris, mission-related debris, and end-of-life debris. The diversity of debris creation mechanisms makes accounting for debris a difficult prospect. "Unlike smokestack pollutants, for example, the externality cannot be directly priced to automatically and optimally exploit all the debris reduction strategies. In particular, debris managers cannot observe small debris releases from craft, nor can society credibly commit to penalties for large debris generation when defunct craft may remain in (actively used) orbits for decades or more."[††††††††††††]

Dealing with these diverse mechanisms

[‡‡‡‡‡‡‡‡‡‡] *Ibid*.

[§§§§§§§§§§] *ITU Recommendation*, *supra* at 3.

[***********] Rendleman & Mountain, *supra* at 2.

[†††††††††††] Michael V. Nayak, "Implementation of National Space Policy on US Air Force End of Life Operations and Orbital Debris Mitigation " at (2012) American Institute of Astronautics at 2.

[‡‡‡‡‡‡‡‡‡‡‡] *Ibid* at 3.

[§§§§§§§§§§§] Macauley, *supra* at 161.

[************] *Ibid.*

[††††††††††††] *Ibid*.

requires implementation of multiple solutions, which from a technical perspective can include: orbital maneuvering capability, graveyarding capability, and/or shielding. As discussed by Molly Macauley, orbital maneuvering increases the possibility for a spacecraft to evade observable debris, graveyarding capability removes the satellite from the path of usable satellites through atmospheric burn-up or retirement to an unused orbit, and shielding that reduces damage risk and creation of additional debris in case of a collision. As discussed in the ITU recommendations, graveyarding capability requires monitoring and maintaining sufficient fuel to ensure that there will be capability to move the satellite to the appropriate graveyard orbit or de-orbit path.[‡‡‡‡‡‡‡‡‡‡‡‡] Additional steps to be taken can include de-energizing batteries, propellant, and other systems and augmenting the satellite to improve the ease of tracking for conjunction assessment.[§§§§§§§§§§§§] All of these would be documented in a project's technical specifications and an insurer with sufficient technical specialization could price a premium accordingly not only with the general risks faced by the design, but also for debris mitigation which, importantly, includes collision avoidance technologies.

As explained in mathematical detail in Molly Macauley's article, there are means to determine an economic impact of likely debris creation and debris mitigation strategies in order to appropriately price such an endeavor. The U.S. Joint Space Operations Center (JSpOC) provides warning of possible satellite collisions, generally 72 hours in advance, but it is ultimately up to the satellite operator to determine whether or not to perform an avoidance maneuver.[*************]

The decision taken involves a cost-benefit analysis, balancing on the one hand a risk of collision and on the other the mission disruption, use of propellant or other resources, and any risks associated with the maneuver. Insurers may be in a position to advise insured satellite operators regarding collision avoidance maneuvers if satellites are equipped in accordance with insurer requirements or recommendations. A centralized unit within a space insurer could be created to provide such a service utilizing both actuarial data and experience from insuring a large number of satellites, for a fee or built into the cost of the policy.

Insurers can also purchase services through the Commercial Space Operations Center (ComSpOC) or other such emerging services for collision avoidance and manage notifications for insureds. ComSpOC offers a "facility that fuses satellite-tracking measurements from a continually growing global network of commercial sensors" generating highly accurate space situational awareness data.[†††††††††††††] As we will see below, there are historical precedents for insurers undertaking such specialized, technical mechanisms in order to ensure the safety and sustainability of the insured industries.

VI. HISTORICAL EXAMPLE: HARTFORD STEAM BOILER INSURANCE COMPANY

Step back in time to the late 1850s, where steam power had become a regular facet of daily life, though a dangerous one. In the highly competitive boilermaker business, users were resigned to the fact of boiler explosions, assuming them unavoidable (explosions in the U.S. were occurring about once every four days).[‡‡‡‡‡‡‡‡‡‡‡‡‡]In the now-competitive and also hazardous launch and satellite industries, the creation of some level of debris has come to be expected, though efforts are being made to mitigate that level. Much like the space industry, the early steam boiler industry had strong ties to the military and participants frequently undertake military contracts.[§§§§§§§§§§§§§]

In 1866, the Hartford Steam Boiler Inspection and Insurance Company (HSB) came into being, on the model of the English entity,

[‡‡‡‡‡‡‡‡‡‡‡‡] *ITU* Recommendations, *supra* at 6.
[§§§§§§§§§§§§] Rendleman & Mountin, *supra* at 3.
[*************] *Ibid* at 3-4.

[†††††††††††††] "Overview" online: *ComSpOC*, (https://comspoc.com).
[‡‡‡‡‡‡‡‡‡‡‡‡‡]Glenn Weaver, *The Hartford Steam Boiler Inspection and Insurance Company 1866-1966* (Hartford: Connecticut Printers, 1966) at 6-7.
[§§§§§§§§§§§§§] *Ibid* at 79, 107.

the Steam Boiler Assurance Company.[*************] HSB was (and still is in 2015) more than just an insurance company, they are "an institution devoted to industrial safety."[†††††††††††††] Inspections were (and are) the soul of HSB's business model; upon a thorough inspection, a boiler would historically be rated as a first, second, or third-class risk. The insured would generally follow the recommendations of their inspector to improve the class of their risk. In fact, their reputation was so positive that state and local authorities would accept HSB inspections in place of governmental ones. In that time period, some U.S. states improved their boiler inspection laws with the assistance of an HSB officer in writing the legislative bill.[‡‡‡‡‡‡‡‡‡‡‡‡‡]

HSB was not only successful (they steadily increased their premiums written from $203,507 in 1880 to $1,148,040 in 1900), but they were able to provide an equitable rate while providing the highest level of service to their insureds.[§§§§§§§§§§§§§] By definition, an insurer has a pecuniary interest in sustainability of their equipment and the HSB shareholders found that a business could perform these safety and sustainability services at a fair rate and still make a profit.[**************] I argue, that likewise, space insurers can take an active role in promoting space debris mitigation in a way that is beneficial for the space industry and the insurers as well, by maintaining the sustainable usability of outer space moving forward.

HSB offered a number of special services to their insureds: advice as to construction of boilers, installation of boilers, and use of safety devices, a "shop inspection" service in which they would supervise the beginning-to-installation construction of a boiler, "extended coverage" to cover business interruption and loss of rents, and many others.[††††††††††††††] In 1930, nine out of ten boilers that were built within the U.S. had been inspected by HSB.[‡‡‡‡‡‡‡‡‡‡‡‡‡‡] Importantly, HSB developed both the "Hartford Standards" (which were adopted by the American Boiler Manufacturer's association as the "Uniform Steam Boiler Specifications") and the "Hartford Settings" for boiler use.[§§§§§§§§§§§§§§] This is one precedent for an insurer developing standards ahead of governmental standards that substantially improve the safety and sustainability of the industry, and demonstrate the business feasibility of implementing such standards without facing the initial burden of an 'undue' governmental regulatory burden. It is also much easier for an insurer to develop and improve standards than it is for a government to continue to evolve regulations through a complex administrative process. Thus, standards can develop at an insurer level ahead of those developed within governments or intergovernmental organizations.

HSB expanded their business model by using specialists with technical knowledge of their fields; they were able to insure flywheels, pressure vessels, turbines, and internal combustion engines.[***************] In more modern times, HSB provides inspection and insurance services for nuclear power plants in addition to boilers and other such machinery. They also employ "a unique proactive inspection service strategy that helps to identify insureds with equipment that local law or code requires be inspected"[†††††††††††††††] – this is translatable to the space industry in terms of helping insureds avoid regulatory risk with regard to their space technologies. Technical experts in the space field could be utilized in a similar way for mission review and recommendations, as well as the provision of additional services.

HSB, along with six other similar companies, formed the Steam Boiler and Fly-Wheel Service and Inspection Bureau (later the Boiler and Engineering Insurance Service Bureau), an insurance association to regulate

[*************] *Ibid* at 7-8

[†††††††††††††] *Ibid* at 46.

[‡‡‡‡‡‡‡‡‡‡‡‡‡] *Ibid* at 26-28.

[§§§§§§§§§§§§§] "The history of Hartford Steam Boiler" online: *MunichRe,* (http://www.munichre.com/HSB/hsb-history/index.html); Weaver, *supra* at 33, 42.

[**************] *Ibid* at 28, 52.

[††††††††††††††] *Ibid* at 48-49, 57.

[‡‡‡‡‡‡‡‡‡‡‡‡‡‡] *Ibid* at 49.

[§§§§§§§§§§§§§§] *Ibid* at 50.

[***************] *Ibid* at 64-66.

[†††††††††††††††] "Welcome to Hartford Steam Boiler" online: *MunichRe,* (http://www.munichre.com/HSB/about-hsb/index.html).

standards of inspection.[‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡] They also joined with boiler manufacturers and steam users to create the Uniform Boiler and Pressure Vessel Laws Society, which secured the adoption of the American Society of Mechanical Engineers Code by thirty-nine U.S. states as well as a number of other jurisdictions. [§§§§§§§§§§§§§§§§]

VII. CONCLUSIONS AND FINAL REMARKS

Despite the fact that the research in the area of space debris highly points toward a need for increased mitigation and/or remediation of debris, "[e]ven now, the spacecraft operators and insurance industry do not appear overly concerned with addressing space debris."[****************]This is not only unfortunate, but counterintuitive. In order to maintain the safe and sustainable operation of orbital spacecraft (and eventually more frequent missions that will pass through Earth orbit to travel beyond) and maintain reasonable but still profitable insurance premiums, this issue must be addressed.

Insurers are in a unique position to be able to take additional steps promote debris mitigation. By employing technical experts within insurance companies, it is possible to implement both additional services and more effective review for implementation of premiums that take into account effective debris mitigation measures (or lack thereof). Perhaps most importantly, insurers are in a position to develop more stringent and specific debris mitigation guidelines, or even requirements, than would possible for political or other reasons at a governmental or intergovernmental level. As has been shown in this paper, there is precedent for such standards being subsequently adopted as regulations within relevant jurisdictions.

Additionally, insurers may be able to procure situational awareness data for their insureds as a group, and provide recommendations to their insureds regarding whether or not to undertake maneuvers from a risk perspective when an SSA provider advises such maneuvers. Ultimately, awareness and explration of such options is the first step to developing innovative solutions to foster the development of a sustainable space industry.

[‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡] Weaver, *supra* at 69-70.
[§§§§§§§§§§§§§§§§] *Ibid* at 72-72.
[****************] Schaub, *supra* at 69.