



NSS Position Paper

# Space Debris Removal, Salvage, and Use: Maritime Lessons

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October, 2019

## Abstract

In noting the commonalities between debris or pollution in the oceans and seas of the world and debris in orbit, NSS proposes mechanisms and systems to overcome barriers to creating a safe space environment via active debris remediation and salvage, including ways to overcome daunting liability and compensation impediments. NSS recommends actions that would furthermore create strong incentives for private owners and State Parties to rapidly remove space debris, or salvage it for later use, both in orbit and on planetary surfaces. Because spacecraft or payload owners and State Parties working alone might not have capability or economic means to carry out such debris remediation actions, we recommended a way to enable market forces to help service the debris problem. We also propose funding for liability compensation through mechanisms such as protection and indemnity (P&I) space clubs in collaboration with other stakeholders. In addition, we propose a multilateral system that would strongly incentivize owners and launch-registered State Parties to relinquish control of derelict objects to thereby create a system where it is less expensive and dangerous to remove debris than to let it persist. Finally, we provide a notional agreement to establish a Space Salvage Entity (SSE).

## Introduction

The National Space Society (NSS) foresees that that over the next couple of decades there will be a significant expansion into space. In the longer term NSS vision, much industry will eventually move off-Earth and millions of people will someday be living and working in space in thriving communities for the benefit of all humans, including those on Earth. Given that level of expansion of space industries and activities in both the near and longer term, advanced space projects would greatly benefit from the ability to salvage and re-purpose

derelict spacecraft. In addition, safety-of-navigation will require that we “dredge the harbor” of dangerous orbiting debris. More specifically, derelict pieces of orbital debris need to be either actively deorbited, or repaired, refurbished, repurposed, or recycled in orbit. NSS believes that private space salvors and other commercial contractors tied to a Space Salvage Entity (SSE) could play a major role in carrying out these actions, and crucial to commercial entities carrying out these actions would be multilateral agreements for managing liability risk and compensation.

Unfortunately, salvage and debris remediation is very difficult under the current international legal space regime and orbital conditions, all of which disincentivize action. First, per Article VIII of the Outer Space Treaty (OST)<sup>1</sup>, a State Party on whose registry an object is launched into outer space retains jurisdiction and control of the items launched. Moreover, Articles VI and VII of the OST and Article IV of the Liability Convention<sup>2</sup> make multiple launching States involved in a space debris intervention jointly and severally liable for any harm or damage to the persons or property of other States Parties. Further complicating liability assessment, a lot of orbital debris is unclaimed and neither the spacecraft owner nor operator nor the launching State can be determined. Per Brian Weeden of Secure World Foundation, “Of the 500,000 estimated human-generated objects in orbit bigger than 1 cm, we only know which country put it there for about 16,000 objects, and less than half of those 16,000 were registered with the UN.”<sup>3</sup> Moreover, deorbiting debris will often require moving the junk through lower orbits. Further aggravating the issue, moving debris to salvage yards for later use will sometimes require moving the debris through higher orbits. In each case, there will likely be an increased risk of collision or other accidents.

While it may be unclear if anyone is liable for unclaimed debris, it can be argued that the moment a State Party to the OST via its national entity touches the debris, the State Party assumes liability for whatever happens per Article VI of the OST, which mandates that State Parties bear “international responsibility” for national activities in outer space and also requires “authorization and continuing supervision” of the involved national actors.

Fortunately, individual liabilities or lack thereof can be determined via liability apportionment agreements per Article V of the Liability Convention.<sup>4</sup> An example of such is the liability agreement used for the nation states collaborating on construction and operations of the International Space Station (ISS).<sup>5</sup> But even with a multilateral agreement to determine the liability of various actors in a space debris intervention, there would remain the issue of funding the compensation for any party harmed. Given this complexity, can any lessons be gleaned from liability and compensation regimes for salvage or the removal of pollution and debris in the maritime context?

## Salvage lessons from international marine salvage tradition and law

In developing liability and compensation provisions to manage orbital debris, it is important to note that Earth orbits are present in an environmental situation more akin to the maritime environment than the aviation environment. Among other things:

- When aircraft create debris consequent to catastrophic failure over land, it is usually confined to one identifiable terrestrial area. Conversely, ocean vessels sometimes suffer loss of control, are shipwrecked, or contaminate large swaths of the maritime environment with mobile debris: solid objects, such as abandoned vessels, flotsam and jetsam; or liquids, such as oil. Such consequences of catastrophic failure and normal operations also result in the outer space environment, where whole defunct spacecraft and other debris remain uncontrolled in orbit.
- Space tourism will turn out to be more like cruise ship tourism, where destinations may be part of the package, but at least part of the fun will be enjoying the cruise itself, usually with others. With aviation, you simply want to get to another destination as soon as possible. Except on very rare occasions, travel on the aircraft itself is not a tourist attraction. Also, space tourism, beyond short suborbital trips, could potentially last as long as some ocean and river cruises, thus requiring orbits free of debris and other dangers.
- Space activities sometimes resemble specialized maritime activities, where the destination is an emplaced artificial structure (the ISS, for example) in the space medium and serviced by spacecraft, like ships servicing offshore oil rigs within an ocean medium.
- The commercial space-launch industry resembles the maritime sector much more than the air-transport sector in that a large part of the business is exposed to international competition. The US aviation industry, however, enjoys a very large protected domestic market and is further protected by international aviation agreements.

Given the similarities of navigating and working in the two above-described environments, liability and compensation lessons learned and applied in the high seas could potentially inform liability and compensation strategies in space. However, because of unique liability provisions of the international space treaties, especially the Outer Space Treaty<sup>6</sup> and Liability Convention<sup>7</sup>, maritime strategies cannot be applied wholesale.

For example, the current international regime for compensation for damage caused by oil pollution is based on two conventions: International Convention on Civil Liability for Oil

Pollution Damage, 1969 (CLC 69) and International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1971 (Fund 1971), an intergovernmental entity that provides access to liability compensation funds only to CLC 69 State Parties.<sup>8</sup>

However, the main principles and provisions of CLC 69 cannot be used in the space context for two main reasons: First, the general principle provided in CLC 69 is that those causing the pollution should pay the compensation. However, as noted above, often the party causing the orbital debris cannot be determined. And second, Article III of CLC 69 makes the owner of the ship strictly liable *even in the absence of any fault*. While Article III of the Liability Convention provides that, *spacecraft owner and operator aside*, the *launching State* is *absolutely* liable only if damage is done on Earth or to aircraft in flight but liable *based on fault* if damage occurs in outer space. The Liability Convention addresses the spacecraft owner's liability only as connected to the owner's launching State. Moreover, per both space treaties, multiple launching States can simultaneously bear joint and several liability.

Given that CLC 69 and Fund 1971 are not helpful to solving the liability and compensation issues in the outer space context, are there other maritime traditions and legal regimes from which we can draw helpful lessons? The answer is a resounding "yes." Let us start with examining the maritime liability and compensation history connected to commercial salvors.

### **Maritime tradition of compensation and liability for commercial operators**

Much can be learned from the long tradition of maritime salvage, which dates from the ancient Phoenicians, Greeks, and Romans. To deal with human-produced sea perils, commercial "salvors" were and still are rewarded financially for rescuing ships and their cargo, clearing shipwrecks from shipping lanes, and eliminating or preventing other environmental hazards.<sup>9</sup>

Historically, commercial salvors were rewarded only if they met three conditions: 1) the vessel or cargo must be in peril; 2) the salvor must be acting voluntarily and under no contract existing before the peril; and 3) the salvor must be successful in his efforts ("no cure, no pay"), although payment for partial success was traditionally granted under certain circumstances. Salvage tradition until 1980 only recognized a ship, cargo on board, freight payable, and fuel ("bunkers") carried on board as subject to salvage, if in "peril," defined broadly.

However, the concept of special compensation beyond pure property salvage *for preventing environmental damage* was codified and expanded by the International Convention on Salvage, 1989 (Salvage Convention),<sup>10</sup> which entered into force on 14 July 1996. Article 14 of the Convention considers protection of the environment (even beyond oils spills, for debris) as part of salvage and therefore subject to reward if contamination is prevented by the salvor. Such reward, informally called “liability salvage,” is officially termed “special compensation” by the Convention, as opposed to compensation for property salvage. Because acquiring “special compensation” under Article 14 of the Salvage Convention proved to be time-consuming and somewhat limited, an alternative system for awarding special compensation, known as the Special Compensation Protection and Indemnity Clause (SCOPIC) was developed by Protection and Indemnity (P&I) Clubs, salvors, underwriters, and ship owners.<sup>11</sup>

### **Funding maritime protection and indemnity (P&I) insurance with P&I clubs.**

Protection and indemnity (P&I) insurance is a form of mutual maritime insurance provided by a P&I club. A P&I club is a mutual insurance association, a non-profit cooperative, that provides risk pooling, information, and representation for its members—nowadays ship owners, ship operators or charterers, freight forwarders, and warehouse operators. Whereas the insured pays a premium to an underwriter for coverage lasting for a specified time, the P&I club member pays a “call”—a sum of money paid into the club’s pool. If at the end of the year, there are still funds in the pool, each member will pay a reduced call the following year. But if the club has a major payout, club members will have to pay a further call to replenish the pool. By eliminating the underwriter’s profit margins, P&I insurance is significantly cheaper.<sup>12</sup>

Marine insurers offer insurance on measurable risks: hull and machinery insurance for ship owners, and cargo insurance for cargo owners. P&I clubs provide insurance for broader, indeterminate risks that marine insurers usually do not cover, such as third-party risks. These risks include: a carrier’s liability to a cargo-owner for damage to cargo, a ship owner’s liability after a collision, environmental pollution and P&I war risk insurance, or legal liability due to acts of war affecting the ship. P&I space clubs could likewise provide indemnification for risks, which traditional space insurers will not handle.

## Compensation for preventing or removing pollution in maritime or space environment

NSS believes that standard agreements detailing liability compensation based on pre-agreed-upon tariff rates in accordance with pre-agreed-upon liability apportionment among all the parties involved in an orbital debris effort present a pathway forward. P&I space clubs (composed of commercial spacecraft owners, operators, debris remediation salvors/contractors) could carry out liability apportionment and compensation agreements with national governments, underwriters, investors, etc.—basically all the stakeholders in a space debris effort, whether in orbit or on a planetary surface. As in the maritime case, compensation funding would be provided before any debris remediation effort via “calls” into a mutual pool, with contributors this time being not only the P&I space club members, but also traditional insurance company underwriters, freight forwarders, national governments, and all other stakeholders in a given orbital debris remediation effort.

## Other helpful maritime conventions

Beyond the above-mentioned mechanisms and conventions dealing with maritime debris liability and compensation, there are two other international maritime conventions that could be used as partial models for dealing with space debris, whether in orbit or on a planetary surface. Those conventions are the London Convention<sup>13</sup> and MARPOL 1973/1978.<sup>14</sup>

The London Convention is a set of rules against the “dumping,” i.e. the deliberate disposal of wastes and *other matter* from vessels and aircraft (emphasis ours). The provisions of the Convention prohibit dumping except for the wastes listed in Annex 1 of the Convention.

The combined instrument MARPOL 1973/1978 deals with the prevention of pollution by oil or chemicals, or by harmful substances in packaged form, sewage, and garbage. Besides providing various harmful discharge prohibitions, MARPOL 1973/1978 also laid down a mechanism to check the seaworthiness of a ship by providing a framework for the certification of ships with respect to safety and pollution compliance.

Further description of these conventions and how their provisions might apply to the space context is beyond the scope of this paper. However, we encourage our readers to continue this line of study.

## Beyond the maritime tradition and law

Because myriad unclaimed/undesigned orbital debris objects exist, even the best written liability and compensation agreements would be inadequate for dealing with the orbital debris remediation problem without some voluntary mechanism or system for facilitating the adoption (jurisdiction and control) of debris objects. Fortunately, there are also non-maritime approaches that can illuminate a path towards such a mechanism or system. Even so, for the sake of cost-effectiveness, such a system must offer incentives for States to *prefer* using commercial operators as their jurisdiction and control agents to work on, salvage, or deorbit debris, while they limit the commercial operator's liability.

A way forward appears possible following a theorem developed by economist Robert Coase, and often discussed in the context of externalities such as pollution—and orbital debris *is* pollution. This theorem argues that under conditions of low transaction costs<sup>15</sup> and competitive markets, “parties to a dispute over property rights (not necessarily ownership, *per se*) will be able to negotiate an economically optimal solution, regardless of the initial distribution of the property rights.”<sup>16</sup> More formally the theorem states that “if trade in an externality is possible and there are sufficiently low transaction costs, bargaining will lead to a Pareto efficient outcome regardless of the initial allocation of property.”<sup>17</sup> The key is to remove obstacles to bargaining and better define the equivalent property rights to allow easy trade in the externality of the risk imposed by debris.

Two precedents are important to the discussion: First, according to Dr. Armel Kerrest, “A space object may be sold/bought while in outer space” and “There is no objection by principle to a transfer of registration,”<sup>18</sup> which brings with it “jurisdiction and control” per Article VIII of the OST. Such a transfer has already taken place with the transfer of AsiaSat 1 and 2 from the United Kingdom to China,<sup>19</sup> the first occurring in 1984, and later when Sweden bought in-orbit the United Kingdom's BSB-1 (“Marpolo-1”) and renamed it Sirius-1 in 1996.<sup>20</sup> Second, as mentioned above, the 1998 Multilateral Agreement among States involved in International Space Station (ISS) operations<sup>21</sup> contains a cross-waiver of liability provision, which addresses liability issues for all ISS member states.

## Creating a Space Salvage Entity (SSE)

We propose the establishment of an intergovernmental Space Salvage Entity (SSE) by multilateral agreement, responsible for:

- 1) assuming jurisdiction and control, ownership, and some degree of liability for *unclaimed* derelict space objects;

- 2) licensing and contracting commercial entities to deorbit or salvage space debris, whether in orbit or on a planetary surface, for immediate or eventual recycling of materials, or for spacecraft servicing, rehabilitation, refurbishment, enhancement, or repair.
- 3) selling salvaged, recycled, or refurbished items at market auctions.

### Actuarial Index

We propose that this SSE create an actuarial (statistical calculation of) risk for every trackable piece of orbital debris, using actuarial models to generate probability and severity of collisions due to mass and orbit, similar to how NASA establishes impact risk for asteroids. We propose that creating such a rank-ordered “leaderboard” of the most potentially consequential pieces of debris become a basis for insurance costs, creating natural incentives to remove risk.

NSS believes that insurance firms and P&I space clubs would pay close attention to an independent index of actuarial risk and to which State Parties those risks are attributed. If insurance companies now account risk to State Parties based upon such an actuarial index of risk, it will be to the advantage of State Parties to either remove high-risk debris or divest of debris for which they have jurisdiction and control and liability risk.

### Assumption of Liability Risk

We further propose that a State Party that transfers registration (and therefore jurisdiction and control) to the SSE *be relieved of liability risk*, and that such jurisdiction and control and associated risk be assumed collectively by the member State Parties of the SSE in coordination with the P&I space club system.

While States would be allowed to directly transfer registration/jurisdiction and control of an asset for disposal or salvage independently of the SSE, once transferred to the Space Salvage Entity that piece of salvage now exists as an asset that may be sold via auction, contingent on the relevant State Party of the buyer assuming registry ownership and therefore jurisdiction and control over the auctioned asset per OST Article VIII and the Registration Convention.<sup>22</sup> Liability would be apportioned between the buyer, the relevant State Party of the buyer, and Space Salvage Entity by agreement, with acceptable insurance coverage (from a P&I space club and/or traditional underwriter) being required of the buyer.



The SSE would be empowered to provide licensing for deorbiting or salvage to the buyer or the buyer's contracting commercial operator. In coordination with the relevant State Party or Parties, the SSE would license the deorbiting or salvaging commercial operator/salvor. Risk liability would be apportioned by agreement between the operator, the Space Salvage Entity, and the relevant State Party or Parties of the operator(s) conducting the deorbiting or salvage. In designing the liability apportionment agreement, partial liability protection for the operator would help to incentivize the deorbiting or salvaging operation.

### The Bottom Line

The SSE would become a platform enabling multiple actors to collaborate in a market to dispose of or salvage derelict objects. Such an entity would reduce transaction costs for all participants. For example, satellite owner-operators could work within the SSE to place economic rewards, compensation, or bounties on specific debris objects or actions to prevent debris. We anticipate that there could be private economic interests for whom it would be economically efficient to clear specific orbits at rates faster than set by the SSE. Owners and operators of satellites, be they States or commercial firms, often have disproportionate incentive to clear particular debris objects or orbits due to the value of their current or future investment. For example, a company wishing to launch a large LEO satellite constellation might desire to have that orbit cleared before they populate that orbit. Since most owner-operators will not have their own de-orbit capability, they would desire to be able to access de-orbiting like a commodity or market. Because the SSE would ideally already have structured a market with minimal transaction costs, private entities would be able to make use of it. Toward that end, we propose that the SSE be structured to allow States, owner-operator firms, insurance firms, private, or non-governmental organizations to place special financial rewards on clearing objects and orbits.

### **Kessler Credit System**

Finally, we also propose to put in place a metric-driven system to incentivize the rapid consolidation or removal of space debris, through a "Kessler Credit System" modelled on other pollution-removing credit systems. The member parties of the Space Salvage Entity would annually agree to overall goals to reduce total debris risk and to remove or consolidate specific amounts of mass annually, as well as to set specific risk and related mass reduction goals for high value orbits. For instance, the member parties might have a goal of reducing conjunction risk in Sun-Synchronous Orbit (SSO) by 10%, as well as to annually remove a total of 40 metric tons from Low Earth Orbit (LEO).

Then, based on the actuarial risk, a credit system would be established. As with proposals for a global carbon-trading credit system, global goals would be set, and State Party pledges secured to remove a certain number of tons of debris annually. Countries could sell their credits to others to enable a collective market-based response to remove debris in the most efficient way possible. Optimal allocation of credits might be usefully explored using game theory.

## A NOTIONAL AGREEMENT CONSTITUTING THE SPACE SALVAGE ENTITY

- Recognizing the aspirations of mankind to become a spacefaring civilization.
- Recognizing the desirability of the safe removal or salvaging of space debris to enable safety of navigation and sustainability of the space environment.
- Affirming the desirability to repurpose derelict objects toward operating space infrastructure.
- Recognizing the need to create the incentives for operators and launching states to accomplish these goals.
- Recognizing the need for a regime that overcomes the tragedy of the commons, lowers transaction costs, and enables a variety of actors to coordinate via a common platform.

The parties hereby constitute the **Space Salvage Entity (SSE)**.

- The governing council will be composed of State Parties to the OST.
- Nothing in this document shall preclude the power of States to transfer ownership, jurisdiction and control, and a portion of liability risk to see to their own debris removal or to directly contract with others.
- It shall be a responsibility of the SSE to assign actuarial risk for collision to all space objects above a mutually agreed upon size range.
- The SSE shall be responsible to set annual goals for the reduction of space debris, whether in orbit or on a planetary surface, and to issue “Kessler Credits” to commercial operators corresponding with actuarial risk, which would reflect on liability risk.
- The parties agree that the SSE takes jurisdiction, control, and liability for all unclaimed and unregistered objects. The SSE may hold these items in perpetuity.
- The SSE shall have the power to acquire registration and with it jurisdiction and control and assume liability risk for derelict objects.
- The SSE shall have the power to set bounties for the removal or salvaging of orbital debris.
- The SSE shall have the power to license debris removal operations authorized under its charter.

- The SSE shall have the power to hold auctions for removal or salvage.
- The SSE shall have the power to reimburse national space agencies on a market-cost basis or cost basis for removal or salvaging activities.
- The SSE may accept special bounties from space operators, salvors, or insurance agencies to incentivize removal of space debris, whether in orbit or on a planetary surface.

## References and notes

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<sup>2</sup> Convention on International Liability for Damage Caused by Space Objects.

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<sup>5</sup> NASA. Partners Sign ISS Agreements. January 29, 1998.

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<sup>6</sup> United Nations. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies.

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<sup>7</sup> Convention on International Liability for Damage Caused by Space Objects.

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<sup>10</sup> International Convention on Salvage, 1989.

<https://www.jus.uio.no/lm/imo.salvage.convention.1989/portrait.letter.pdf>

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<sup>11</sup> A Protection and Indemnity or P&I club is a non-governmental, non-profit mutual or cooperative association of marine insurance providers to its members, consisting of ship owners, operators, charterers and seafarers.

<sup>12</sup> "Protection and Indemnity Insurance," *Wikipedia*,  
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<sup>13</sup> Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972. United Nations, Treaty Series, vol. 1046, p 120. [https://www.gc.noaa.gov/documents/gcil\\_lp.pdf](https://www.gc.noaa.gov/documents/gcil_lp.pdf)

<sup>14</sup> International Convention on the Prevention of Pollution from Ships, 1973/1978.  
<http://documents.worldbank.org/curated/en/860841468330898141/MARPOL-73-78-International-Convention-for-the-Prevention-of-Pollution-from-Ships>

<sup>15</sup> Beggs, Jodi. Introduction to the Coase Theorem. *Thoughtco*, January 17, 2019.  
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