



Maritime Lessons for Removal or Salvage of Orbital Debris and Repair or Enhancement of Spacecraft

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Why *now* so important?

Advances in software, miniaturization, off-the-shelf components, reusability ==> *explosive growth* of satellites & debris in orbital space.



Debris (**shrapnel** + **masses**) threaten orbital safety!

- c. 8000 tons of debris orbiting Earth
- c. 5000 satellites functioning/3600 defunct sats
- 1000s of upper stage rocket bodies



Debris will grow for **200 years** -- *without
new launches!*

But over **70,000** new satellites are being
planned!



Mitigation alone is *NOT* sufficient.

We must “dredge the harbor” of
dangerous orbiting objects.



We need orbital debris cleanup
(remediation)!



But **identification, liability, & funding** issues stand in the way.



Identification/Ownership Problem

Art. VIII of OST says a State Party on whose registry an object is launched retains **jurisdiction & control**.

But only 16,000 of 34,000 trackable objects can be tied to a launch registering State Party.*

* at least 128 million smaller pieces of untrackable debris

State Party Liability Problem

Art. VI & VII of OST & Art. V of the Liability Convention make *multiple* launching States jointly & severally liable for any harm to persons or property.



But what if it's a private entity that:

- procures or carries out a launch?
- provides a property or facility for a launch?
- carries out spacecraft repair/enhancement,
debris recycling, removal, or salvage?

Still NO Liability Escape for State Party

OST Art. VI: “**State Parties** (...) bear international responsibility (liability) for national activities in outer space (...) whether such activities are carried out by governmental agencies or by non-governmental entities.

(...) “the activities of **non-governmental entities** (...) shall require **authorization** and continuing **supervision** by the appropriate State Party (....)”

Good news!

Liability **waivers or apportionment** agreements per **Art. V** of the **Liability Convention** can apportion liability protection among stakeholders, including **private contractors**.

Ex.: Mutual liability waiver agreement used by States collaborating on the International Space Station.



How can we **compensate** liability-sheltered private contractors who de-orbit, salvage or rehabilitate spacecraft?

Can we learn anything from **maritime** custom and law?



Maritime tradition for **compensating** private parties who rescue vessels & prevent destruction:

- 1) Phoenicians, Greeks, & Romans rewarded “salvors” for rescuing ships & cargo.
- 2) Now, commercial salvors are rewarded for rescuing ships, cargo, clearing shipping lanes, & eliminating or preventing environmental hazards.*

* See International Convention on Salvage, 1989, plus the Special Compensation Protection & Indemnity (P&I) Clause (SCOPIC) developed by shipping stakeholders, especially P&I (non-profit insurance) Clubs.



Why Repair, Service, or Salvage instead of deorbit?

Every kg in orbit is potentially worth many times the value of that kg on the ground!

Costs and benefits?

- 1) *What is the **cost** (in profits/lost services) of **NOT** clearing debris?*
- 2) How much is an **orbital band free of debris** worth?
- 3) How much is it worth to have sats repaired, refueled, or upgraded, ***while they are still earning profits?***



How to overcome **identification/ownership impediments** to repair, rehabilitate, salvage, or sell orbital debris?



Establish **Space Salvage Entity (SSE)** by intergovernmental agreement which:

- 1) assumes *jurisdiction and control, supervision, ownership, and liability* for **unclaimed** and **claimed** derelict space objects & 2) carries out agreements to:
 - A) license & contract commercial entities to service, rehabilitate, refurbish, repair, deorbit, or salvage unclaimed & claimed* debris/*spacecraft*; and
 - B) sell unclaimed & claimed salvaged, recycled, or refurbished items & materials at market auctions.

* For claimed objects, the SSE receives jurisdiction & control and all connected obligations and rights via agreement with the State Party claiming the objects.



Jurisdiction/control of space object **transferred** by State Party of registration to SSE, per OST Art. VIII & Registration Convention.

Object then exists as 1) **asset** either **sold** at auction or 2) as ongoing **hazard** to become focus of **State Parties & private companies** to remove it for mutual benefit.*

Liability (+P&I Club* insurance) **apportioned** among parties via mutual liability apportionment or waiver agreements.

* States, commercial companies, P&I Clubs, or NGOs may wish to place special **bounties** on clearing objects from orbits.

* Protection and Indemnity (P&I) Clubs are collaborative, non-profit insurance organizations comprised of maritime stakeholders.



Space Salvage Entity

A platform enabling multiple actors to collaborate in market to dispose of, salvage, or repair derelict objects *or repair/optimize working spacecraft.*

(For more info see “Catalyzing space debris removal, salvage, and use: Maritime lessons and a proposal for a space salvage entity and pollution credit system” in *The Space Review*)



Funding to pay contractors attached to SSE comes from transparently operated *International Trust Fund*

A 1% *end-user* fee on commercial sat services would raise billions of \$ for the fund annually!



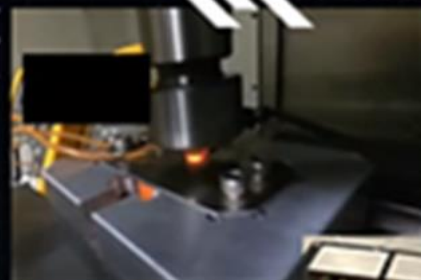
Private sector repair/enhancement of satellites *already happening!*

Two **SpaceLogistics** Mission Extension Vehicles since 2020
providing propulsion & pointing control to satellites in GEO.

Astroscale



Nanoracks



Trash to Treasure

Space Debris Recycling Ecosystem

Live Demonstration
October 19, 2021

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Thank you for your time & attention!

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Extra Slides



Incentivizing Transfer of Jurisdiction & Control to SSE

- 1) SSE creates statistical **calculation of risk** for every trackable piece of orbital debris to generate probability & severity of collisions;
- 2) SSE will use this data to **create a rank-ordered “leaderboard”** of object-intervention **liability risk** to become the basis for insurance costs;
- 3) State Parties & P&I Clubs **will pay close attention to leaderboard statistics** to calculate contract awards/bounties & annual calls.