Trash Trek Challenge

Orbital Debris and Spatium lautus

By: The Incine rators

Orbital Debris

Orbital debris or Space Trash is essentially **“man-made objects remaining in space though they no longer serve any useful purpose.” The amount of space trash** is **growing bigger each year**, because of satellites hitting each other, or the debris hitting the satellites and making even more debris (The Kessler Syndrome).

The main problem that space debris poses is that it can potentially collide with satellites, damaging billions of dollars of technology, including the International Space Station.

Problem Analysis

Kinetic Energy = 0.5 * Mass * Speed^2

- Space debris contains an extreme amount of kinetic energy
- The **average speed** of debris is **around 7 km/s.**
- More than **21,000** pieces of orbital debris, are zooming around in the sky.
- If debris is **> 10 cm,** it will be classified as **large orbital debris.**
- A 10 cm piece of space debris is as powerful as 10 sticks of dynamite.
- They are **tracked routinely** by the **U.S. Space Surveillance Network.**
- The ISS is probably the most heavily shielded object in orbit.
- Prevention is the only current solution.
- Most debris reside within 2,000 km of the Earth. The amount of debris varies significantly with altitude.

- The greatest concentrations of debris are found near 750-800 km. We only need about one launch, for 140 Spacium Lauti.

- Space trash can include **broken satellites, used/burnt up rocket stages, or even globs of paint!** Orbital debris is **usually caused by explosions,** or **crashed/damaged satellites.**

- There is lots of research to be done when sending satellites to space.

- A satellite must be protected with shields and other protective materials against the highly probable collisions with oncoming space debris.

What caused the problem?

- One big cause of the amount of space debris in space is the previous negligence to clean up used satellites/rocket boosters in space.
- China's **anti-satellite testing** in 2007 that was used to destroy an old weather satellite, added more than **3,000** pieces to the debris problem.
- In 2009, two satellites collided, adding **1,000** pieces of debris to orbit.
- Trash poses such a great threat, that even the **ISS has to avoid it**.
- It's also too hard to detect smaller orbital debris from Earth, so people just have to hope the trash doesn't hit their machines.

Some previous Solutions

- **Laser Broom** - A laser to **vaporize a tiny bit of the space junk,** the resulting puff of vapor would create enough drag to slow down the target so it would fall into the atmosphere, where the entire thing would burn up.
    - Strengths: Ground-based lasers avoid launching costs and propellant limitations. Engineer Claude Phipps from the company Photonic Associates, LLC estimates that a medium-powered laser could remove small objects for a few thousand dollars apiece and large objects for $1 million.
    - Weaknesses: NASA's chief scientist for orbital debris, Nicholas Johnson, says aiming a ground-based laser and **hitting a satellite exactly where you want to is no easy feat.** "These objects are not nice spheres—they're more like tumbling cornflakes," he says. "They can be very unpredictable." If the laser accidentally hit the wrong object, such as, say, a Chinese satellite, it could spark an international incident. If it hit the right target but in the wrong place, it's possible that the laser accidentally could give the debris more energy and push it into a higher orbit.
- **“Whoosh it away” -** A system that can fire targeted air puffs into the paths of unsuspecting space trash, increasing drag and forcing the junk to de-orbit. The researchers are considering using air field blasts, explosions, or similar techniques. The amount of debris that one device could eliminate would depend on the density of the junk.
    - Strengths: The air pulses fall back into the atmosphere, so the device leaves no residue behind and has a minimal impact on the space environment.
    - Weaknesses: **May not be strong enough to take down large objects.**

Team Solution - Project Spatium lautus The Space Cleaner

- To solve this problem, we have come up with a solution similar to **plankton nets** used by fishermen.
- Our solution will **target smaller varieties of orbital debris.**
- Our solution consists of a hollow cone made of graphene. To slow down the debris, layers of Aerogel are placed in the opening of the cone. This substance was used by NASA in their previous Stardust mission. Aerogel is a solid material of extremely low density, produced by removing the liquid component from a conventional gel.
- We chose **graphene** due to its **strength and flexibility**.
- **The cone will, in a sense, swallow the incoming space debris.**
- The debris caught in the cone can then be studied by scientists in the International Space Station. Objects under 10 cm are nearly invisible on the Earth, so scientists have never really been able to observe the debris before.
- We have also presented this solution to scientists and engineers at Jet Propulsion Lab.

The math

Surface Area of SL = $16m^2$

Volume of SL = $4m^3$

Investigated weight of Graphene (material of SL body) = 2 mg/cm3

Investigated weight of Aerogel (filled into SL body) = 20 mg/cm3

Weight of empty SL (body only) = 0.3 kg

Weight of Aerogel filling = 80 kg

Total weight of SL = Weight of empty SL + Weight of Aerogel = 80 kg

Price of Graphene is $160,000

Price of Aerogel is $24,000

Investigated dimensions of largest rocket = 42m x 10m

Investigated weight of empty rocket = 44 tons

Based on dimensions of SL, this will fit 140 total SL packed in, with some room for thrusters and other fillers

Total weight of all SL = 12.1 tons

Weight of empty rocket + Weight of all SL = $2.2 * 10^5$ tons

Weight of all SL * 10,000 = $1.2 * 10^6$ tons

Investigated cost of rocket launch = $20,000 per kg

Cost of launch = $2.5 billion

Cost of 1 Spatium Lautus = $185,000

Innovation

This solution is going to be quite handy, for the future. This is how we expect our project is going to help:

- Our net army (it should be mass produced) will capture quite a lot of trash.
- The trash could then be brought back to the ISS, where scientists on board can study it. This is new, as in the past, debris under 10 cm were nearly invisible. **Now, scientists can interact hands-on with these pieces of space trash.**
- **This newly available research will help us understand space debris better than ever before.**
- **After observing them, the larger pieces of space debris can be used as radiation shields, while the smaller ones can be compacted into cubes and/or sent back down to Earth.**

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Contacts

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FAQ

1. **What are the launch costs? Any ways to reduce them?**

Launch costs can vary, but we estimated that our rocket and payload cost 2.47 billion dollars.

2. **What are potential risks?**

The only risk we see is: our cubesats or gyro sensors are broken, but that is highly unlikely, for they are extremely tiny targets, and protected. If, they get harmed, then another SL will send it to the ISS, to be repaired. The ISS actually completes almost 16 orbits a day, so it shouldn’t take long.

3. **How many Spatium Lauti are required to completely clean up space debris?**

The amount of the debris has built up so much that it is borderline impossible to remove all of it in one shot. 140 Spatium Lauti are launched to make an impact by clearing as much debris as possible.

FAQ

4. **Any other choices of material?**

We looked for extremely strong material to use for the cone, and the two strongest, were graphene and diamond. We chose graphene due to its flexibility and its price in respect to pure diamond.

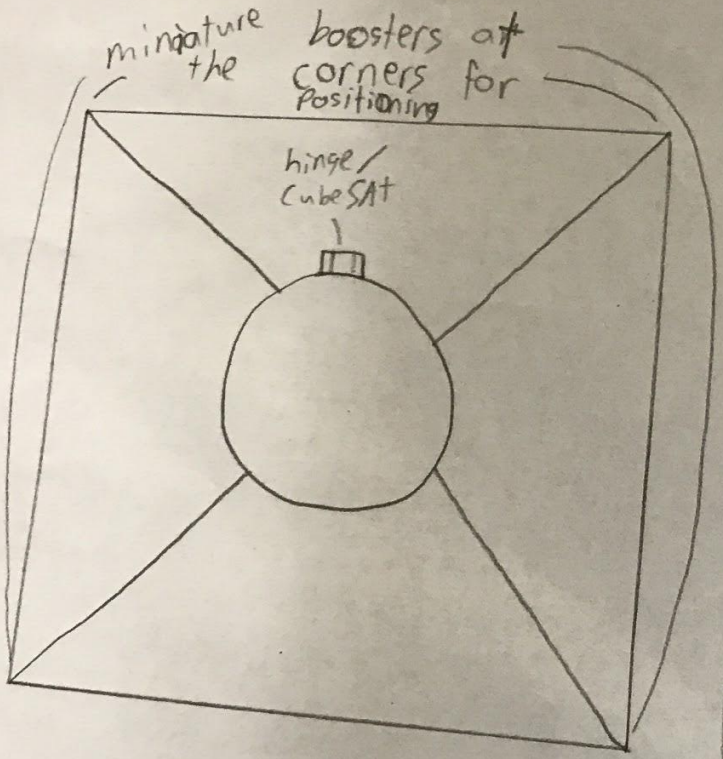
5. **Why a cone, and not a cylinder?**

We decided to use a cone, as the debris might bounce out of the back if it had a flat base. The cone’s tip will help the debris stay in the cone, and bounce in a web-like pattern, not straight out.

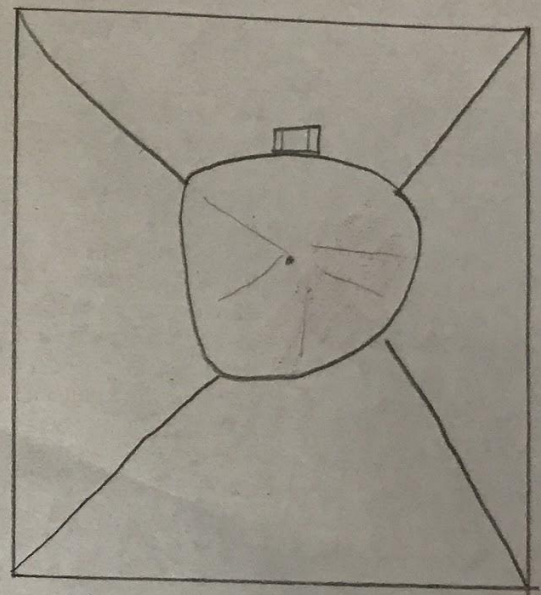
6. How would the SL capture space trash orbiting the other way?

Multiple Spatium Lauti would be orbiting in opposite directions, so each orbital direction has at least one Spatium Lautus capturing trash.

front view



back view



Side View/Top/bottom View