Incentivizing Space Environmentalism and Sustainability: Mitigating Space Debris to Enable Mars Exploration and Space Tourism

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Space Debris and our Pathway to Mars

- Space debris is a threat to our way of life and our ability to explore Mars
- Think about how life is impacted by data from satellites
- How fragile are these satellites when a piece of metal collides with it at a relative speed of thousands of miles per hour
- We need to have an environmental plan for space
- Deorbiting strategies must be included in launch projects
- Space agencies can incentivize sustainability and space environmentalism by awarding contracts to companies with solid deorbiting strategies

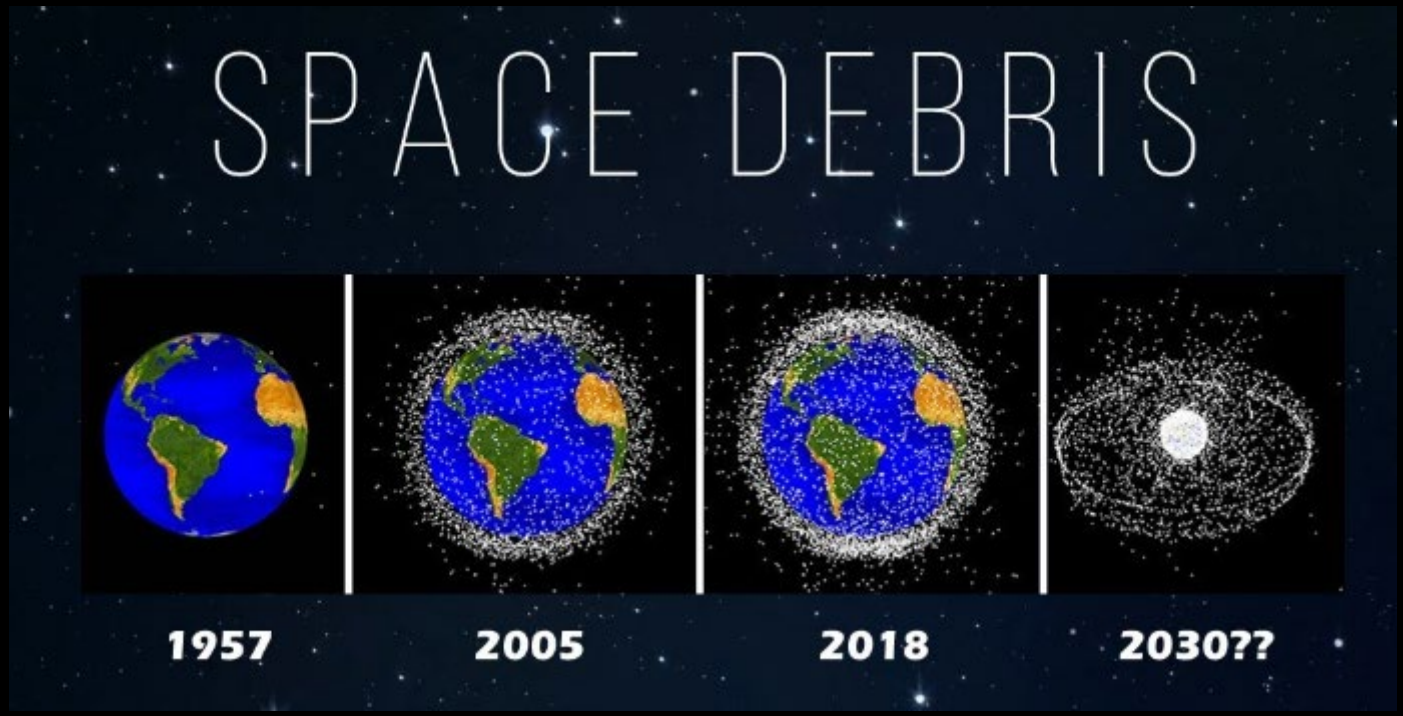
What does a broken, abandoned bicycle have to do with space environmentalism?

If you were riding your bicycle and it broke down,
would you go back later to retrieve it,
or just abandon your bicycle where you left it indefinitely?
Most of us would retrieve it

Space litter is a problem just as Earth litter is a problem…but space litter can negatively impact our ability to explore Mars

Debris clogging orbital roads will makes launches, space travel, exploration, and tourism more cumbersome, as objects break apart and may create an almost impassable wall.

Kessler Syndrome



The Kessler Syndrome

- Dr. Donald Kessler theorized the Kessler Syndrome
- The Kessler Syndrome describes a situation of a debris field through which no spacecraft can pass
- I phoned Dr. Kessler to discuss the issue and he read my paper and shared opinions about space debris
- Eventually, one piece of space debris crashes into another piece of debris, then that debris follows suit, and eventually the debris adds up.
- This scenario represents the issue with space debris that cause damage to satellites and rockets

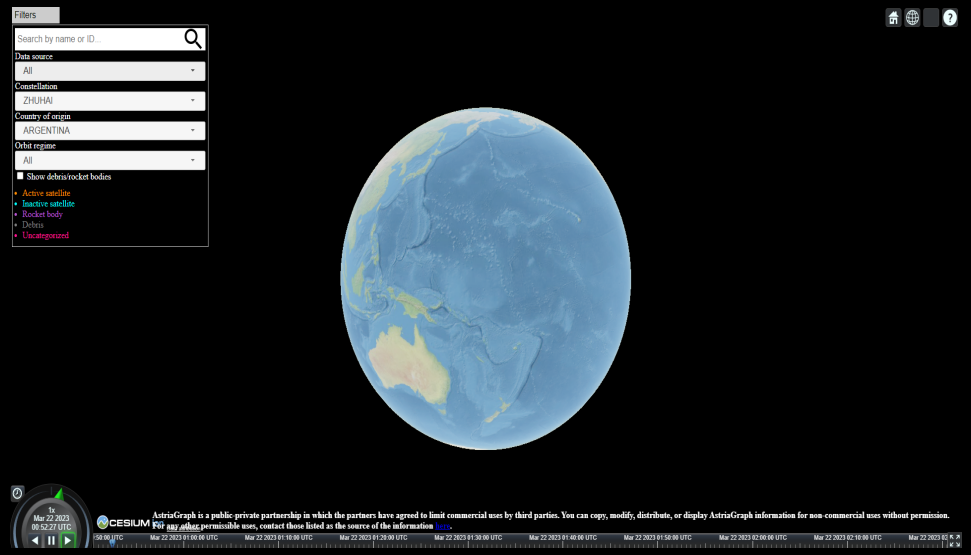
Quantifying Space Debris

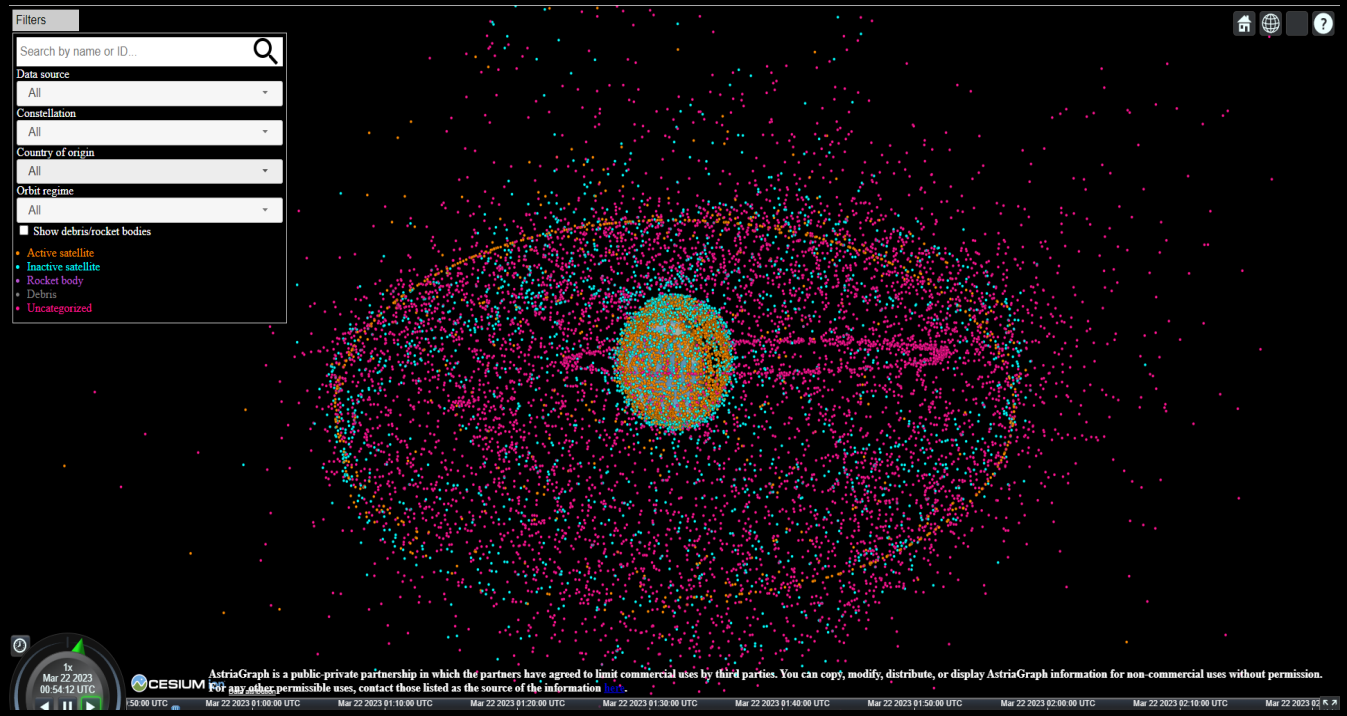
- Hard to give a concrete number, but probably over 100 million pieces of variably-sized debris – from a paint chip to a school bus
- It is like counting leaves in a hurricane

https://www.esa.int/Space_Safety/Space_Debris/The_current_state_of_space_debris

Space Environmentalism
Dr. Moriba Jah's Astriagraph

http://astria.tacc.utexas.edu/AstriaGraph/





Astronauts' Perspectives: Dr. Sian Proctor shared with me:

"Space Environmentalism isn't an issue to be tackled, it is a philosophical ideology of humanities views toward our stewardship of the space ecosystem now and for future generations."

Astronauts' Perspectives: Chris Sembroski shared with me:

"Space debris hitting the space station is always a concern…While we did not dock with the ISS (which is around 400km in altitude), our orbit took us to a higher altitude than the station of 590km. Statistically, that put us at an elevated risk for encountering space debris…"

"…a potential impact of space debris with Crew-2's Dragon shortly after getting to orbit. The crew had to take quick actions to mitigate the effects of a potential impact; fortunately, it turned out to be a false alarm. Even still, Dragon is designed to withstand impacts from micrometeorites. And we did take some hits! But the objects we encountered were the size of a grain of sand or smaller, and it was expected that this would happen. Anything larger that was able to be tracked by the Space Force would have required Dragon to alter its course to avoid a potential collision."

Space Tourism

- I spoke with Marc and Sharon Hagle who went up with Jeff Bezos' New Shepherd rocket
- They spoke to me about how it transformed them to see the fragility and beauty of the Earth
- There are several pathways which may prevent an incident that would have a negative financial impact upon economies and industries associated with the satellite and space exploration/ tourism industry.

Talking with the Experts

- I started my research speaking with Dr. John Crassidis of UB who gave me insight as to the current scope of the problem
  - We need to keep working on this issue because there is no quick solution yet

- I spoke with Explore Mars Europe Founder/CEO, and United Nations Space4Women representative, Artemis Westenberg,
  - ESA and NASA are searching on solutions, but international U.N. cooperation is crucial for making space policy viable. In order to be able to settle Mars, we need a safe and clear orbital highway.
  - "It is important that companies and agencies work together, but the cleanup can't be fully funded by the government, because then civilians are paying extra taxes for big business to clean up their act."

International Guidelines and Space Law

- UNOOSA rules suggest deorbiting of defunct objects in five years
- Michel Van Pelt, the head of ESTEC Cost Engineering at the ESA.
    - He feels strongly that this issue has to be addressed but governments cannot be the driving factor. It has to be financially beneficial to contribute to the common good.
    - He conveyed to me the importance of having corporate buy-in to ensure that space debris is deorbited
    - Many contracts for satellites are distributed by government space agencies such as NASA, ESA, and JAXA. It is crucial to have the space agencies adhere to the UNOOSA guidelines for space launch of objects and the five-year rule.
    - Chiefly, one wants to ensure that there is no reentry risk to humans, so the work of companies such as ClearSpace and D-Orbit are important and supported by the European Space Agency.

Incentivizing the Cleanup

- Contact Capture or Contactless Retrieval
- Tentacles or Robotic arm(s)
- Flexible netting, tethering, gripping, harpooning, or rope lassoing
- Tractor pulling using gravity or electrostatic/magnetic charges

Obruta Space Solutions is an Ottawa, Ontario based company focusing on on-orbit servicing and space logistics, servicing the new space economy.

- Researching tethered net space removal technology and making autonomous piloting software
- Working with Canadian Space Agency
- I asked the CEO/Co-founder, Kevin Stadnyk about their business strategy:
  - Others create the satellites to clean up space, but Obruta makes the parts that enables the functionality and perform in-orbit servicing.
  - Obruta is making software to enable services for use with in-orbit service missions.

Space Traffic Police?

- Tracking and cataloging pieces that are larger than 1 mm
- It is not necessarily easy to give a defunct satellite a ticket or pull it over
- The U.S. Space Force/Space Command shoulders the burden by tracking all working satellites and cataloging debris
- **But is this really the job of the military?**
- Is it possible for a commercial entity to monitor space debris? What are the dangers and risks involved with the privatization of collision monitoring?
- At AIAA in Cape Canaveral last fall, I heard the Technical Director for Launch and Range Operations for Space Force's Space Systems Command speak.
  - Mark Bontrager said one of their priorities is to monitor everything around us in orbit to keep us safe on the ground, and our assets in space functioning

Rewarding Innovation

- The problem lies in the small number of countries and companies who cause debris, making travel more difficult, eventually creating an impassable wall.
- This scenario represents the issue with space debris, deorbiting satellites do not cause a problem when retrieved, but the small fraction of satellites and rocket staging that cannot deorbit stay in orbit and crash into other spacecraft and cause debris in the orbits, which cause damage to more and more satellites and rockets
- Governments and space agencies should reward companies that have deorbiting plans that follow UNOOSA guidelines

Where do we go from here

We need to develop strategies to mitigate the issue and take the Kessler Syndrome seriously in order to make Mars exploration a reality.

We need to have an environmental plan for space so that we can explore Mars and create safe passageways to new extraterrestrial communities.

- Thank you for listening!
- If you wish to contact me
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Special Thanks

The genesis of my interest in this topic came from my college and homeschool studies that were supplemented with classes from:

- My Astra Nova Planetary Science teacher Dr. Trudi Hoogenboom,
- My CubeSat teachers Kevin Simmons and Shawna Christenson
- My Astra Nova critical analysis skills teacher and founder, Josh Dahn,
- My space law mentor, Shawn Case
- My orbital mechanics mentor Khushbu Patel of Relativity Space
- My Buffalo Squadron of Civil Air Patrol unit
- And most of all my space education teachers throughout Covid, Janet Ivey and Artemis Westenberg.
- Janet has literally been inspiring me since I was a child with Janet's Planet, and I want to thank her for extending her kindness to allow me to speak about this important space environmental issue

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