



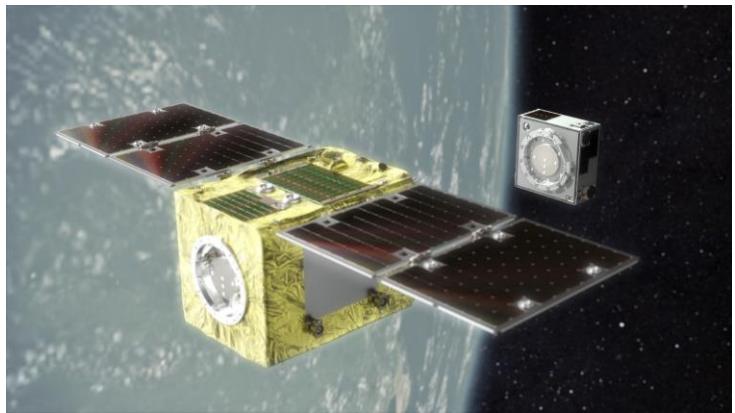
[The European Space Agency]

This shows a visual of space junk made by the European Space Agency.

How the ELSA-d Prototype Satellite Retrieval Technology can Address our Space Debris Problem

Catherine Boss

Penn State College of Engineering
The Pennsylvania State University
10 April 2024



[Astroscale]



The graphic shown is a visual by Astroscale, the designers and owners of the ELSA-d and ELSA technology

What is the End of Life Service by Astroscale – demonstration (ELSA-d) And Why Is It Relevant?



[hpcwire.com]

The Growing Space Debris Crisis Is Yet To Be Addressed And Is Only Escalating



[Astroscale]

How the ELSA-d Will Revolutionize Space Sustainability

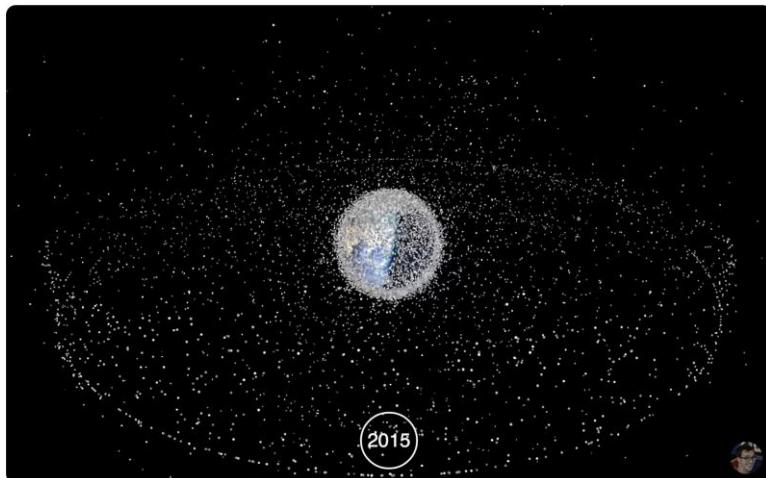


[CNN.com]

Future Implications And Consequences

- The Space Debris Crisis is escalating and has not been addressed
- The ELSA-d is the first privatized solution and has great potential
- If we do not take action we will lose the use of our orbits

The Problem of Space Junk In Our Atmosphere Has Only Escalated In Recent Centuries



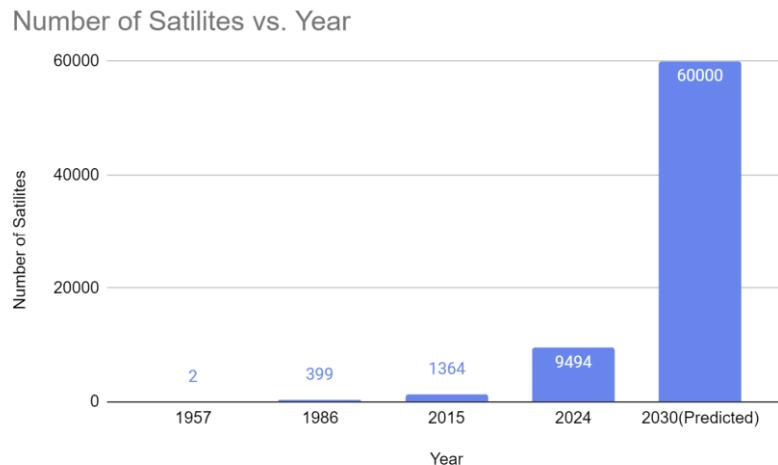
[Stuart Grey]

- Sputnik was released in 1957
- Somewhere between 20,000 –40,000 individual pieces of space debris
- Starlink has released ~5,400 satellites in the last 4 years, plans to get to 12,000 or expand to 42,000
- The number of things in space has increased exponentially as time goes on with no indication of it slowing down or stopping

Matney, M., Manis, A., Anz-Meador, P., Gates, D., Seago, J., Vavrin, A., & Xu, Y. L. (2019, December). The NASA orbital debris engineering model 3.1: development, verification, and validation. In *International Orbital Debris Conference (IOC)*(No. JSC-E-DAA-TN73945).

Singh, P. R. A. B. H. A. T., Chand, D. S., Pal, S. O. U. R. A. V., & Mishra, A. A. D. Y. A. (2020). Study of Current Scenario & Removal Methods of Space Debris. *International Journal of Mechanical and Production Engineering Research and Development*, 10, 223-236.

The Problem of Pollution in Space is Only Accelerating With No Signs of Leveling Out



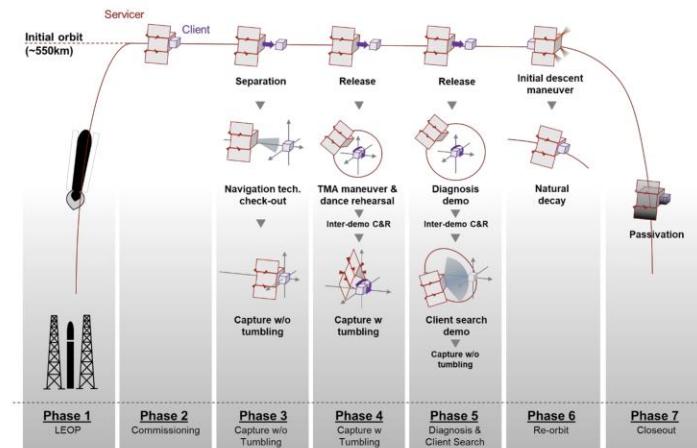
[Statista Research Department]

- Here is the previous data in table form
- In 2030 we are predicted to have 60,000 active satellites

Government Accountability Office. (2022, September). *Large Constellations of Satellites*. Report to Congressional Addressees. chrome-extension://efaidnbmnnibpcajpcglclefindmkaj/https://www.gao.gov/assets/gao-22-105166.pdf

Statista Research Department. (2023, December 1). *Number of active satellites from 1957 to 2022*. Statista. <https://www.statista.com/statistics/897719/number-of-active-satellites-by-year/>

End of Life Service by Astroscale – demonstration (ELSA-d) Is A Proof Of Concept Demonstration for Satellite Retrieval



[Astroscale]

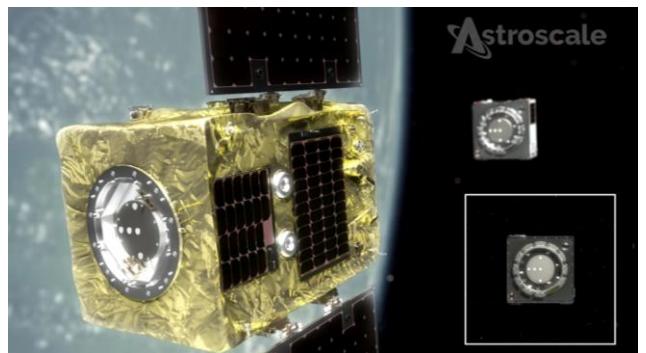
- The ELSA has wrapped up the demonstration with a fully successful execution
- We are currently in phase 6/7 where the satellite components are burning up the atmosphere

- the device uses magnet ports to latch onto the client satellites
- The client satellites may be deorbited or decommissioned based on readings
- the tumbling satellites are really hard to address, but ELSA does it well

Blackerby, C., Okamoto, A., Iizuka, S., Kobayashi, Y., Fujimoto, K., Seto, Y., ... & Bradford, A. (2019, October). The ELSA-d end-of-life debris removal mission: preparing for launch. In *Proceedings of the International Astronautical Congress, IAC*(Vol. 8).

Park, S. H., Laboulais, J. N., Leyland, P., & Mischler, S. (2021). Re-entry survival analysis and ground risk assessment of space debris considering by-products generation. *Acta Astronautica*, 179, 604-618.

The ELSA Technology Uses Unique Magnet Ports to attach to Stable and Tumbling Client SATLILTIES

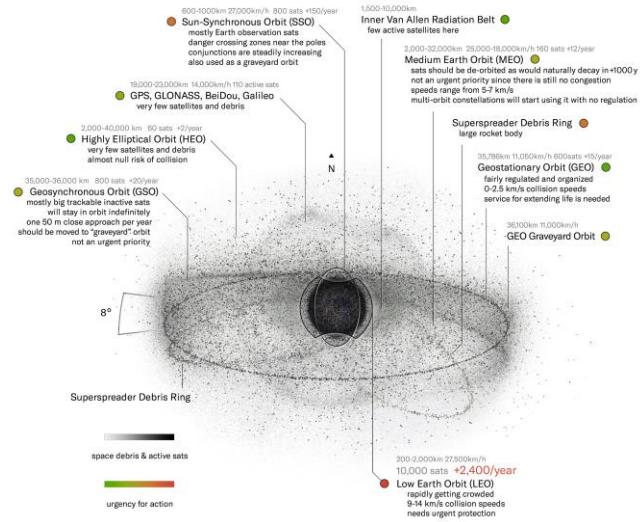


[Astroscale]

- Talk about the special magnet port
- Talk about tumbling capture

Astroscale. (2023, June 12). *Elsa-m / end of life services by astroscale - multiple*. YouTube. <https://www.youtube.com/watch?v=y1v-eF26mCc>

Without Intervention, Earth's Orbit Will Become So Polluted Future and Current Missions Will Be Impossible



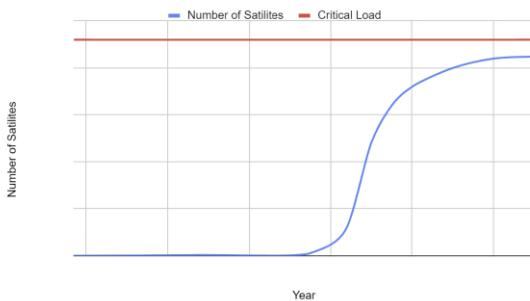
[Budassi]

Reinforce how unsustainable our current satellites setup is

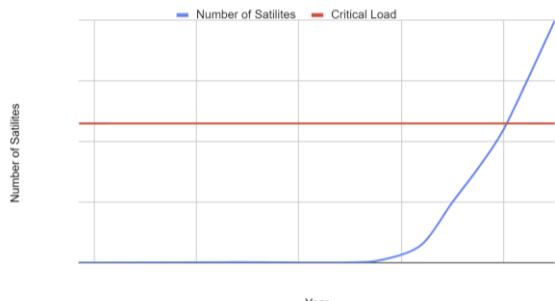
Budassi, P. C. (2023). *Space sustainability urgency in earth orbits*. Retrieved April 10, 2024.,

By Kessler's Law Our Increase In Satellites Will Lead To A Critical Level of Space Junk Impeding Orbital Access

Satellite Load With ELSA



Satellite Load Without ELSA



[Nomura et al]

- Talk about critical load
- Kessler's law and how increasing satellite numbers contribute

Nomura, K., Rella, S., Merritt, H., Baltussen, M., Bird, D., Tjuka, A., & Falk, D. (2024). Tipping points of space debris in low Earth orbit. *International Journal of the Commons*, 18(1). <https://doi.org/10.5334/ijc.1275>