SMALL SATELLITE ACTIVE SPACE DEBRIS REMOVAL APPLICATION FOR UNCOOPERATIVE SPACE DEBRIS

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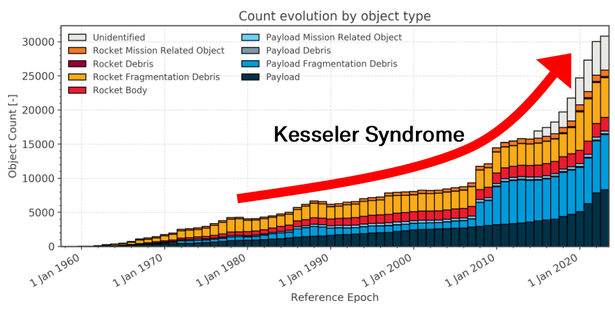
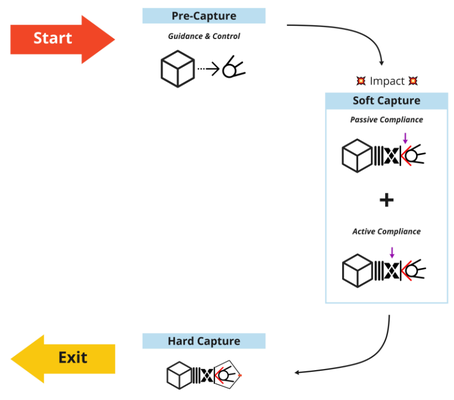
CONTEXT

- Exponential growth of space debris in orbit
- Active Debris Removal (ADR) needed for stabilising the exponential growth of space debris
- Developed systems are one-to-one design solutions for large debris (1 system able to capture 1 debris)



DESIGN REQUIREMENTS

- **Data Analysis** of the trackable objects in Low-Earth Orbit (LEO)
- A **one-to-many solution** → 1 system can be used to capture different debris
- Integrates two types of capture:
  - **Soft Capture** complies and retains the debris from being pushed away at the impact.
  - **Hard Capture** secures the link with the debris and ensures the system ready for deorbiting.
- The mechatronic system must be **autonomous**.
- The system targets **flat surfaces**.

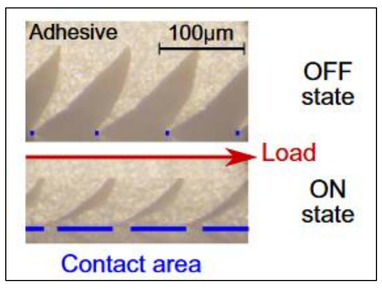


HYBRID-COMPLIANT CONCEPT

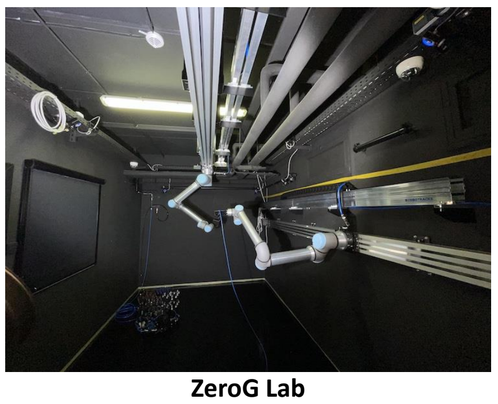
- **Hybrid-compliant mechanism** → **Active + Passive** Compliance, dissipating impact energy
- **Active Compliance** → linear actuators + impedance controller
- **Passive Compliance** → revolute joints + torsional springs

*The system's stiffness can be **adaptative** to the debris mass, and approach velocity*

- Use of **bio-inspired dry adhesive** from the gecko fingers
- Van der Waals interactions to stick with the debris surface.
- Tests in **the ZeroG Lab** of SpaceR



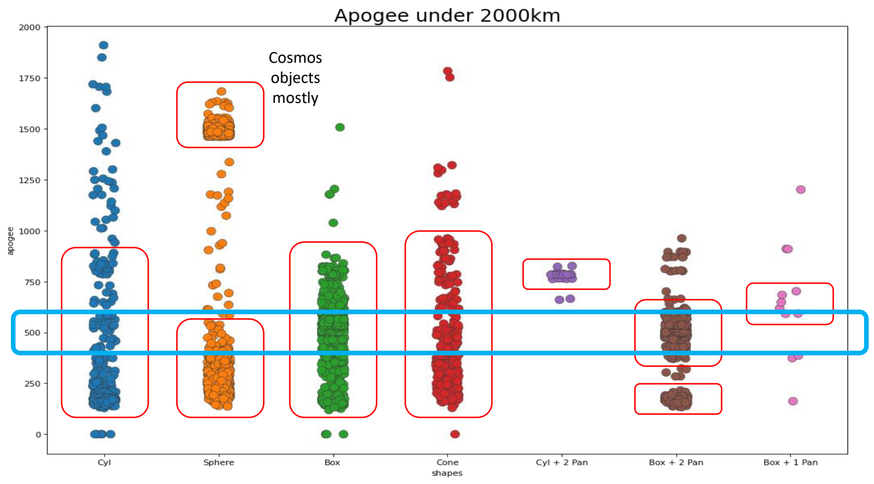
Gecko material principle



ZeroG Lab

RESEARCH

What range of debris to target?



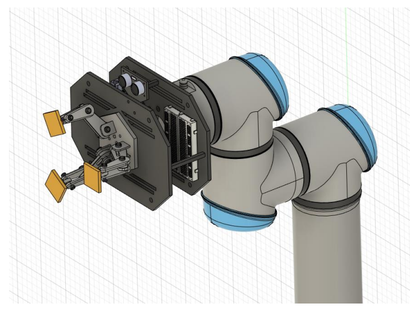
Shape	Amount	% of LEO small debris total
Sphere	1044	25.08
Box	949	22.80
Box + 2 Pan	669	16.07
Cyl	457	10.98
Cone	274	6.58
Box + 2 Ant	113	2.72

Table 1. Main Debris Shapes Found In LEO (mass ≤ 100 kg)

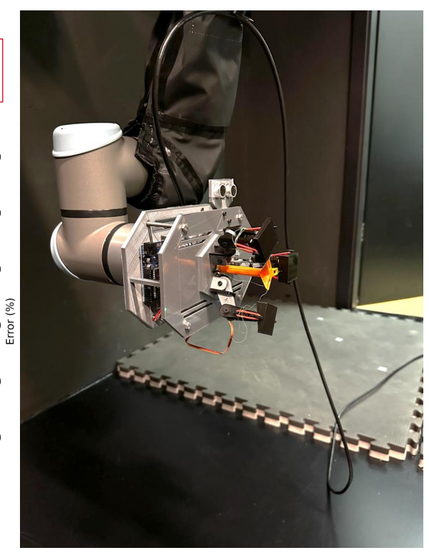
Passive Compliance Unit

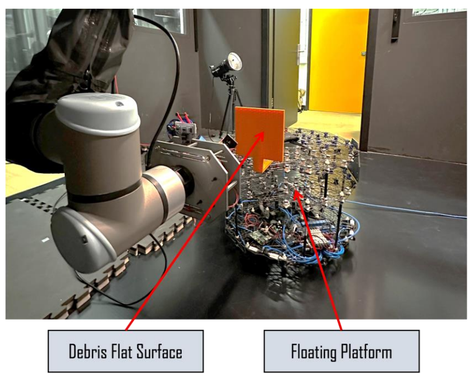
From Concept...

...to Prototype...,

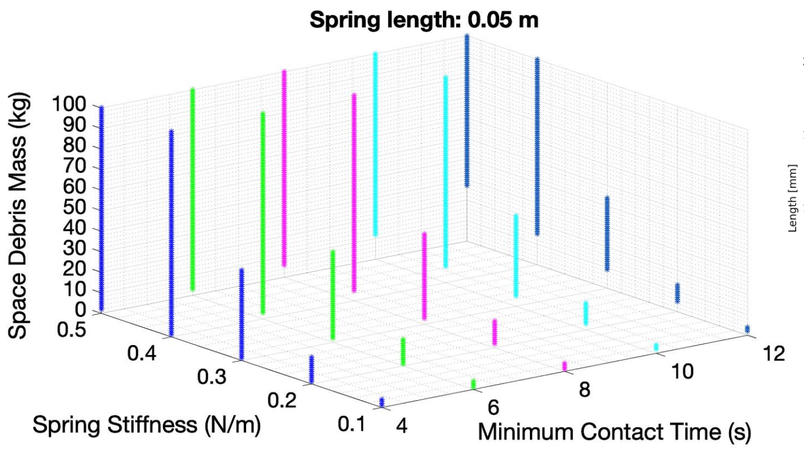


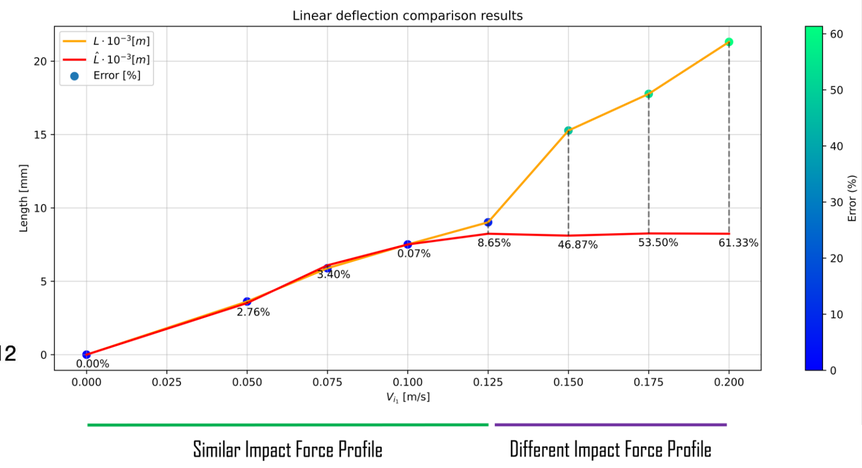
...Ready to be tested in the lab!





Impact Behaviour Simulations & Tests





FUTURE WORKS

→Implement and test Passive Compliance + Active Compliance in the ZeroG Lab

→Concept, Prototype and Tests of the Hard Capture

→Disseminate the results in journals and conferences

REFERENCES

- Hubert Delisle, M.; Christidi-Loumpasefski, O.-O.; Yalçın, B.C.; Li, X.; Olivares-Mendez, M.; Martinez, C. Hybrid-Compliant System for Soft Capture of Uncooperative Space Debris. *Appl. Sci.* **2023**, *13*, 7968. https://doi.org/10.3390/app13137968
- Yalçın, B.C.; Martinez, C.; Hubert Delisle, M.; Rodriguez, G.; Zheng, J.; Olivares-Mendez, M. ET-Class: An Energy Transfer-Based Classification of Space Debris Removal Methods and Missions. Front. Space Technol. **2022**, 3, 23.

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