JANITOR: Active Debris Removal Satellite. S. Rovera [1] and B.H. Foing[2] [1](solim.rovera@epfl.ch), [2]LUNEX EuroMoonMars, EuroSpaceHub, EPFL/Leiden/ISU (bernard.foing@epfl.ch).

Introduction: Due to the increasing space activities of human beings, the number of spacecrafts being launched into orbit is increasing exponentially. This is causing a rise in the number of space debris in orbit. With an estimated 36500 objects larger than 10 cm in orbit [1], there is an ever-increasing possibility of a Kessler Syndrome, the consequences of which would be devastating. The need for space sustainability is becoming increasingly important. The cost of having to cleanup space after a collision is incomparably high compared to removing the pieces of space debris before such event. Therefore, it is necessary to have an end of life plan for every spacecraft launched in orbit. This abstract summarizes the JANITOR concept mission, an Active Debris Removal mission to remove Envisat from orbit, developed in the context of the EPFL course *Spacecraft Design and System Engineering*.

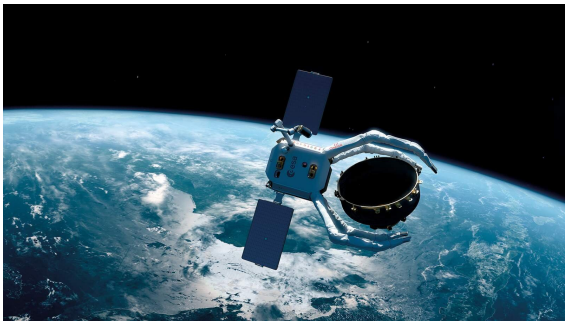

Figure 1: Clearspace-1 spacecraft

Background: Some ADR missions have already been and some small ones have already flown. For example, e.Deorbit [2] was a mission planned by ESA to deorbit Envisat, however, funding for the mission stopped in 2018. Instead, ESA decided to fund the ClearSpace-1 mission [3], from the Swiss startup ClearSpace. This mission aims to remove a 112 kg Vespa upper stage in 2026.

ADR missions are inherently complex and pose many challenges. One of them is to successfully capture non cooperative objects in orbit, as these objects could be uncontrollably tumbling with high angular momentum. There are two options to detumble such objects: contact methods and contactless methods, which both have advantages and disadvantages. Another challenge is to have a working business model and to find enough funding to make the mission happen. With the decreasing cost of components and the introduction of new launchers, the cost to access space is rapidly decreasing and soon these missions could become economically viable.

JANITOR planning and objectives: The objective of the JANITOR mission is to remove the inactive earth observation satellite Envisat [4] from orbit. Being the largest earth observation satellite to ever fly, it is particularly dangerous and has the potential to collide with other spacecraft and cause irreparable damage. JANITOR aims to demonstrate the feasibility of deorbiting large uncooperative objects. The mission will be divided into 5 stages:

1) Launch and early operations.
2) Orbit correction and phasing.
3) Rendez-vous.
4) Capture and stabilization.
5) Reentry.

JANITOR will be launched in 2028 and the mission is expected to last less than 10 months.

Spacecraft: Based on e.Deorbit concept spacecraft and Airbus Spacetug preliminary design [5], the spacecraft will have a launch mass of 2500 kg. It will have a 2500 W power system and will be powered by two solar panels with a combine surface area of 12.5 m^2. The spacecraft will be able to identify the target through multiple sensors, mainly LIDAR, visual and infrared cameras. Onboard image recognition and ACDS will work hand in hand to correctly position the spacecraft relative to the target. The detumbling of the target will be achieved through plume impingement [6] until the relative angular momentum of the spacecraft is low enough. Using a robotic arm, JANITOR will capture ENVISAT and once a zero relative motion is achieved JANITOR will be able to clamp the target. The JANITOR-ENVISAT complex will then do a safe and controlled deorbit maneuver into Earth atmosphere.

References:

[1] ESA. `https://www.esa.int/Space_Safety/Space_Debris/Space_debris_by_the_numbers`, August 2022.

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[5] Stéphane Estable et al. *Journal of Space Safety Engineering*, 7(1):52–66, 2020.

[6] Thomas V. Peters. https://indico.esa.int/event/128/attachments/734/867/04_COBRA_cleanspace_ppt_v1.pdf, 2016.