Spacecraft concept for active de-tumbling and robotic capture of Ariane rocket bodies

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Background

The 2009 Iridium-Kosmos collision highlights a growing hazard to satellites from space debris. Expended upper stages, also called Rocket Bodies (RB), represent a significant fraction of the debris population that can cause catastrophic loss of space-based assets. Active Debris Removal (ADR) will play a crucial role in mitigating rapid growth of the debris population over the coming decade.

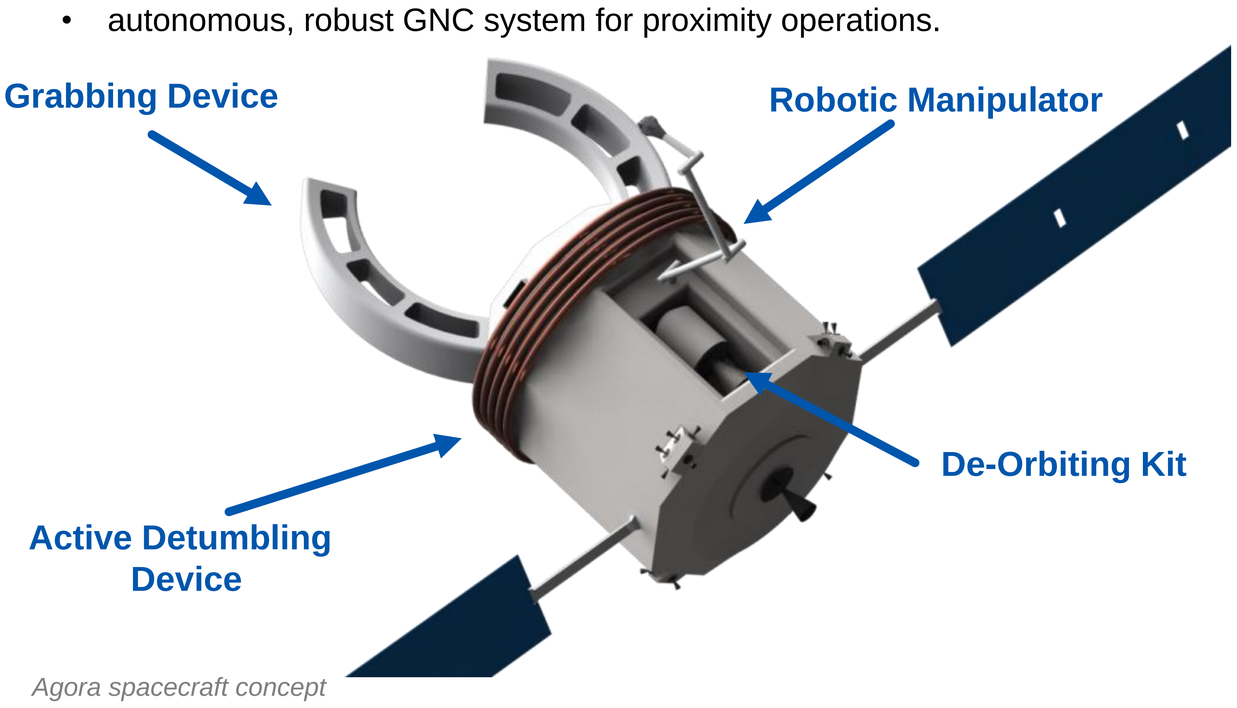
Mission Goal

The Agora mission will:

- demonstrate technologies to remove an Ariane RB,
- within a cost cap €200 M FY2015,
- by 2025 at the latest.

The **key technologies** that will be demonstrated are:

- novel, active detumbling device based on eddy currents,
- robotic grabbing system, including a semi-rigid clamping mechanism and a robotic manipulator,
- usage of a de-orbiting kit for ADR,
- autonomous, robust GNC system for proximity operations.



Agora spacecraft concept

Spacecraft Concept

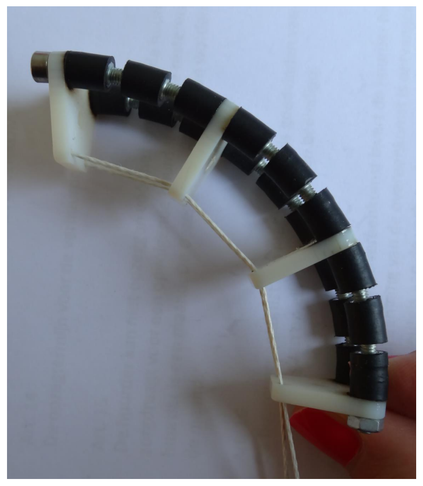
The Agora technology demonstrator will be designed to enable fully-autonomous removal of non-cooperative RBs. The chaser will detumble, capture, and de-orbit its target RB: the upper stage used to place it on-orbit. The detumbling device will use eddy currents to actively reduce the tumbling rate of the target. During the capture phase, the semi-rigid clamp will be employed to secure the target, so that the robotic manipulator can deploy the de-orbiting kit within the main nozzle of the target RB.

Spacecraft Specifications

Mass	**Dry Mass**	2000 kg
	Propellant Mass	500 kg
	Total Mass	2700 kg
Power		709 W
Size		5.4 (L) x 3.3 (D) m
Volume		22 m^3

Robotic Payload

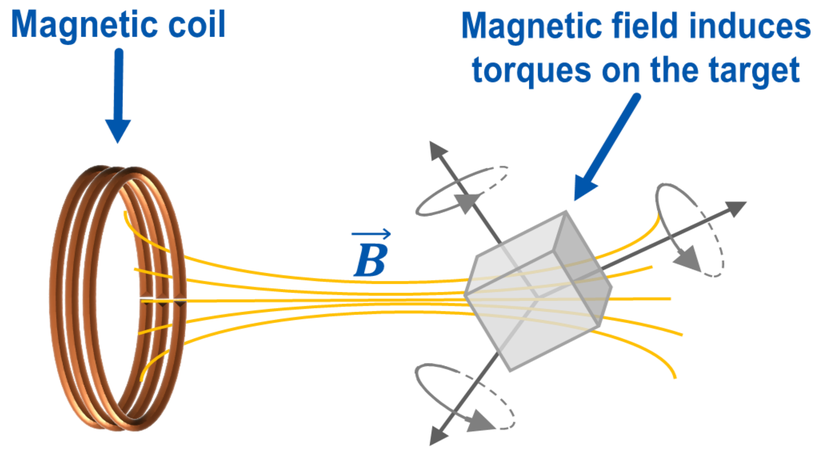
- Robotic manipulator:
  - 7-DOF lightweight design
  - Space-proven hardware
- Grabbing device:
  - Semi-rigid clamping mechanism
  - Anthropomorphic design
  - Lightweight design
  - Feature-independent grasping



Prototype of the grabbing device

Detumbling Payload

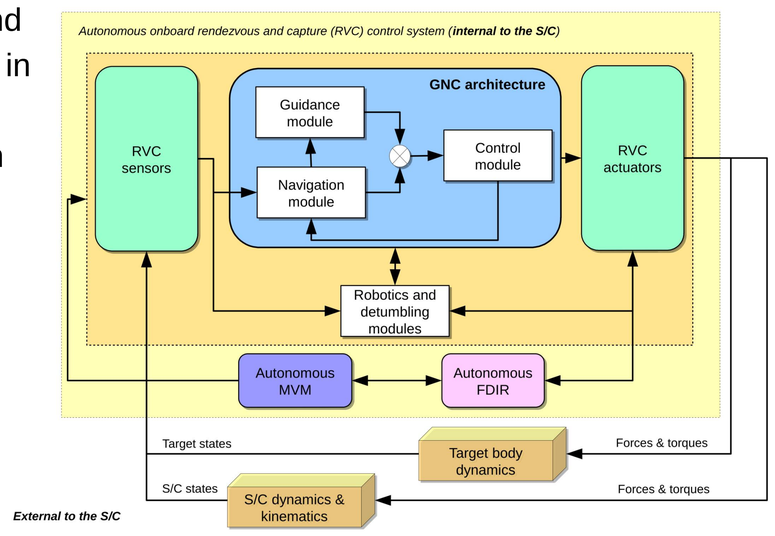
- Active de-tumbling method based on the generation of eddy currents:
  - Dissipative process based on Joule's effect
  - Non-invasive: no risk of generating new debris
  - All angular components can be damped
- Magnetic coil based on 2nd generation High Temperature Superconducting (HTS) wires
- Active cooling based on Loop Heat Pipe (LHP) and cryocoolers
- Experimental tests carried out at Airbus Defence & Space



Schematic illustration of the detumbling process

GNC architecture: key characteristics

- Fully autonomous: ground station is not considered in the loop
- Modular, scalable design
- Dedicated to proximity operations
- Prediction and compensation of non-linear, free-floating dynamics



Autonomous onboard RVC control system architecture

Future steps

- GNC simulations including fly-around, de-tumbling and capture phases
- Optimization of design of chaser subsystems
- GNC code implementation
- Experimental tests
  - De-tumbling process
  - GNC code validation at DFKI's INVERITAS HIL facility

References

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2. Jankovic, M., Paul, J., Kirchner, F.; 'GNC architecture for autonomous robotic capture of a non-cooperative target: preliminary concept design'; Advances in Space Research, Special Issue: Asteroids & Space Debris, September 2014 (*in press*).
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