CAT

CAPTURE BAY DESIGN AND END-TO-END VERIFICATION OF DESIGN FOR REMOVAL (CAT)

Clean Space Industry Days

11th October 2022

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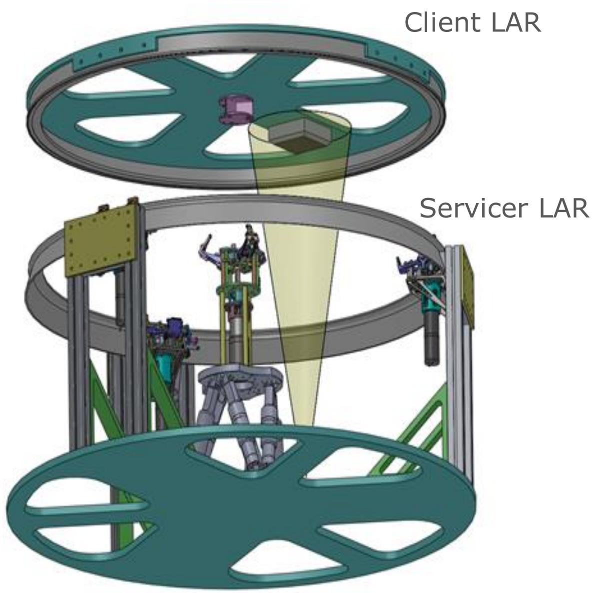
Project motivation

- ESA taking a proactive role by preparing the satellites for a possible **removal** as part of the **End-of-Life management** which in the future may be adopted by other satellites
- Bridging the work done in D4R and ADR technology preparation through an **end-to-end test** by integration of D4R technologies and equipment for in-orbit monitoring of the client and capture
- Copernicus Sentinel Expansion missions will be the first ones implementing D4R requirements.
- CAT has the vocation to become the cost-effective **capture payload** of choice for LEO ADR, covering both cooperative and uncooperative
- 2-year activity up to TRL 4

Project objectives & overview

1. ***Design a Capture Bay (CAT) system, which is a capture system for an Active Debris Removal (ADR) servicer satellite, that consists of:***

- *a **rendezvous functionality**: guidance, navigation and control chain (e.g. image processing algorithms and avionics hardware architecture).*
- ***capture equipment** (e.g. robotic assembly and end-effector, visual servoing system).*
- *equipment for **transferring the disposal loads** (e.g. clamping mechanism) during the disposal operations.*



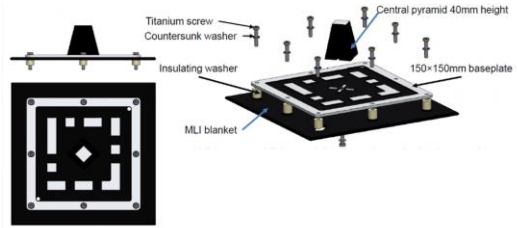
Project objectives & overview

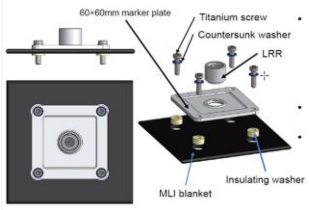
*Compatible with the **Design for Removal interfaces** on the Client side, including:*

- *Rendezvous markers (3D marker and 2D markers)*
- *Mechanical interface for capture (MICE)*
- *Interfaces for disposal loads (baseline VEGA C Launch Adaptor Ring – LAR, "VAMPIRE 1194").*

1. ***Verify through testing the functional and performance requirements of the system.***

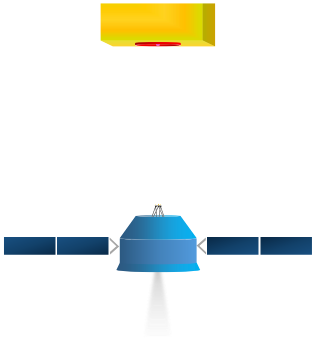
2. ***Derive lessons learnt from the Breadboard and test of CAT in order to mature:***
    - *CAT and servicer system design and operational requirements*
    - *IRD requirements verification approaches for client satellites*



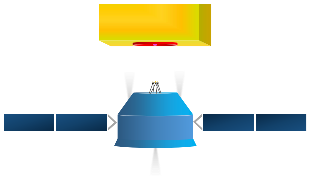


Capture Operations Concept

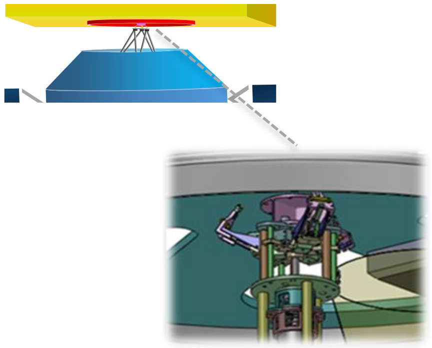
1) Last approach 5 - 1.5m



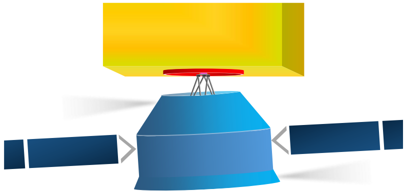
2) Last approach 1.5m –10 mm



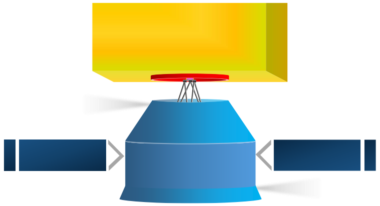
3) Grasping



4) Braking of Stack

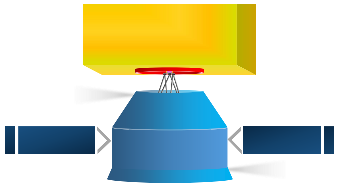


5) Relocation of Stack

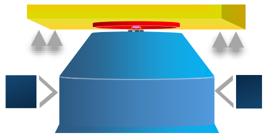


Capture Operations Concept

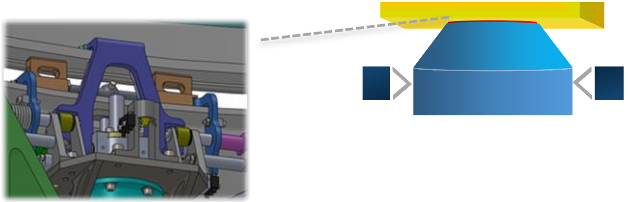
5) Relocation of Stack



6) Approach for clamping



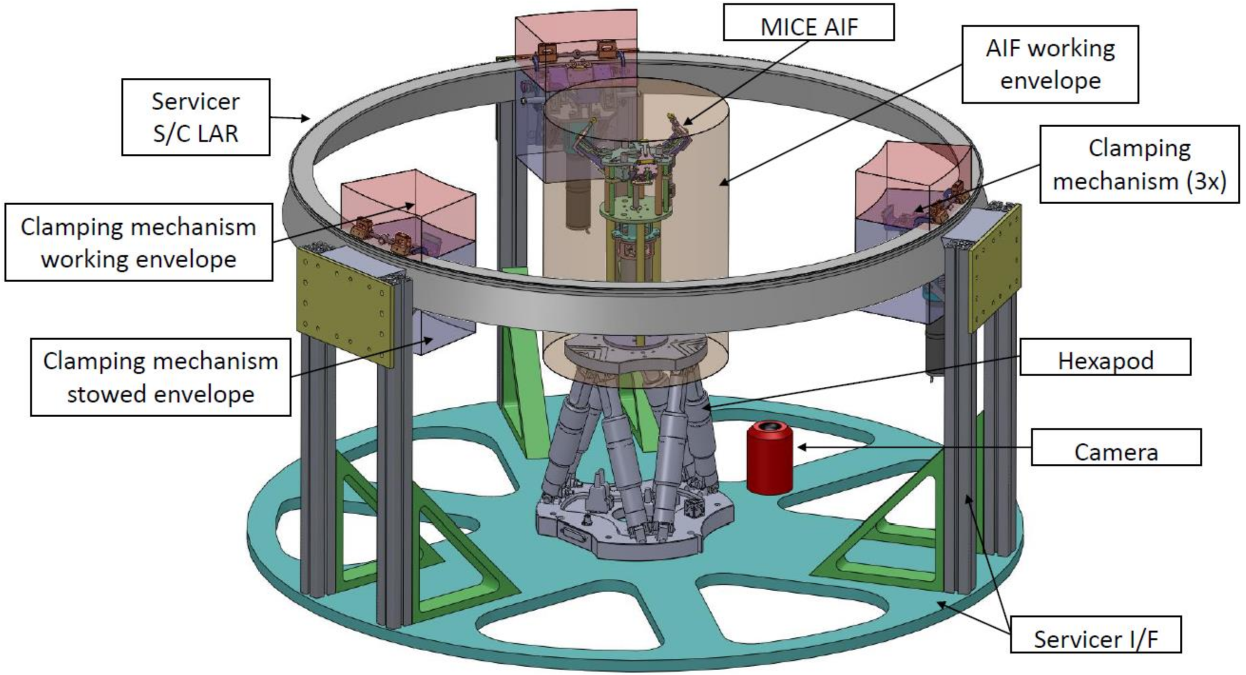
7) Clamping actuation



8) De-orbiting

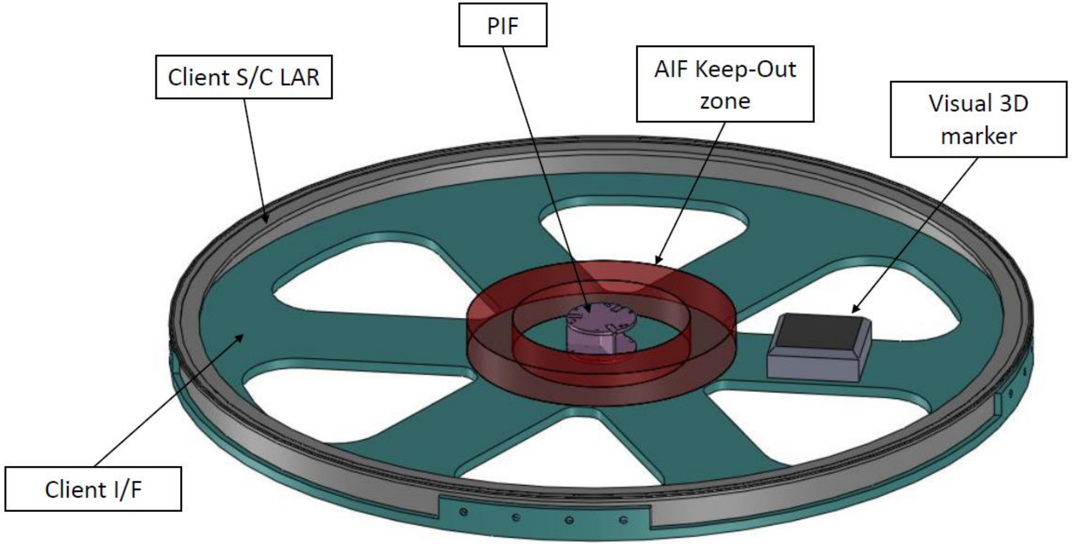
CAT bay

- CAT Concept / Servicer side



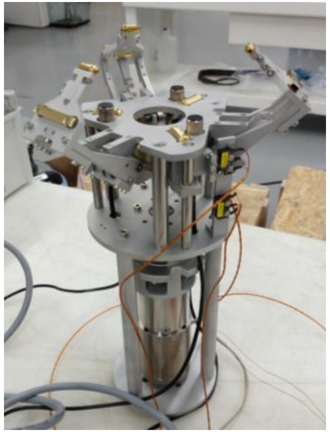
Client bay

- CAT Concept / Client side



CAT components

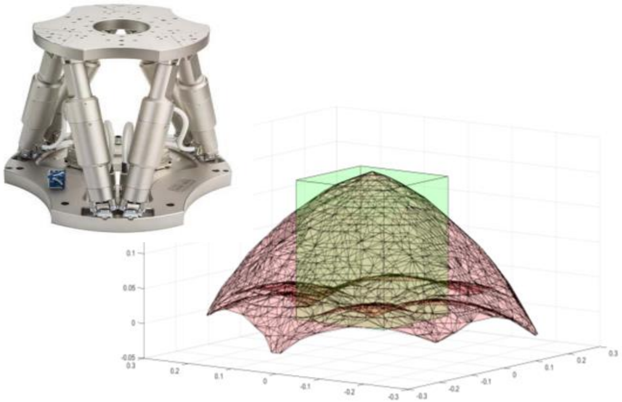
- Servicer Capture Bay (baseline design)



Gripper

Baseline: MICE Gripper

Redesign and refurbishment in accordance with the outcomes of the requirement assessment



Robotic actuator

Baseline: Gough-Stewart platform compatible to misalignment and load requirements

Force/torque feedback for compliant modes

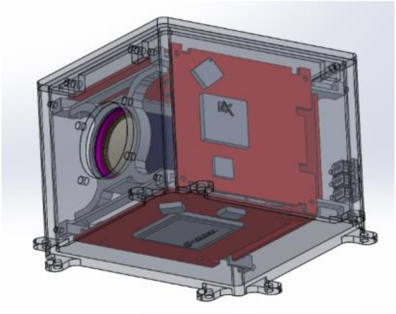
Co-engineering for control related aspects

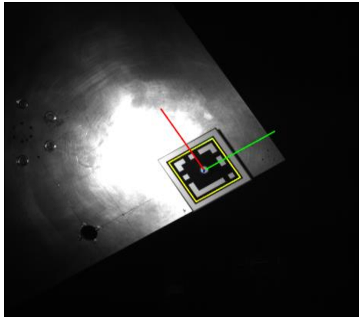
Clamping mechanisms

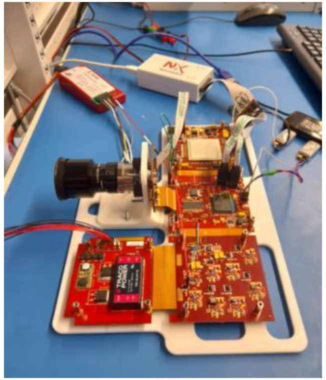
Baseline: Clamping mechanism developed by the consortium AVS-OHB in the frame of the activity CLM updated as required

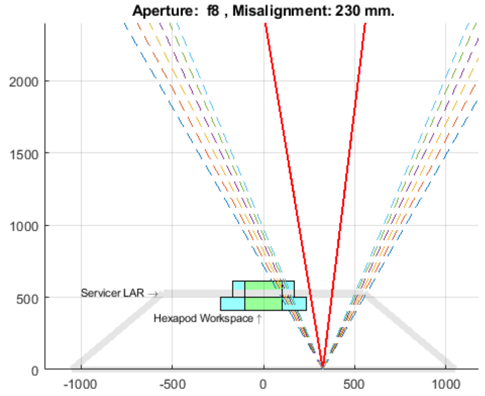
CAT components

- CAT Navigation & Avionics:
  - Last approach 6 DoF navigation w.r.t. 3D marker and transition from 2D markers
  - Robotic actuator (position + force/torque feedback) and gripper control
  - Provides navigation, status and safety/limits information to the vehicle MVM/GNC
- **G-Theia1+** modular camera design (CMV4000 1” 2048x2048 px. sensor) with option for IP FPGA
- Placing analyses and optical parameters revisit for resolution, DoF, compatibility to illumination conditions and occlusions avoidance
- Onboard computer (flight baseline based on SoC architecture)
- Compliance controller in co-engineering with robotic actuator design



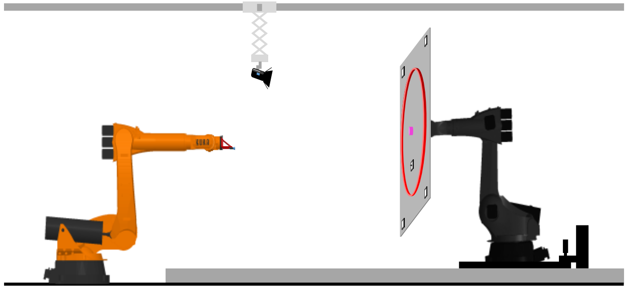


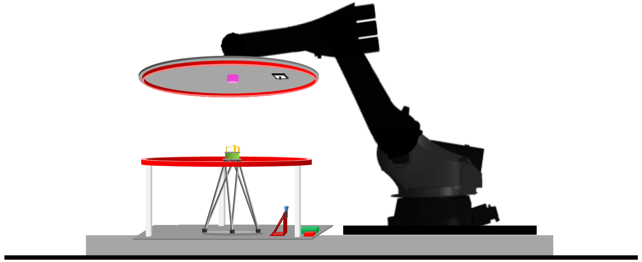




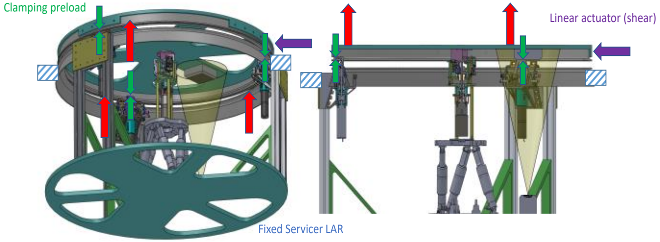
CAT V&V

- HIL facility (platform-art) set-up for the long-range and short-range navigation and control tests (including stack phases).



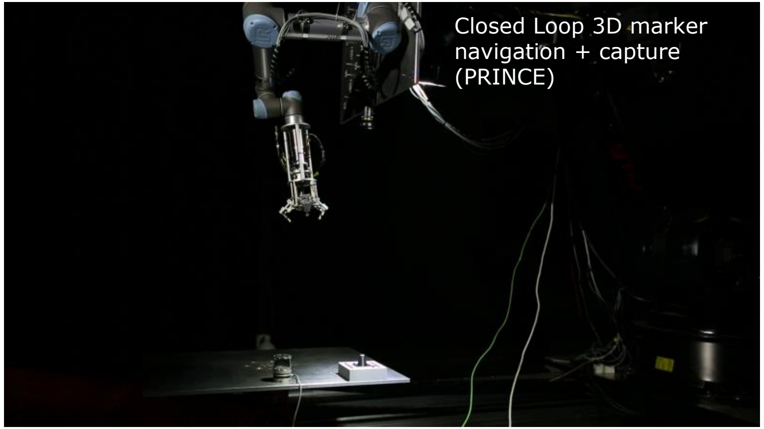


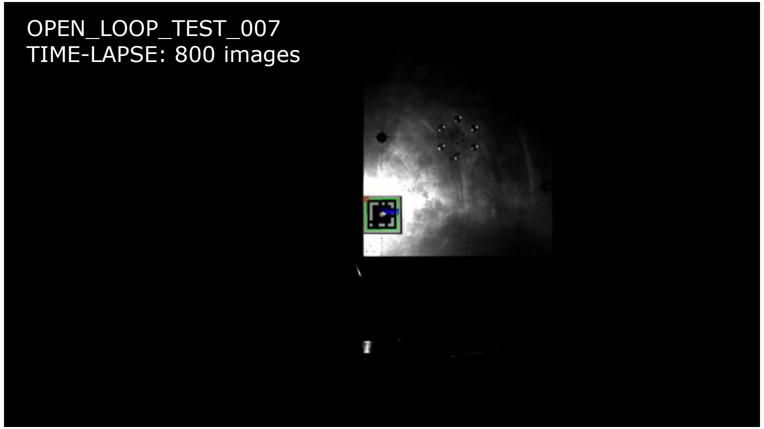
- Specific metrology set-up for large load tests in stack configuration

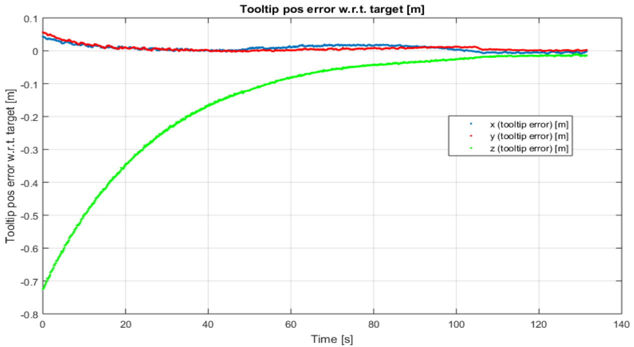


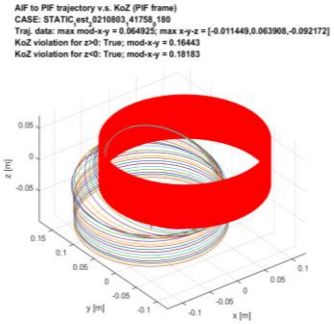
CAT breadboarding and V&V

- Precursor technology development & maturation activities









Max. misalignment & KoZ verification tests (MICE)

Summary & Conclusions

- ESA taking an active role by implementing D4R requirements on **Copernicus** Sentinel Expansion missions
- CAT is bridging **D4R** at Client side with technologies on the **Servicer** side to produce a Capture Bay system that is effective and cost-effective for ADR in LEO
- Concept of Operations and CAT design at system level are targeted to simplicity and clean and safe interfaces to the Servicer vehicle (MVM & GNC).
- Interrelations and dependencies at different levels between mechanisms, robotics, navigation and control, mission management, safety monitoring etc… call for co-engineering of the different units and design iterations.
- Precursor D4R and Servicer technology developments have demonstrated to be effectively paving the road for CAT to become the Capture system of choice for ADR.

Thank you

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