CAT-IOD

CAT IN-ORBIT DEMONSTRATION MISSION FOR A PREPARED ACTIVE DEBRIS REMOVAL SCENARIO

gmv INNOVATING SOLUTIONS

avs added value solutions

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2. Target of Opportunity

3. CAT Payload

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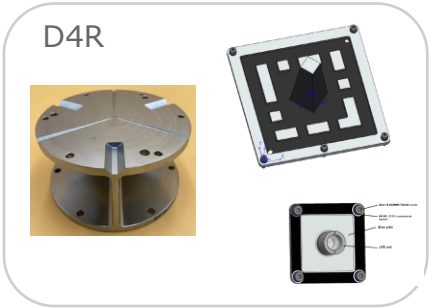
CAT-IOD Phase 0 – Introduction

Background

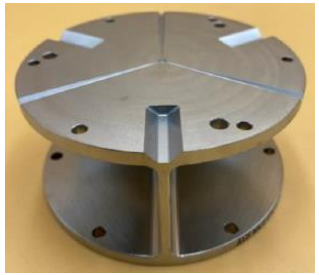
- ESA Design for Removal (**D4R**) Interface Requirements Document (IRD) adopted by six **Copernicus Sentinel Expansion Missions** and is being used to prepare these satellites for possible removal missions.
- GMV leading a consortium responsible for designing and validating a **CAT** (Capture Bay for Active Debris Removal, ADR) system:
  - Breadboard has been just **tested and validated** within the platform-art© robotic test facility at GMV's premises, in Madrid.
  - Capture equipment (gripper/hexapod/control SW) + securing devices (clamping) + close-proximity navigation & avionics.
  - EM development will start soon.
- **CAT** has the vocation to become the **cost-effective capture payload** of choice for LEO ADR, covering both cooperative and uncooperative scenarios for prepared satellites.



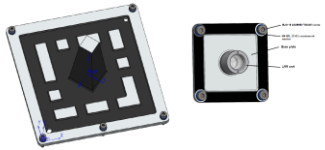
CAT-IOD Phase 0 – Introduction

The mission

- Assessment study for a **cost-affordable In-Orbit Demonstration mission** with focus on both Servicer (CAT) and Client (D4R aids) technologies for **Copernicus Sentinel Expansion Missions** active removal.

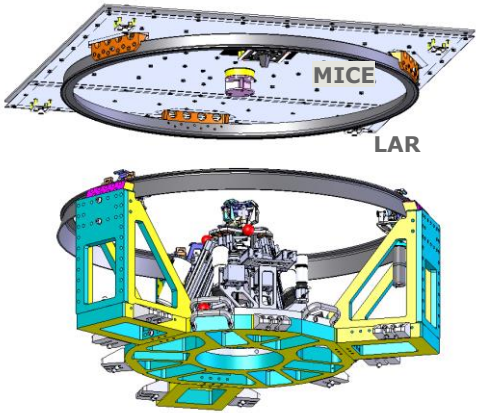


MICE

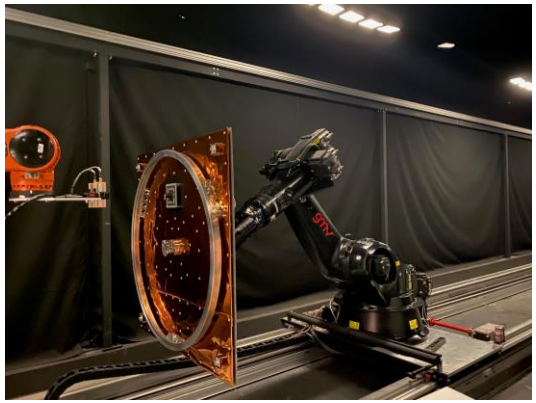


2D and 3D markers

CAT robotic assembly



CAT bay



CAT Client Mock-up

CAT-IOD Phase 0 – Introduction

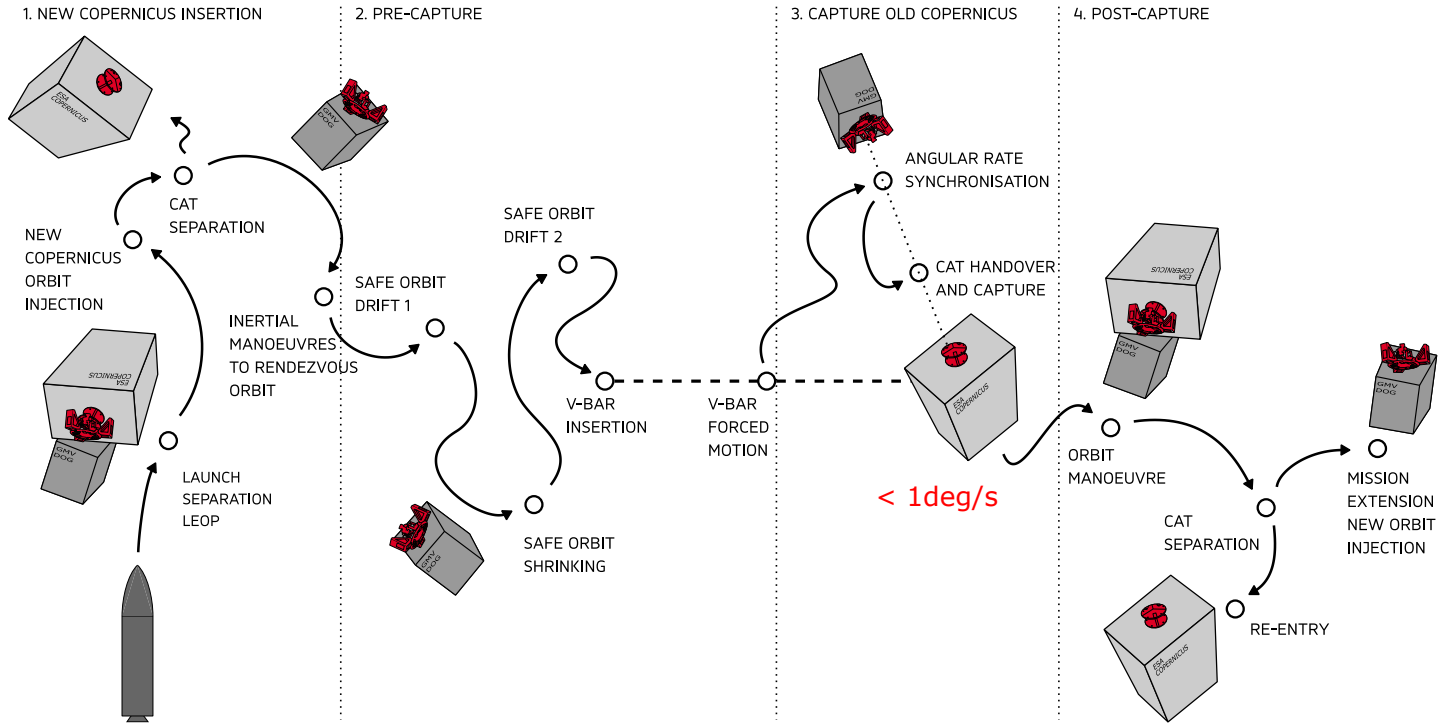
Object

- **CAT-IOD** main **objectives** and **requirements:**
  - CAT-IOD shall preliminarily design a Servicer satellite carrying on-board the CAT mechanical device.
  - CAT-IOD shall use a target of opportunity: p.e. the AVS's LUR-1 satellite.
  - CAT-IOD shall demonstrate the scalability towards larger client satellites (i.e. Copernicus).
  - CAT-IOD shall evaluate the technical feasibility of the proposed mission in terms of costs and representativity.

- **CAT-IOD shall be as representative as possible of an ADR mission for removing the next generation of Copernicus satellites using the MICE device.**
  - Primary objective is to test CAT scale 1:1.
  - Test GNC and full CONOPS for prepared satellites, cooperative and non-cooperative

CAT-IOD Phase 0 – Introduction

Copernicus NG ADR



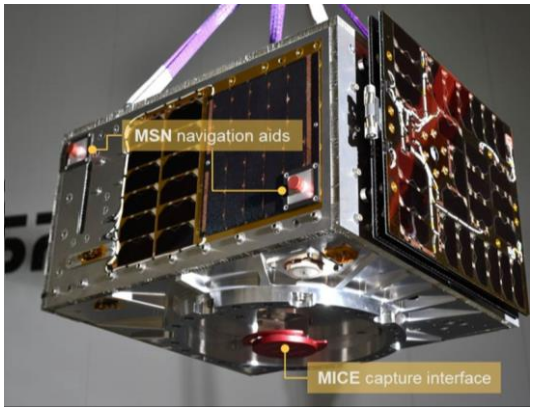
Capturing is the phase in which CAT-IOD shall demonstrate full representativity

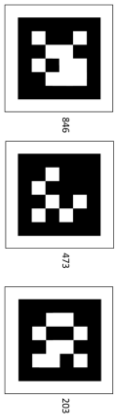
CAT-IOD Phase 0 – Target of Opportunity

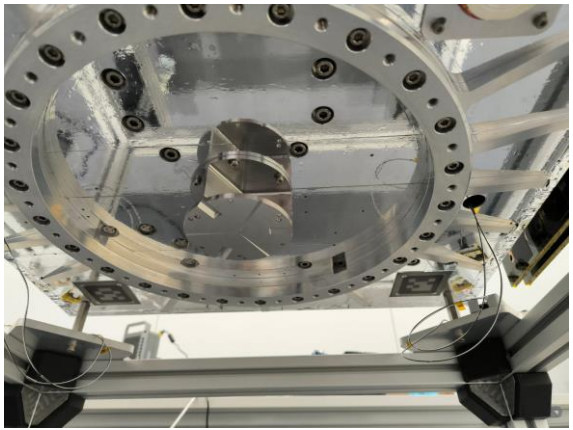
CAT-IOD Phase 0 – Target of opportunity

LUR-1 Satellite Data

- ❑ Microsatellite Platform, 57kg wet mass.
- ❑ Nominal 510 km altitude.
- ❑ Launched August 2024.
  - Commissioning is proceeding as planned.
- ❑ Several modifications were added to make it compliant with mission & design for removal requirements. E.g. LRR markers added, ArUco markers added on MICE face for navigation representativity during CPO & capture.







CAT-IOD Phase 0 – CAT Payload

1. Introduction

2. Target of Opportunity

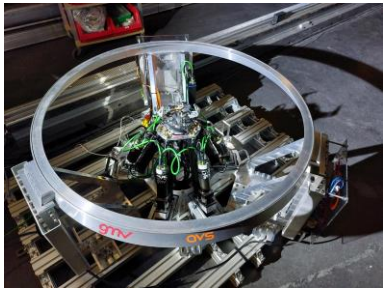
3. **CAT Payload**

4. CONOPS & Delta-v

5. Conclusions

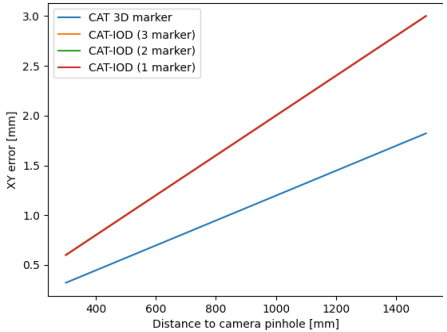
CAT-IOD Phase 0 – CAT Payload

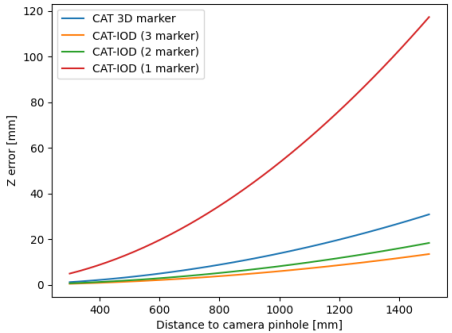
CAT Specifications & Performance Degradation Analysis

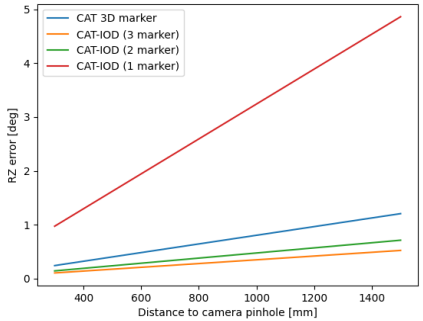


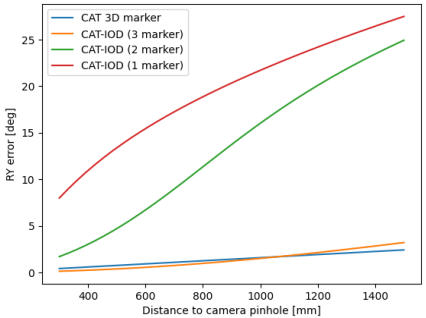
CAT to be maintained at scale 1:1 & with nominal specs. for complete representativity

- ❑ Missing 3D Marker due to lack of available area in LUR-1 is a deviation from D4R requirements. (This holds for any SmallSat platform)
- ❑ Navigation performance degradation with an alternative configuration has been analysed









An alternative concept for navigation aids using three smaller flat markers has been proposed.

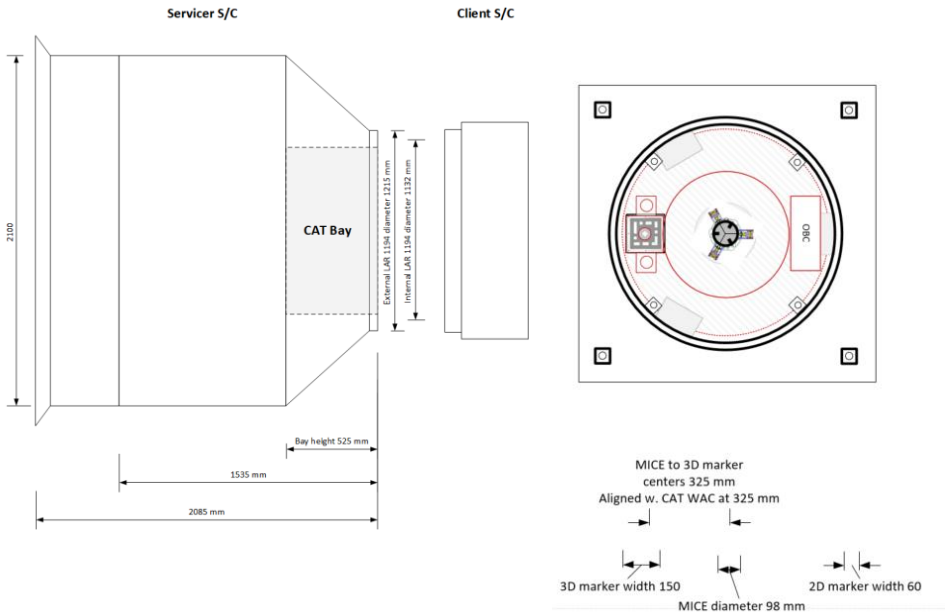
The mission must be designed to avoid occlusion of CAT-IOD markers during RdV & capture to guarantee IP determination errors within requirements.

CAT-IOD Phase 0 – CAT Payload

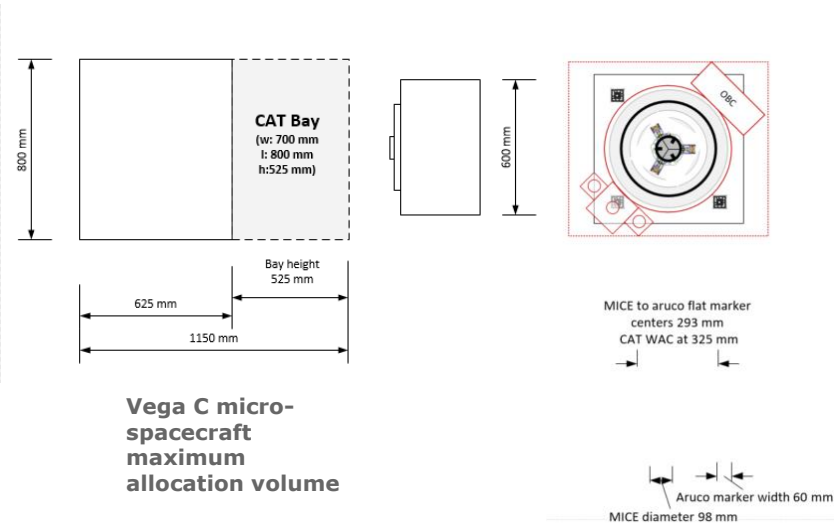
CAT Configuration Tailoring

- ❑ Tailored configuration without clamping and for a small servicer satellite.
- ❑ Mass reductions shall be incorporated to allow for the Micro-spacecsraft configuration.

DOG – Copernicus NG



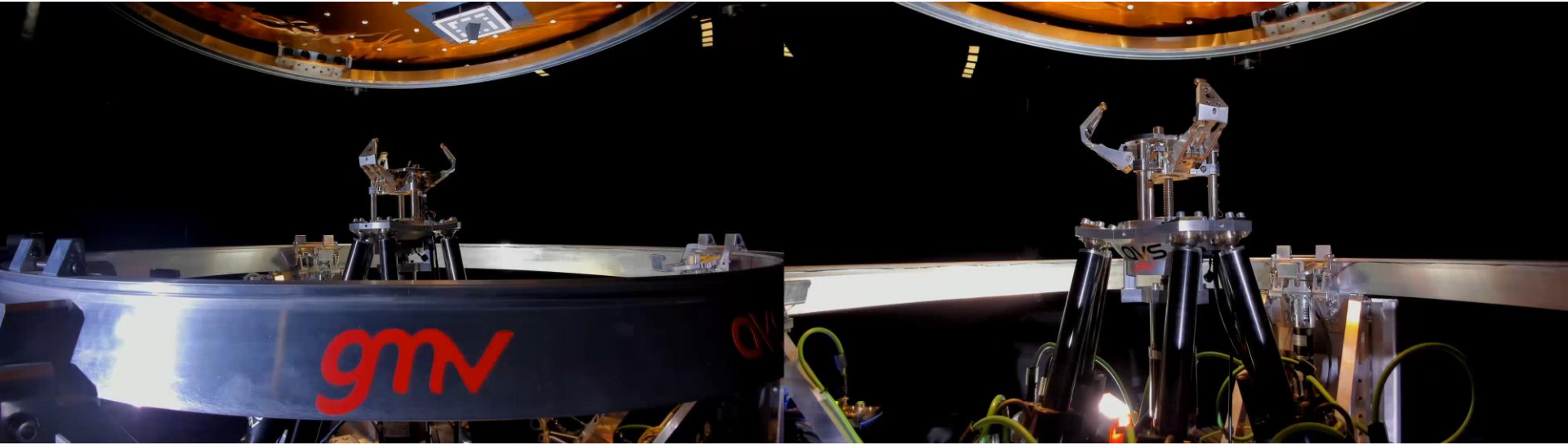
DOG – LUR-1



Vega C micro-spacecraft maximum allocation volume

CAT-IOD Phase 0 - CAT Payload

CAT BB V&V @ GMV's *platform-art©*



CAT-IOD Phase 0 – CONOPS & Delta-V

1. Introduction

2. Target of Opportunity

3. CAT Payload

4. **CONOPS & Delta-V**

5. Conclusions

CAT-IOD – DOG Platform Design

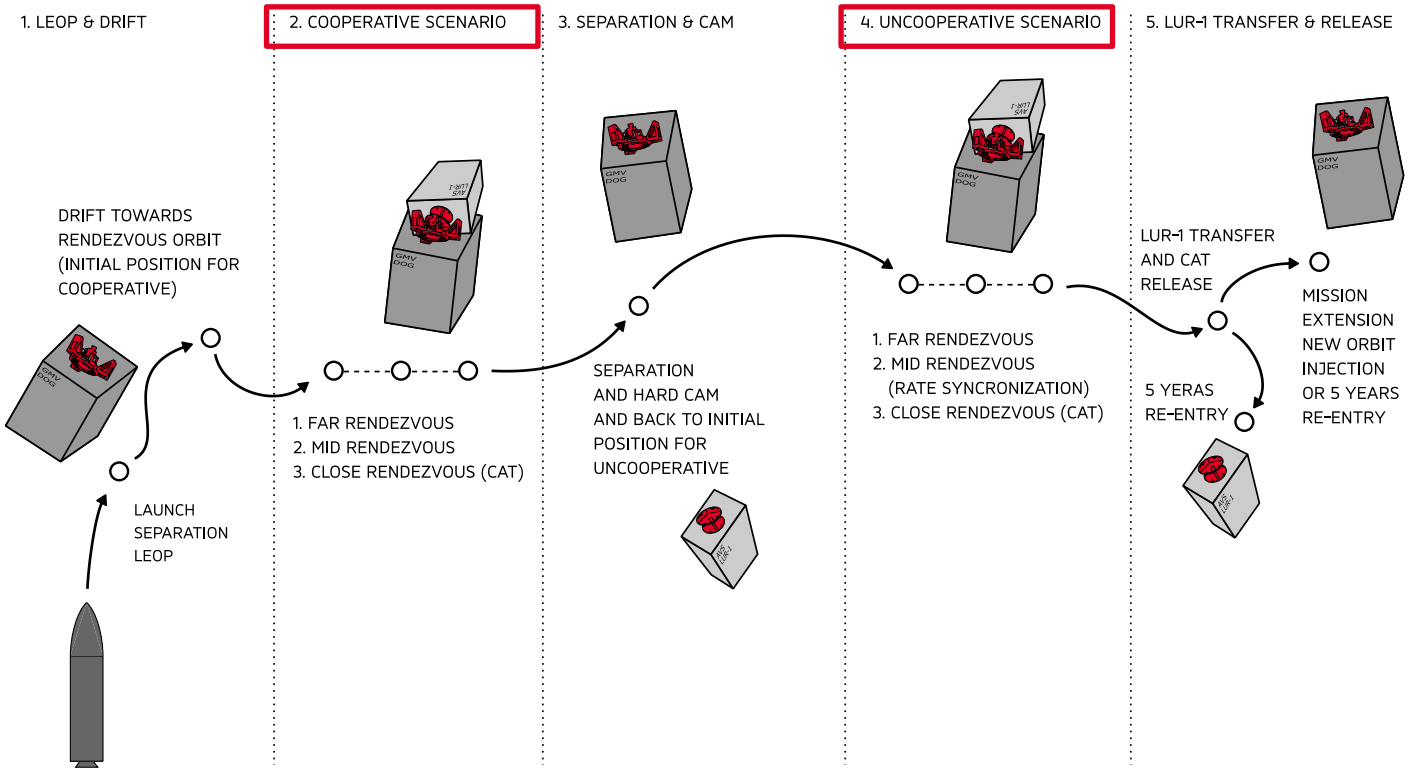
DOG Platform Summary

- Baseline assumes no CAT mass reduction.

Parameter	Value
Proposed launch date	End of 2027 (goal) /Early 2028
Operational lifetime	6 months
Launch system	Compatible with: VEGA C (rideshare), Ariane 6 (rideshare), RFA, ISAR, Orbex, Himpulse, PLD, MAIA, Space X (rideshare)
Mission goal	Demonstrate CAT functionalities using D4R technologies
Capture mechanism	CAT
Deorbit strategy	Releasing the target in a 5-years de-orbiting orbit
Target orbit	Circular 515 km, SSO, LTAN 22:30 / TBD as from final target
Relative sensors	Optical camera
Mission demonstration	• Rendezvous with cooperative and uncooperative target • Capture with CAT • De-orbiting of a target • System autonomy
System wet mass	148.79 kg with margins
Total mission delta-v	196.55 m/s
System dimensions	Base of at least 800(D)x700(W) mm^2 due to CAT dimensions, and height of at least 525 mm (CAT height) plus what required by the platform

CAT-IOD – DOG Platform Design

Full Mission CONOPS

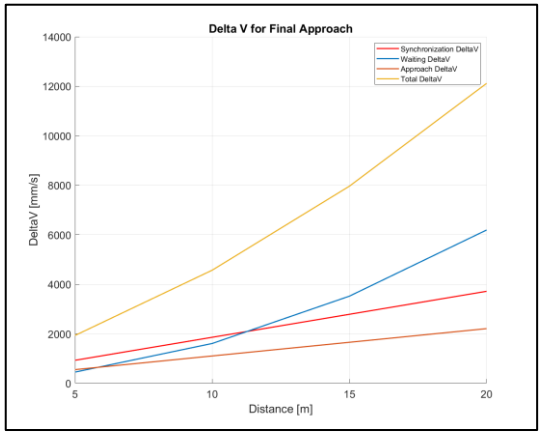


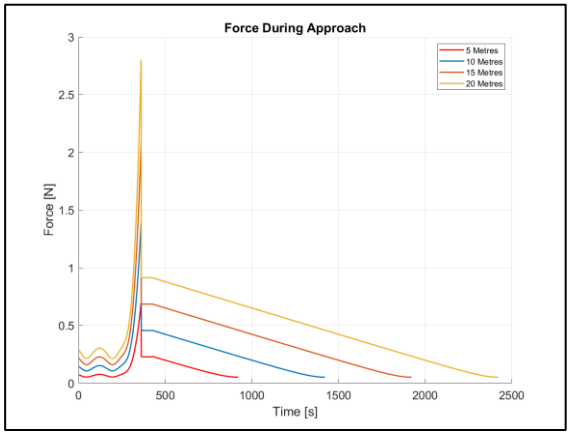
CAT-IOD Phase 0 – CONOPS & Delta-v

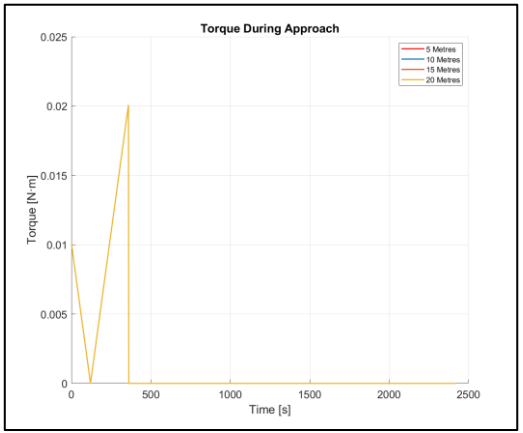
Rate Synchronisation

Critical function of CPO, rendezvouz & capture

- ❑ Hypotheses:
  - Synchronisation time of 360 s (could be modified in function of the requirements).
  - Wait time of 600 s.
  - Approach velocity of 10 mm/s.
- ❑ Assumed to performed rate synchronisation at 10m distance.





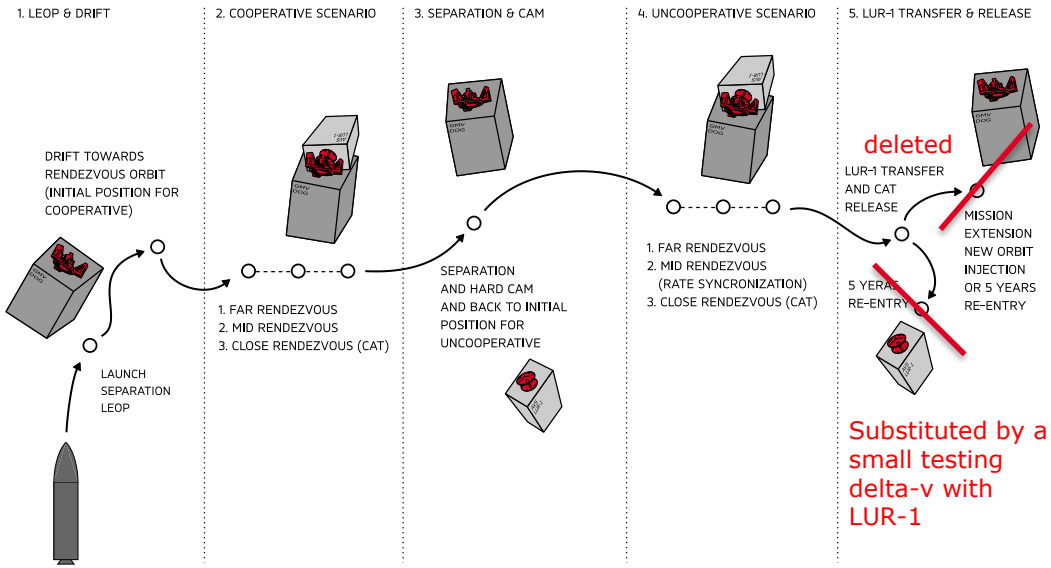


CAT-IOD – DOG Platform Design

DOG LIGHT option

LIGHT BASELINE:

- ❑ Assumes **CAT** with reduced mass.
- ❑ NO LUR-1 deorbiting -> CAT-IOD will perform only a small delta-v (5 m/s) when joined with LUR-1 for testing purposes (as per MRD).
- ❑ LUR-1 shall be already compliant to ESA deorbiting rule on its own.
- ❑ N0 mission extension to look for a second possible target.
- ❑ **Final Mass reduced from 148,79 kg to 96,87 kg without impact on mission goals**



CAT-IOD Phase 0 – Conclusions

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CAT-IOD – Conclusion

Conclusions

- ESA Design for Removal (**D4R**) Interface Requirements Document (IRD) adopted by the six **Copernicus Sentinel Expansion Missions** and is being used to prepare these satellites for possible removal missions.
- In the last years GMV has been leading two ESA's contracts to develop a passive mechanic interface, **MICE** and an active capture device, **CAT**. AVS has been deeply involved in both projects.
- GMV performed a CAT-IOD mission phase 0 whose objective is to test all the CAT functionalities.
- The AVS's LUR-1 satellite, mounting a MICE device, has been modified so to be a potential representative target of opportunity for CAT-IOD.
- The study assessed and demonstrated the feasibility of **cost-affordable In-Orbit Demonstration mission** and its representativeness.
- CAT-IOD intends to be an active contributor the ESA's Zero-debris policy.

Thank you

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