ClearSpace-1
In-Orbit Demonstration Mission

clearspace today

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ESA ESTEC, OHB System AG, ClearSpace

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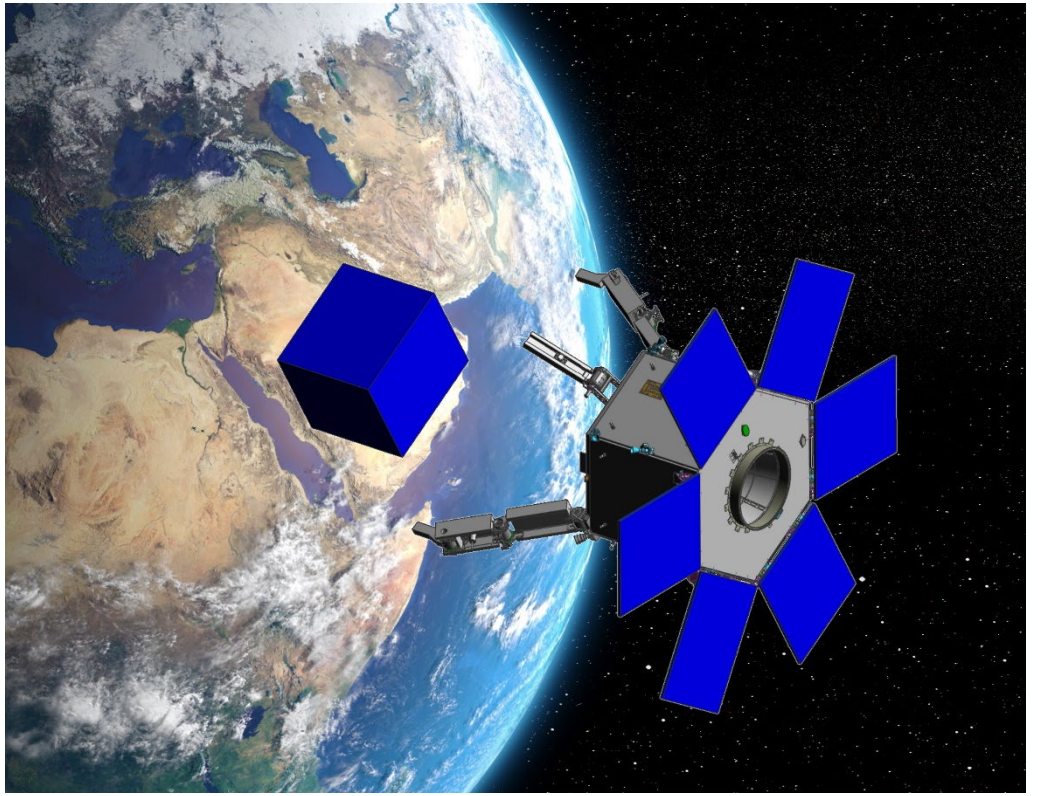
Introduction

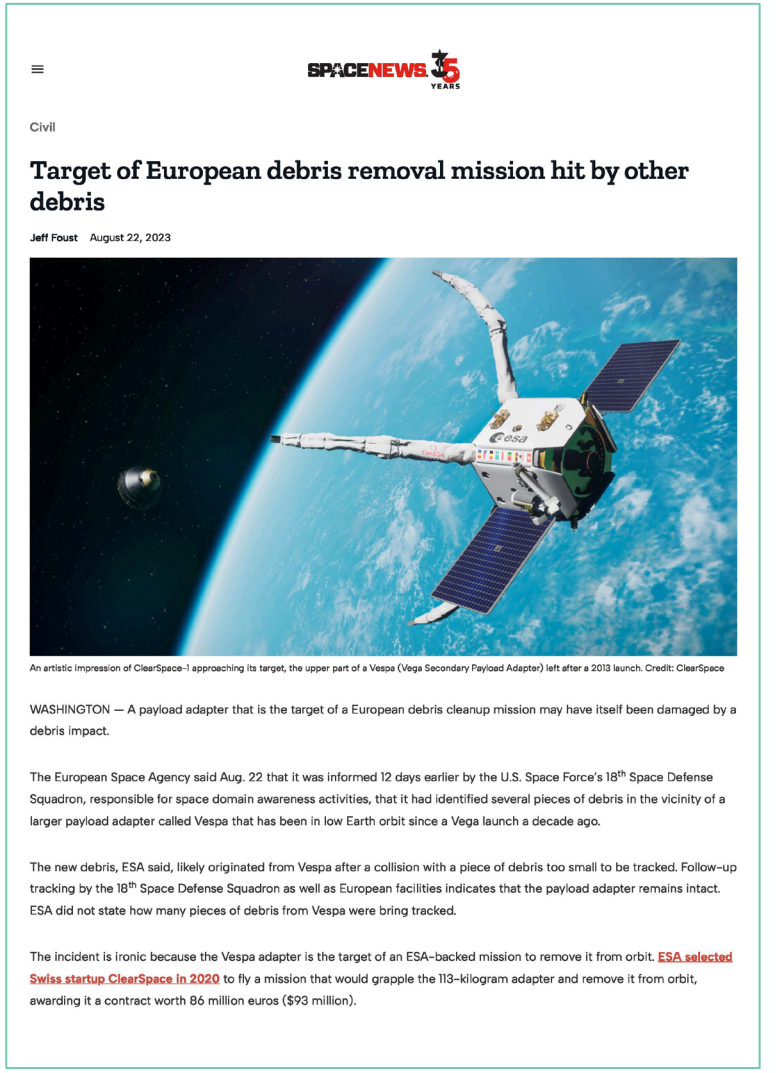
- ClearSpace-1 mission is to demonstrate the safe rendezvous with and capture of an unprepared and uncooperative space object
- Mission will incrementally demonstrate the key capabilities and functions required
- Phase A/B1 is currently ongoing with a System Requirements Review to confirm the mission design and requirements baseline



Revision of Mission Baseline

- Originally, ClearSpace-1 was aiming at capturing and removing a VESPA launch vehicle adapter
- Collision of space debris with VESPA in August 2023 increased risk for original ClearSpace-1 mission to unacceptable level
- ClearSpace-1 mission major re-orientation based on results of joint ESA / ClearSpace exercise
  - Object to be removed is now PROBA-1 satellite
  - Direct injection by European micro-satellite launcher
  - Mission duration 1 year
  - Uncontrolled re-entry expected
  - Use of available COTS platform components for spacecraft
  - Use of ClearSpace-1 Legacy phase developments by ClearSpace adjusted for the new client spacecraft

Artistic impression of ClearSpace-1 capturing VESPA (courtesy ClearSpace)



SPACENEWS 35 YEARS

Civil

Target of European debris removal mission hit by other debris

Jeff Foust August 22, 2023

An artistic impression of ClearSpace-1 approaching its target, the upper part of a Vespa (Vega Secondary Payload Adapter) left after a 2013 launch. Credit: ClearSpace

WASHINGTON — A payload adapter that is the target of a European debris cleanup mission may have itself been damaged by a debris impact.

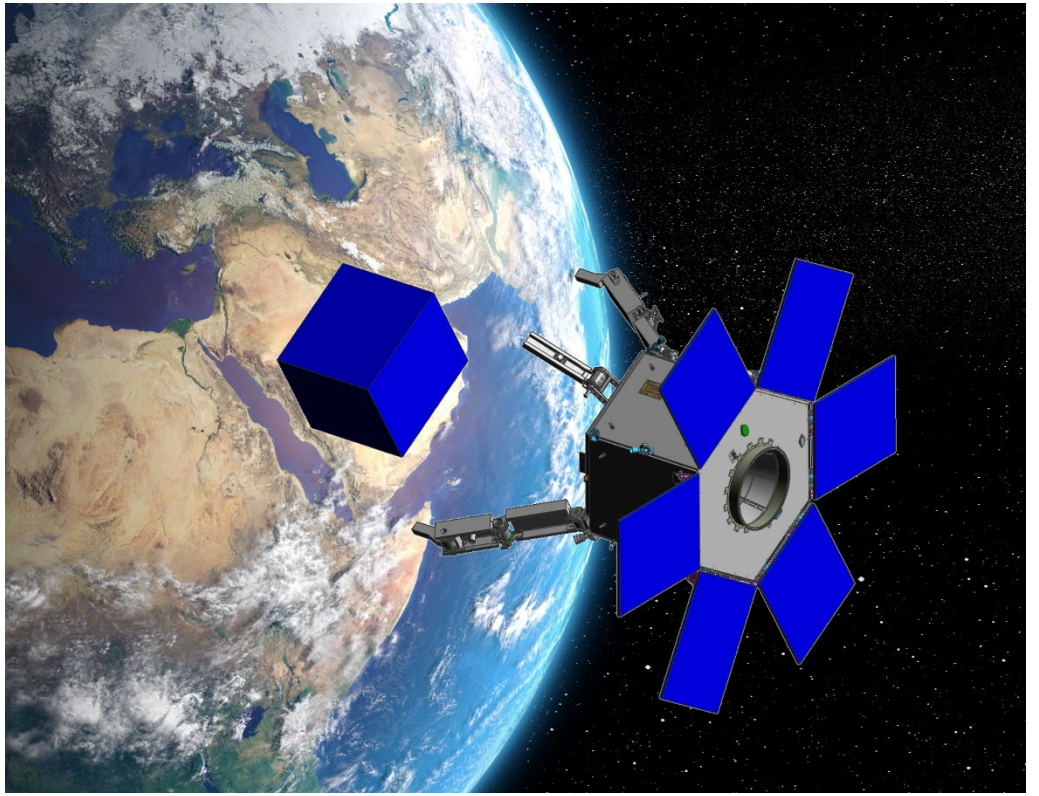
The European Space Agency said Aug. 22 that it was informed 12 days earlier by the U.S. Space Force's 18th Space Defense Squadron, responsible for space domain awareness activities, that it had identified several pieces of debris in the vicinity of a larger payload adapter called Vespa that has been in low Earth orbit since a Vega launch a decade ago.

The new debris, ESA said, likely originated from Vespa after a collision with a piece of debris too small to be tracked. Follow-up tracking by the 18th Space Defense Squadron as well as European facilities indicates that the payload adapter remains intact. ESA did not state how many pieces of debris from Vespa were bring tracked.

The incident is ironic because the Vespa adapter is the target of an ESA-backed mission to remove it from orbit. ESA selected Swiss startup ClearSpace in 2020 to fly a mission that would grapple the 113-kilogram adapter and remove it from orbit, awarding it a contract worth 86 million euros ($93 million).

IOD Mission Objectives

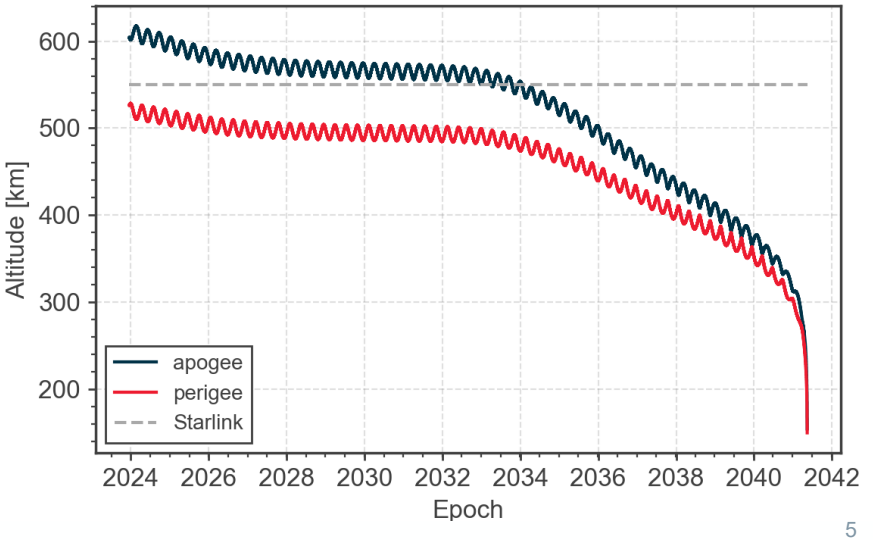
1. Demonstrate the GNC technologies required to approach an object to be removed from low Earth orbit into close proximity.
2. Inspect and characterise a space object in LEO to prepare its safe catching.
3. Demonstrate the capability of the servicer to avoid collision with the space object to be removed by Collision Avoidance Manoeuvre.
4. Demonstrate the capability to synchronise the motion of the chaser spacecraft with the space object to be removed.
5. Demonstrate the safe capture of an uncooperative and unprepared space object with the chaser spacecraft in synchronised motion.
6. Demonstrate the capability to relocate a space object.



Client Spacecraft (1 of 2)

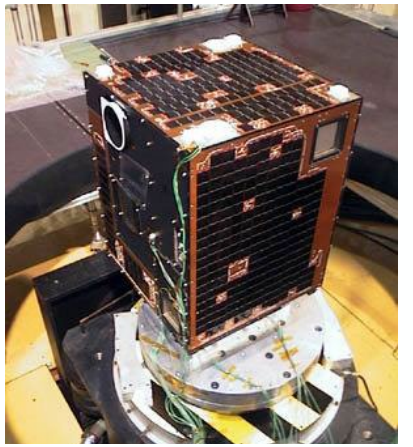
- PROBA-1 (COSPAR ID 2001-049B) selected as client spacecraft to be removed
- ClearSpace-1 mission will be conducted in LEO protected region
- Compliance of servicer spacecraft and servicer / client stack with Space Debris Mitigation Requirements and Re-entry Safety Requirements is mandatory
- Apogee altitude in principle expected below Starlink constellation except for combinations of small effective cross-sectional area and low Solar activity
- Perigee lowering manoeuvre expected to be required for the stack to re-enter within 5 years

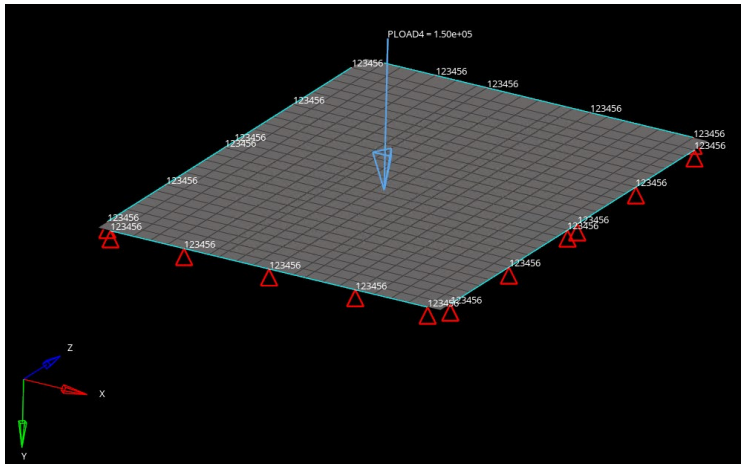
Orbit Parameters Predicted for 2027-12-31			
Solar Activity Case	Mean	Low	High
SMA [km]	6911.03	6921.19	6800.48
Eccentricity [-]	0.0047	0.0052	0.0008
Inclination [deg]	98.02	98.02	98.03
RAAN [deg]	40.45	36.58	72.43
AoP [deg]	30.77	42.08	254.90

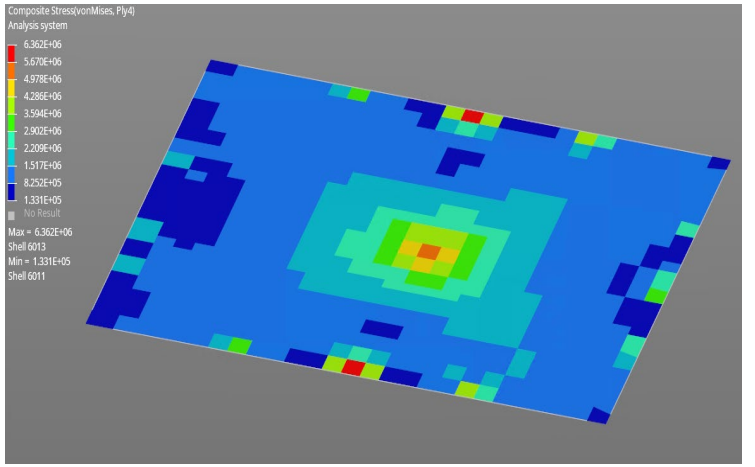


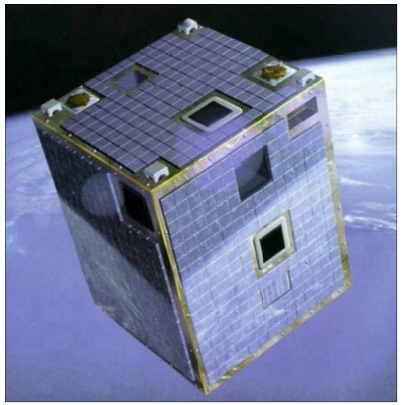
Client Spacecraft (2 of 2)

- PROBA-1 designed as cube-shaped structure based on aluminium honeycomb panels
- 5 surfaces outer panels covered with solar cells in compliant layer of adhesive between cell and panel substrate
- Contact force applied with 50% margin and conservative boundary conditions in PROBA-1 FEM
    - No risk of solar cells breaking, as long as the capture system coming in contact with the target has no sharp edges









Operational Concept

Closing:

Servicer approaches the client on passively safe relative orbit, slowly reducing relative semi-major axis in spiralling approach

Fly-around:

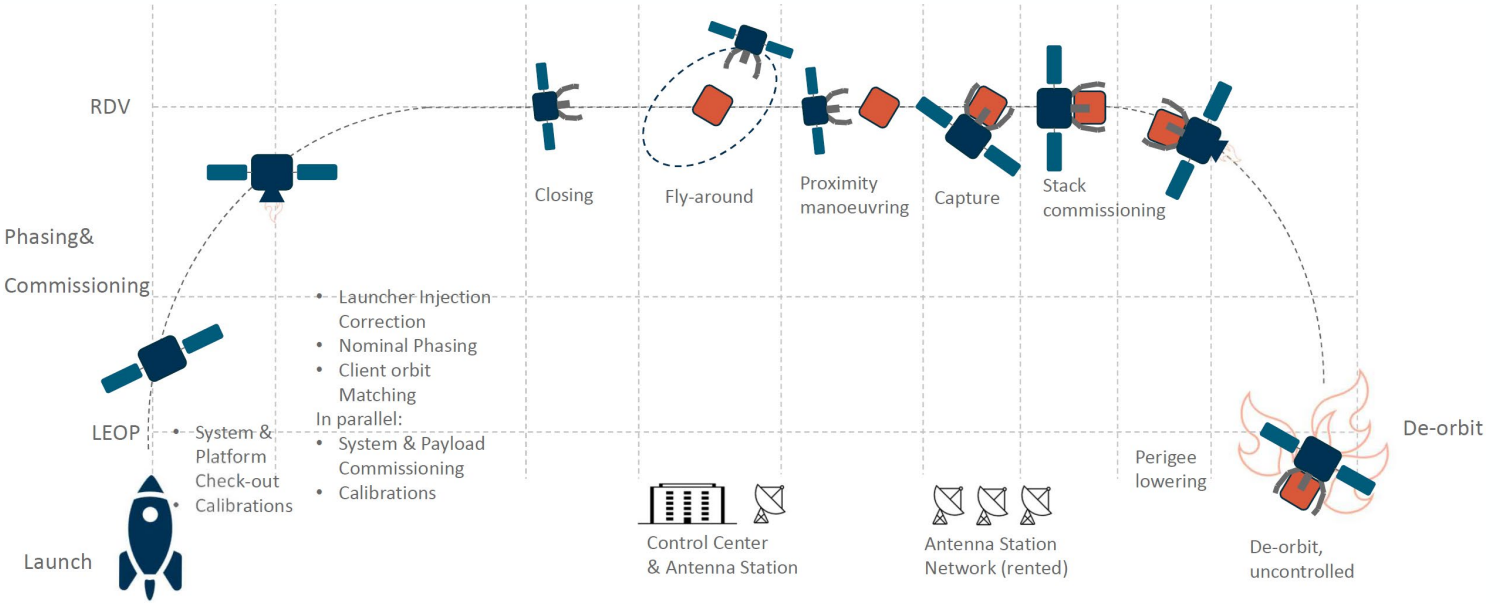
Multiple waypoints centred on the client object at gradually decreasing ranges will be passed until the working range of each sensor is reached.

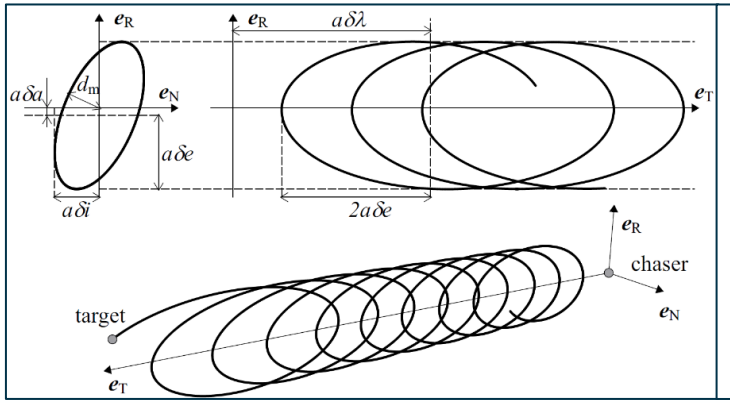
Proximity Manoeuvring:

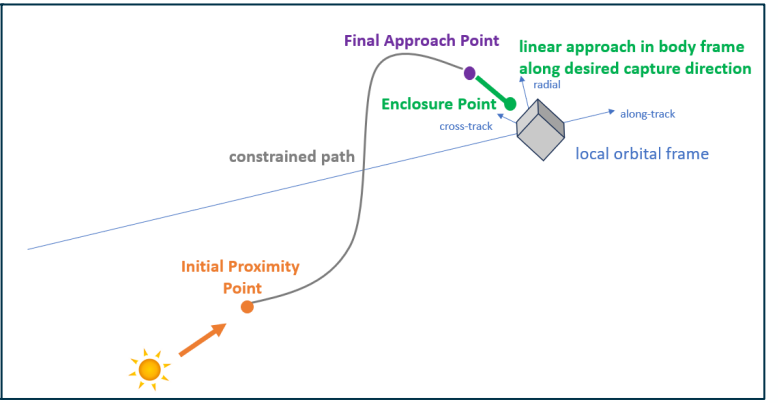
Transition from Formation Keeping Point (FKP) to Initial Proximity Point (IPP), followed by forced motion trajectories with relative orbit no longer passively safe, keep out zone around the client protected by Collision Avoidance Manoeuvre function, back to FKP at the end.

Capture:

Final approach to client from FKP to IPP station keeping with relative pose estimation in the loop, from IPP to Final Approach Point (FAP) and to proximity trigger, enclosure and capture operations. Capture confirmation and stack stabilisation to achieve a stable sun-pointing attitude.

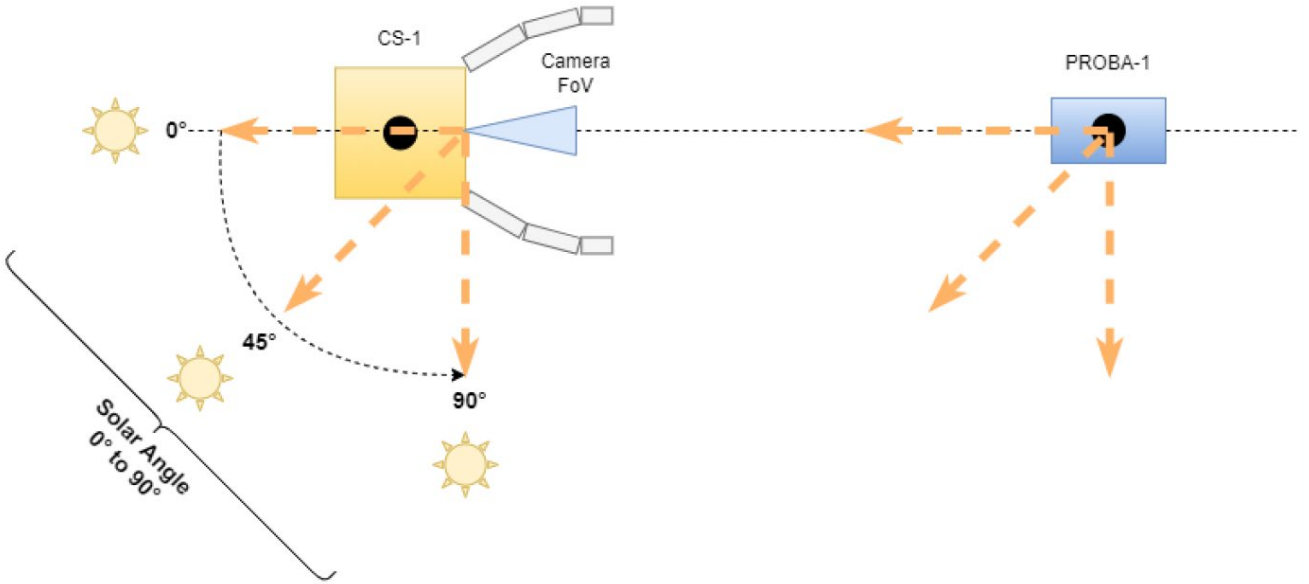






Operational Concept

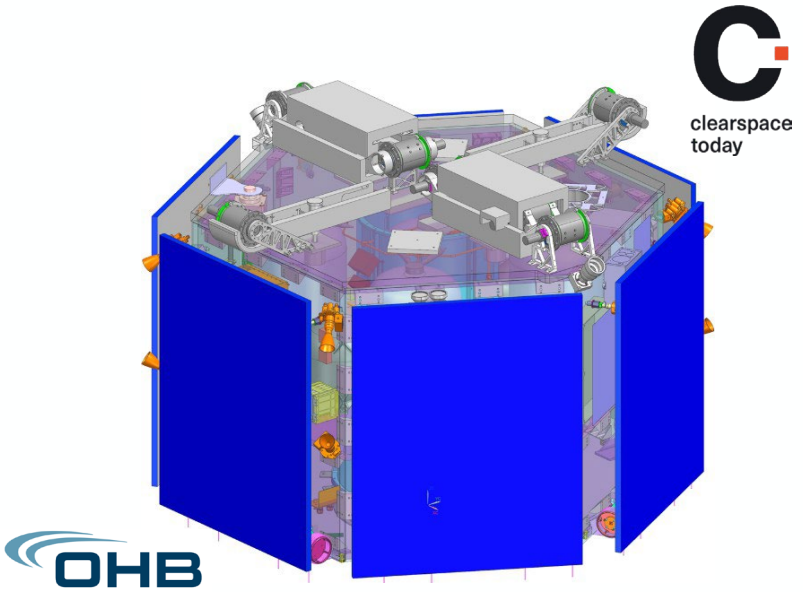
- Visual-based Navigation relative to the client spacecraft during proximity manoeuvring and capture phase
- Navigation performance sensitive to illumination conditions of the client spacecraft
- Further constraints applied to ease the approach for the demonstration:
  - No overlap between Earth and client in the image
  - Sun direction aligned with the camera boresight (<45 deg)
  - No shadow of the servicer casted on the client
  - Intersatellite distance small enough to ensure visibility of client details



System Design

CS1 Spacecraft in launch configuration

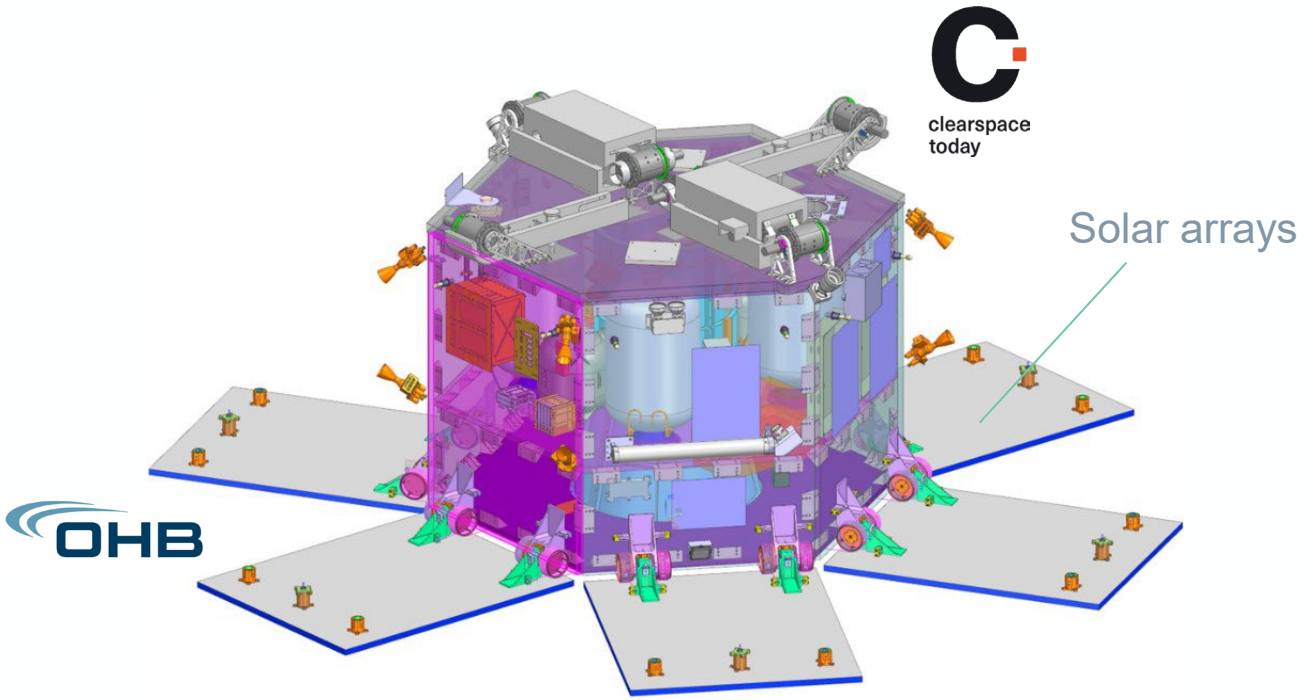
Spacecraft Parameters	
Total mass	580 kg wet, including SRR margin
Total volume	1600 mm (width), 1300 mm (height)
Launch vehicle interface	24-inch standard
Propulsion system	Chemical, green bi-propellant



System Design

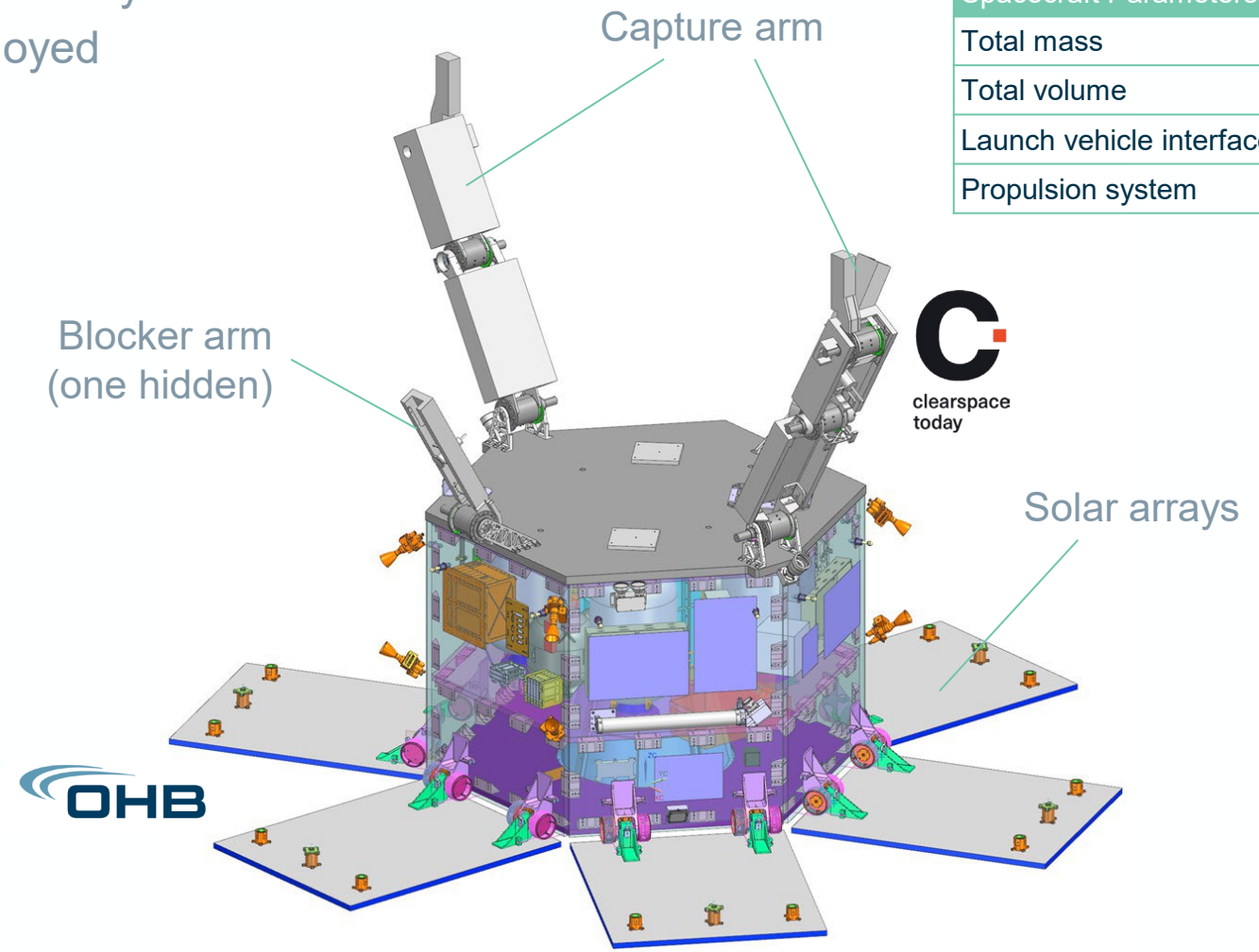
CS1 Spacecraft with Solar Arrays deployed

Spacecraft Parameters	
Total mass	580 kg wet, including SRR margin
Total volume	1600 mm (width), 1300 mm (height)
Launch vehicle interface	24-inch standard
Propulsion system	Chemical, green bi-propellant



System Design

CS1 Spacecraft with Solar Arrays and Capture System deployed



Spacecraft Parameters	
Total mass	580 kg wet, including SRR margin
Total volume	1600 mm (width), 1300 mm (height)
Launch vehicle interface	24-inch standard
Propulsion system	Chemical, green bi-propellant

System Design

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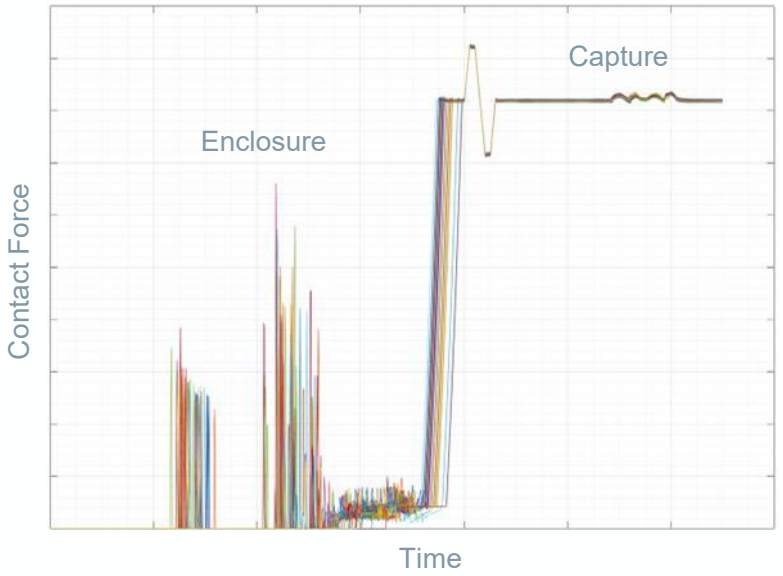
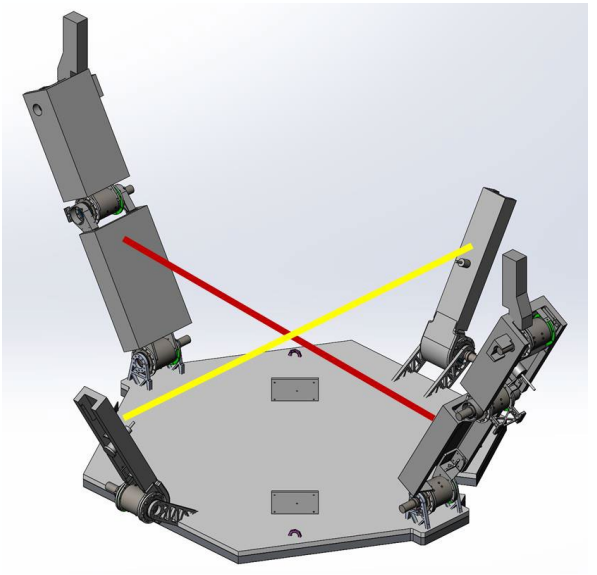
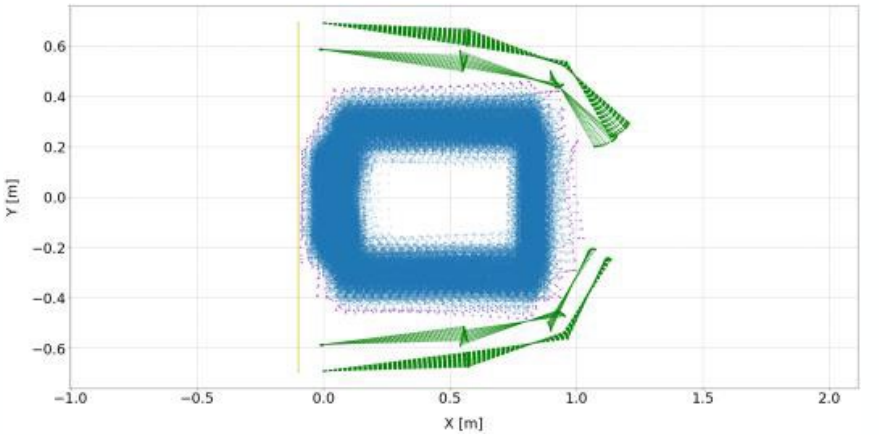
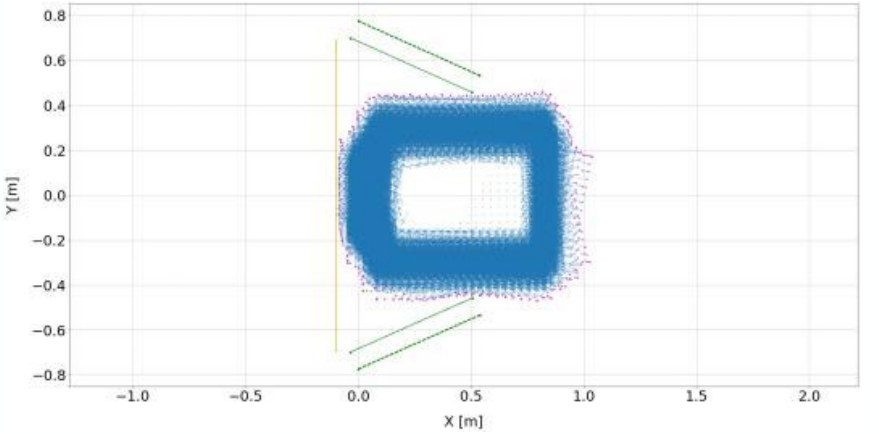
CS1 Capture System

- Autonomous client detection within the capture envelope
- Motion of arms to enclose, grasp and securely capture the client
- Absorption of the contact loads and avoidance of damage to the client or the servicer by force limitation
- Securing of the client for stack formation









Launch Vehicle Candidates

- Direct injection of the servicer spacecraft into the target orbit to save propellant budget
- Injection 10 km below the client orbit expected to avoid a conjunction with the uncooperative client satellite
- For the European large launchers VEGA-C and Ariane 6 a rideshare or piggy-back would be feasible, provided the direct injection in the correct orbit can be offered at the time of need
- Shared launch is expected heavy design driver due to elevated propellant budget and extended operational periods expected
- European and non-European micro-satellite launch vehicles currently considered for ClearSpace-1

Questions?

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