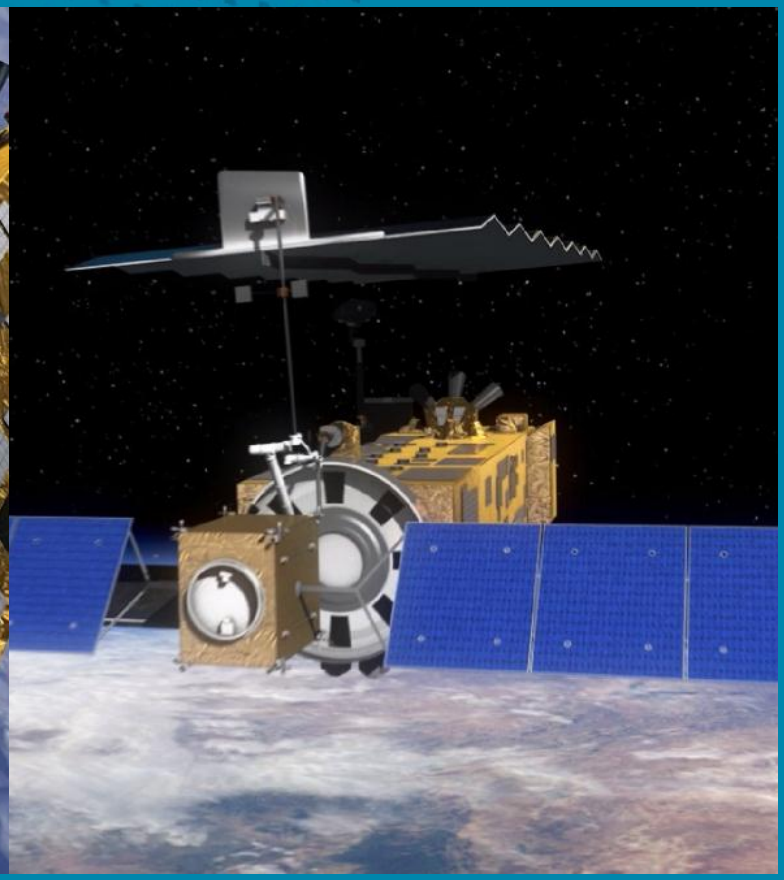
AIRBUS DEFENCE & SPACE

SURREY SATELLITE TECHNOLOGY LTD

DLR

aviospace an EADS-ASTRIUM company

gmv INNOVATING SOLUTIONS



e.Deorbit Symposium, Mai 6 2014

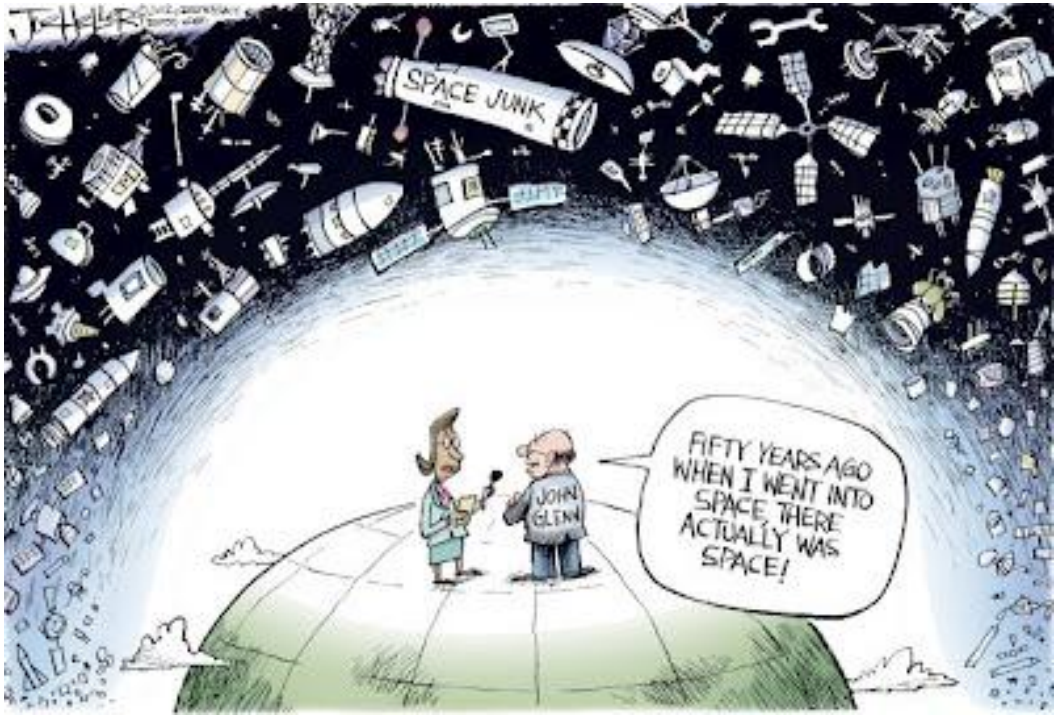
What is the appropriate technical approach for the disposal of orbital debris?

Mission dependability, safety and security – No catastrophic consequences of failures (loss of life and system, generation of new debris).

Cost optimization - Mission and chaser as simple as possible, but not simpler than requested for reaching mission dependability and safety.

Which mission risk level is the customer willing to agree on?

Perspectives of the proposed solutions based on this high investment – Long term scenarios for orbital infrastructure to be considered.



Team

Consortium	Activities
AIRBUS DEFENCE & SPACE	**Airbus (D, F, UK)**, to bring the experience of a large system integrator, a large spectrum of existing spacecraft platforms and existing concepts for the three “eDeorbit” mission approaches
SURREY SATELLITE TECHNOLOGY LTD	**Surrey Satellite Technology Ltd (**SSTL**, UK)**, to challenge Astrium’s vision and to bring the low-cost approach and complementary platforms in particular for the re-orbitation mission
DLR	**DLR Institute of Robotics and Mechatronics (**DLR-RM, **D**), to bring the expertise in robotics and in rigid link based capture
aviospace an EADS-ASTRIUM company	**Aviospace (I)**, to bring the expertise in flexible link based capture
gmv INNOVATING SOLUTIONS	**GMV (SP)**, to bring the expertise in mission analysis and re-entry simulation

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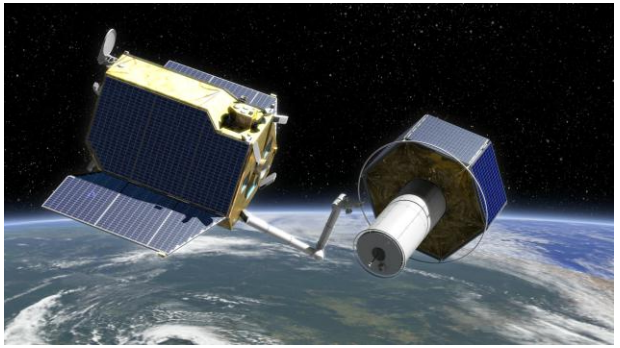
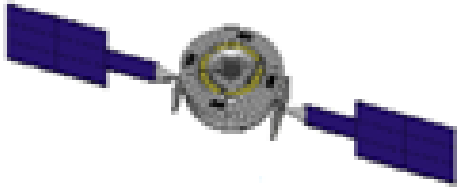
Heritage and on-going projects

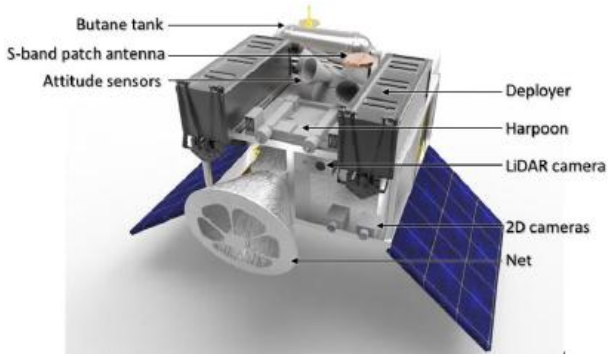
- DEOS (DLR): Airbus DS
- OTV (CNES): Airbus DS, GMV, SSTL
- FP7 RemoveDebris (EC): Airbus DS, Aviospace, SSTL
- ADR Service (ESA): Airbus DS, Aviospace, SSTL
- Capture and De-orbiting Technologies (Regione Piemonte, Italy): Aviospace
- SYSNOVA (ESA): GMV



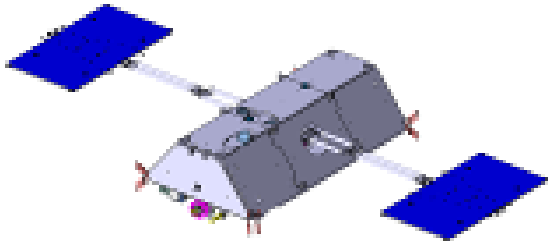
DEOS



OTV



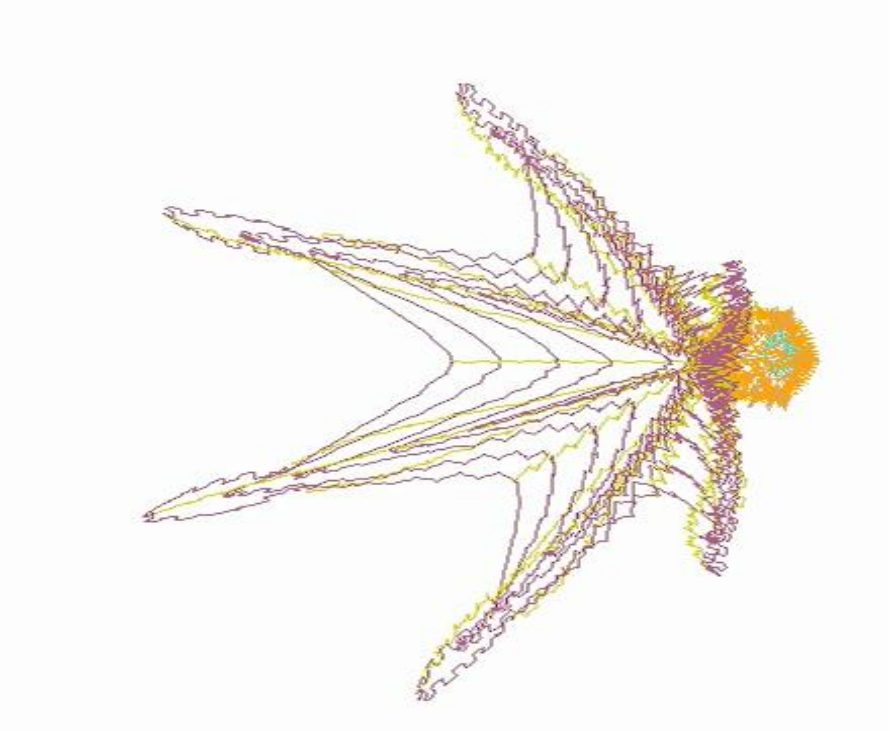
Remove Derbis



SYSNOVA

Mission Option 1
Net Capture & Deorbit

Net-based capture concept for mission option 1 flexible link



Main characteristics	
Mass	90kg in total (2 nets)
Size	Diameter: 30 m
Position on chaser	Head panel
Power	20W average, 40W peak

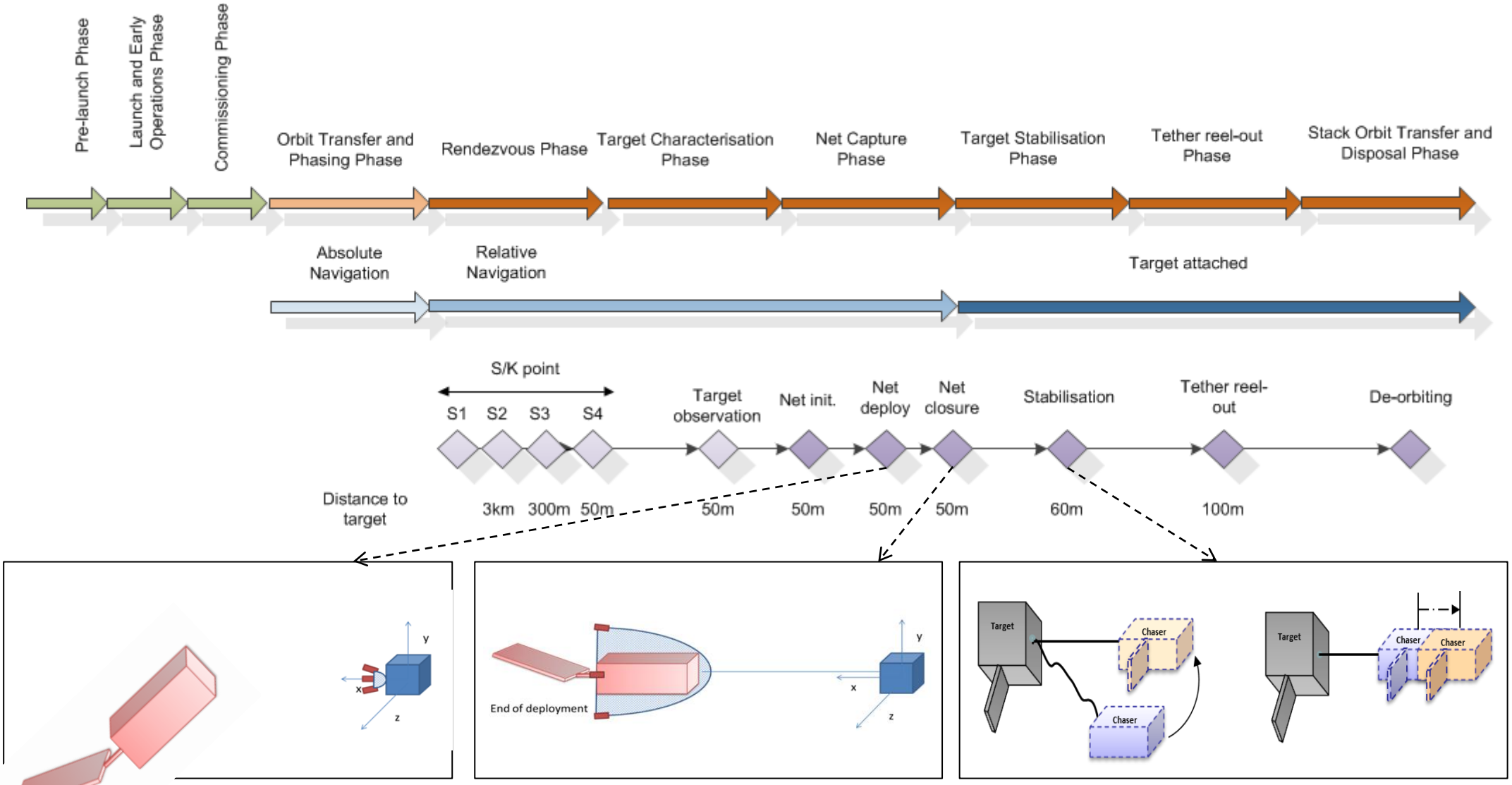
Advantages

- Simple and robust ejection and capture mechanisms
- 2 nets can be accommodated on the chaser providing required redundancy (2 attempts).
- Simple synchronisation between net ejection and target rotation prior to net ejection
- No collision risk between chaser and target during capture (distance 50m).

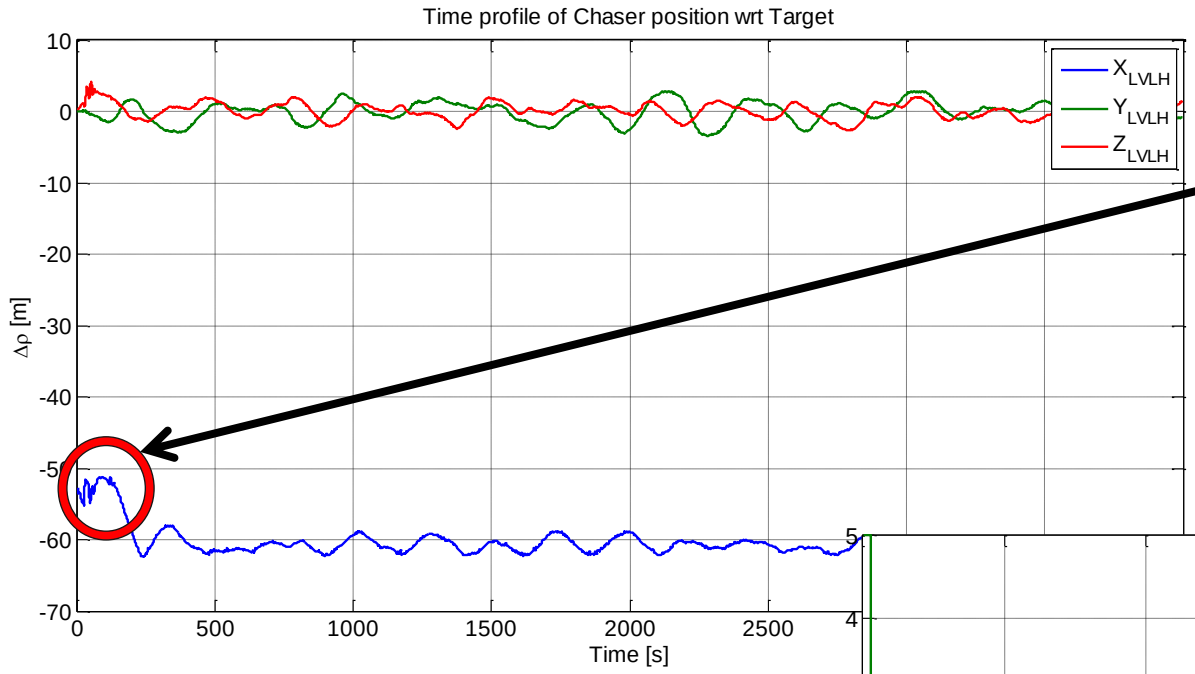
Challenges

- Complex interactions between net and Envisat occurring during capture and tether pulling phases very difficult to evaluate.
- Full scale test and verification not possible. Verification strongly relies on simulations and reduced scale 0g tests with an Envisat model.
- High dynamic target stabilisation phase mandatory as the chaser is not synchronised with Envisat.

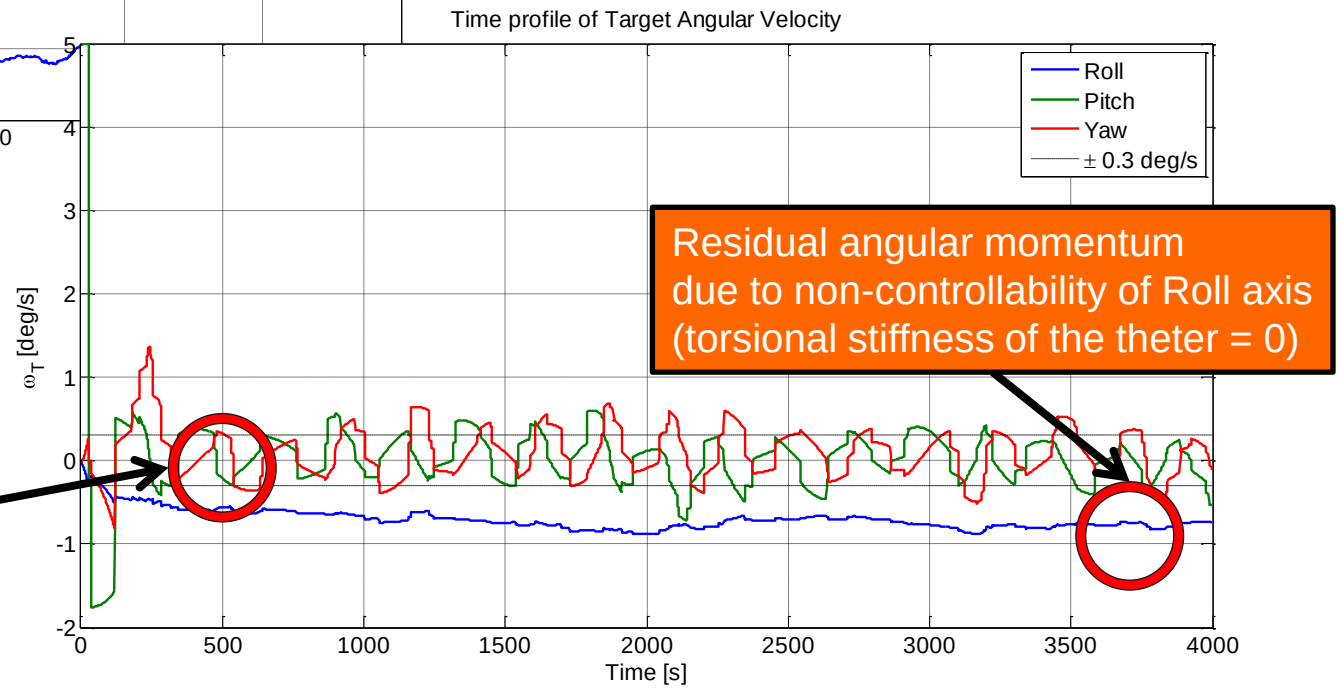
Timeline scenario mission option 1



Analysis on GNC flexible link



Yo-yo effect minimized by the control law to reduce the risk of collision



Residual angular momentum due to non-controllability of Roll axis (torsional stiffness of the theter = 0)

Pitch/Yaw angular velocity damping in 400 s (7 min)

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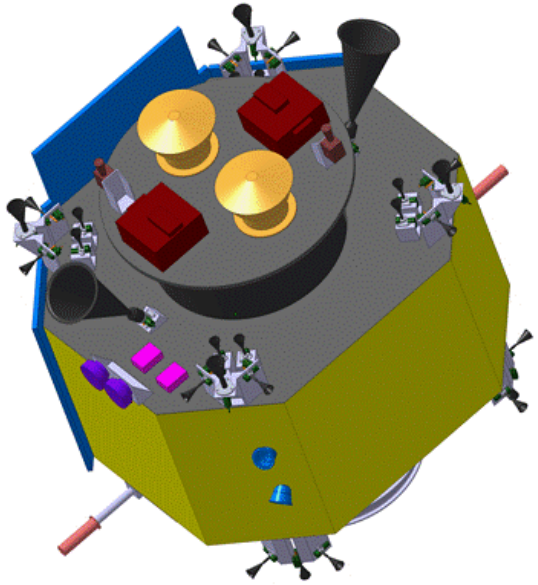
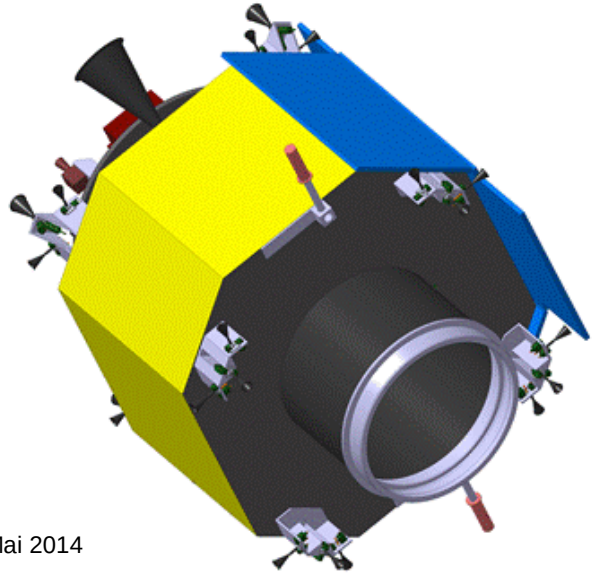
Chaser baseline configuration mission option 1



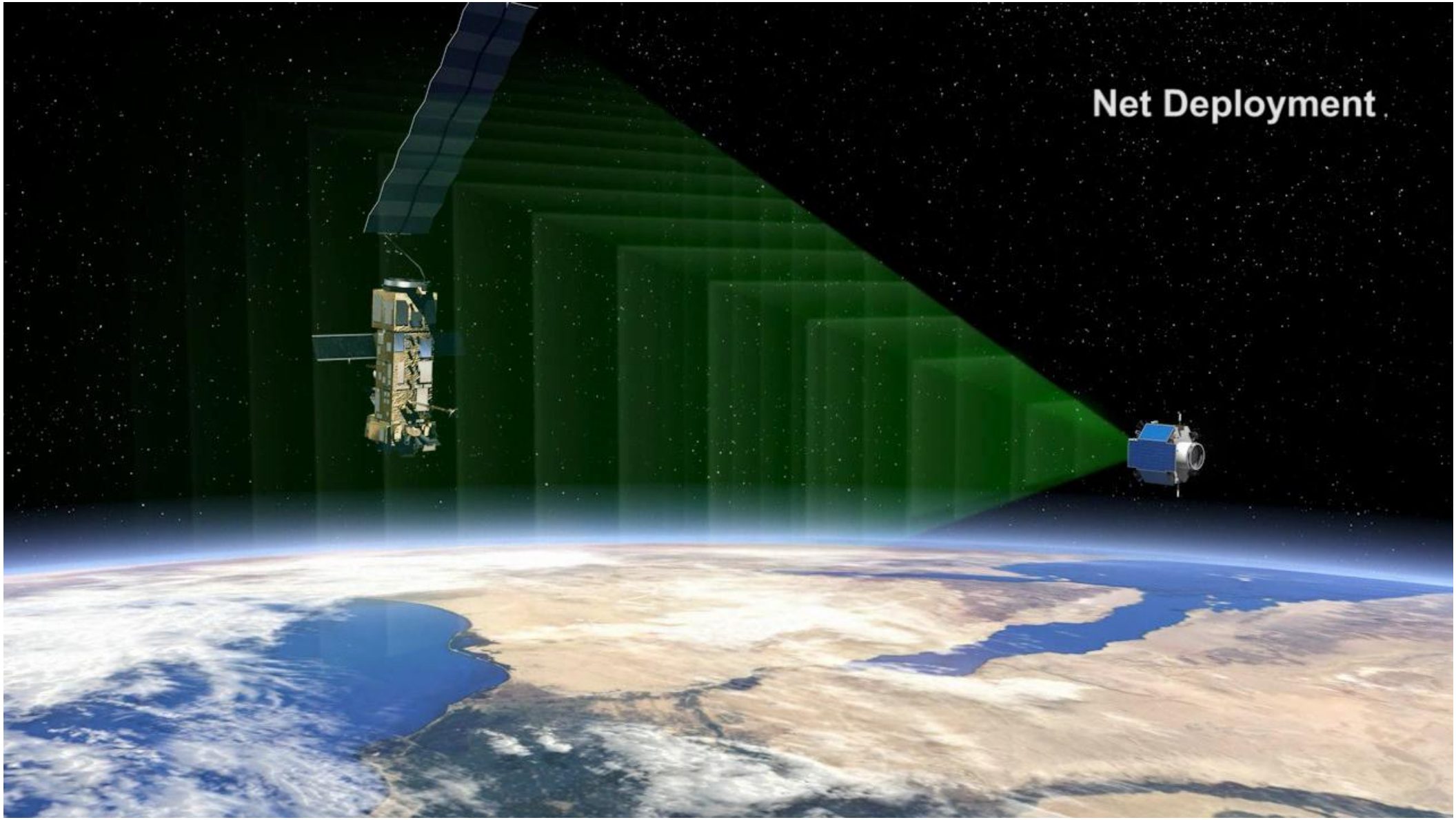
Current design concept



Characteristics
For VEGA Launch: 1550kg payload mass according to current VEGA user manual (user manual update in preparation)
Requiring ascent 400km ➔ 760km
Total dry mass: 750kg
Consumables: 936kg
Wet launch mass: 1686kg

Vega physical accommodation

Animation of the net-based capture sequence



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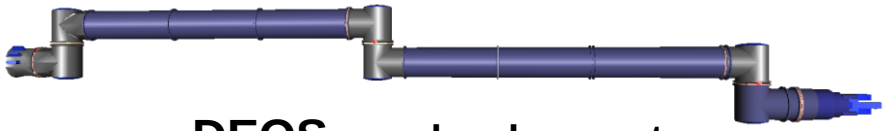
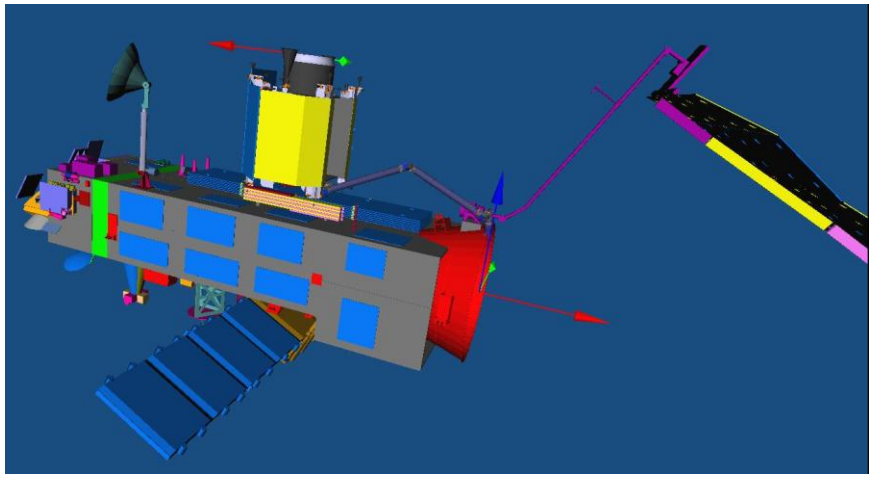
Mission Option 2
Robotic Capture & Deorbit

Robotic-based capture concept for option 2 rigid link deorbit



DEOS pre-development



Main characteristics	
Mass	80 kg
Size	4 m
Position on chaser	Side
Power	150W average, 250W peak

Advantages
Low absolute position accuracy between chaser and target sufficient.
Board automatic operations and ground based teleoperations possible. Time available for capture and attachment state assessment.
No generation of debris during capture subsystem nominal operation and deorbiting.
Trimming of the CoM alignment between chaser and target possible.
Straightforward stabilisation phase of the target.

Challenges
Advanced manoeuvres and GNC subsystem mandatory to synchronise the chaser with the target.
Advanced CAM capability requested.
Additional GNC and control complexity of platform and robot due to robot arm operations with activated ACS.

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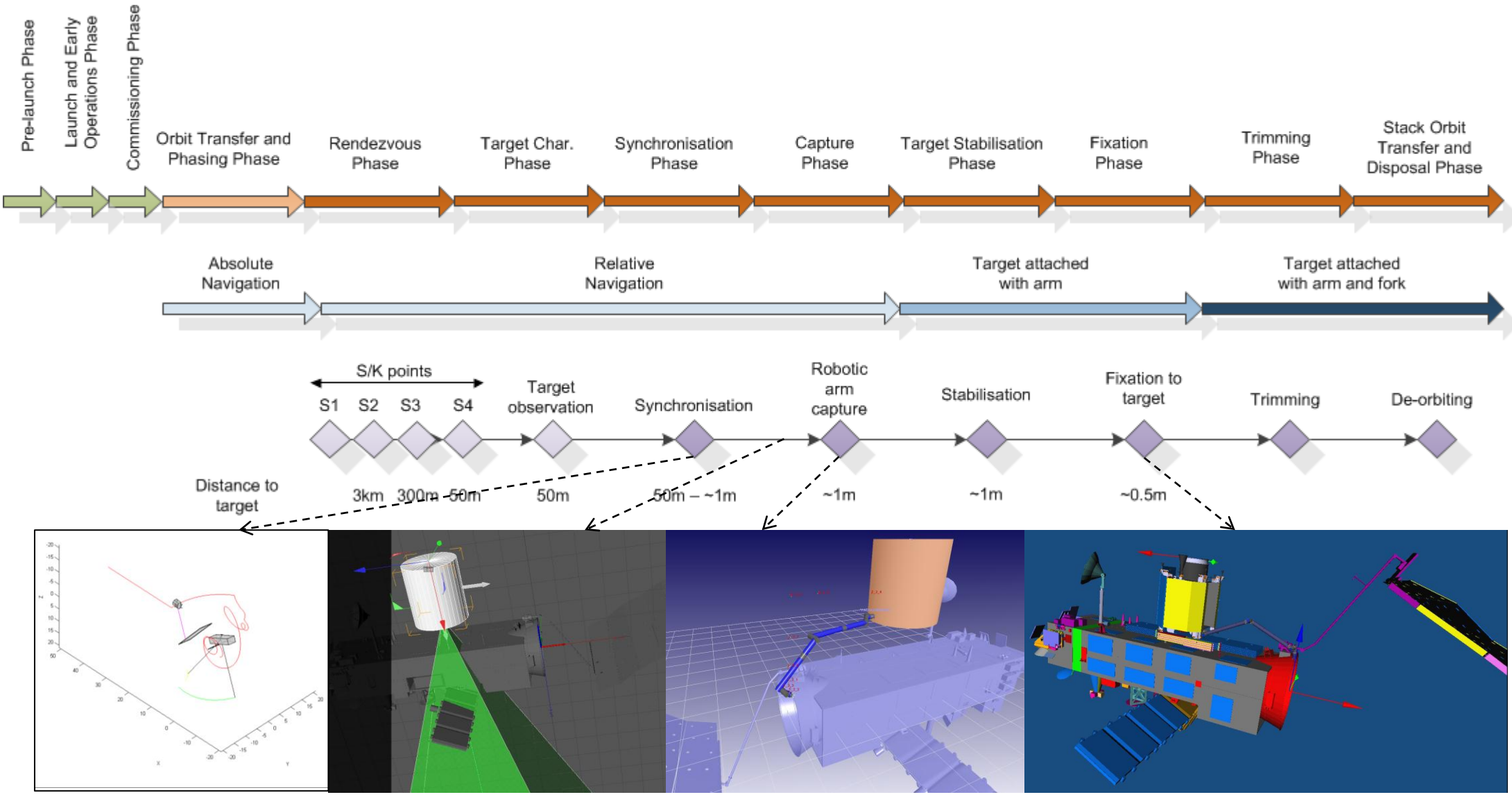
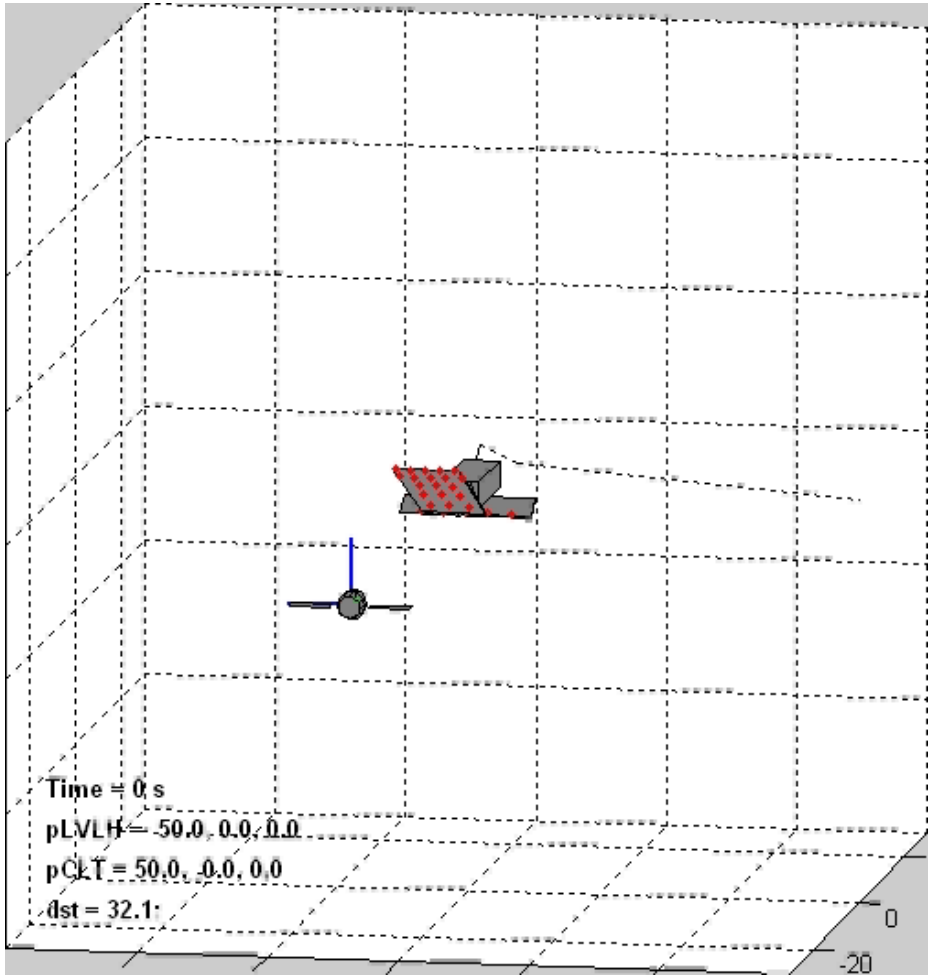
Timeline scenario mission option 2

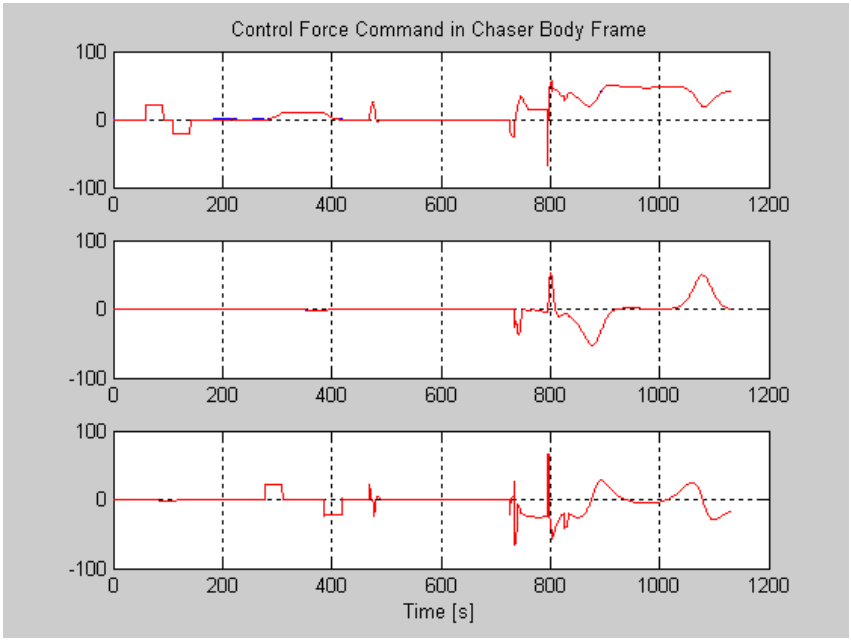


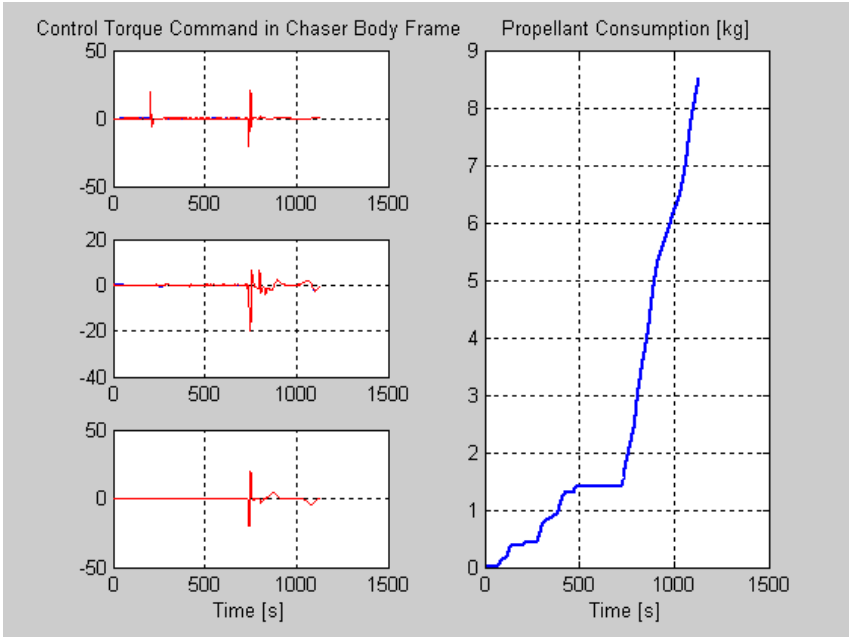
Analysis on GNC configuration

Attitude dynamics based on DEOS heritage

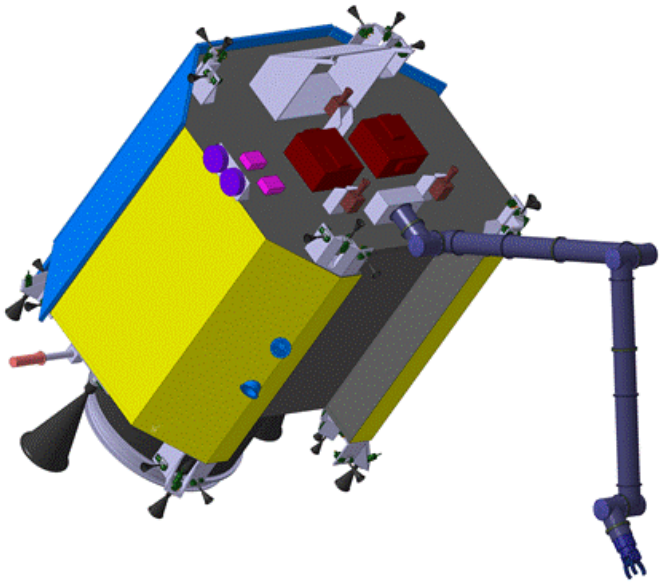


„90 deg nutation“ case

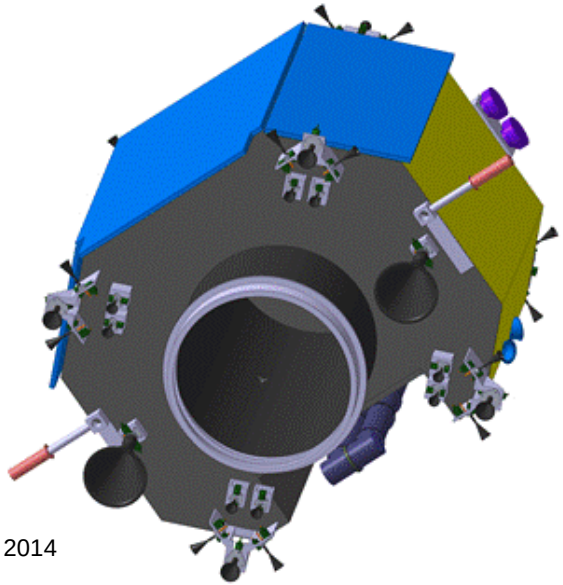




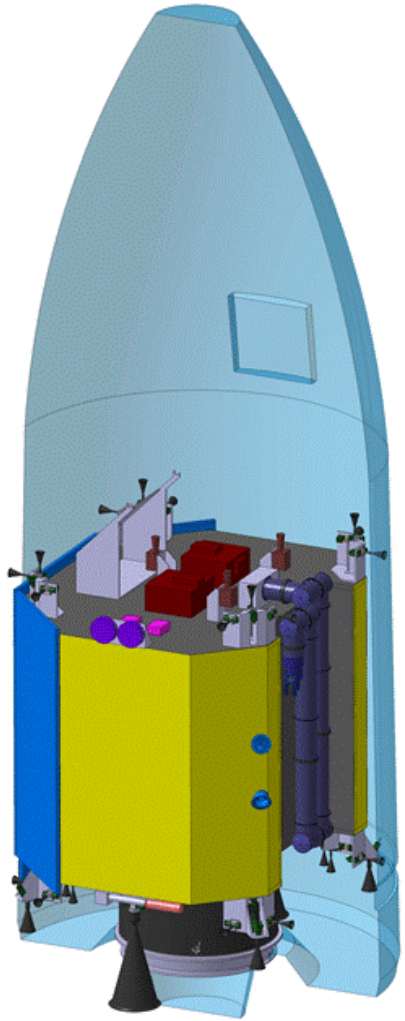
Chaser baseline configuration mission option 2



Current design concept

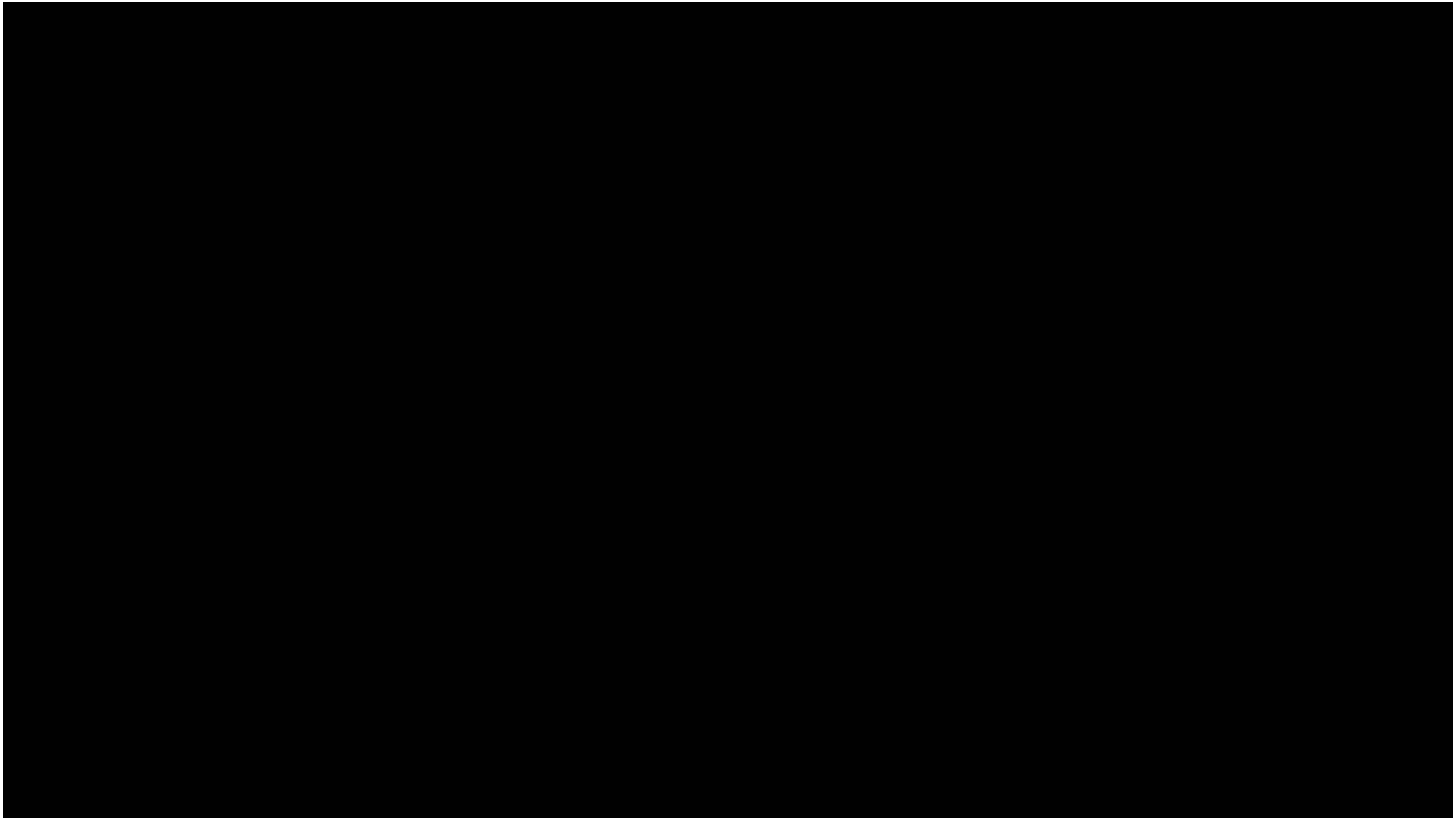


Characteristics
For VEGA Launch: 1550kg payload mass according to current VEGA user manual (user manual update in preparation)
Requiring ascent 400km ➔ 760km
Total dry mass: 754kg
Consumables: 874kg
Wet launch mass: 1628kg



Vega physical accommodation

Animation of the robotic-based capture sequence for deorbit



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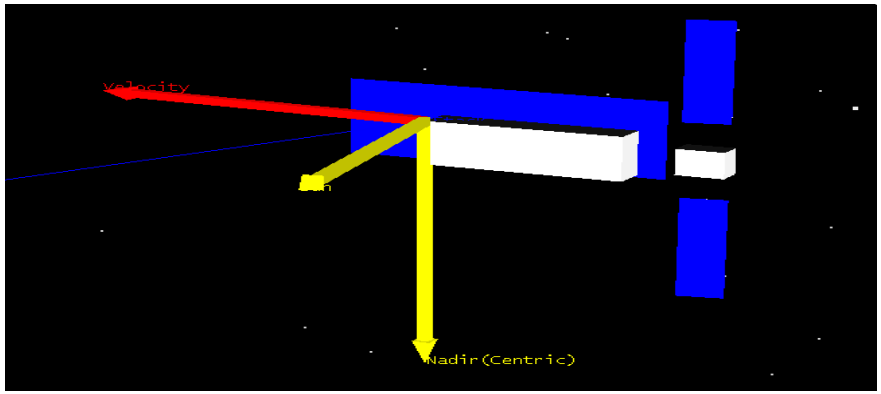
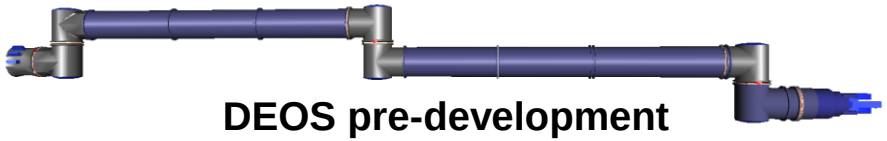
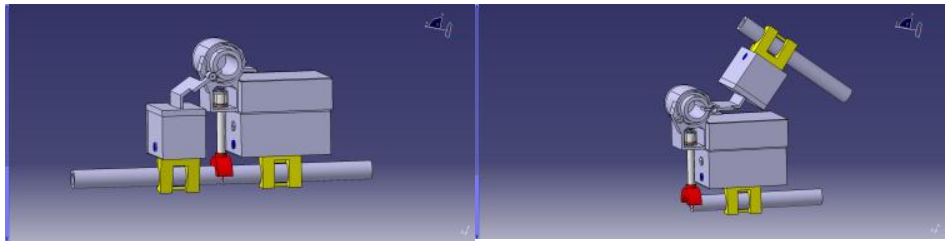
Mission Option 3
Robotic Capture & Reorbit

Robotic-based capture concept for reorbit





DEOS pre-development



Main characteristics	
Mass	90 kg
Size	4 m
Position on chaser	Top
Power	150W average, 250W peak

Advantages
Low absolute position accuracy between chaser and target sufficient.
Board automatic operations and ground based teleoperations possible. Time available for capture and attachment state assessment.
Trimming of the CoM alignment between chaser and target possible.
Access to optimal position w.r.t. Envisat shadowing.

Challenges
Advanced manoeuvres and GNC subsystem mandatory to synchronise the chaser with the target.
Advanced CAM capability requested.
Additional GNC and control complexity of platform and robot due to robot arm operations with activated ACS.
Advanced operations for cutting the mast and moving the chaser around Envisat.

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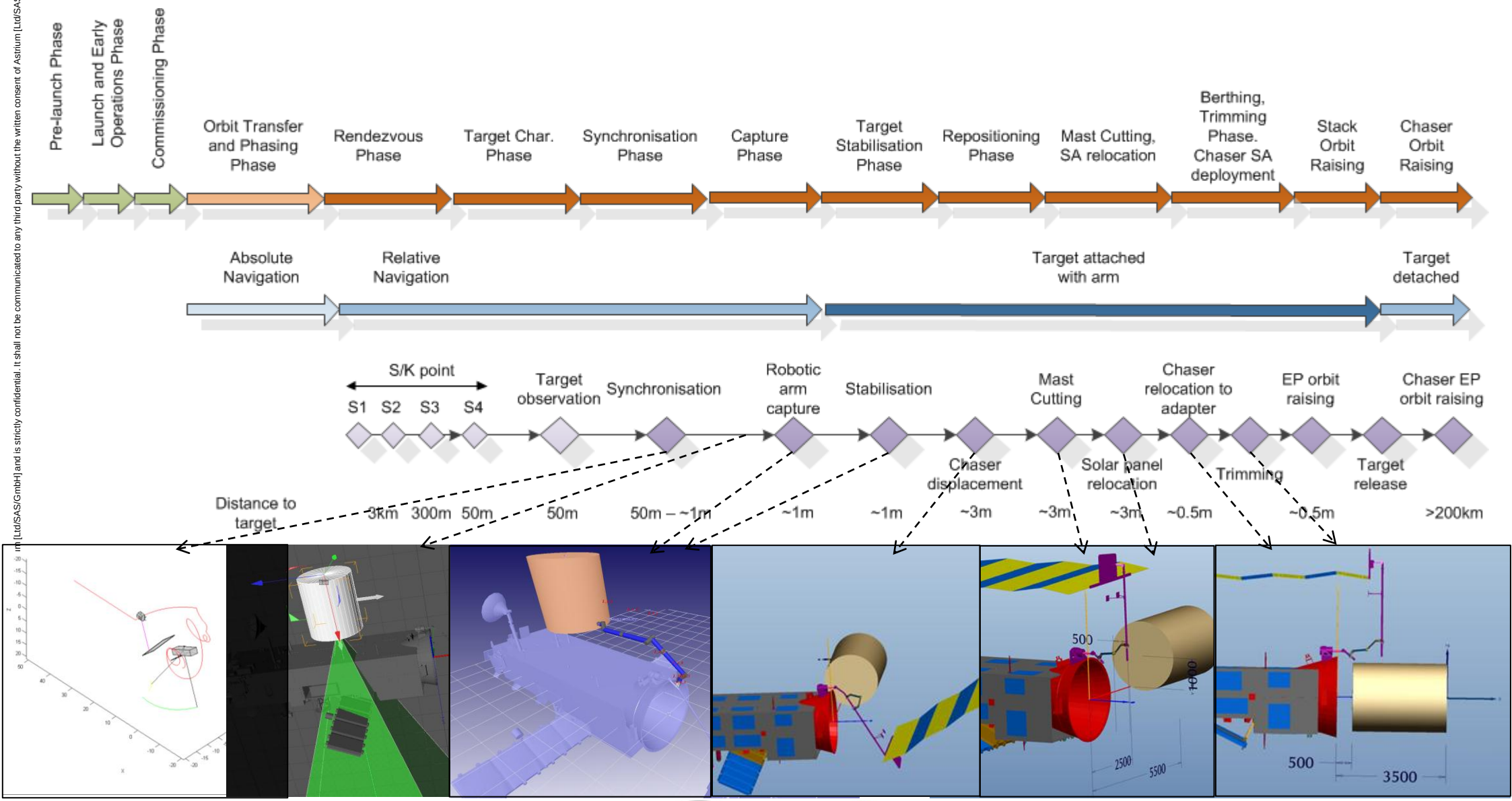
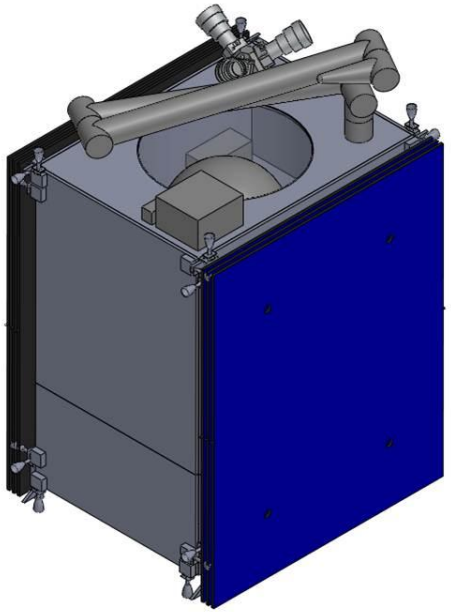
Timeline scenario mission option 3

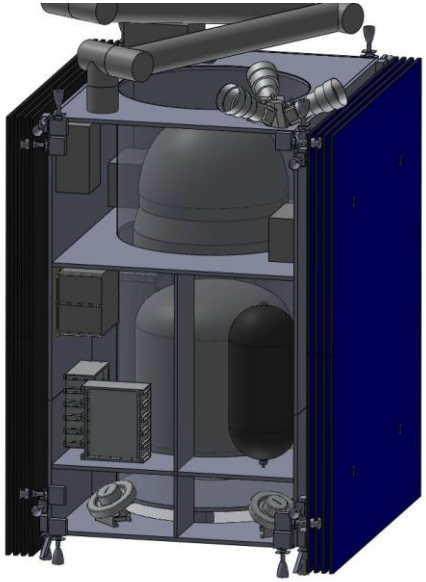


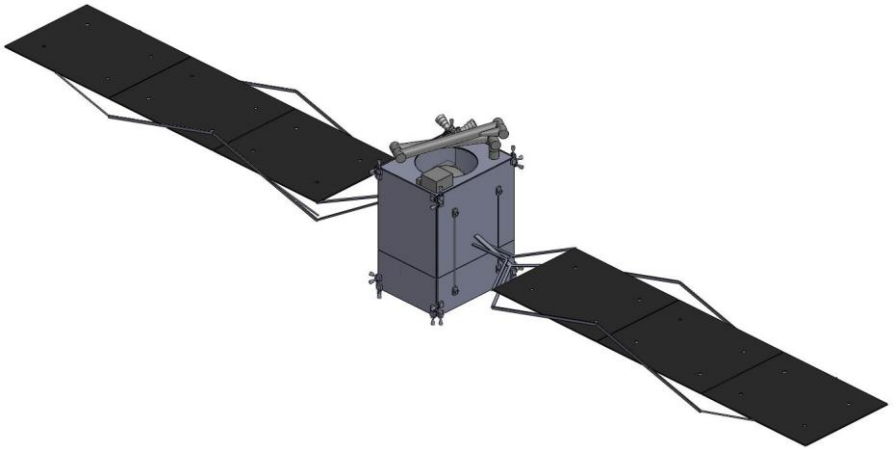
Chaser baseline configuration mission option 3

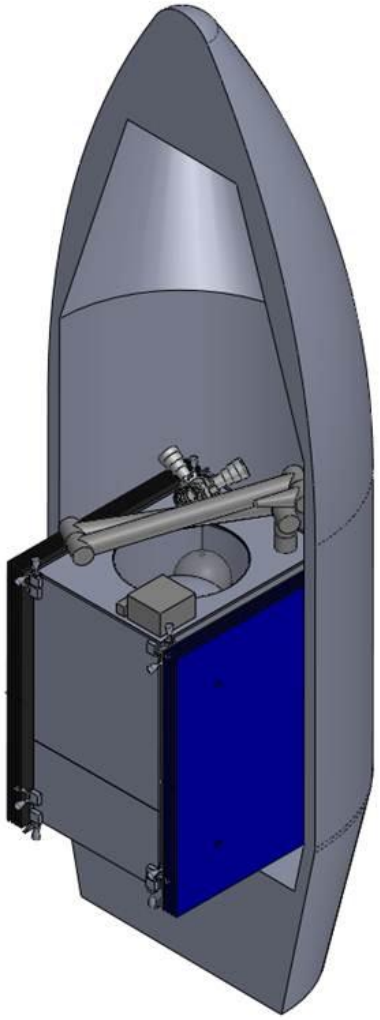


Current design concept

Characteristics
For VEGA Launch: 1550kg payload mass according to current VEGA user manual (user manual update in preparation)
Requiring ascent 400km ➔ 760km
Total dry mass: 1039kg
Consumables: 411kg
Wet launch mass: 1450kg







Vega accommodation

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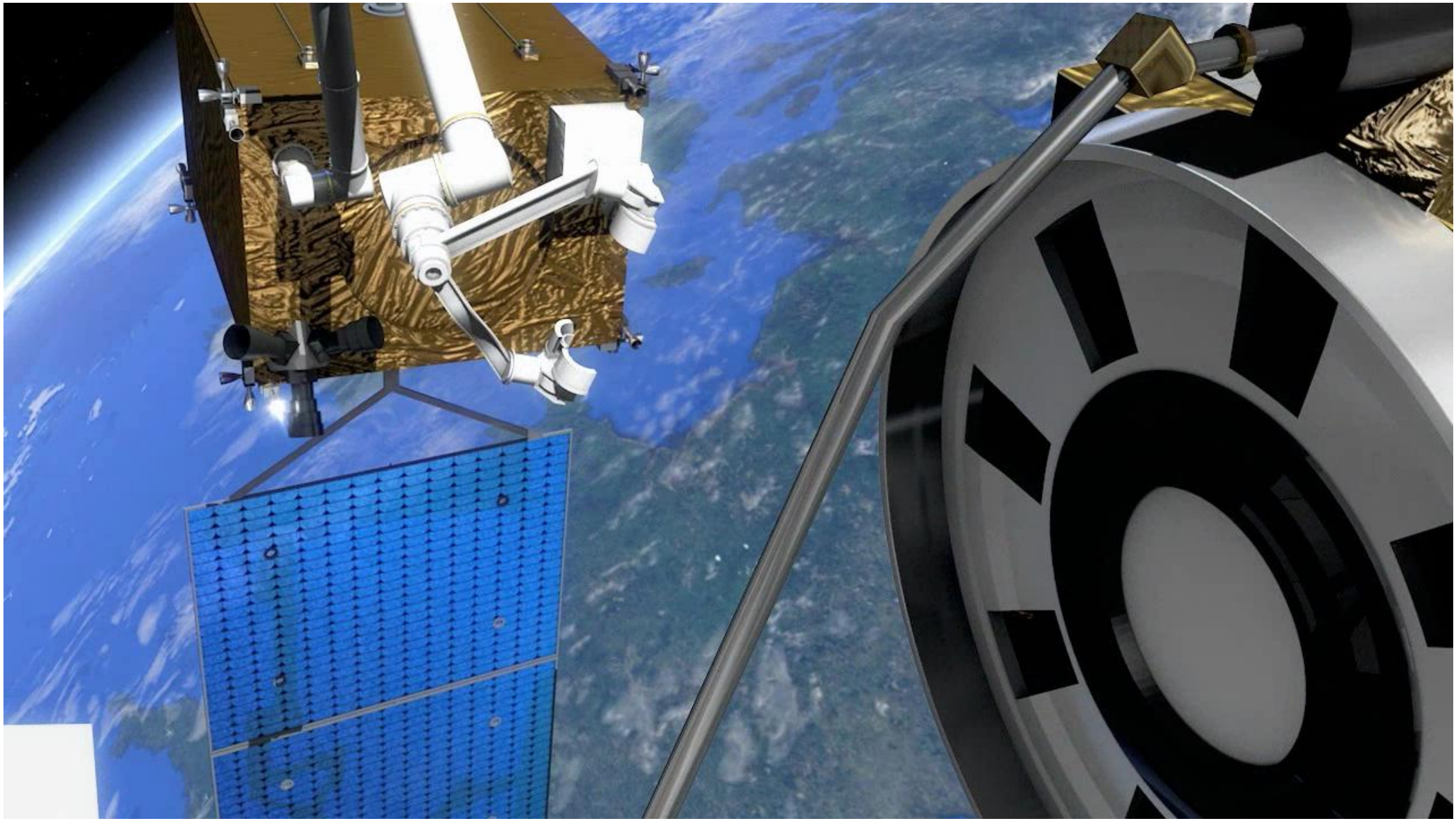
Animation of the robotic-based capture sequence for reorbit



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Status and outlook

- Mission scenario and chaser configuration baselines identified for each mission option
- ESA 5 deg/s goal seems to be feasible (no show stopper identified so far)
- In the 2. study iteration the baselines will be optimized in terms of cost (1. priority) and mass. Definition of configuration options.
- In a dialog with ESA the requested mission reliability levels will be defined (i.e. mission risks accepted by the customer and the derived component selection and redundancy approach with the according cost)
- The results of the ADR Service study will be considered as well:
  - ADR calls for innovative technologies that can be reused for other purposes
  - ADR technologies and versatile vehicle as preferred approach could benefit other programs such as on-orbit servicing

- **Airbus DS is open for cooperation with further partners !**

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