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ORBITAL SATELLITE SERVICES

OLEV – AN ON-ORBIT SERVICING PROGRAM FOR COMMERCIAL SPACECRAFTS IN GEO

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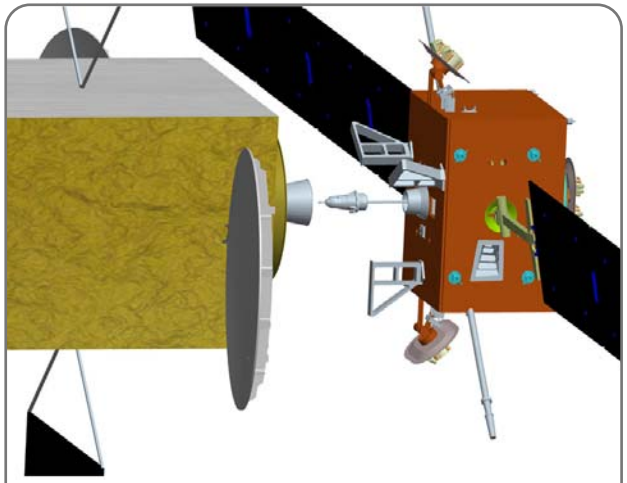
Business Case

- **Situation today:**
  Telecommunication satellites with full operational payload have to finalize its mission due to missing fuel for further attitude and orbit control maneuvers.

- **Idea:**
  To perform these attitude and orbit control maneuvers by a service satellite **(OLEV)**, which docks to the client satellite and perform all required operations as an service up to the transfer of the client into its final graveyard orbit.

➡ Development of a Service Satellite providing universal Rendezvous and Docking capabilities for GEO satellites life extension of up to 12 years



OLEV approaching to a client satellite. Only existing docking interfaces are the following standardized elements:

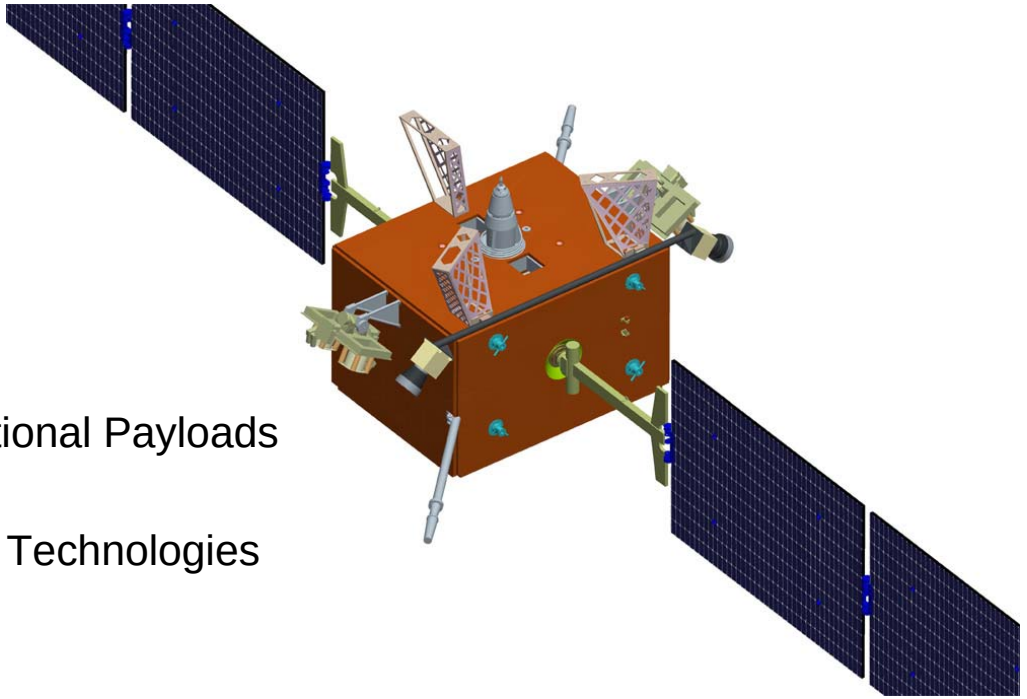
- Launch Adapter I/F Ring
- Liquid Apogee Engine Nozzle

ORBITAL SATELLITE SERVICES SENER Swedish Space Corporation KAYSER-THREDE

Market

Customer:

- Operators of Telecom Satellites
- Insurances
- Institutional Market (Space Agencies, Military)



Offer:

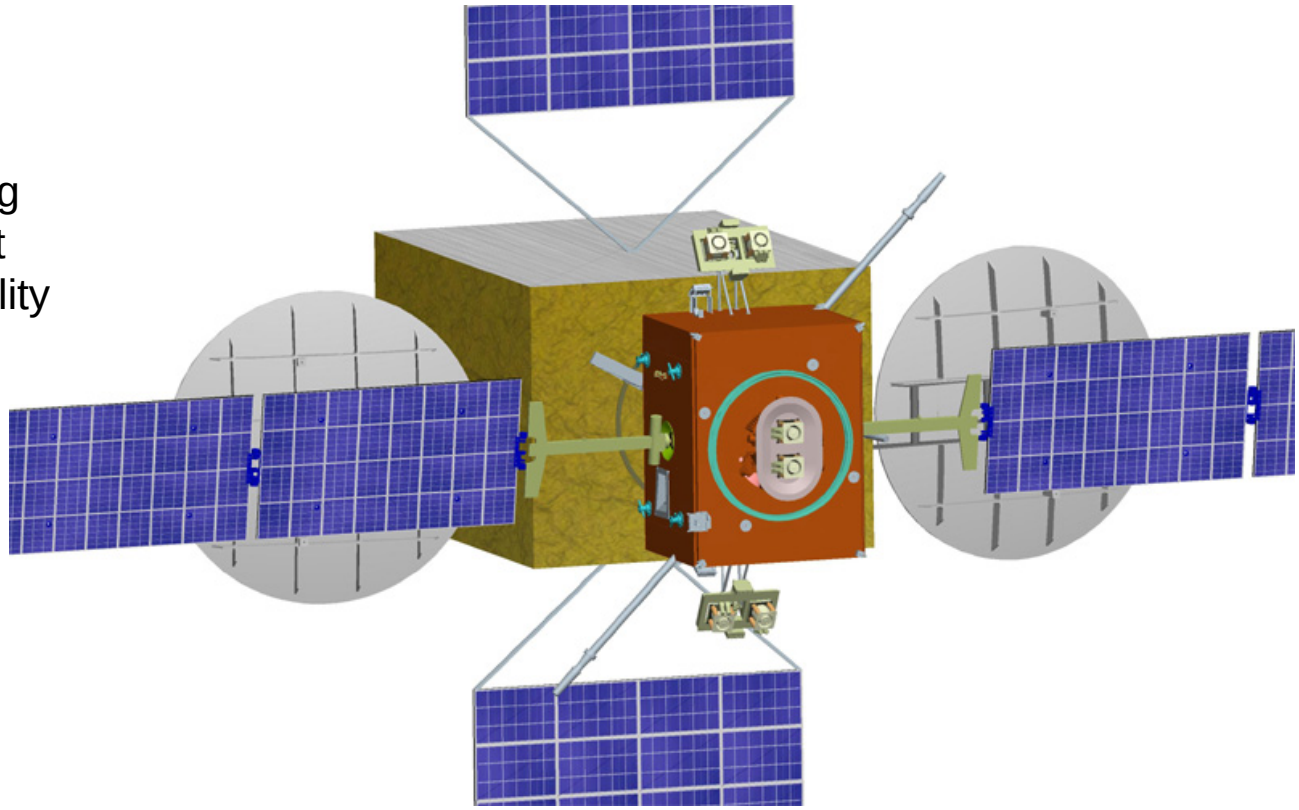
- Dedicated Fleet Management of GEO-Satellites
- Life Extension of GEO-Satellites with Full Operational Payloads
- Berthing of Stranded New Satellites in GTO
- In-Orbit Testing and Demonstration of New RVD Technologies

Advantages for the Customer:

- Delay Capital Expenditures for New Investments
- Optimization of Telecom Services
- Reduction of Insurance Rates
- Increase of Operational Efficiency of “Space Assets”
- Emergency Services

OLEV Overview

- Focus is set on non-cooperative clients enabling a “soft-docking” by being 3-axes stabilized with sensor part of AOCS switched off.
- Use of the specific German docking technology “Capture Tool” as heart of SMART-OLEV under responsibility of Kayser-Threde being the Rendezvous & Docking Payload Prime Contractor and responsible for the Docking Phase.
- Use of SMART-1 platform technology and heritage incl. electric propulsion system under responsibility of SSC as Platform Prime Contractor.
- GNC Architecture and Rendezvous Phase under Sener responsibility.



OLEV Services (a-f) and Mission Profile (1-6)

a. Life Extension (design point 12 years for a 2 t EOL client)

b. Relocating in the geostationary arc

c. Undocking and re-docking from one Client to another (up to five times).

d. Orbital node rotation

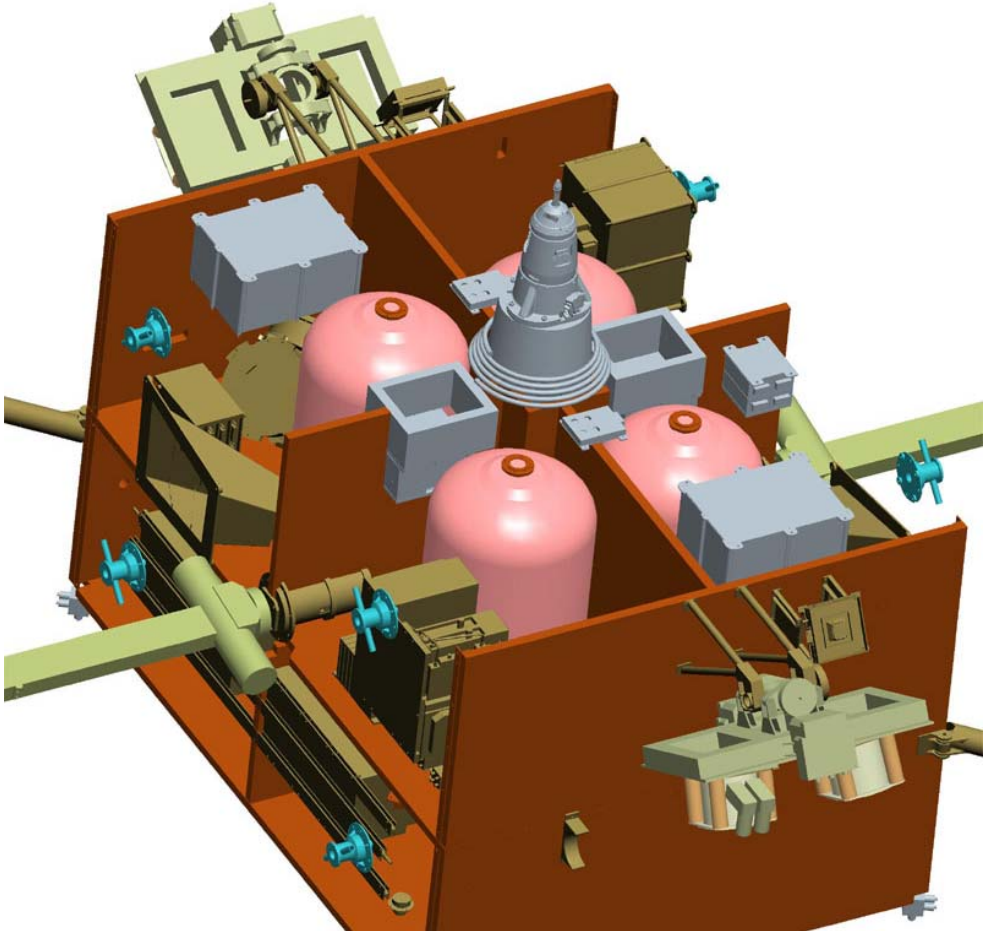
e. Inclination Removing

f. Disposal/moving to graveyard orbit

1. Launch & Early In-Orbit Operations (some days)
2. Orbit Transfer (150 days)
3. Rendezvous & Docking (1 day)
4. On Station Operation (maximum 12 years)
5. Disposal (some days)
6. Undocking and Return to GEO (some days, back to 3.)

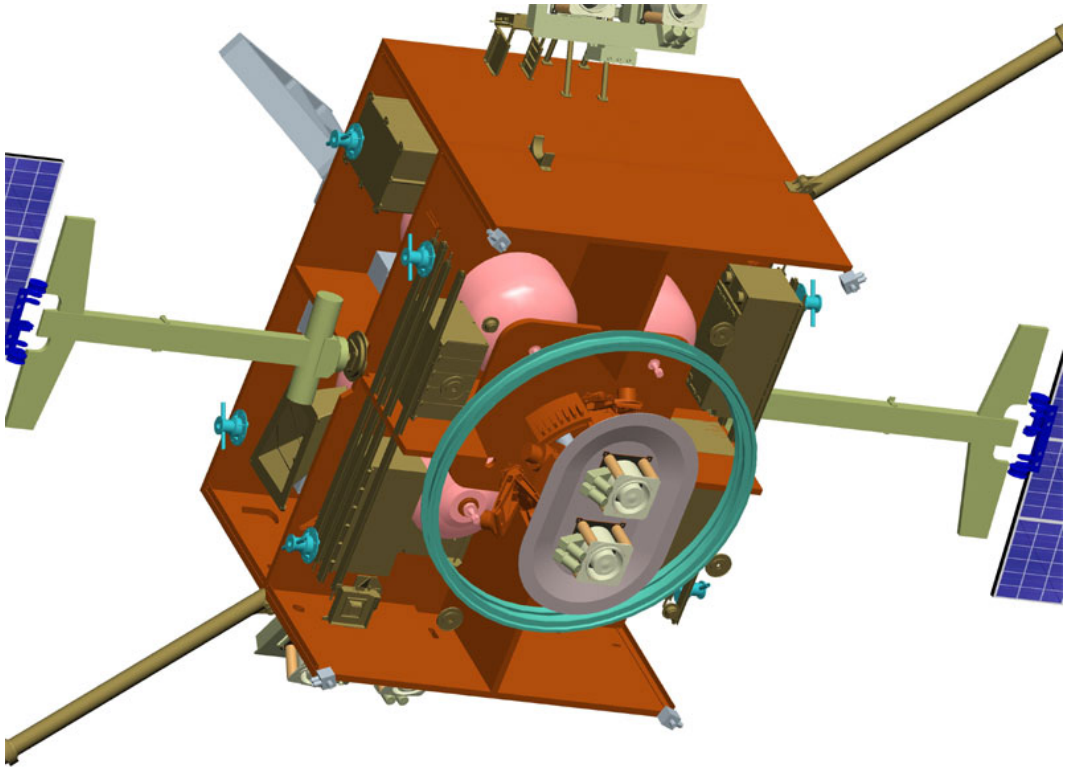
Spacecraft Overview (1)

- Communications: S-band transponders and deployable antennas with ranging capabilities
- Data Handling: Onboard processor and CAN data bus with 1 Mbps data rate
- AOCS: 3-axis stabilized using reaction wheels, star trackers, sun sensors, gyros and (RVD Payload) cameras
- Power: Two solar array wings with GaAs triple junction cell panels delivering 4.5 kW at BOL. Regulated power bus at 100 and 28 V.

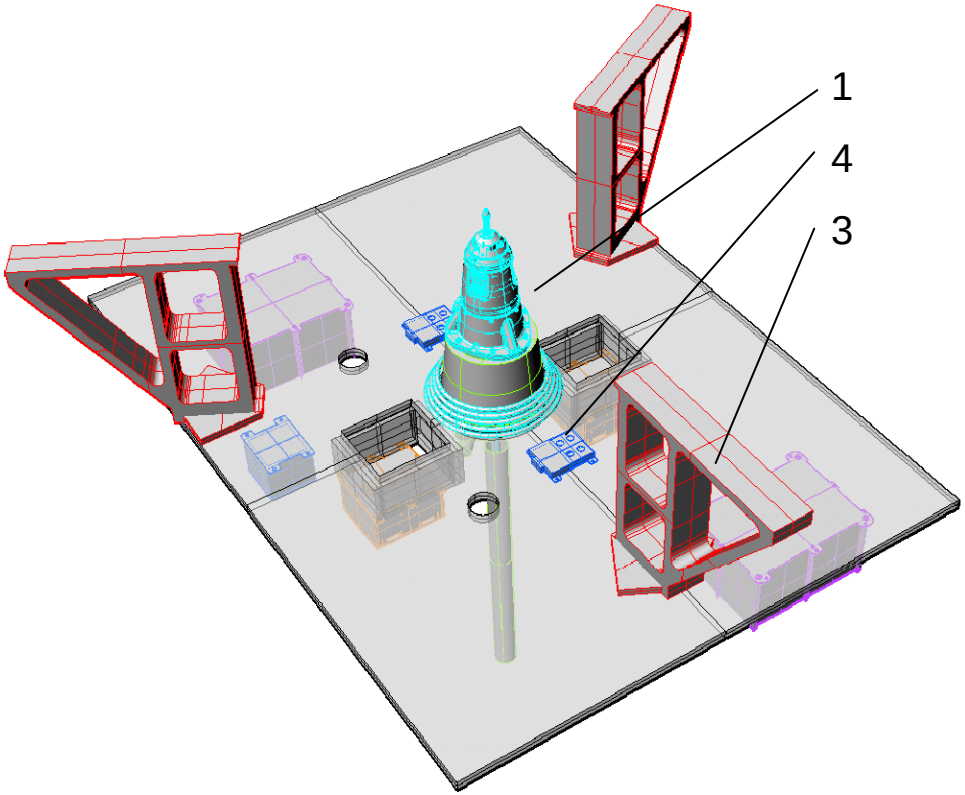


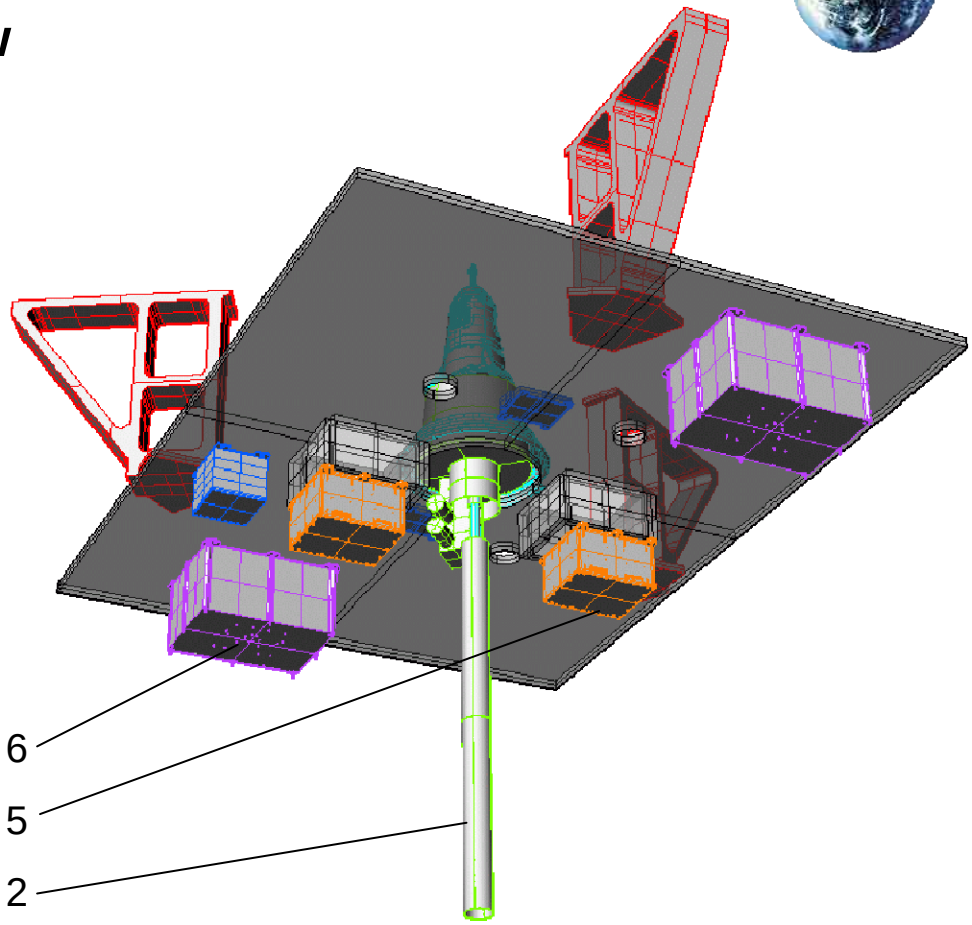
Spacecraft Overview (2)

- Structure: Structure using lightweight panels and webs.
- Thermal Control: Use of constant conductance heat-pipes, blankets, thermistors, heaters and thermostats
- Reaction Control: 24 cold gas thrusters using Xenon gas for increased control authority when required.
- Electric Propulsion System: Six Hall effect thrusters using Xenon-gas (330 kg capacity on board) including thruster re-orientation mechanisms for thrust vectors fine adjustment needed for flexible station keeping maneuvers in composite configuration for different clients.



Rendezvous & Docking Payload Overview (Kayser-Threde as Prime Contractor)



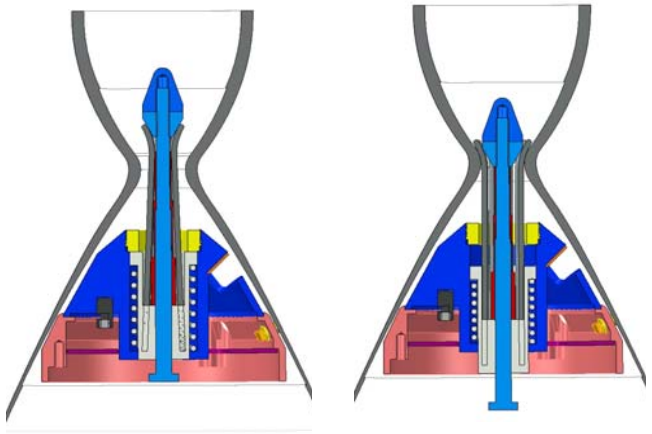


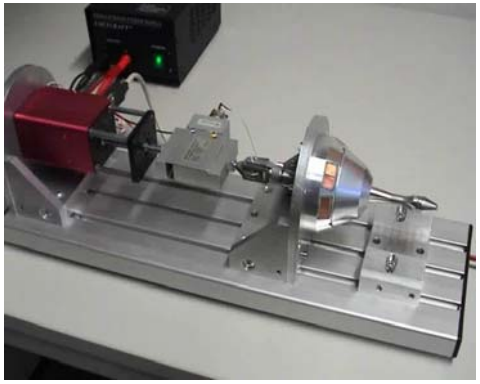
1) Capture Tool (CT)
2) CT Deployment Mechanism (CDM)
3) Client Support Brackets (CSB) (3x)
4) Target Illumination System (TIS) (2x)
5) Cameras (Far-, Mid-, Near-Range) (2x)
6) DP Control Unit (2x)

The Capture Tool

Key payload element for capturing is the Client's apogee engine nozzle.

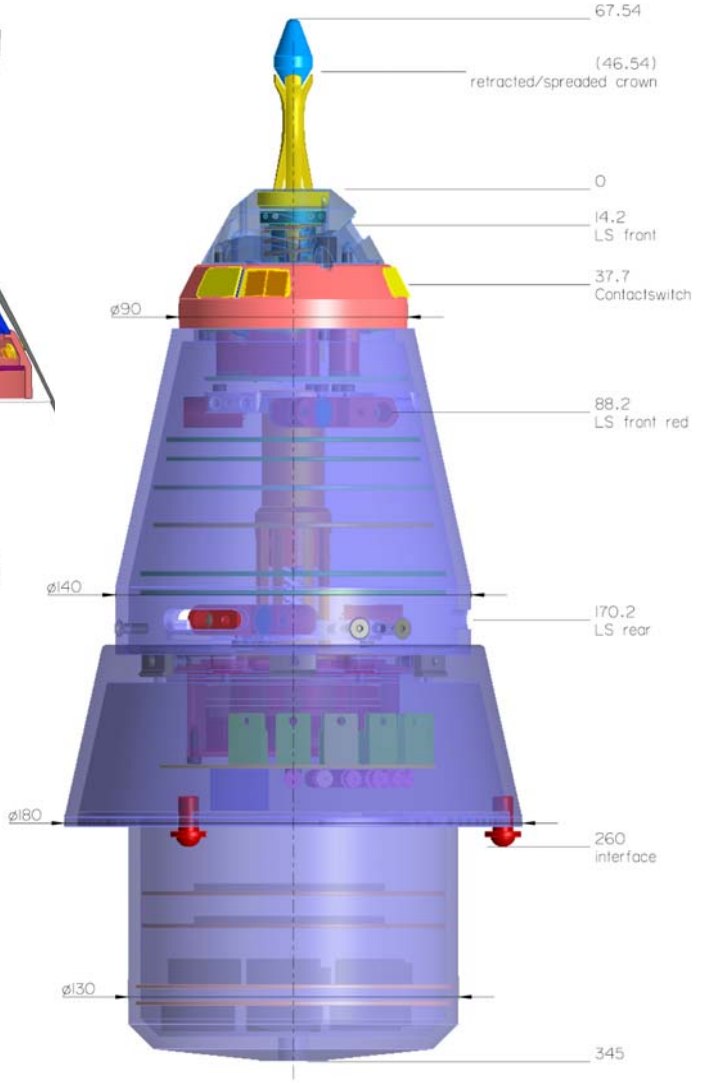
Technology developed by DLR Institute of Robotics and Mechatronics in Oberpfaffenhofen, Germany.



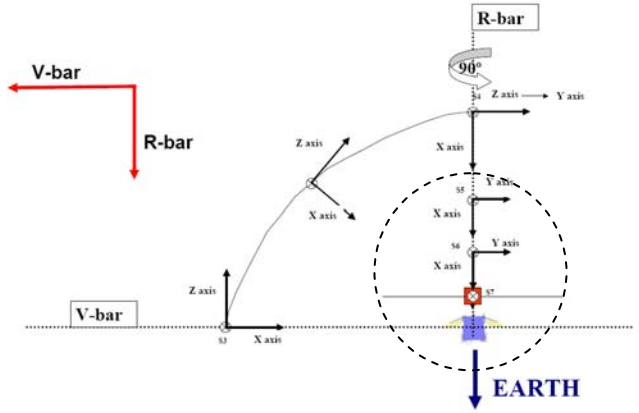


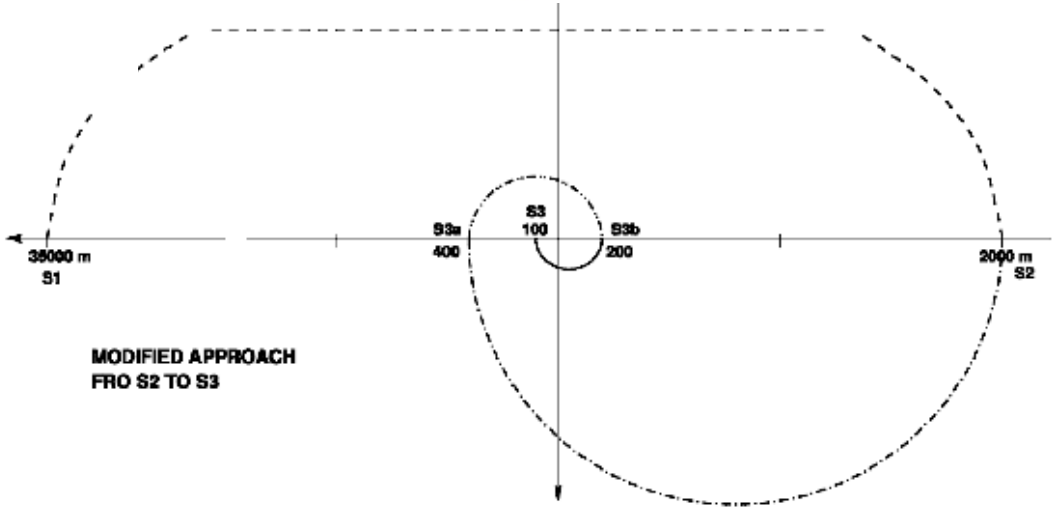
Re-design of Crown:

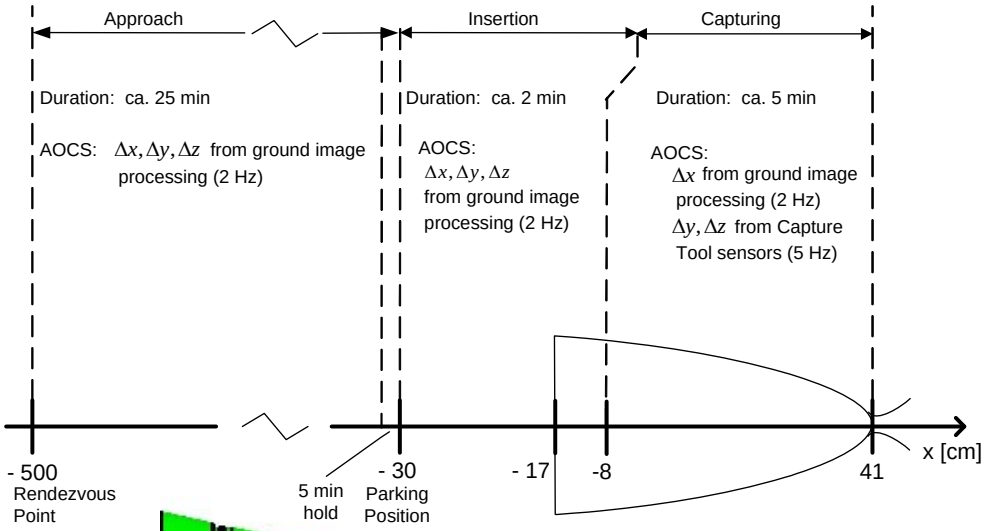
Now one crown size fits all existing (16 mm – 22mm) nozzle throats

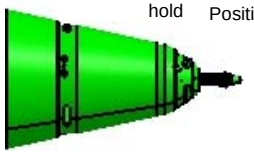


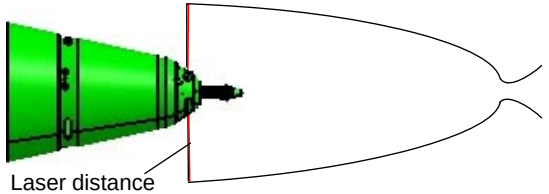
Rendezvous & Docking Maneuvers & Strategy

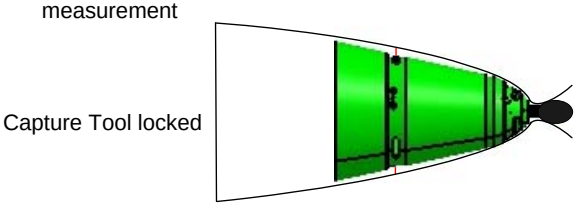




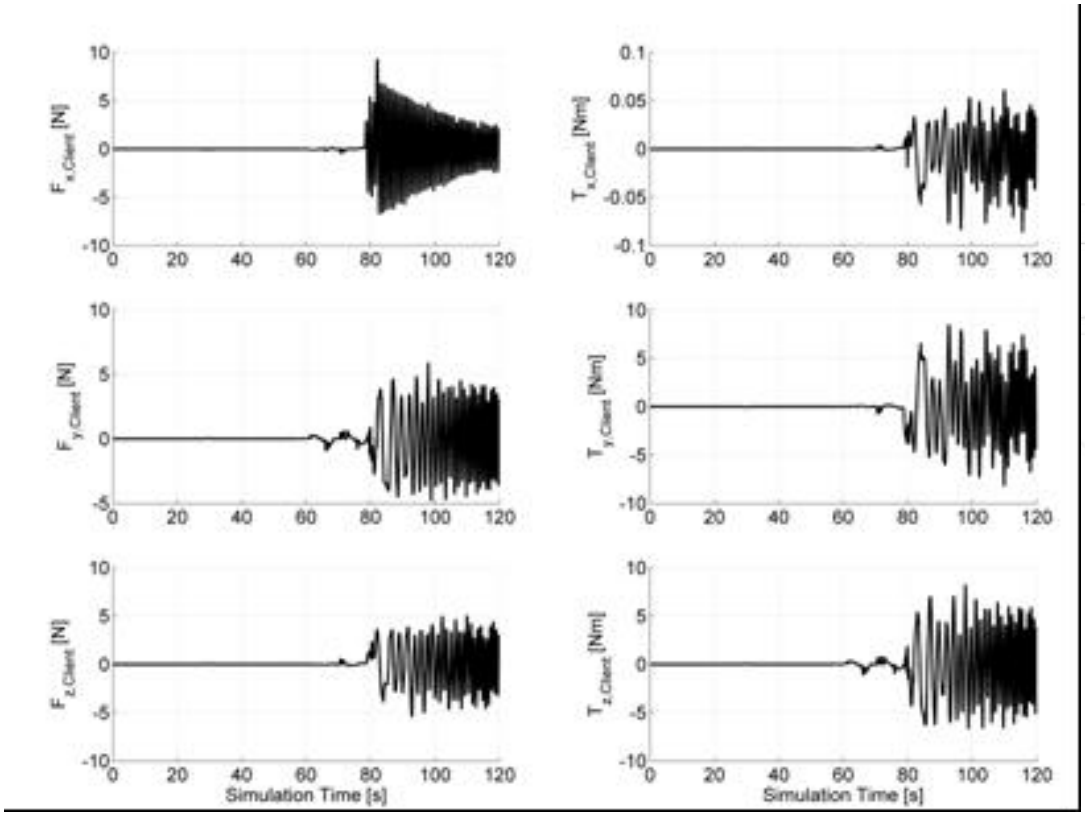


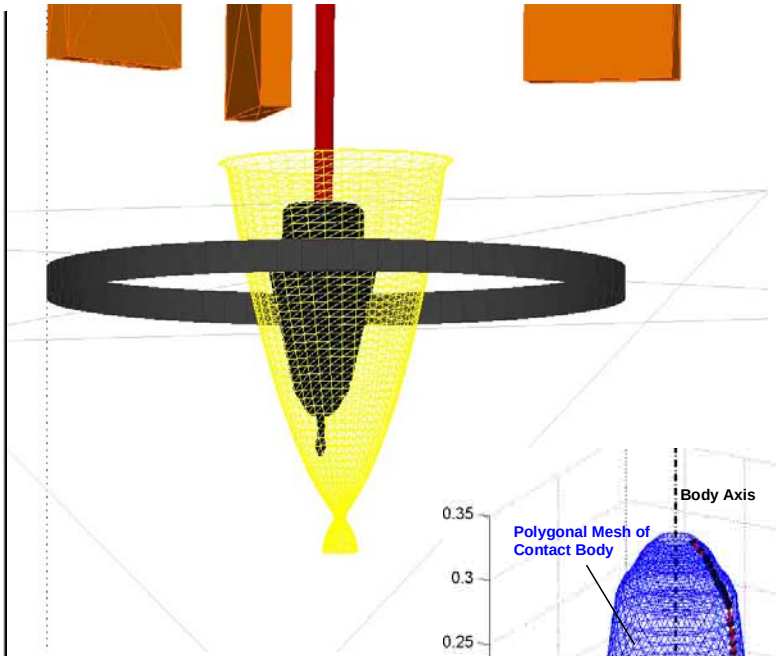


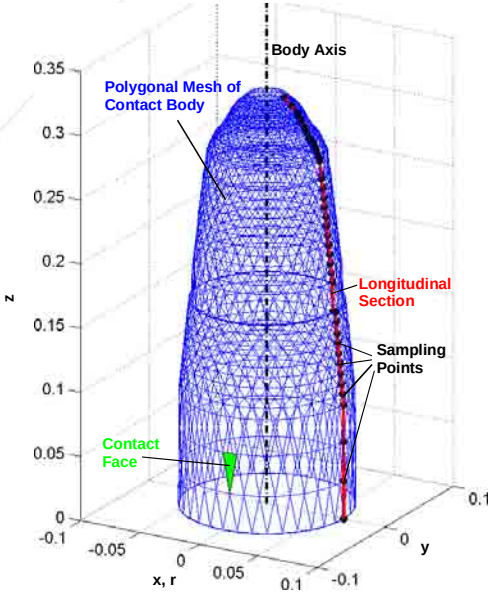




Capturing & Docking Simulation

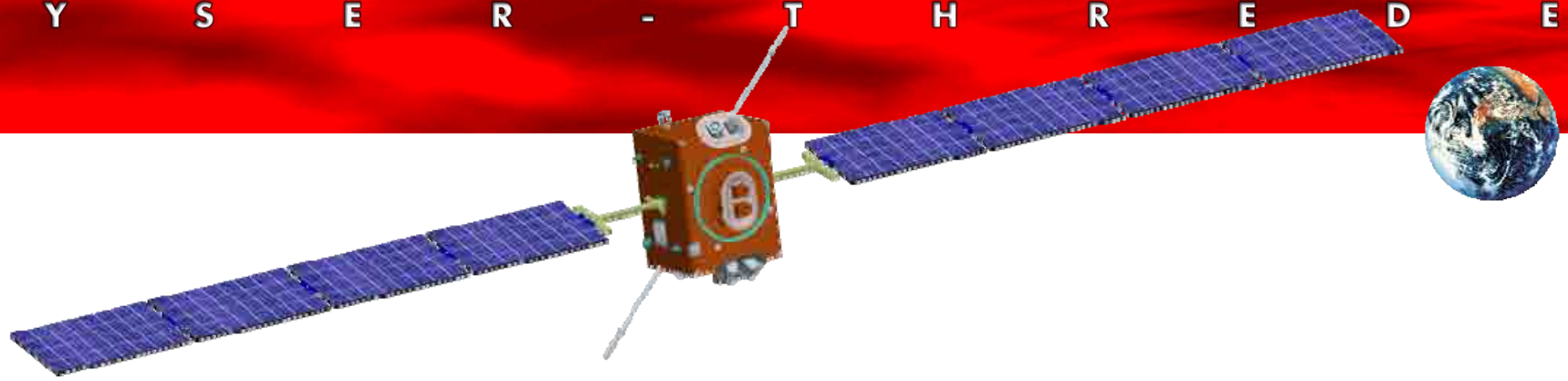






Docking simulations taking into account contact dynamics [RD02]:

- deployment speed is controlled as a function the CT position in the nozzle
- small contact forces during initial contact
- off-nominal cases analyzed showing capability to dock even under worst case conditions



Outlook

- A PDR and PDOR process has been successfully finalized in June 2008 together with the launching customer.
- The three industrial partners are close to finalize the selection of subcontractors.
- Start of Phase CD is scheduled for first quarter of 2009.
- Realization of first Mission using real client(s) within the frame of a commercial program with contribution of both national and the European Space Agencies by co-funding specific new technologies needed.
- Main part of the Non-Recurring Phase by private investments.
- Goal is to finalize all financing issues until end of 2008.

[RD01] C. Kaiser, F. Sjöberg, J,-M. del Cura, B. Eilertsen: SMART-OLEV – An Orbital Life Extension Vehicle for Servicing Commercial Spacecrafts in GEO, 58th IAF Congress, 24.-28. September 2007, Hyderabad, India, IAF-Paper IAC-07-D1.1.06

[RD02] C. Kaiser, P. Rank, R. Krenn, K. Landzettel: Simulation of the Docking Phase for the SMART-OLEV Satellite Servicing Mission, 9th International Symposium on Artificial Intelligence, Robotics and Automation in Space, February 25-29, 2008 Los Angeles