The Space Rider System key-role for a future cleaner and sustainable space environment

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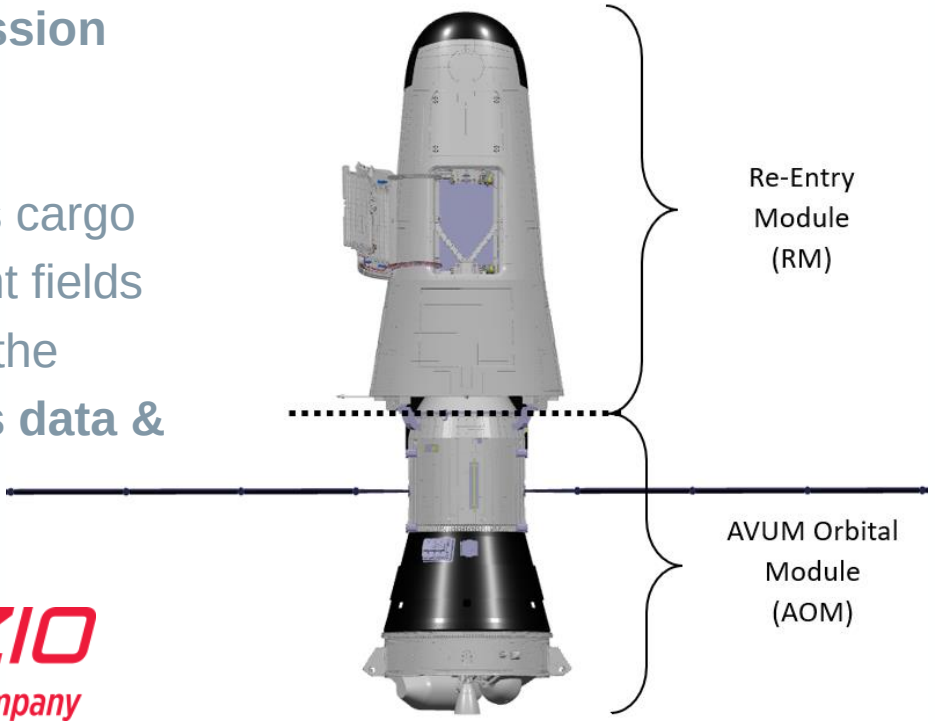
The Space Rider System (SRS)

The first European **affordable**, **independent**, **re-usable**, **uncrewed end-to-end commercial transportation system** for **routine access** to and **return** from LEO.

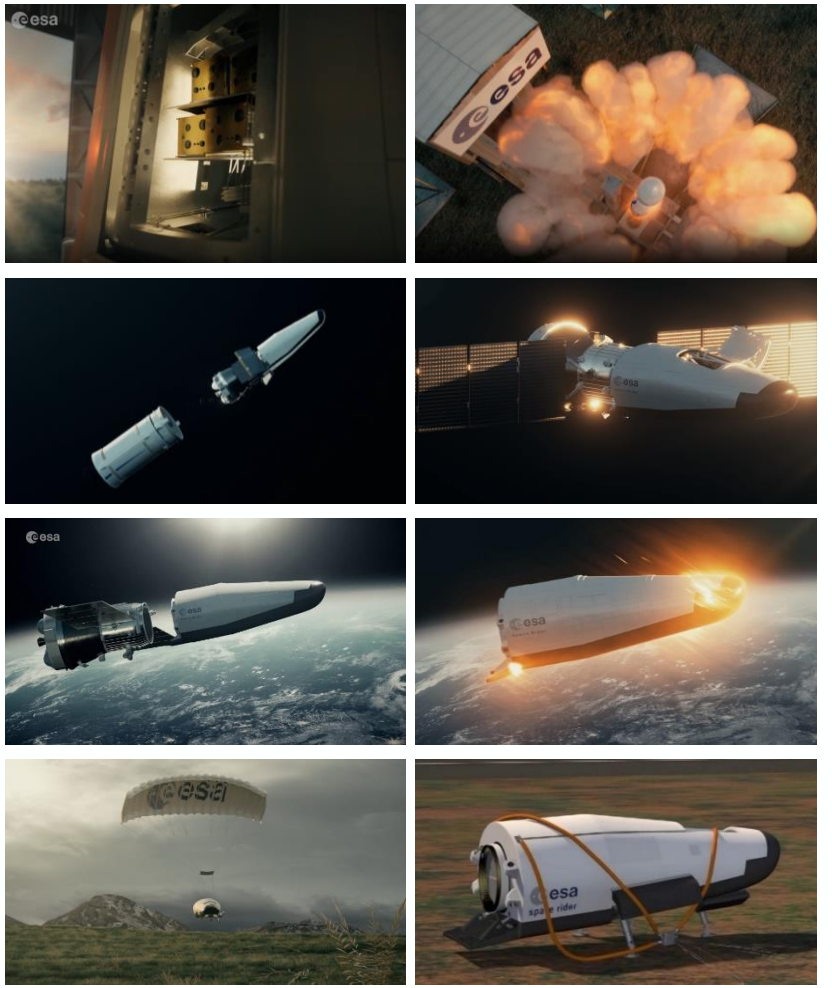
Space Rider (SR) vehicle: uncrewed robotic laboratory (part of SRS) composed by a **re-entry module** (**RM**) built by **TAS-I** (study co-author) and an **orbital module** (**AOM**) built by **AVIO**. Hosts P/Ls for an **array of applications**, **orbit altitudes** and **inclinations** (w.r.t. performance of the launcher), and **mission durations**.



In orbit for about **two months**, while **performing experiments** inside its cargo bay such as technology demonstration and research activities in different fields (e.g., pharmaceutics, biology, physical science, ...) communicating with the **Ground Segment** for **orbital vehicle control** (by **Telespazio**) and **P/Ls data & landing management** (by **ALTEC**).

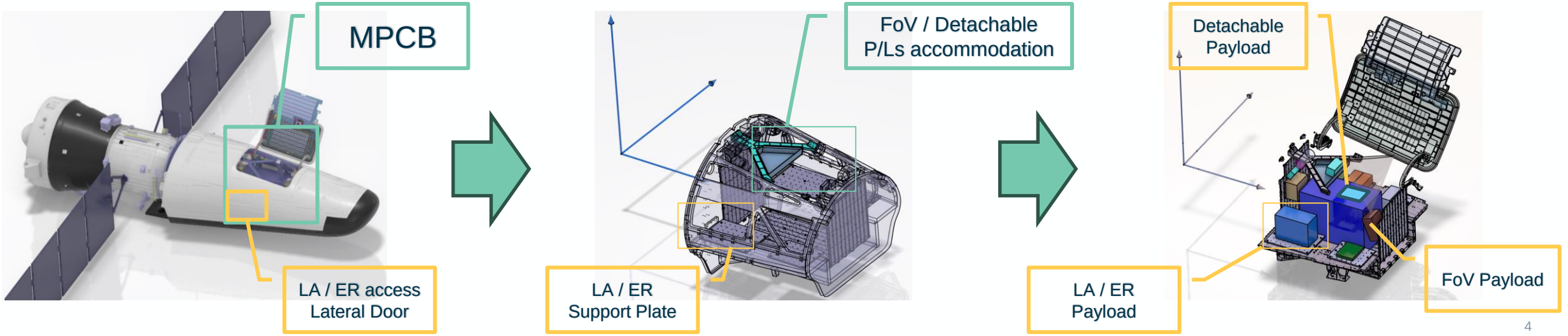
Space Rider – Mission ConOps

- **Pre-launch**: pre-integration and tests, transport to launch site final integration and tests, installation on launcher and transport to launch pad;
- **Launch and ascent**: launch vehicle mission, into near-circular orbit nominal inclinations (5-55º), extendable up to SSO;
- **Orbital flight:** payloads operations for a period of two months and more, each orbit lasting approximately 90 minutes;
- **De-orbiting**: reconfiguration of the Space Rider vehicle for deorbit, execution of the deorbit manoeuvre, separation of AOM and RM;
- **Re-entry and Landing**: AOM destruction and RM re-entry going from hypersonic to transonic flights till the deployment of a subsonic parachute at an altitude of 6-10 Km (M=0.2), followed by the triggering of a guided parafoil for a controlled descent till the landing site.
- **Post-Landing**: P/Ls retrieval, RM moved to refurbishment facilities;
- **Post-Flight**: RM inspection, analysis and refurbishment for next flight. The turn-over time is six-month. The RM is designed to perform 6 flights.



Space Rider – Multi Purpose Cargo Bay (MPCB)

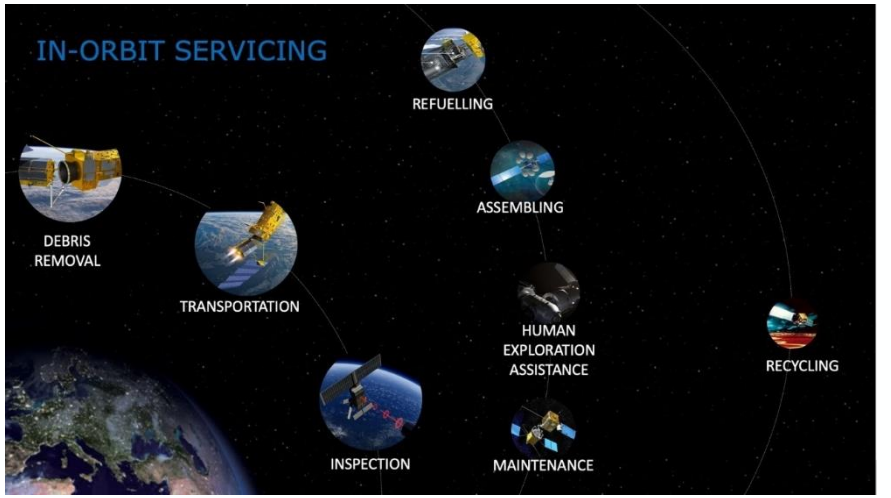
- Accommodation of **multiple P/L configurations**, **sealed** or **vented** P/Ls **directly** or **partially exposed** to space environment (e.g., direct illumination, FoV, …) **movable** or **detachable** (released from cargo-bay).
- Geometrical volume up to **1.2 m³**, up to **600 Kg** of P/Ls instruments mass.
- Equipped with **power** and **data lines** plus **7 payload Support Plates** (**SP**) which purposes are to be:
  - Mechanical standardized fixing interface between the P/L and the RM cold structure.
  - Thermal conductive path between the P/L and the RM Thermal Control System.
- **Late-Access** (**LA**) and **Early-Retrieval** (**ER**) for environmental sensitive P/Ls, integration and retrieval through RM lateral doors dedicated access to the outer face of P/Ls mounted on LA/ER MPCB support plates.



Space Rider – Current and Future capabilities

Baseline concept can be **extended** to serve as an **IOS / CPO platform** in addition to a **unique commercial exploitation medium**. SR can be eventually **equipped** to be and configured as:

- A **cooperative** & **prepared target** to be optionally **captured** by another S/C(s)
- A **chaser** able to **manoeuvre**, **reach** and **inspect / capture** a target S/C(s)



Space Rider IOS / CPO Present and Future Use Cases

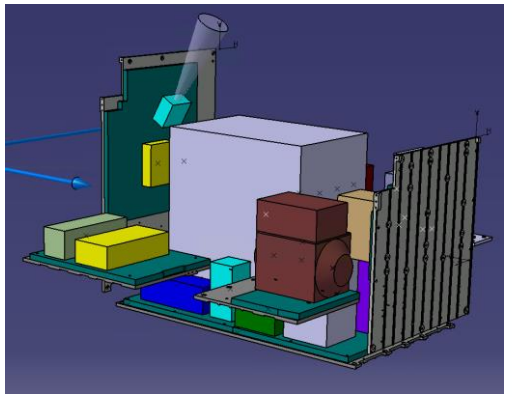
- **IOD/IOV of Enabling Technologies & Deploy (and Retrieval) of P/Ls**: P/Ls for IOD/IOV of re-entry and debris mitigation technologies and PLs able to be deployed (optionally retrieved) from cargo-bay. Deployable P/Ls with manoeuvrable capabilities can also perform retrieval and/or re-visitation tasks (e.g., **S-ROC**)
- **Rendez-vous, Docking / Berthing and Joint Operations**: acting as a cooperative & prepared target for rendez-vous, docking or berthing operations with dedicated robotic arm to perform tasks with other S/Cs (e.g., exchange of P/Ls, mission life extension, available services improvement, de-orbiting capability …).
- **Inspection, Refurbishment, Assembly and Manufacturing**: acting as a chaser performing inspection tasks using its manurable capability and dedicated robotic arm equipped with cameras or other effectors eventually used for refurbishment, assembly and or in-orbit manufacturing.

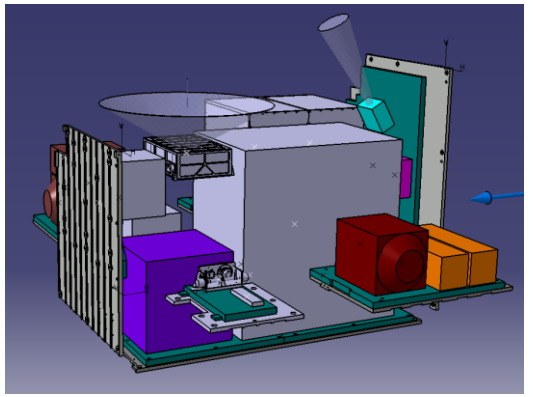
Maiden Flight – Payloads Aggregate Status

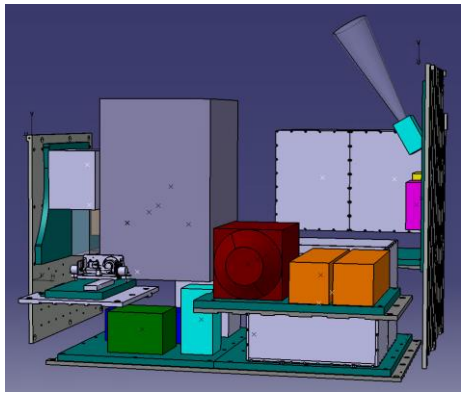
Space Rider **Payloads Aggregate** design for the **Maiden Flight** is currently **on going:**

- **18 Payloads** from both **commercial** and **institutional** customers are preliminarily on board, representing various typologies of experiments:
  - ✓ **Pharma/biotech micro-g R&D**
  - ✓ **Technology IOV/IOD**
  - ✓ **Physical science, remote sensing**
  - ✓ **In-orbit operation technologies and processes**

Alternative aggregate configurations for future flights are also under study



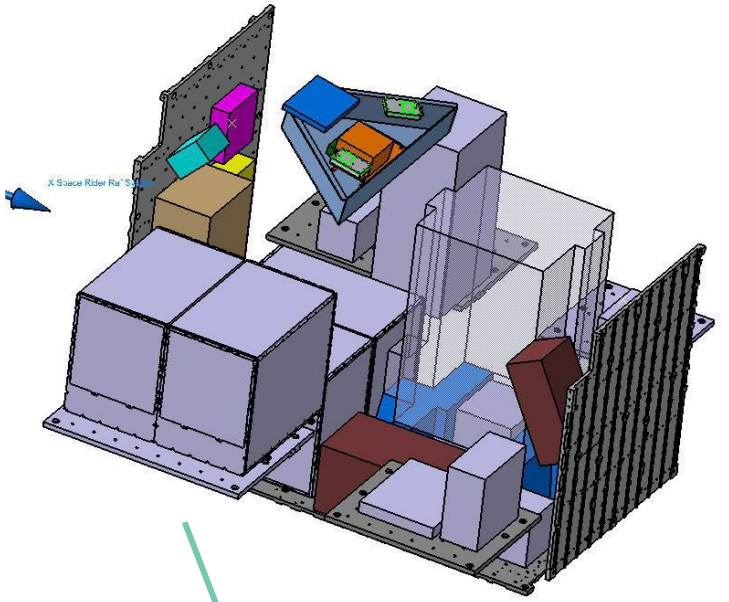




Current Capabilities – In Orbit Experimentation

The Payload Aggregate hosts P/Ls with innovative technologies under development to guarantee cleanliness of Space and effectively organize debris removal:

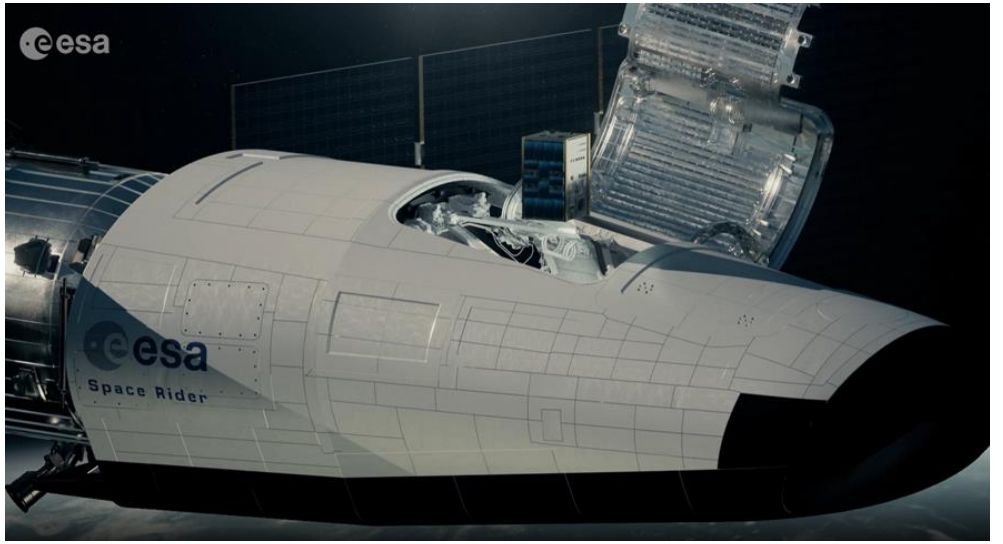
- **Radiation and outer space exposure**:
  - Experiments involving the **response of materials** to **LEO orbit environment**, such as materials for **drag sails**, **docking** and other activities, can be conducted to gain insights into their behavior in the ambient conditions and qualify their suitability.
- **Orbit tracking**:
  - Experiments for **orbit tracking**, **trajectory estimation**, and **calculations**, which are vital technologies for **debris removal** and **de-orbiting satellites**. These experiments aim to ensure **precise predictions of debris positions** and enhance clean-space activities..

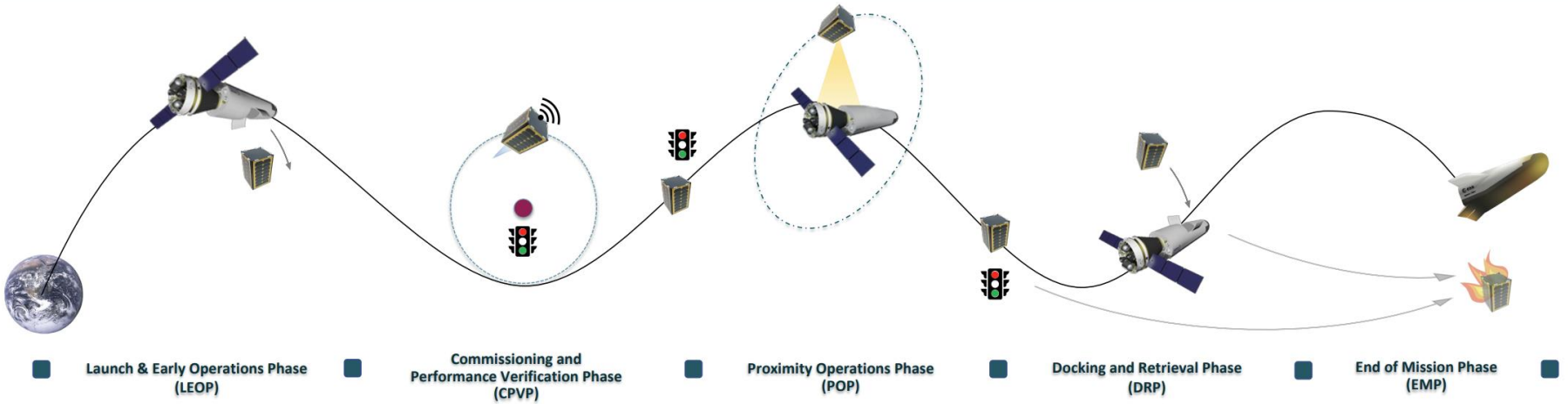


Radiation, outer space exposure and orbit tracking P/Ls have submitted proposal to flight with SR

Current Capabilities – Deploy (and Retrieval) of P/Ls

- The **Space Rider Observation Cube** (**SROC**) is an ESA technology demonstration mission.
- Based on a CubeSat deployed from Space Rider, it will be able to perform **inspection**, **rendezvous** and eventually **dock** with a **dedicated retrieval mechanism** hosted in the SR cargo-bay
- SROC will allow the development of **in-orbit demonstration** technologies and capabilities for **small-satellite proximity operations**, with a particular focus on **propulsion**, **GNC**, and **docking/retrieval mechanisms**

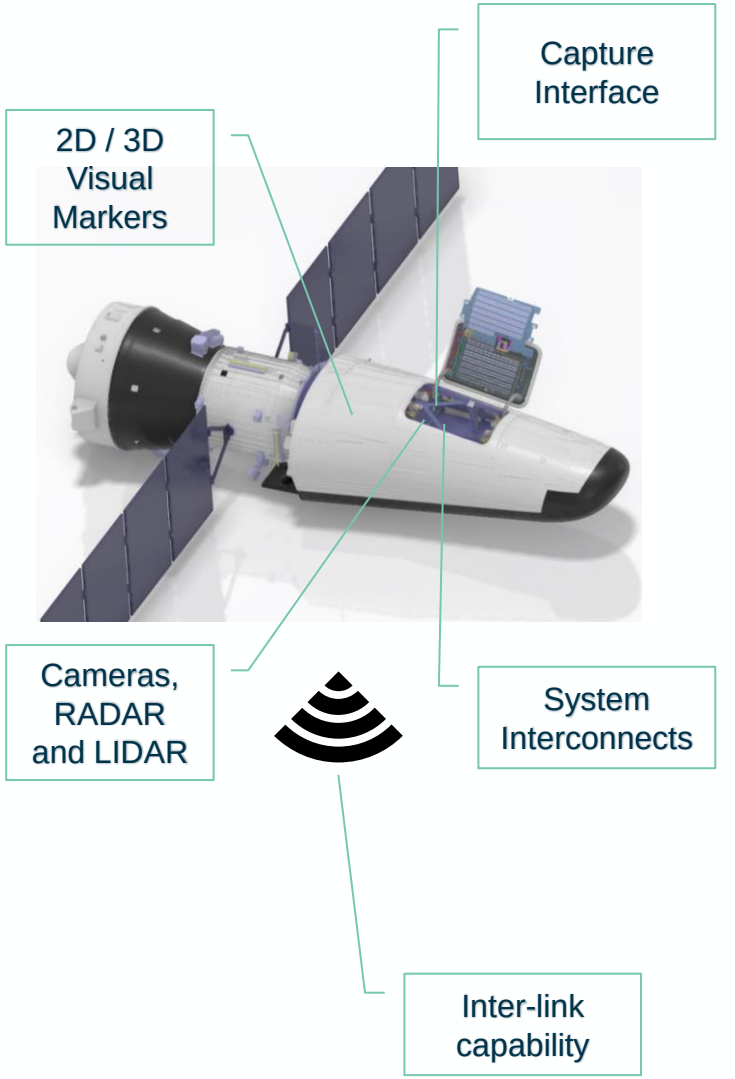




Future Capabilities – IOS / CPO Interfaces

An activity for the **identification** of the best solutions to equip SR with **physical interfaces** to support **future IOS / CPO use-cases** is ongoing, exploring the following aspects:

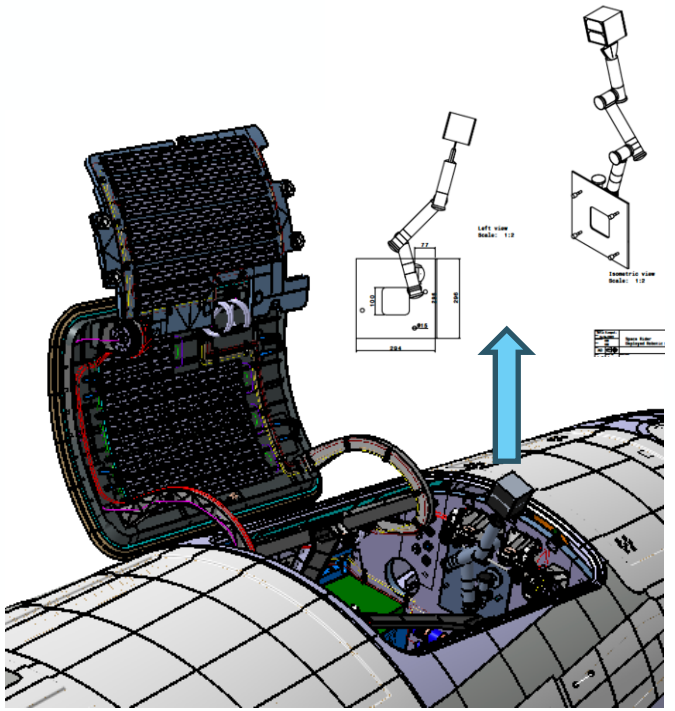
- **Visual Markers**: 2D/3D visual markers to support relative and close navigation during rendezvous up-to docking / berthing operations.
- **Cameras, RADAR, LIDAR**: high-resolution, low latency camera and/or RADAR/LIDAR sub-systems to provide Space Situation Awareness.
- **Mechanical Capture / Grappling Interfaces**: mechanical fixture to enable the SR capture by another S/C, sustaining the design loads, requires detailed multi-body analyses.
- **System Interconnects**: an advanced interface for exchanging power, data, and other services (e.g., fuels)
- **Standard-based Data and T&C Inter-link**: chaser / target inter-link for communication of vital T&C for CPO in a cooperative scenario (and related security aspects in additional cases) and GNC co-ordination.

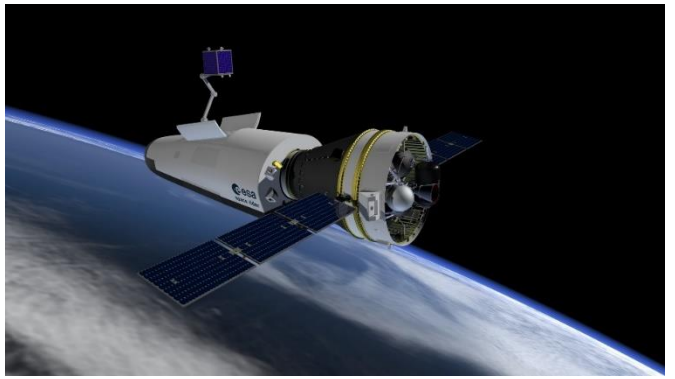


Future Capabilities – IOS / CPO Robotics

Ongoing studies with **robotic arm(s)** to **manipulate** P/Ls from / to or within the cargo-bay, perform **inspection** duties or other **handling operations**.

- SR as a platform for robotic technologies **research**, **development** and **TRL raising**. Key capability to **retrieve test data** and **HW** for post flight inspections.
- Development of **in-space complex operations**, interactive operations with Space Rider, **enhanced mission servicing** and **in-orbit operations**.
- Enable / enhance **small-sats retrieval** and **re-use**, satellites **orbital life extension**, **precision in-orbit placement** and **de-orbit capabilities**.
- Enhance in-space manufacturing via **on-board 3D printing and parts assembling.**

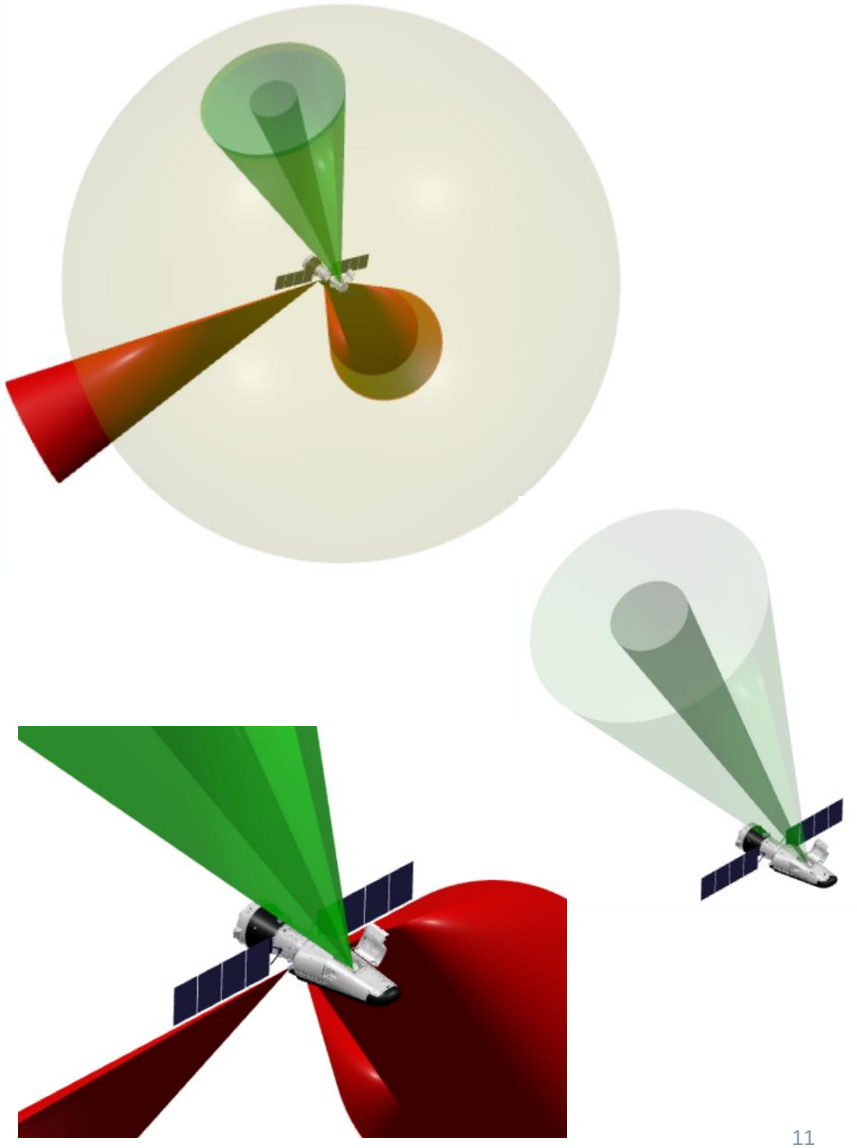




Future Capabilities – Operational Interfaces

Based on "ESA Guidelines on Safe Close Proximity Operations" we have defined the **design principles** and **best practices** to ensure **safe and sustainable** CPO activities with SR defining the **operational requirements** and **procedures** for **current** and **future use-cases**:

- Definition of SR vehicle **parameters** for a **reference CPO configuration** (i.e., passive cooperative and prepared target to ensure safe operation capability)
    - *Empty weight, balance sheet, variable weights, C.G. position and tensor of inertia, propulsion location, plume type and geometry potential proximity sensors and markers positions, mapping of potential sensitive areas or equipment (e.g., physical or other nature shading risk areas), …*
- In accordance with **safety requirements**, the **definition** of suitable system requirements for CPO activities with SR
    - *Preliminary definition of **Approach Zone** and **Keep-out Zone** around the vehicle, a proper **Approach Corridor(s)** to its cargo-bay, **forbidden zones** needed for vehicle attitude control (e.g., star-trackers FoV, …) etc.*



Final goal: Commercial Exploitation

- **ESA** is **committed** to **support** and **provide access to space** to **European research**, **development** and **commercial** entities;
- **Microgravity exposure capability** is **fundamental** for development and commercialisation of new products.
- Several **studies** are ongoing to **estimate** the **current and future IOD/IOV** and **IOS/CPO related markets** in **Europe** and **Worldwide**.
- Commercialisation **potential** and European **competitiveness** are the **focus area** for ESA which is mapping the value chain, European supply and world-wide demand with the final goal to promote international market access to SR project.

- SR is a **game-changer** in this emerging market thanks to service, flexibility, and potential short lead time response to customer needs.
- Microgravity market survey accumulated knowledge suggest forthcoming steep increase of market demand for experimentation and in-space manufacturing in LEO for pharmaceutical and bio-tech applications
- A new version (2.0) of the **Space Rider User Guide** is under release, to be used as the access point to be part of the SR journey!

Thanks for your attention and follow the Space Rider journey!

Interested in Space Rider? Please contact:

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