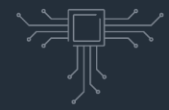
LEONARDO

Space Business Unit

# In Orbit Servicing

Robotic System


Electronics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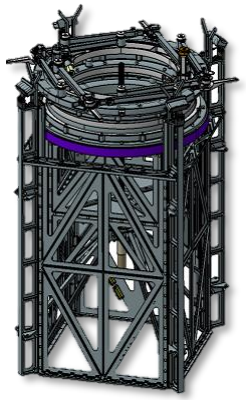
# IOS: Robotic system

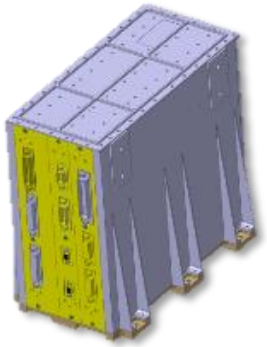
## IOS Robotic System Product Tree

**Robotic system (LDO)**

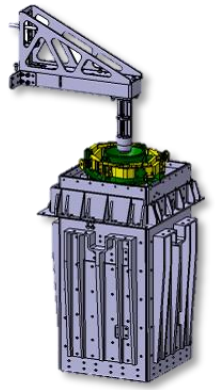
- Robotic Arm (LDO)
- Hard Berthing system (SAB-I)
- Robot Control Unit (LDO)
- Refueling Interface (LDO)

- → 7 robotic joints (LDO)
- → End Effector (SAB)
- → 3 HDRM (LDO)
- → 5 Servo Control Units (LDO)
- → Arm harness (LDO)





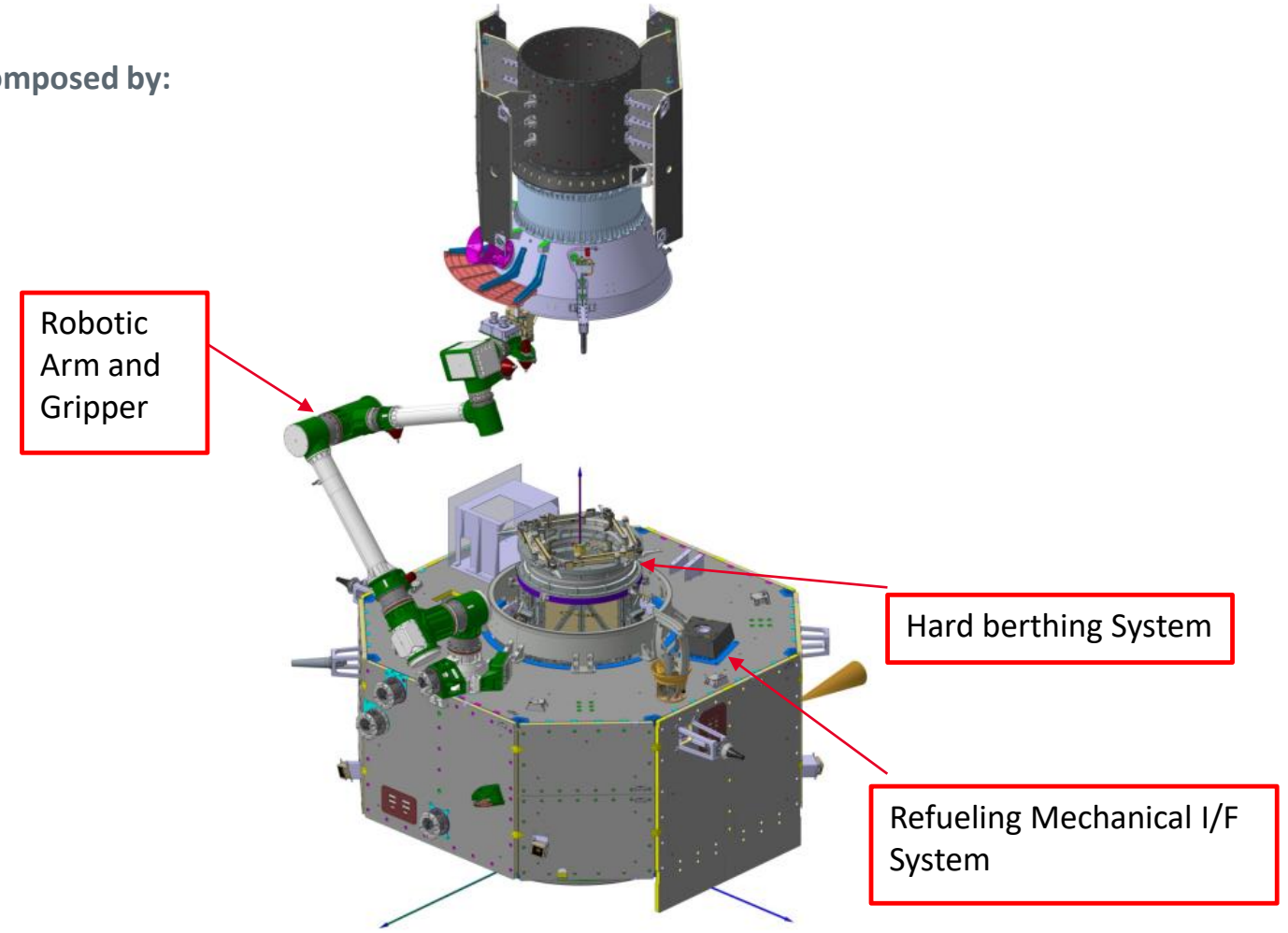
- → Power module
- → Actuator module
- → Robot Control module



# PNRR IOS – CAPTURE SYSTEM

- **Leonardo is developing an In Orbit Servicing Capture System, composed by:**
  - Robotic Arm and Gripper
  - Hard Berthing System
  - Refueling Mechanical Interface
  - Control Electronics

- **The main functions of the capture system are:**
  - Perform a soft capture on the Target's LAR, dissipating residual relative velocity
  - Move the Target towards the Servicer
  - Perform the Hard Berthing compensating misalignments, in order to fix the Target to the Servicer
  - Correctly engage the refueling mechanical interface

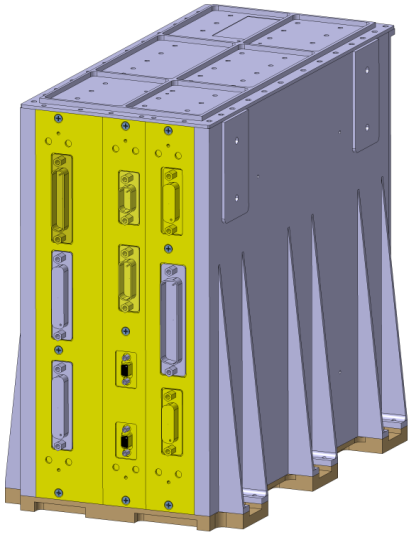


# IOS – RCU Architecture

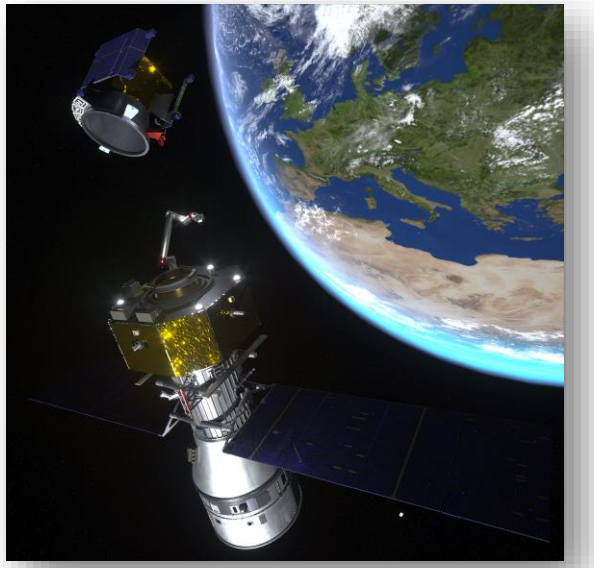
## RCU Overview

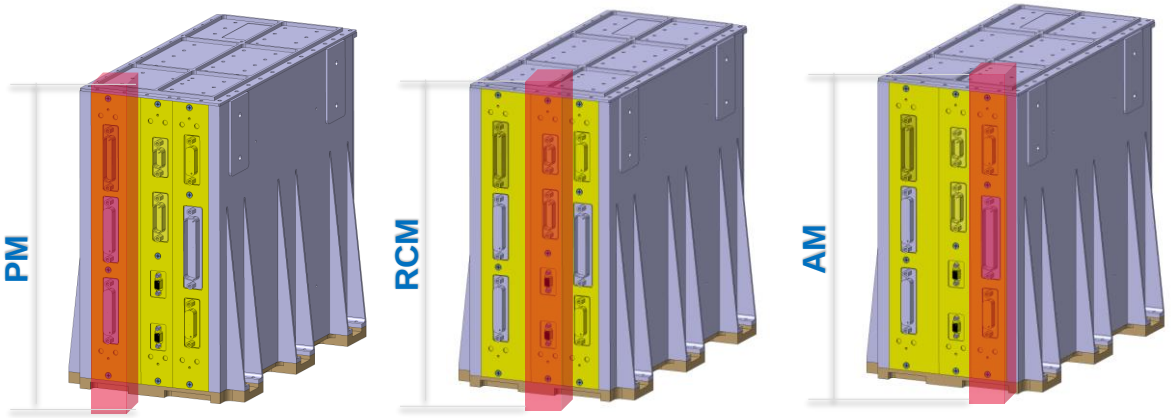
Robot Control Unit (RCU) key feature:

- **Max Dimension**: 300mm (H) x 300mm (W) x 300mm (L)
- **Platform Interface Function**:
  - electrical platform interface for both power and data
  - high level software: generation of low level set points of the arm and control of servicer mechanisms related to robotic system
  - thermal control of low level control electronics (5x Servo Control Units) distributed along the robotic arm. Main advantage is to decrease dramatically the complexity of ARM harness, reducing mass and cable stiffness.
- **Internal Function**: RCU function are deployed through its own internal module:
  - *1x Power Module – PM*: power distribution to IOS Robotic System and Sub-Units; HDRM actuation
  - *1x Robot Control Module – RCM*:
    - High-Level TC/TM from/to On-board Computer (OBC) via 1553B I/F
    - Low-Level Commands/Telemetries to/from SCUs via 2 isolated CAN bus 2.0B @1Mbps
    - Test Connector Interface (HW – Earth Operation)
  - *1x Actuator Module – AM*:
    - Sense and Actuation of Hard Berthing mechanism (2 DoF) and Refueling Interface
    - Thermal Control of Servo Control Units (SCU)



IOS - RCU



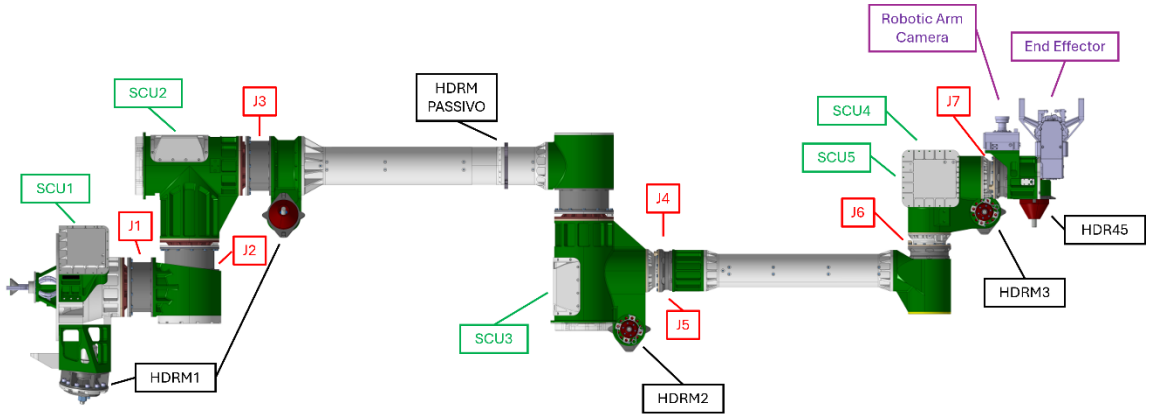


# PNRR IOS – ROBOTIC ARM

- **The main tasks of the Robotic Arm are:**
  - Catch the LAR of the target Spacecraft within GNC limits
  - Pull the target Spacecraft towards the hard berthing mechanism
  - Perform services on target Spacecraft

- **The characteristics of the arm are:**
  - Length of **2,6m** to comply with GNC performance
  - **7 DoF** configuration to be dexterous enough to cope with a variety of services actions
  - **Distributed electronics** with internal routing of harness, due to the length of the arm and the necessity to manipulate in environment with obstacles
  - Force / Impedance control is performed using torque sensors in the Joints

- **End effector:**
  - Placed at the tip of the arm
  - Performs the capture by closing its two fingers when the LAR is in the correct position
  - Optcial sensing for LAR presence detection

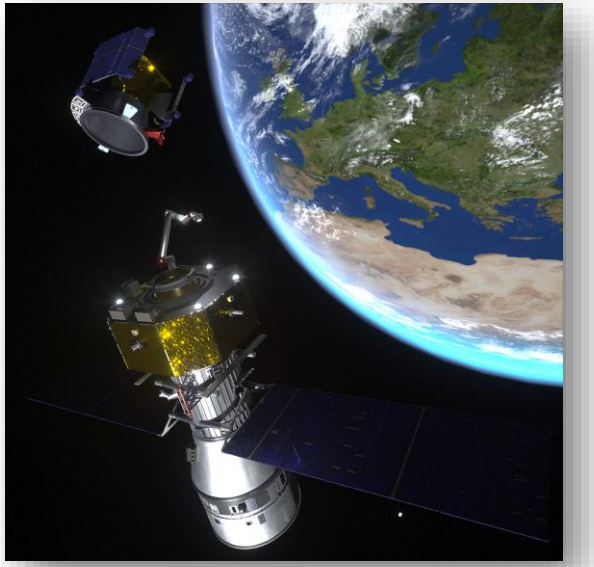



# IOS – SCU Architecture

## SCU Overview

Servo Control Unit (SCU) key feature:

- **Position**: installed into the IOS Robotic arm in order to implement the position/ speed/current control of Revolute Joints and End Effector (i.e., Gripper).
- **General Function**:
  - Actuate/sense/control the revolute joints of the IOS Robotic Arm. Specifically:
    - Each SCU commands 2x DoF, i.e., SCN
    - Each DoF is a joint or the End Effector.
  - Acquire and condition for each SCN driving a joiont/EE, i.e., 1x DoF the following sensor tipology: motor position sensor, actuator position sensor, force sensor, temperature sensor, photosensor (only for EE)
  - Themal Control of Joints;
  - ctivate the Safatey Chain: available to both DoF of each SCU (globally there will be 8x DoF);

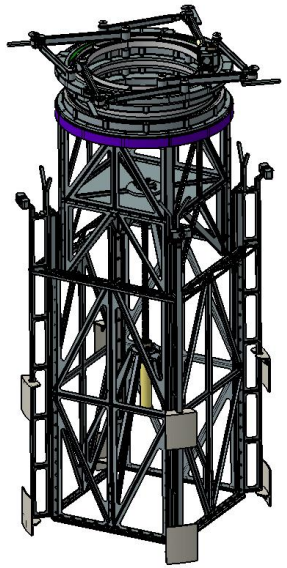


# IOS: Robotic system

## Hard berthing mechanism

- The Hard berthing mechanism has the objective of rigidizing the Target on the Servicer spacecraft

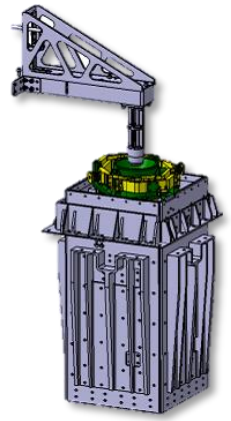
- It has two degrees of freedom:
  - It can extend vertically inside the launch adapter ring of the target
  - The arms can open locking the lunch adapter ring from inside
  - After the arms are fully locked, the Hard Berthing mechanism retract to finalize the rigidization of the two spacecraft



## Refuelling interface

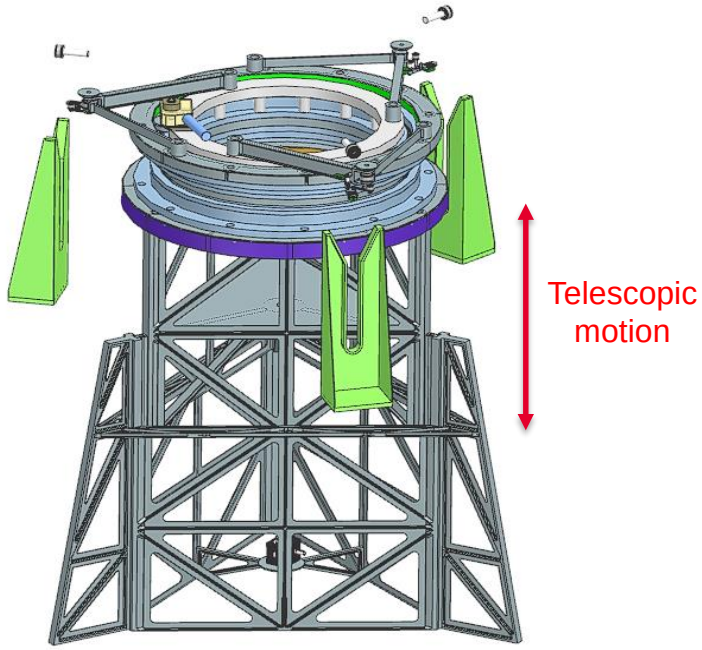
- The Refuelling interface is a mechanism that has the objective of acquiring a stable interface between the target and the launcher to allow liquid transfer between the two

- It has one dof that extends the interface and maintains a preload on the target's probe to avoid fluidic leaks

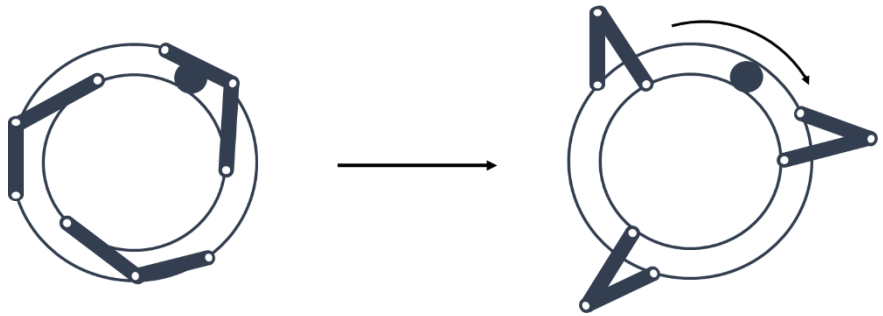


# PNRR IOS – HARD BERTHING

- **The main tasks of the Hard Berthing mechanism are:**
  - Compensate residual misalignments to guarantee a successful mating of the refueling interfaces
  - Establish rigid connection between the two spacecraft to sustain de-tumbling operations



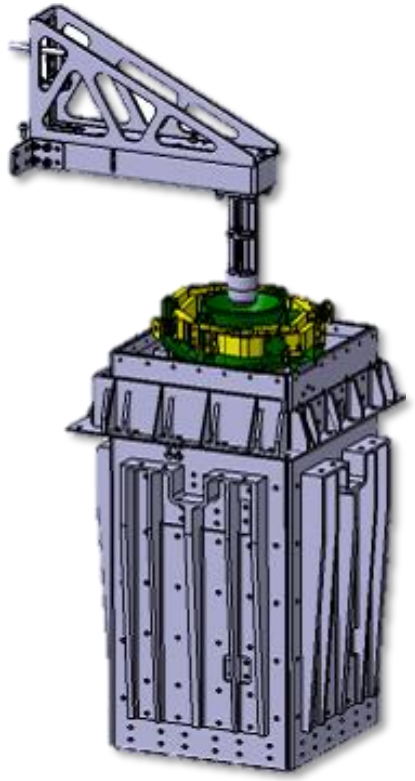

- **The mechanism has 2 degree of freedom**
  - Relative rotation between inner and outer wheel increases the diameter of the virtual circumference of the berthing mechanism → Allows different LAR sizes to be captured using only one degree of freedom (see figure on the right)
  - Vertical telescopic motion → Extract and retract the upper stage, preload in the stacked configuration
  - 1 additional passive dof: rotation of the upper stage to allow compliance in the mating phase



# PNRR IOS – REFUELING SYSTEM INTERFACE

- **The functions of the refueling interface are:**
  - Recover residual misalignment during mating
  - Maintain a sealed fluidic connection between the female part (target) and the male part (servicer)
  - Provide sensors that checks that the interface is ready to perform fluidic transfer

- **The main refueling operations are:**
  - **Passive alignment:** probe and cone are engaged and misalignment in the horizontal plane is compensated through the mechanical clearance of the hard berthing system
  - **Actuation and Refueling:** the probe is moved vertically to apply force to the contact surface and seal the two parts. The fluid transfer can be initiated at this point.
  - **Detachment:** The probe is retracted and the two interfaces are disengaged.



# PNRR IOS – CURRENT DEVELOPMENT STATUS

**Robotics System PDR completed in 2025.**

**Robotics Technologies (Arm, Mechanisms) Breadboard and Engineering Models manufactured and successfully.**

**Robotics Technologies (Arm, Mechanisms) EQMs under qualification campaign-**

**Robotics System CDR planned in September 2026.**

**Robotics System PFM DRB in 2027.**

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# THANK **YOU**
# FOR YOUR ATTENTION

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