H2020 OG7 - EROSS

OG7 EROSS Presentation at the PERASPERA 3rd Workshop – Brussels 02/04/2019
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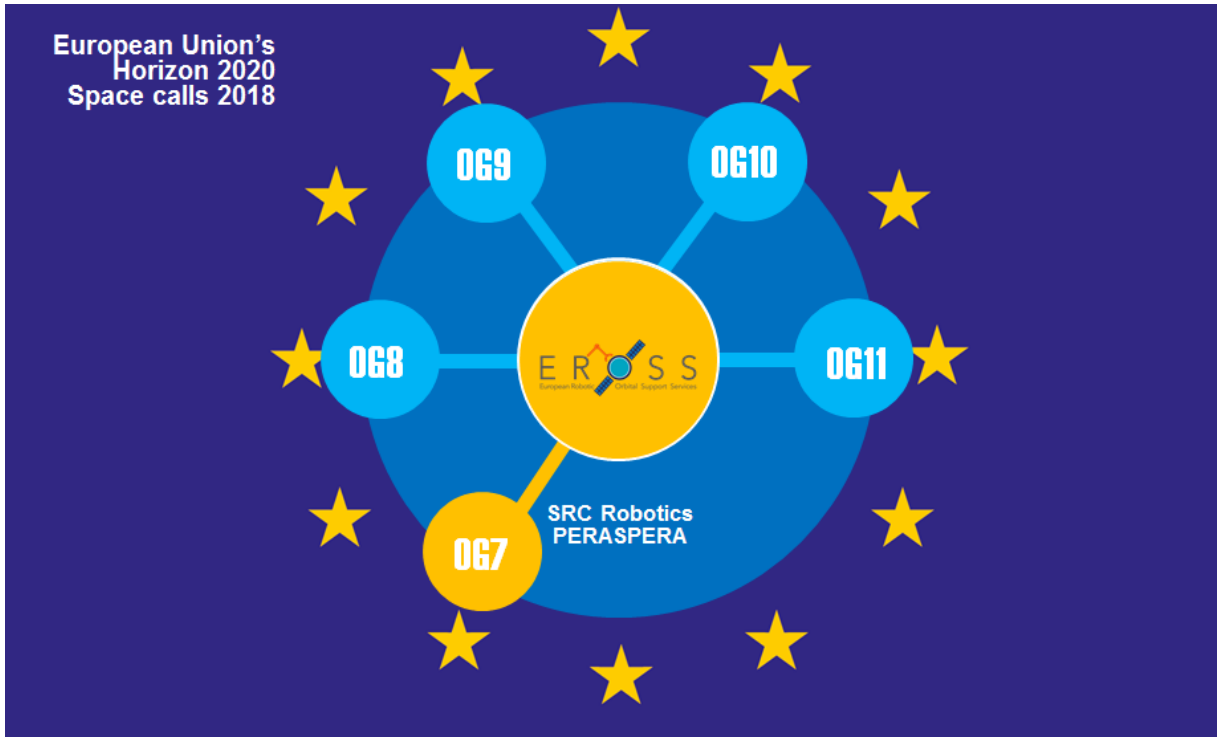
Outline

- General Presentation of EROSS
  - Context
  - Objectives
  - Outcomes
- EROSS Concept
  - Scenario
  - Design
- EROSS building blocks
  - Software and Hardware
  - Previous OGs building blocks
- Conclusion & Q&A

EROSS General presentation

- **EROSS objective is**
  - to demonstrate the European solutions for the Servicers and the Serviced LEO/GEO satellites
  - to enable a large range of efficient and safe orbital support services
  - to assess and demonstrate the capability of the on-orbit servicing spacecraft (chaser) to perform
    - rendezvous
    - capturing
    - grasping
    - berthing
    - manipulation of a collaborative client satellite (target) provisioned for servicing operations such as refuelling and payload transfer/replacement

- **EROSS is also the product maintainer of previous building blocks OG4 I3DS: Integrated 3D sensors.**



EROSS Consortium

- 10 complementary partners from 8 European Countries
  - 3 large industrials: THALES ALENIA SPACE,GMV,SENER
  - 1 large company: PIAP SPACE
  - 1 academics: NTUA
  - 2 SMEs: SAS & SODERN
- 2 companies as third parties:
  - MDA and QINETIQ Space

EROSS AIM

❑ Context : *Orbital Servicing for Life Extension*

- **Lifetime & Cost :** expensive systems looking for profitability
- **Green Space** : reduce space debris impact
- **Modular Systems** : in-orbit assembly of large structures
- **Samples return :** scientific challenges with RDV & Capture

❑ Technologies Trends

- **Genericity** : standard platforms / elements for modularity
- **Interfaces standardization** : CBM, IBDM, SIROM…
- **Processors capability :** new generations of processors to embed on board guidance or image processing algorithm
- **Guidance, Navigation & Control (GNC)** : advanced functions for rendezvous and relative navigation beyond traditional Attitude & Orbit Control System (AOCS)
- **Sensors/Actuators compactness :** for handling and storage on the servicer platform

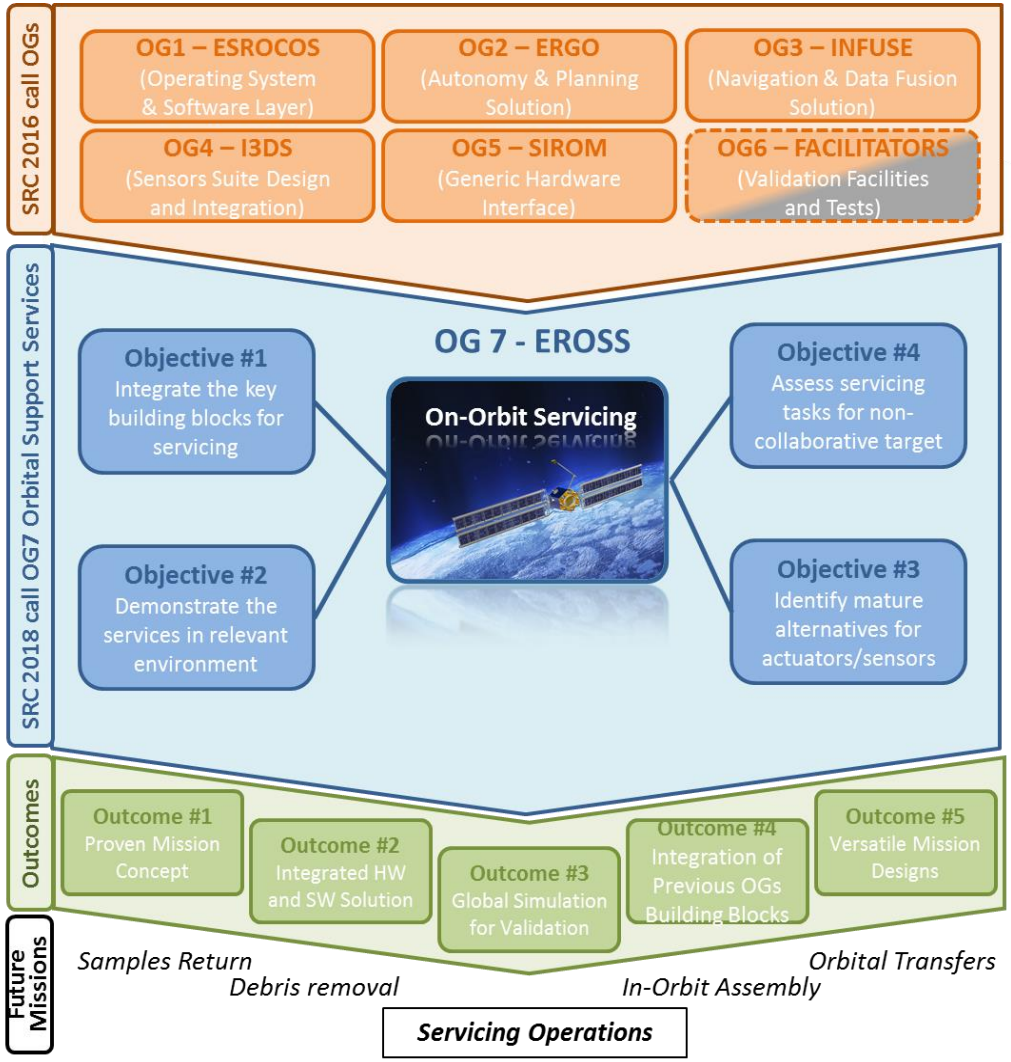
❑ EROSS Use-Case

- **Servicer equipped with a "*robotic servicing payload*"**
- **Target designed to be serviced**
- **RDV & Capture of the cooperative (=stable) target**
- **Servicing tasks once captured**

EROSS General presentation

- The European Robotic Orbital Support Services (EROSS) study will develop and demonstrate key robotic building blocks for the benefits of many future space missions:
  - LEO satellites / constellations
  - GEO satellites
  - Interplanetary science
  - Space station operations
  - Servicers/SpaceStart

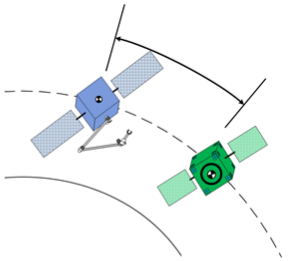
EROSS Objectives & Outcomes



EROSS General presentation

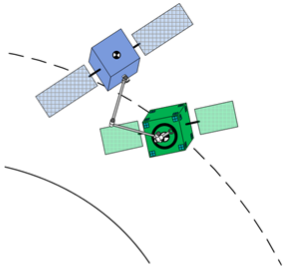
- **Through EROSS, the complete robotic chain will gain in maturity:**
  - **The robotic computing system**
  - **The robotic sensors**
  - **The robotic actuators**
  - **The GNC algorithmic chain**
    - **Relative & Absolute Navigation**
    - **Guidance**
      - Long-range guidance
      - Inspection
      - Proximity operations
    - **Control**
      - Local & composite control
      - Multi-DoF & flexible structures
  - **The development framework, EGSE & test labs**

EROSS Mission scenario



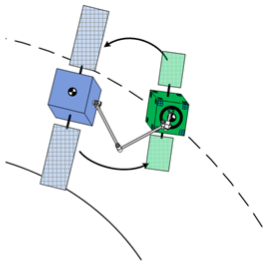
1. Forced Motion (100-50m)

- Tracking of target within sensors FoV
- Target dynamics estimation
- Trajectory planning for capture
- Arm deployment & capture planning
- Collision avoidance & Escape manoeuver



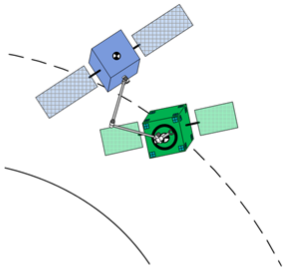
2. Capture (<5m)

- Tracking of target & visual markers
- Platform trajectory to reach station keeping
- Coordination of arm trajectory to track visual markers and grasp grapples fixtures
- Collision avoidance & Escape manoeuver



3. Stabilisation (~2-3m)

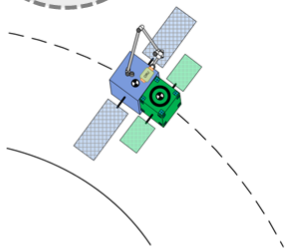
- Servicer platform stabilisation to dampen the composite angular momentum
- Coordination of arm trajectory to absorb momentum from target with platform act.
- Arm obstacle avoidance



6 . Release (~2-3m)

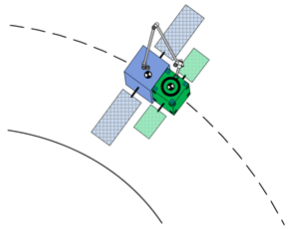
(inverse phase of docking+ capture)

- Robotic grasping of target's grapple fixtures
- Release of mating interface
- Robotic motion for chaser/target spacing
- Target release
- Chaser passive exit (drift)



5. Servicing (contact)

- Servicing operations:
  - Refuelling through ASSIST
  - Transfer of ORU with SIROM
  - Data transfer through SIROM
  - Data transfer through SIROM
  - Upgrade of OBSW through SIROM
- Fixed-base robotic motion planning/control
- Attitude control of the composite for Earth pointing & data transfer on ground



4. Docking (contact)

- Motion of composite system
- Alignment of chaser/target docking system
- Latching & locking of mating interface
- Arm release
- Arm obstacle avoidance

Servicing mission and operational lifecycle for EROSS

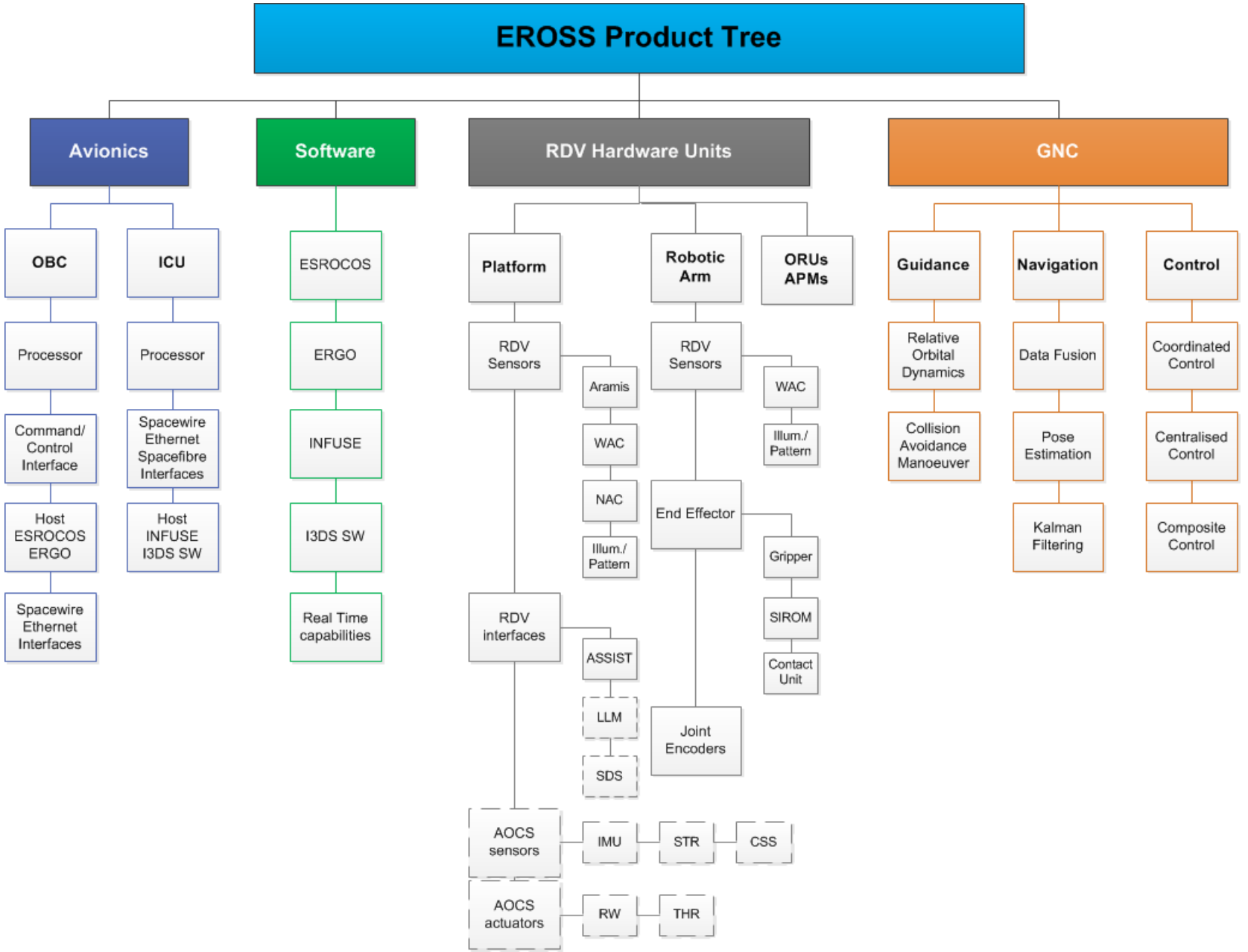
Mission scenario baseline for validation

❑ Mission Design : System-level process (V cycle)

- **Mission Goal :** Refuelling, Software update and payload exchange
- **Mission Profile :** Final rendezvous and capture(forced motion)
- **Vehicle Architecture :** System design of critical functions & related subsystems for both vehicle**S**
  (chaser & target for a collaborative rendezvous)

- ***Development of system design and simulator for both the real mission and the demonstration***

Semi-cooperative servicing -- Validation Baseline --
MISSION : RdV & Capture of a known and designed target
CHASER DESIGN : coordinated platform & arm motion
ARM : Medium-size robotic arm (reach ~4-5m)
INTERFACES : Berthing by gripper + Docking ASSIST interface (Male)
TARGET DESIGN : for capture with visual markers, & for servicing with refuelling interface *=> Passive target : rotation and translational drift*
INTERFACES : Launch Adapter Ring (or grapple fixture) + ASSIST (Female)
MODULE : 1x module with SIROM interface


EROSS Product Tree
Avionics
Software
RDV Hardware Units
GNC
OBC
ICU
ESROCOS
Platform
Robotic Arm
ORUs APMs
Guidance
Navigation
Control
Processor
Processor
ERGO
RDV Sensors
RDV Sensors
Relative Orbital Dynamics
Data Fusion
Coordinated Control
Command/ Control Interface
Spacewire Ethernet Spacefibre Interfaces
INFUSE
Aramis
WAC
WAC
Illum./ Pattern
Collision Avoidance Manoeuver
Pose Estimation
Centralised Control
Host ESROCOS ERGO
Host INFUSE I3DS SW
I3DS SW
WAC
NAC
End Effector
Illum./ Pattern
Kalman Filtering
Composite Control
Spacewire Ethernet Interfaces
Real Time capabilities
Illum./ Pattern
Gripper
RDV interfaces
SIROM
ASSIST
Contact Unit
LLM
Joint Encoders
SDS
AOCS sensors
IMU
STR
CSS
AOCS actuators
RW
THR

EROSS re-use of the previous building blocks

- Reuse of OG1-ESROCOS with its specific tools: for design, deployment and validation of the Robot Control Operating System (RCOS) and with RCOS Development Environment (RDEV);
- Reuse of OG2-ERGO through an architecture with two main components: an executive layer (ERGO Agent) for implementing the control loops with a functional layer to perform the actions for goals setup & observations requests;
- Reuse of OG3-INFUSE for the navigation solution: by using the data products developed for target detection and 3D pose estimation;

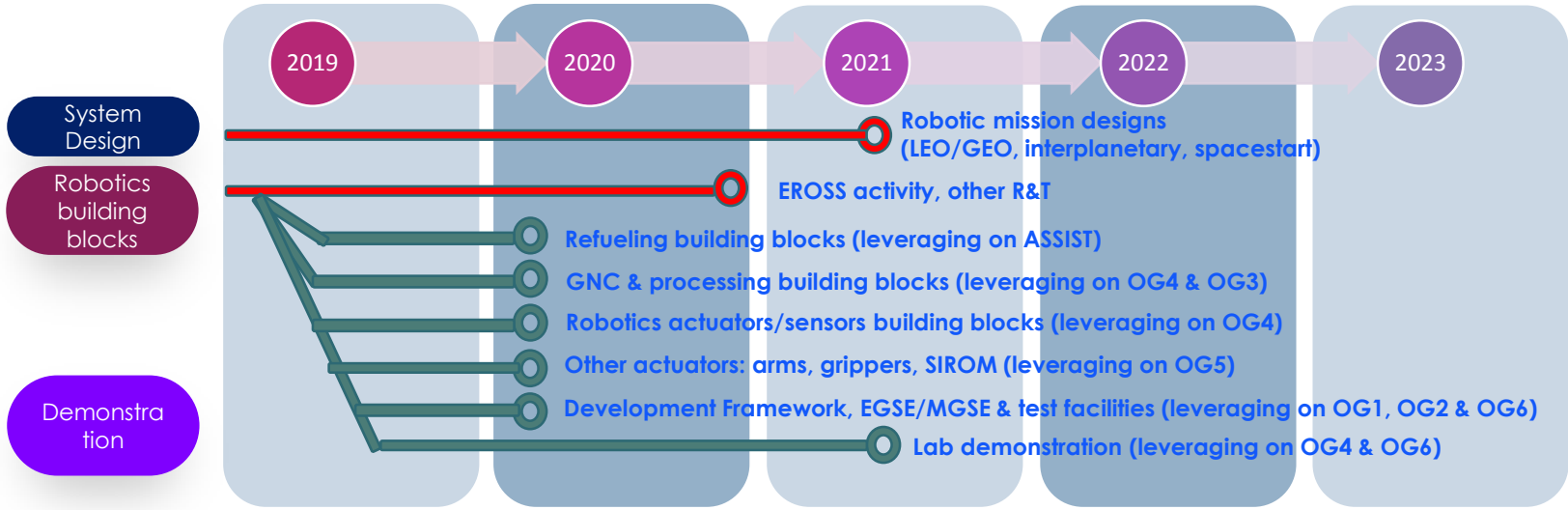
- Reuse of OG4-I3DS for the relative sensors suite: by integrating the relative 3D sensors, their hardware interface and their software solution on the OSS platform;
- Reuse of OG5-SIROM for the unit interfaces: the multi-purpose interface developed by OG5 is reused to ensure the mechanical, data and power links between the ORU elements, and between one ORU and the platform.

Conclusion

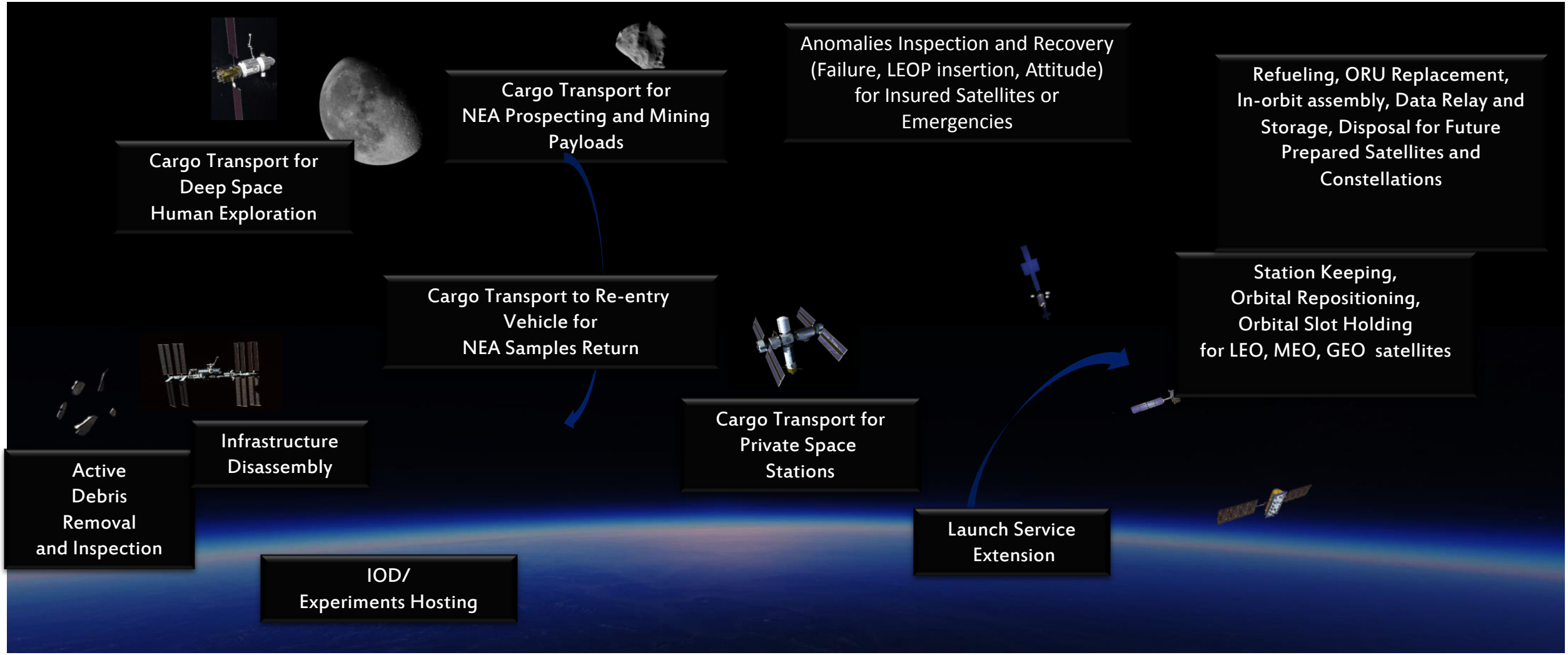
❑ EROSS leverages on many developments to enable a challenging project

- Demonstrate cooperative servicing in representative environment
  - Berthing &Docking &Latching
  - Refueling
  - Payload exchange
- Assess non-cooperative servicing

- Identify mature solutions for actuators/sensors to answer to variability in robotics designs per mission scenarios
- Synchronize with other OGs
- Be on-time with business & in-orbit demonstration opportunities



Future Servicers potential Market enabled by



Any questions ?

Thank you !