FUTURE RENDEZVOUS & ON-ORBIT SERVICING MISSIONS BY AUTONOMOUS GNC & VISION-BASED NAVIGATION

CLEAN SPACE INDUSTRY DAYS
ESTEC (NOORDWIJK, NL)
10-14/10/2022

Pierre Dandré, Thales Alenia Space in France

ThalesAlenia Space
a Thales / Leonardo company

Date: 07/06/2022
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AGENDA

/// Overview of key technologies and avionics architectures developed by **Thales Alenia Space**

/// Two main milestones presented (among many others!):

- Horizon 2020 OG7 | EROSS (2019-2021)
- Horizon 2020 OG12 | EROSS+ (2021-2023)

/// One major program to come

- Horizon Europe | EROSS In-Orbit Demonstration Flight 2026

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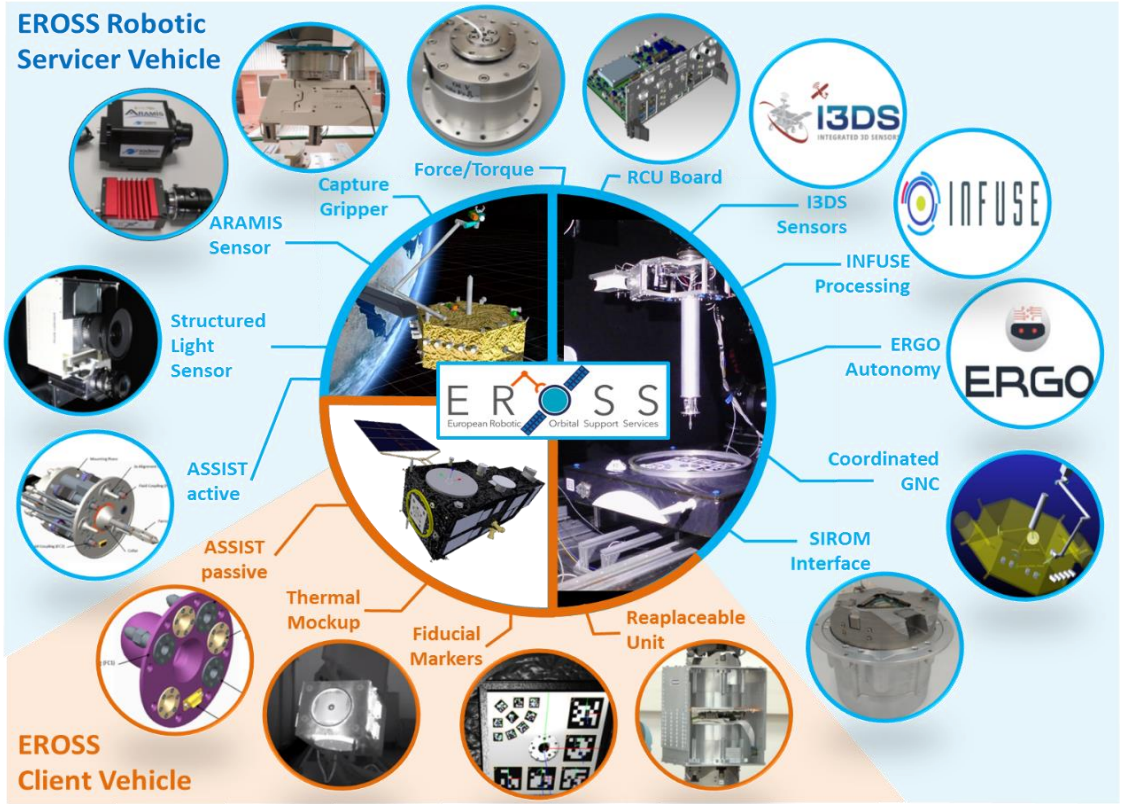
H2020 OG07 – EROSS

(EUROPEAN ROBOTIC ORBITAL SUPPORT SERVICES)

2019 – 2021

GROUND DEMONSTRATIONS OF GNC & ROBOTICS TECHNOLOGIES TOWARDS RENDEZVOUS AND ON-ORBIT SERVICING MISSIONS – VISION-BASED NAVIGATION OVERVIEW

« EROSS in a nutshell »



❑ EROSS "ID Card"

- **Context:** H2020 - European Commission
- **Prime:** Thales Alenia Space France
- **Partners:** GMV, SINTEF, NTUA, PIAP, SENER, SODERN, SAS
- **Budget:** 4 M€
- **Topic:** Robotic technologies for On-Orbit Servicing

❑ EROSS Main Achievements

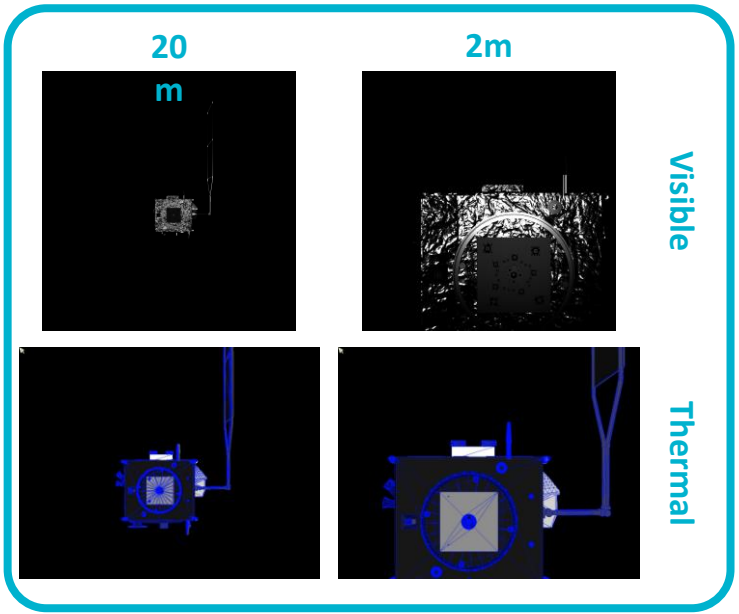
1. TRL raising of the key robotic building blocks (BB)
2. Building Blocks Integration in a System Demonstrator
3. Coordinated robotic GNC architecture of Platform/Arm
4. Autonomy raised to E3 level for safety
5. **Closed-Loop demonstration of performance & autonomy with Vision-based Navigation** *(incl. contingency)*

EROSS vision-based navigation

❑ "Vision-based Navigation" = Image Processing + Navigation Filter

- **Development Phase**
  - **STEP A.1 : Set up Image Generation tool**
    => **SPICAM** by Thales Alenia Space
    => Visible & Thermal images
  - STEP A.2 : Processing design & tuning
    => INFUSE solution by Space Applications Services
    => ARAMIS solution by SODERN
  - STEP A.3 : Delay & Noise model equivalence in open loop
  - STEP A.4 : Navigation Filter and Controller design & tuning

- **Validation Phase**
  - STEP B.1 : [MIL] Numerical validation in closed-loop
  - STEP B.2 : [SIL] Image Processing comparison with noise model
  - STEP B.3 : [PIL] Image Processing code deployment on RCU
  - STEP B.4a : [HIL] OL Validation with Processing & Cameras
  - STEP B.4b : [HIL] CL Validation with Guidance-Navigation-Control loop



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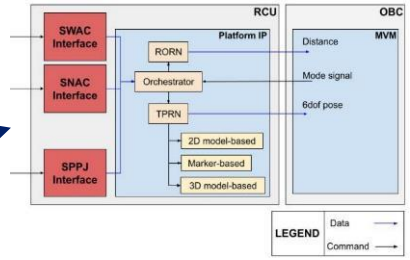

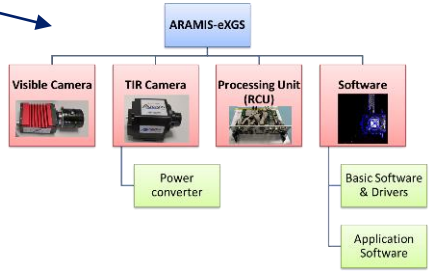

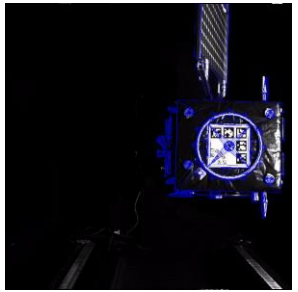

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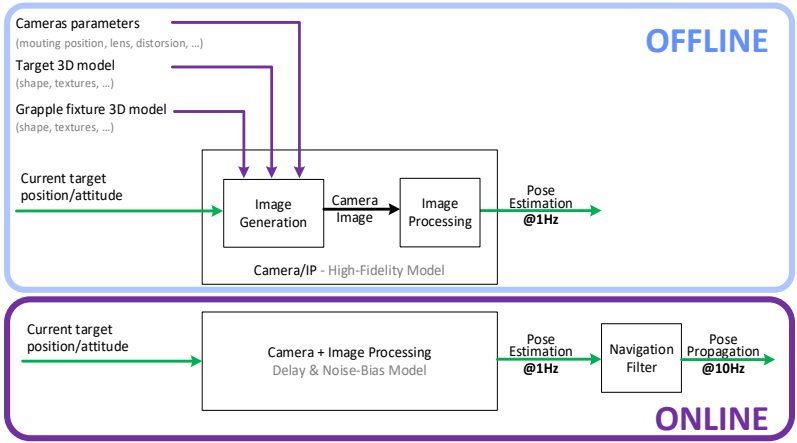

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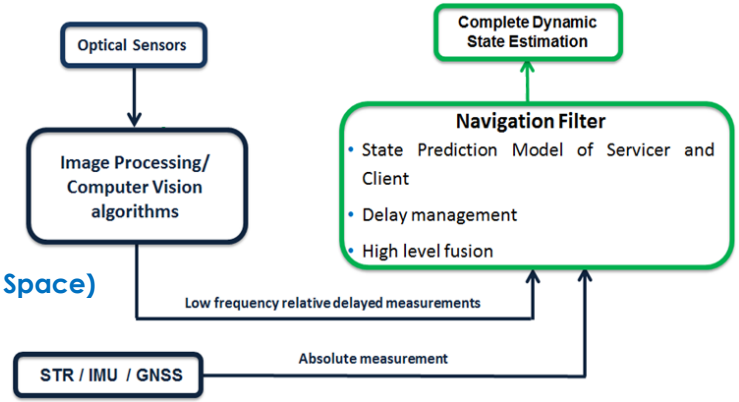

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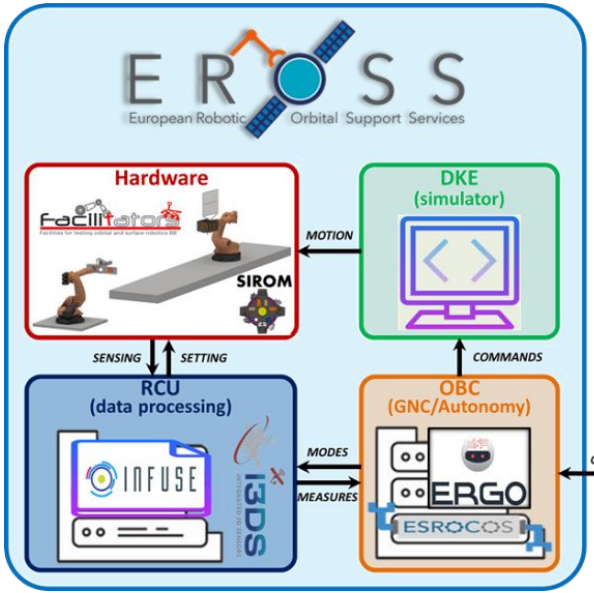
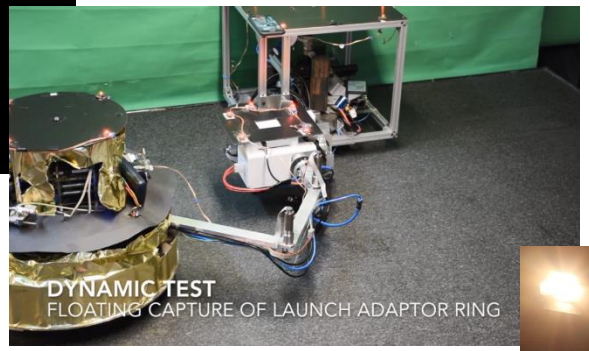


OG = "Operational Grant" = *Consortiums of past H2020 projects*

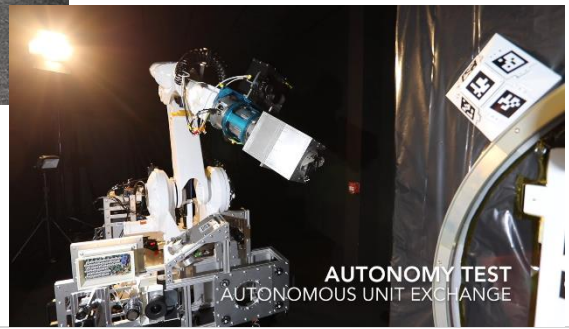
EROSS experimental demos

Approach and Rendezvous by GNC
& Vision-Based Navigation Validation
[Platform-Art, @GMV, April 2021]



Robotic Capture by Coordinated
Platform/Robot Controller Validation
[SRE bench, @NTUA, May 2021]

Orbital Unit Exchange
by Autonomous Task Planning
[ROBY bench, @TASF, June 2021]



H2020 OG12 – EROSS+

(EUROPEAN ROBOTIC ORBITAL SUPPORT SERVICES)

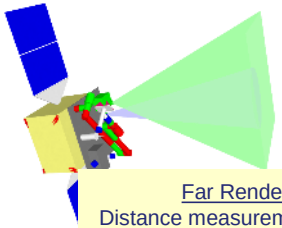
2021 – JAN 2023

PHASE A/B1 TOWARDS AN IN-ORBIT DEMONSTRATION OF KEY RENDEZVOUS AND ROBOTIC TECHNOLOGIES FOR ON-ORBIT SERVICES

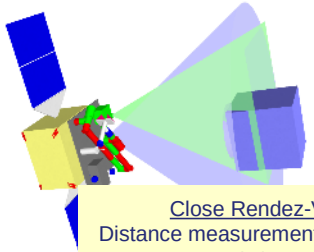
EROSS+ MISSION DESCRIPTION

https://intranet.peopleonline.corp.thales/news/article/index.cfm?nid=965517

Rendez-Vous

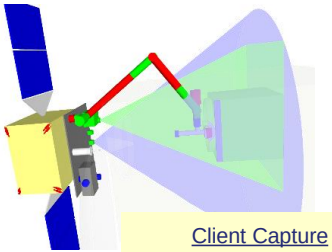


Far Rendez-Vous
Distance measurement monitoring
NAC Camera
Arm Stowed

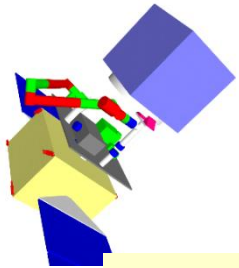


Close Rendez-Vous
Distance measurement monitoring
WAC Camera
Arm Stowed

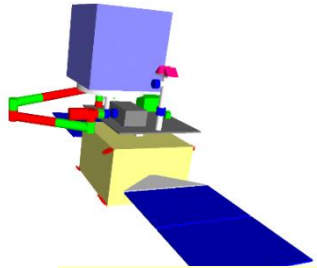
Servicing of Client



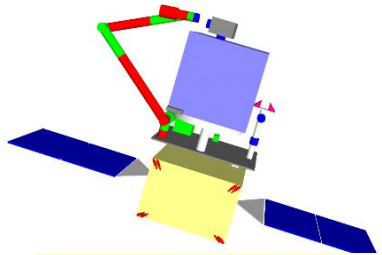
Client Capture
Relative sensor not used
Robotic arm deployed
Robotic Camera
Robotic Gripper



Client Mating
Relative sensors not used
Robotic arm release
Mating interface locking



Refuelling of Client
Inertial sensors/actuators for composite Servicer+Client
Robotic arm release & storage



Client Reconfiguration
Inertial sensors/actuators
Robotic arm coordinated control
Robotic Camera
Standard Interfaces

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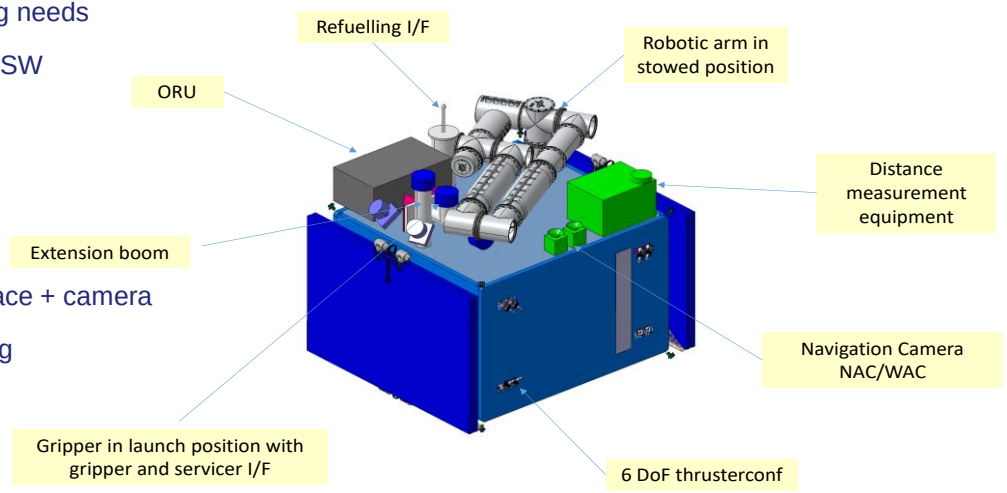
EROSS+ SERVICER CONCEPT

/// Modular design between Platform & Rendezvous / Robotic Payload

- Parallel development to match tight planning
- Anticipate transition to commercial service with specific servicing needs
- Segregation of platform mission critical SW from demonstration SW

/// Rendezvous / Robotic Payload

- Optical navigation cameras S-WAC / S-NAC
- Distance measurement equipment for monitoring
- Robotic Arm : 7 joints with compliance control + Standard interface + camera
- Robotic Tool : Gripper with 2 standard interface for LAR grasping
- Standard interface for berthing capture client
- Refuelling interface for refuelling client
- Orbital Replaceable Unit (ORU) with 2 standard interfaces
- Dedicated computer “Servicing Control Unit” (SCU) to support rendezvous vision and robotic SW, and to implement their equipment interfaces



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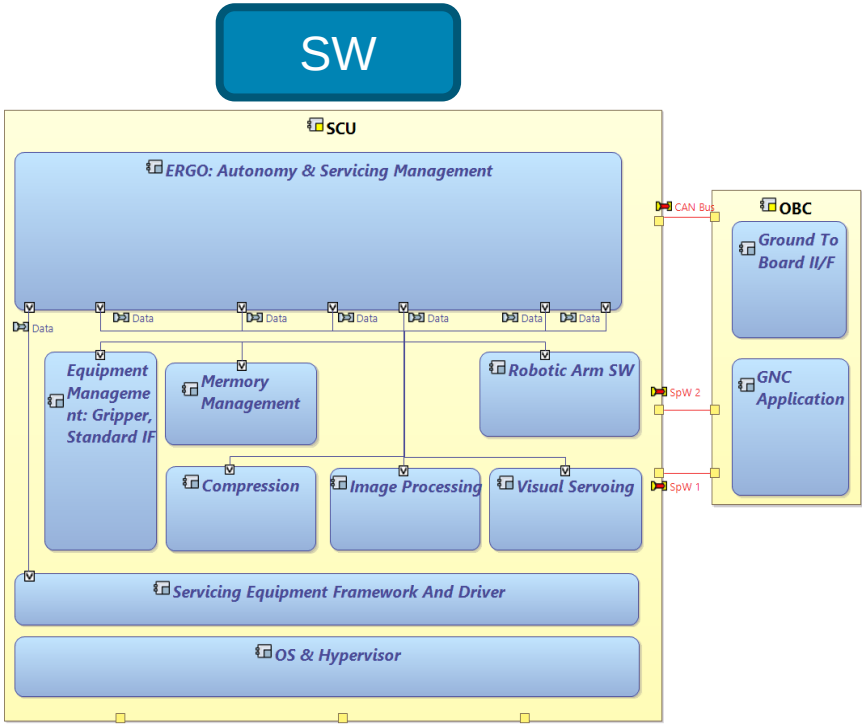
AVIONICS: SERVICING CONTROL UNIT (SCU) / SW ARCHITECTURE

Servicing **C**ontrol **U**nit **– SCU** manages all the Servicing Units (RendezVous and Robotics)
*(previously named **R**obotic **C**ontrol **U**nit **- RCU**)*



SW Components to embed:

- Rendezvous - Image Processing SW
- Robotic - Arm Controller & Skill Engine
- Robotic - ERGO autonomous agent (Servicing Planner)
- Robotic - Image Processing SW
- Common - I3DS Equipment Layer and the management of other equipment: Standard Interface, Gripper, etc…
- Common - Image Compression
- Common - Mass Memory Management

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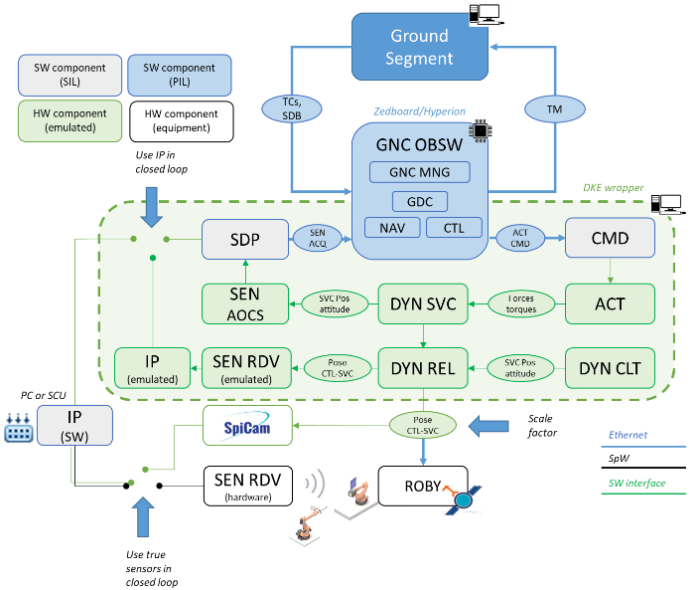
ON-BOARD SOFTWARE: GNC VALIDATION

/// Avionics/Robotic test bench

- Flight representative OBC HW & Operating System
- EGSE with
  - ✓ Dynamics, Kinematics, Environment (DKE)
  - ✓ Image Generation : SPICAM Generator (by TASinF)
  - ✓ Image Processing : C++ code (before SCU implementation)

/// Validation Perimeter

- Cruise and stand-by (conventional AOCS)
  - ✓ AOCS equipment modelled (not procured yet)
  - ✓ Preliminary derisking/validation up to SIL
  - ✓ Final PIL/HIL to be completed in avionics test bench
- Long-range rendezvous
  - ✓ PIL/HIL validation of SNAC/SWAC image processing
  - ✓ Final PIL/HIL to be performed on robotic test bench



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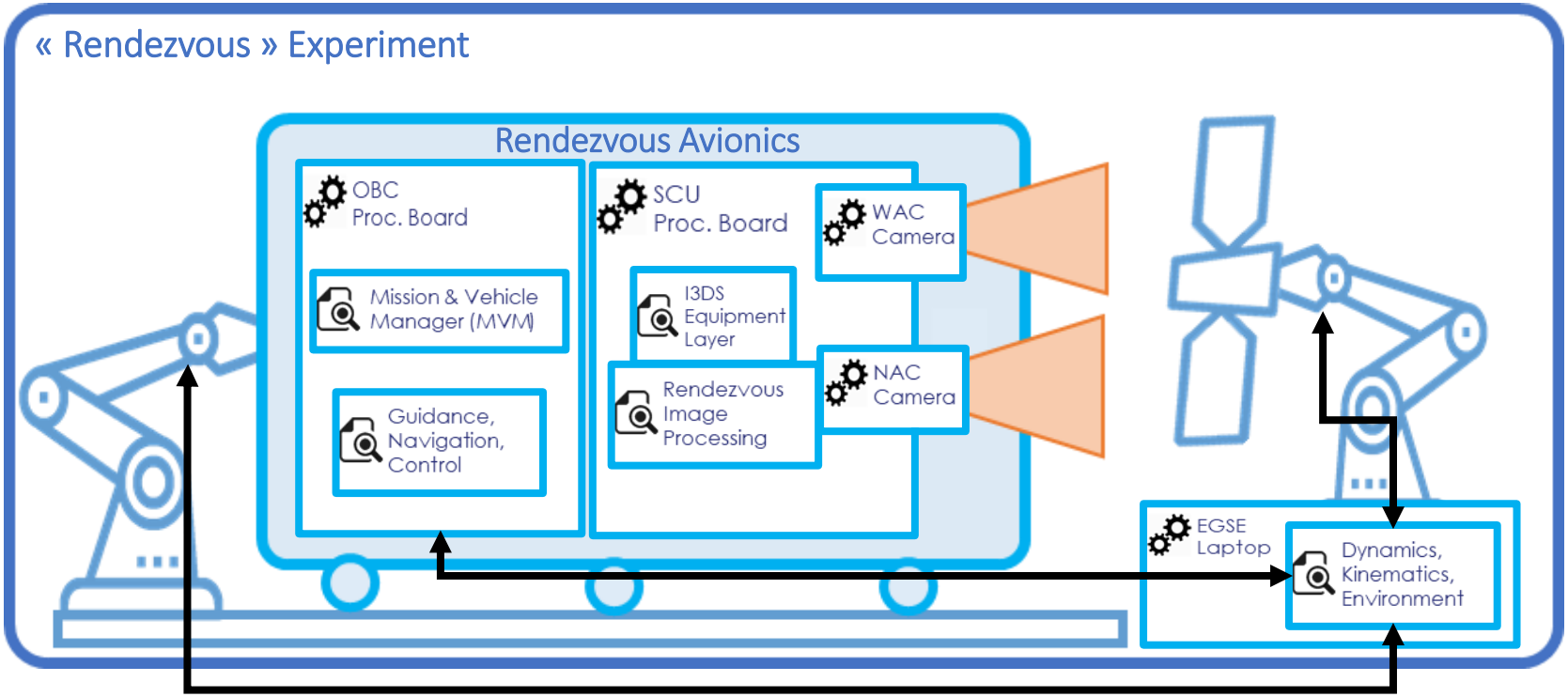
KEY TECHNOLOGIES: RENDEZVOUS EXPERIMENT

/// « Rendezvous Demonstration » : relative motion based on GNC & autonomy



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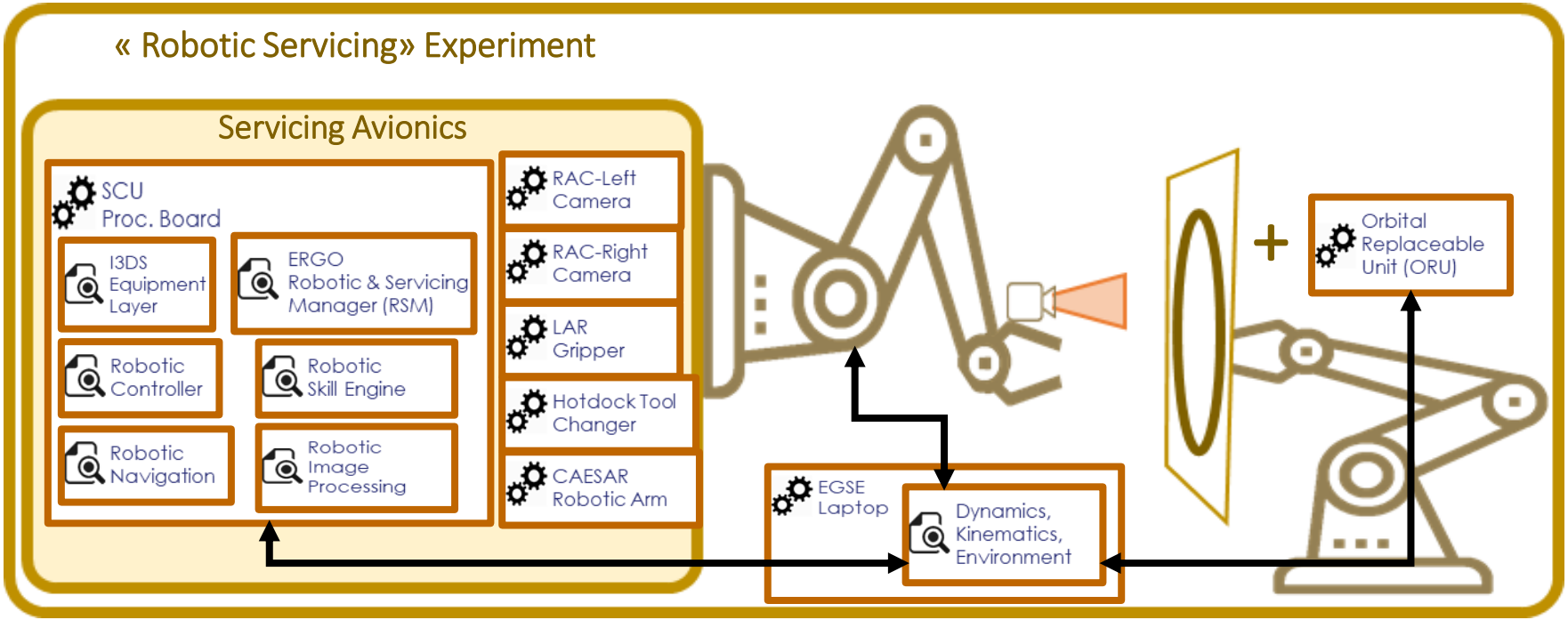
KEY TECHNOLOGIES: ROBOTIC SERVICING EXPERIMENT

/// « Robotic Demonstration » : from arm deployment to capture and client servicing



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