



# Thales Alenia Space avionics solution for Vision-Based Navigation in Space Robotics Mission : “EROSS” scenario

**15th ESA Workshop on  
Avionics, Data, Control and Software Systems (ADCSS)**  
Virtual Edition  
16-18 / 11 / 2021

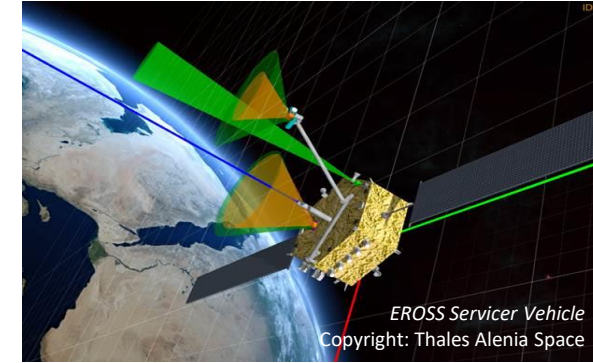
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 821904



# EROSS Context

## EROSS "ID Card"

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



Numerical  
Validation



1 - Straight Line Approach



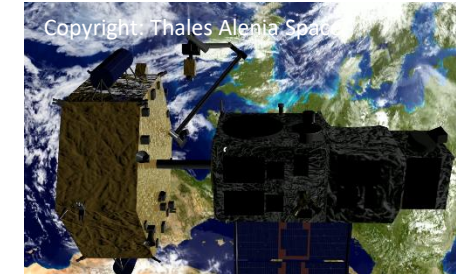
2 - Station Keeping



3 - Robotic Capture

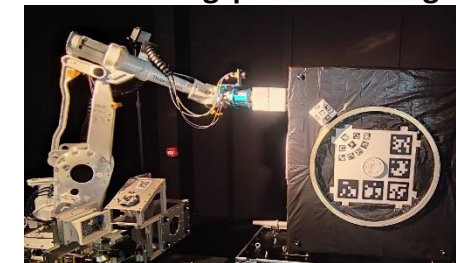
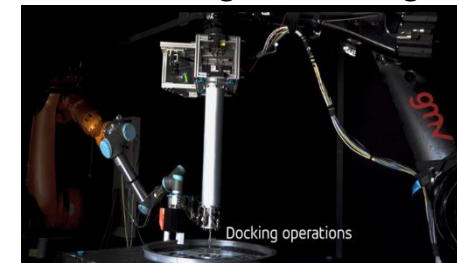
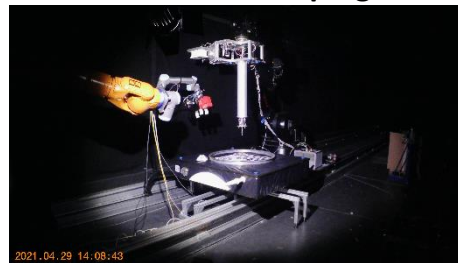
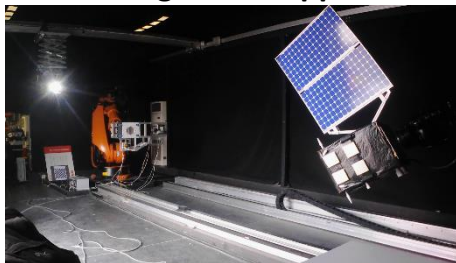


4 - Docking & Refuelling



5 - Servicing | Unit exchange

Experimental  
Validation



100m

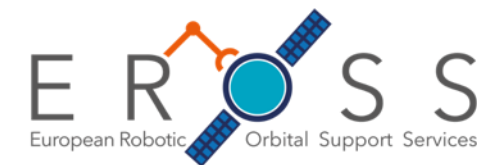
20m

2m

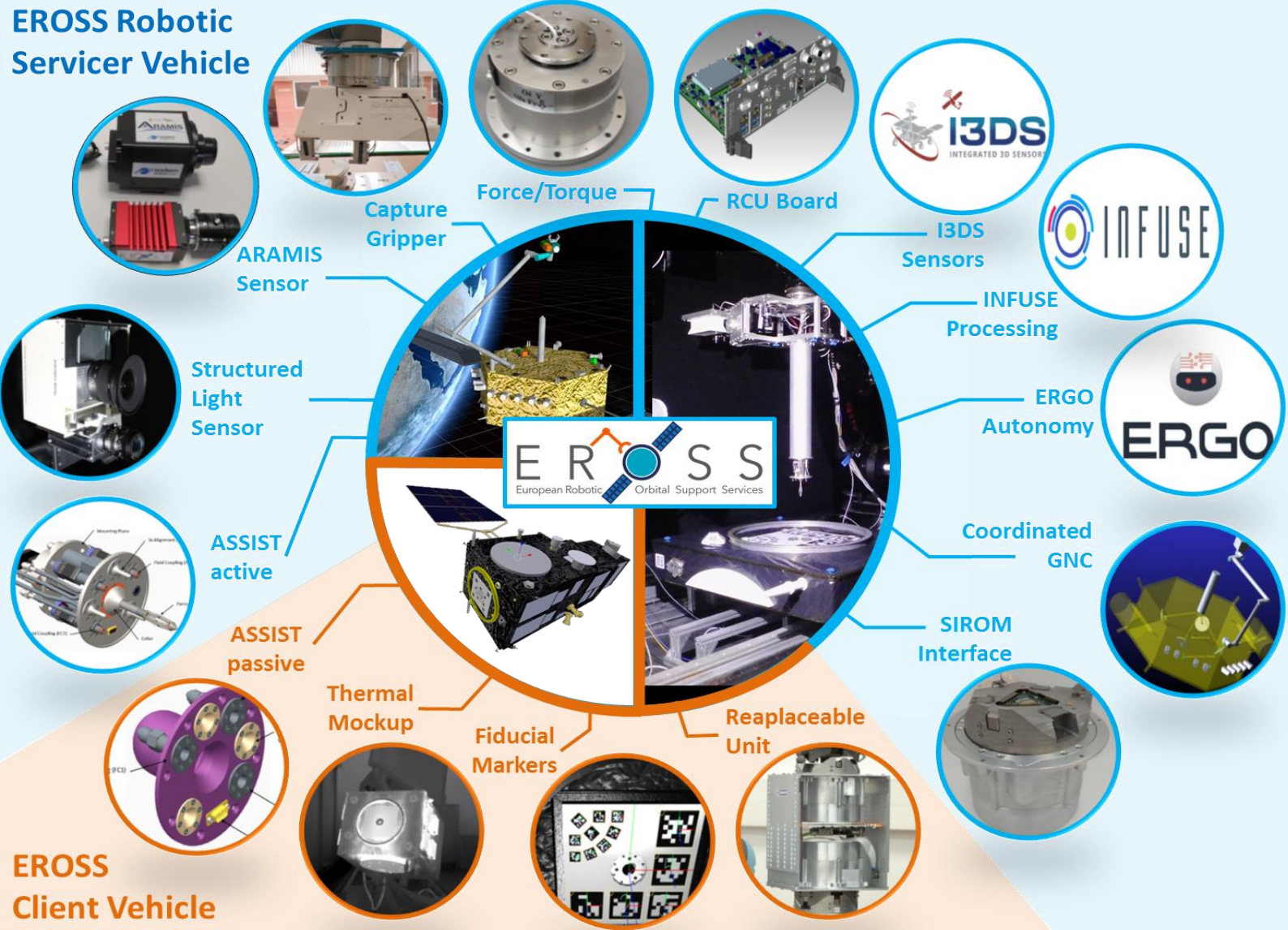
Contact



# « EROSS in a nutshell »



## EROSS Robotic Servicer Vehicle



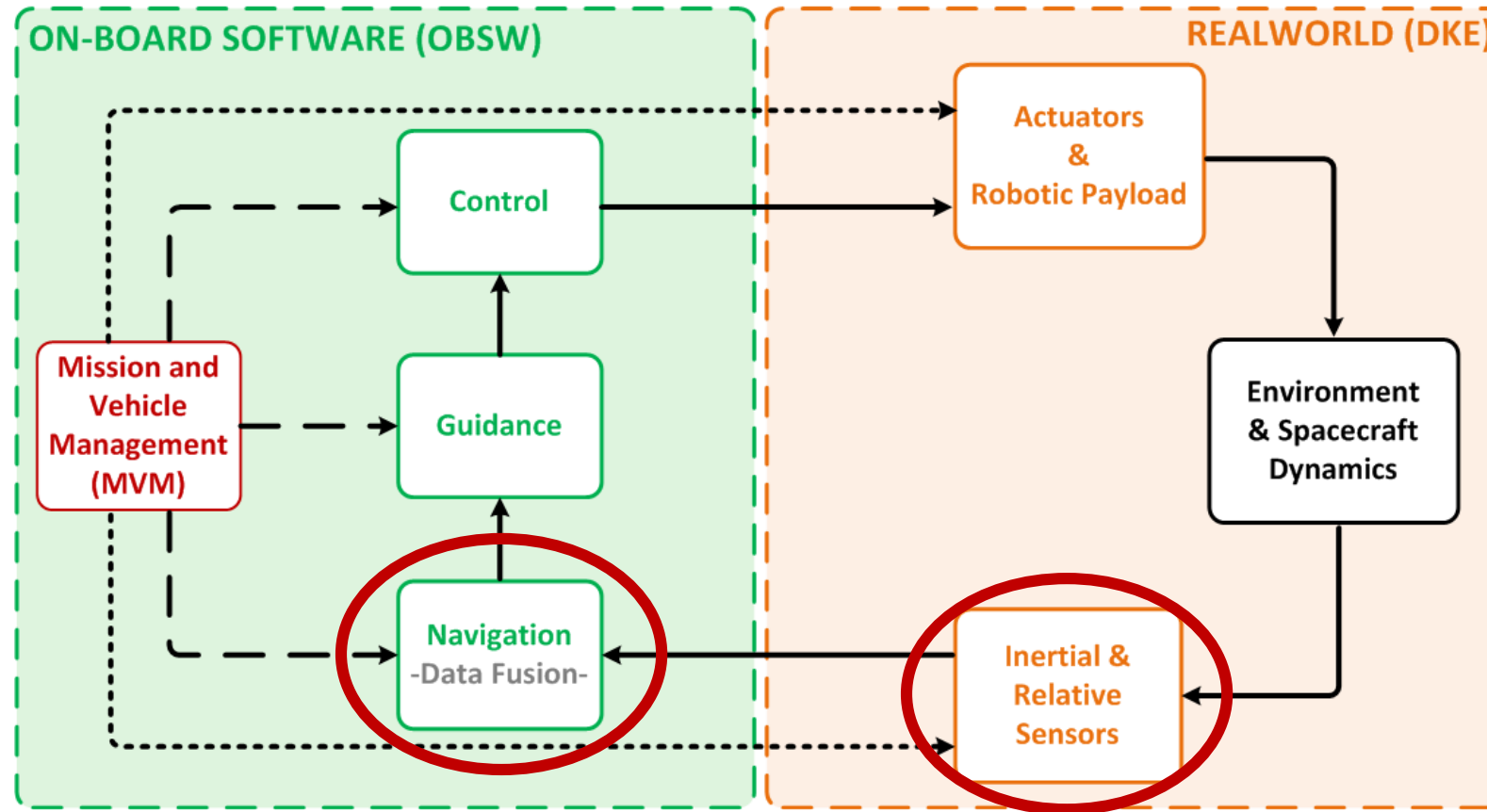
## EROSS Main Achievements

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



# EROSS Vision-Based Navigation

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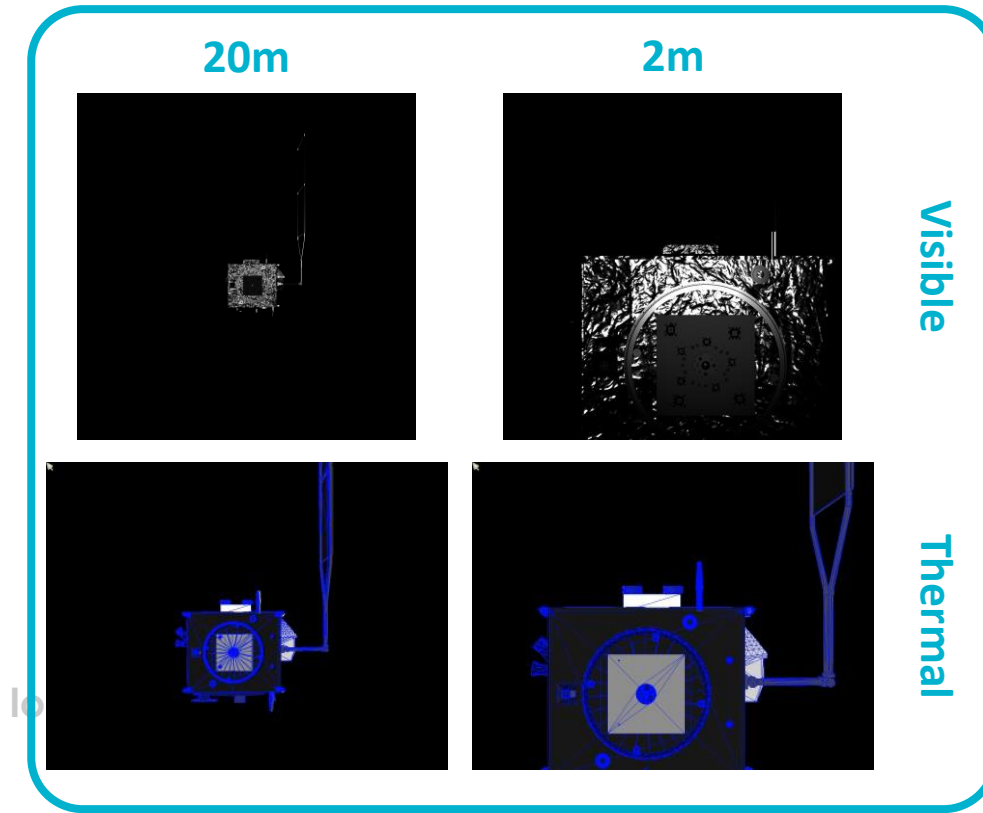
SpiCam

### ■ 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
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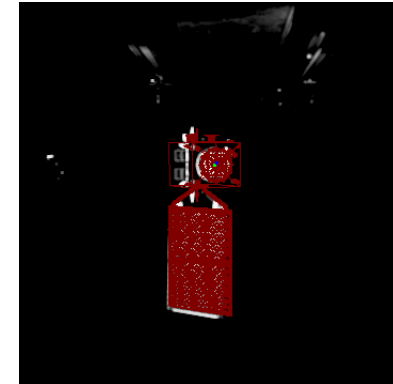
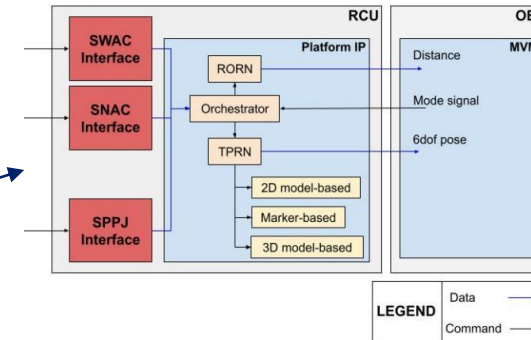


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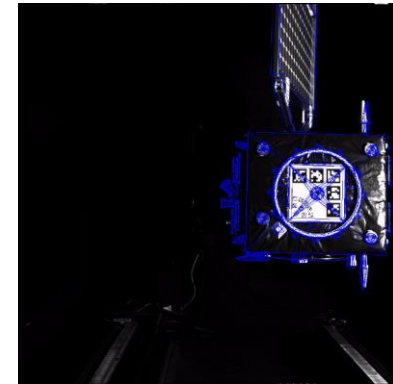
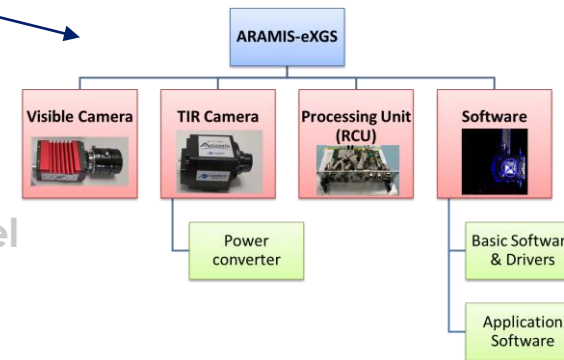
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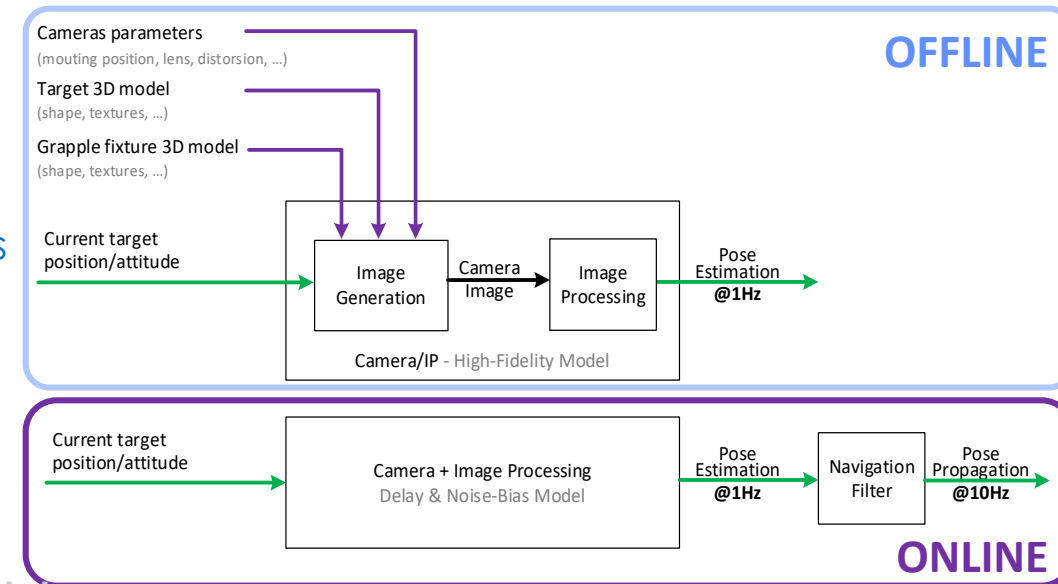
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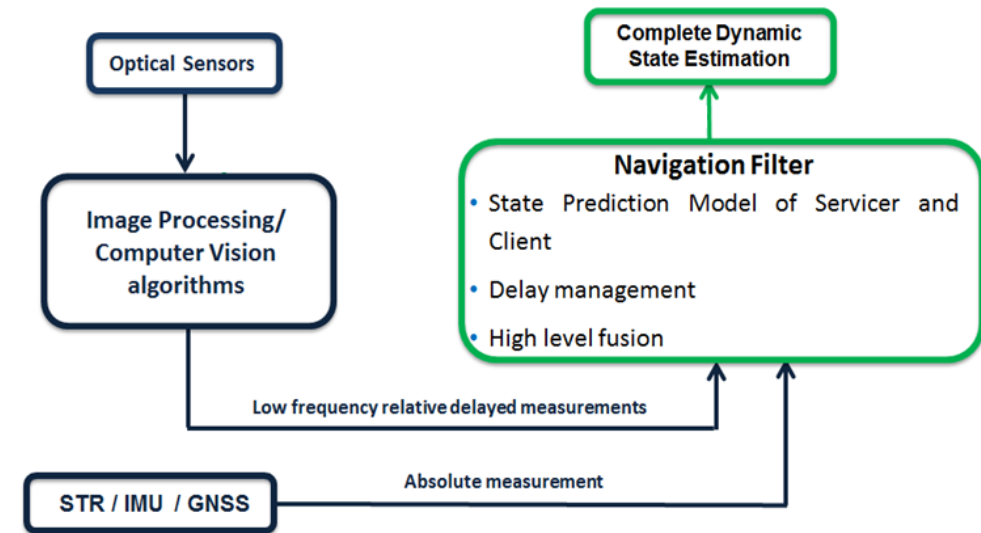
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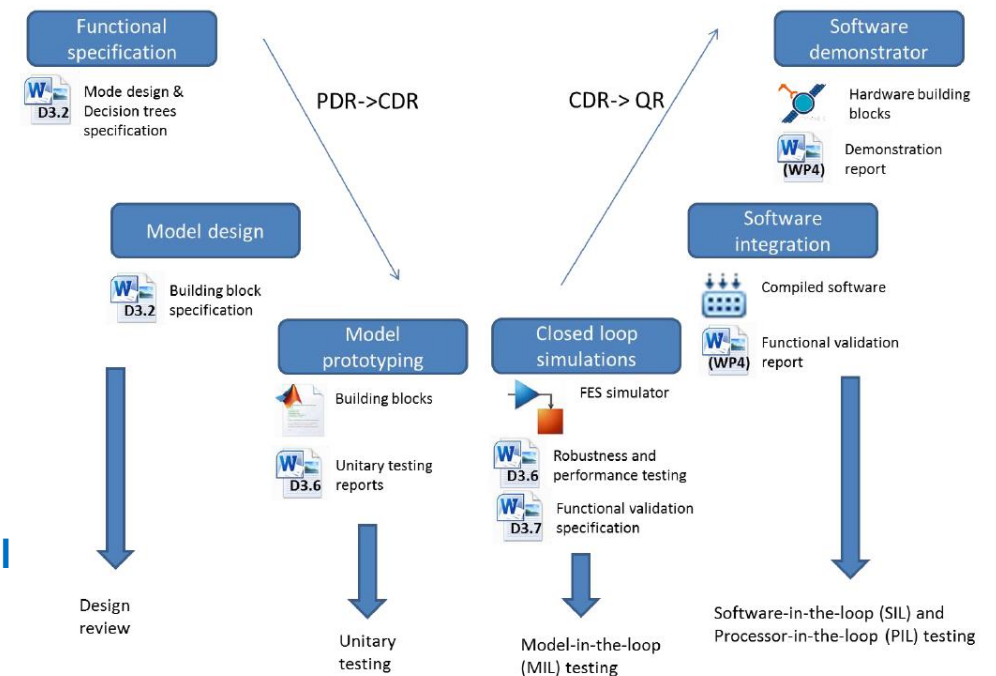
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Model-in-the-loop (MIL) | Software-in-the-loop (SIL) | Processor-in-the-loop (PIL) | Hardware-in-the-loop (HIL)



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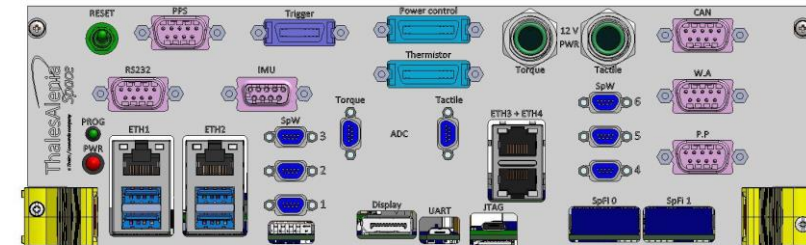
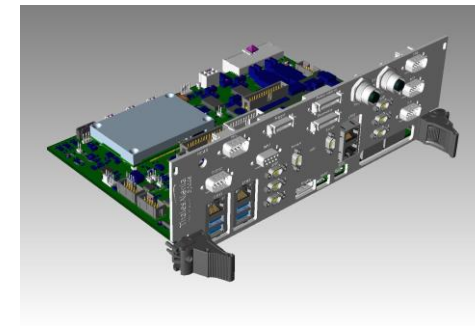
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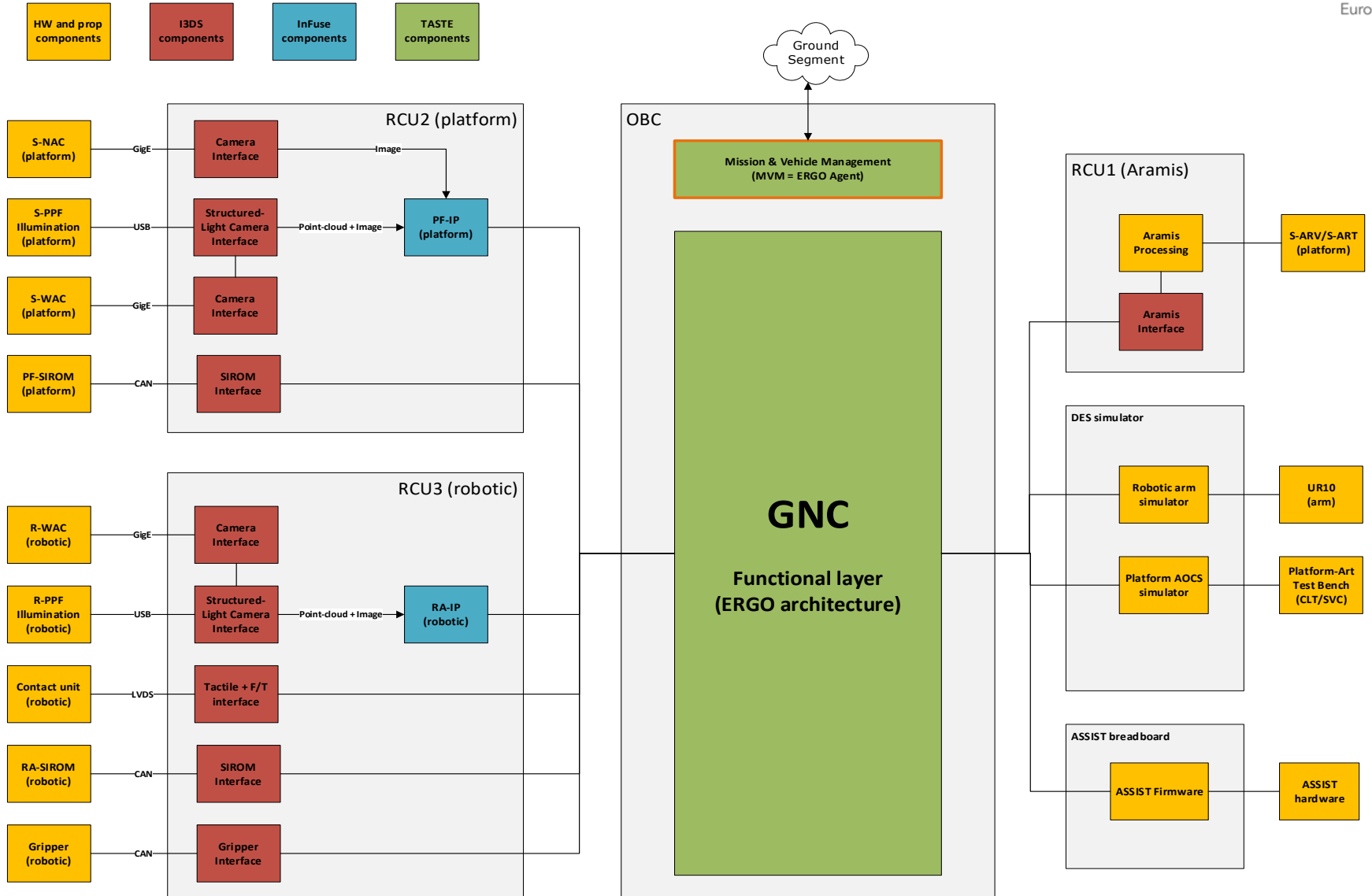
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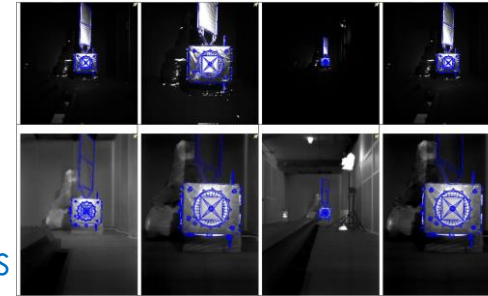


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### Pose Estimation

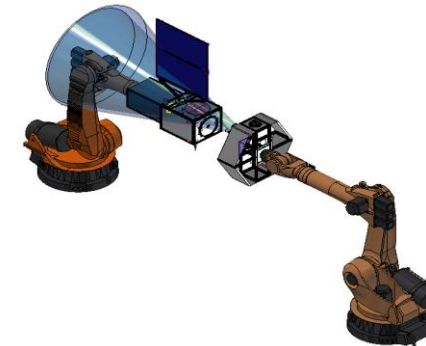


### Time Delay



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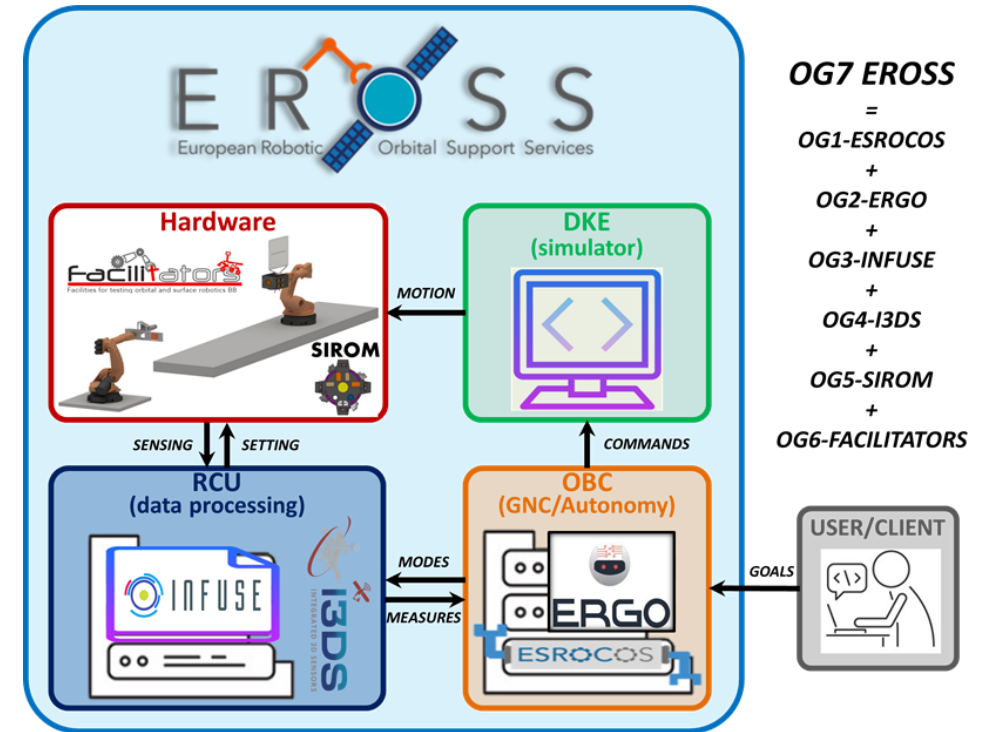
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OG = “Operational Grant” = Consortiums of past H2020 projects

# EROSS Building Blocks Integration

## □ Main Outcomes

- Integration of previous H2020 SW/HW Building Blocks in the frame of On-Orbit Servicing scenario.
- Recording of numerous datasets to characterize visual navigation solutions in visible & thermal spectrum
- Demonstration of the rendezvous approach in autonomous closed-loop with a visual navigation chain
- Demonstration of the autonomy to handle nominal and contingency scenarios in case of failure

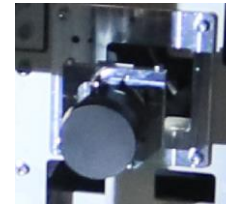
		MIL	SIL	PIL	HIL
					
Main Components	<b>GNC Algorithms</b>	Matlab model	Compiled C Code in PC	Compiled C Code in OBC	Compiled C Code in OBC
	<b>MVM/ERGO</b>	Emulated	TASTE compiled in PC	TASTE compiled in OBC	TASTE compiled in OBC
	<b>Image processing</b>	Emulated	Emulated	INFUSE running in RCU (I3DS)	INFUSE running in RCU (I3DS)
	<b>Sensors</b>	Emulated 	Emulated 	Emulated 	SWAC/SNAC camera
	<b>Actuators</b> <b>Spacecraft dynamics</b>	Emulated	Emulated	Emulated	Emulated and replicated by robots

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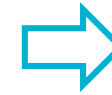
# EROSS Vision-based Datasets

## □ Main Outcomes

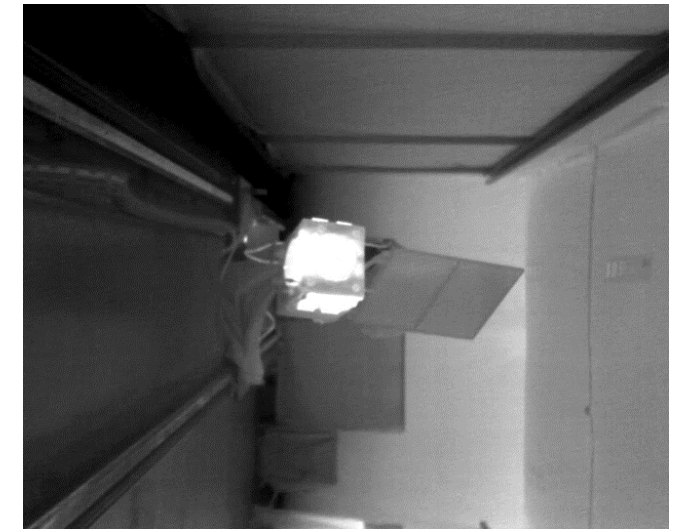
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Visible



Thermal

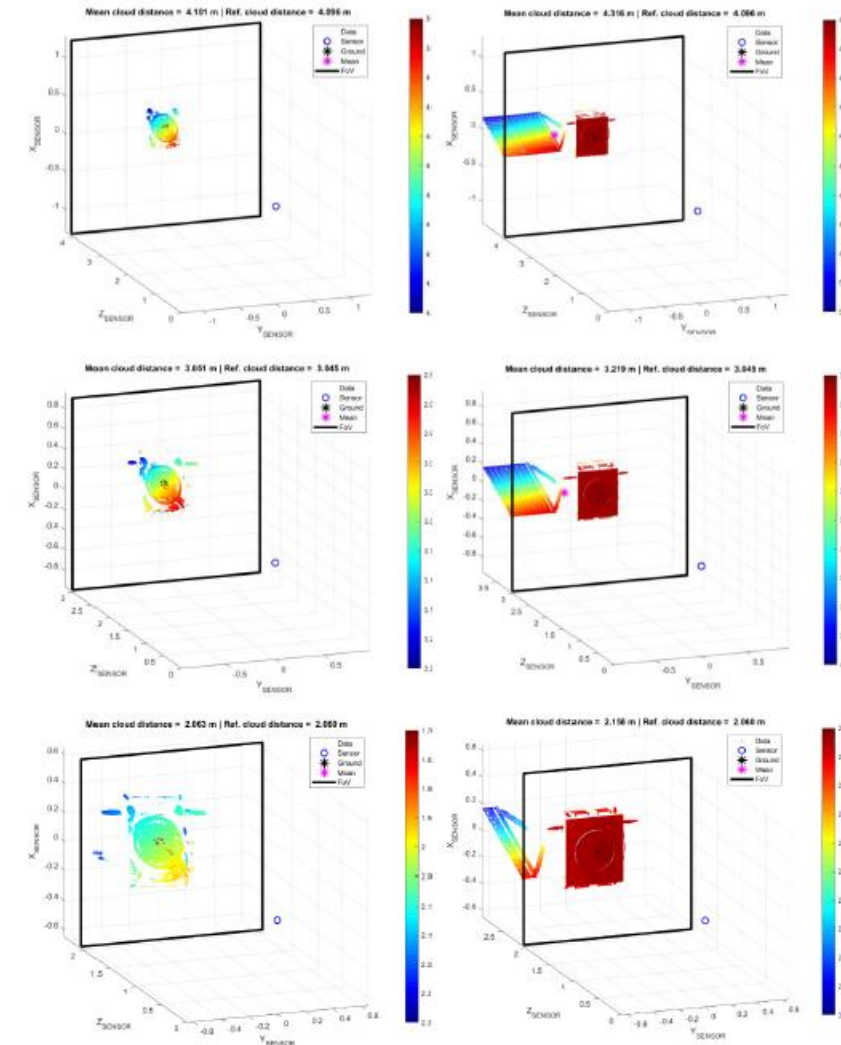


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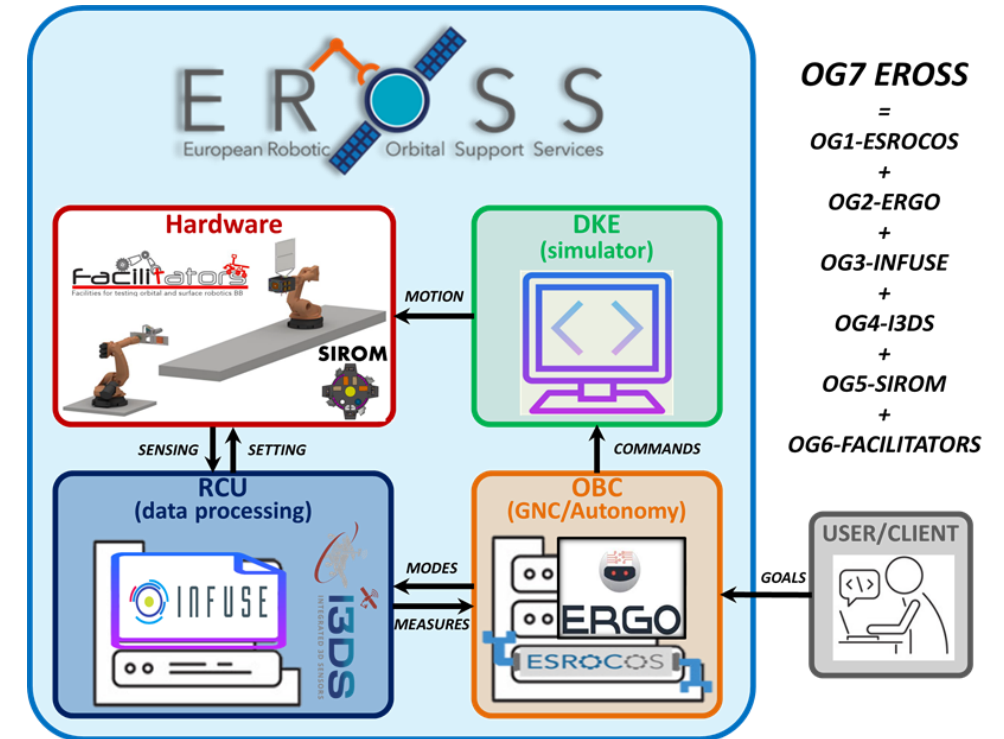
### « Structured Light » 3D Dataset



# EROSS Closed-Loop Results

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NOMINAL SCENARIO : 36m -> 2m

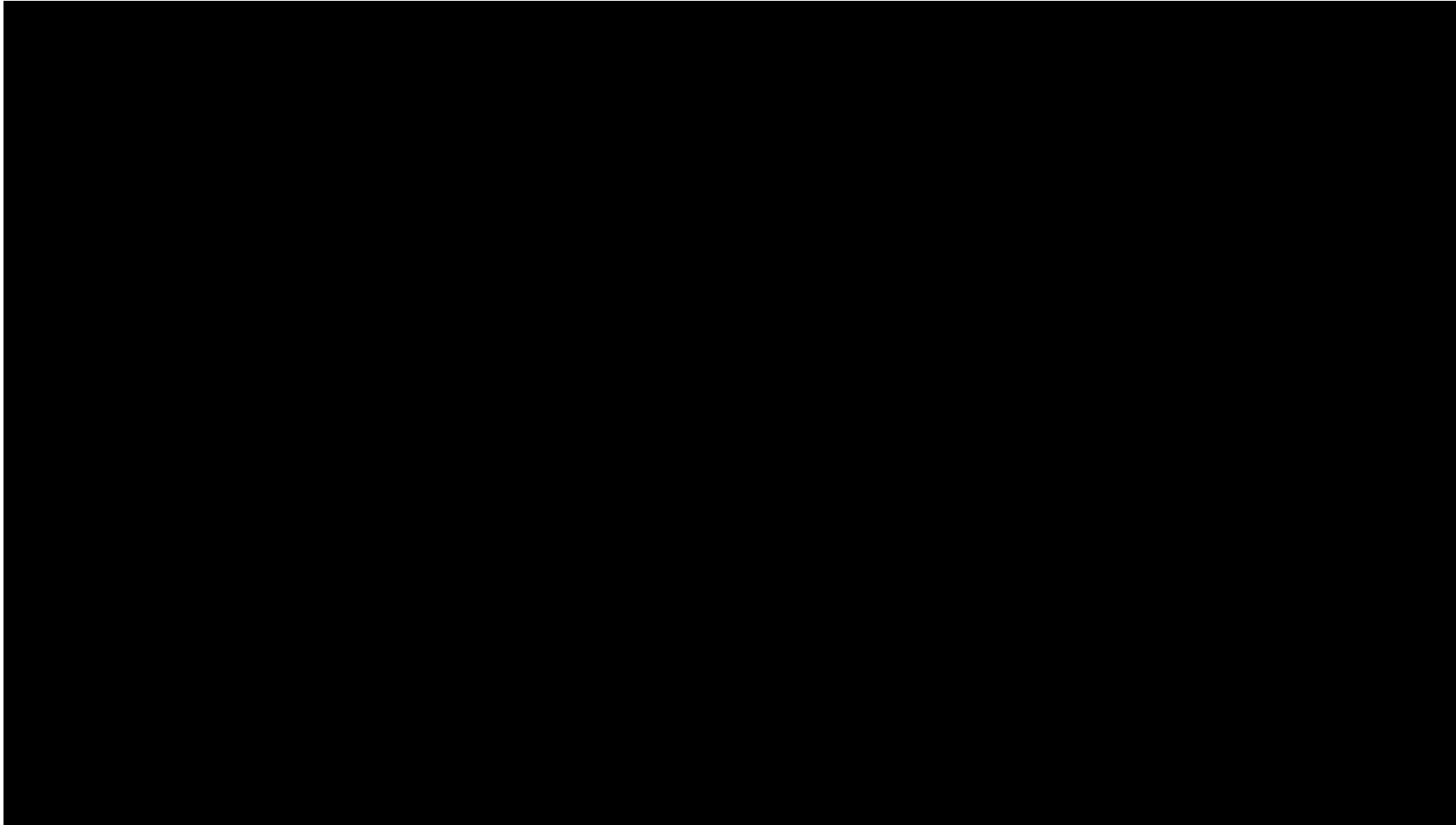


CONTINGENCY SCENARIO : 36m -> 20m



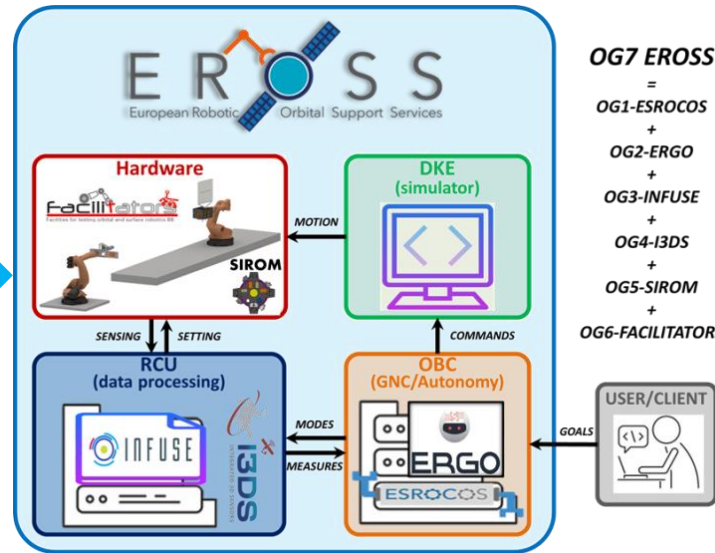
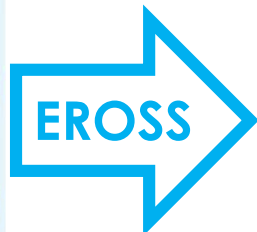
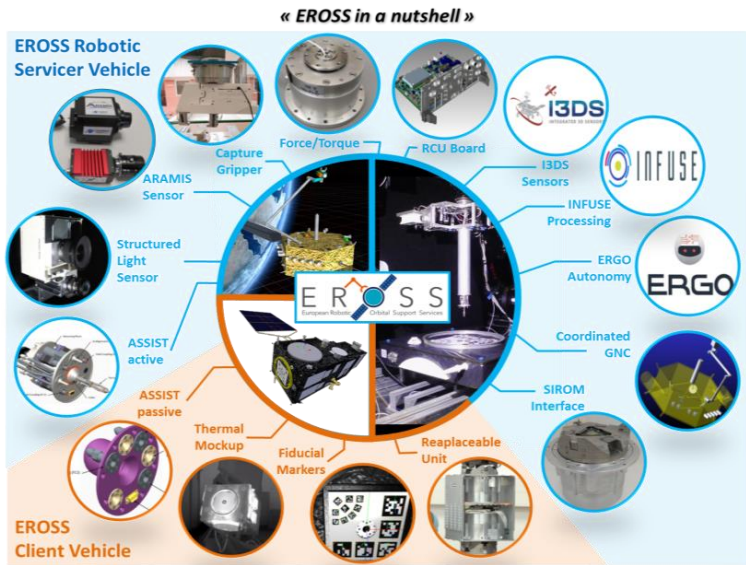
# EROSS Experimental Results

## □ Test Campaign Overview

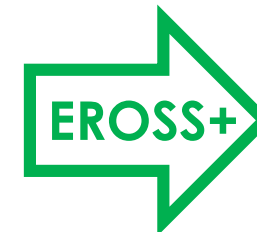


# EROSS Lessons Learnt & Way Forward

- How to move from a set of BUILDING BLOCKS to a harmonized SOLUTION...
- ...and to a IN-ORBIT DEMONSTRATION !



OG7 EROSS  
 =  
 OG1-ESROCOS  
 +  
 OG2-ERGO  
 +  
 OG3-INFUSE  
 +  
 OG4-I3DS  
 +  
 OG5-SIROM  
 +  
 OG6-FACILITATORS



# EUROPEAN ROBOTIC ORBITAL SUPPORT SERVICES

TOWARDS IN-ORBIT DEMONSTRATION  
PHASE A/B1 LED BY THALES ALENIA SPACE

Enable major advances in space robotic technologies for future on-orbit missions robotics and proximity rendezvous)

Represent a risk taking, disruptive approach to enable new commercial opportunities in space



# THANK YOU FOR YOUR ATTENTION !

