



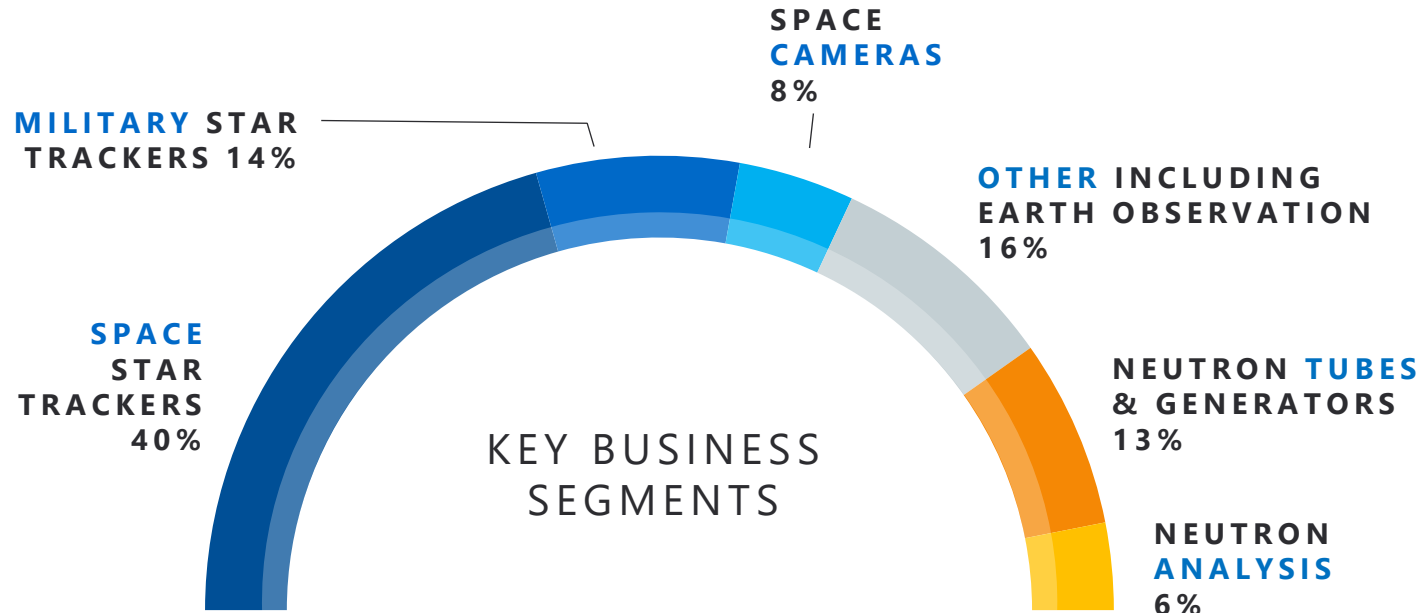
# A Reliable Visible Camera Suite for In-orbit Servicing

**Laurent Majewski**  
**Clean Space Industry Days – 18 October 2023**

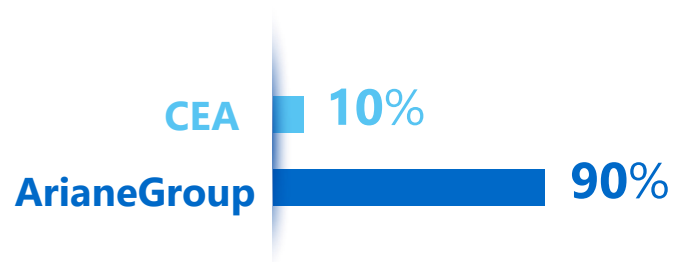
#

E N A B L I N G  
Y O U R  
A M B I T I O N S

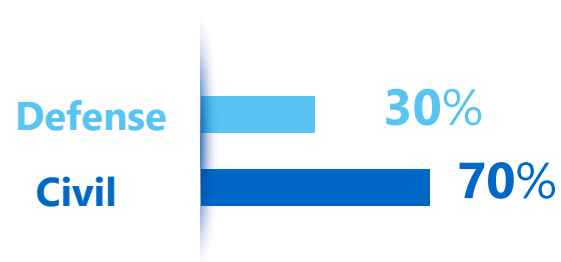
# Sodern at a glance



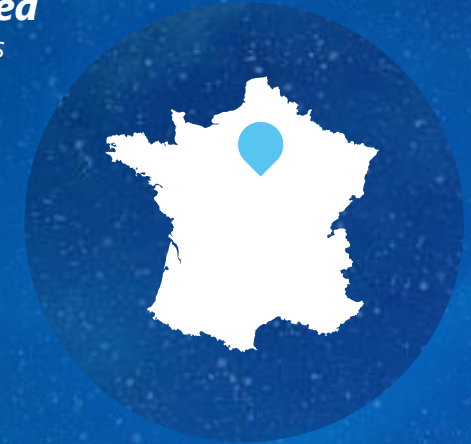
## SHAREHOLDING



## BREAKDOWN OF ACTIVITY



**Headquartered**  
in Limeil-Brevannes  
Paris region



**€85M (\$90M)**

in 2022

**20,600m<sup>2</sup>**  
of facilities

**450+**  
**employees**

**60%**  
**engineers**

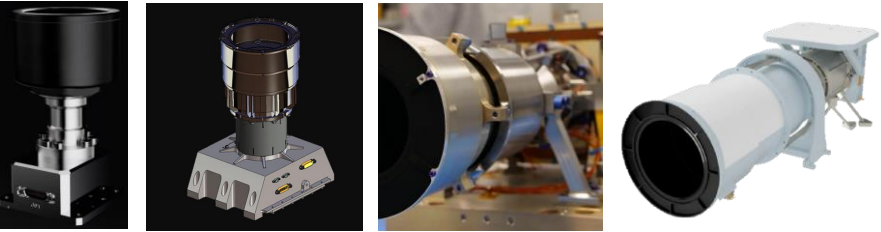


# Sodern products



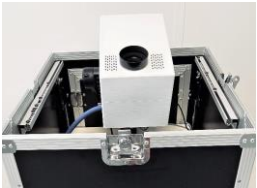
**Space  
Star Trackers**

- Auriga family, Horus, Hydra family
- World's largest Star Tracker portfolio



**Space  
Cameras**

- SSA/SDA
- **Navigation, Rendezvous, IOS**
- Monitoring & Landing
- Exploration & Science



**Daytime  
Star Trackers**

- Daytime star tracker for ships and aircrafts



**Military  
Star Trackers**

- Star trackers for French MoD



**Neutronics**

- Neutron Tubes & Generators for French MoD and commercial market
- Cross belt analysers and neutron logging tools

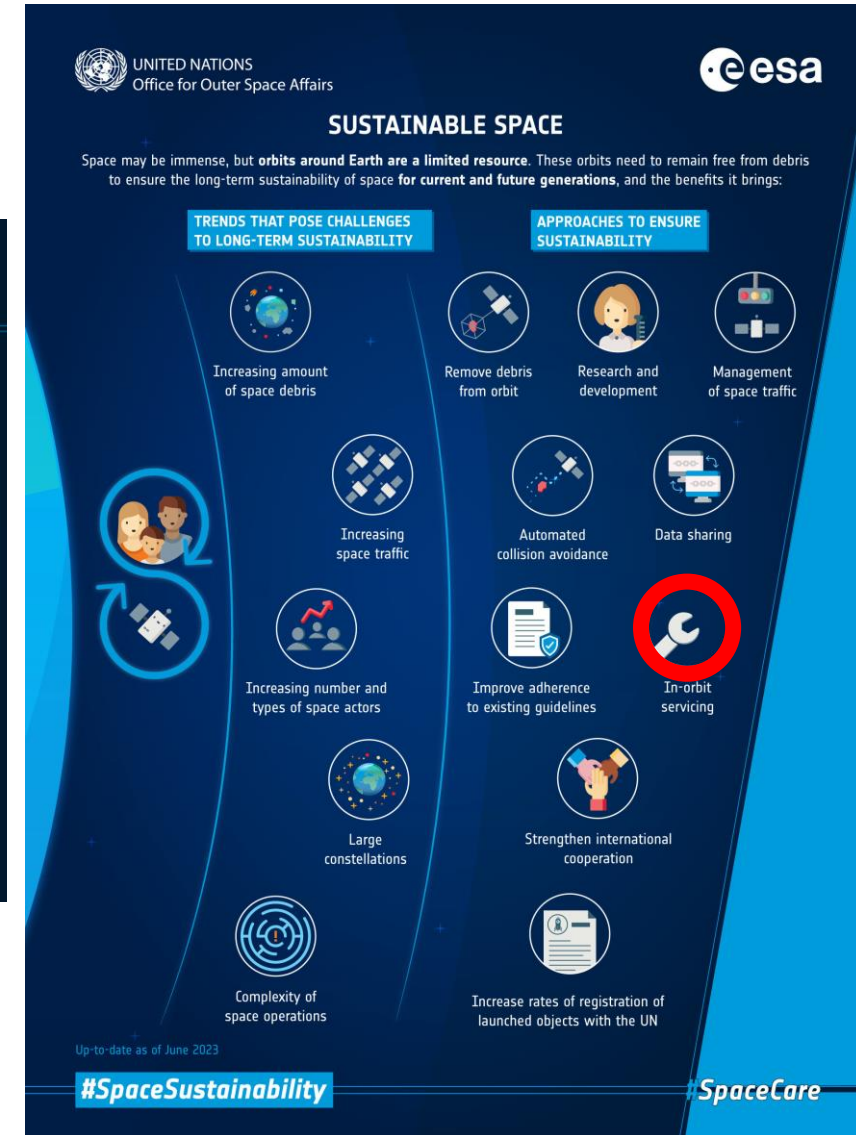
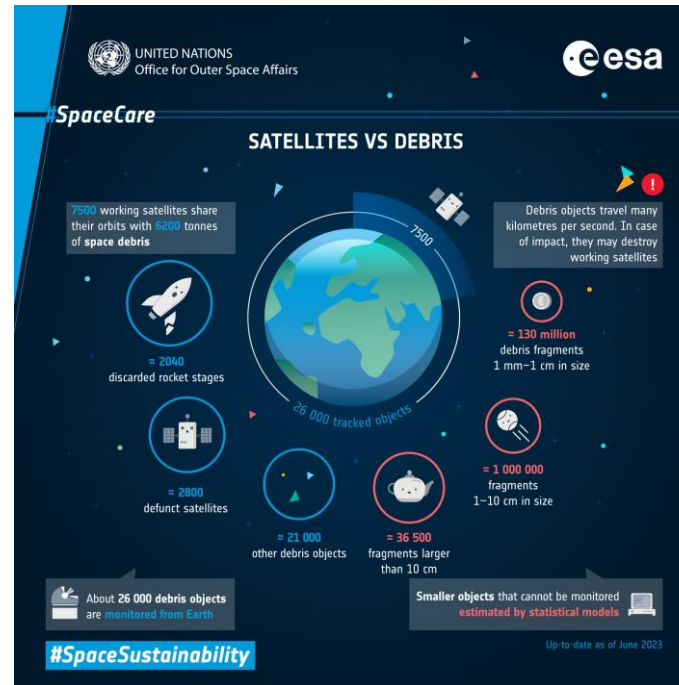
# Sodern Motivations for IOS

## Long-term space and space market sustainability

- Sharp increase of satellites
- 2000s : ↗ ~100 per year
- 2020s : ↗ > 1000 per year
- Risk of collisions ↗ and endangers the usage of space

## Supporting our customers and partners in the effort for a sustainable space

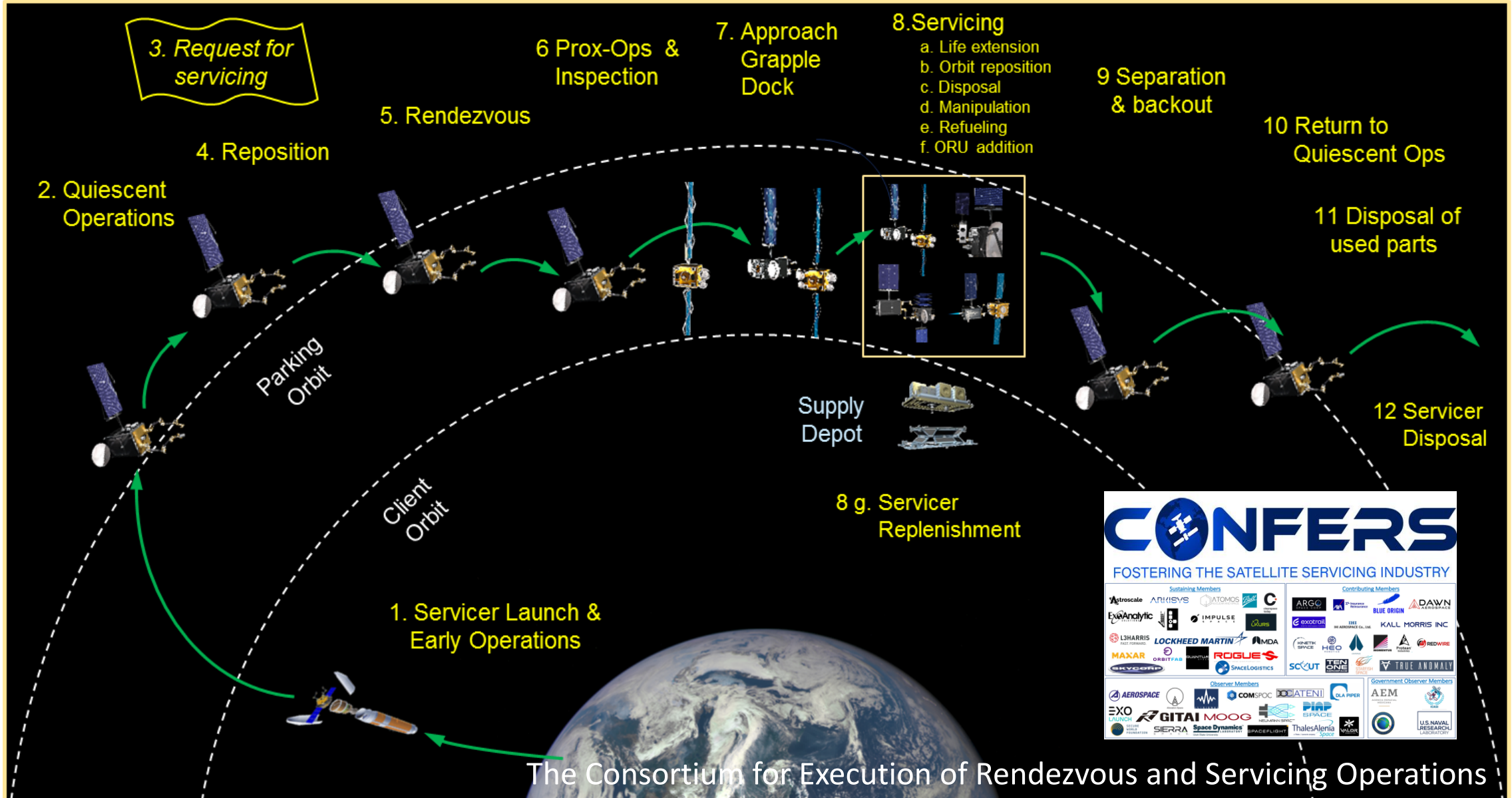
## Company business growth opportunities



Credit ESA and the United Nations Office for Outer Space Affairs (UNOOSA)

# In-Orbit Servicing Mission Phases

Credit The Consortium for Execution of Rendezvous and Servicing Operations (CONFERS)

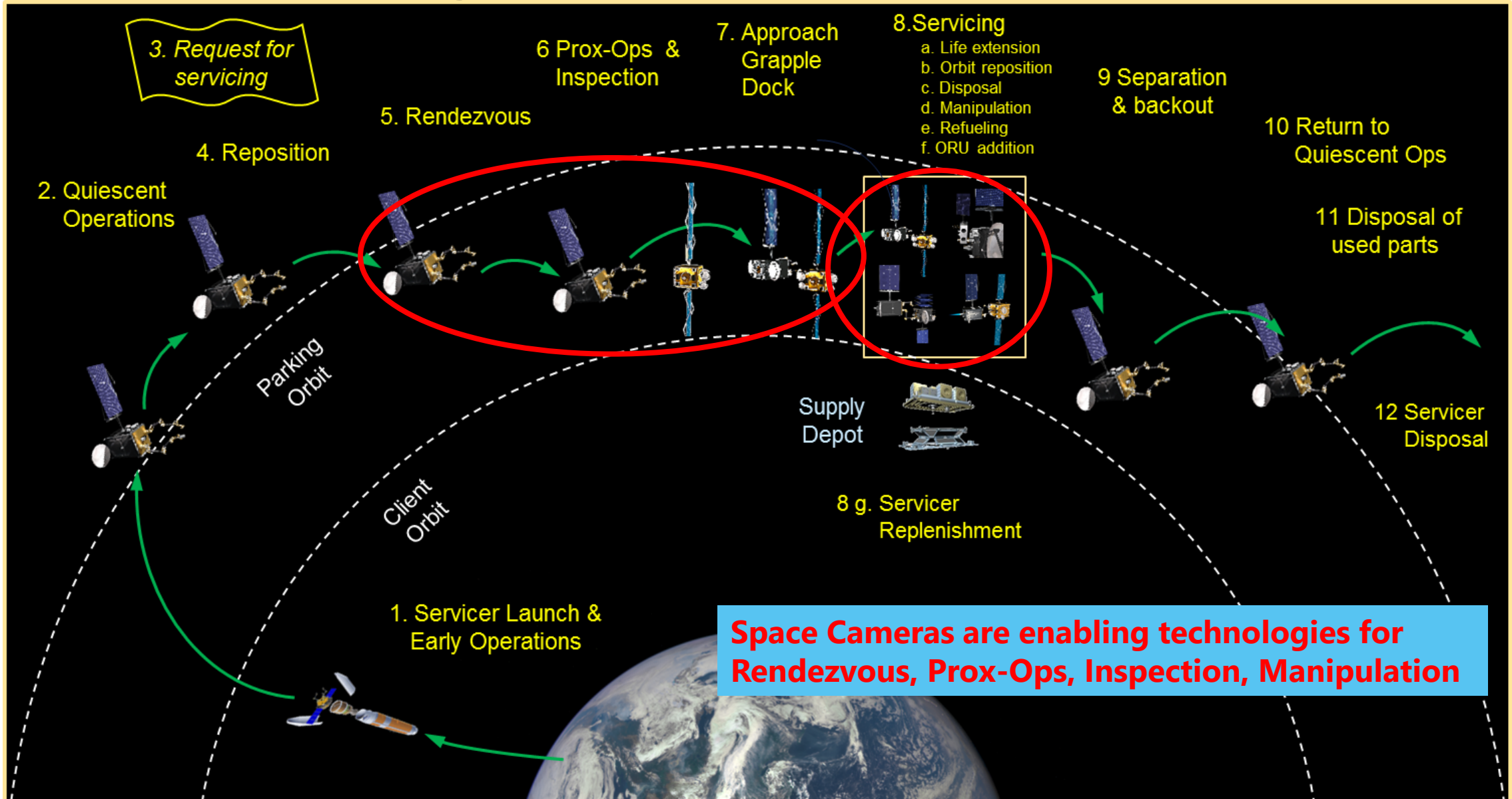


The Consortium for Execution of Rendezvous and Servicing Operations



# In-Orbit Servicing Mission Phases

Credit The Consortium for Execution of Rendezvous and Servicing Operations (CONFERS)



# On-board camera needs for IOS

- **Diverse Client** satellites and **sizes**
- Diverse **distances** involved (different phases)
- Long **mission durations** of Servicer satellites (servicing of multiple Clients)
- High **reliability** missions
- ...

... require on-board cameras with :

- Several **fields of view** options
- **Configurable** aperture and focus
- Good **image quality** and **signal-to-noise ratio** (compatible with image processing)
- Good **resolution**
- Good **frame rate** (compatible with navigation filters)
- STR-class **lifetime** and **reliability**

# AURICAM Camera (1/3)

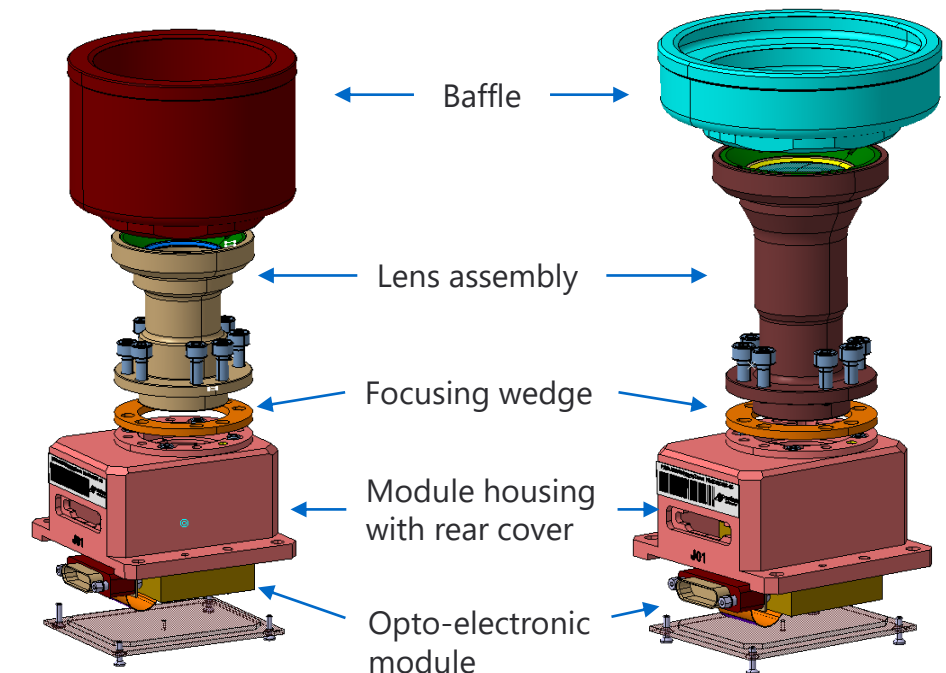
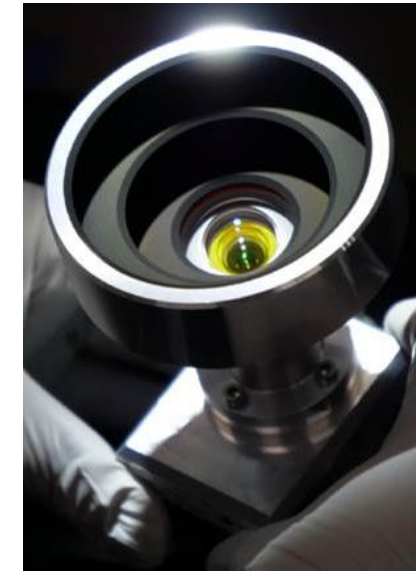
## Overview

- **Compact and lightweight** visible camera
- Based on same architecture as **AURIGA™** Star Tracker
- Available with 2 lenses: **35°** and **80°** diagonal FoV
- Foreseen additional lens with narrow **8°** diagonal FoV
- Fixed (on-ground) **configurable** aperture and focus
- **Radiation-hard** lenses
- Compatible with **LEO and GEO**
- Functions (existing VHDL): raw images, binning, bit depth adjustment (10 or 12 bits), windowing (single window)
- **Options** : EGSE, OGSE, Numerical Model
- **Future advanced functions** (new VHDL in development): auto-exposure, contrast enhancement, distortion correction,...

AURICAM D35



AURICAM D80





# AURICAM Camera (2/3)

## Key figures

- Image sensor resolution: **2048 x 2048 pixels**
- Shutter type: **Global shutter**
- Image type: B&W (standard), Color (on request)
  
- Diagonal FoV: **35°** / **80°**
- Focal length: 25 mm / 10 mm
- Fixed Aperture: **F/3.5 to F/8** / **F/4 to F/8**
- Sun Exclusion Angle: 38° / 64°
- Typical EOL detection capability: > mag 6 / > mag 4
- Resolution capability: **2 cm @100m** / **5 cm @100m**
  
- Mass: **< 420 g** / **450 g**
- Volume with baffle: **140 x 71 x 65 mm** / **135 x 71 x 65 mm**
  
- Temperature range (op. / non-op.): -35 to +55 °C / -45 to +60°C
- EEE parts quality grade: **ECSS Class 1** or Industrial grade
- Lifetime: **7 years in LEO, 15 years in GEO**
  
- Interface: **SpaceWire**
- Power supply: 4.75 to 6 V
- Power consumption: < 2 W
- Frame rate (full frame images): **up to 5 fps** (with binning) with existing VHDL  
**up to 10 fps** (with binning) with new VHDL in development

**AURICAM D35**



**AURICAM D80**

# AURICAM Camera (3/3)

## Qualification (on-going)

- Qualification is on-going, end is expected in **Q4 2023 (D35)** and **Q1 2024 (D80)**
- Qualification addresses all environments:
  - Mechanical environment (sine & random vibrations, shocks)
  - Thermal-vacuum cycling
  - Straylight testing
  - Radiations
  - EMC/ESD
- Camera performance tests are performed before and after environmental tests

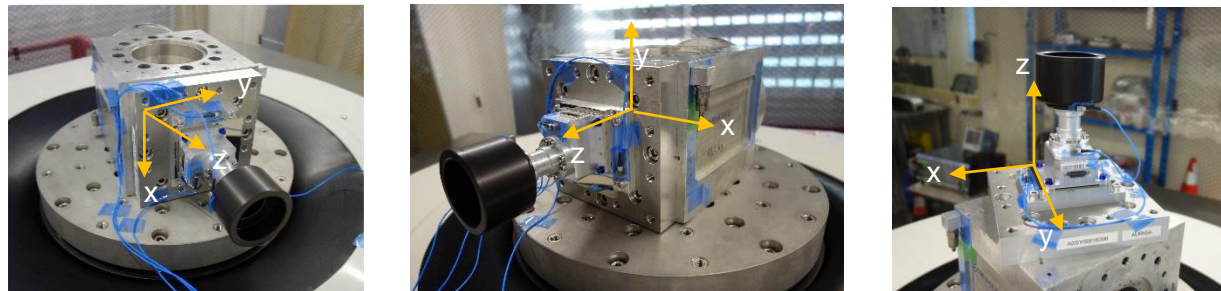


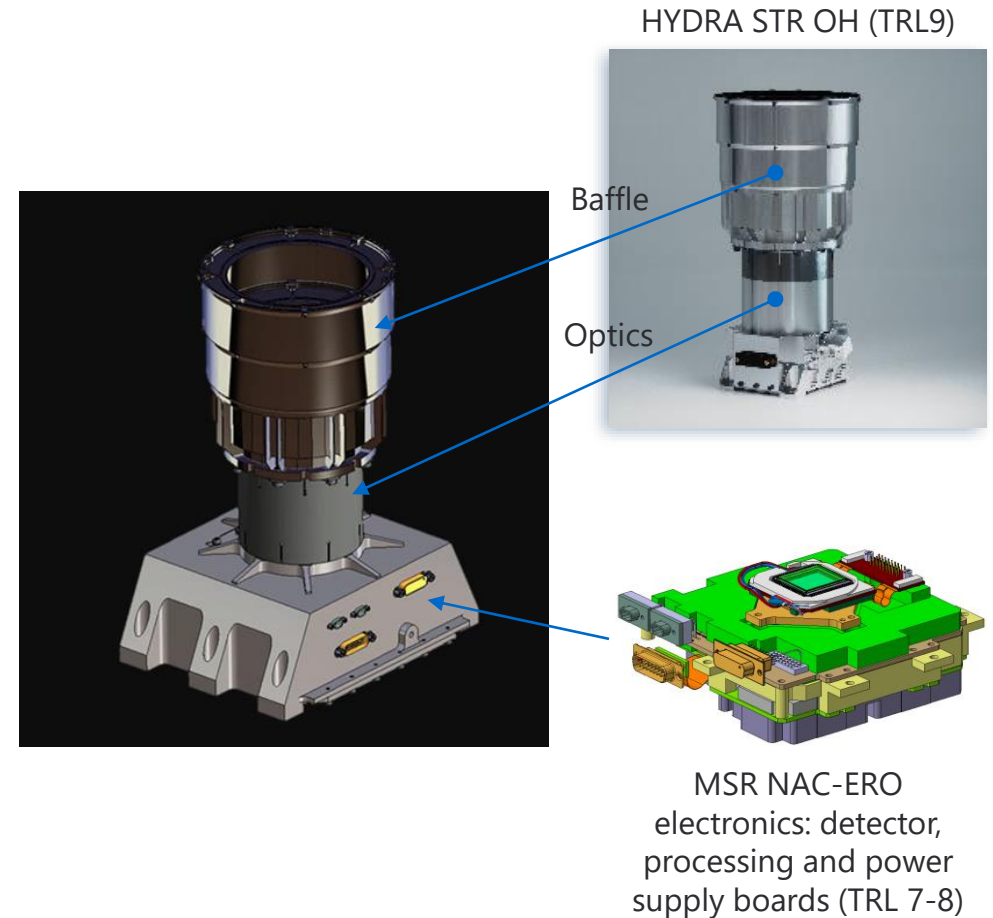
Figure 1 : AURICAM 35° on shaker (X, Y and Z axis)

## In-Orbit Demonstration with ESA (foreseen 2025)

# HiCAM Camera (1/2)

## Overview

- 1 Mpixel camera using **FaintStar2** rad-hard detector
- **17°** diagonal FoV
- Based on **high TRL** sub-assemblies
- Reuse of **HYDRA** star tracker baffle and optics (TRL9)
- Reuse of **MSR NAC-ERO** electronics (TRL 7-8)
- Detector **cooling** (TEC) for low noise
- **High magnitude** detection
- **On-going development** in the frame of a project for CNES

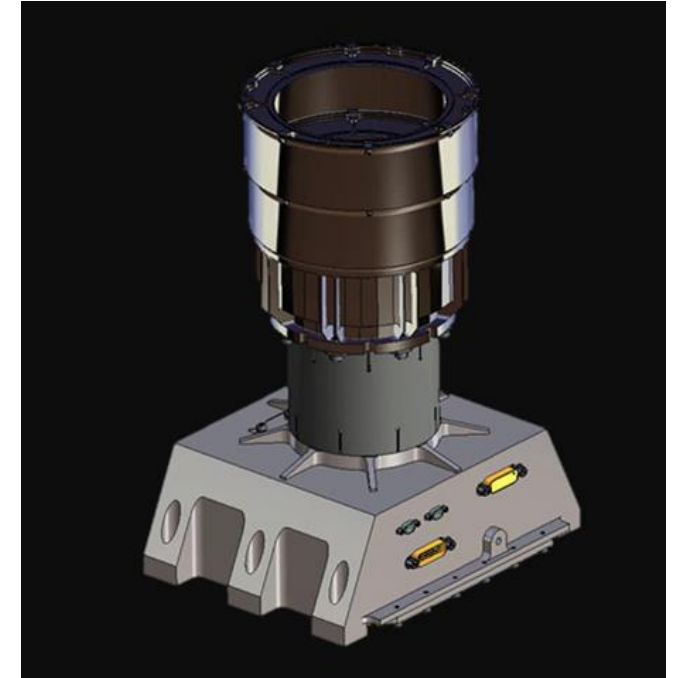




# HiCAM Camera (2/2)

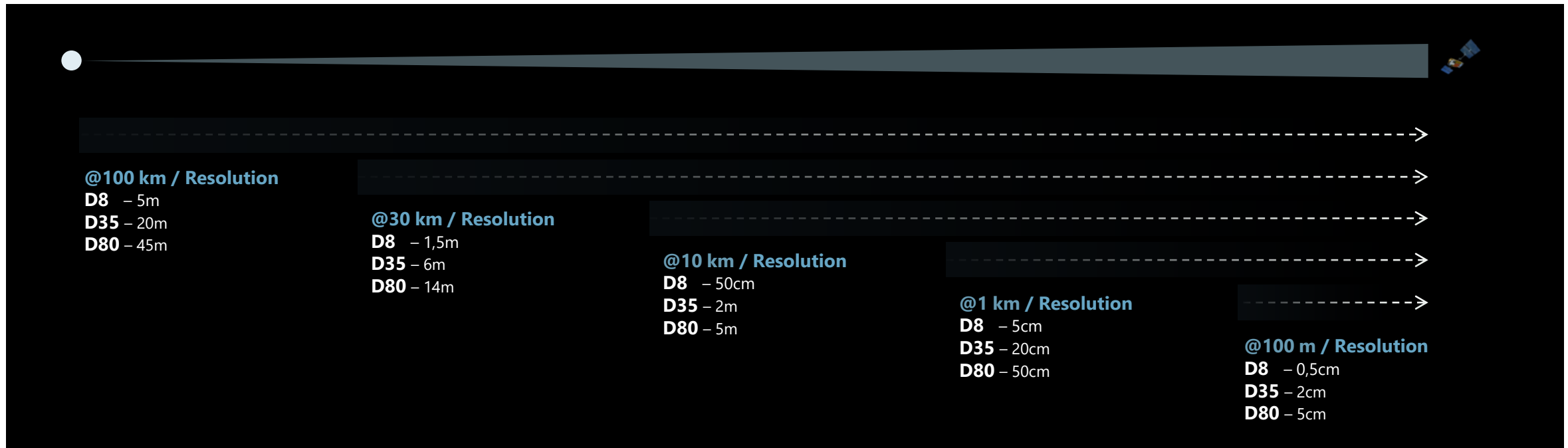
## Key figures

- Image sensor: **FaintStar2**
- Resolution: 1020 x 1020 pixels
- Shutter type: **Rolling shutter**
- Bit depth: 12 bits
- Image type: B&W
  
- Diagonal FoV: **17°**
- Focal length: 47.7 mm
- Aperture: F/1.4 (34 mm)
- Sun Exclusion Angle: 26°
- Typical EOL detection capability: **mag 11** (1s integration time)
  
- Mass: **< 3 kg**
- Volume with baffle: 209 x 175 x 295 (Height) mm
  
- Temperature range (op. / non-op.): -25 to +50 °C / -40 to +70°C (TBC)
- EEE parts quality grade: **ECSS Class 1**
- Lifetime: **7 years in LEO, 15 years in GEO**
  
- Interface: **SpaceWire (redounded)**
- Power supply: **28 V**
- Power consumption: **< 12 W (TEC ON)**

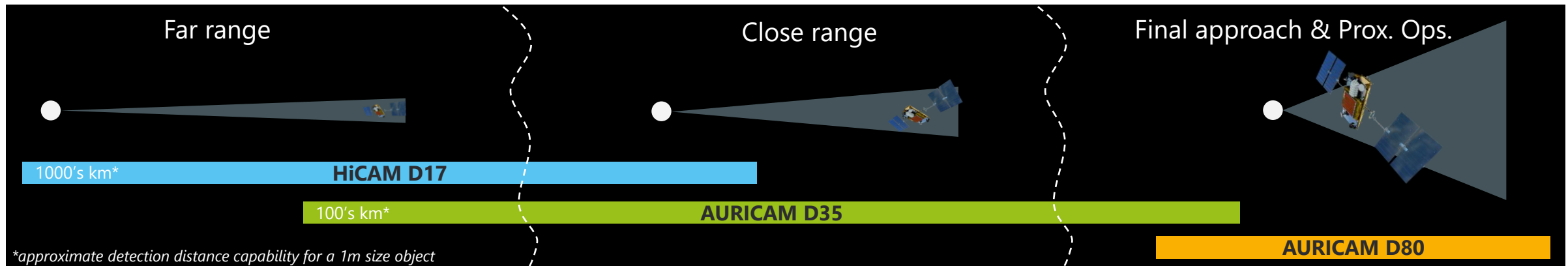


# AURICAM for Inspection

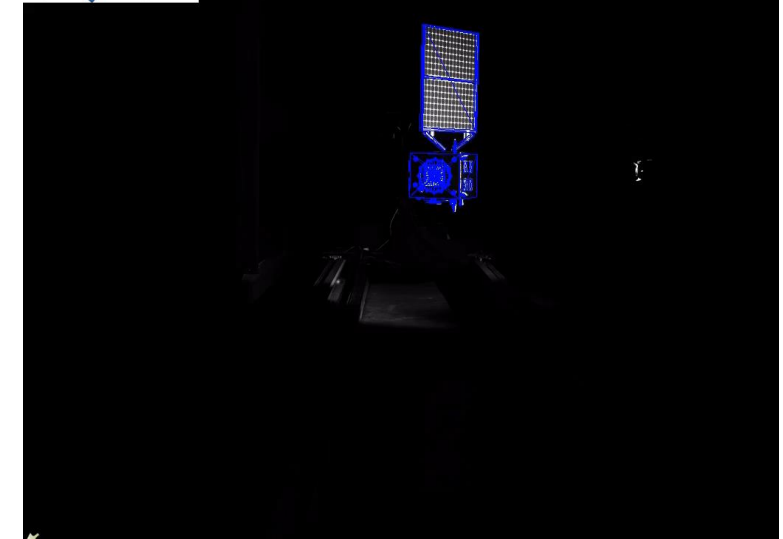
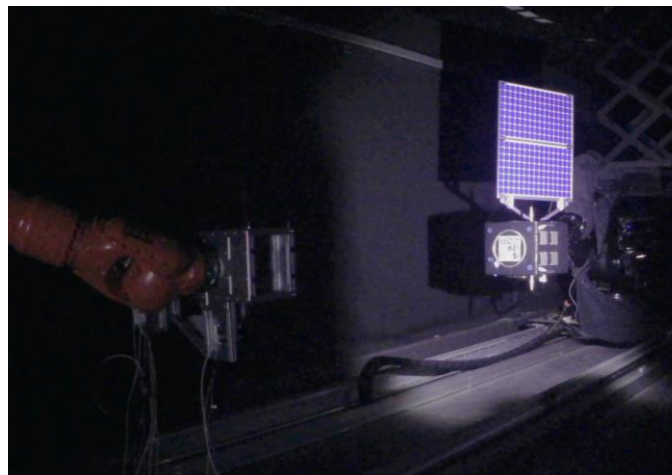
- **Inspection may be needed prior rendezvous and servicing** of the Client satellite
- **Resolution** is then the main performance metrics
- Different **AURICAM versions offer different resolutions**



# AURICAM and HiCAM for Vision-Based Rendezvous



- **All servicing missions** (life extension, orbit transfer, refueling, upgrade, repair...) will **require rendezvous with the Client satellite**
- AURICAM and HiCAM cameras could be **used sequentially for far range rendezvous, close range rendezvous and proximity operations**
- Example of final approach with AURICAM
  - EROSS H2020 project (2019-2021)
  - Coordinated by TAS-F
  - **Demonstration of key building blocks for in-orbit servicing**
  - Sodern contributed with a **demonstrator of ARAMIS 6 DoF smart sensor using a camera representative of AURICAM**





# Summary

- Sodern is concerned with the long-term space and space market **sustainability**
- In-orbit servicing is a one approach to ensure sustainability
- Space cameras are an **enabling technology** for Rendezvous, Proximity Operations and Inspection
- AURICAM is a **compact multi-purpose camera** derived from flight proven AURIGA™ star tracker
- AURICAM D35 (resp. D80) will be qualified by **Q4 2023** (resp. Q1 2024)
- **IOD with ESA** foreseen in 2025
- Additional AURICAM NAC D8 is foreseen to complete the product line
- HiCAM is a **high magnitude detection** camera derived from HYDRA star tracker and MSR NAC-ERO
- HiCAM will be available by **2025**
- AURICAM and HiCAM are expected to be reliable building blocks for **vision-based navigation, rendezvous** and **inspection** solutions in space
- AURICAM and HiCAM can also serve **Space Situational Awareness**



# Acknowledgments

Sodern would like to thank:

- CNES, as the AURICAM camera development was co-founded by CNES, in the frame of the 'Plan Investissement Avenir' launched by the French Government.
- ESA for their partnership for AURICAM IOD

**THANK YOU FOR YOUR ATTENTION !**

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