Emmanuelle HAREL
Key Account Manager

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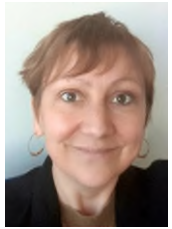


NAC ERO

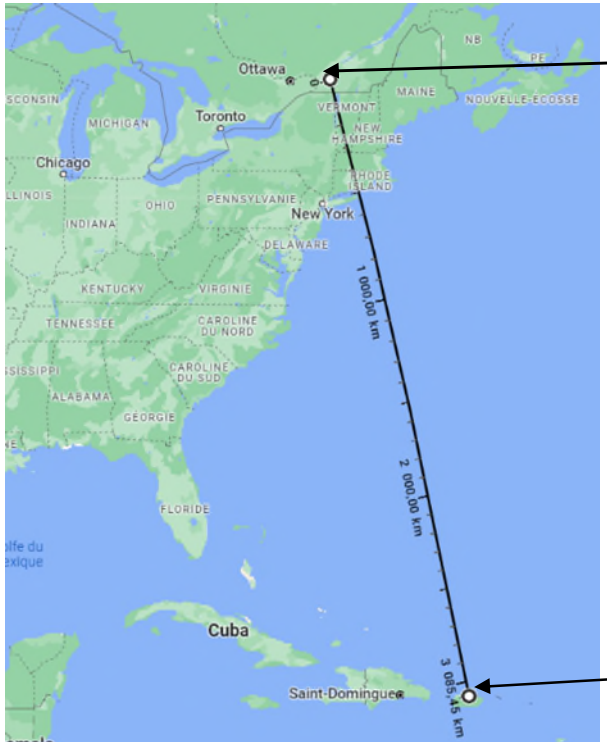
NARROW ANGLE CAMERA – EARTH RETURN ORBITER

Moving to Mars

17th November 2022

ERO NARROW ANGLE CAMERA

How to retrieve a soccer ball?



Montréal

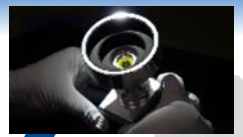
Puerto Rico

… 3000 km away

In the middle of a rock concert

SODERN: WORLD LEADER in SPACE OPTRONICS

SPACE CAMERAS



STAR TRACKERS (Space, day, military)

Located South of Paris, with 450 employees
83 M€ Revenue in 2021

World wide company with 50% of export sales

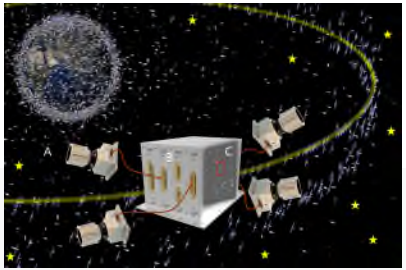
NEUTRONIC

SPACE CAMERAS

Auricam

- Surveillance & Detection
- Monitoring
- Rendez-Vous
- Exploration & Science

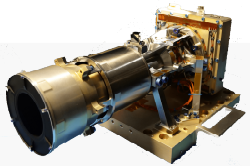
FOV 35°/60°
Mass <450g
Low Power <2W
7/15 year lifetime



Panoptes

- Multi-camera system for wide surveillance area
- On-board detection and tracking of intruders and debris
- Automatic recording of intruder image
- Star detection for accurate camera pointing

Custom Made



- Highly complex environments missions (scientific, military and commercial)
- Example: JUICE mission, ERO mission

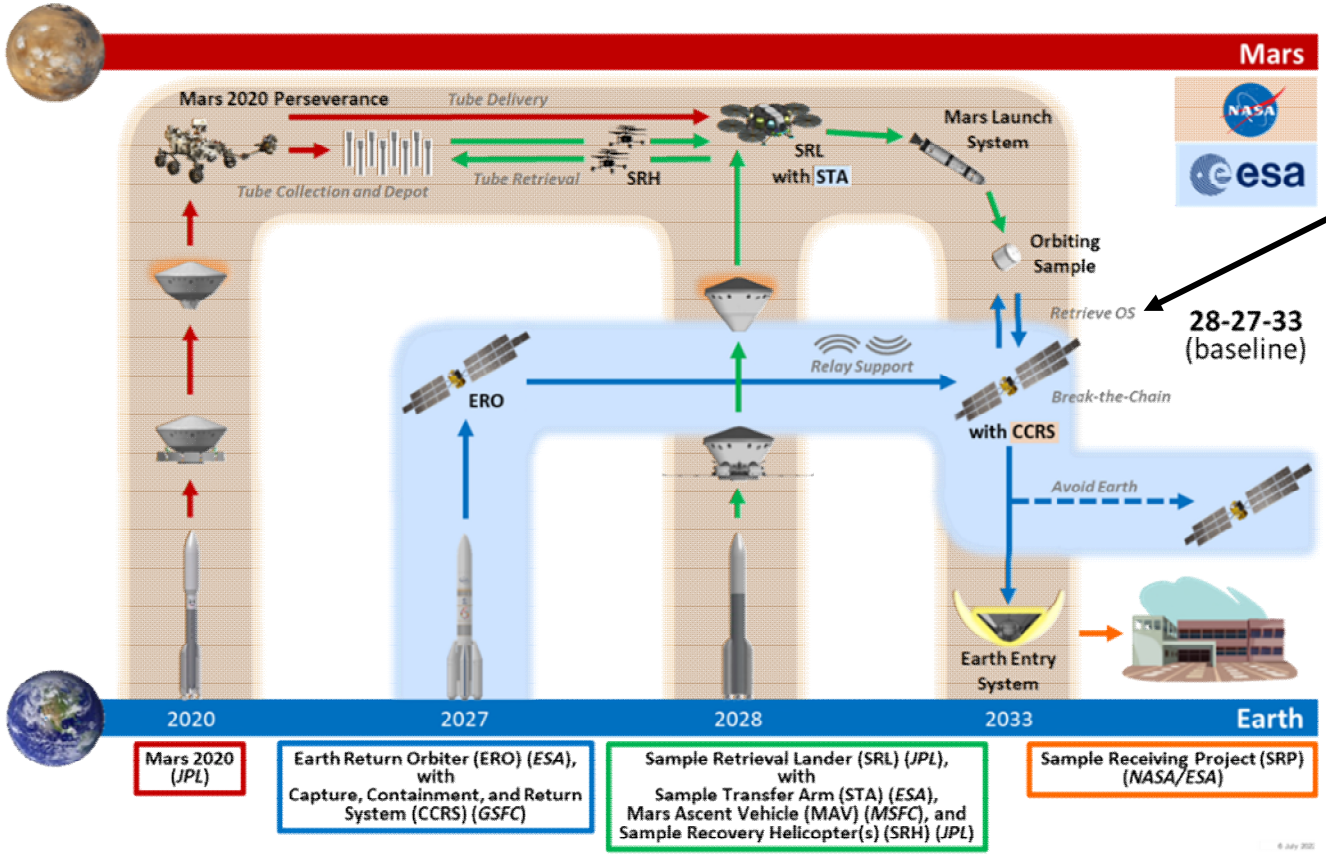
Aramis

Software for:

- Rendez-Vous
- Relative Navigation
- Final approach
- Lateral sensor

VIS & Infrared
Non-cooperative navigation
6°of Freedom
Long-range detection

OVERVIEW OF THE MARS SAMPLE RETURN PROGRAM



ERO (by Airbus)
with
2 x NACs

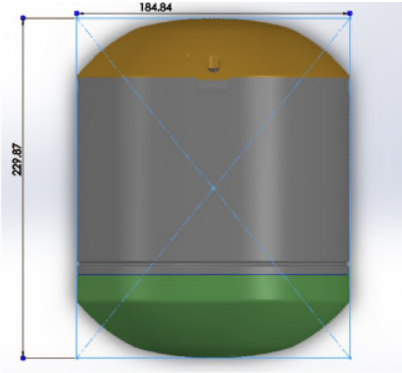
ORBITING SAMPLE

Canister storing the samples from Mars, about the size of a soccer ball

It is painted white to maximize the albedo

It is completely passive (no RF beacon, no light emitter)

It will be launched in orbit with poor precision



Preliminary dimensions of the OS

NAC MISSION OBJECTIVES

1. OS detection

considering

- up to 3000km distance
- with OS magnitude: up to 12,6
- with Mars at 12,5° of the line of sight

NAC images the OS & download images

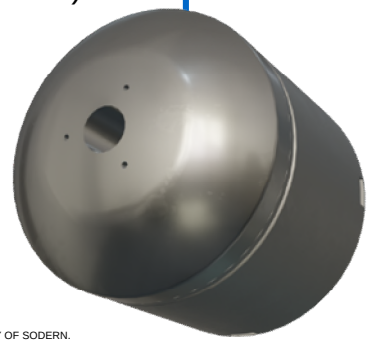
(No algorithm on board / Image treatment on earth)

2. Rendez-vous and Capture

NAC detects and calculates the OS centroid

Guides ERO for the orbit-matching with the OS

[last rendez-vous <400 meter made with another LIDAR system]



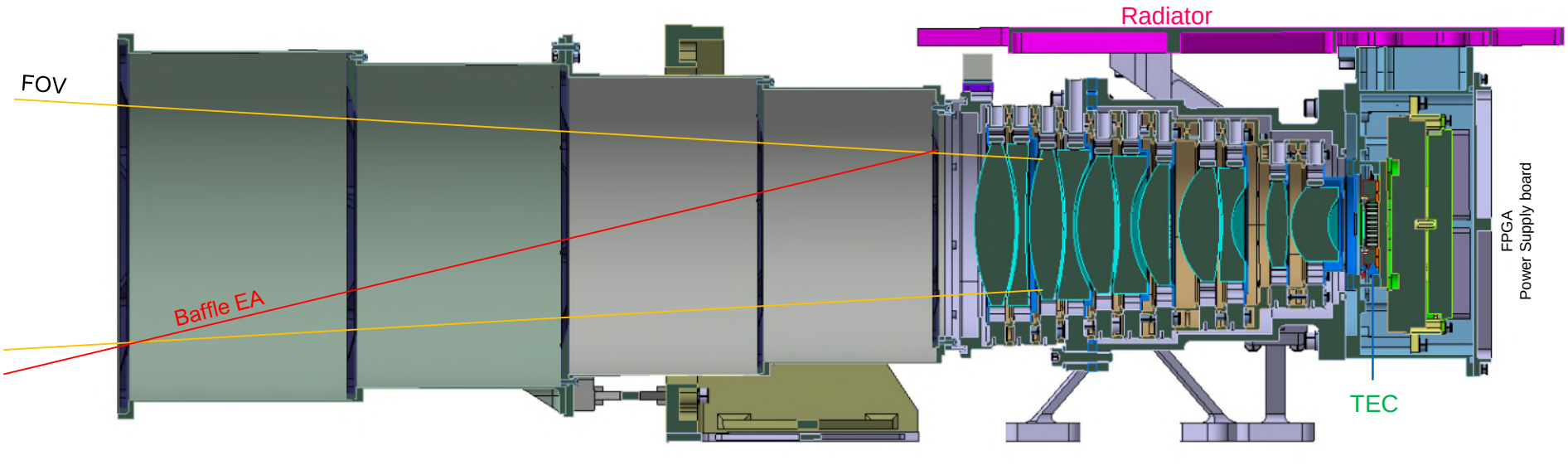
NAC CAMERA MAIN FEATURES

NAC reuses major elements of SODERN star tracker (power supply, detection module). **Optical Module & baffle** are specific developments.

Ultra Stable Optical Mount inherited from S5 UV-VI Spectrometer

Accurate thermal control to minimize impact of dark signal & defect pixels

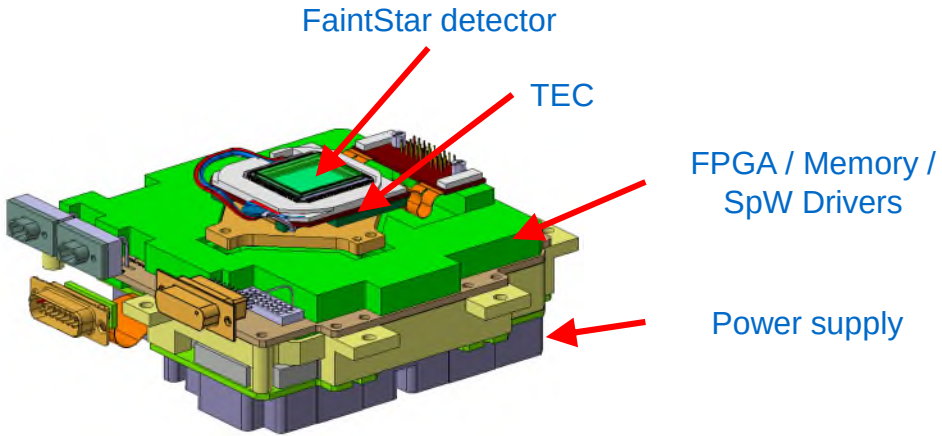
- SNR >3
- Field of view circular 4,5° circular
- Baffle exclusion angle : 14°
- Pupil: Ø80mm
- 14,5 kg
- Top ~20°C
- Pmax = 12 W



NAC PERFORMANCES

To achieve SNR performance (>3):

- Detector, cooled at -15°C for Dark Signal minimization
- High aperture optic: Ø80mm



All sources of noise are characterized before delivery to Airbus: Fixed pattern noise, Photo response non uniformity, Dark signal, distortion, chromatism

To the way to Mars, radiation may damage the detector

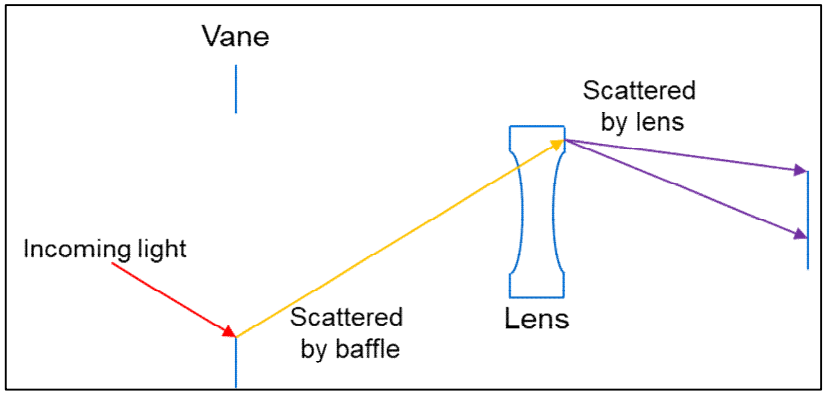
=> A calibration will be performed once the camera will be around Mars, for detection of defective pixels (spikes)

Ultimately: main contributor to noise is **Straylight** from Mars & Sun

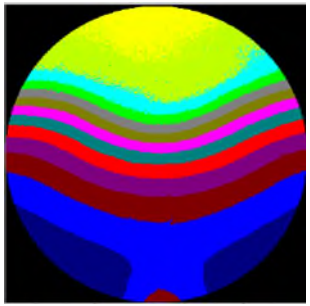
STRAYLIGHT MANAGEMENT

Straylight is generated by:

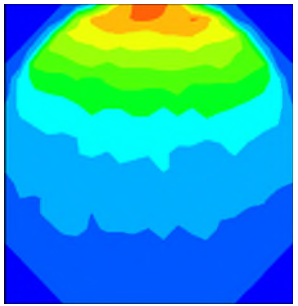
- Sources from outside the field of view (Sun, Mars), whose secondary reflections could reach the detector
  The role of the baffle is to protect the detector from such reflections as far as possible.
- Sources from inside the field of view (ghost images)



Straylight formation principle



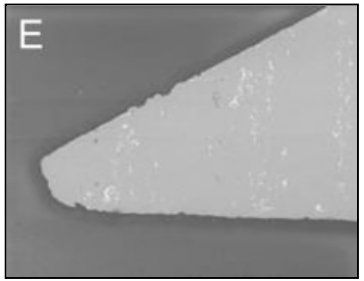
Observed by test with HYDRA

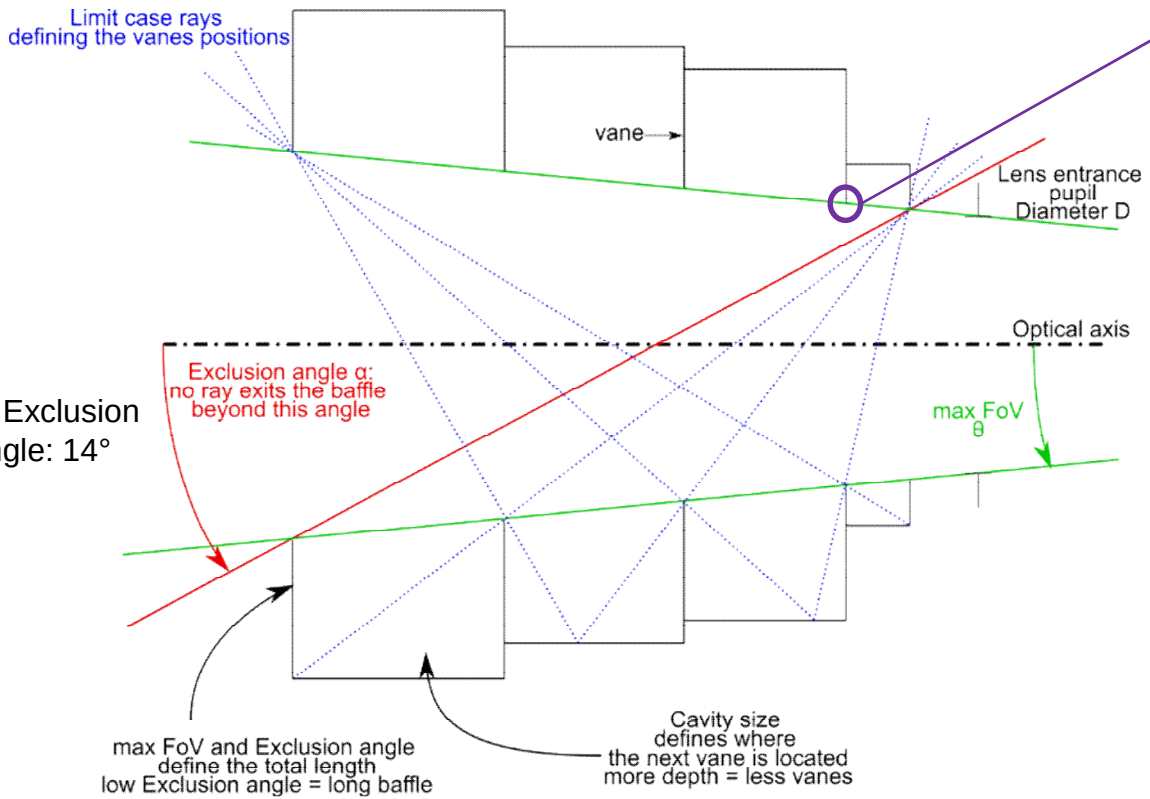


Simulated

NAC BAFFLE

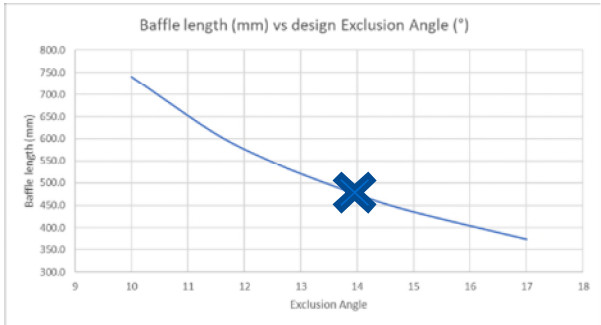
Vane radius 15-20µm





NAC Exclusion Angle: 14°

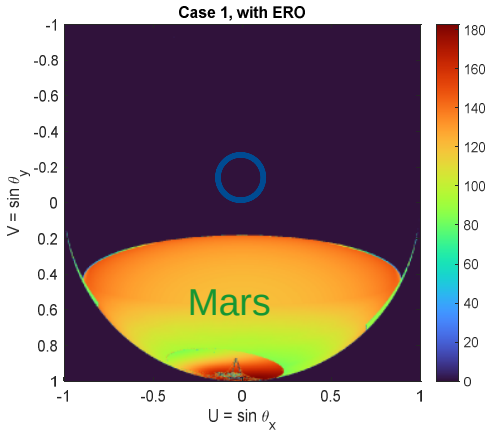
Min length of baffle



NAC STRAYLIGHT SIMULATION

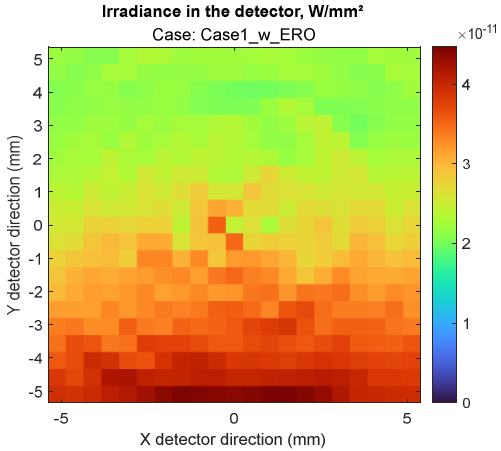
Sodern developed an **innovative simulation method for Straylight simulation**: **ATOS©** [15 years experience]

→ Enables construction of Straylight response based on scenes provided by our customer



Scene in front of the NAC in orbit around Mars

Courtesy of Airbus Defense and Space



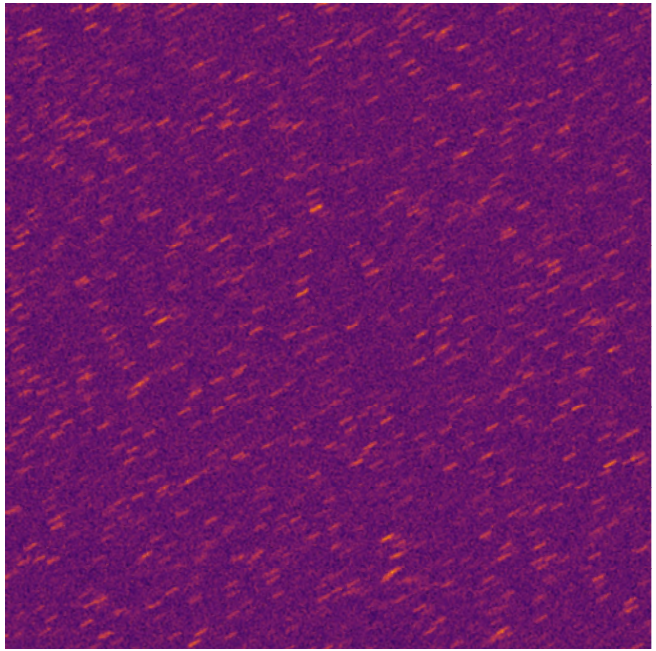
Straylight irradiance on the detector

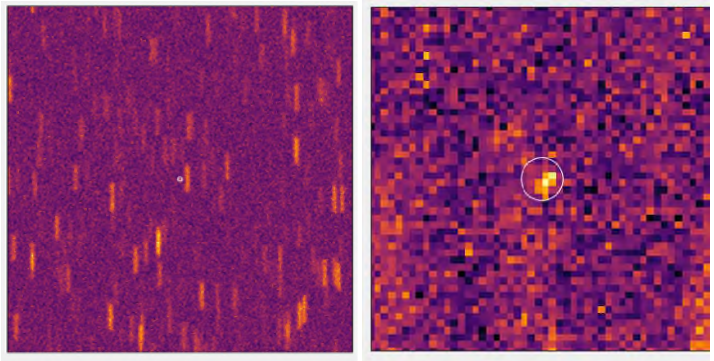
To learn more about this method :

Dubroca & al., Straylight Minimization in the design of the ERO Narrow Angle Camera, Proceedings of ICSO2022 (in press)

EXAMPLE OF NAC IMAGE

Image simulation using Sodern ATOS© camera simulator





- Orbiting samples at 1200km
- Integration time: 2s
- Simulates: space environment , radiation, samera, detector noise, star catalog
- Raw images will be downloaded on ground for OS detection

ERO NARROW ANGLE CAMERA

NAC Straylight performance test

A specific Straylight test is being developed in CSL (Liège).

Vacuum is necessary for this test

Project status and next steps

- PDR has been passed successfully
- NAC Engineering model fabrication is ongoing
- EM tests from May to October 2023
- CDR in July 2023
- FM fabrication for delivery to Airbus end of 2024

Courtesy of CSL / Liège Space Center

Thank you

The Narrow Angle Camera development is carried under the Earth Return Orbiter program, funded by the European Space Agency.
The views expressed herein can in no way be taken to reflect the official opinion of the European Space Agency.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