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ESA CLEAN SPACE DAYS

**ACCURATE AND COMPREHENSIVE SPACE CAMERA
DIGITAL TWIN FOR IMPROVED IOS MISSIONS**

# Presentation overview

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# INTRODUCTION

# Introduction

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## IOS MISSIONS POSE SEVERAL CHALLENGES TO OPTICAL SENSORS

- SNR / SATURATION
- RADIATIONS
- TEMPERATURE
- STRAYLIGHT

## SODERN HAS DEVELOPED A DIGITAL TWIN THAT ACCURATELY SIMULATES THE BEHAVIOUR AND THE PERFORMANCES OF ITS CAMERAS: AURICAM AND HICAM.

- COMPARING SOLUTION ON DIFFERENT SCENARIOS BEFORE DESIGN PHASE.
- IDENTIFYING POTENTIAL PROBLEMS OR IMPROVEMENTS FROM THE INITIAL PHASES OF DEVELOPMENT.
- MITIGATING RISK ON HARDWARE.

## CAMERA DIGITAL TWIN BENEFITS FROM SODERN LONG EXPERIENCE IN STAR TRACKERS
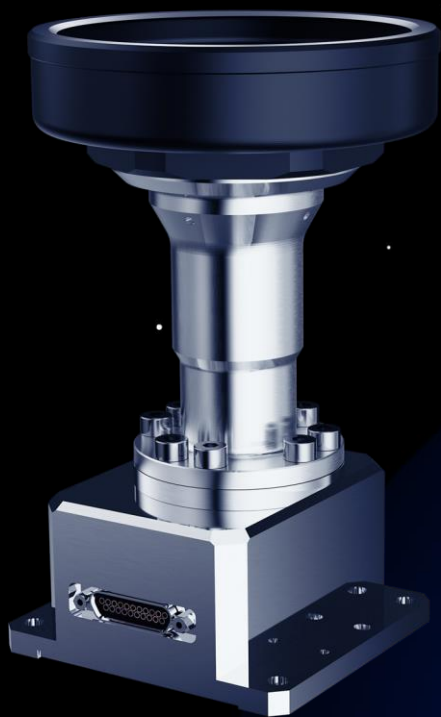
**DIFFERENT FIELDS OF VIEW:**   **8°** / **35°** / **80°** (in diagonal)

**MAIN CHARACTERITICS**

| Size | 140 x 71 x 65 mm |
|---|---|
| Detector | 4M pixels |
| Mass | <420 g |
| Lifetime in LEO/GEO | 7/15 years |
| Interface | Space Wire |

**MAIN PERFORMANCES**

| Magnitude | 6 − 9 |
|---|---|
| Resolution | 4 Mega pixels |
| Operational temperature | -25° up to 45° c |

**MAIN OPTIONS:**

- **Electronic Unit**
- **Digital twin**
- **EGSE & OGSE**

# HICAM

**DIFFERENT FIELDS OF VIEW:** **17°** (in diagonal)

**MAIN CHARACTERITICS**

| | |
|---|---|
| Size | 210 x 180 x 300 mm |
| Detector | 1024x1024pix / 10µm pitch<br>Detector cooling for low noise |
| Mass | < 3 kg |
| Lifetime in LEO/GEO | 7/15 years |
| Interface | Space wire |

**MAIN PERFORMANCES**

| | |
|---|---|
| Magnitude | 11<br>Distance: up to 30 000 km |
| Resolution | 1 Mega pixels |
| Baseplate operating range<br>(full perf with detector <5°C | -25° up to 20° C |

**MAIN OPTIONS:**

- **Target Imaging & Centroiding processing**
- **Digital twin** *(on request)*
- **Electronic Unit** *(on request)*
- **EGSE & OGSE** *(on request)*

# CAMERA DIGITAL TWIN

# Camera digital twin

ENTIRE CAMERA DETECTION CHAIN IS SIMULATED, IN THE CONTEXT OF VARIOUS MISSIONS.

- LEO, GEO, SSO
- AT BEGINNING OR END OF LIFE
- FOR DIFFERENT ENVIRONMENTAL CONDITION : TEMPERATURE, RADIATION

OPERATES IN 3 STEPS:

1) OPTICAL STIMULUS GENERATION
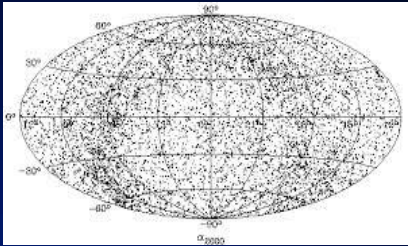
2) NOISING AND DIGITALIZATION
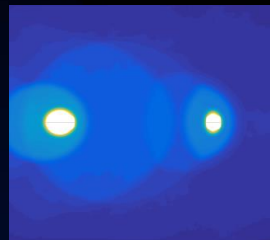
3) PROCESSING

# Camera digital twin

## STEP 1 : OPTICAL STIMULUS GENERATION

### SIMULATE CELESTIAL SCENE AND ENVIRONMENT
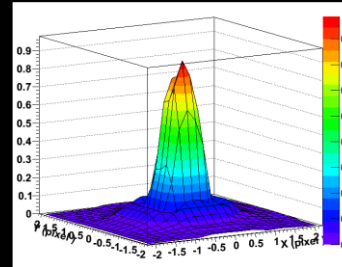
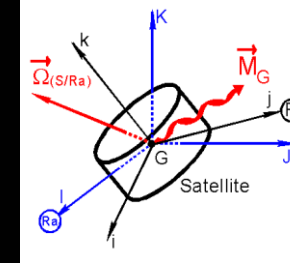Star catalogue          Straylight          Intrapixel sensitivity          Satellite kinematic          Object
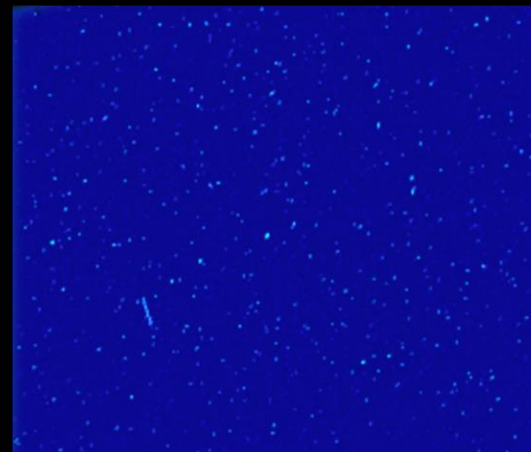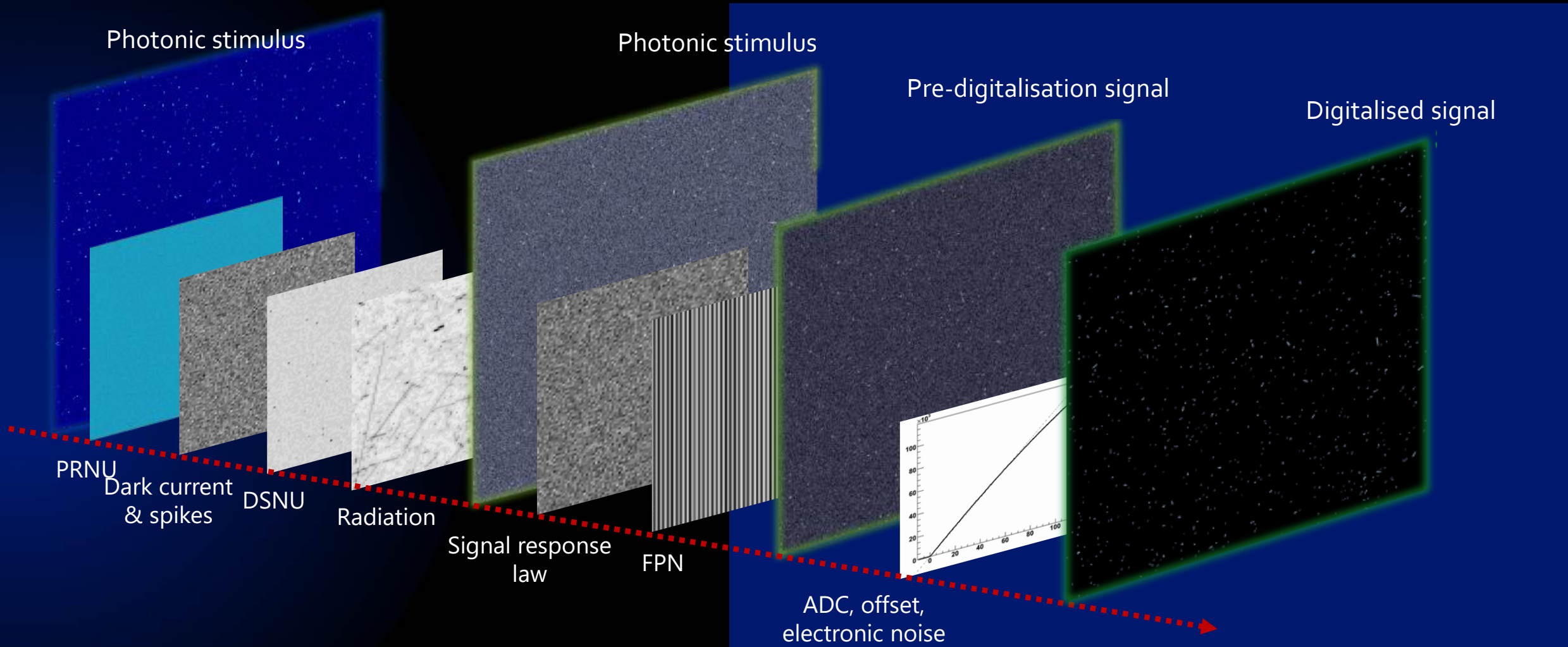


Photonic stimulus

# Camera digital twin

## STEP 2 : NOISING AND DIGITALIZATION

SUCCESSIVELY GENERATES AND SUPERIMPOSES LAYERS TO CREATE A MULTI-PHYSICS IMAGE.



Photonic stimulus

Photonic stimulus

Pre-digitalisation signal

Digitalised signal

PRNU

Dark current
& spikes

DSNU

Radiation

Signal response
law

FPN

ADC, offset,
electronic noise

# Camera digital twin

## STEP 3 : PROCESSING

REALIZES PROCESSING INCLUDED IN OPTICAL HEAD OR ELECTRONIC UNIT.

Digitalised signal

Auto exposure effect

### PROCESSING INCLUDES

- RADIATION/SPIKE/PARTICLE FILTERING

- AUTO EXPOSURE

- BACKGROUND SIGNAL CORRECTION

# USE CASES

# Use cases

## EVALUATE CAMERA PERFORMANCES

Digital twin is parametrable for different orbits, age, temperature ...



LEO - BOL



LEO - EOL

# Use cases

## EVALUATE DEBRIS DETECTION ALGORITHM

OBJECTS CAN BE ADDED WITHIN IMAGES
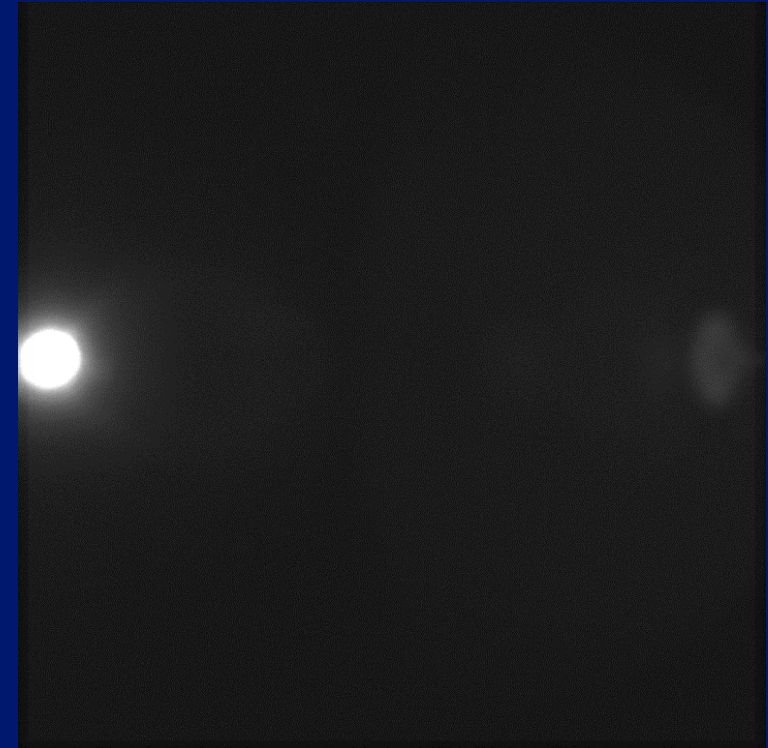


Point like objects



Extended objects

# Use cases

## EVALUATE CAMERA PERFORMANCES ON SPECIFIC CASE

FOR INSTANCE, MOON CAN BE ADDED IN THE FIELD OF VIEW



Moon at 0°



Moon at 15°

# Conclusion

CAMERA DIGITAL TWIN IS A MULTI-PHYSIC SIMULATION C/C++ LIBRARY FOR ALL SODERN CAMERAS

- TRY AND ERROR AT LOW RISK AND COST.

- MAXIMIZES ACCURACY, REDUCES COSTS AND LEAD TIMES.

VALIDATED BY

- 20 YEARS OF HERITAGE FROM ATOS ( STAR TRACKER SIMULATION TOOL DEVELOPED BY SODERN).

- COMPARISON WITH REFERENCE (FOR INSTANCE VALIDATED WITH ESA FOR JOVIAN ELECTRONS INTERACTIONS AGAINST HEAVY GEAT4/FASTRAD RADIATION CODES & GROUND TESTS).

- SIMULATION PARAMETERS FROM REAL HARDWARE MEASURED ON TEST BENCHES.

- DEVELOPED FOLLOWING SOFTWARE DEVELOPMENT GUIDELINES.

AVAILABLE IN 2025 WITH USER MANUAL.

QUESTIONS