A FLASH-LIDAR FOR IN-ORBIT SERVICING

A.H. HANSEN, T. KIRKHUS, V. DUBANCHET, K.H. HAUGHOLT

ASTRA, 19-OCT-2023, LEIDEN, NL

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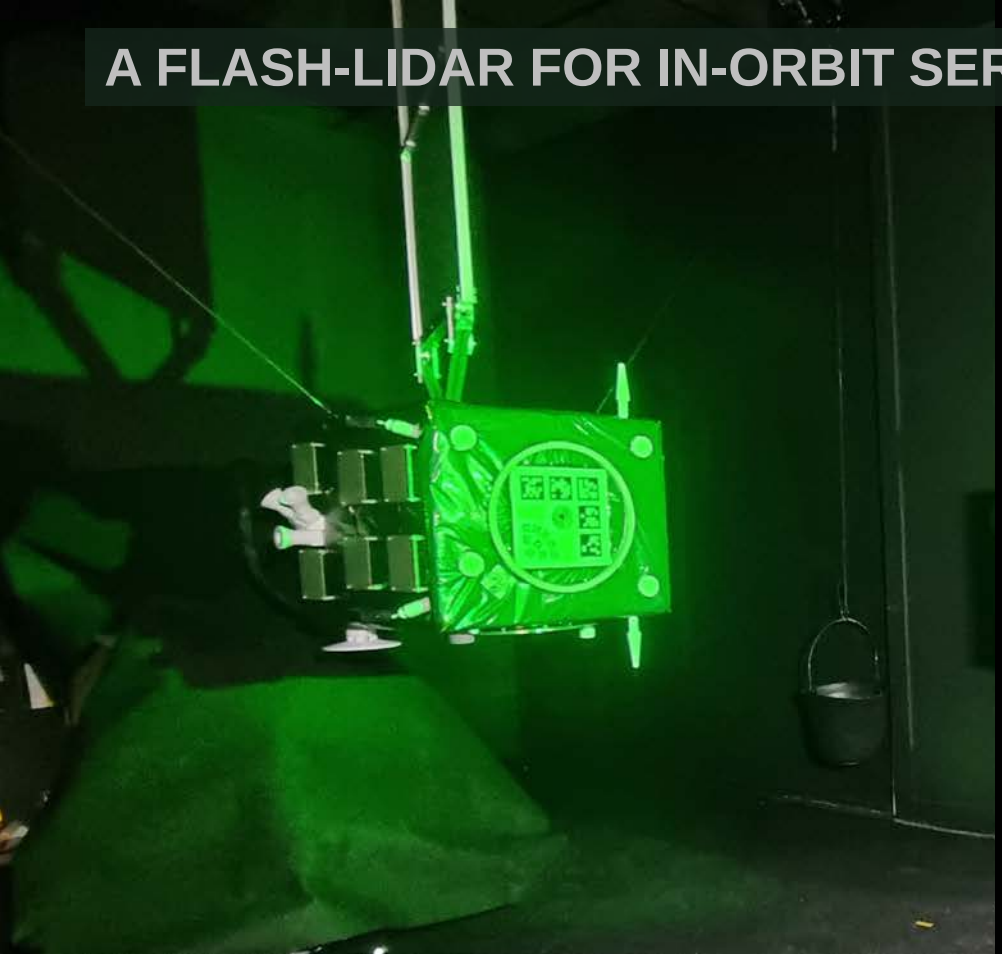

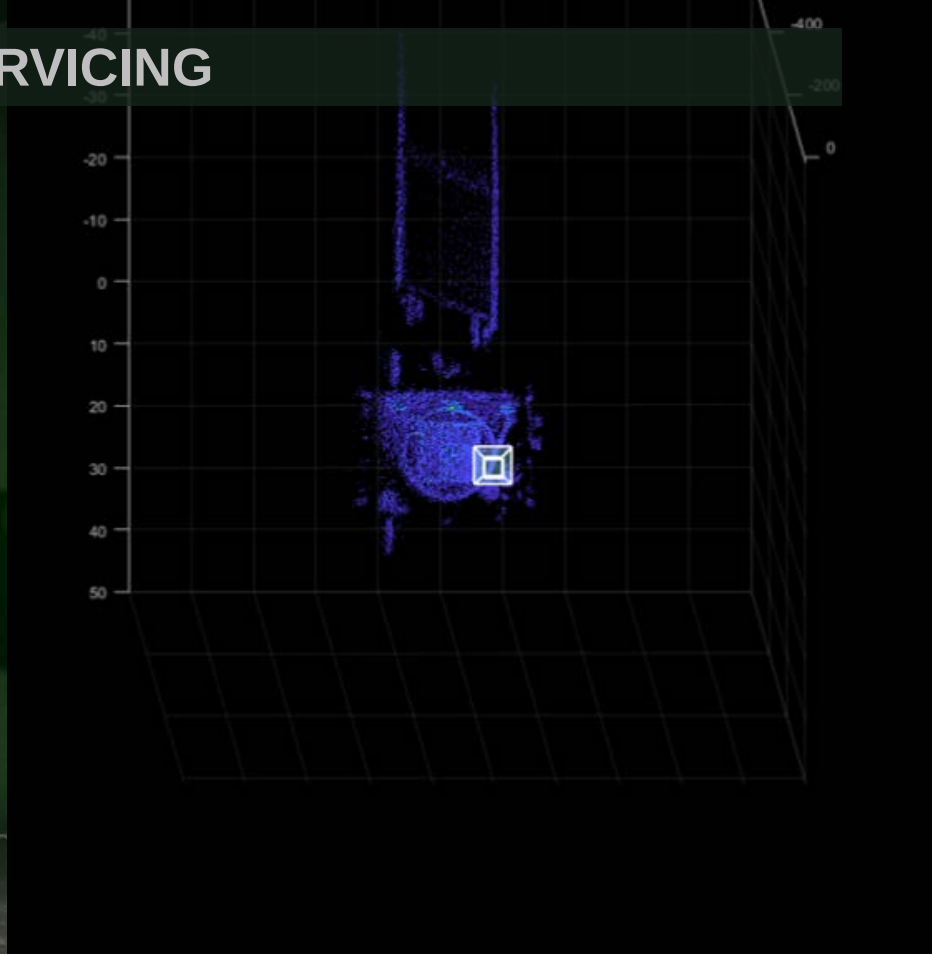

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EROSS IOD
European Robotic Orbital Support Services
In-Orbit Demonstration

WHY 3D VISION IN SPACE?

///Accurate ranging at long distances

///Direct measurement of shape and distance

///Decisions based on actual shape,
not 3D-model

///Independent of range and illumination

///Ease of segmentation

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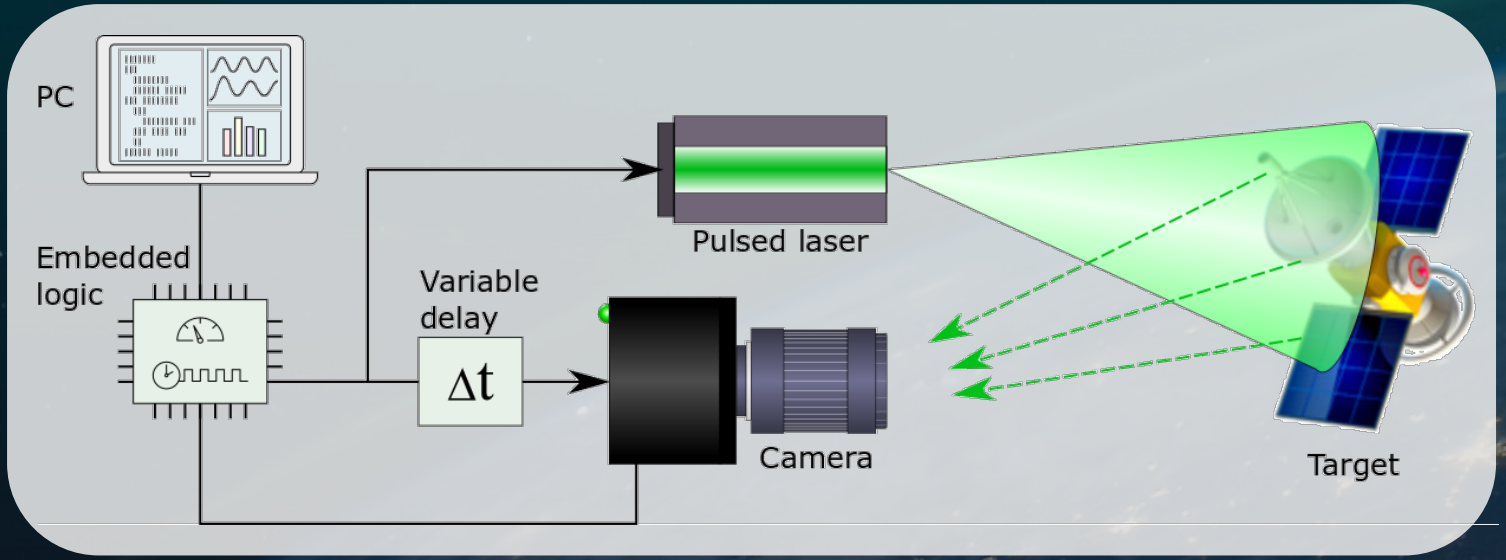
TIME-OF-FLIGHT IMAGING



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RANGE-GATED 3D

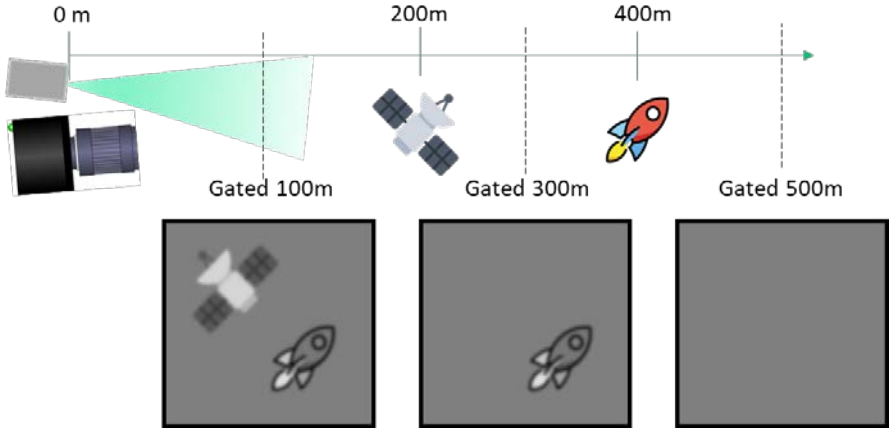
/// Delay line between laser and camera

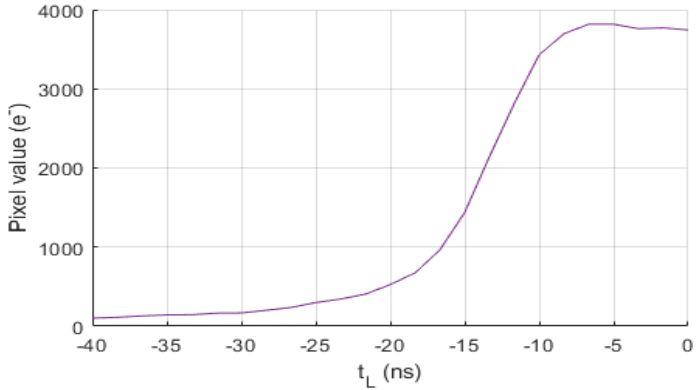
/// Makes camera "blind" to foreground

/// Delay sweep to get 3D

/// Typical step size 1.7 ns (25 cm)

/// Computationally light super-resolution algorithms





P. Risholm et al., “Real-time super-resolved 3D in turbid water using a fast range-gated CMOS camera,” Applied Optics, vol. 57, no. 14, p. 3927 (2018)

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RANGE-GATED 3D – REAL DATA

/// Empirical data from Nittedal Teleport, Norway

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THE UTOFIA STORY

(Underwater Time-Of-Flight Image Acquisition)

/// Horizon 2020, 2015 – 2018,
coordinated by SINTEF

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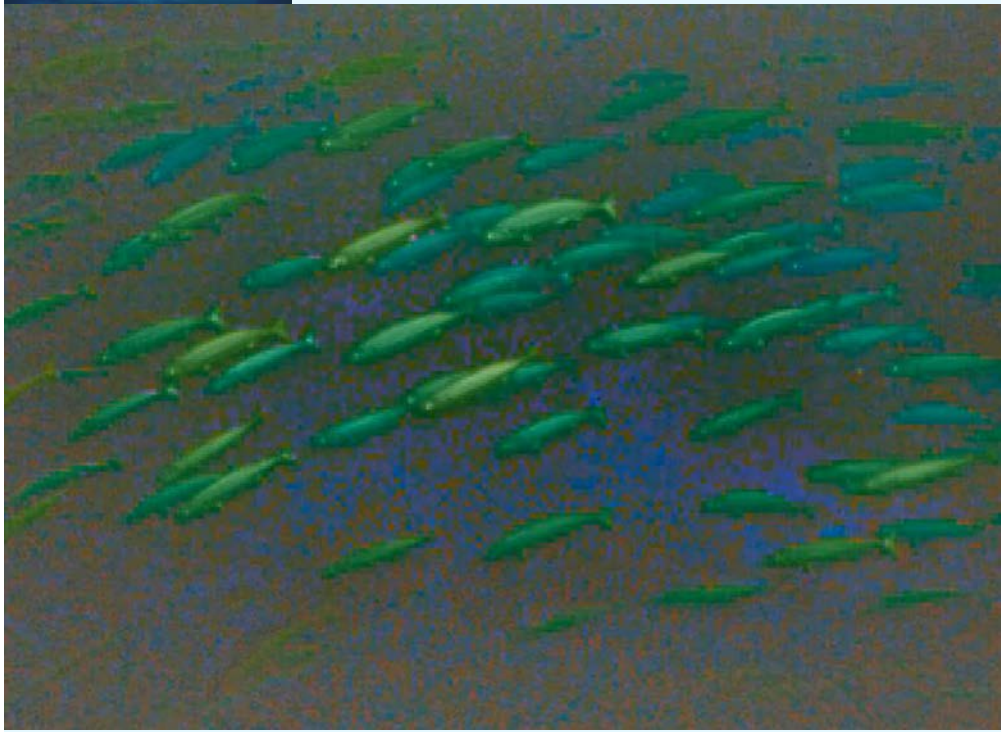

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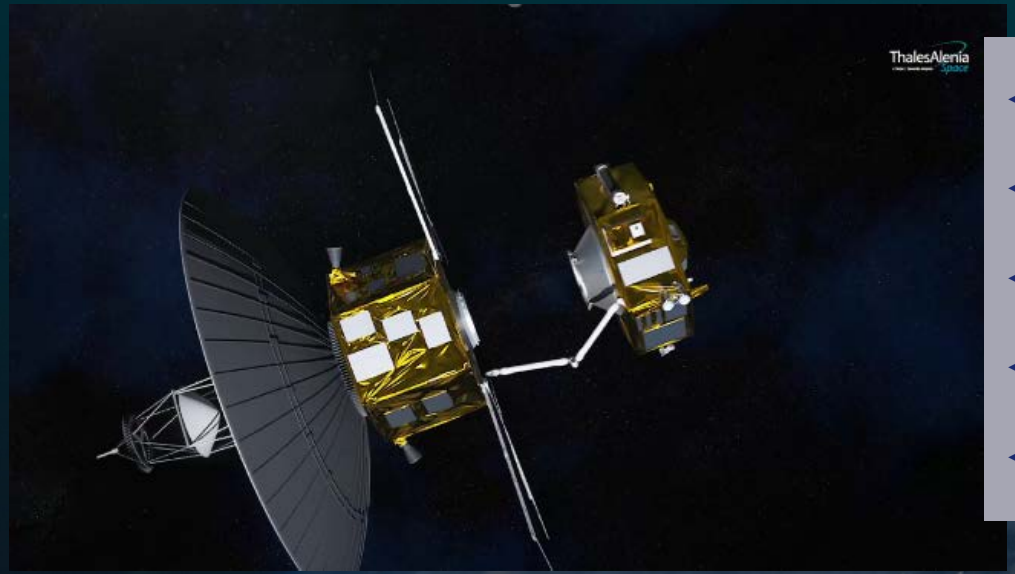
IN-ORBIT SERVICING



- Inspection
- Docking
- Refueling
- Payload upgrade
- De-orbiting

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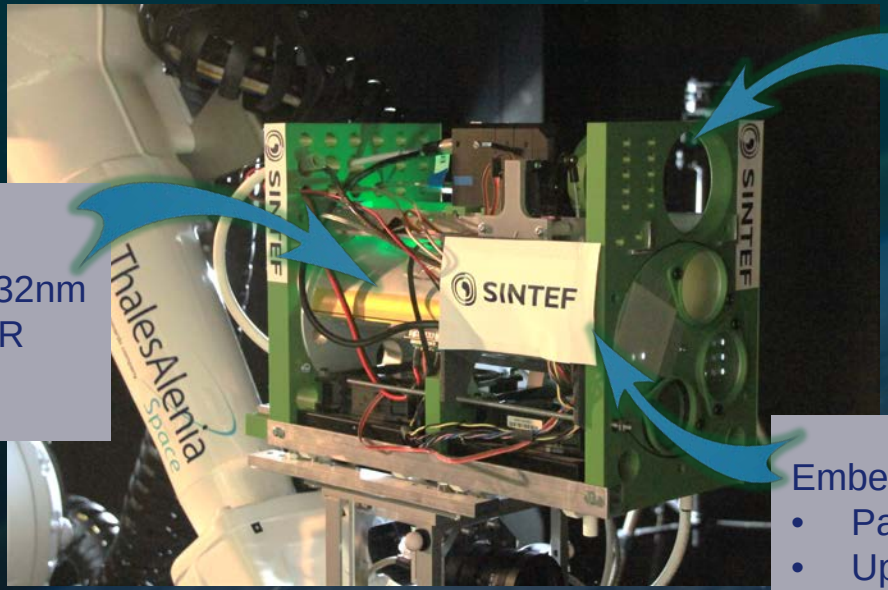

Nd:YAG Laser
- Frequency-doubled to 532nm
- 4 mJ pulses at 1kHz PRR
- Ultra-low timing jitter

CMOS Sensor
- 1.3 MP format
- Low timing jitter

Embedded Logic
- Parallel 3D rendering
- Up to 10x super-resolution

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OSLO LANDMARKS

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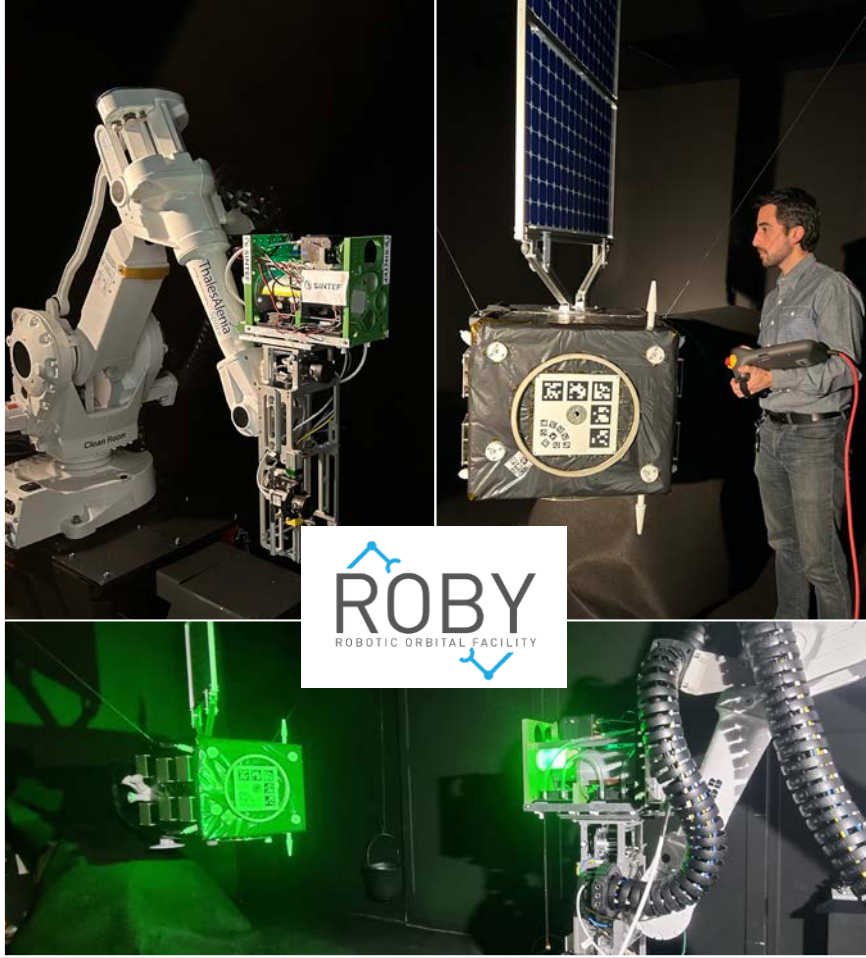
ROBY TEST BENCH AT THALES ALENIA SPACE

/// Robotic Orbital Facility (ROBY)
TAS-F, Cannes, France

/// Dual robotic arms + rail track
6 + 6 DoF; 2 – 12 m range

/// In-motion, open-loop data collection

/// Pose tracking of flash-lidar point clouds compared with robotic positioning data



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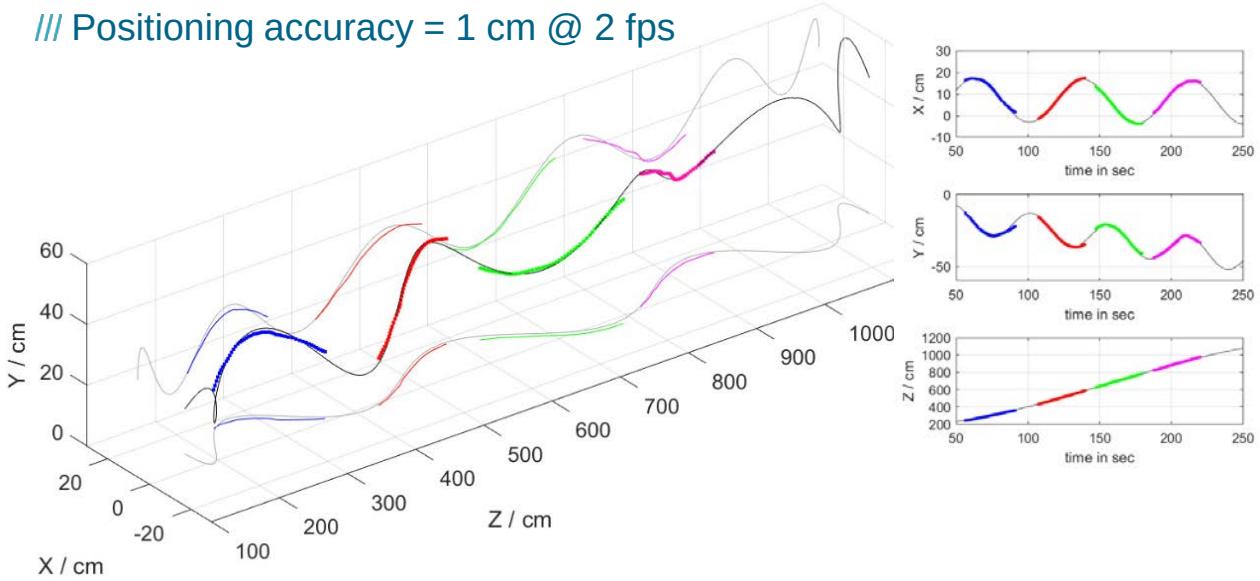
In-Orbit Demonstration

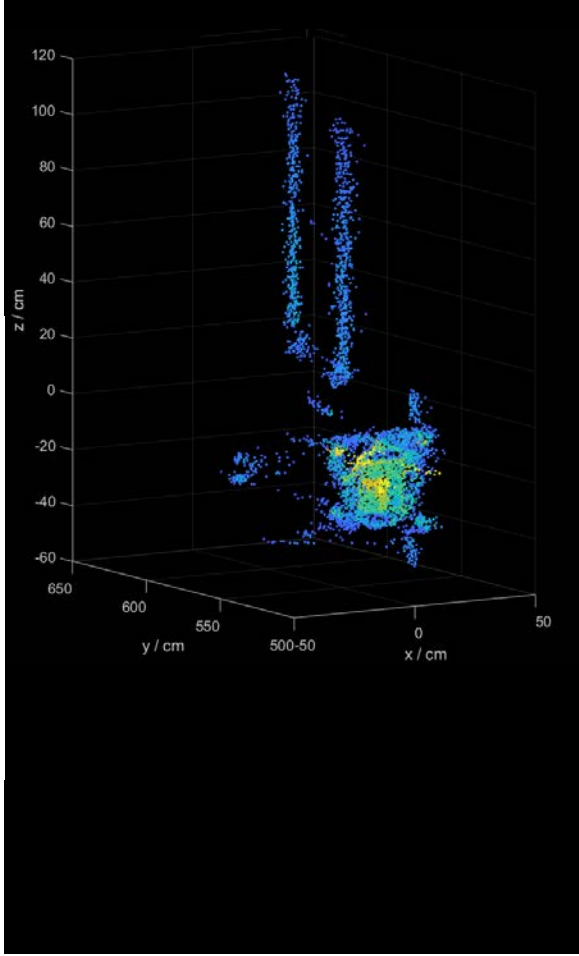
PATH TRACKING

/// Satellite approach recorded in 4 segments

/// Test bench data in gray

/// Positioning accuracy = 1 cm @ 2 fps





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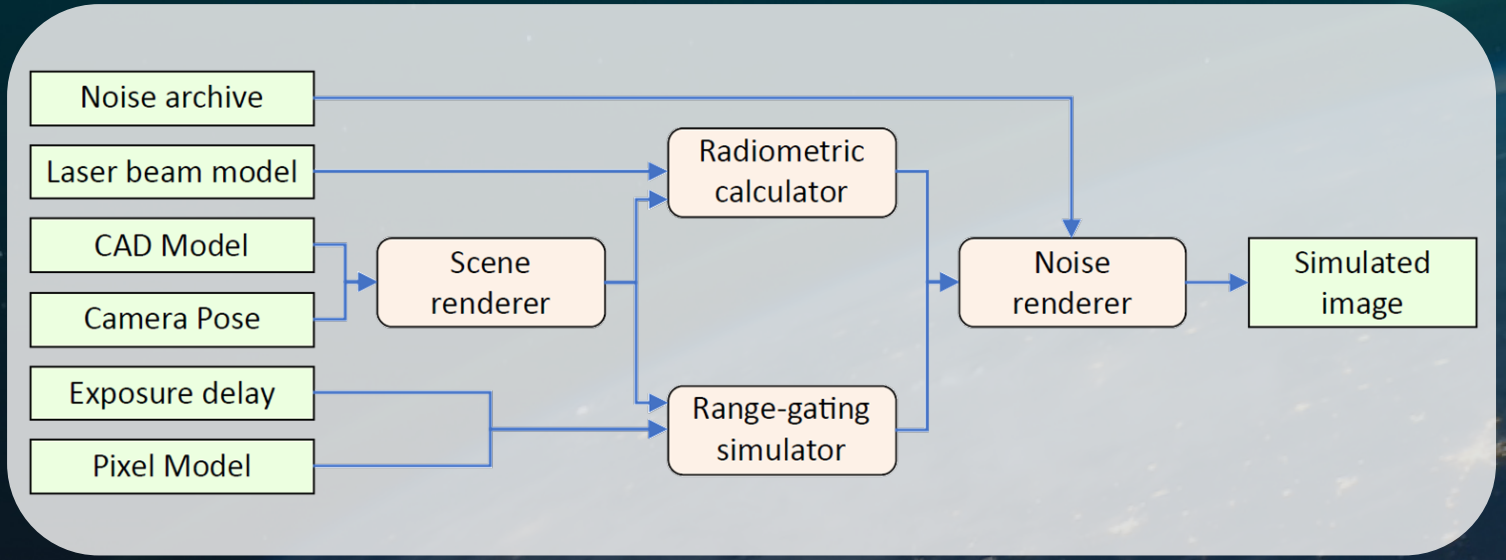
SIMULATOR



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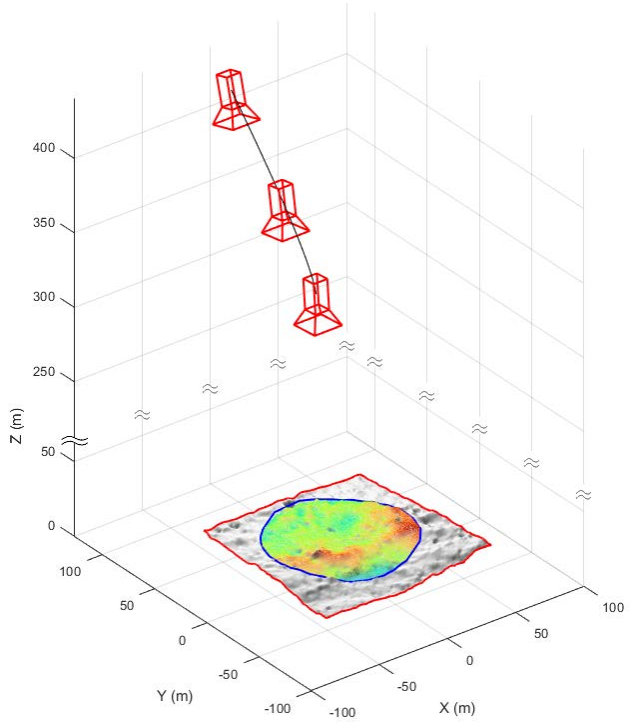
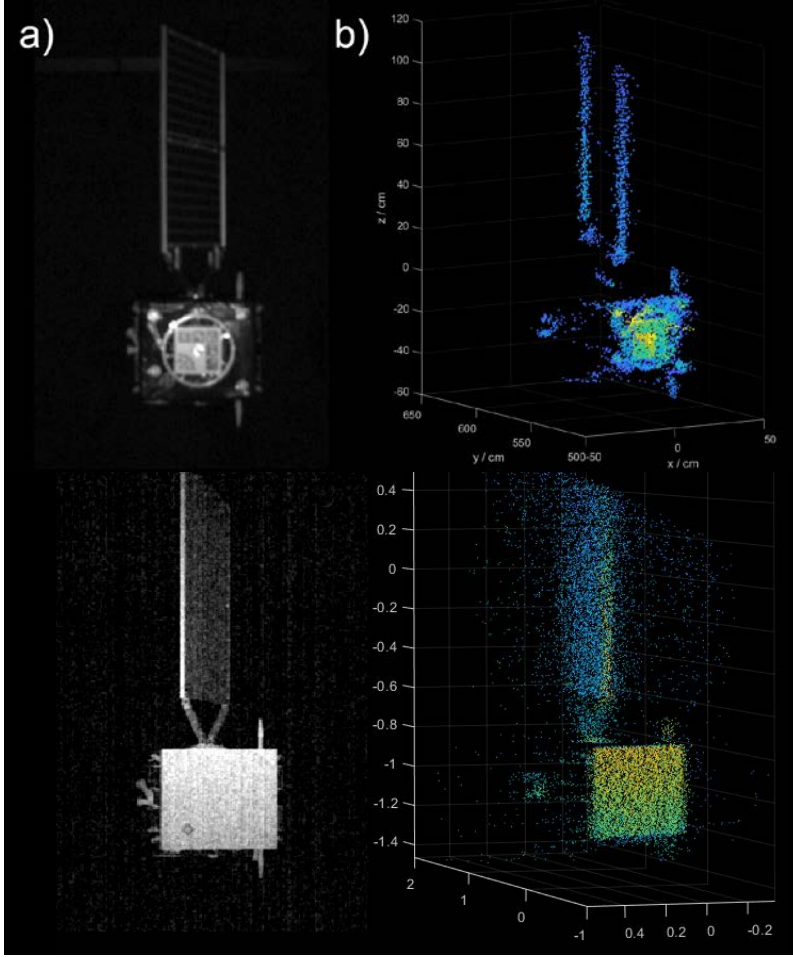
SIMULATION TOOL: EXAMPLES





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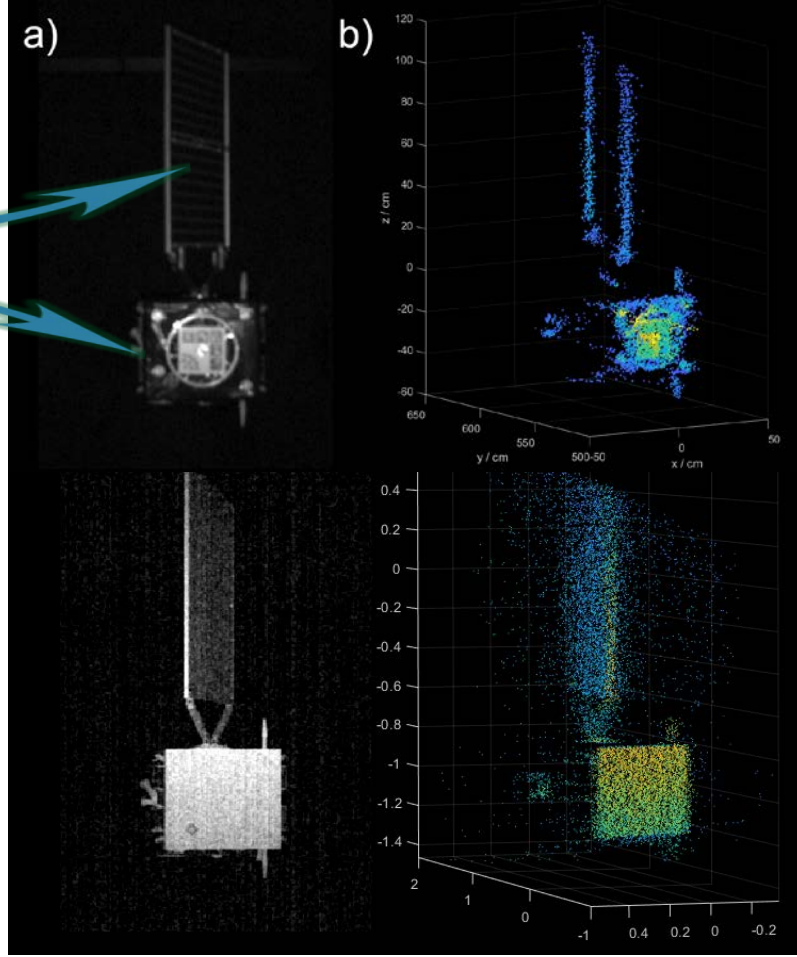
SIMULATION TOOL: EXAMPLES

/// Main difference: Specular surfaces

- No data from solar panels
- MLI yields reduced and uneven reflectance

/// Best performance on matte surfaces:

- Brushed metal
- Plastic & 3D print
- Marker plates



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3D VISION FOR IN-ORBIT SERVICING

/// Flash-LIDAR is well-suited for rendezvous operations, until ~1m range

Very long-range High measurment rate Raster-free 3D No moving parts

/// At the shortest ranges, geometric 3D is more accurate than time-of-flight

	Flash-lidar	Scanning lidar[1]	Structured light[2]	2D vision
Range	2 m - 4 km	1 m - 1.5 km	0.5 m - 1.5 m	0.5 m - 1.5 m
Accuracy	~ 1 cm	?	~ 0.1 mm	~ 1 mm
Pixel rate	10 MP/s	40 kP/s	2.5 MP/s	>> 10 MP/s
SWaP	High	Very high	Low	Very low

[1] Based on specs from Jena Optronics RVS-3000-3D

[2] Please stay for our colleague J. Thielemann's presentation on structured-light 3D! ☺

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