The RVS3000 and RVS3000-3D LIDAR Sensors: Recent Technological Advances and Future Applications

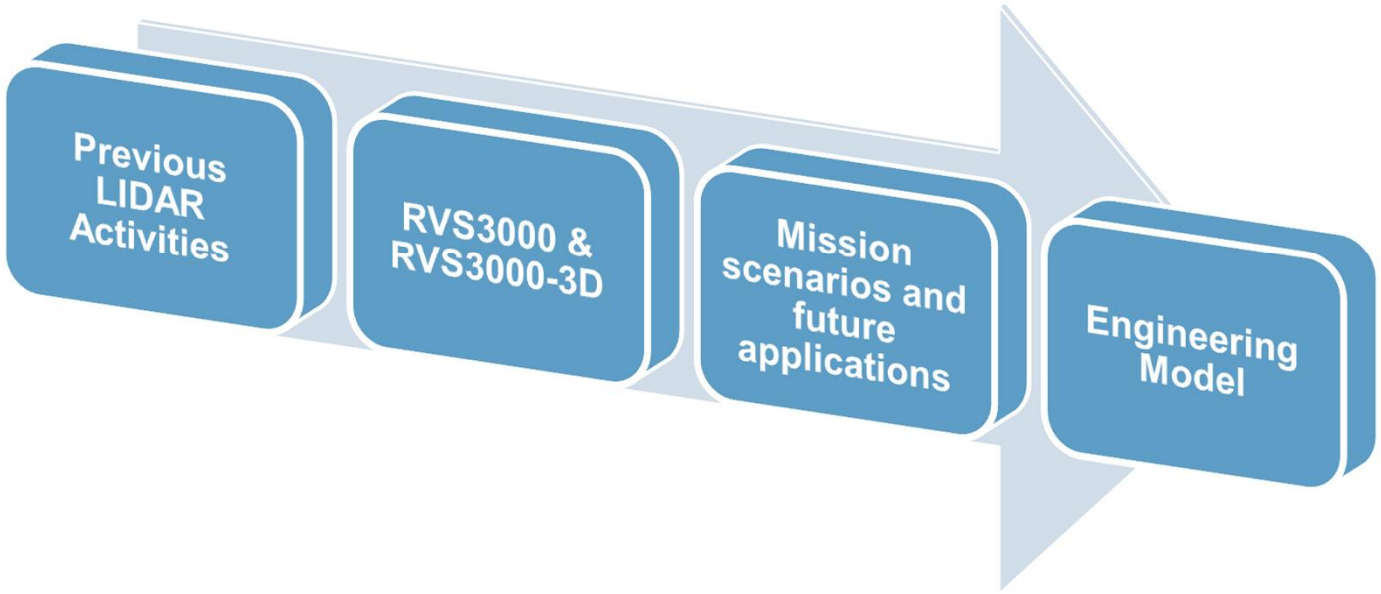
CleanSpace Industrial Days, 25-Oct-2017 @ ESTEC

Florian Kolb, Sebastian Dochow, Mario Rößler, Christoph Schmitt, Michael Windmüller

OVERVIEW

jenaoptronik

Overview



PREVIOUS LIDAR ACTIVITIES

Jena Optronik

Jena-Optronik LIDAR Sensors



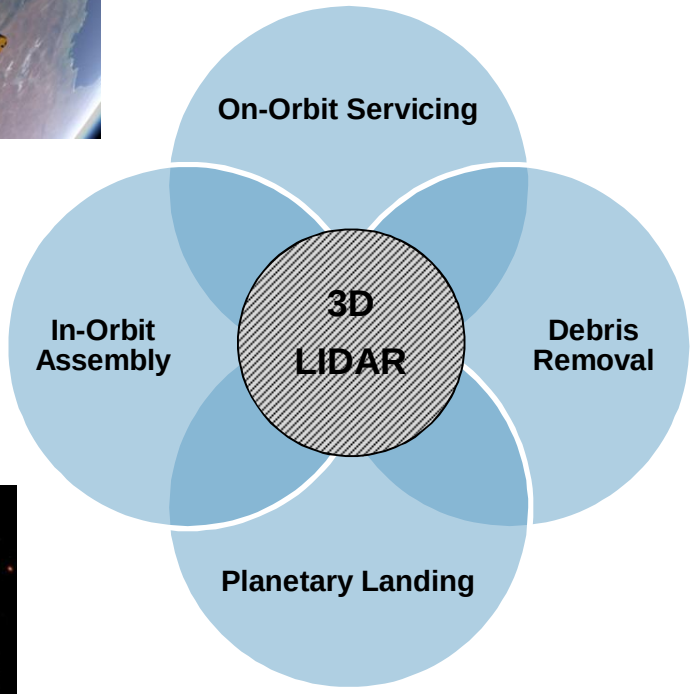

RVS-ARP

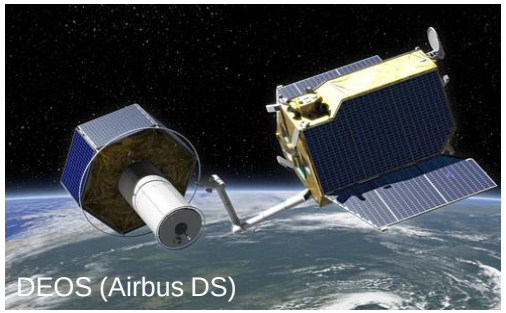
RVS for ATV / HTV / Cygnus

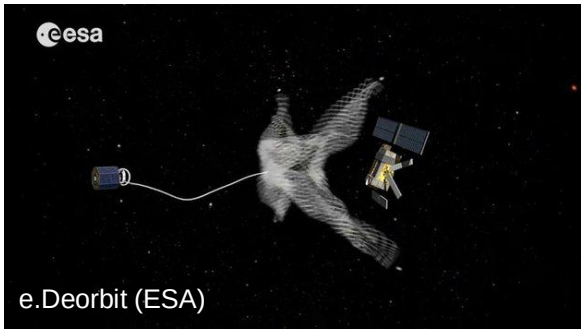
42 Flight Models delivered, 48 under contract, flawless flight heritage


jenaoptronik

New Challenges



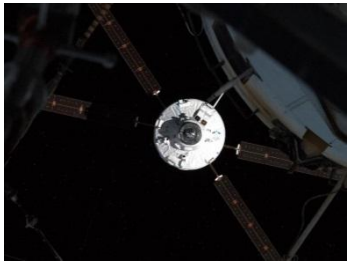
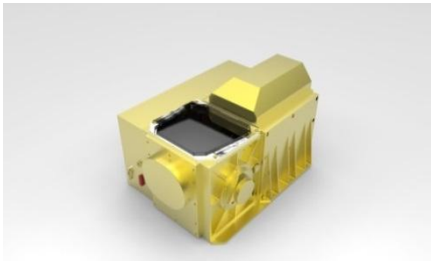




Jena-Optronik LIDAR Sensors



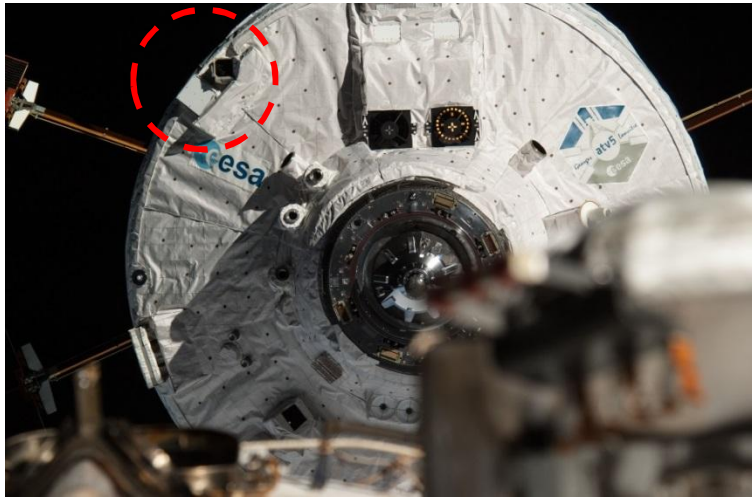

RVS-ARP → **RVS for ATV / HTV / Cygnus**
42 Flight Models delivered, 48 under contract, flawless flight heritage

LiQuaRD* → **LIRIS-2 on ATV-5** → **RVS3000**

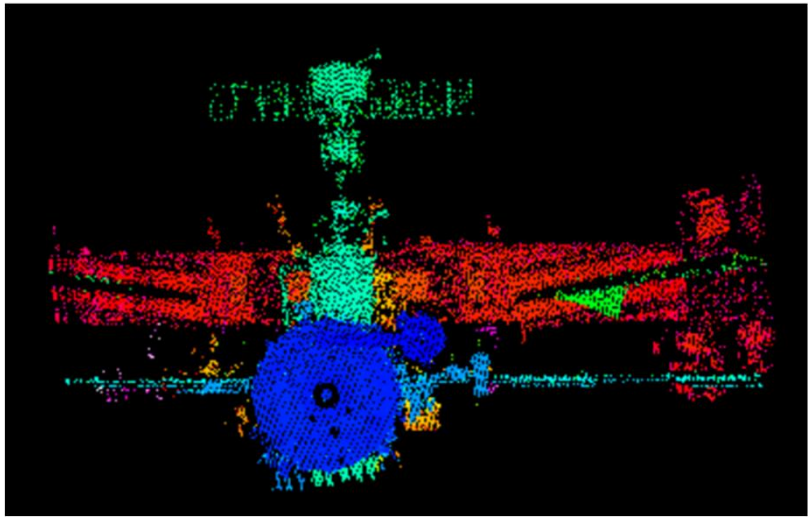
* LIDAR Qualification for Rendezvous and Docking (DLR)

LIRIS-2 – RVS3000 Prototype on ATV-5



RVS3000 prototype on ATV-5

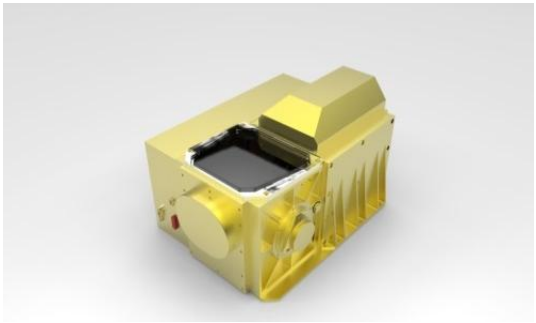
- Recording of 3D point clouds from ISS during rendezvous and docking
- Demonstration of 3D LIDAR technology



ISS at about 30m distance from docking port

RVS3000 & RVS3000-3D

One Box – Two Versions



jenaoptronik

LIDAR Sensors
RVS3000 and RVS3000-3D

RVS3000

cooperative targets

3D-LIDAR in One-Box-Design

ISS Re-Supply

- intended for cooperative targets (retroreflectors), e.g. ISS sup
  → short-duration LEO
- Operating Range: <1 p to 3000m
- internal data processing for retroreflector targets
- reduced laser power for eye safety
- One-box-design for simplified test, handling and installation
- Interface and software-compatible with heritage RVS

RVS3000-3D

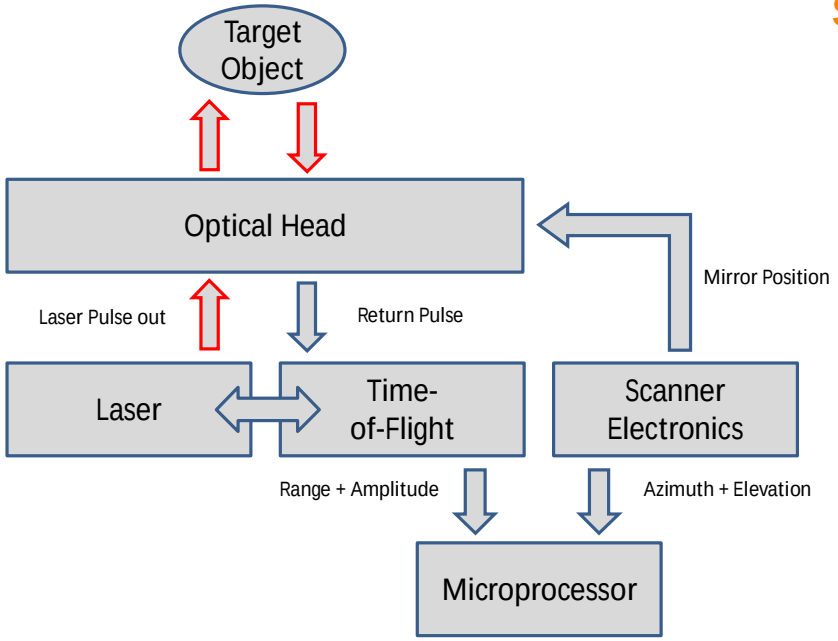
non-cooperative targets

3D Imaging LIDAR in One-Box-Design

Space Robotics

- intended for non-cooperative targe
  space robotics, on-orbit-servi
  → long-duration LEO/G ions
- Operating Range: dep ding on target reflectivity characteristics, e.g. for reflectivity 0.16 → <1m up to appr. 1500m
- more powerful internal processing than RVS3000 (additional Image Processing FPGA)
- high laser power for large operating range against non-cooperative targets

RVS3000(-3D) Design Concept



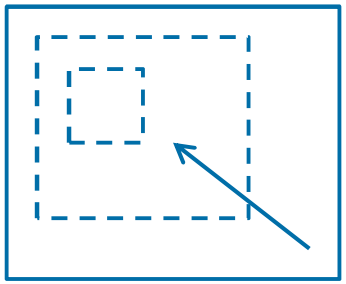
Scanning LIDAR system

- Optical Head with scan mirror assembly
- Laser and time-of-flight range finder provides range and amplitude information (+ rough pulse duration)
- Scanner electronics drives the optical head and provides LOS information
- Microprocessor unit combines the data into a 3D („4D“ with amplitude) data stream and performs data processing and interface to spacecraft

Features of Scanning LIDAR Concept

Large degree of flexibility with respect to Field-of-View

- Freely defined rectangular scan windows within total Field-of-View



Variable scan speed

- Slow high-resolution scans with “megapixel” images
- Fast scans for proximity operations with moving/rotating objects.

High dynamic range and range resolution/accuracy

- One send/receive channel – this channel can be designed to allow for a high dynamic range, a high range resolution, and a high accuracy.
- Constantly high performance within the total LIDAR FOV
- Switchable laser power levels

RVS3000

Mission Scenarios and Future Applications

jenaoptronik

Mission Scenarios

Retro Reflector RvD

- Identification and tracking of a target equipped with retro reflectors
- Robust measurement against high reflectivity retro reflectors
- Identification of reflectors based on JOP heritage algorithms for ISS scenario

RVS3000

Satellite Servicing and Debris Removal

- Acquisition and tracking of an uncooperative target
- Aquisition of 3D PointClouds against mostly diffuse surfaces
- Application of 6DOF model-based image processing algorithms

Planetary landing

- Acquisition of high resolution maps
- Measurement against a variety of materials and reflectivity characteristics
- Enabling image processing for safe landing spot detection

RVS3000-3D

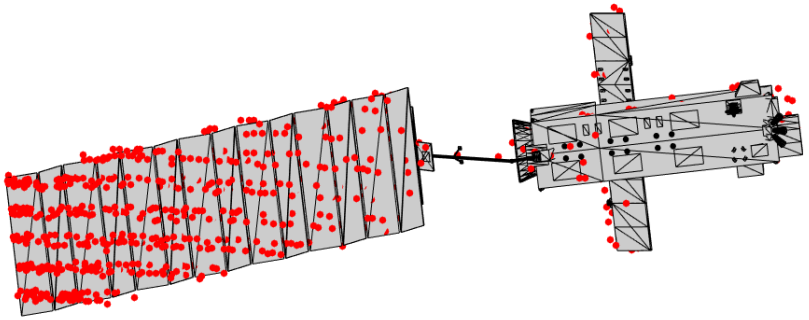
RVS3000-3D

LIDAR Pose Estimation

RVS3000-3D Pose Estimation

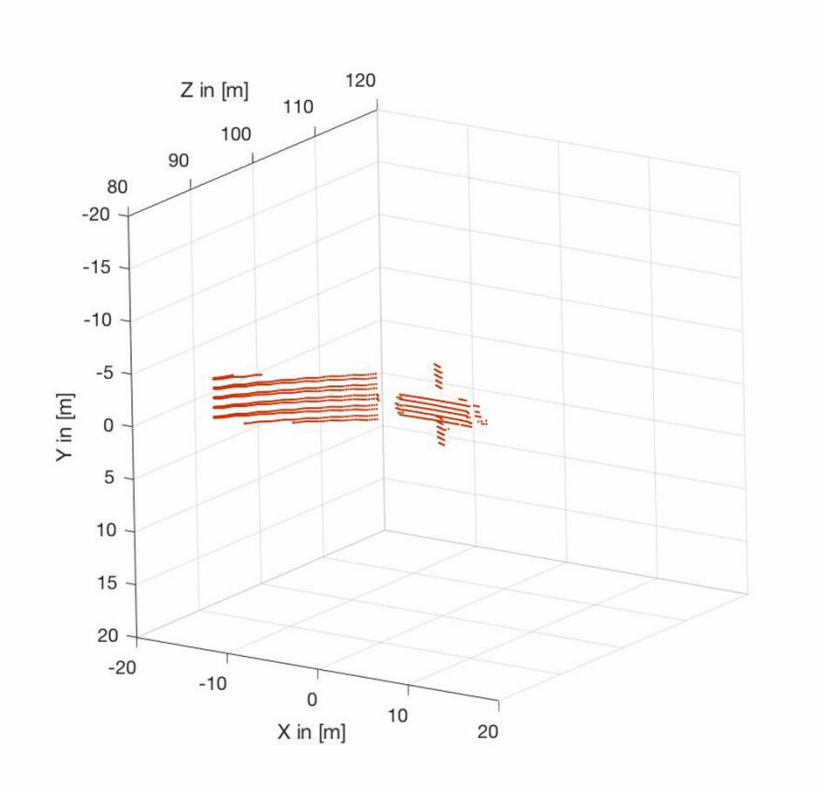
- LIDAR + Image processing = “One Box Solution”
- Real-time calculation of 6DOF information
- Application of Iterative Closest Point Algorithm
- Matching between LIDAR scans and target CAD model

Debris Removal Scenario

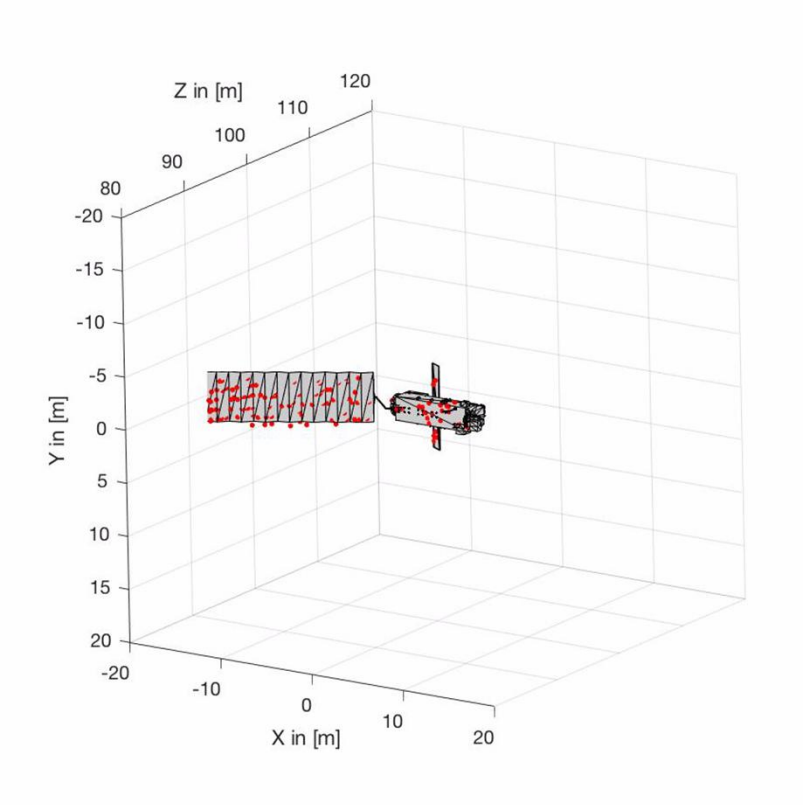


Match Scan Data with CAD Model

Debris Removal Scenario



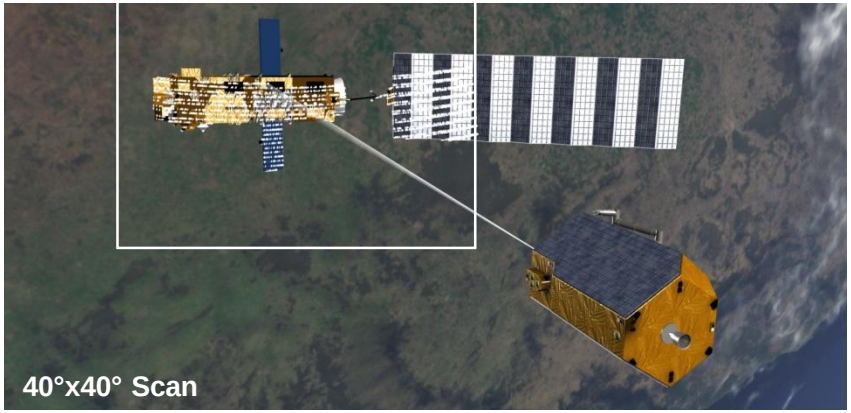
Simulated 3D PointClouds

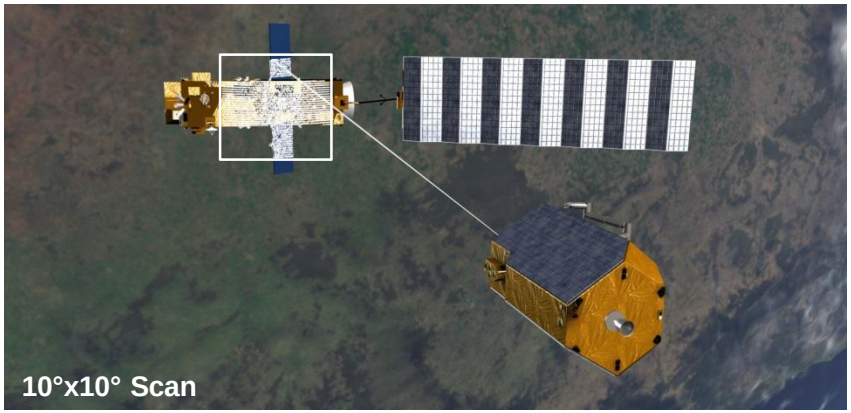


Reconstruction of Target Pose via CAD Model Matching

jenaoptronik

Scanning LIDAR





- Scanning LIDAR provides high flexibility in choice of scan parameters
- Unique **synergy** between image processing and LIDAR scan commanding due to autonomous real-time interaction
- Enabling high performance even in challenging scenarios (e.g. only limited 3D features visible/utilizable like dynamic solar arrays)
- Intelligent system design for robust and reliable relative navigation

RVS3000 & RVS3000-3D

Hardware Outlook

RVS3000 Hardware

- RVS3000 Engineering Model built in 2017 within DLR German Space Agency project
- Contract for RVS3000-3D for reusable ISS resupply vehicle SNC DreamChaser

QUESTIONS?