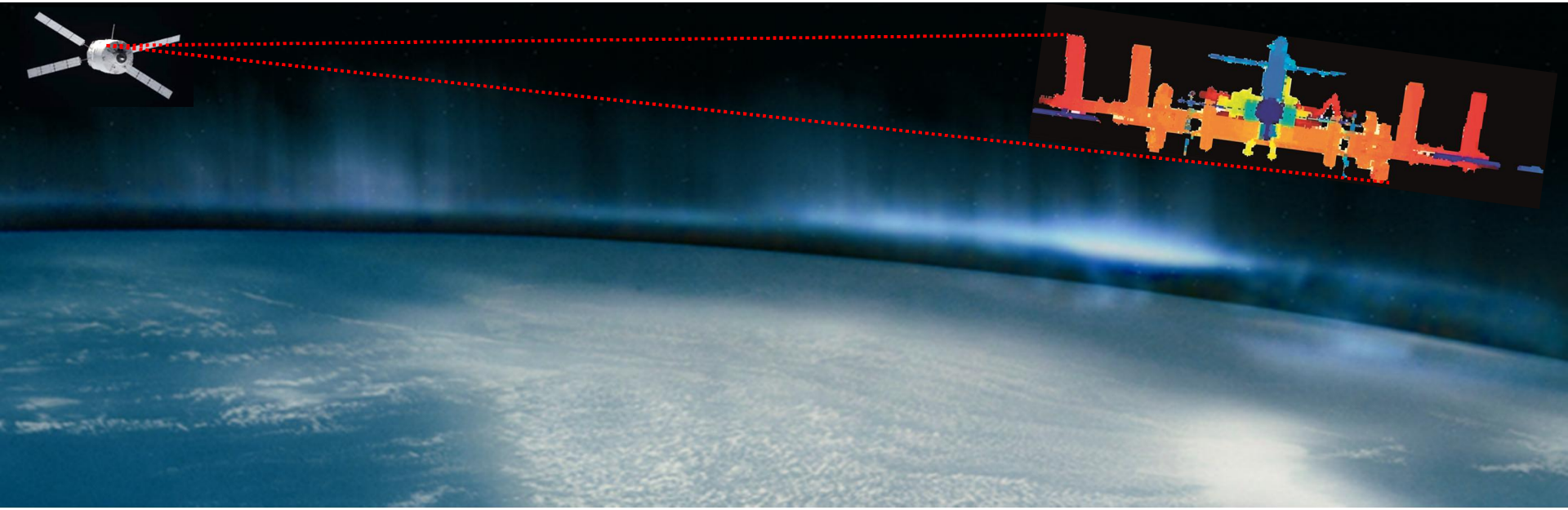
The LIRIS-2 3D Imaging LIDAR on ATV-5

Florian M. Kolb, Michael Windmüller, Mario Rößler, Bettina Möbius (Jena-Optronik)
Pierre Casiez, Bruno Cavrois (Airbus Defence and Space, Les Mureaux)
Olivier Mongrard (ESA-ESTEC)



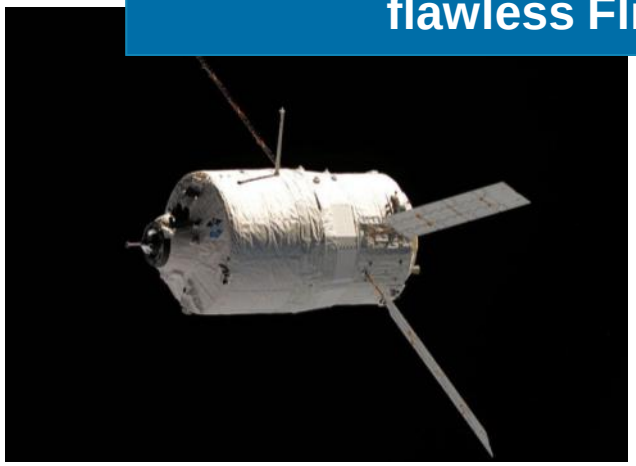
RVS(TGM) Rendezvous- and Docking-Sensor Heritage

2 Demo Flights with Space Shuttle Atlantis (RVS-ARP)

JAXA HTV 4 Flights

40 Flight Units already delivered flawless Flight Heritage

ESA ATV 5 Flights

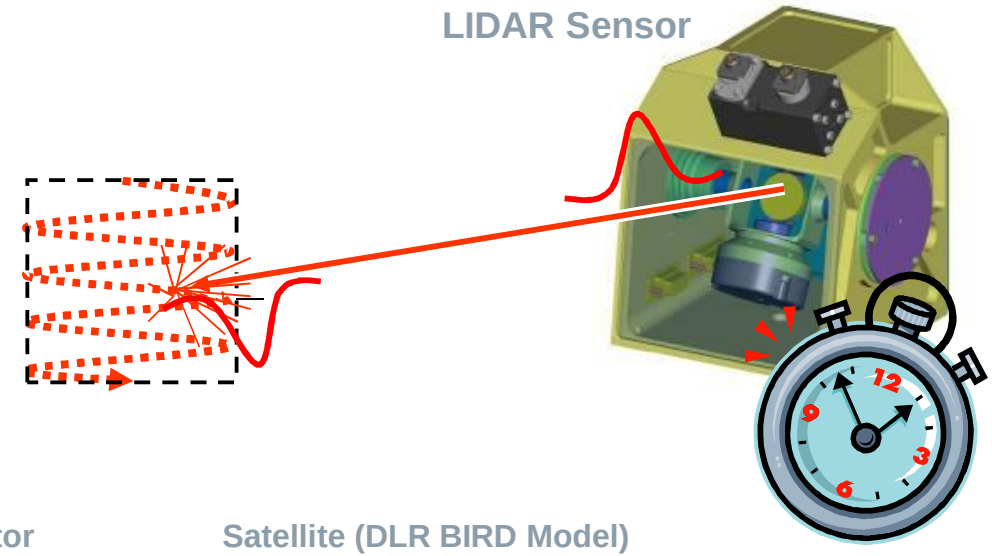


Orbital Sciences Cygnus 3 Flights

Time-of-Flight LIDAR Working Principle

LIDAR Sensor

Scan Pattern

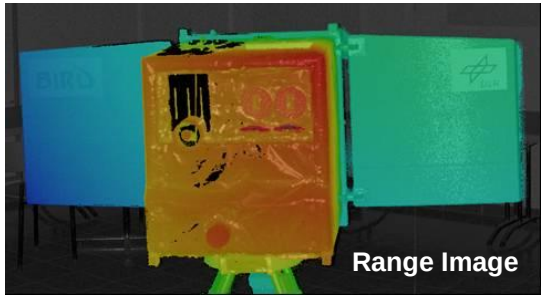


1) Scanning of a target object with a moving scan mirror

2) Range measurement with time-of-flight of a laser pulse

Retro Reflector

Satellite (DLR BIRD Model)



2.9 m — 3.8 m

LIDAR Sensor Applications

- Rendezvous and Docking
- Planetary Landing
- Planetary Exploration

Why 3D Imaging LIDAR?

RVS (TGM) for rendezvous and docking to ISS uses retroreflectors

- ISS as „cooperative“ target

Other applications for LIDAR do not have a target prepared for the sensor…

- Space debris removal & on-orbit servicing
- Planetary surface (craters, rocks, hills, …)

… or more flexibility is required

- independent of retroreflector arrangement
- option to image the target object, e.g. for inspection purposes

Design Goals of LIRIS-2 3D Imaging LIDAR

Starting Point

- Short timeframe of less than 1 ½ years between start of project and integration of sensor on ATV
- No significant changes to architecture and flight software of ATV possible

Design Goals

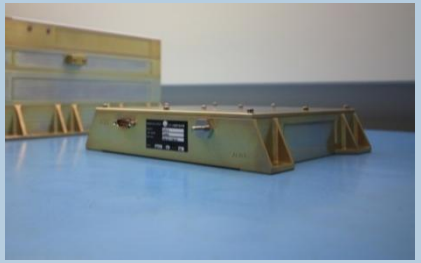
- Demonstrate 3D Imaging LIDAR technology by collecting 3D point cloud data (+ amplitude) of the ISS during ATV-5 rendezvous and docking
- Collect internal housekeeping and telemetry data of LIDAR sensor to verify design assumptions and as basis for future developments

Design Approach

In order to fulfill the goals under the challenging boundary conditions, the following design approach was selected

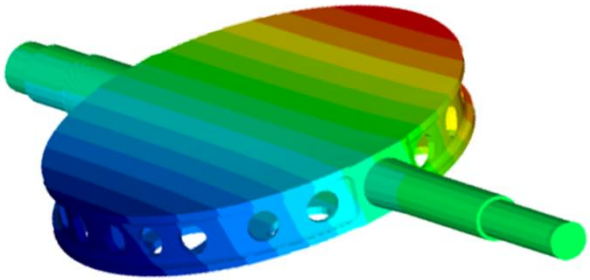
- Build on existing 3D Imaging LIDAR components from DLR project „LiQuaRD“ (scanning optical head, fiber laser)
- Addition of further LIDAR components (scanner electronics, range finder, power converter)
- Separate data storage unit located in ATV pressurized cargo section
- Avoid in-flight processing and related software on the sensor, but implement fixed scan modes based on known relative trajectory of ATV to ISS
- Reduced laser power due to ISS eye-safety regulations

LIRIS-2 Sensor Overview

Optical Head (LIDOH)	Electronics Box (LIDELN)	Data Recorder (LIDREC)
		

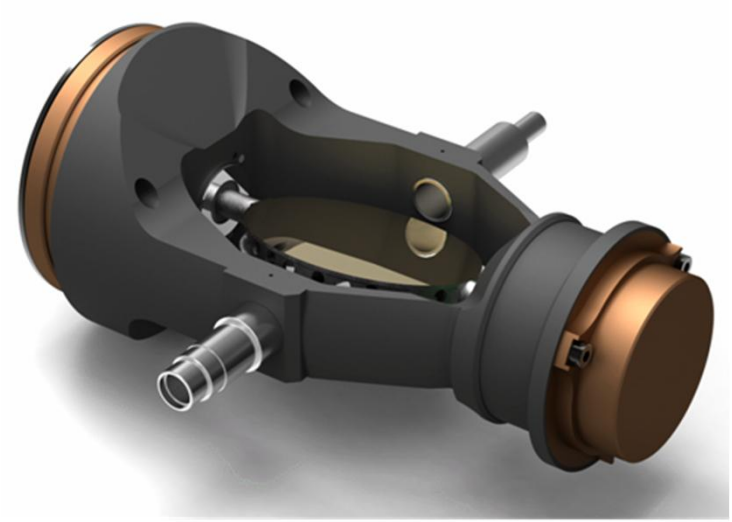
Parameter	Value
Field-of-View	ca. 40° x 40° (uncorrected)
Operating range against cooperative targets	ca. 3,5 km
Operating range against non-cooperative targets	ca. 260 m (due to ISS eye-safety regulations, otherwise >1000m)
Image frame rate	up to 3 Hz
Power consumption	ca. 25 W…55 W
Data storage	2x 2 GB redundant NAND-Flash solid state memory

LiQuaRD Design Solutions for High Performance Optical Head



Highly optimized scan mirror made from Beryllium alloy

- Minimal weight (14 g) & moment of inertia
- High stiffness at scan frequencies up to 100 Hz



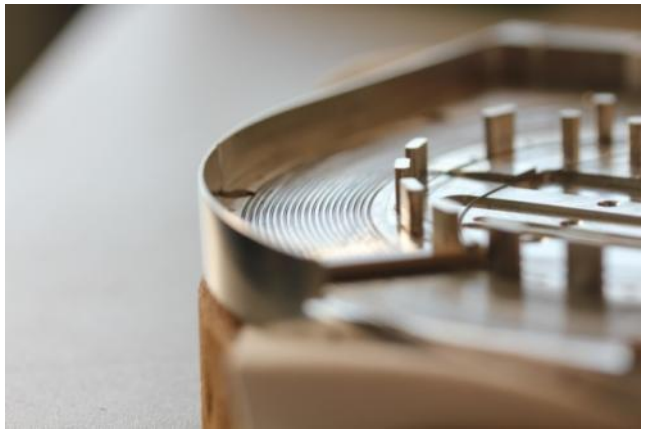
Optimized scan motors

- High torque at low weight and low power consumption

Optics design

- Coaxial optical frontend for measuring range of ca. 3.5 km against retroreflectors and ca. 250 m against satellite materials

LiQuaRD Fiber Laser



Development of a qualified fiber laser for space applications together with Fraunhofer IOF, Jena

- Wavelength: 1550 nm (Erbium-doped fiber)

Protoflight Test Campaign

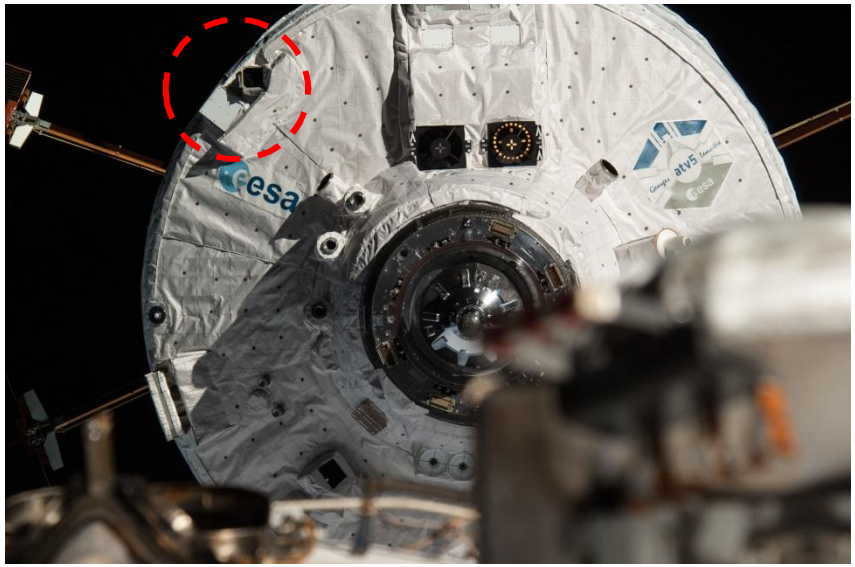
Complete protoflight test campaign performed for LIRIS-2 sensor

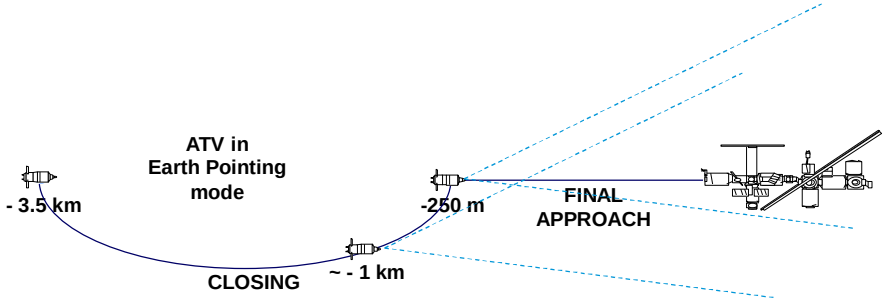
- Off-gassing test for LIDREC @ ESTEC (ISS-internal component)
- Functional and Long-Range Tests
- EMC Test
- TV Test
- Mechanical Loads Test

→ No issues detected

ATV-5 „Georges Lemaître“ Docking to ISS

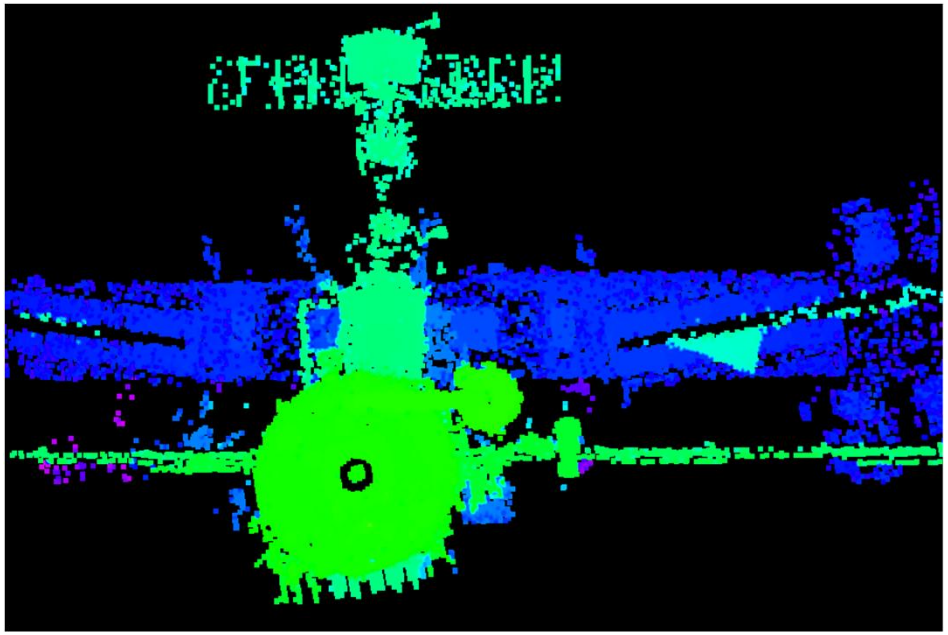
- Launch of ATV-5 on 29-July-2014
- Switch-on of LIRIS-2 on 13-August-2014
- about four hours later: docking confirmed by ATV-CC at CNES, Toulouse
- Recording of over 1,2 GB of science and housekeeping data
- Return of LIDREC data recorder back to Earth with Sojuz
- LIDREC available at Jena-Optronik end of September 2014



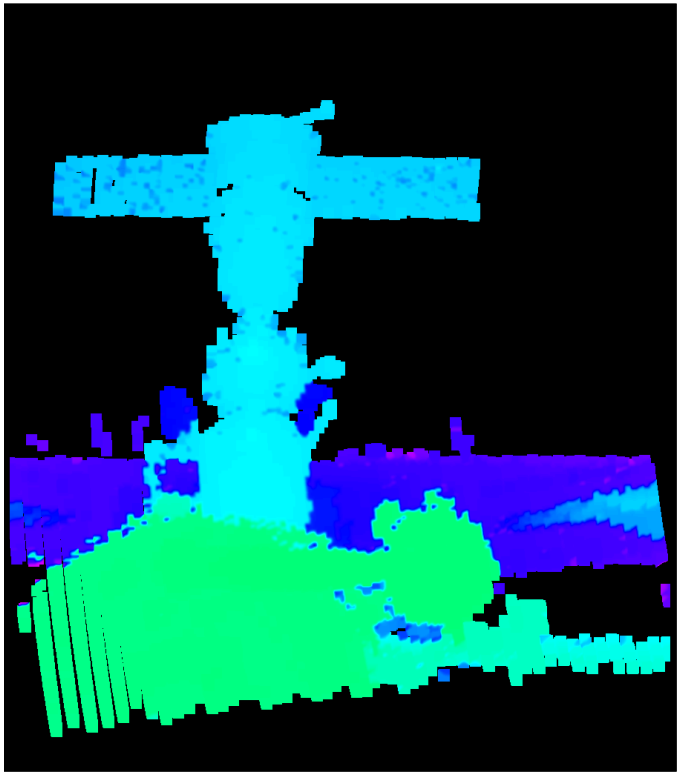


Recorded Image Data

ISS at about 30m distance from docking port



ISS at about 10m distance from docking port



Nominal performance of LIRIS-2 during rendezvous and docking

Nominal behaviour after undocking (6 months in space)

Summary

The LIRIS-2 3D Imaging LIDAR is a fully functional LIDAR sensor for collection of 3D data during the ATV-5 approach to the ISS.

All main components of the LIDAR sensor have been integrated and subjected to protoflight testing without any issue.

The LIRIS-2 data is synchronized with other ATV sensors (RVS, VDM, LIRIS-1) for a complete sensor database at ESA.

The sensor is the basis for further LIDAR developments and applications in space, e.g. RvD, space debris removal, on-orbit servicing, planetary landing and exploration.

Thank you!