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

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RVS(TGM) Rendezvous- and Docking-Sensor Heritage

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

ESA ATV 5 Flights

JAXA HTV 4 Flights

Orbital Sciences Cygnus 3 Flights

40 Flight Units already delivered flawless Flight Heritage
Time-of-Flight LIDAR Working Principle

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

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

LIDAR Sensor

Scan Pattern

Retro Reflector

Satellite (DLR BIRD Model)

Range Image

2.9 m 3.8 m
LIDAR Sensor Applications

- Rendezvous and Docking
- Planetary Landing
- Planetary Exploration
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
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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td><strong>Field-of-View</strong></td>
<td>ca. 40° x 40° (uncorrected)</td>
</tr>
<tr>
<td><strong>Operating range against cooperative targets</strong></td>
<td>ca. 3,5 km</td>
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<tr>
<td><strong>Operating range against non-cooperative targets</strong></td>
<td>ca. 260 m (due to ISS eye-safety regulations, otherwise &gt;1000m)</td>
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<td><strong>Image frame rate</strong></td>
<td>up to 3 Hz</td>
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<td><strong>Power consumption</strong></td>
<td>ca. 25 W…55 W</td>
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<tr>
<td><strong>Data storage</strong></td>
<td>2x 2 GB redundant NAND-Flash solid state memory</td>
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### Optical Head (LIDOH)

![Optical Head (LIDOH)](image)

### Electronics Box (LIDELN)

![Electronics Box (LIDELN)](image)

### Data Recorder (LIDREC)

![Data Recorder (LIDREC)](image)
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
Development of a qualified fiber laser for space applications together with Fraunhofer IOF, Jena

- Wavelength: 1550 nm (Erbium-doped fiber)
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
Nominal performance of LIRIS-2 during rendezvous and docking
Nominal behaviour after undocking (6 months in space)
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!