PLATFORM FOR FUTURE OPTICAL SPACE SURVEILLANCE TECHNOLOGY: DLR's 1.75 M OPTICAL TELESCOPE

Gerd A. Wagner[(1)], Frank Schramm[(1)], Wolfgang Riede[(1)], Thomas Dekorsy[(1)],

[(1)] *German Aerospace Center (DLR), Institute of Technical Physics, Orbital Photonics Group, Pfaffenwaldring 38-40, 70569 Stuttgart, Germany, Email: gerd.wagner@dlr.de*

Egon Döberl[(2)], Dietmar Weinzinger[(2)]

[(2)] *ASA Astrosysteme GmbH, Galgenau 19, 4212 Neumarkt im Mühlkreis, Austria*

ABSTRACT

Knowledge of the low Earth orbit (LEO) space debris matrix is of key importance for current and future space missions. As past missions have left a substantial amount of debris made of various materials and as LEO traffic increases mainly due to commercial activities, origin and material properties remain often unknown due to space aging, fragmentation, and avalanche effects.

The German Aerospace Center (DLR) has therefore decided to develop passive and active optical surveillance and tracking technologies for LEO. Consequently, DLR initiated a project (MS-LART: Multi-Spectral Large Aperture Receiver Telescope) for an optical telescope with a primary mirror diameter of 1.75 m.

This contribution introduces to MS-LART, a 1.75 m optical telescope as a unique instrument for space surveillance, and highlights major milestones achieved since project kick-off in May 2019. The paper closes with a summary and an outlook.

1 MOTIVATION AND OBJECTIVE

DLR's satellite laser ranging (SLR) station at the local astronomical observatory (Stuttgart, Germany) served as an initial development platform for the past years. Due to limited space at the observatory, a successor station was needed to serve as future development platform for LEO space surveillance technology.

Furthermore, the increased overall LEO activities due to commercial and research projects triggered the development of a successor station with increased capabilities for active satellite laser ranging and passive object tracking technologies.

Science topics for MS-LART include material analysis of space debris, material aging, fragmentation, and avalanche effects.

Independent assessment of the LEO space environment and the protection of space assets are further tasks for MS-LART.

2 REQUIREMENTS FOR LASER RANGING

The requirements for SLR and space debris laser ranging (SDLR) can be divided in four main categories: laser, transmitter, receiver, and data acquisition.

Current systems for SLR and SDLR are mostly based on Nd:YAG laser technology with an average power >5 W and pulse lengths of ns (nanosecond) and ps (picosecond) at pulse repetition rates >10 Hz. For SDLR, generally higher pulse energies are required. Frequency doubling to 532 nm takes advantage of silicon-based detectors with high quantum efficiency.

The transmitted beam for SLR/SDLR should be as large as possible to take advantage of the laser beam-parameter product.

The receiver telescope for SLR/SDLR has a diameter >400 mm and the receiver path includes the detector for the backscattered photons.

A high-speed data acquisition using time interval analyzers (TIA) including time reference is used to process the signals of the detector circuit and determine the overall laser pulse propagation time for the ranging measurement.

For MS-LART, a special focus will be on the application of eye-safe laser technology with a wavelength >1400 nm for SLR/SDLR with detectors in the 1 µm – 2 µm spectral region.

3 PROJECT OVERVIEW

Besides the overall motivation for MS-LART as outlined, it was required that the facility for MS-LART could be reached on a daily basis within commuting distance to the Institute of Technical Physics at DLR Stuttgart.

The observatory for MS-LART is depicted in Fig. 1 and consists of 2 levels: level 1 serves as an operator room and lab space for instrumentation and level 2 hosts the telescope.

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Initial project application for MS-LART was in September 2018 and the project was selected in March 2019. An implementation plan including risk analysis was completed within 2 months followed by project kick-off in May 2019.

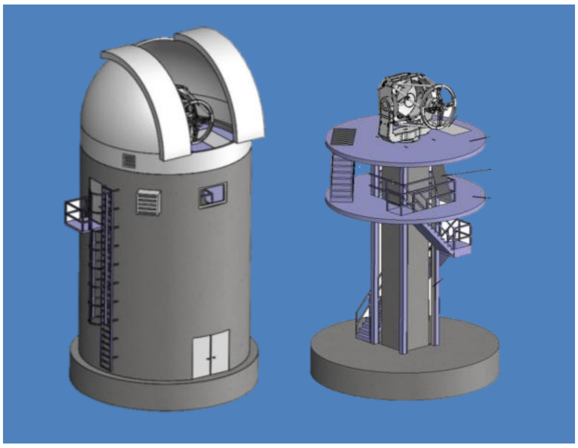

Figure 1. Overview of observatory for MS-LART. Image: ASA.

4 CONSTRUCTION

The site of the observatory for MS-LART is at Innovationscampus Empfingen [1] which is located 65 km South of Stuttgart. ASA Astrosysteme GmbH [2] was selected as main contractor for the telescope and observatory. Construction at Innovationscampus Empfingen started July 27, 2020.

4.1 OBSERVATORY

Fig. 2 shows the observatory building completed (Dec. 18, 2020). Additional containers serve as a small lab for preparation of experiments and storage. The transportable SDR/SDLR station of DLR (STAR-C [3]) will also be stationed in Empfingen.

Figure 2. Observatory for MS-LART at Innovationscampus Empfingen on Dec. 18, 2020. Image: DLR.

4.2 TELESCOPE

The ASA AZ1750 will be the telescope for MS-LART and Fig. 3 shows the telescope at the factory acceptance test on Dec. 15, 2020. The Richey-Chrétien (f/6) telescope features a 1.75 m primary mirror with 4 Nasmyth foci ports for instrumentation. An additional astrograph (ASA H400) is mounted piggyback on the AZ1750 for wide field of view observations.

Figure 3. ASA AZ1750 with H400 at factory acceptance test on Dec. 15, 2020. Image: ASA.

5 INSTRUMENTATION

For passive observations (object tracking, light curves) in the VIS (visible) and NIR (near infrared) spectral region, a set of cameras including a grating spectrograph are considered.

Lasers and detectors in the NIR spectral region will enable SLR/SDLR measurements.

Further details on instrumentation and specifications will be published at a given time.

6 PROJECT STATUS

At the time of writing (April 2021), the main observatory building including electrical installations is completed. The dome for the observatory (manufactured by Gambato [4]) was installed March 3, 2021 (Fig. 4) followed by the telescope the following day (Fig. 5).

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Figure 4. Installation of dome (Gambato) at observatory (Mar. 3, 2021). Image: DLR.

Figure 5. Installation of ASA AZ1750 (Mar. 4, 2021). Image: DLR.

7 SUMMARY AND OUTLOOK

Within the past 2 years, DLR's MS-LART project has been substantially progressed and major milestones have been achieved. Site acceptance test (SAT) is scheduled for May 2021.

First SLR/SDLR measurements are expected to be in early 2022.

8 FUNDING

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9 ACKNOWLEDGMENT

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Certain commercial equipment, instruments, or materials are identified in this paper in order to specify the experimental procedure or proposed design setup adequately. Such identification is not intended to imply recommendation or endorsement by the German Aerospace Center (DLR), nor is it intended to imply that the materials or equipment identified are necessarily the best available for the purpose.

10 REFERENCES

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