Overview of laser ranging activities at the Institute of Technical Physics (...and related topics)

*Wolfgang Rieder*
Active Optical Systems, Institute of Technical Physics
German Aerospace Center (DLR), Stuttgart Germany

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• Motivation

• Ground stations / sensors

• Modelling
  • Global Network Performance
  • Laser Material Interaction

• Outlook
Radial distribution of catalogued orbital objects in LEO

LEO object statistics

- 16,000 catalogued objects (LEO)
- 1338 active satellites (LEO)
- 2061 active satellites (all orbits)

Large satellite constellations

- SpaceX Starlink (US)
  - 11,943 Sats (60 in orbit as of 24/05/19)
- OneWeb (UK)
  - 648 -> 2,622 Sats (6 in orbit as of 27/02/19)

Summed up: 14,565 satellites

Increasingly unstable environment!
Uhlandshöhe Research Observatory (UFO) – ILRS Engineering station

- Test-bed for new technologies and techniques for satellite laser ranging
- NIR laser wavelength (1064 nm)
- Highly repetitive SLR system (1 kHz / 200 kHz)
- Current status: spectral light curve measurement
- Operation discontinued in 2021

- miniSLR / STAR-C / MS LART

**Technical tour on Thursday, Oct. 24th**
Surveillance sensor (passive-optical staring sensor)

- Smallest object LEO: 0.3 m
- FoV: 15°

Encapsulated staring system (APPARILLO)
Retroreflectors for DLR satellite missions

- DLR Firebird & CubeL missions

½ inch CCR for DLR „CubeL“ mission

CCR for DLR Firebird compact sat

Far-field measurement setup

"Design and qualification of a recessed satellite cornercube retroreflector for ground-based attitude verification via satellite laser ranging"
miniSLR

- Compact SLR system
- Low cost ground station module
- Space traffic monitoring
- On display poster session room

-> Novel concepts session Daniel Hampf

“The miniSLR system: a standardized solution for routine SLR observations”
Transportable Space Debris Laser Ranging System (STAR-C)

- 20 ft ISO Container, overall weight 10 tons
- Elevatable platform
- Robust and environmentally shielded
- 50 W on-board commercial laser
- Flexibility in site selection

Technical tour on Thursday, Oct. 24th (German Weather Service)
ISO Container with high-power debris laser ranging system
Laser source upgrade – DLR in-house development (2021)

Yb:YAG Thin disk amplifier module
Implementation of laser amplifier in ISO container
Containerized laser source for tracking of small objects (~10 cm size) in LEO

ISO Container with multi stage laser amplifier

Final specifications:
Average power kW level
multi kHz repreate, pulse energy 100 mJ, nanosecond pulse duration

Coupled container system
Laser Ranging Network Performance Analysis

- cloud fraction / average wind and gusts
- Python-based script accessing AGI software tools ODTK and STK

European Centre for Medium-Range Weather Forecasts (ECMWF)

- 0.75° x 0.75° lat/lon grid
- 28 km average distance to candidate sites
- For most products, 3 hour temporal resolution

Simulation network N = 46 laser ranging sites and a sample high sun synchronous orbit ground trajectory.

1-σ position uncertainty during laser ranging measurements with a 20 station network for an high sun synchronous orbit (~ 850 km)
Concept for remediation and laser-based orbit lowering of debris
Simulation and laboratory experiments (impulse transfer, integrity, heating ..)

Laser ablation and laser nudging principle

Laboratory demo experiment (GSI nHelix System)
Laser ablation effect
Single shot pulse energy 80 J, 1064 nm, 10 ns
Vakuum: 10 Pa
Outlook: High-end ground station

MS-LART: Multi Spectral - Large Aperture Receiver Telescope

- 1.75 meter aperture telescope
- (bi-static) SLR receiver telescope
- eye-safe laser transmitter platform
- spectral light curves
- expected operational status in 2021
- Facility location: 45 minutes drive by car from DLR site (highway A81)

-> Poster Session 4 Gerd Wagner:
“MS-LART: DLR’s latest telescope platform for satellite and space debris laser ranging”

Intended design shown by similar system
(Photo courtesy by ASA - Astrosysteme Austria).
Summary

• SLR technology for space debris tracking

• (Global) SDLR network approach for weather mitigation

• High-end laser systems and tracking platforms needed for ~10 cm sized non-cooperative objects

• Laser-based orbit lowering for collision avoidance under consideration (simulation studies and laboratory confirmation)
Thank you!