

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

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ILRS Technical Workshop

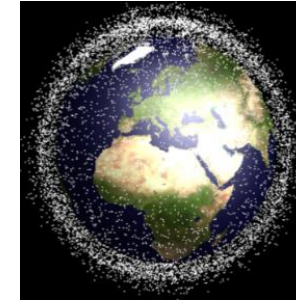
Stuttgart, October 21st, 2019



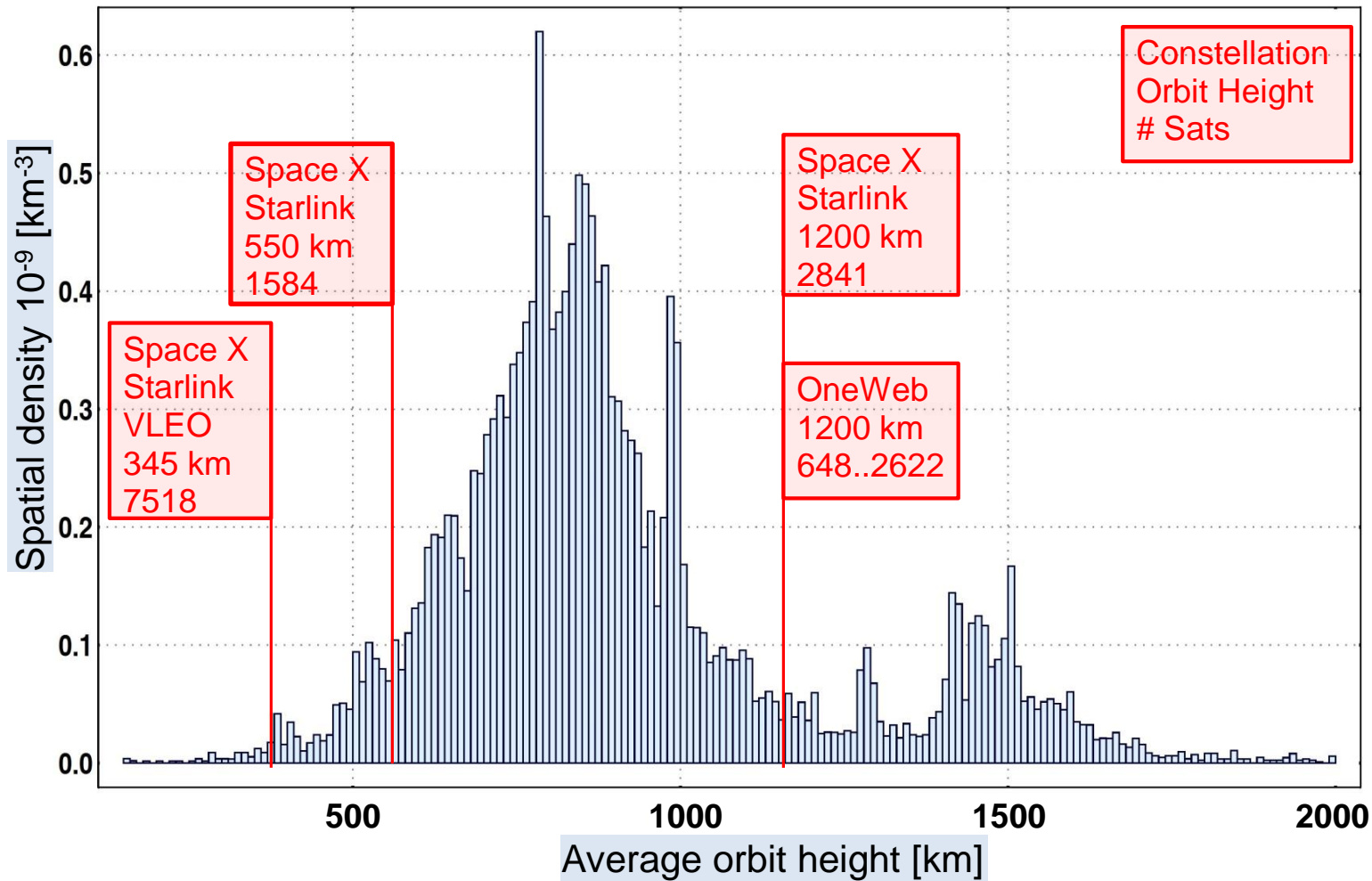
Wissen für Morgen



- 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)
Reference: ESA Annual Space Environment Report 2018

- 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)

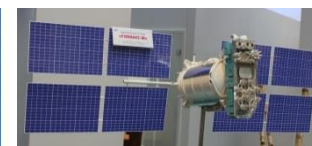
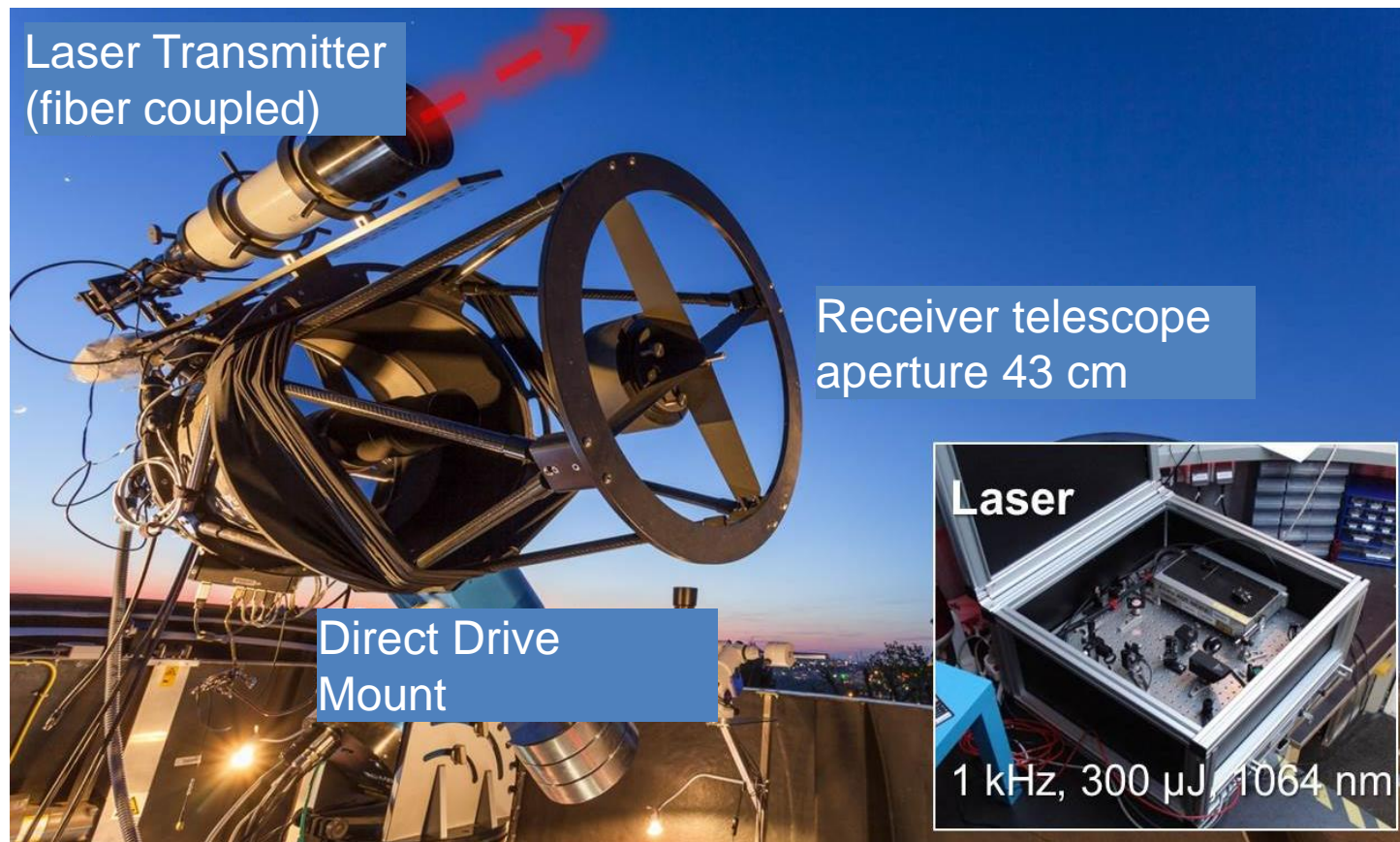
648 -> 2,622 Sats (6 in orbit as of 27/02/19)

Summed up: 14,565 satellites

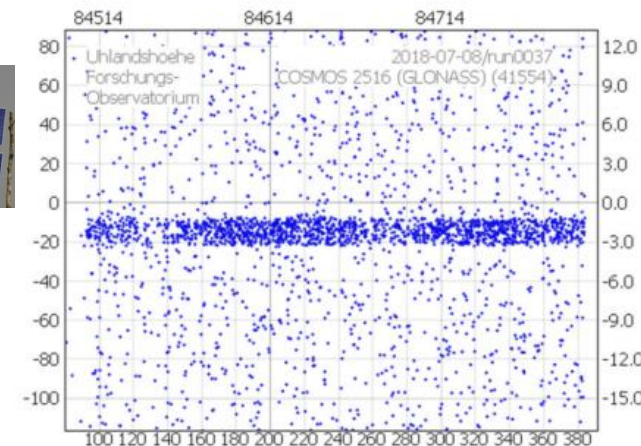
Increasingly unstable environment!



Uhlandshöhe Research Observatory (UFO) – ILRS Engineering station



GLONASS



- 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

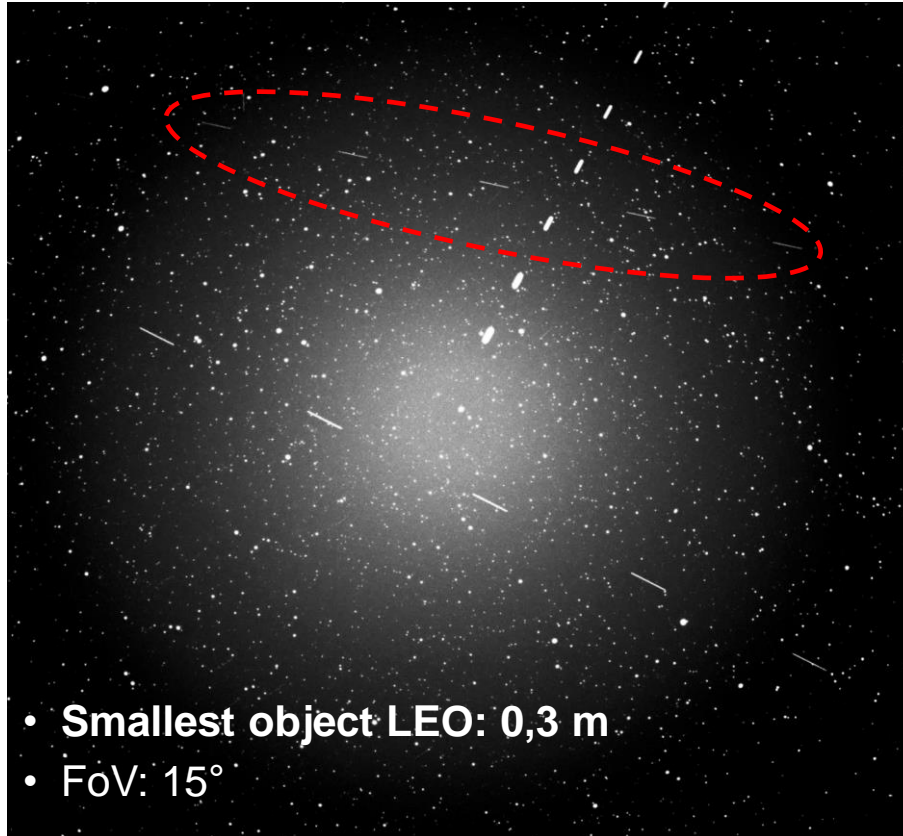
Technical tour on Thursday, Oct. 24th



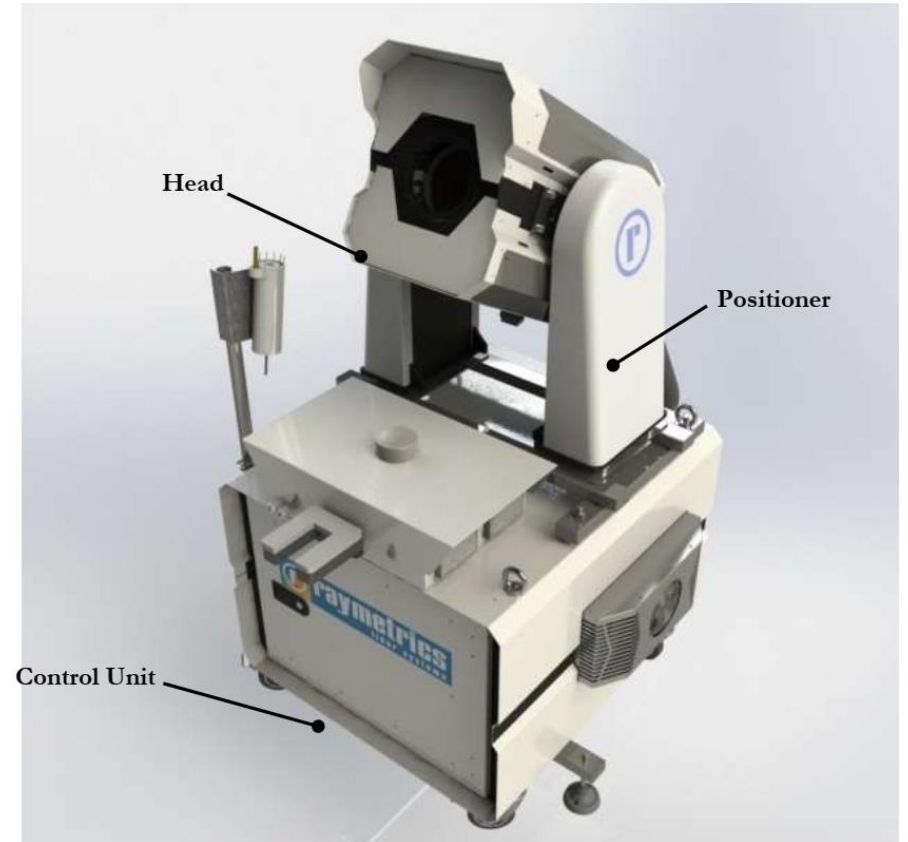
Surveillance sensor (passive-optical staring sensor)



Megapixel Staring Cam



- **Smallest object LEO: 0,3 m**
- **FoV: 15°**

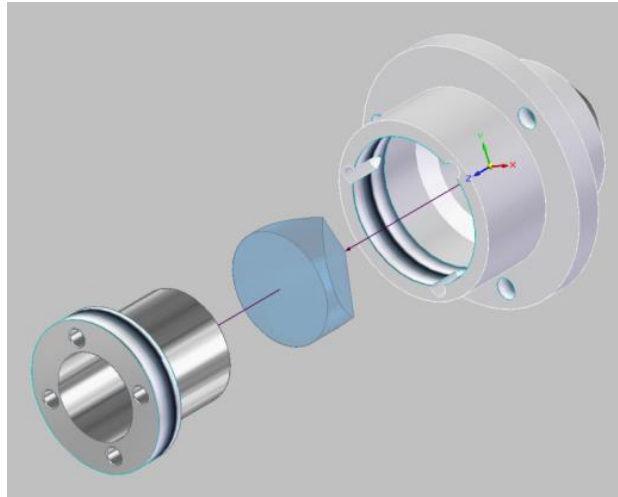


Encapsulated staring system (APPARILLO)

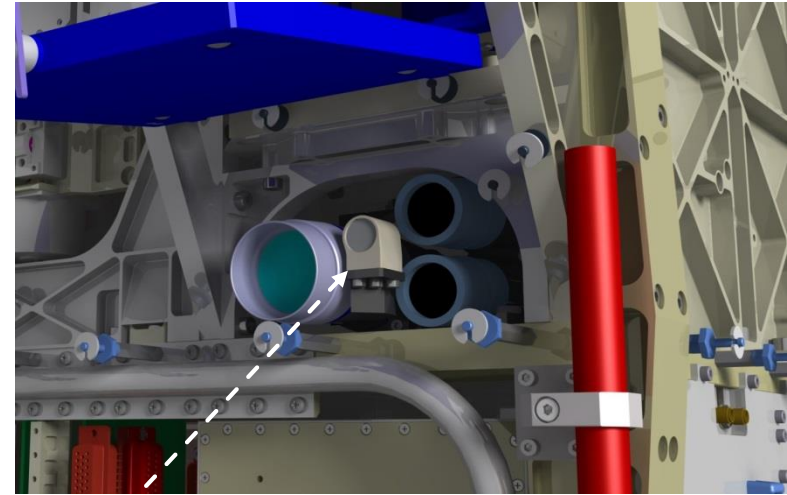


Retroreflectors for DLR satellite missions

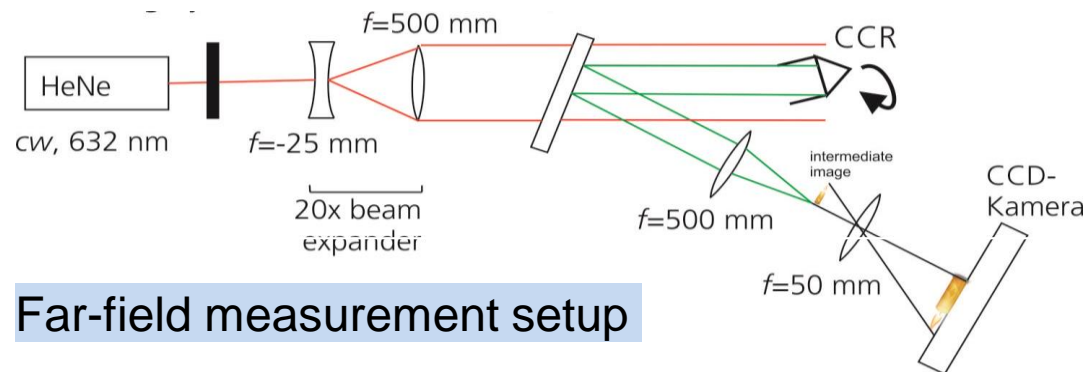
- DLR Firebird & CubeL missions



1/2 inch CCR for DLR „CubeL“ mission



CCR for DLR Firebird compact sat



Far-field measurement setup

-> **Poster Session 3 Nils Bartels:**

“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)



Transfer for field tests

© DLR/Eppler

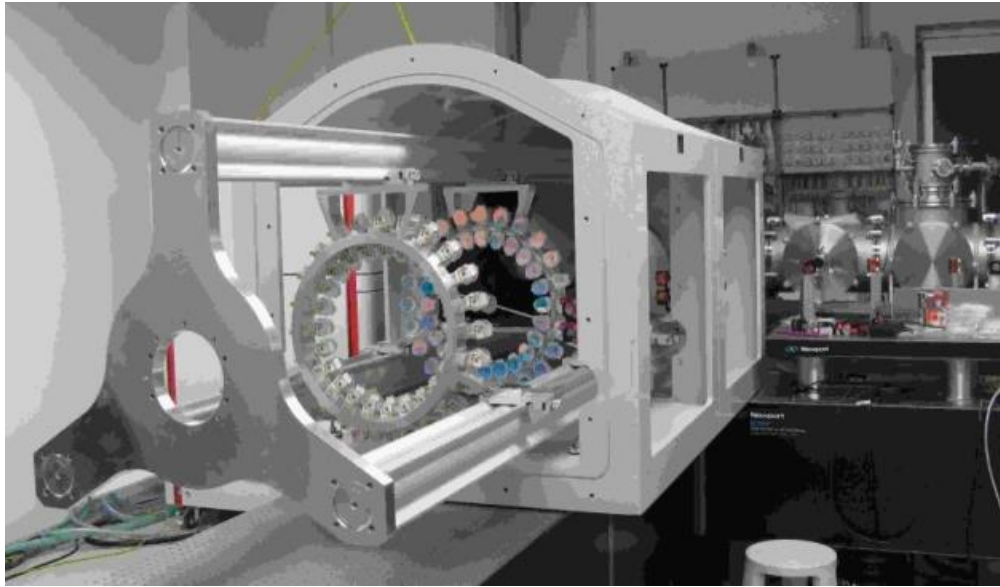
- 20 ft ISO Container, overall weight 10 tons
- Elevatable platform
- Robust and environmentally shielded
- 50 W on-board commercial laser
- Flexibility in site selection



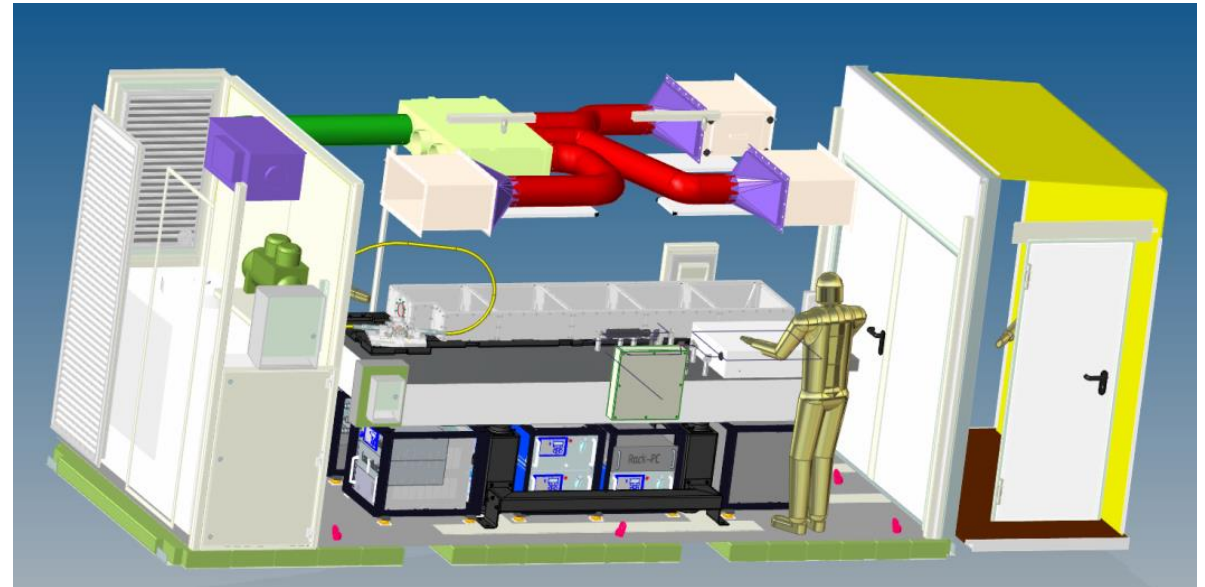
**Technical tour on Thursday,
Oct. 24th (German Weather Service)**



ISO Container with high-power debris laser ranging system Laser source upgrade – DLR in-house development (2021)



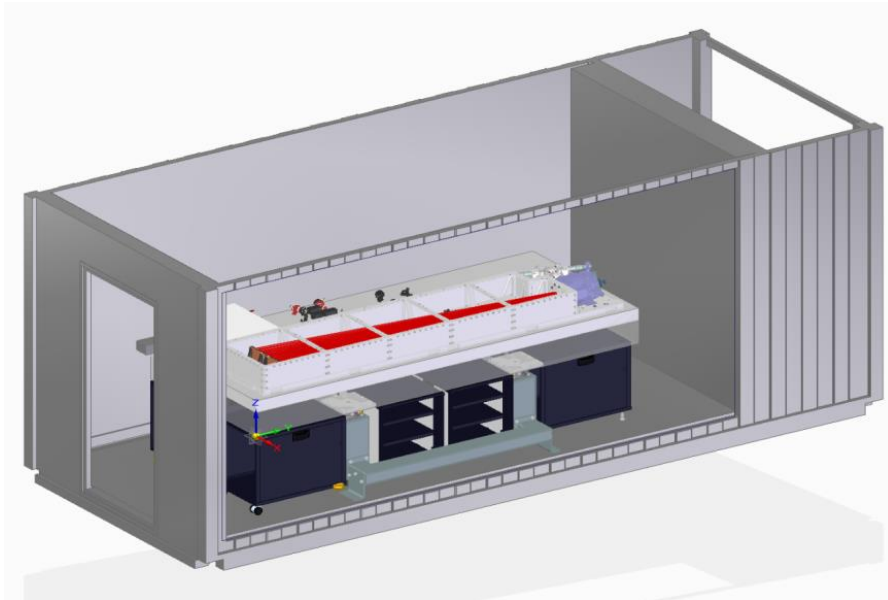
Yb:YAG Thin disk amplifier module



Implementation of laser amplifier in ISO container



Containerized laser source for tracking of small objects (~10 cm size) in LEO



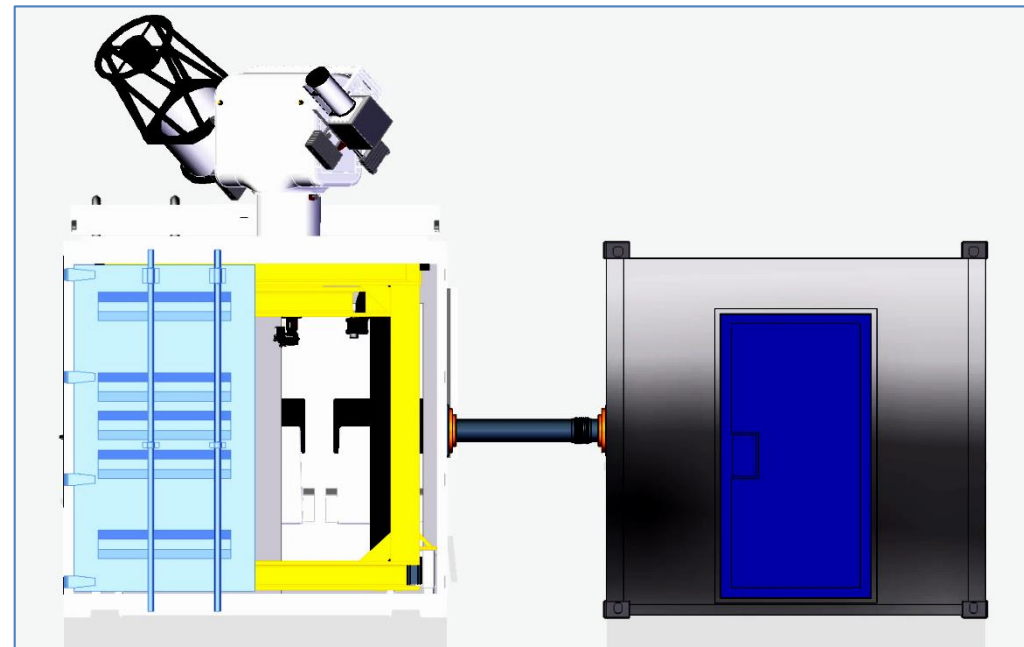
ISO Container with multi stage laser amplifier

Final specifications:

Average power kW level

multi kHz replate, pulse energy 100 mJ,

nanosecond pulse duration



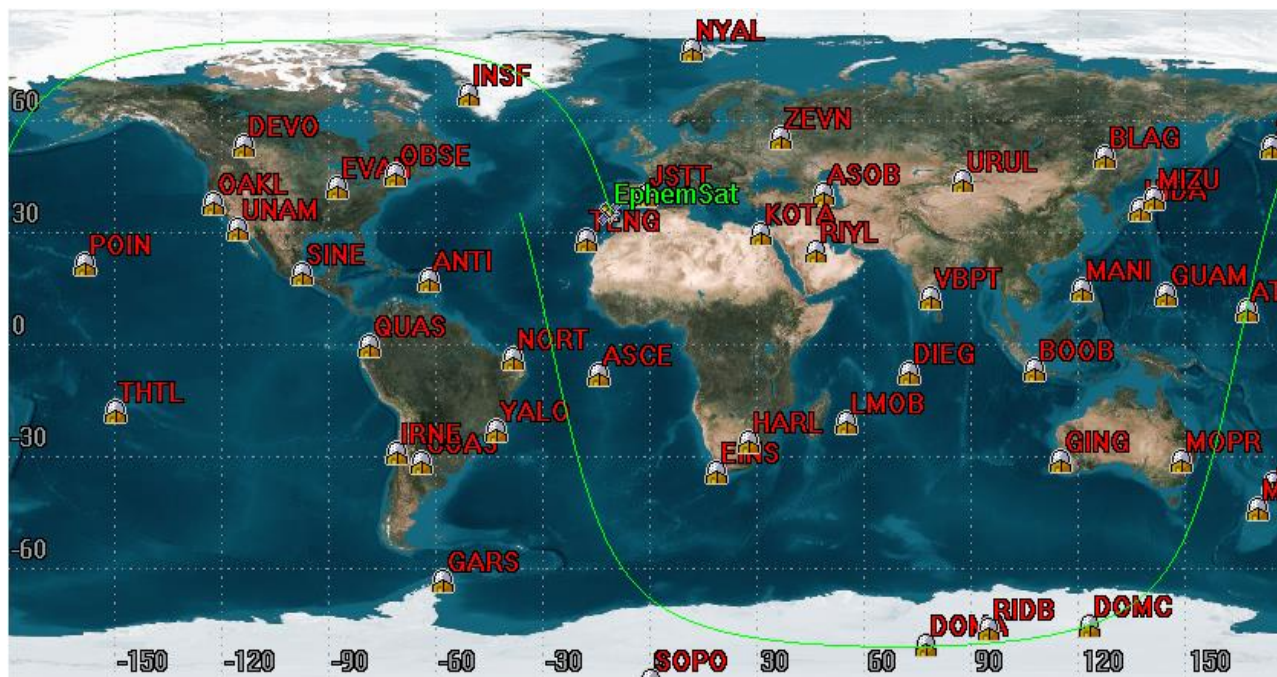
Coupled container system





Laser Ranging Network Performance Analysis

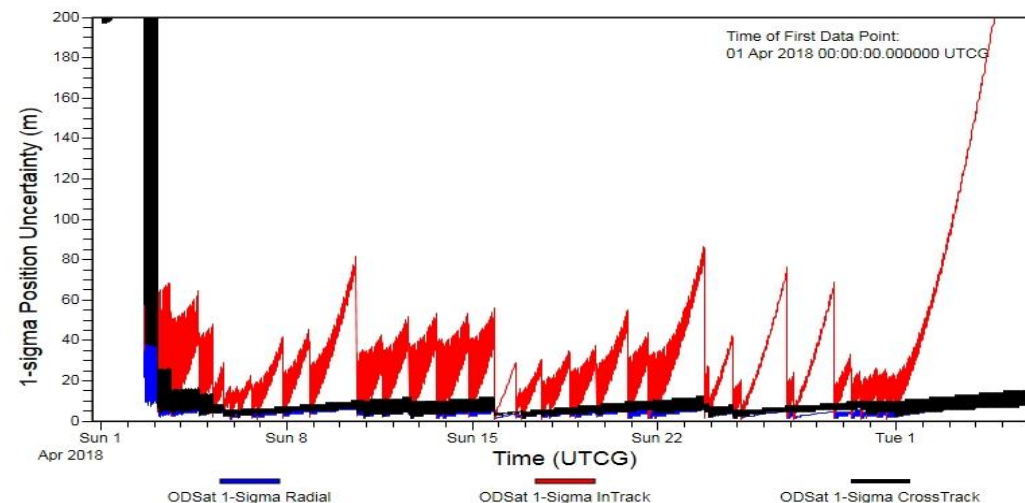
- cloud fraction / average wind and gusts
- Python-based script accessing AGI software tools ODTK and STK



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

European Centre for Medium-Range Weather Forecasts (ECMWF)

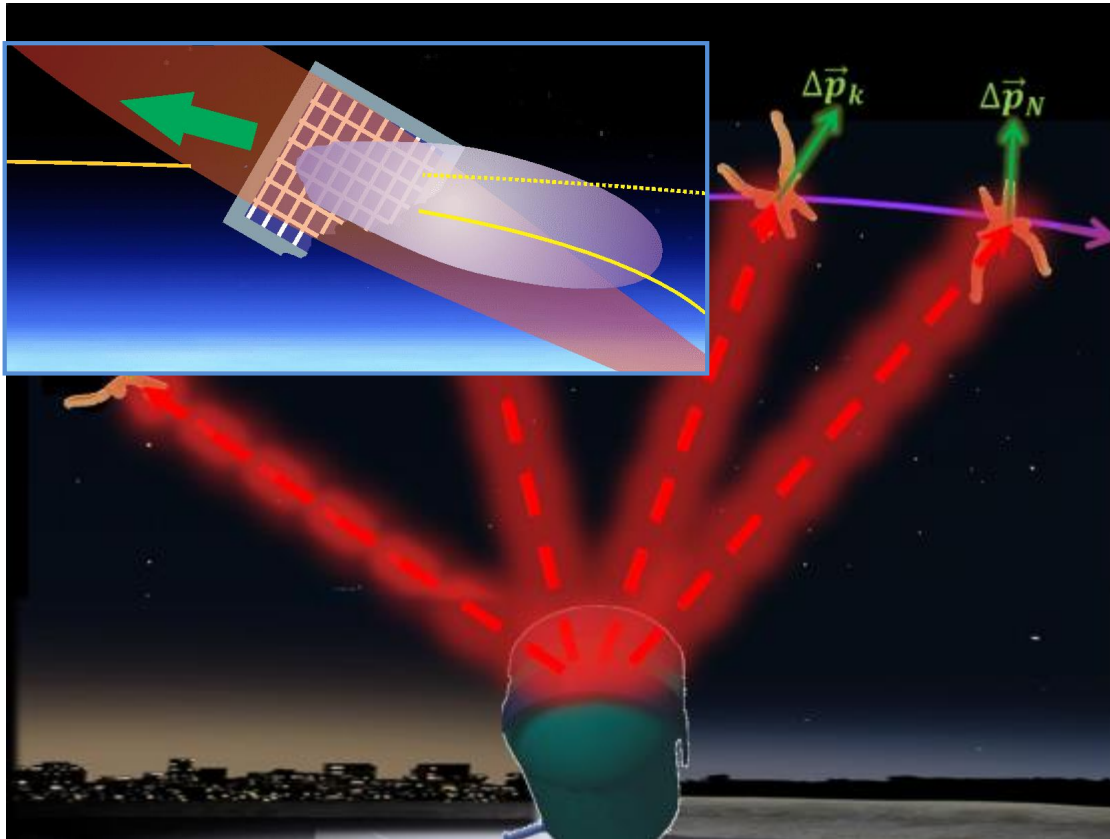
- 0.75° x 0.75° lat/lon grid
- 28 km average distance to candidate sites
- For most products, 3 hour temporal resolution



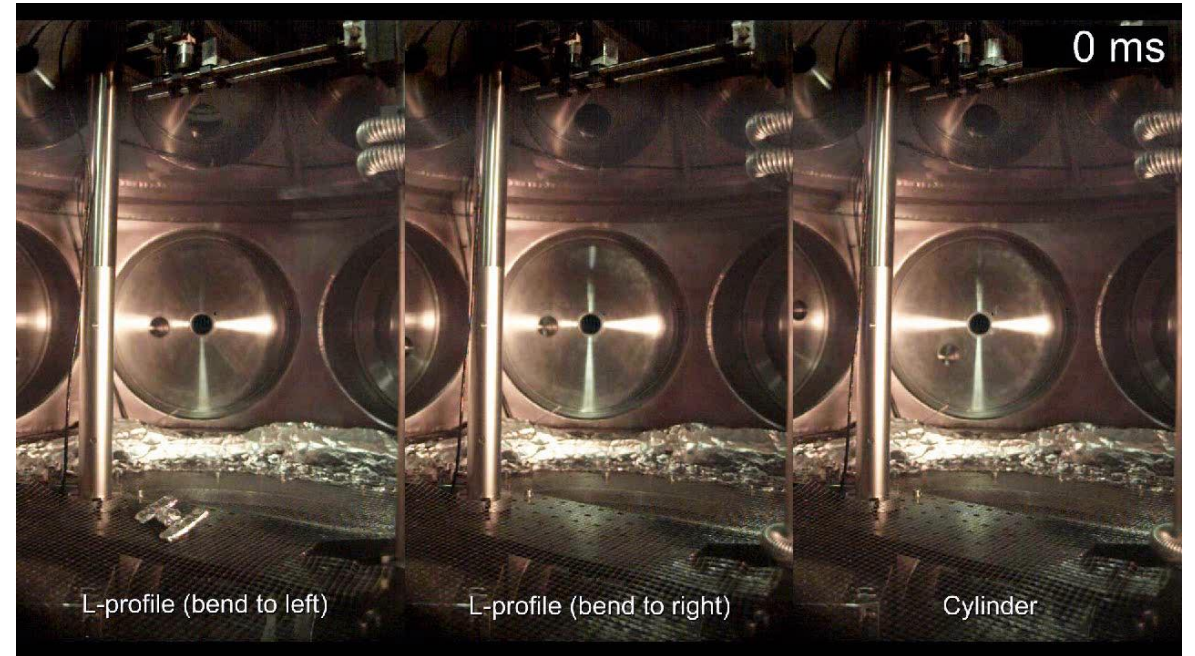
1- σ position uncertainty during laser ranging measurements with a 20 station network for an high sun synchronous orbit (~ 850 km)



Concept for remediation and laser-based orbit lowering of debris Simulation and laboratory experiments (impulse transfer, integrity, heating ..)



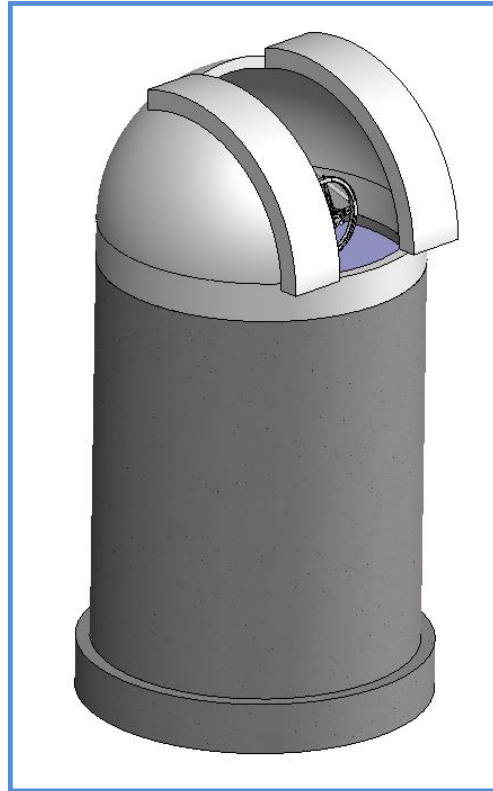
Laser ablation and laser nudging principle



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



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

MS-LART: Multi Spectral - Large Aperture Receiver Telescope

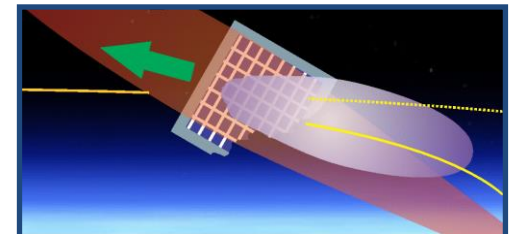
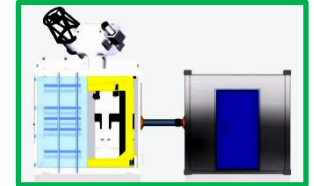
- 1.75 meter aperture telescope
- (bi-static) SLR receiver telescope
- eye-safe laser transmitter platform
- spectral light curves
- expected operational status in 2021
- Facility location: 45 minutes drive by car from DLR site (highway A81)

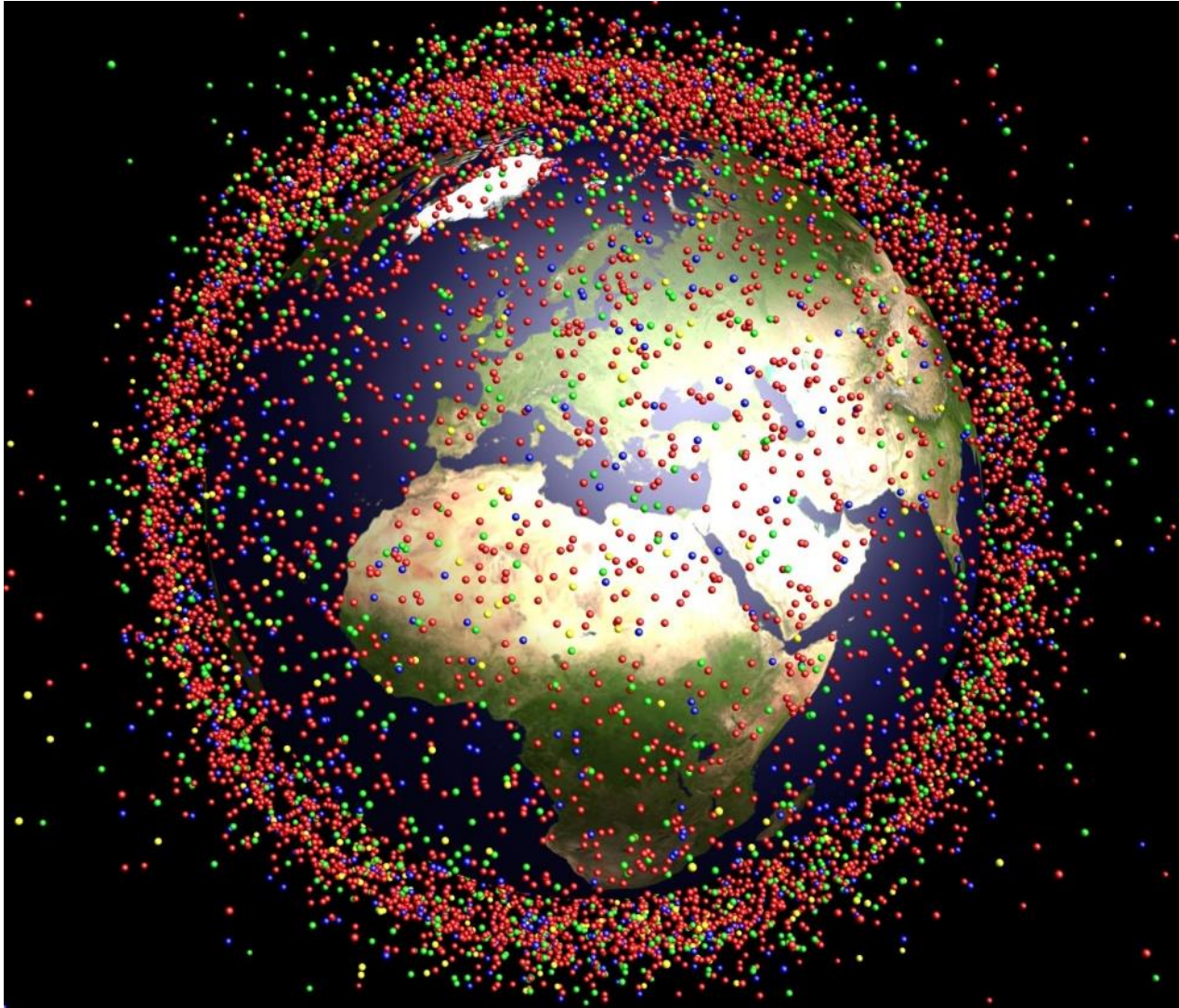
-> Poster Session 4 Gerd Wagner:
“MS-LART: DLR’s latest telescope platform for satellite and space debris laser ranging”



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!

