SATELLITE RETROREFLECTORS AND LASER RANGING FOR SPACE TRAFFIC MANAGEMENT

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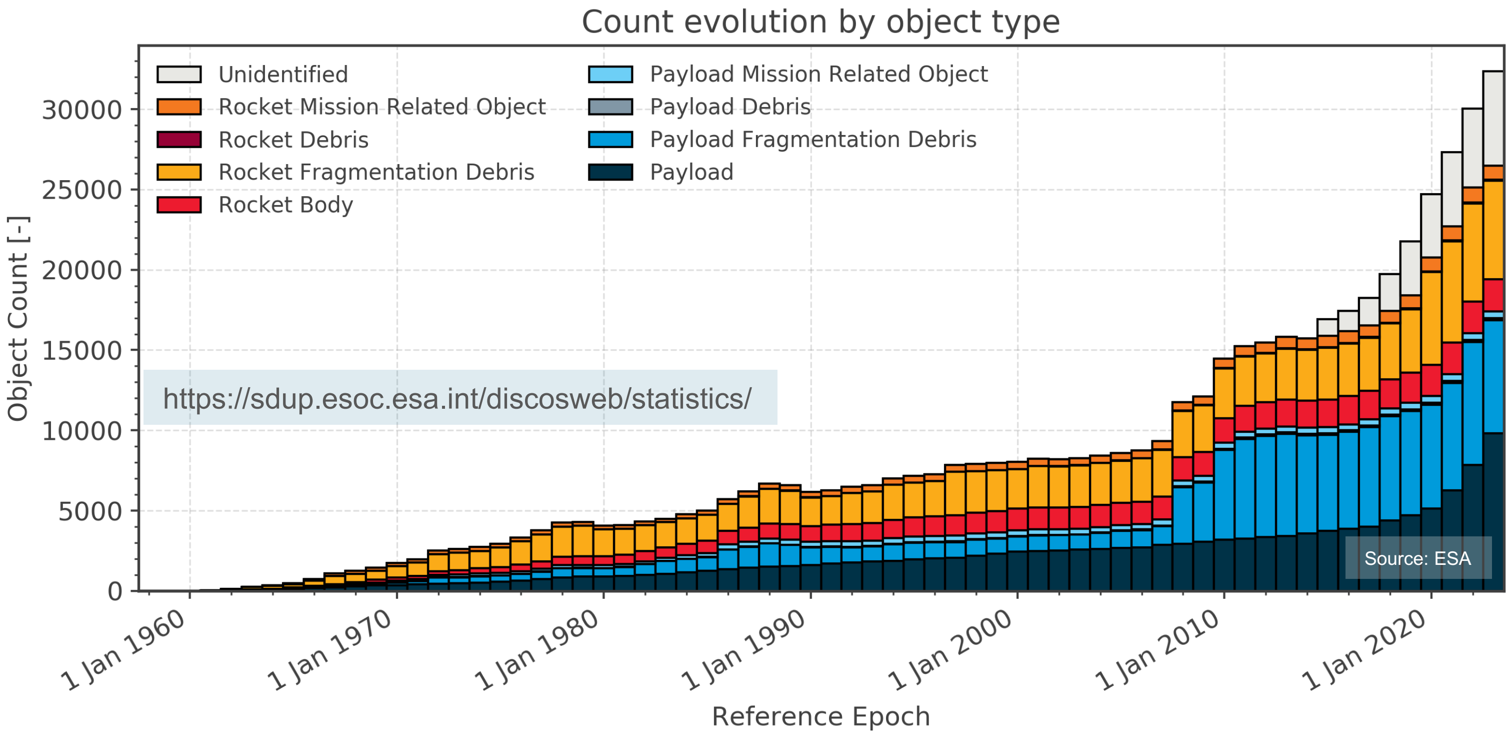
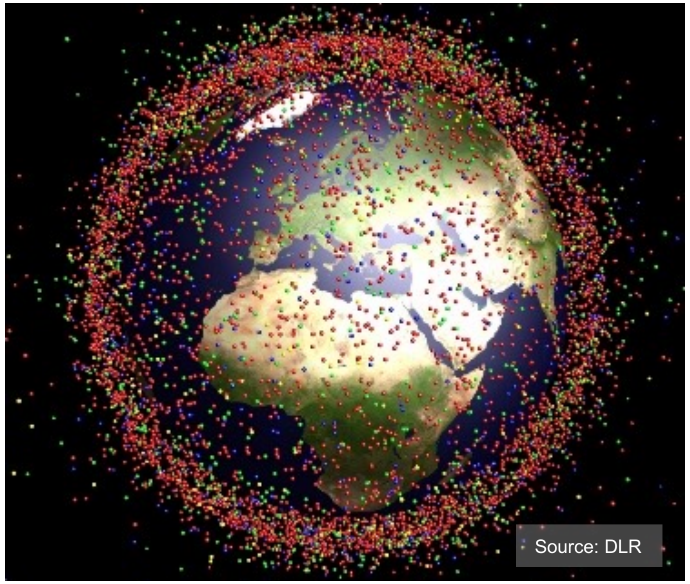
Actual and future challenges in orbit environment

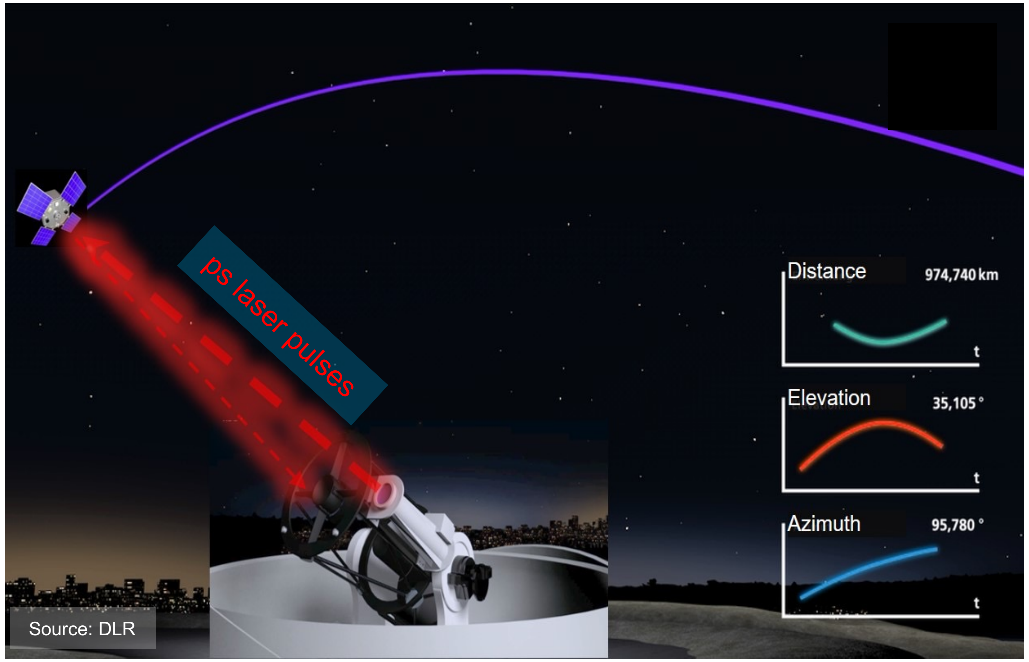




- Space is getting continuously more crowded (actual population in LEO: 8000 operational satellites and 12000 debris objects / defunct satellites - ESA space environment statistics 12/2022)
- Number of satellite launches still increasing strongly (driven by setting up of megaconstellations)
- Number of threatening encounters of objects in space increases: https://celestrak.org/SOCRATES/
  Satellite Orbital Conjunction Reports - Service providing pending conjunctions on orbit over the coming week

Satellite laser ranging (SLR): Mature and operational technology

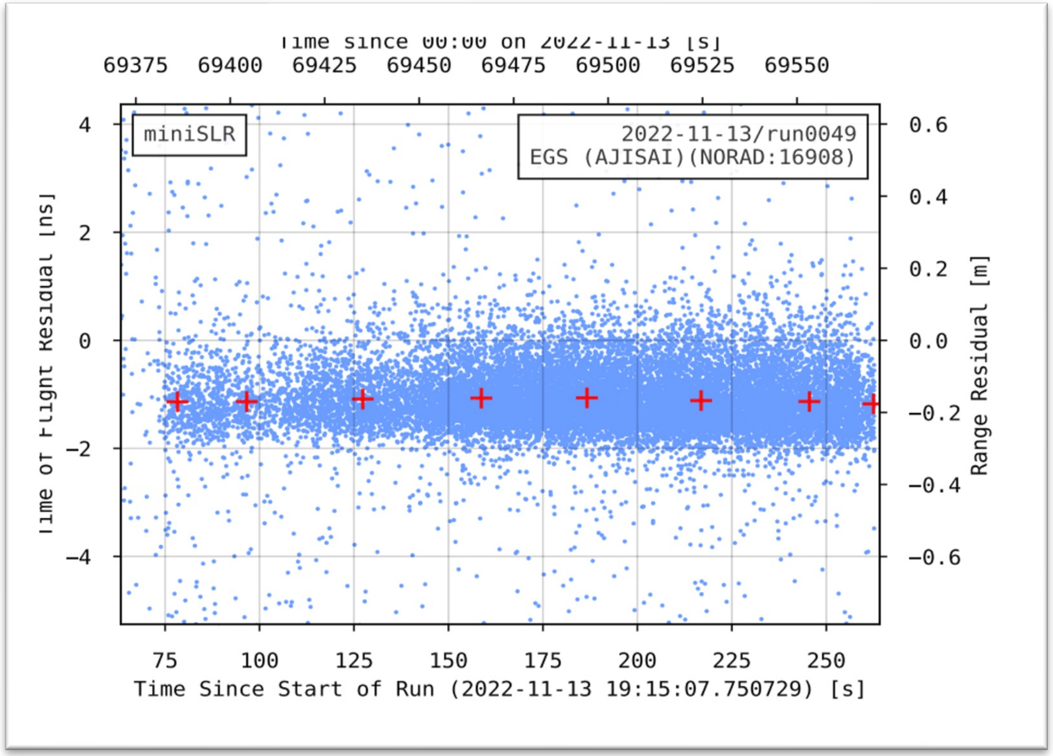
Source: ILRS



Source: DLR

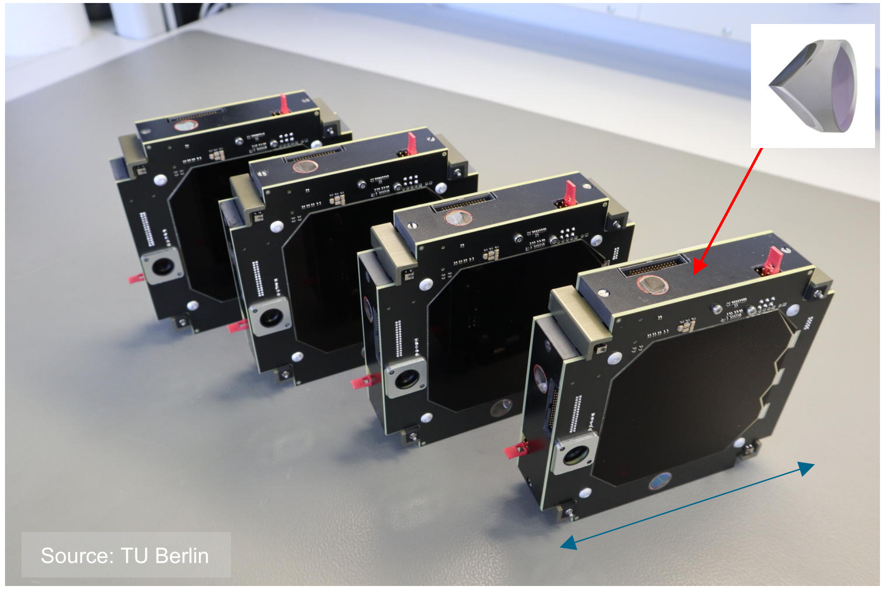
- International Laser Ranging Service (ILRS): Global laser optical ground station network of more than 40 active stations for geodetic / geophysical applications, 12 stations are planned to be set-up
- Extremely high laser ranging precision (few mm) of orbits of cooperative objects (equipped with retroreflectors)
- ILRS members and ground station operators accumulate several decades of technology experience

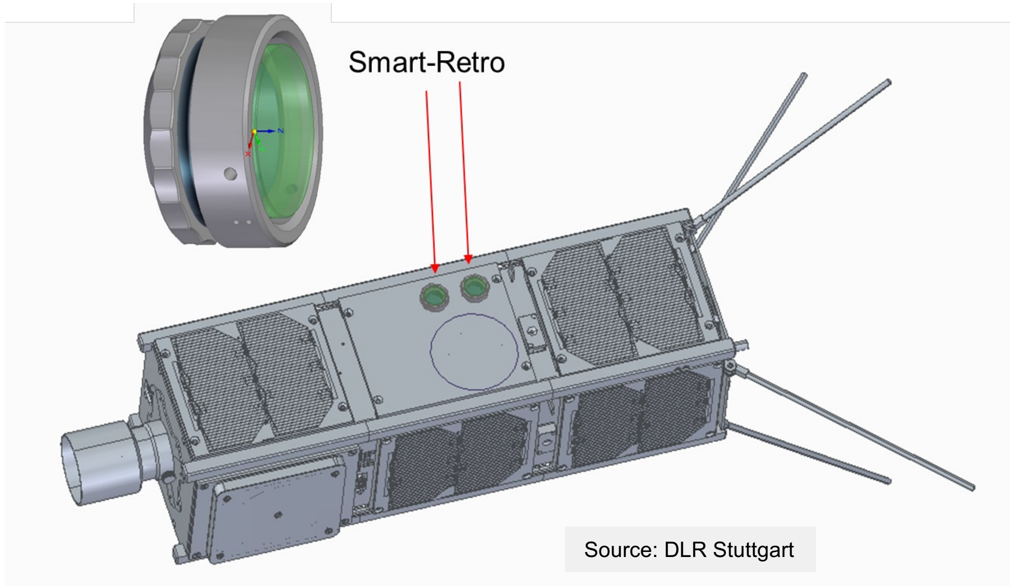
Progress in SLR ground station development



- SLR ground stations are approaching promisingly low SWaP values (size, weight, and power) i. e. makes SLR an affordable and accessible technology for many applications
- Weight of miniSLR system DLR Stuttgart: 600 kg, transportable, small area footprint (< 3 m^2), rooftop operation, low pulse energy & high repetition rate (50 kHz) (averaging single photon returns)
- New SLR ground stations are approaching a reliable, low service effort operation

Satellite retroreflectors: From geodetic to orbital safety applications





- Retroreflectors are small, low cost and can easily be integrated into all satellites including CubeSats
- DLR is performing all necessary qualification tests for long term operation in orbit (vibration, thermal vacuum, energetic radiation tests, thermal performance..)
- DLR retroreflector development allows for implementation of optical tagging technology by polarimetric discrimination (Smart Retro concept) -> CubeSat Confusion
- Development of SLR ground station and passive orbit component (retroreflectors)

Outlook and recommended steps

- Transferring SLR technology to non geodetic satellites

- International “Whitelist” of retroreflector equipped satellites or rocket bodies orbiting in LEO; (items on this list are explicitly endowed with permission for laser ranging)
- Demonstration of high value of orbit data of cooperative orbital objects
  - Efficient conjunction maneuvers
  - Decreasing collisional risk with improved

-> SLR as a contribution for a sustainable use of densely populated orbits

THANK YOU VERY MUCH

Picture: DLR

Selection of related literature

- Space Safety Coalition: Best Practices for the Sustainability of Space Operations, 2019, https://spacesafety.org/wp-content/uploads/2020/12/Endorsement-of-Best-Practices-for-Sustainability_v39.pdf
- European Space Agency, "ESA-OPS-SC-RD-2023-001, Design for Removal – Interface requirement document for LEO missions", 2023.
- European Space Agency, "Spacecraft tracking implications on operations and the design of small satellites", 2018, https://nebula.esa.int/sites/default/files/neb_study/2478/C4000120262ExS.pdf
- D. Hampf, „SpaceWatchGL Opinion: A beacon of light in the sea of darkness: Why all space objects should have retroreflectors", https://spacewatch.global/2022/07/spacewatchgl-opinion-a-beacon-of-light-in-the-sea-of-darkness-why-all-space-objects-should-have-retroreflectors/
- M.A. Skinner: CubeSat Confusion: Technical and Regulatory Considerations, The Aerospace Corporation, 2021, https://aerospace.org/sites/default/files/2021-01/Skinner_CubeSatConfusion_20210107.pdf
- N. Bartels et al., „Space object identification via polarimetric satellite laser ranging"Commun Eng 1, 5 (2022), https://www.nature.com/articles/s44172-022-00003-w