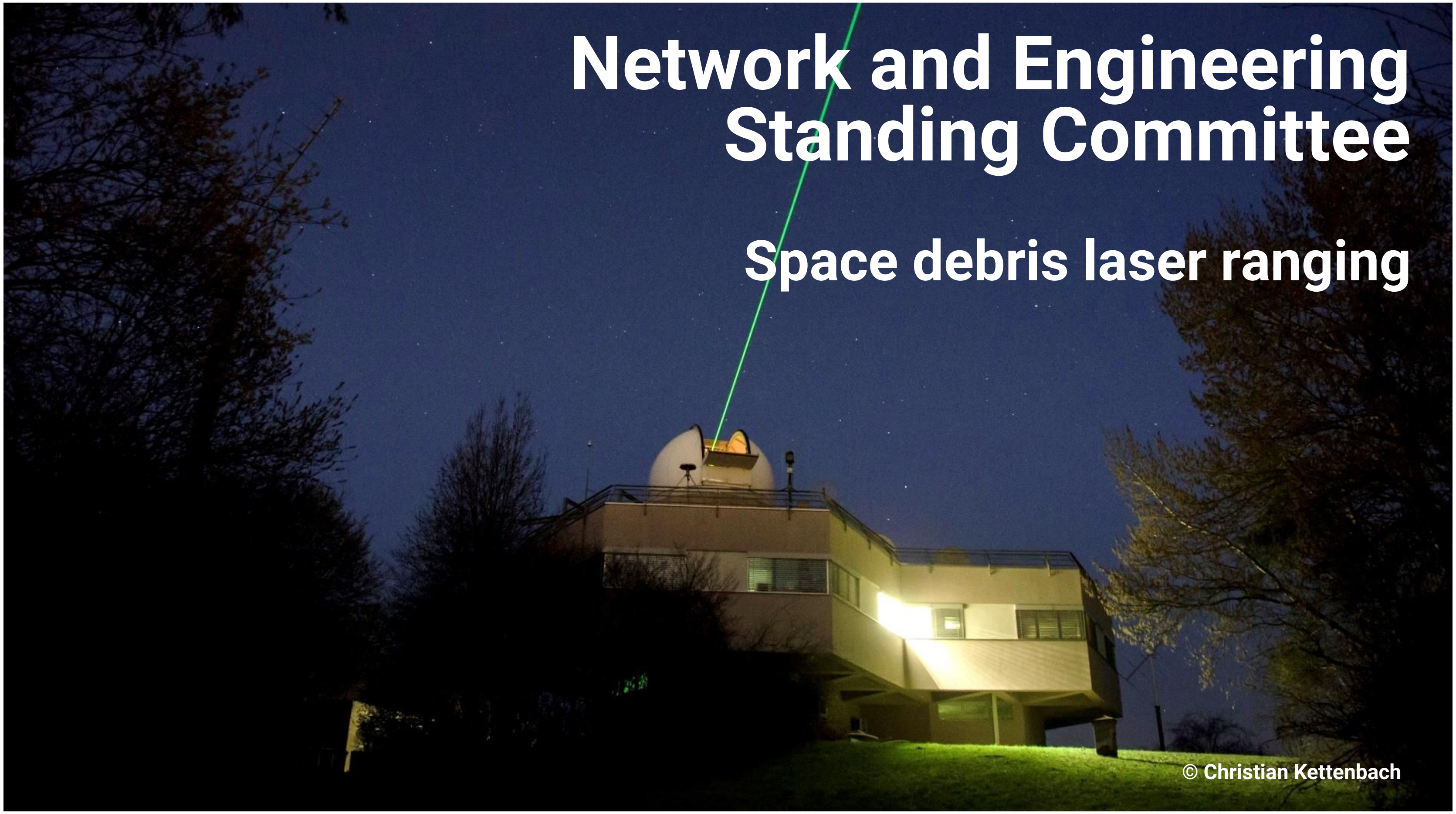
ILRS WORKSHOP 2022



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Space Research Institute, Austrian Academy of Sciences

SPACE DEBRIS LASER RANGING

Space debris (laser ranging) - Main future aspects

Connect „satellite laser ranging“ and „space debris laser ranging“

- Key technology issues as driving factor for both worlds
- Future Picosecond MHz SLR: ?? One laser to rule them all ?? --> No switching times (space debris in LEO gaps ?)
- Backup CCRs on side faces of future satellite missions

Increase network of SLR + SDLR capable stations

- Upgrade of exisiting stations, building new stations (e.g. Izana)
- Bistatic: No space debris laser necessary -> astronomical telescopes ?

Improve prediction quality for priority targets

- More stations -> better predictions
- Bi- and mulitstatic static SDLR

Attitude determination: Data fusion of different sensors

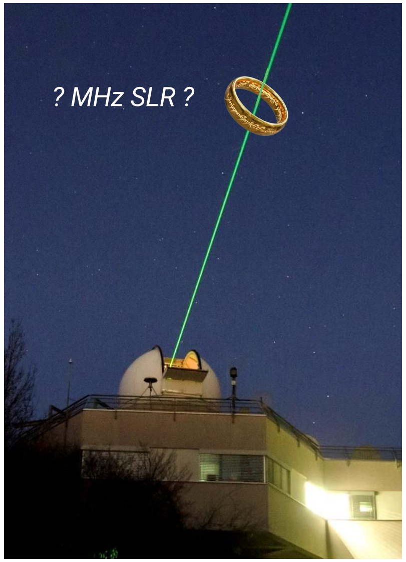
- Radar, SLR, SDLR, optical light curve, SP light curve
- Support for future removal missions

Improve output & observation times

- Daylight, higher power, noise reduction

Automation

- Daytime target detection, time bias correction



GRAZ MHZ RESULTS

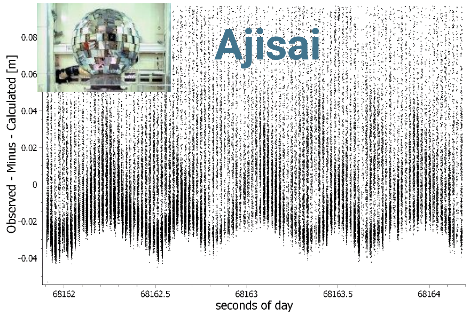
$$RMS = \sqrt{\frac{1}{n}\sum_{j}\left(FR_j - \overline{FR}\right)^2}$$

Graz, MHz laser ranging test results

- 10 ps, 100 kHz - 1 MHz, 20-40 Watt, <100 µJ depending on repetition rate
- Up to 250,000 returns / second
- 100x more for some LEOs, 10x for GNSS

Future: MHz laser specs should allow for…

- High precision SLR
- Space debris laser ranging
- No switching times between laser setups
- Observe debris target in LEO gaps
- High resolution satellite signature (purely single photon)
- More test results to come … a few steps needed towards routine operation



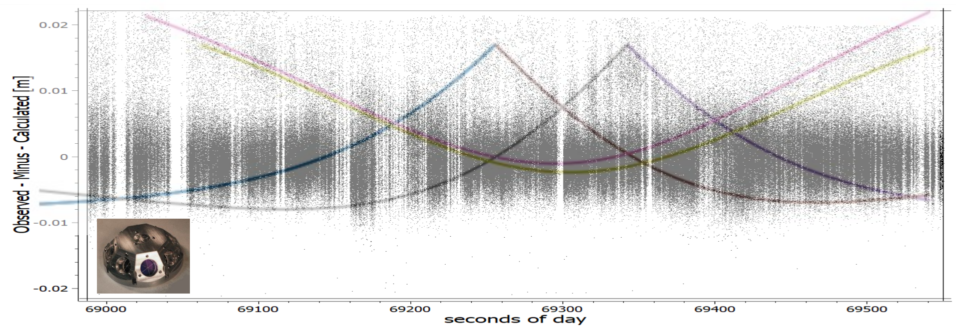
ÖAW IWF

BACKUP CCRS ON SIDE FACES

SLR residual simulations

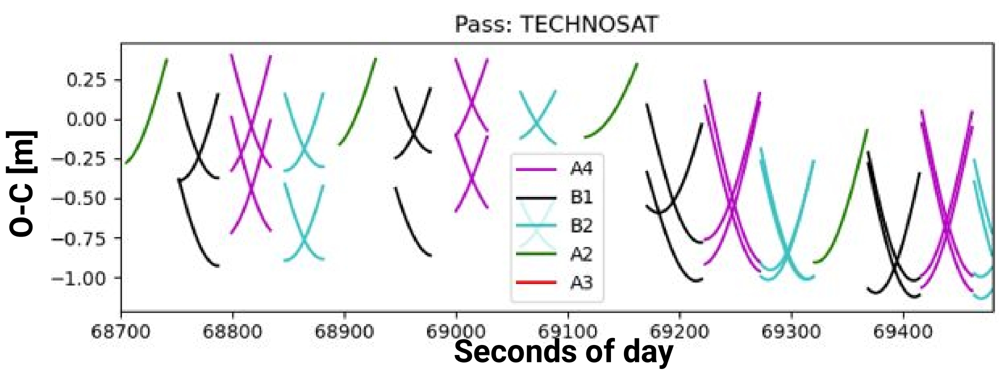
- Backup CCRs on future satellite mission
- 12.5 mm COTS CCRs ok for LEO
- Attitude + orbit determination
- End of life time, out of operation
- Cube sat confusion
- Removal strategies

Jason 3: Simulated vs. Measured

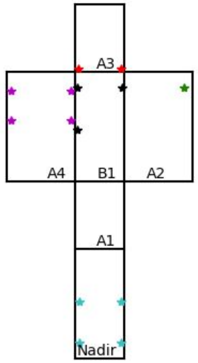


Test case: cuboid satellite: no pyramid on nadir side, 1-4 LLRs on each side

- T_{rot} = 180 s, rotation axis: A1->A3, GCRS = [1, 0, 0]



CCR placement color coded



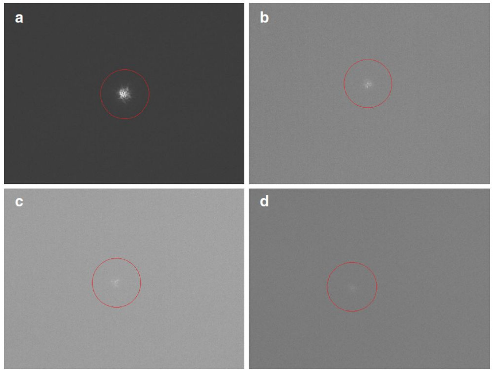
[1] Steindorfer, Schneider, Koidl, Wang, Jonglez, Barschke, Soares, Padilla, Cipriano
Reflector-based attitude detection system, 72nd International Astronautical Congress, 2022

EXTEND OBSERVATION TIMES

Improve predictions -> Easier SDLR tracking

- Synergies between different technologies (Radar, SLR, optical)
- Larger station network
- Blind tracking of debris

Stars, ASI 120
a) m = 0.15, b) m = 3.00, c) m = 6.95, d) m = 8.25

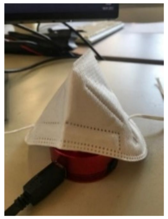


Correct inaccurate predictions

- Time and across track corrected via image analysis
- Range bias: more difficult during daylight SDLR tracking

Noise reduction + daylight detection

- Detector technology (1064 nm, MHz, >100 µm SPADs)
- Make targets visible during daylight
- Different wavelengths, noise reduction



Automation

- Target tracking algorithms
- Automated time bias correction

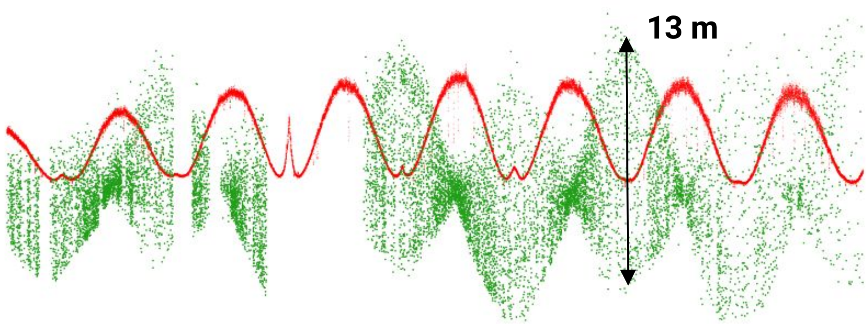
ATTITUDE DETERMINATION

Data fusion – combine different techniques

- SLR, SDLR, LC, SP-LC, Radar, Pointing determination, Plate Solving
- Stations should utilize the additional light gathered by SLR telescope -> light curves

- Recently well studied: Jason 2 spin-up (since 2020)

SDLR + LC data fusion



Envisat: CCR, body, panel (?)