COTS REFLECTORS SIMULATION AND APPLICATION ON TECHNOSAT

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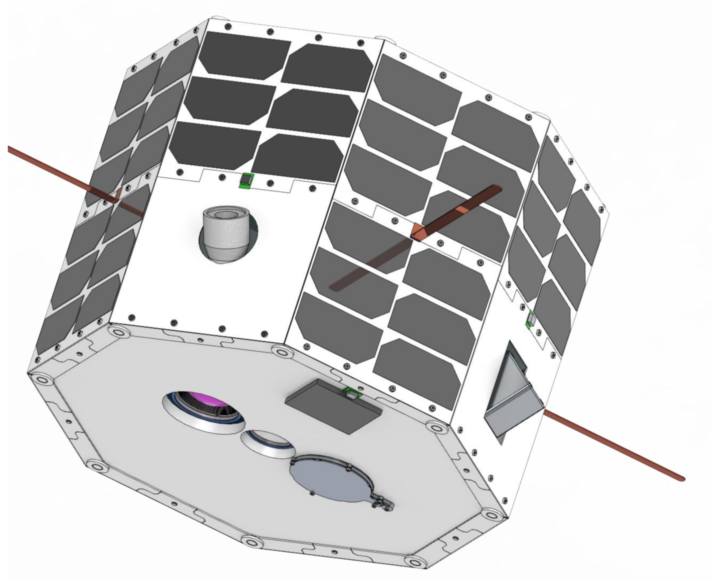
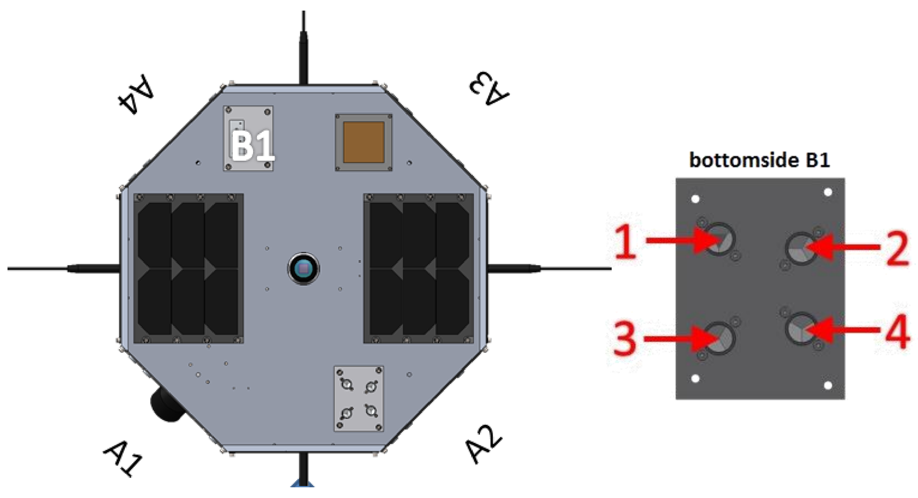
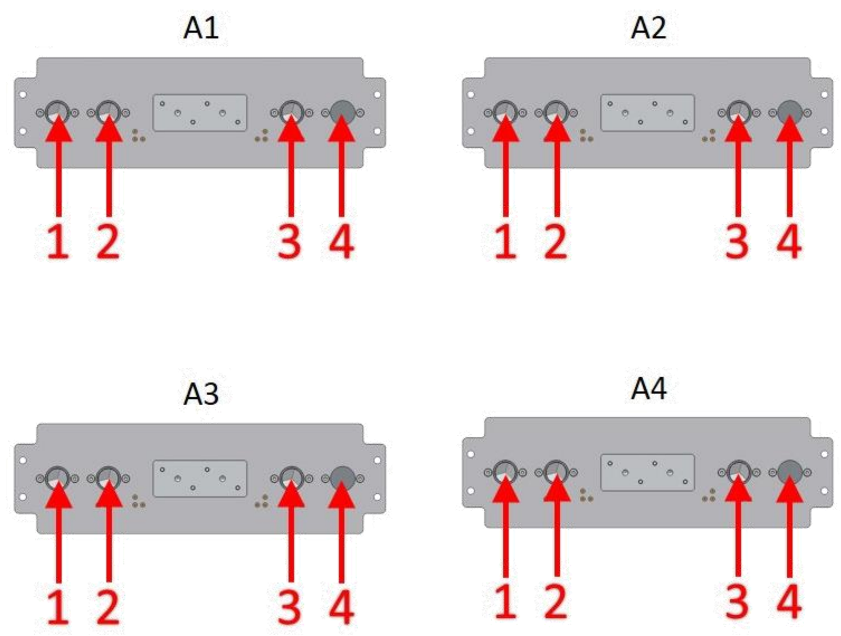
Technosat is a nanosatellite mission of Technical University of Berlin, which was launched on July 14, 2017 and has been tracked **successfully** by several ILRS stations. Across the 10 surfaces of the 8-edge prism satellite 14 small (10mm diameter) COTS (Commercial off-the-shelf) laser retroreflectors are distributed. The COTS retro-reflectors have been measured by GFZ Potsdam; Graz characterized and simulated several different distributions of these retro-reflectors to optimize identification of satellite attitude, and to determine spin parameters after its operational / stabilized phase.

- SLR and POD; determine attitude of the satellite; determine which side of the satellite is showing to observatory;
- Verification of satellite attitude sensors via laser retro-reflectors



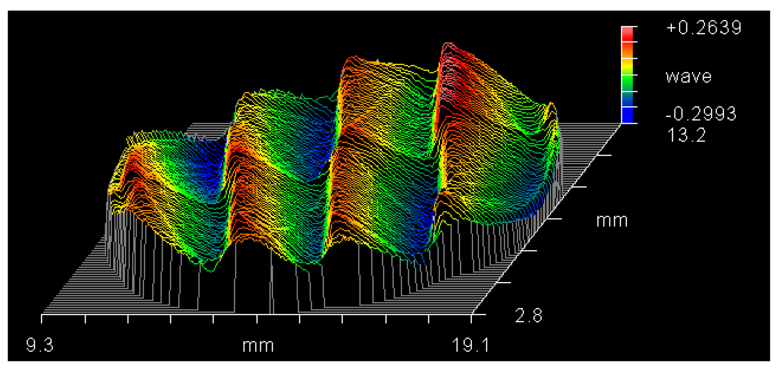


- Ø10mm;
- Beam Dev. ±3'';
- Fused silica;
- Commercial reflectors



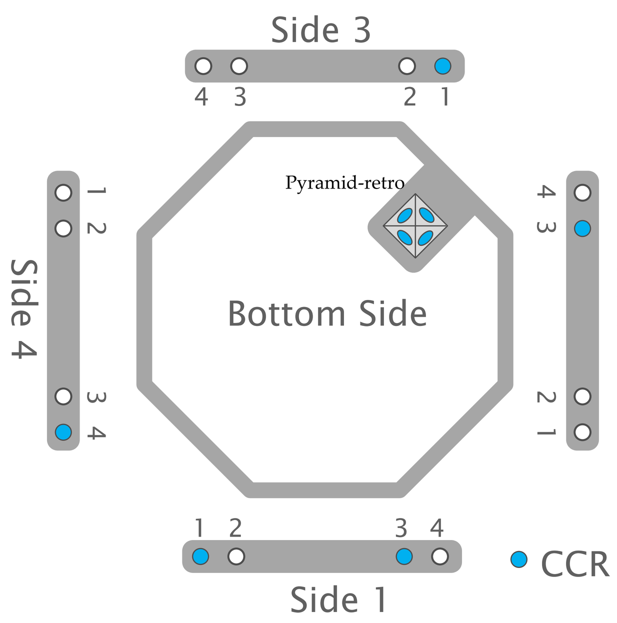
Satellite model mounted on a Tripod

CCR

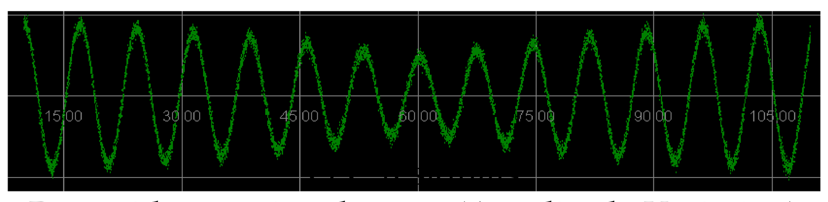


On a small mountain about 32 km southwest of Graz station we placed a wire grid model of the satellite – with various numbers and distributions of retro-reflectors - on a tripod; this satellite model was rotated by stepper motors, simulating attitude motions while we measured the distance with our 2 kHz SLR system.

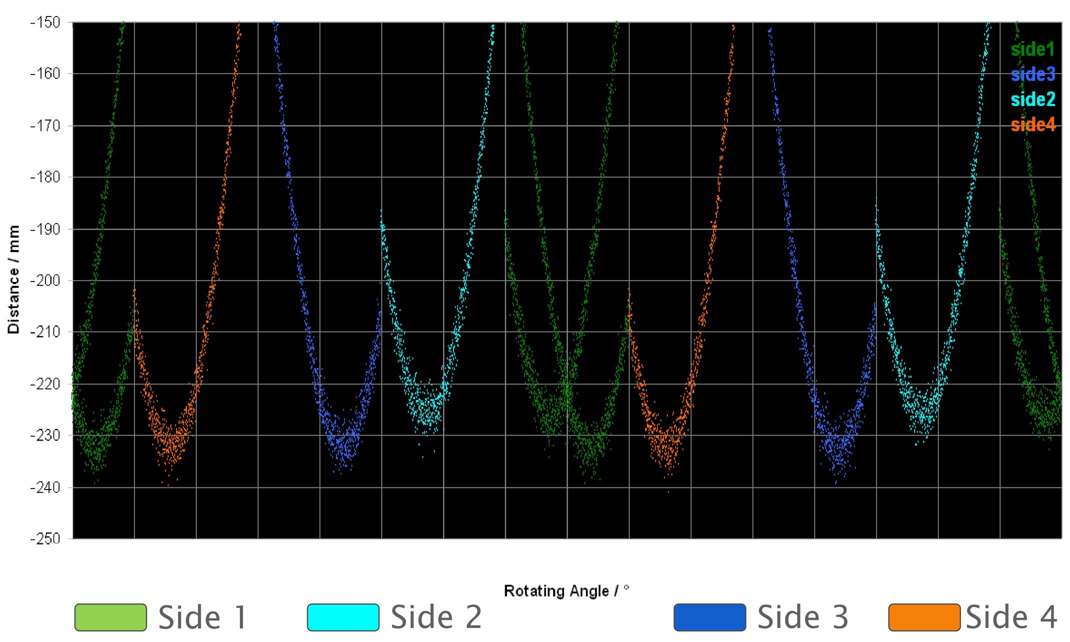
Design 1 --- Simulation and measurements

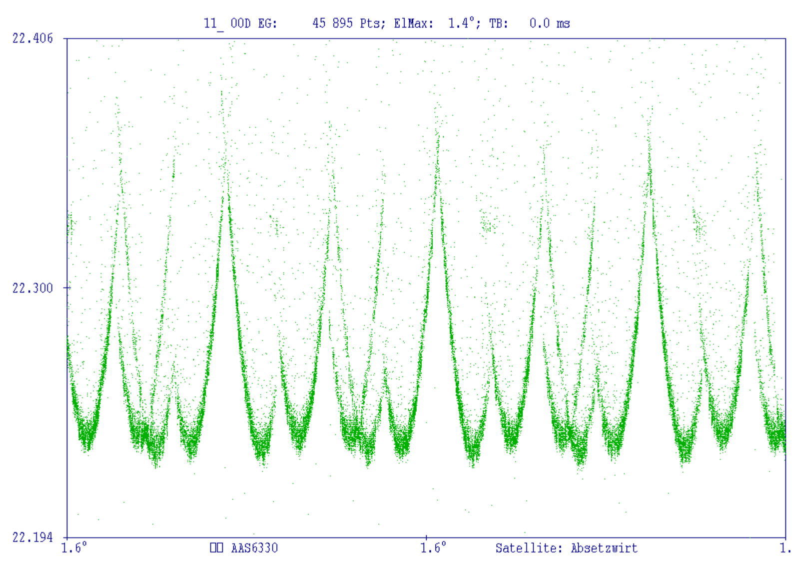


- Measuring period of side 1(2 peaks) yields spinning rate after stabilized phase;
- Attitude can be determined by measuring signal traces of bottom CCR
- Side can be identified by few factors:
  - -- Min. time difference: side2«»side3
  - -- Max. time difference: side3«»side4
  - -- Amplitude Diff.(e.g. on side 1, #1>#3)



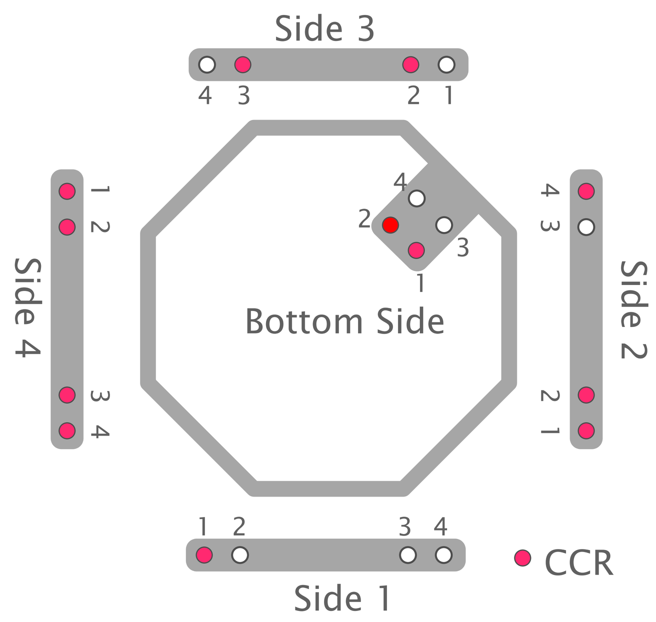
Pyramid-retro signals trace (Amplitude Variation)



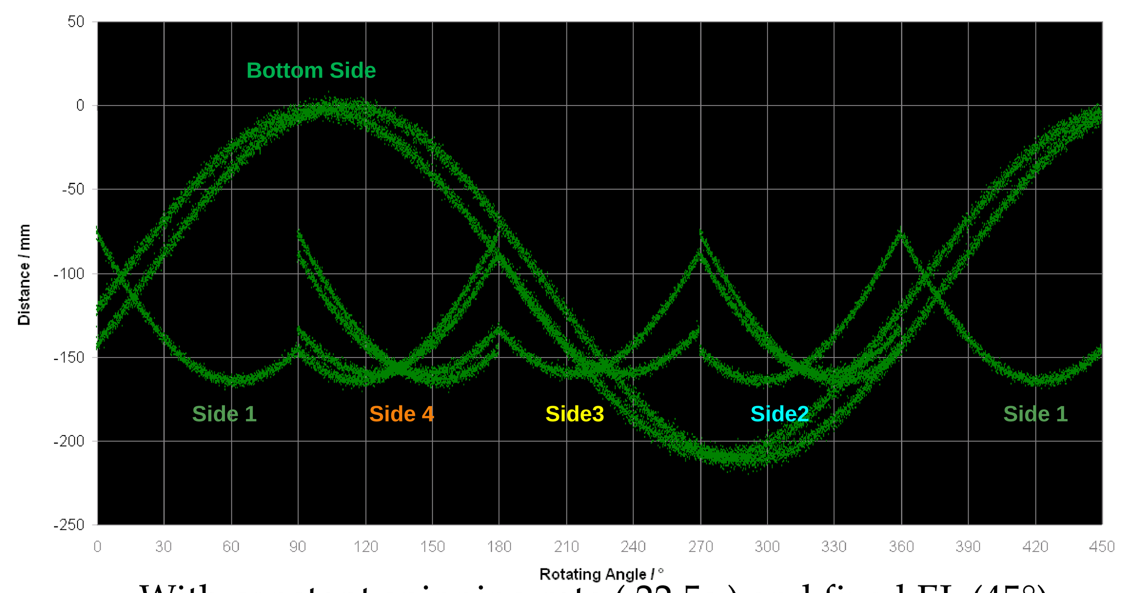


O-C residuals measured with model and Graz 2kHz

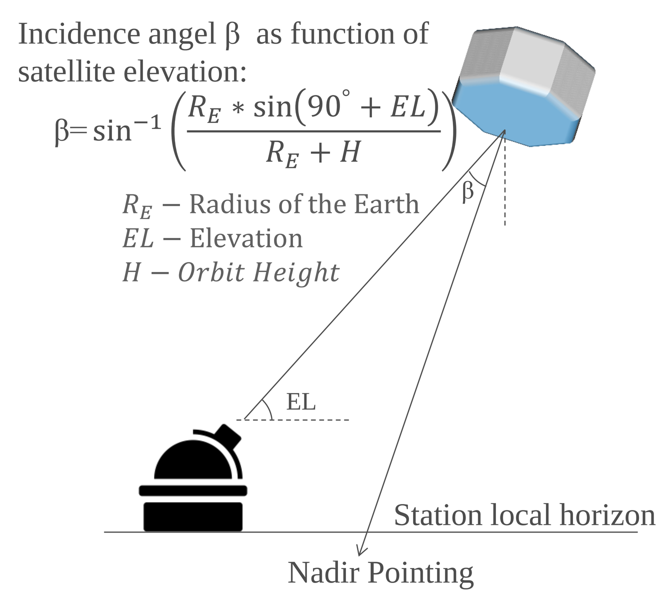
Design 2 --- Simulation and measurements

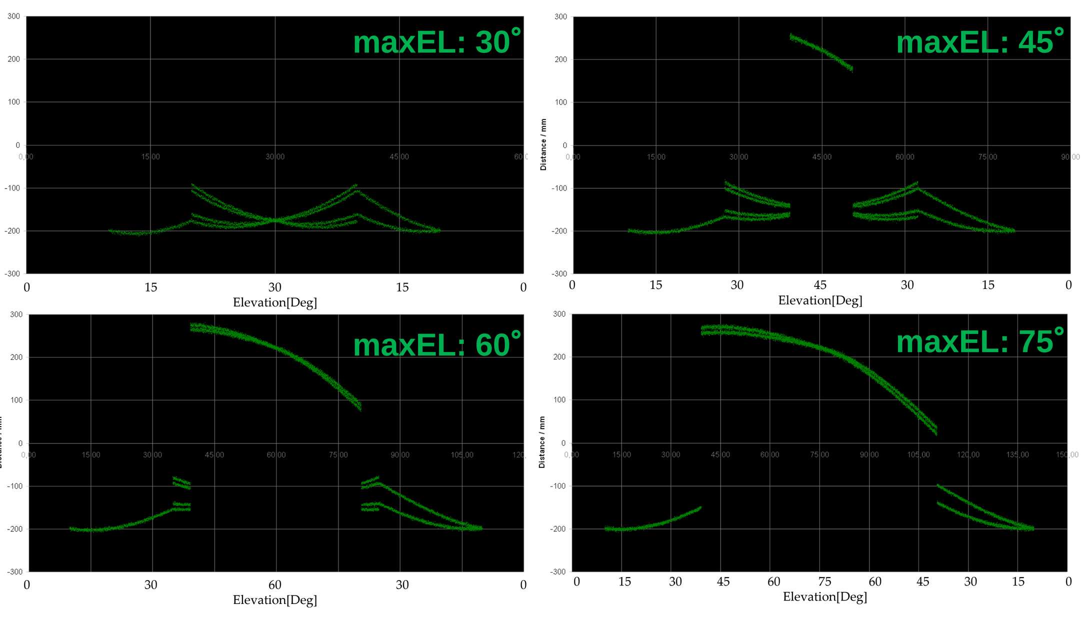


- In design 1, difficult to identify the side when no spinning ;
- Apply 12 CCR, simulate and test with variant satellite elevations (whole pass);
- Slightly change of adding 2 CCR on the top side, this design is applied on Technosat FM

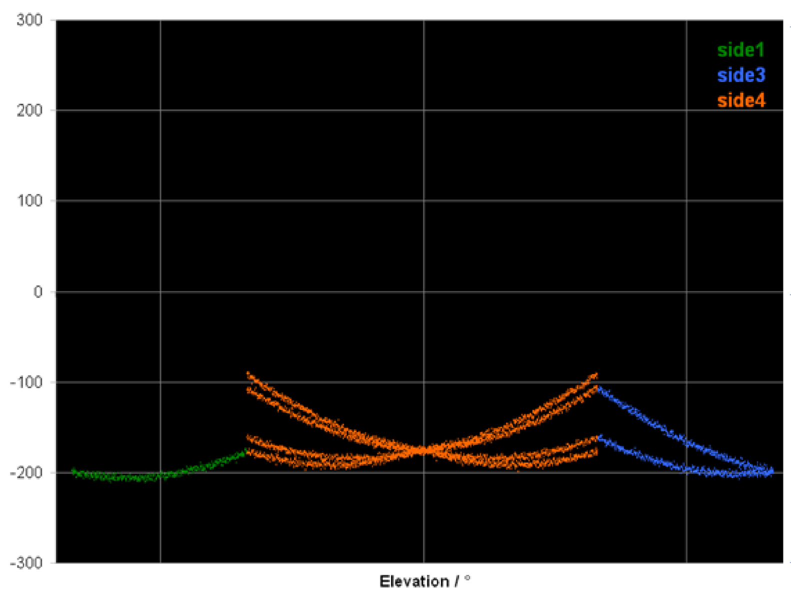


With constant spinning rate (22.5s) and fixed EL (45°)

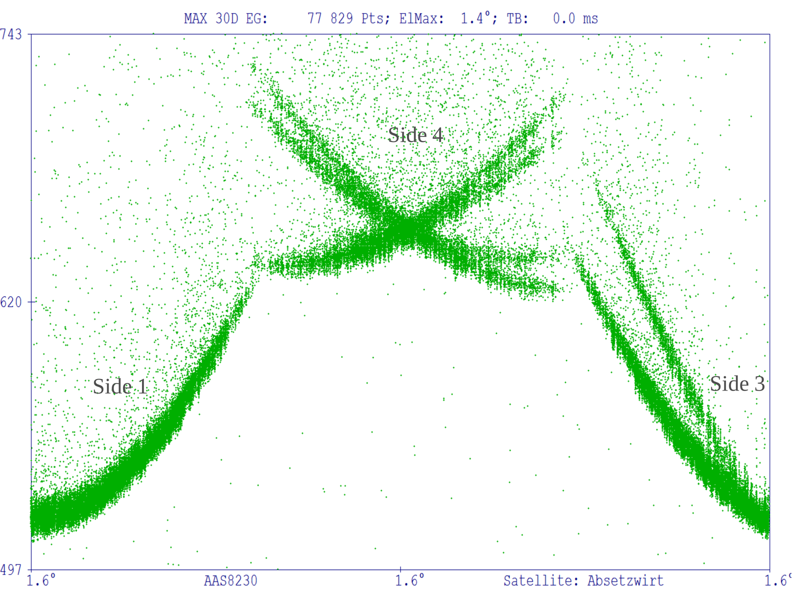


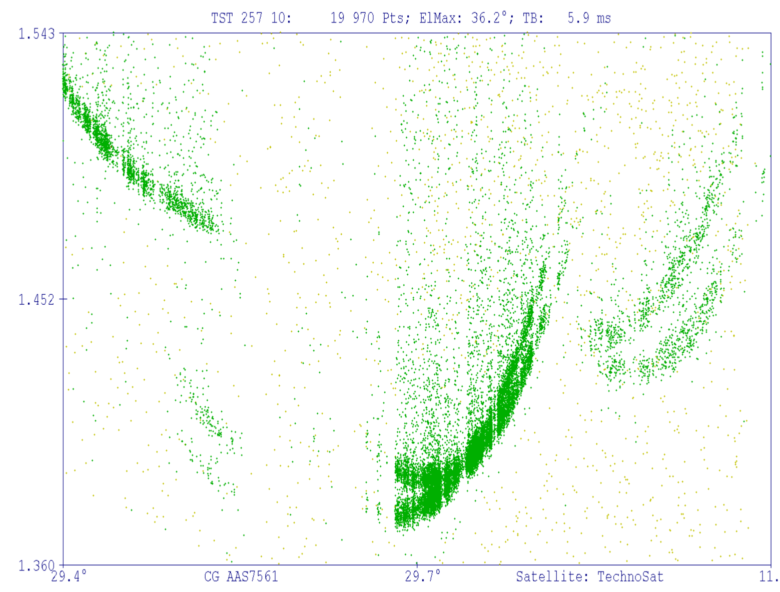


Bottom signals appear and side surfaces disappear when EL >40°



No bottom side signal during whole pass with of maxEl=30°; higher elevation was not able to measure due to tripod ability.





Graz Technosat Pass (29°»EL »11°)
UTC10:25 Sep. 7, 2017

SUMMARY

Applying several well-distributed commercial CCR on each surface of satellite allows not only for SLR, POD and on-board sensor comparison, but also for attitude determination, and for spinning and face identification even after operational phase or in case of satellite problem.

Reference

1) https://ilrs.cddis.eosdis.nasa.gov/missions/satellite_missions/current_missions/tech_general.html
2) Kirchner, G., Grunwaldt, L., Neubert, R., Koidl, F., Barschke, M., Yoon, Z., Fiedler, H., Hollenstein, C., 2013. Laser Ranging to Nano-Satellites, in: 18th International Workshop on Laser Ranging.

2017
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