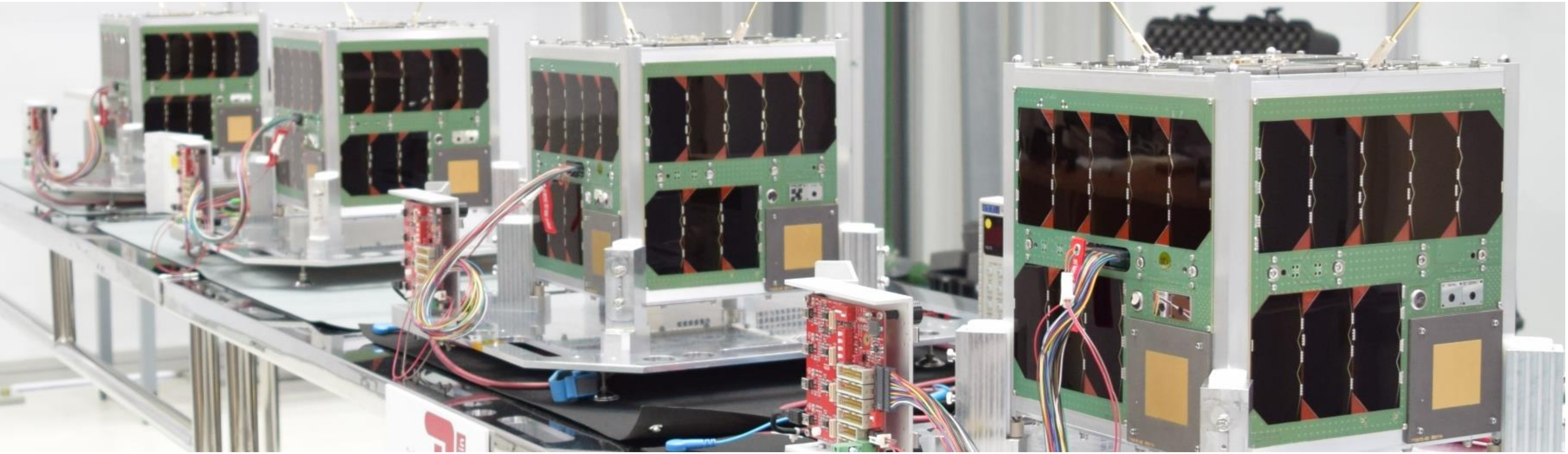
NanoSatellite Mission S-NET



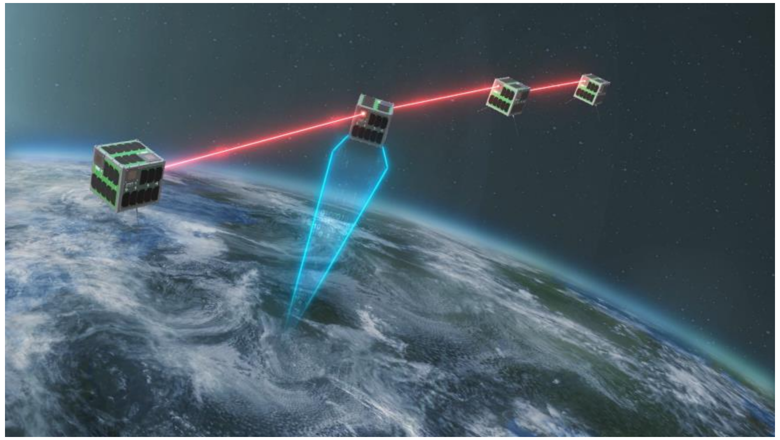
Zizung Yoon, Walter Frese, Klaus Briess

Institute for Aeronautics and Astronautics, Technische Universität Berlin, Zizung.yoon@tu-berlin.de

Peiyuan Wang, Hannes Almer, Georg Kirchner, Franz Koidl, Michael Steindorfer

Space Research Institute, Austrian Academy of Sciences, Peiyuan.wang@oeaw.ac.at

Objectives

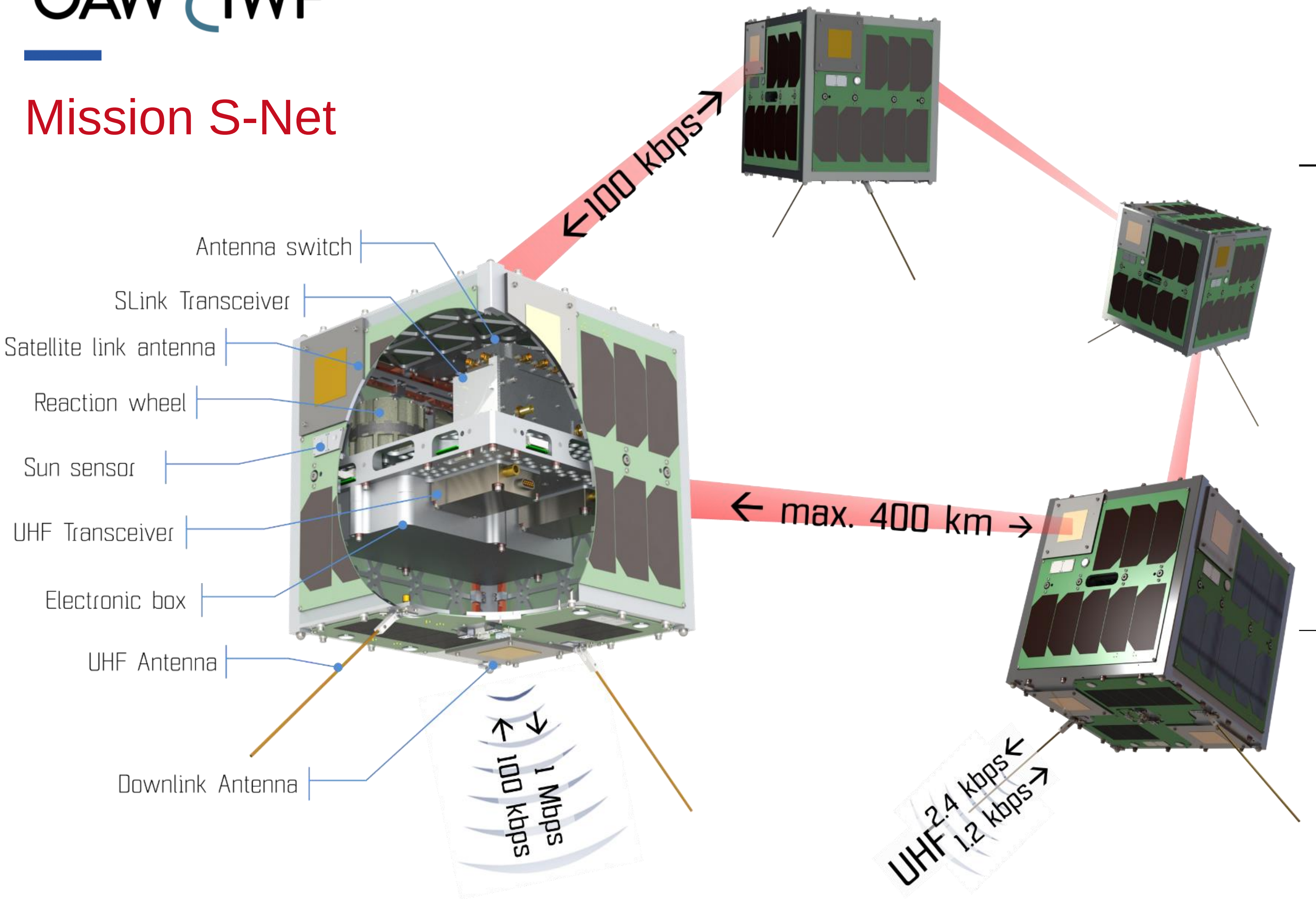


Mission statement:

„Demonstration of inter satellite communication within a nanosatellite network"

- demonstrate multipoint ISL with S-band transceiver
- verify the newly developed / optimized ISL communication protocols
- analyze the stability of a nanosatellite formation
- demonstrate the feasibility of nanosatellites as a base for demanding communication missions

Mission S-Net



Satellites	4
Satellite mass	8.7 kg
Satellite size	25 x 25 x 25 cm3
Power (nominal)	< 4.5 W
Orbit	SSO < 600 km
Launch	Soyuz / Fregat via Dispenser
Payload	S-band transceiver, Laser reflector
Launch	1. Feb. 2018
Design lifetime	1 year

Relative Distances

- 4 Snet drift away(~0.1 km/day) from each other after launch due to perturbation
- Required for the inter-satellite distances :
  - -- 4 months with an assumption of distances less than 100 km
  - -- 7 months after launch less than 200 km
  - -- max. 400km for ISL

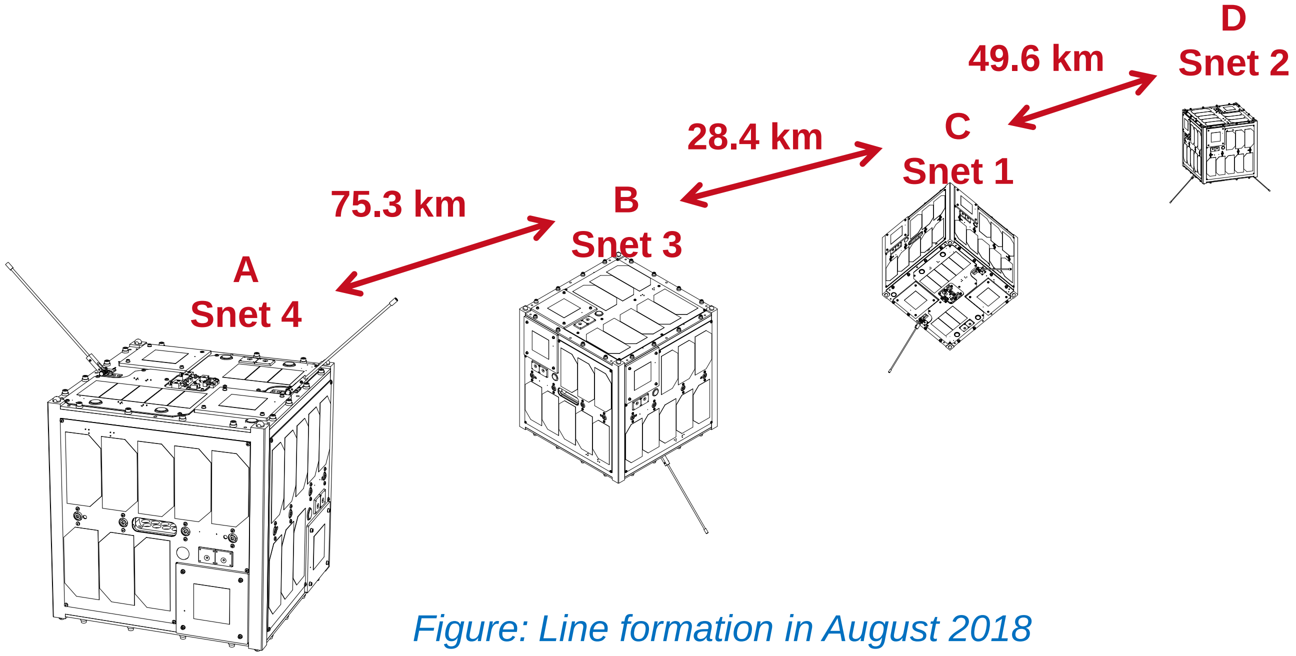


Figure: Line formation in August 2018

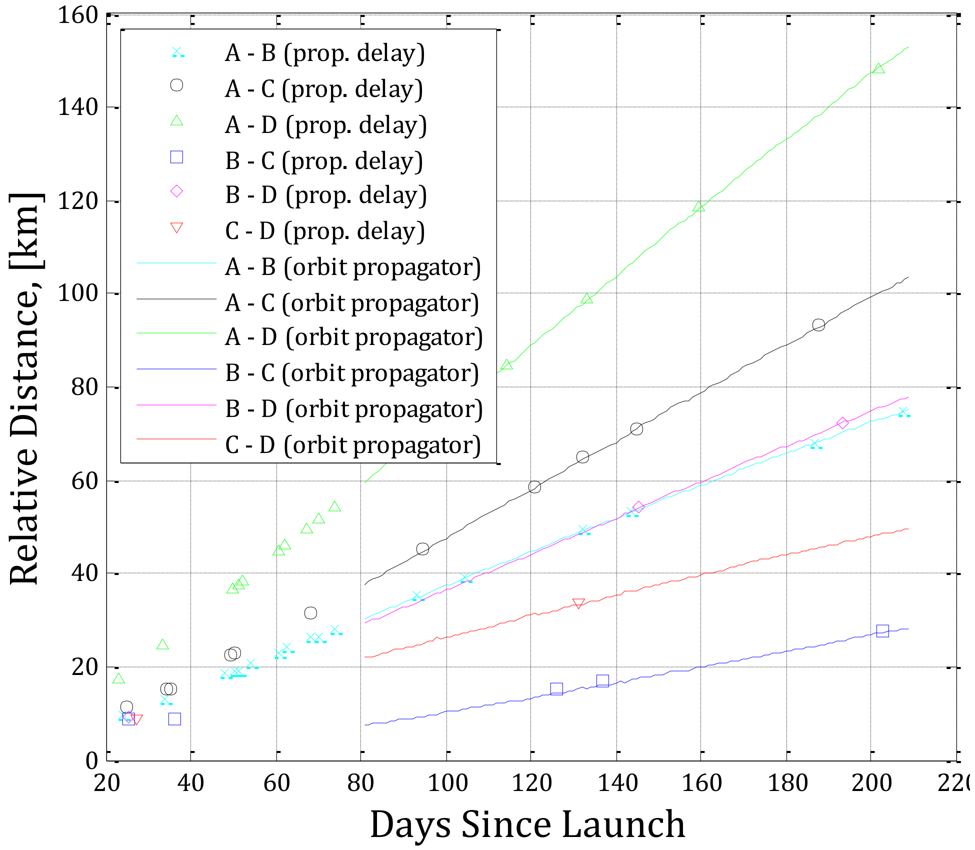


Figure: Measured (signal propagation) and propagated (space radar) distances between satellites

LASER RANGING

Obit determination and control

- Radar (TLE prediction), SLR, distances measurement by SLink
- No ☹, but by controlling initial seperation parameters

Attitude determination and control

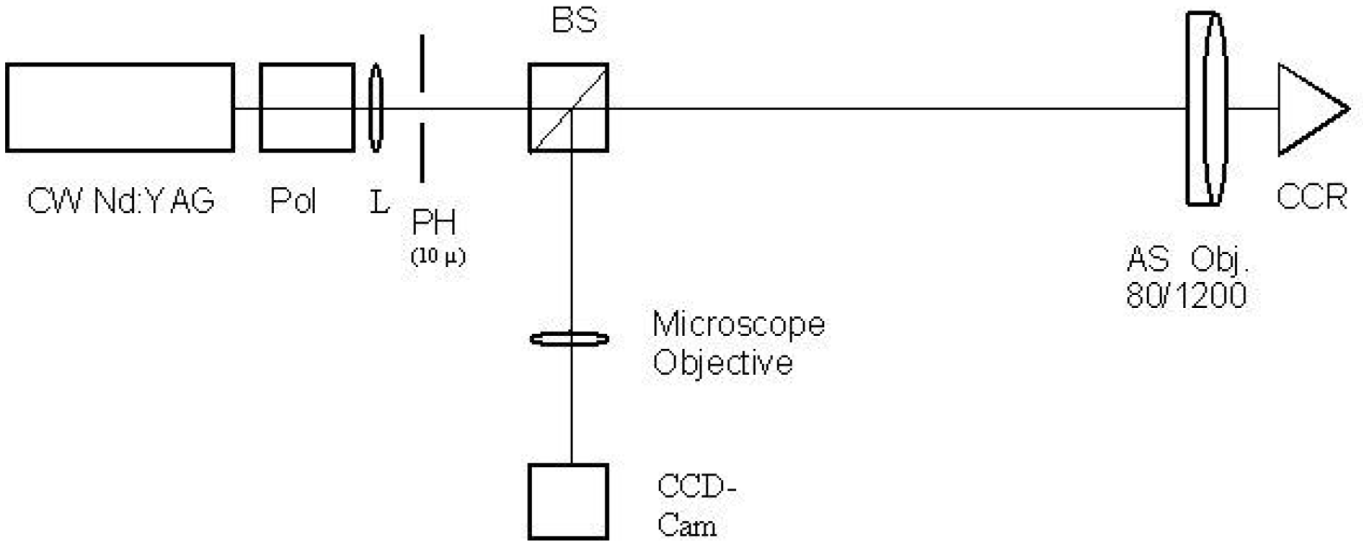
- Attitude control +/- 20°
- MEMS GYRO and Sun sensor
- Reaction wheel

Laser Ranging Purpose

- Test quality of ϕ10mm COTS(commercial off-the-shelf) CCR in orbit
- Identify the satellites in early orbit phase, since the satellites are deployed with very low drift
- Calibration of distance measurement of S-Link module (based on RF-signal propagation time)
- Precise distance measurement for drag control experiment to control relative distance of satellites
- Attitude analysis ???

CCR Selection

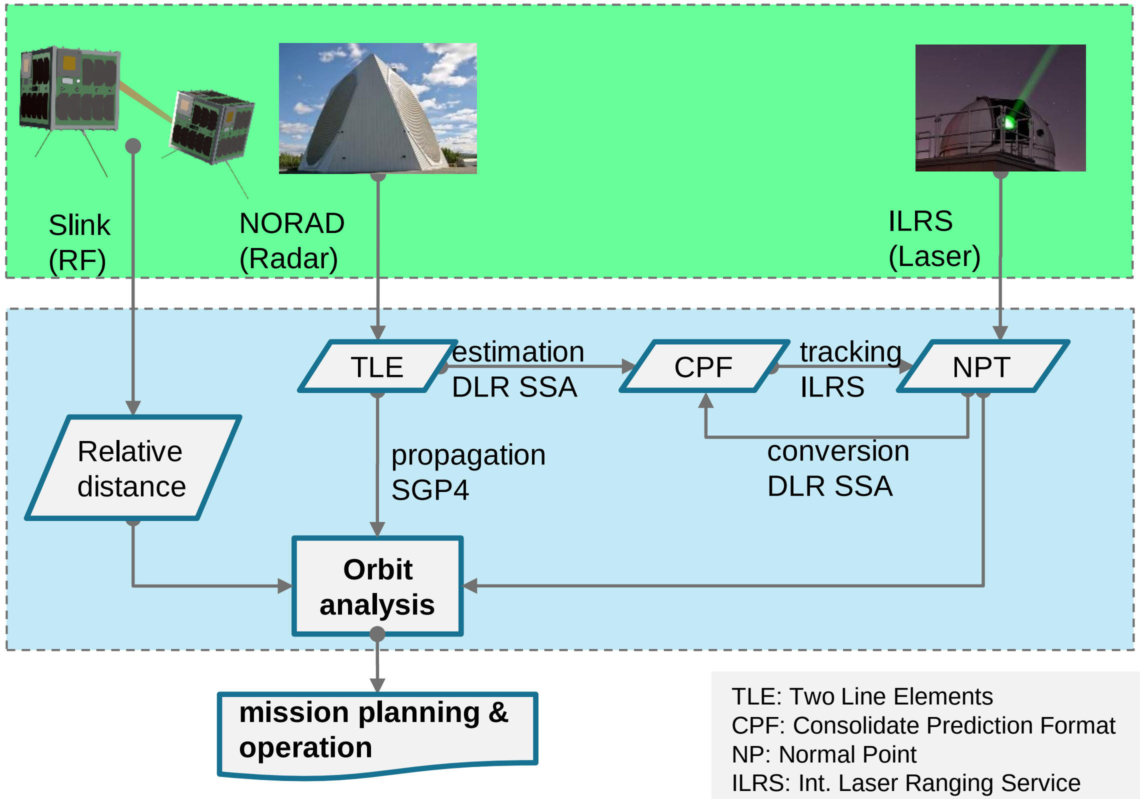
- Fused silica cubes ϕ10 mm (Hengrun Optoelectronics, China)
- Refractive index of material: 1.461 for λ=0.532
- Tolerance: no offset, +/-3 arcsec accuracy
- Silver coating
- Far Field Diffraction Patterns Measurement by GFZ Potsdam



[Test FFDP for CCR ; L. Grundwaldt, GFZ Potsdam]

Laser Ranging Operation

- Nominal mode: nadir pointing:+/- 20 °
- No restrictive attitude or angle
- Normal point bin size (time span): 5 sec
- Generation of CPF by DLR or IWF
- Position measurement by HF signal propagation: 100m accuracy

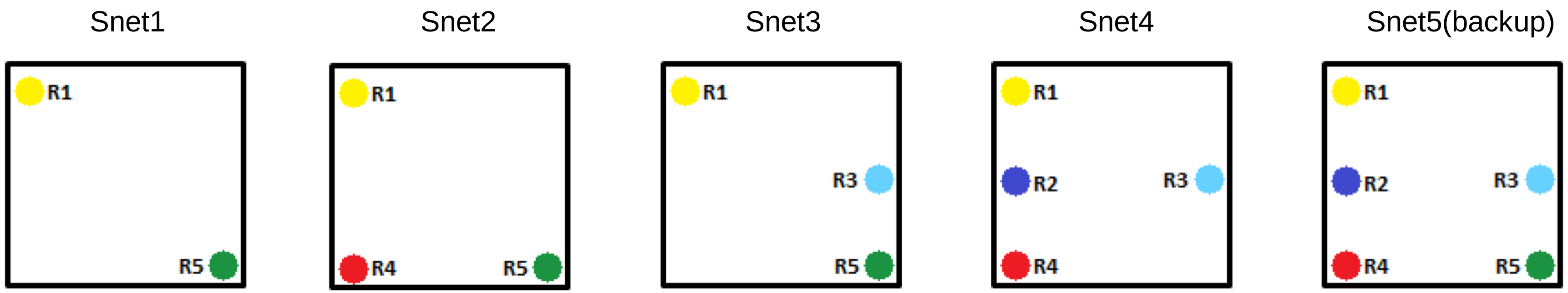


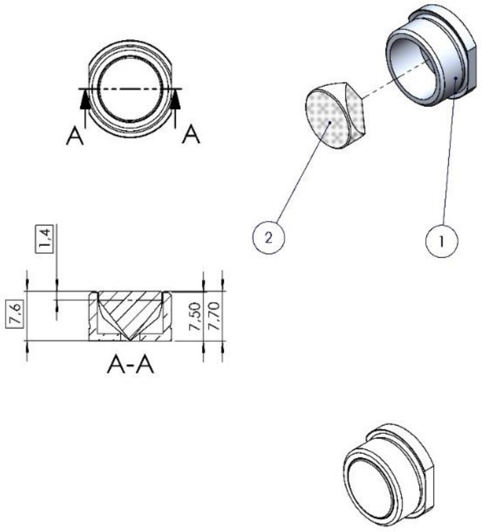
TLE: Two Line Elements
CPF: Consolidate Prediction Format
NP: Normal Point
ILRS: Int. Laser Ranging Service

Well done with ready CCR and CPF, identification and attitude analysis???

CCR unique configuration

- **#1-5** side of each four satellites are identical and equipped with one reflector.
- **#6** of each satellite has different pattern to identify between each other.





Modell of the satellite on a tripod driven by a step motor

- Align the modell to our LASER-station in Graz
- Let the modell spin while LASER is shooting to the modell
- Repeat that for different scenarios

•Measurements confirm simulation

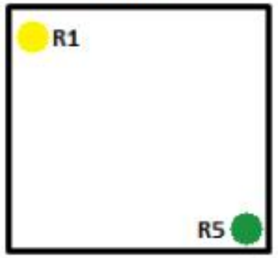
•Identification of satellites easily possible

•Angle of satellite can be determined by measuring the distance between top and low peak of amplitude of signal trace

•Spin rate of satellite can be determined by measuring peak-to-peak time

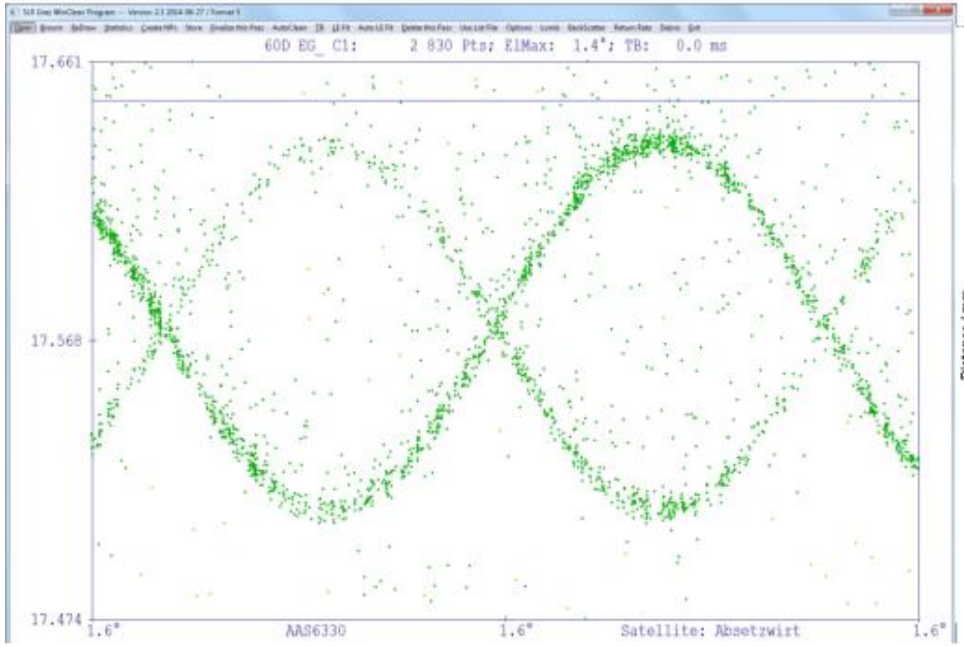
- Angle: 60°
- Signaltrace of spinning motion of the bottom side

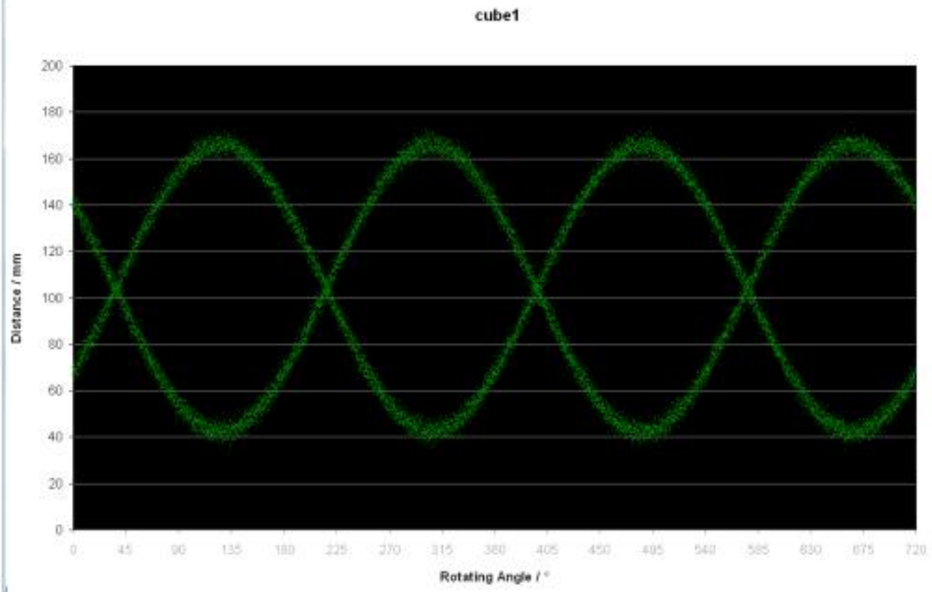
cube1



Measured data

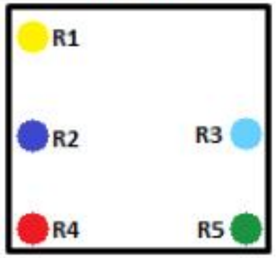
Calculated data





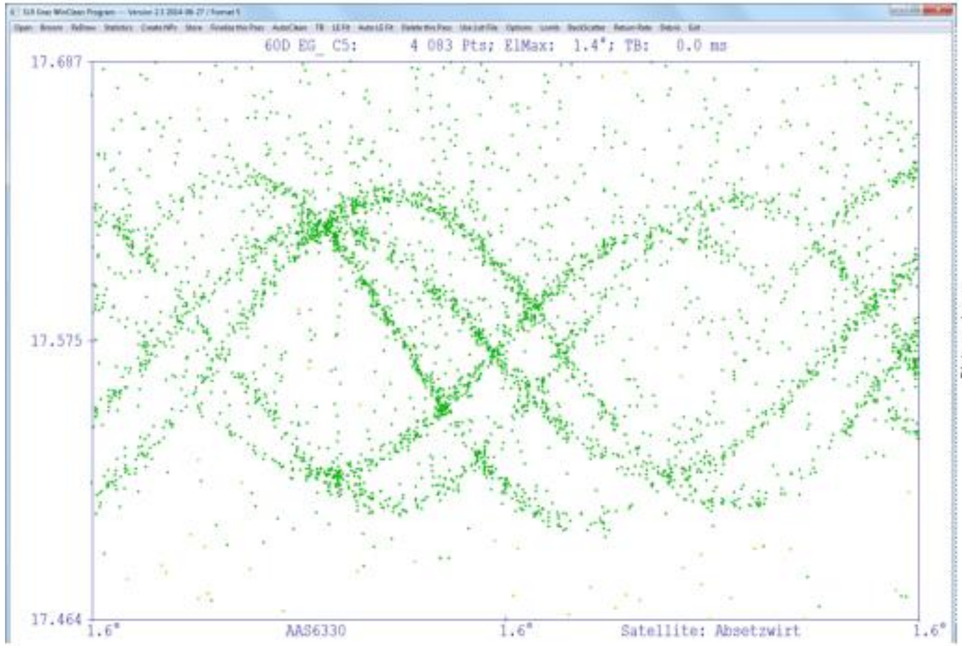
- Angle: 60°
- Signaltrace of spinning motion of the bottom side

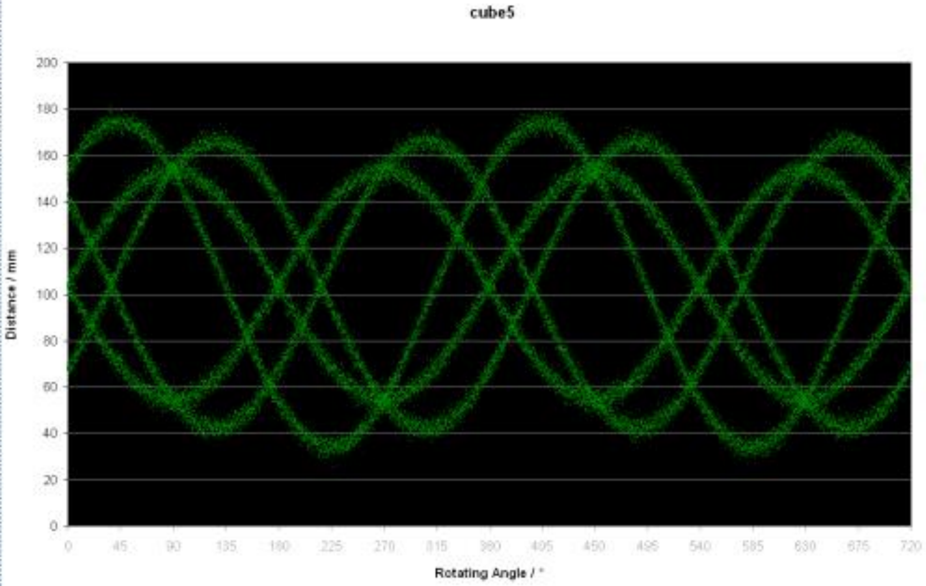
cube5



Measured data

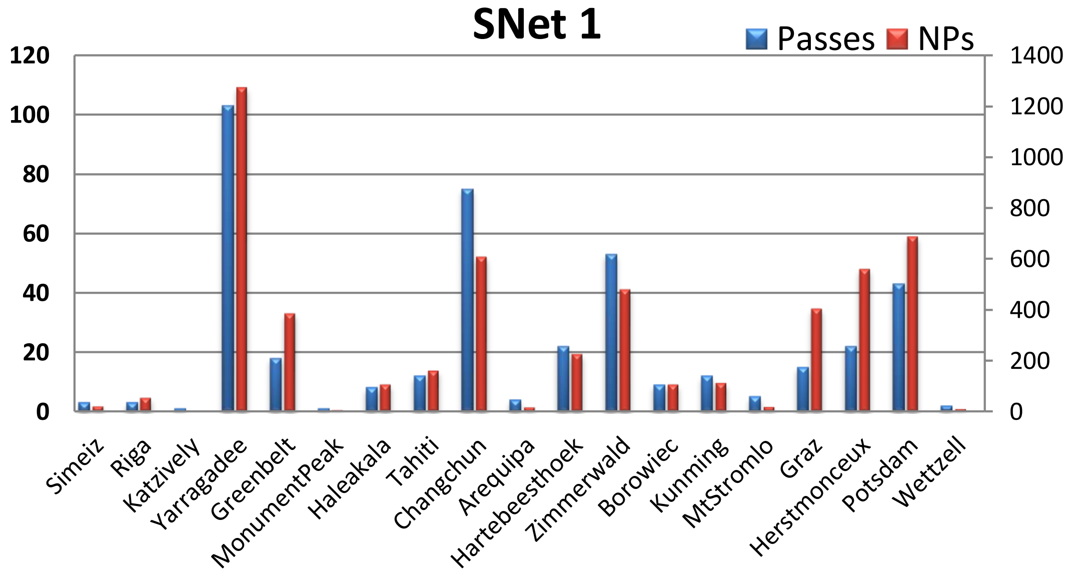
Calculated data

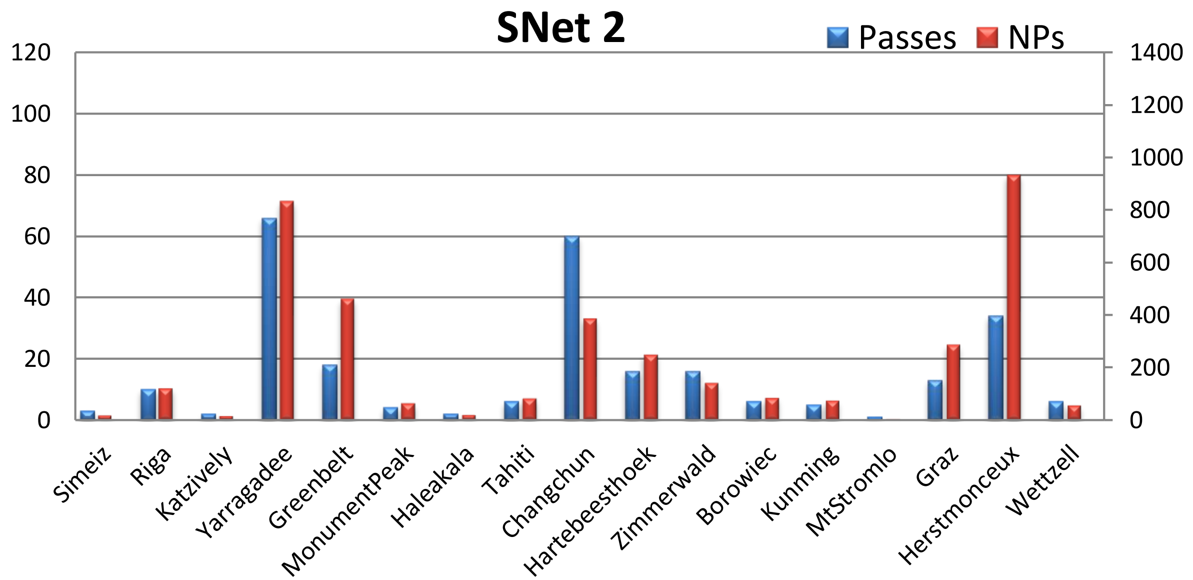


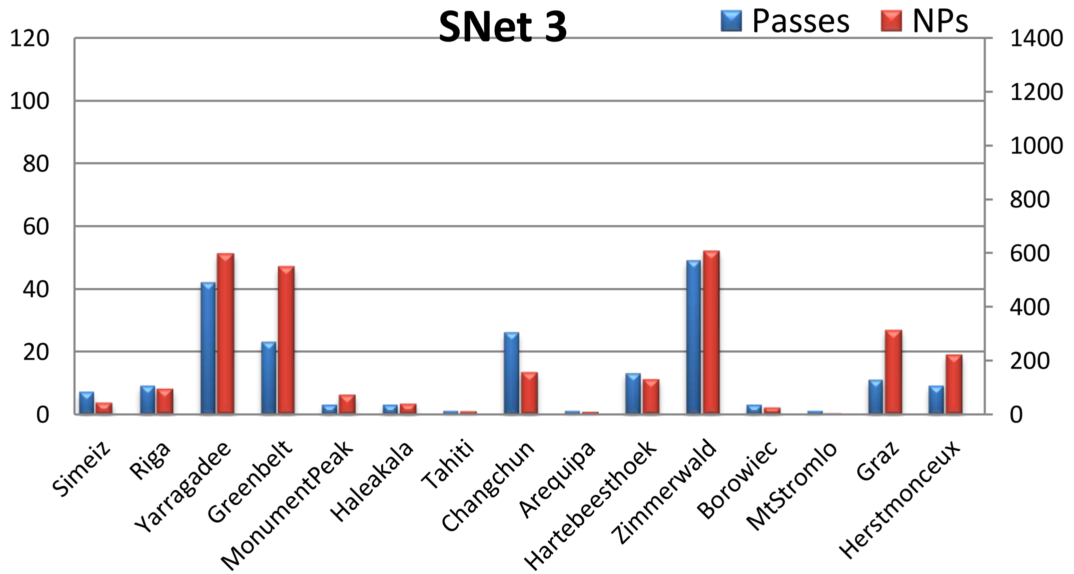


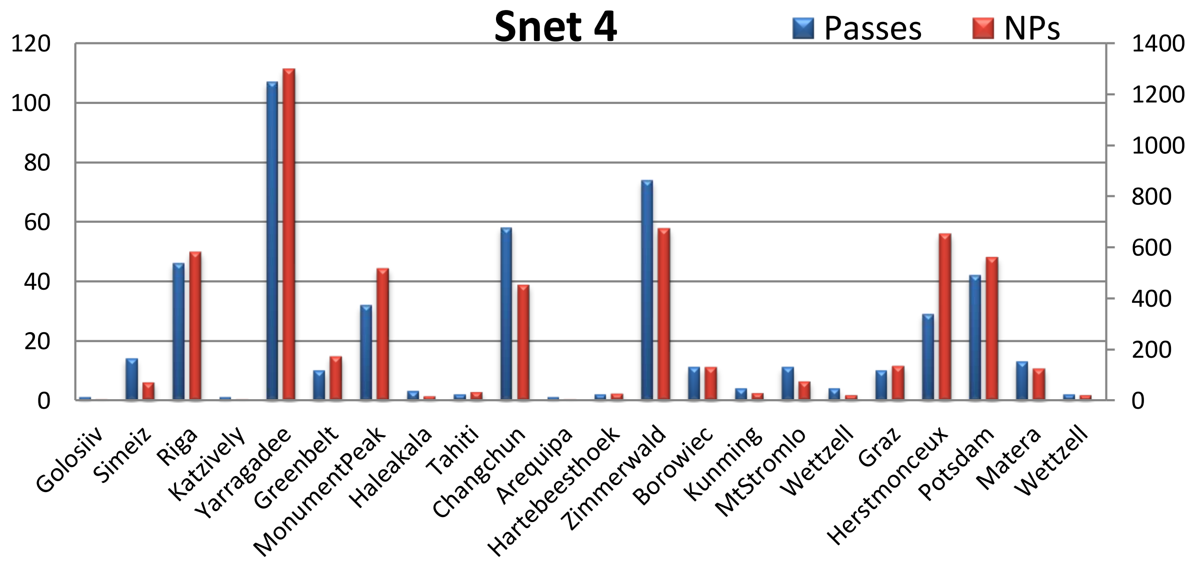
ILRS Observations

Ref. EDC, last update: 2018-10-31 02:01:34

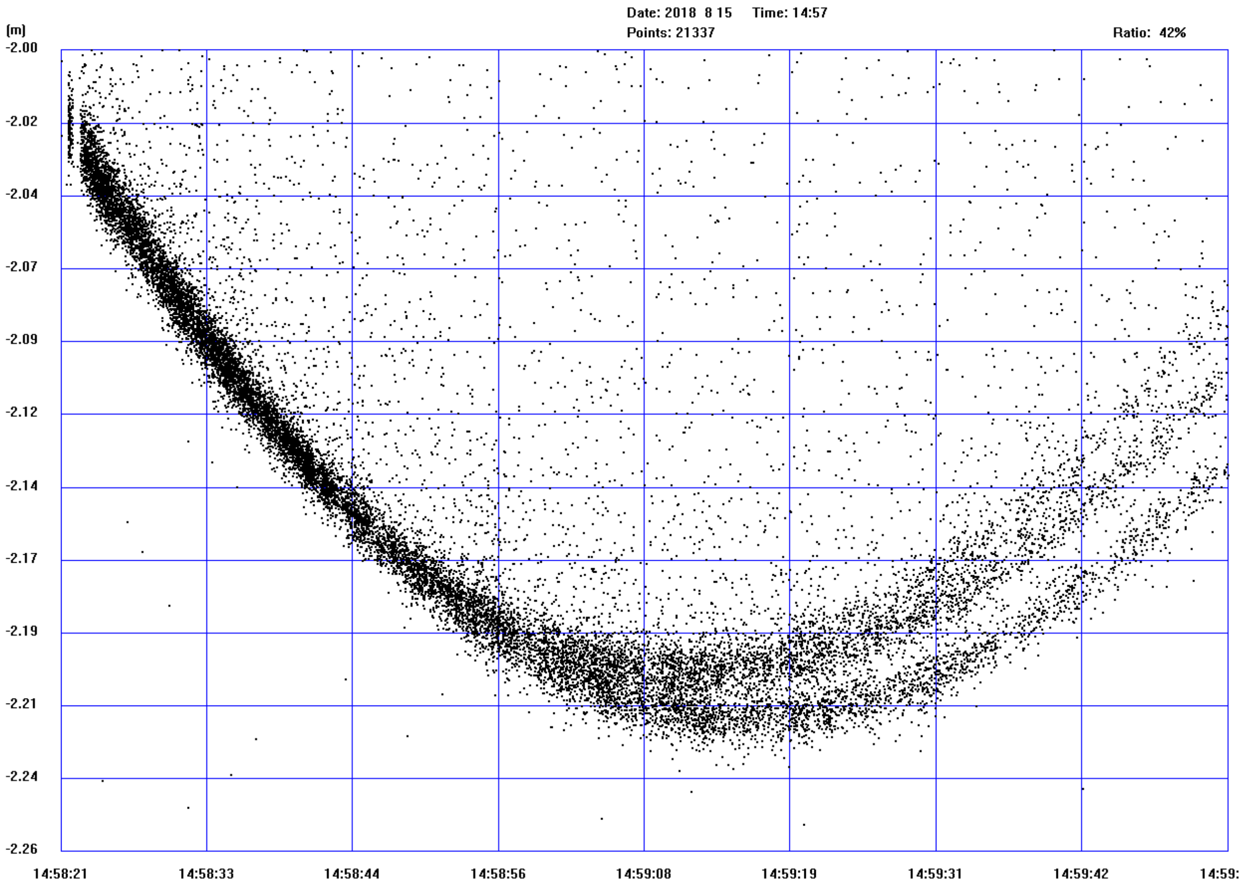


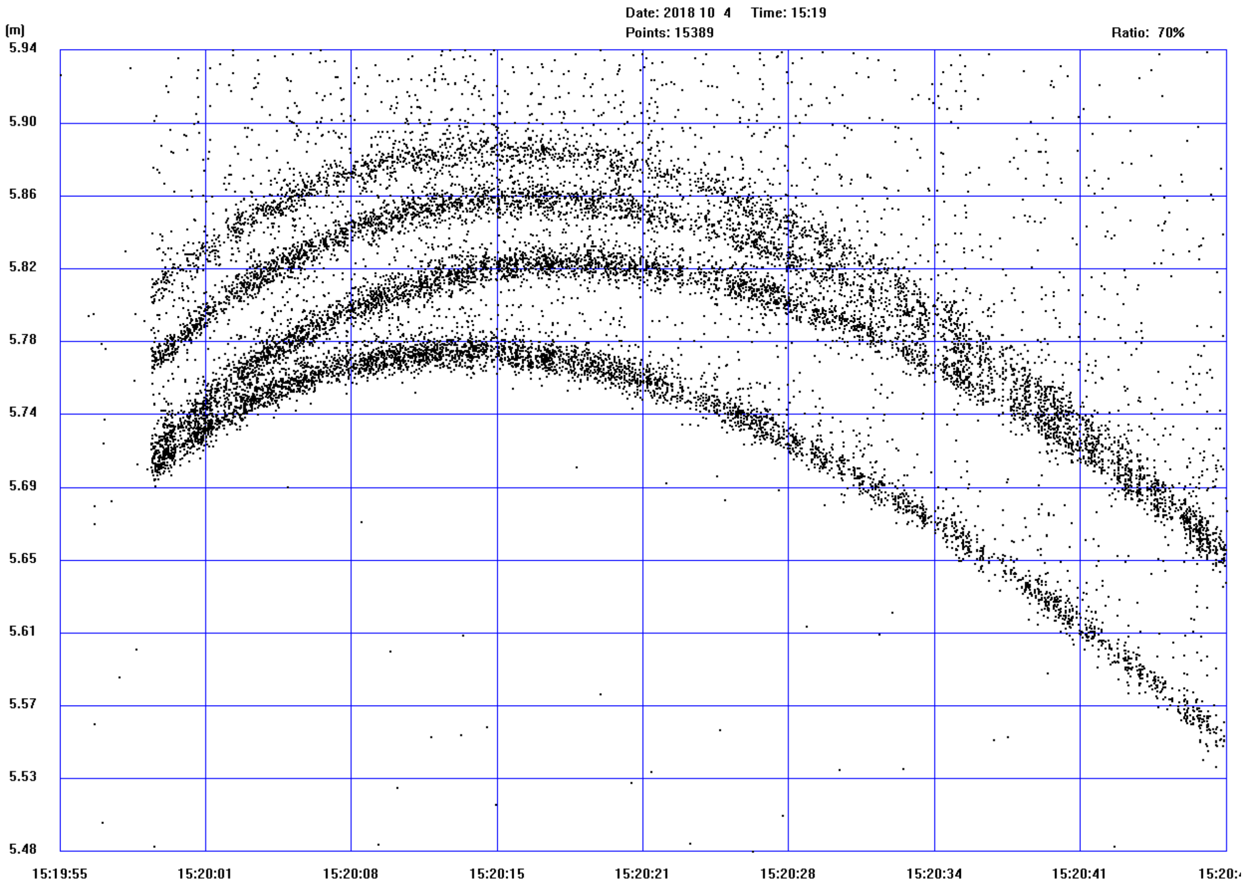


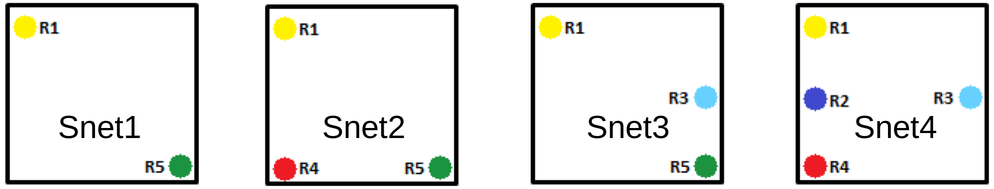




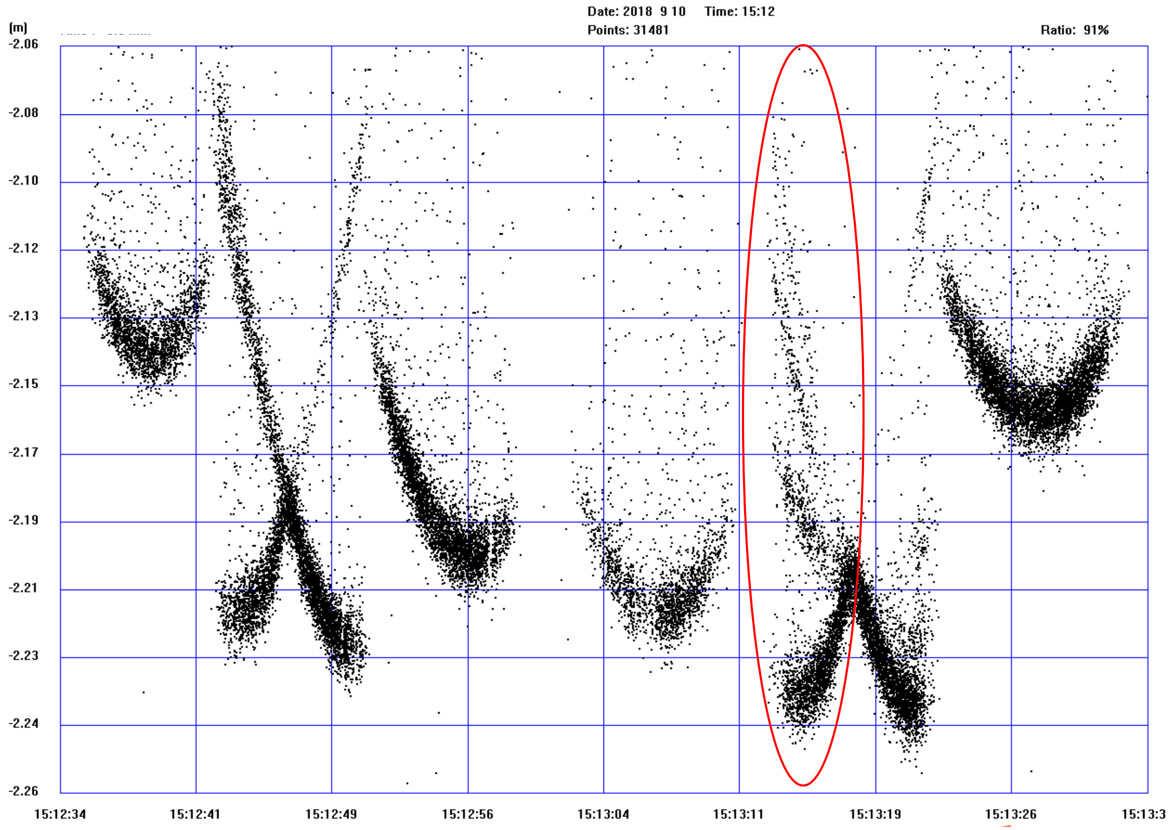
CCR configuration for identification

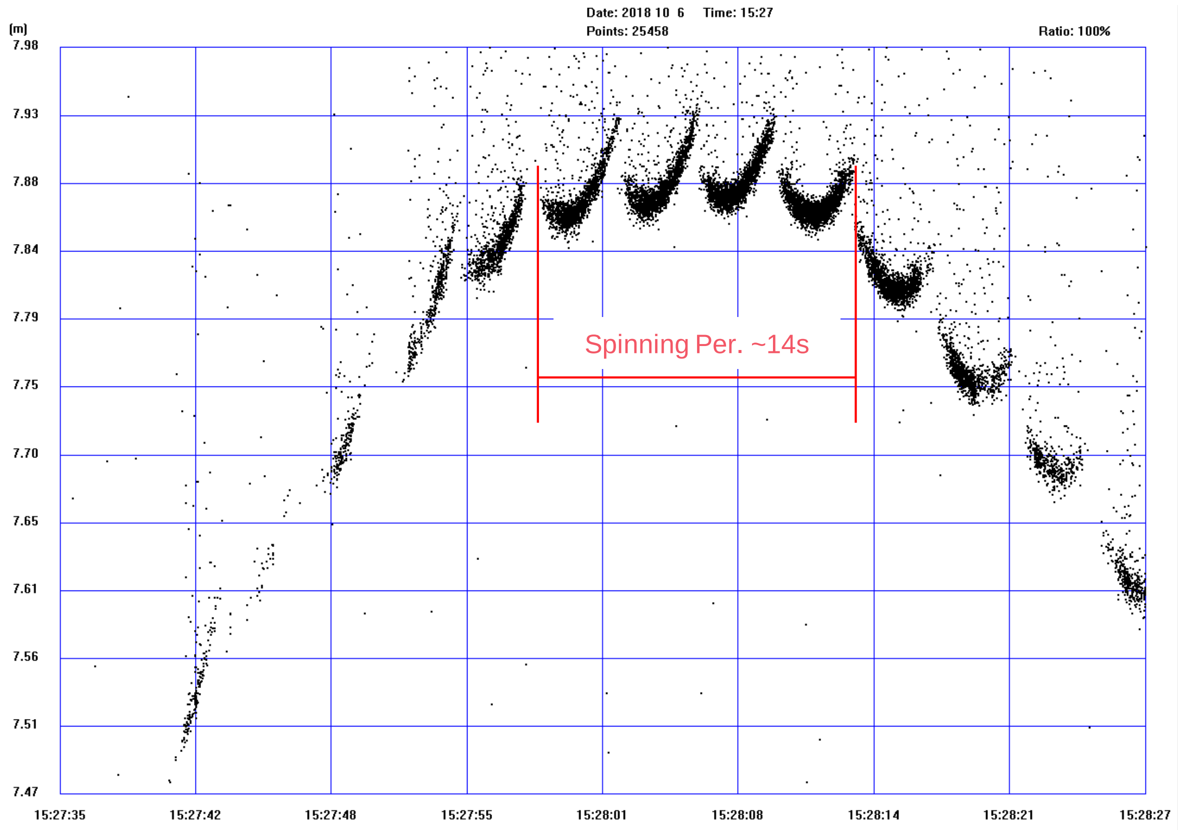




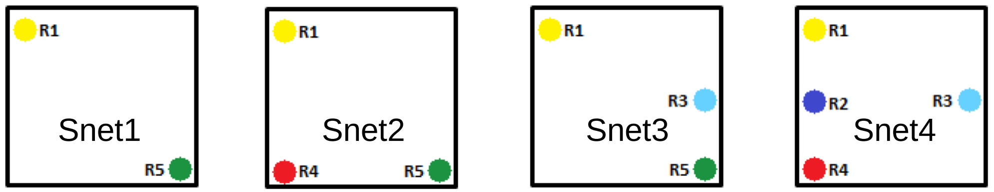


CCR for attitude analysis or identification





Session6 : Wednesday, Nov.7, 09:00~09:15
kHz SLR application on the attitude analysis of Technosat



Summary

- Laser ranging was great support during **early orbit phase**
  - Very small drift 0.12 km/day (Snet 1-2) made TLE based orbit determination unprecise
  - Distance measurement based on RF-signal runtime works > approx. 5km
  - Precise estimation of cluster drift behaviour could be done via ILRS

- Request ILRS to track more passes
- Prediction
  - No SLR observation, no accurate Cpf--- dead loop
  - AAS, DLR rely on observations, or change to TLE

Technische Universität Berlin

berlin

Gefördert durch:

Bundesministerium für Wirtschaft und Technologie

aufgrund eines Beschlusses des Deutschen Bundestages

DLR Deutsches Zentrum für Luft- und Raumfahrt e.V.

SNet team kindly appreciate all past contributions from ILRS community

and are expecting more in future

Questions and comments?

To: Zizung Yoon (Zizung.yoon@tu-berlin.de)