# Metsähovi Geodetic Research Station – a future GGOS core station

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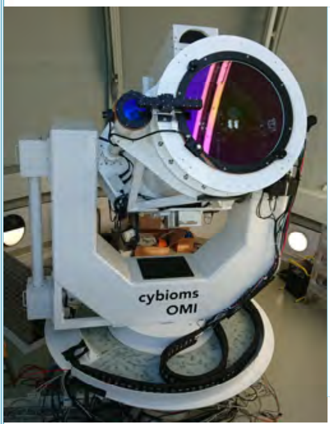
## Introduction:

Metsähovi Geodetic Research Station in Southern Finland is becoming one of the core sites of the Global Geodetic Observing System (GGOS). The station includes all-in-view GNSS receiver, an absolute and two superconducting gravimeters, a seismometer as well as a DORIS beacon close-by. Geodetic VLBI observations have been carried out a few sessions per year and the first and second generation SLR systems were operational 1978-2005. The new modern SLR system is undergoing the final phases of becoming operational. First on-sky tests are expected late 2018 and the system will become fully operational during 2019. In addition a new VGOS standard VLBI radio telescope is currently being built at the station. The new VLBI system is expected to be operational 2019 with a broadband receiver. Local ties between the sensors are carried out regularly with total stations and GNSS and new improved methods are studied to achieve GGOS's sub-mm goal.

## Upgraded instrumentation at Metsähovi

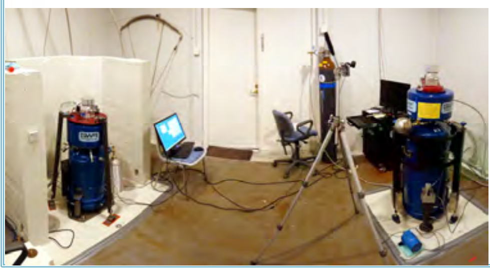


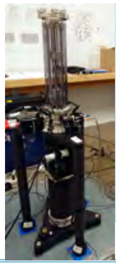
### SLR

- A bistatic kHz SLR-system, 50cm Rx, 10cm Tx telescopes by Cybioms-OMI
- A 15cm refractor for visual imaging
- Operational 2019
- Delay due to problems with motor controllers
- HighQ laser SEED diode & NLO peltier replaced Aug 2018
- The system is designed to be modular to allow future expansions for, e.g., more powerful space debris laser or infrared observations.
- Control software by DiGos GmbH

### VLBI

- A new VGOS telescope, built by MT Mechatronics GmbH
- Final phases of testing, operational 2019
- Antenna size: ~13 m dish
- Slew speed: >=720 deg/min
- Sensitivity: <=2500 SEFD
- Recording rate: 8-16 Gbps
- Data transfer: e-transfer
- Broadband receiver (2-14 GHz),built by IGN (Spain, Yebes)
- Backend: DBBC3 full VGOS capable of eight 4 GHz
- Recording system: Flexbuff of 480 TB





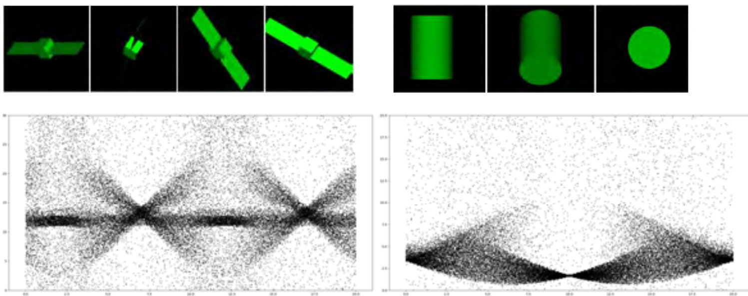
### Gravity

- Upgraded FG5X-221 absolute gravimeter, next measurement is in Antarctica at Scott Base during November 2018, before returning back to Metsähovi
- Two superconducting gravimeters: iGrav-013 and iOSG-022, continuous gravity measurements since 1994
- Hydrological and meteorological instrumentation for modelling gravity variations induced by local environmental effects

## Ongoing space debris and and system automation research at Metsähovi

### Space debris

- Feasibility study on the optimization of the SLR system for debris
    - Possibility for a dedicated powerful debris laser
- Method & software development for spin and attitude determination from SLR and optical lightcurve observations: Lomb-Scargle; Phase Dispersion minimization; MCMC
- Method & software for raytracing simulations of SLR observations from an arbitrary shaped objects without retroreflectors (Wilkman 2018).
    - Below: simulations of a box-wing and cylinder shaped objects



### Automatic cloud detection

- A Python 2.7 software to automatically detect clouds from an allsky image
- Image manipulation is made with numpy and OpenCV.
- The thresholding of the images is based on the Hybrid Thresholding Algorithm (HYTA) technique by Li et. al (2011), which combines both fixed and adaptive threshold methods.
- Relatively good selection results between images taken on different days compared on using only fixed thresholds.
- Next step: integration to observing software to automatically give go-nogo flags for satellites depending on the cloudiness
- Raw allsky image (left), the binary mask based on the image (middle), the mask-applied raw image (right).

**References:**
**Li C., H. and Lee C.,K.,, 2011,** Minimum cross entropy thresholding,, Department of Electronic Engineering, Hong Kong Polytechnic, Hung Hom, Hong Kong
**Wilkman O., 2018.** Ray-tracer for modeling interactions of light with space objects. Presented at AMOS 2018 Conference17-20.9.2018, Maui, USA. https://amostech.com/TechnicalPapers/2018/SSA/Wilkman.pdf

**Acknowledgements:**
This work has been supported by the Academy of Finland as well as Finland's Scientific Advisory Board For Defence (MATINE).

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