Metsähovi Radio Observatory Network Station 2015–2016 Biennial Report

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Abstract In 2015–2016, Metsähovi Radio Observatory, together with the Finnish Geospatial Research Institute, has observed seven IVS sessions: four T2 and three EUROPE sessions.

1 General Information

The Aalto University Metsähovi Radio Observatory and the Finnish Geospatial Research Institute (FGI) are two separate institutes which together form the Metsähovi IVS Network Station. Metsähovi Radio Observatory operates a 13.7-meter radio telescope on the premises of Aalto University at Metsähovi, Kylmälä, Finland, about 35 km from the university campus. The Metsähovi Fundamental Geodetic Station of FGI is in the same area, next to the Metsähovi Radio Observatory.

2 Component Description

FGI is responsible for the geodetic VLBI observations and is the owner of the S/X receiver. The radio telescope is owned and operated by the Aalto University, and an annual agreement is made on its use for geodetic VLBI sessions. It is not possible to increase the number of annual geodetic sessions (currently typically four) because the telescope is mainly used for astronomical observations.

1. National Land Survey of Finland, Finnish Geospatial Research Institute
2. Aalto University Metsähovi Radio Observatory

2.1 Metsähovi Radio Observatory

The Metsähovi Radio Observatory has been operational since 1974. The telescope was upgraded in 1992–1994. The radome was replaced with a new one, and new surface panels were installed. Metsähovi, together with FGI, began observing IVS T2 and EUROPE sessions in 2004. Approximately four to six sessions are observed per year.

Metsähovi is known for its long-term quasar monitoring, the VLBI and solar observations. The surface accuracy of the present telescope is 0.1 mm (rms) and the speed of the Metsähovi antenna is 1.2 degrees per second. Astronomical VLBI observations are carried out with the 22 GHz, 43 GHz, and 86 GHz receivers while the geodetic observations use the S/X narrow band receiver. The geodetic VLBI receiver uses right circular polarization and 8.15–8.65 GHz and 2.21–2.35 GHz frequency bands.

2.2 Metsähovi Geodetic Fundamental Station

FGI is running the Metsähovi Geodetic Fundamental Station. It is a part of the IAG GGOS Core station network. The instrumentation includes geodetic VLBI (in co-operation with Aalto University), Satellite Laser Ranging (SLR), DORIS, and GNSS equipment and absolute and superconducting gravimeters.

Fig. 1 A view of the Metsähovi Fundamental Geodetic Station. At the center of the picture is the new building of the SLR telescope. At right, the radome of the 13.7-m radio telescope of Aalto University can be seen.

Table 1 Staff at Metsähovi Radio Observatory and at FGI involved in geodetic observations during 2015–2016.

Staff at Metsähovi Radio Observatory		
Name	Title	Responsibility
Ph.D. Joni Tammi	Head of Metsähovi Radio Observatory	Metsähovi Radio Observatory
Ph.D., Lic.(tech.) Juha Kallunki	Technical staff manager	VLBI equipment and observations
M.Sc.(tech.) Ari Mujunen	Laboratory engineer	VLBI equipment
D.Sc.(tech.) Minttu Uunila (until 11/2015)	Post-doctoral researcher	VLBI observations
M.Sc.(tech.) Petri Kirves	Operations engineer	Receivers
Staff at Finnish Geospatial Research Institute		
Name	Title	Responsibility
Prof. Markku Poutanen	Head of the Department	Metsähovi research station
Ph.D. Jenni Virtanen	Research manager	Space geodesy research group
Ph.D. Jyri Näränen	Research manager	Metsähovi infrastructure
Ph.D. Nataliya Zubko	Senior research scientist	IVS observations, analysis; VGOS project manager
D.Sc. (tech.) Guifré Molera Calvés	VLBI technical expert	VLBI development
M.Sc. Veikko Saaranen	Special research scientist	IVS observations, operations
Adj. prof. Kimmo Lehtinen	Special research scientist	IVS observations, operations
M.Sc. Ulla Kallio	Senior research scientist	Local ties measurements

Currently, instrumentation is being renewed based on special funding from the Finnish Ministry of Agriculture and Forestry. During the years 2015–16, a new dome for SLR was constructed, and a new SLR telescope and optical instruments were installed. Currently, the system finalization is ongoing, and it is expected to be operational by 2018.

At the start of 2015, the Finnish Geodetic Institute became a part of the National Land Survey of Finland (NLS) as the Finnish Geospatial Research Institute (the abbreviation remaining FGI).

2.3 New Radio Telescope System

The Finnish Ministry of Agriculture and Forestry and NLS have granted FGI special funding to build a new radio telescope system which will be compatible with VLBI2010 Global Observing System (VGOS), the next-generation geo-VLBI observing technique. The VGOS project started with the tendering process for the new telescope in early 2016, and in December the contract was signed with the manufacturer; MT Mechatronics (Germany) is responsible for building and assembling the 13.2-m dish telescope. In addition to the telescope, an innovative signal chain will be built to meet the VGOS requirements. Once operational

(first light expected by 2019), the telescope system is planned to be a part of the IVS network.

3 Staff

Operations during the geo-VLBI sessions and technical questions are handled jointly between Aalto University and FGI. All other technical work, telescope maintenance and maintenance of instrumentation are done by the Metsähovi Radio Observatory personnel. The preparation, operation of IVS observations, and submission of data are provided by staff from FGI. Personnel working with IVS observations are listed in Table 1.

4 Current Status and Activities

4.1 IVS Sessions

Metsähovi, together with FGI, observed altogether four IVS sessions during 2015: two T2 sessions (T2 105 and T2 108) and two EUROPE sessions (EUR 137 and EUR 138). During 2016, altogether three IVS sessions were observed: two T2 sessions (T2 110 and T2 111) and one EUROPE session (EUR 141). There were no technical issues or problems during the observations or correlations.

4.2 Research Visits

In preparation for the telescope tendering process in the VGOS project, Nataliya Zubko and Jyri Näränen visited the Onsala Space Observatory (Chalmers, Sweden) in October 2015. They also attended the 2nd IVS Training School on VLBI for Geodesy and Astrometry, March 9-12, 2016 (Hartebeesthoek, South Africa). Guifre Molera Calvés and Jyri Näränen visited the Onsala Space Observatory again in December 2016 to discuss the signal chain design for the VGOS project.

4.3 Technical Activities

The VLBI observations continued to be conducted using the DBBC. No problems were detected during the sessions.

Two new active hydrogen masers were delivered to Metsähovi in February 2015. One is working as a frequency reference for various VLBI devices, and the second one is working as a back-up frequency reference.

In June 2016, due to a heavy thunderstorm and lightning, the DBBC's 1pps distribution board (1pps TTL driver board MAX9372) broke. This was fixed locally in the observatory (July 2016).

In addition all the motors of the 13.7-meter radio telescope were replaced in January 2016.

4.4 Data Analysis

Data analysis at FGI was performed by Dr. Zubko. The project of source structure study and its influence on estimated geodetic VLBI parameters was continued in cooperation with Dr. Rastorgueva-Foi and Lucia Plank from University of Tasmania. The latest results on this research were presented at the 22nd EVGA Working Meeting in 2015 (Sao Miguel, Azores).

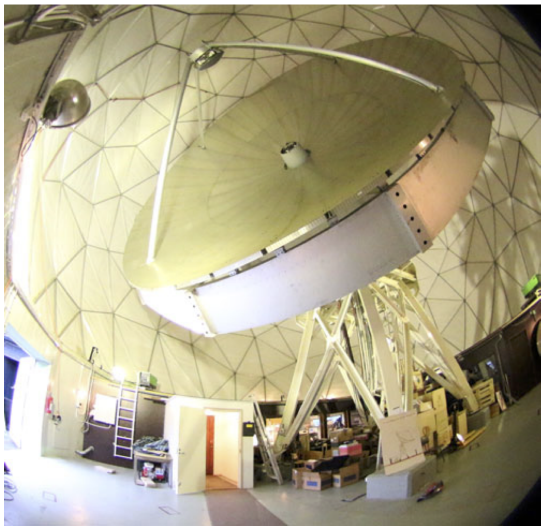

Fig. 2 Metsähovi radio telescope (Photo by Merja Tornikoski).

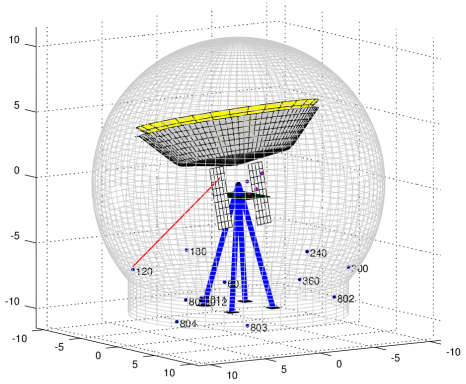

Fig. 3 Robot tachymeter aimings were precalculated and optimized using the antenna schedule file before the local tie measurement campaign.

4.5 Local Tie Measurements

In August and September 2015, Metsähovi participated in the EMRP SIB60 local tie experiment. With the co-operation of Frankfurt University of Applied Sciences, Laboratory for Industrial Metrology, SP Technical Research Institute of Sweden, Chalmers University of Technology, Onsala Space Observatory, two different local tie methods were used simultaneously for measurements of a VLBI baseline (Onsala-Metsähovi) and a GPS baseline between IGS points (ONSA-METS). Local ties were measured with robot tachymeters and with GNSS at Metsähovi and at Onsala at the same time. Monitoring measurements with robot tachymeters were performed using the HEIMDALL monitoring system (see Figure 3). The monitoring network under the radome was connected to the local pillar network at Metsähovi soon after the monitoring. Besides the dedicated campaign we reprocessed 25 GPS local tie vectors with new GPS antenna calibration values. During the SIB60 project we developed the new Monte Carlo based method to assess the uncertainty of GPS local ties. Besides the Monte Carlo method we assessed uncertainties using time series of GPS based local ties and the comparison of the local ties of the two methods. The realistically achievable uncertainty for the GPS local tie vector according to the assessment is 1 mm for the North and East components and 2 mm for the Up component.

5 Future Plans

In 2017 Metsähovi is scheduled to participate in four IVS sessions: two EUROPE sessions (EUR D01 and EUR D02) and two T2 sessions (T2 116 and T2 120).

The VGOS project at FGI will continue. The installation of the VGOS radio telescope at the Metsähovi Geodetic Fundamental Station is scheduled to start in April 2018. The location of the antenna has already been selected, less than 100 meters away from the FGI main building. Work for the site preparation has already begun with cutting out the forest area and will continue with foundation work during spring 2017.