Metsähovi IVS Network Station Report

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Abstract In 2019–2020, Metsähovi Radio Observatory, together with the Finnish Geospatial Research Institute (FGI), National Land Survey of Finland, has observed several IVS T2 sessions. FGI has constructed a new VGOS radio telescope in 2018. A new VGOS system is under development and commissioning. The Metsähovi Radio Observatory had renovation work in 2020, with a new radome replacing the old one.

1 General Information

The Aalto University Metsähovi Radio Observatory (MRO) and the Finnish Geospatial Research Institute (FGI) are two separate institutes which together form the Metsähovi IVS Network Station. The 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 Geodetic Research Station of FGI is in the same area, next to the Metsähovi Radio Observatory, where the VGOS 13.2-meter telescope was built. The new system is under commissioning and finalization.

IVS sessions are observed with the 13.7-meter radio telescope owned by MRO. The technical preparation and support are provided by MRO, while session preparation and operation are performed by FGI. The main purpose of the MRO telescope is astronomical observations; thus, the number of the annual geodetic sessions is very limited.

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Metsähovi Network Station

IVS 2019+2020 Biennial Report

1.1 Metsähovi Radio Observatory

The Metsähovi Radio Observatory has been operational since 1974. MRO, together with FGI, began observing IVS T2 and EUROPE sessions in 2004. Approximately three to six sessions are observed per year. MRO is known for its long-term quasar monitoring, VLBI, and solar observations. The surface accuracy of the present telescope is 0.1 mm (rms) and the slewing 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 the 8.15–8.65 GHz and 2.21–2.35 GHz frequency bands.

1.2 Metsähovi Geodetic Research Station

FGI runs the Metsähovi Geodetic Research Station. Observations at the Metsähovi Geodetic Research Station started in 1978. It is a part of the IAG GGOS Core Station network. The instrumentation includes the VGOS telescope, Satellite Laser Ranging (SLR), DORIS, GNSS equipment, and absolute and superconducting gravimeters. Renewal of most of the instrumentation has been ongoing since 2013. A new VGOS-compatible radio telescope system was built at Metsähovi Geodetic Research Station during the sum-

Fig. 1 Metsähovi Geodetic Research Station and Metsähovi Radio Observatory. Photo: Jyri Näränen

mer of 2018. The telescope has a fast moving telescope dish with a diameter of the main reflector of 13.2 meters and a ring focus design. The telescope is equipped with a broadband receiver with a working frequency range of 2–14 GHz.

2 Activities during the Past Two Years

2.1 IVS Sessions

The Metsähovi Network Station observed altogether four T2 IVS sessions during 2019–2020. The EUROPE sessions were canceled; thus, the total number of the observed sessions was reduced. There were no technical issues or problems during the observations or correlations, with the exception of RFI disturbing some channels in S-band.

2.2 VGOS Project

The new FGI-owned VGOS radio telescope was commissioned in 2019. Telescope technical characteristics can be seen in Table1. It is equipped with a quad-ridge horn, a 2.1–14 GHz broadband receiver manufactured by the IGN Yebes Technology Development Center, Spain, in November 2019 (Figure 2). The signal from the receiver is divided into low (2.1–4 GHz) and high (3.6–14.1 GHz) frequency bands transmitted to the backend via RF over fiber (RFoF) links.

Table 1 Telescope technical characteristics.

Feature	Description
Antenna mount	Standard azimuth-elevation
Reflector optics	Ring focus
Diameter of the main reflector	13.2
Surf. accuracy of the main refl.	< 0.3 mm rms
Surf. accuracy of the subrefl.	< 0.1 mm rms
Antenna motion:	
Velocity in Az axis	12 deg/s
Velocity in El axis	6 deg/s
Acceleration in Az axis	2.5 deg/s^2
Acceleration in El axis	2.5 deg/s^2

The first light of the Metsähovi VGOS telescope was obtained in November 2019. During 2020 the receiver performance was investigated together with RFI conditions at the site. Substantial RFI sources were observed in the 2–3-GHz band, limiting its usability in observations. A real-time RFI monitoring system is under development. The signal chain is equipped with a DBBC3 backend; a Flexbuff recorder is under development.

2.3 Metsähovi Radio Observatory Renovation

The years 2019 and 2020 included major modernization work at the Metsähovi Radio Observatory. The observatory premises were renovated. The oldest part of the observatory, which was from the 1970s, was dismantled, and new compensatory spaces were built (Figure 3). New premises include a seminar room, flex-

Fig. 2 Receiver installation on the VGOS radio telescope. Photo: Nataliya Zubko

ible office and laboratory spaces, among others. Other older premises were renovated; for instance, building services engineering was renewed. The work started in the summer of 2019 and it was completed in December 2020. The observatory will be fully back to normal operations in the spring of 2021.

Also motors, drives, and high-speed gears of the 14-meter radio telescope were replaced. The old DC-servo drives were replaced with modern AC-drives. The telescope performance and reliability improved as a result of the overhaul. The modernization work was completed in April 2020, causing a three-week break in normal operations.

The replacement of the protective radome of the 14-meter radio telescope was carried out in June 2020. The new radome is identical to the old one, i.e., the electromagnetic performance is similar. Both radomes, the old one and the new one, were removed and installed as a whole, causing a three-hour break for observations. The whole installation project was completed within three weeks.

3 Current Status

FGI and MRO carry out participation in IVS-T2 sessions with the 13.2-meter telescope. FGI continues its work on the integration of the signal chain of the new VGOS system and finalization of the whole system. The Flexbuff recording system development is in progress as well as the automation of the RFI monitoring system.

3.1 Long Distance Frequency and Time Link

FGI has been developing a long distance frequency and time link over optical fiber. The work has been carried out together with VTT MIKES, which is responsible for maintaining the realization of UTC in Finland (UTC-MIKE). The current aim is to achieve redundancy and to test the link against the H-maser. In the future, a stable frequency link would reduce the need of a dedicated maser and allow several stations to share a common clock.

Our optical fiber uses a 55-km dark fiber and connects the Metsähovi Geodetic Research Station with the Otaniemi Campus Area, where VTT MIKES is located. Both commercially available low-jitter White-Rabbit technology (originally developed at CERN) and an in-house developed drift compensated frequency transfer system were tested. Currently we have achieved ca. 1E-14 ADEV at 100 s, with a 5–10 MHz carrier. The project continues until 2023 with the aim of achieving sufficient stability for VGOS observations.

3.2 Local Tie Measurements

National Land Survey of Finland is one of the partners in the EMPIR 18SIB01 GeoMetre project. During the project the new local tie vectors in Metsähovi will be measured between the space-geodetic instruments, including the new VLBI telescope. For this purpose, two GNSS antennas were attached on the left and right edge of the telescope dish with a new type of gimbal system in March 2020. Compensators have an improved damping system which stabilizes the movement of the rather high angular velocity of the VGOS telescope.

Several monitoring test measurements were carried out in 2020 (Figure 4). The terrestrial pillar network for local ties was also updated with new adapters for GNSS antennas and prisms enabling seamless measurements. Automatic monitoring of the VLBI telescope reference point from the network pillars were

Fig. 3 Metsähovi Radio Observatory new premises. Photo: Juha Kallunki

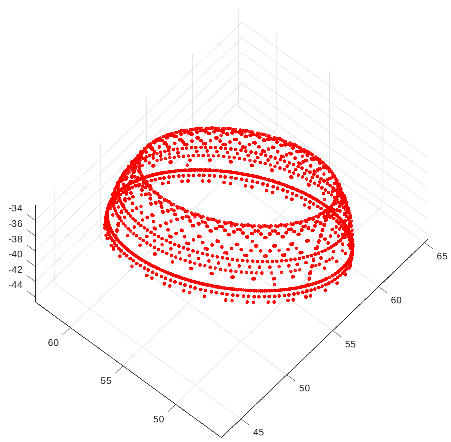

Fig. 4 Combination of the monitoring data from the MET3 GNSS antenna to the VLBI. Coordinates in the figure are coordinate differences w.r.t. MET3 in global orientation.

tested with the robot tacheometer in September simultaneously with GNSS measurements.

4 Future Plans

Tests of the entire telescope system, as well as the integration of the signal chain components are planned for 2021. A 10-Gb Internet connection will be installed at the research station in 2021 for VGOS data transfer.

To improve the thermal insulation and consequently stability of the telescope's steel pedestal, an additional insulation layer is planned to be added. This work is planned for 2021 together with the telescope manufacturer.

A new main building is planned to be build at Metsähovi Geodetic Research station in 2021–2022. It will contain office space and instrumentation rooms, including dedicated VGOS operating and server rooms.

Acknowledgements

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