Onsala Space Observatory – IVS Technology Development Center Activities during 2019–2020

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Abstract We give a brief overview of the technical development related to geodetic VLBI done during 2019 and 2020 at the Onsala Space Observatory.

1 General Information

The technical development work for geodetic VLBI at the Onsala Space Observatory (OSO) was dedicated to the Onsala twin telescopes (OTT) and the Onsala 20-m telescope, see Figure 1. The main activities are summarized as follows and discussed in detail in the subsequent sections:

- A focal-finder for the OTT,
- RFI protection for the OTT,
- TPI logging for VGOS, and
- A field-system-controllable cable delay box for the S/X system on the Onsala 20-m telescope.

2 A Focal-finder for the OTT

The OTT are equipped with slightly different receiving systems. The western telescope (Ow) has a receiving system equipped with an Eleven feed covering 2–14 GHz, while the eastern telescope (Oe) has a receiving system with a Quad-Ridged Feed Horn (QRFH) covering 3–18 GHz. Both types of feeds are subject to frequency-dependent phase center positions. Thus, for optimal performance for VGOS observations, suitable compromise positions for the receivers have to be found. In the OTT installation phase, the receivers were placed at the positions that were supposed to be perfect, according to the design. But, this does not mean that these positions are really optimal. The OTT do not have motor-driven hexapods, so a performance optimization with the sub-reflector position is not easily possible. Thus, in order to test and optimize the receiver positions, a so-called focal-finder was developed to allow the complete receiver to be moved in the z-direction inside the telescope tube between -9 mm and $+26.5$ mm. This focal-finder can be installed temporarily in either of the telescope tubes and thus be used to determine the individual "optimal" positions for the VGOS frequency range by measuring the system equivalent flux density (SEFD) for different receiver positions. A photo of the focal-finder is dis-

Fig. 1 The three telescopes at Onsala used for IVS observing: Ow (left), Oe (middle), and On (right).

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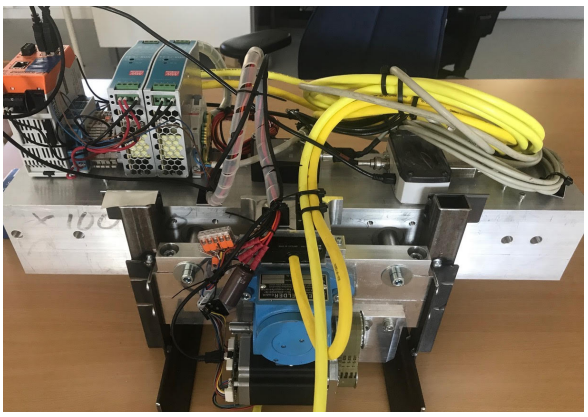

Fig. 2 Picture of the "focal-finder" for the OTT that can be installed in the telescope tube to move the receiver between −9 mm and +26.5 mm in the z-direction to optimize the focal position.

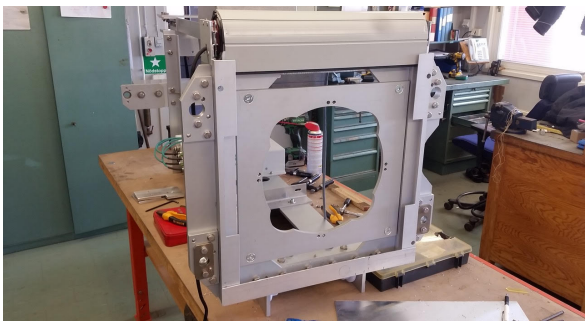

Fig. 3 RFI protection developed for the OTT receivers. The metal blinds can be activated from the VLBI field system to cover the feed horn and thus to protect against strong and potentially damaging RFI signals from, e.g., low earth orbiting radar satellites.

played in Figure 2. Due to the pandemic, the optimization of the focal position could only be done for Oe so far.

3 RFI Protection for the OTT

The OTT are equipped with broadband systems for VGOS observations. These are subject to RFI from various sources, including RFI sources on land, at sea, and in the sky. On several occasions, the OTT low noise amplifiers (LNAs) were destroyed by strong ship radar when the telescopes were looking at low elevations towards the sea, even though the LNAs are equipped with protecting diodes. As a consequence, the OTTs were out of service for several weeks while the LNAs had to be repaired. In order to minimize the risk of future damage due to ship radar, an alarm, "Oden the overseer", was implemented to automatically send warnings via e-mail to the observatory staff, in case the telescopes are looking at the open sea at low elevations.

The usual parking position for the OTT is at zero degrees of elevation towards the north, where a natural barrier in the form of a 30-m hill protects to some extent against land-based RFI. But, because the survival position of the OTT is the zenith position, it is desirable to change to a parking position at zenith. This parking position, on the other hand, is subject to radar signals emitted by remote sensing satellites, such as Sentinel-1a/b, that send rather strong C-band radar pulses. So, in order to protect the sensitive receivers of the OTT when parking at the zenith position, we developed an RFI protection system with metal blinds that can cover the feed horns inside the telescope tubes, see Figure 3. The system can be controlled directly from the VLBI field system, allowing the initiation of opening and closing before and after VGOS sessions. Due to the pandemic, so far only Ow is equipped with this RFI protection.

4 TPI Logging for VGOS

VGOS, with its broad frequency coverage and dual polarization capability, is much more sensitive to radio source structure and variation than the legacy S/X system. Thus, radio source imaging and radio source flux monitoring have become of interest. This requires monitoring of the total power values during on-going VGOS sessions. Routines were developed to allow this and to record the information in so-called extended log files.

5 A Field-system-controllable Cable Delay Box for the S/X System on the Onsala 20-m Telescope

The insertion of a calibrated piece of cable into the cable delay measurement system of the legacy S/X system of the 20-m telescope, before and after VLBI ses-

sions, has been standard for more than 30 years at Onsala in order to determine the cable sign. This information from the “cable”, “cablelong”, and “cablediff” measurements is logged in the log file and used in the final data analysis. During the last 30 years or so, this was done manually as part of the session preparation and finalizing work. Due to the pandemic, the routines to run VLBI sessions needed to be adapted to allow remote operations without the need of having personnel in the control room. Thus also these cable sign measurements needed to be made possible to execute remotely. As a consequence, a field-system-controllable cable delay box was built to allow these measurements to be done remotely before and after each VLBI session.

6 Outlook and Future Plans

The plan for the upcoming two years is to continue to optimize the OTT systems for VGOS operations.