AuScope VLBI Project and Hobart 26-m Antenna

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Abstract This is a report on the activities carried out at the University of Tasmania in support of the three AuScope VLBI observatories and the Hobart 26-m antenna. In 2013 the antennas participated in 110 IVS sessions for a total of 262 antenna days of observing, 116 more than in 2012. An increase in operations funding in 2013 has enabled us to increase our observing load, including 60 days per year for AUSTRAL which is focused on high priority geodetic and astrometric programs in the southern hemisphere. In this report we also briefly highlight our research activities during 2013 and our plans for 2014.

1 General Information

As part of AuScope (www.auscope.org.au), the University of Tasmania (UTAS) operates the AuScope VLBI Array (Lovell et al., 2013), three 12-m diameter radio telescopes on the Australian continent, located near Hobart (Tasmania), Yarragadee (Western Australia), and Katherine (Northern Territory).

The Hobart telescope (Hb) is co-located with the existing 26-m telescope (Ho) to preserve the more than 20-year VLBI time series at the site. Midway between the 26-m and 12-m telescopes is the HOB2 GNSS installation which has been a core site of the International GNSS Service (IGS) since its conception. A hut capable of housing a mobile gravimeter is also co-located on the site. The Yarragadee telescope (Yg) provides a far western point on the continent and is co-located with multiple existing geodetic techniques including SLR, GNSS, DORIS, and gravity. The Katherine site (Ke) is new and provides a central longitude, northern site. The telescope at Katherine is co-located with a new GNSS site that forms part of the AuScope GNSS network.

Each AuScope VLBI observatory is equipped with a 12.1-m diameter main reflector. The telescope specifications include: 0.3 mm of surface precision (RMS), fast slewing rates (5 deg/s in azimuth and 1.25 deg/s in elevation), and acceleration (1.3 deg/s/s). All three sites are equipped with dual polarization S- and X-band feeds with room temperature receivers covering 2.2 to 2.4 GHz at S-band and 8.1 to 9.1 GHz at X-band. System Equivalent Flux Densities (SEFDs) are 3500 Jy in both bands. Data digitization and formatting is managed by the Digital Base Band Converter (DBBC) system, and data are recorded using the Mark 5B+ system. Each site is equipped with a Hydrogen maser time and frequency standard.

All three observatories were designed and constructed to be remotely controlled and monitored to keep operating costs at a minimum. Operation of the AuScope VLBI array is being carried out from a dedicated operations room on the Sandy Bay campus of the University of Tasmania.

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Hobart 12-m and 26-m, Katherine, and Yarragadee

IVS 2013 Annual Report

2 Staff

Staff at UTAS consists of academics Prof. John Dickey (director), Dr. Simon Ellingsen, Dr. Christopher Watson, and Prof. Peter McCulloch. Dr. Jim Lovell is

Project Manager for the AuScope VLBI project. Dr. Jamie McCallum, Dr. Stas Shabala, Dr. Lucia Plank, and Dr. Anthony Memin are post-doctoral fellows who are carrying out research aimed at improving geodetic solutions in the southern hemisphere. Mr. Brett Reid is the Observatory Manager whose position is funded by the university. In addition we have an electronics technical officer, Mr. Eric Baynes. For operation of the observatories during geodetic observations we rely heavily on support from astronomy PhD and post graduate students. Logistical and maintenance support at Katherine is provided by Mr. Martin Ephgrave and at Yarragadee by Mr. Randall Carman and team at the MOBLAS5 SLR station.

Table 1 AuScope and Hobart 26-m antenna participation (number of days) in IVS sessions in 2013. The AUST13 series of observations was a 15-day CONT-like session as part of the AUSTRAL program.

Session	Antenna			
	Ho	Hb	Ke	Yg
APSG		2		
AUST13		15	15	15
AUSTRAL		9	9	9
CRDS	6	5	5	3
CRF	1	3	3	4
OHIG		3	3	3
R&D	6	1	1	1
R1		28	26	22
R4		27	22	23
T2		2	2	1
Total	13	95	86	81

3 AuScope VLBI Project Status

The AuScope VLBI array is currently funded for operations at the level of up to 170 observing days per year until mid 2015. This includes 60 days per year for the AUSTRAL program and, in 2014, the CONT14 campaign. The Hobart 26-m antenna will continue to participate in IVS observations at the level of twelve days per year, primarily to assist in the maintenance and enhancement of the Celestial Reference Frame in the southern hemisphere. The 26 m will also participate in CONT14.

4 Geodetic VLBI Observations

In 2013 the AuScope and Hobart 26-m antennas participated in 110 IVS sessions (up from 72 in 2012) for a total of 262 antenna days of observing, 116 more than the previous year. A summary of the observations is presented in Table 1.

4.1 The AUSTRAL Program

The 60 day per year AUSTRAL Program commenced in July 2013 and will run for two years initially. Observations are being made with the three AuScope antennas as well as the Warkworth 12 m and Hartebeesthoek 15 m (Figure 1). The Hobart 26 m and Hartebeesthoek 26 m also participate for some observations. Scheduling is carried out in VieVS, and data are correlated at the Curtin University software correlator.

The AUSTRAL observing program is divided into three streams focused on high priority geodetic and astrometric aims in the southern hemisphere:

1. astrometric observations to monitor and enhance the southern hemisphere reference frame in preparation for ICRF3;
2. regular observations to improve the density of the geodetic time series for the southern antennas and measure and monitor the motion and deformation of the Australian plate;
3. four 15-day CONT-like sessions over two years to demonstrate the full capabilities of the array, characterize the level of systematic errors caused by the troposphere and source structure, and develop and try error mitigation strategies.

For four experiments during 2014, the 26-m antennas at Hartebeesthoek and Hobart will join the AUSTRAL array. With the same atmosphere and clocks at each site, and with baselines to each pair observing the same source structure, we hope to further understand the systematic uncertainties due to troposphere and source structure.

4.1.1 Post-correlation Data Processing

Starting in late 2012, the University of Tasmania has begun handling the post-correlation processing

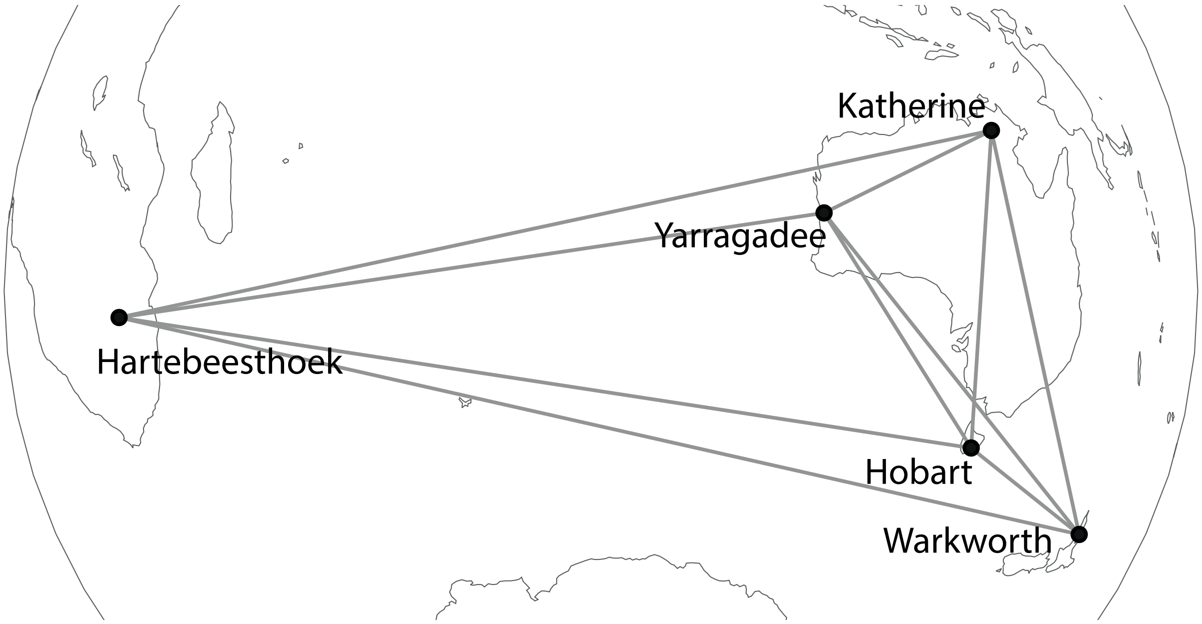

Fig. 1 The AUSTRAL array comprising the AuScope VLBI array, Hartebeesthoek and Warkworth.

of the AUSTRAL experiments correlated at Curtin University. After the Mark IV data are made available from Curtin, they are processed using fourfit, and a correlation report is drafted. We would like to thank Alessandra Bertarini from Bonn for her extensive assistance with these procedures. The database creation is currently handled by David Gordon at NASA GSFC, as the University of Tasmania does not have CALC/SOLVE currently installed. When the standalone version of dbedit is available, this will be used to generate and submit the NGS databases directly. AUSTRAL experiments AUST10 — AUST15 and the first two sessions of the AUST13 campaign have been processed and submitted as NGS databases to date.

5 Research Activities

5.1 Source Structure

A key area of research over the past year has involved investigating the effects of quasar structure and evolution on geodetic solutions. In particular, we have investigated a number of astrophysical metrics relating to quasars, to see whether these are good predictors of position stability. In Schaap et al. (2013) we found that scintillating sources (sources that twinkle, showing flux density variability of a few percent on timescales of days) are significantly more stable than non-scintillating sources. We have also considered multi-frequency variability of radio sources on longer timescales in Shabala et al. (2014) and found that sources which show small time lags between S and X-band light curves have more stable positions. We plan to develop this work further in the coming year, with the ultimate goal of helping schedulers decide which quasars should be included in a given IVS session.

With TU Wien colleagues Lucia Plank and Johannes Böhm, we have also developed a source structure simulator to assess the impact of structure in geodetic VLBI observations. This simulator is implemented in the VieVS software, and it allows for studies of different analysis and scheduling strategies. In the coming year, we plan to use the simulator to investigate various analysis and scheduling-based source structure mitigation techniques, including "clever" scheduling that takes into account some a priori knowledge of source structure.

5.2 Antenna Structural Deformation Study

Preliminary terrestrial surveys of the Hobart 12-m telescope were undertaken in 2013 in order to:

1. assess our ability to resolve time dependent refraction coefficients throughout a longer automated survey and
2. test the limits of Automated Target Recognition (ATR) on the Australian Geophysical Observing System (AGOS) robotic telescope monitoring infrastructure (Leica TDRA6000).

Progress was slower than hoped; however the survey has now been integrated with local site tie surveys undertaken by Geoscience Australia, with the Hobart survey underway at the time of writing. We aim to compare time dependent IVP determinations using both the traditional circle fit and the transformation approach, with results to be submitted in 2014. This submission will include an analysis of a telescope-wide deployment of thermistors used to characterize the spatial variability of temperature throughout the small 12-m steel and aluminium structure. Further work is required to complete the Finite-Element Analysis of the structure.

References

1. Lovell, J. E. J. et al., 2013, J. Geod 87, 527.
2. Schaap et al. 2013, MNRAS, 434, 585.
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