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 2014 the antennas participated in 185 IVS sessions for a total of 551 antenna days of observing, 289 more than in 2013. An increase in operations funding in 2013 enabled us to increase our observing load, including 73 days per year for AUSTRAL, which is focused on high priority geodetic and astrometric programs in the southern hemisphere. All four antennas participated in the 15-day CONT14 campaign as well as a similar AUSTRAL 15-day session in September. In this report we also briefly highlight our research activities during 2014 and our plans for 2015.

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 (Figure 1), 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 of 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. The 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.

2 Staff

The staff at UTAS consist of academics, Prof. John Dickey (director), Dr. Simon Ellingsen, Dr. Christo-

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Hobart 12 m and 26 m, Katherine, and Yarragadee

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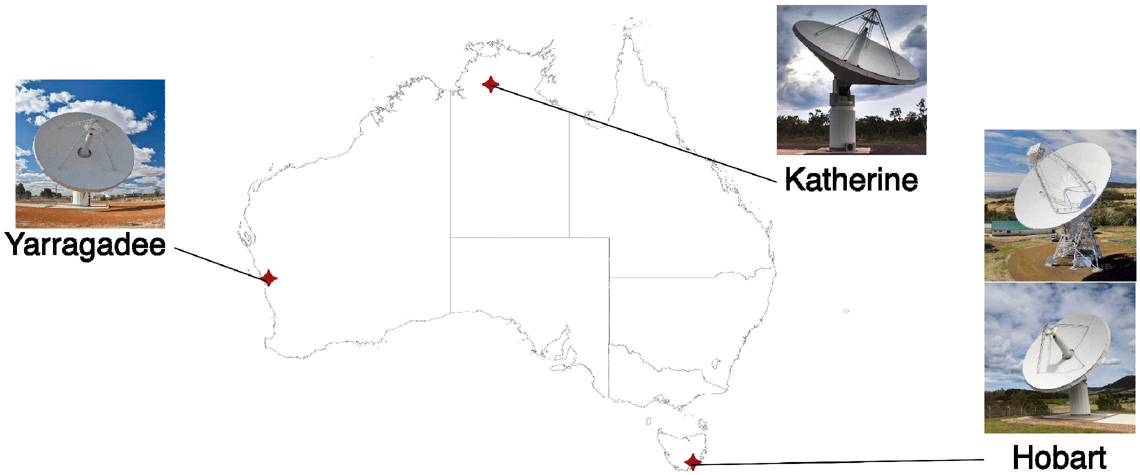

Fig. 1 The AuScope VLBI array and Hobart 26 m.

pher 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, Dr. Elizaveta Rastorgueva-Foi, 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, and Ms. Imogen Jones is employed to assist in operations and media logistics in particular. In addition we have an electronics technical officer, Mr. Eric Baynes. For the operation of the observatories during geodetic observations we rely heavily on support from the 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.

3 Geodetic VLBI Observations

In 2014 the AuScope and Hobart 26-m antennas participated in 185 IVS sessions (up from 111 in 2013 and 72 in 2012) for a total of 551 antenna days of observing, 289 more than in 2013 and 404 more than in 2012. All antennas participated in the 15-day CONT14 campaign. A summary of the observations is presented in Table 1

Table 1 AuScope and Hobart 26-m antenna participation (number of days) in IVS sessions in 2014. The AUST14 series of observations was a 15-day CONT-like session as part of the AUSTRAL program, divided into 17 sessions (some lasted less than 24 hours).

Session	Antenna			
	Ho	Hb	Ke	Yg
APSG		2	2	2
AUST14		17	17	17
AUSTRAL	3	55	56	54
CONT14	15	15	15	15
CRDS	6	6	6	6
CRF		3	3	3
OHIG		5	6	6
R&D	9	2	2	2
R1		31	29	30
R4		36	34	35
T2		1	2	2
Total	33	173	172	172

3.1 The AUSTRAL Program

The $\sim$ 60day per year AUSTRAL Program commenced in July 2013. Observations are being made with the three AuScope antennas as well as the Warkworth 12 m and Hartebeesthoek 15 m. The Hobart 26 m and Hartebeesthoek 26 m also participate for some AUSTRAL 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 to 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 trial error mitigation strategies. One session was held in 2013 and another in 2014, and two are scheduled for 2015.

The AUSTRAL sessions are subject to steady improvements. Thanks to improved scheduling (in cooperation with the Vienna University of Technology), more frequent observations with four and five station networks and improved observations, results in terms of baseline length repeatabilities have been improved significantly. Figure 2 shows the dramatic improvement in baseline repeatability in AUSTRAL sessions following a change in scheduling strategy after AUST30 in July 2014.

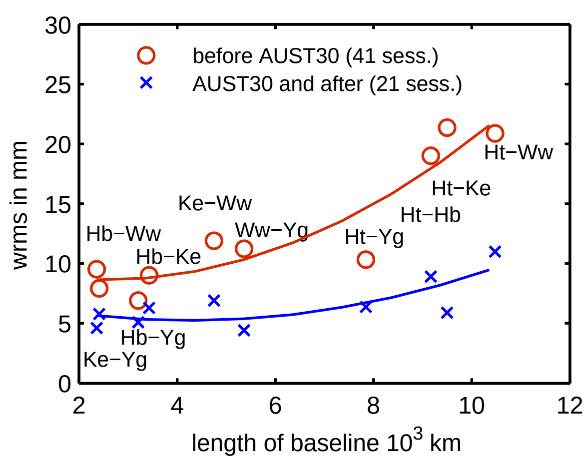

Fig. 2 Baseline length repeatabilities of the AUSTRAL sessions before and after a change in the scheduling strategy.

3.1.1 Post-correlation Data Processing

Starting in late 2012, the University of Tasmania began handling the post-correlation processing of the AUSTRAL experiments correlated at Curtin University. All AUSTRAL data are now post-processed at UTAS and submitted to the IVS as version 1 databases.

4 Research Activities

We have made further progress in investigation of the effects of quasar structure on geodetic solutions. Using the VieVS source structure simulator (Shabala et al. 2015) developed in close collaboration with the TU Wien group led by Johannes Böhm, we have performed simulations to confirm that source structure contributes at the millimeter level to present-day station position determination. Hence the accuracy of present-day measurements is dominated by the stochastic wet troposphere, but quasar structure will become important in the VGOS era. We have also investigated via simulations the possibility of modifying scheduling strategies to include source structure information. This approach appears promising once tropospheric noise is reduced from being the single dominant component in geodetic solutions.

An active area of current investigation is the impact of structure on the CRF, where this effect appears to be much stronger than on the TRF. We have run a number of simulations for various levels of structure, and a paper (Plank et al.) is currently in preparation. Observationally, the thesis work of Rob Schaap (2014) found a strong relationship between the quasar structure index, flux density, and astrometric stability: for a given variable quasar, its astrometric position is most stable and its structure minimized when its flux density is at a maximum. This may be a useful tool for selecting suitable quasars for IVS observations.

A new area of research started last year is the use of sibling telescopes, i.e. the 26-m and the 12-m antennas at Hobart, to determine the local baseline (tie) as measured by VLBI. Several sessions including the 12-m and the 26-m telescopes were observed in 2014, with the analysis ongoing at the moment.

5 References

1. Lovell, J. E. J. et al., 2013, J. Geod. 87, 527.
2. Schaap et al. 2014, J. Geod. 88, 575.
3. Shabala et al. 2015, J. Geod. in press.