Jim Lovell et al.: The AuScope Project and Trans-Tasman VLBI, IVS 2010 General Meeting Proceedings, p.50–54
http://ivscc.gsfc.nasa.gov/publications/gm2010/lovell.pdf

The AuScope Project and Trans-Tasman VLBI

Jim Lovell [1], John Dickey [1], Sergei Gulyaev [2], Tim Natusch [2], Oleg Titov [3], Steven Tingay [4]

[1] *University of Tasmania*

[2] *Auckland University of Technology*

[3] *Geoscience Australia*

[4] *International Centre for Radio Astronomy Research - Curtin University of Technology*

Contact author: Jim Lovell, e-mail: jim.lovell@utas.edu.au

Abstract

Three 12-meter radio telescopes are being built in Australia (the AuScope project) and one in New Zealand. These facilities will be fully-equipped for undertaking S and X-band geodetic VLBI observations and correlation will take place on a software correlator (part of the AuScope project). All sites are equipped with permanent GPS receivers to provide co-location of several space geodetic techniques. The following scientific tasks of geodesy and astrometry are considered.

1. Improvement and densification of the International Celestial Reference Frame in the southern hemisphere;
2. Improvement of the International Terrestrial Reference Frame in the region;
3. Measurement of intraplate deformation of the Australian tectonic plate.

1. AuScope Project

In 2007 the National Cooperative Research Infrastructure Strategy (NCRIS) initiated program 5.13, "Structure and Evolution of the Australian Continent", which is funded by the Department of Innovation, Industry, Science and Research and managed by AuScope Ltd. (www.auscope.org.au). A major component of this project is the establishment of a national geospatial framework to provide an integrated spatial positioning system spanning the whole continent (Figure 1). Total federal funding for this undertaking is AUD$ 15.8 M, together with AUD$ 21 M from Universities, State Governments, and Geoscience Australia. The infrastructure includes:

- three 12-meter radio telescopes and a software correlator
- about 100 GNSS receivers
- upgrade of existing SLR facilities
- an absolute gravimeter and three tidal gravimeters
- improved computing facilities

As part of this effort, the University of Tasmania (UTAS) is constructing three new radio telescopes, located near Hobart, Yarragadee (Western Australia), and Katherine (Northern Territory). UTAS is responsible for construction and operation of three new VLBI sites. The software correlator is being developed at Curtin University of Technology. In a coordinated international effort in New Zealand, Auckland University of Technology (AUT) has purchased a similar radio telescope, now completed and in the commissioning phase.

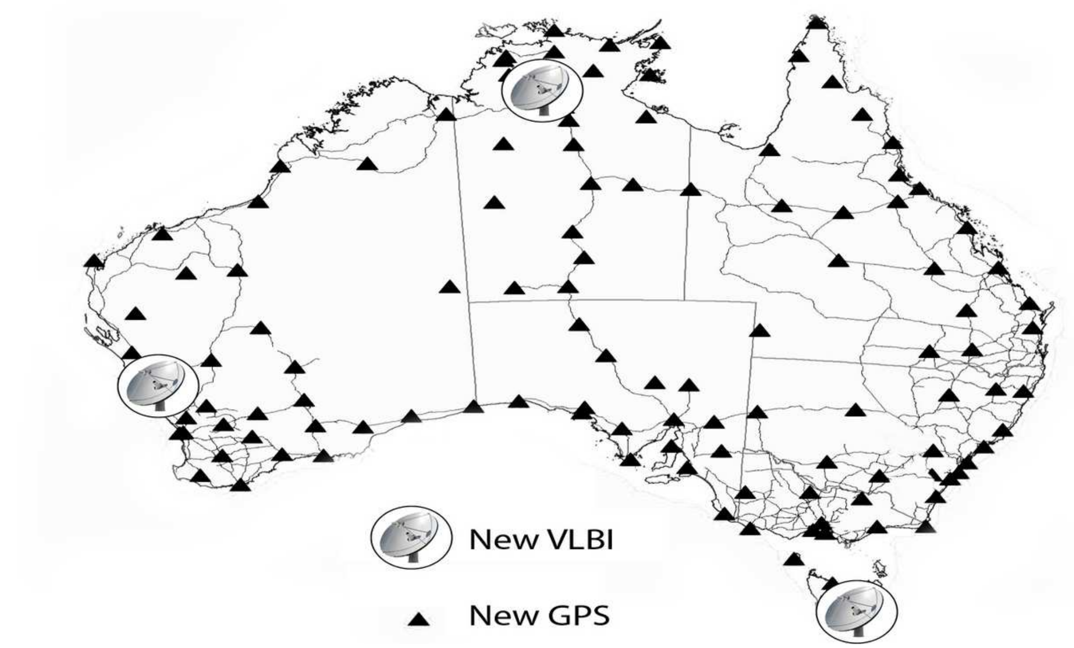

Figure 1. The geographical distribution of VLBI and GPS infrastructure for AuScope. New VLBI stations will be established at Yarragadee (WA), Katherine (NT), and Hobart (Tas) with co-located GPS receivers. An additional ∼100 GPS receivers will be distributed across the continent.

These new telescopes will double the number of IVS stations in the Southern Hemisphere. They will allow the extension of astrometric VLBI solutions to radio sources south of declination –40°, an area of the sky that has been severely under-sampled by the existing array because so few telescopes are available in the South. The AuScope antennas will observe for 180 days per year, increasing the number of geodetic VLBI observations in Australia by a factor of nine. The AuScope and AUT telescopes closely follow the IVS VLBI2010 specification for the next generation of telescopes for geodesy [3] or provide an upgrade path to meet the specification where it is not currently possible to do so.

1.1. AuScope VLBI Observatories

Each AuScope VLBI observatory is equipped with a 12.1 m diameter antenna designed and constructed by COBHAM Satcom, Patriot Products division. The characteristics are: 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 will be equipped with dual polarization S and X-band feeds from COBHAM with room temperature receivers, developed at UTAS by Prof. Peter McCulloch. The receiver systems cover 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 expected to be 2900 Jy at S-band and 3500 Jy at X-band. Data digitization and formatting will be managed by the Digital Base Band Converter (DBBC) system from HAT-Lab, and data will be recorded using the Conduant Mark 5B+ system. Each site will be equipped with VCH-1005A Hydrogen maser time and frequency standards from Vremya-CH.

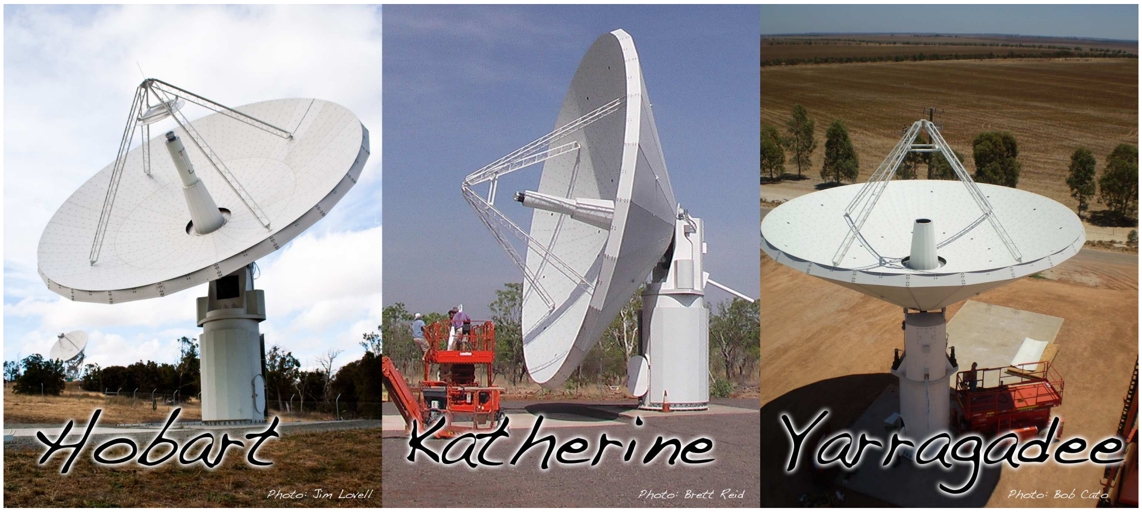

Figure 2. The three AuScope VLBI sites as of March 2010 (photos by Jim Lovell, Brett Reid, and Bob Cato).

At time of writing (April 2010) the Hobart antenna is installed and initial end-to-end testing of the system is under way. Interferometric fringes between the 12 m and 26 m antennas have been detected. Once the hardware and software for Hobart have been completed and tested, duplicate systems for the other sites will be built and tested at Hobart prior to deployment. At Yarragadee, the antenna is in the final stages of acceptance testing, and acceptance tests will take place in Katherine next.

1.2. Sofware DiFX Correlator

The software correlator facility is being developed by Curtin University of Technology. It is an implementation of the DiFX correlator, described in Deller et al. (2007) [1]. The DiFX correlator has been used extensively for radio astronomy and is starting to make a global impact in the geodetic community. DiFX has been compared to the trusted geodetic correlator at MPIfR in Bonn and shown to be capable for geodesy [5]. Other comparisons between DiFX and the USNO correlator show a very high degree of agreement [2], as do comparisons between DiFX and the VLBA correlator [4].

At Curtin University of Technology the software correlator is installed on a 20 node Beowulf cluster, each node containing two quad-core Intel processors, 8 GB of RAM, at least 2 TB of disk space per node, and interconnects using 1 Gbps ethernet. In addition, mass storage is provided by five Apple Xraid chassis, each capable of holding 9 TB in raid5 configuration. Three Mark 5B+ VLBI playback units are integrated into the cluster, for compatibility with the AuScope recording systems. The cluster has a 10 Gbps connection to the iVEC petabyte store, for additional storage and staging of large volumes of data.

The correlator is capable of e-VLBI observations and if high capacity network connections are made available to the AuScope antennas in the future, real-time correlation and extraction of geodetic parameters will be possible.

1.3. AuScope Operations

As the AuScope antennas come on line in 2010 they will participate in more and more geodetic observations, building to a rate of 180 days per antenna per year. Of these, approximately 100 days will be dedicated to existing IVS programs while the remainder will focus on scientific goals with a southern-hemisphere emphasis and include other IVS observatories in the region when available:

- Astrometry of the reference radio sources in the southern hemisphere, especially, with declination south of −40 degrees
- Underpinning of the International Terrestrial Reference Frame
- Measurement of local tectonic motion, for instance, intraplate deformation across the Australian tectonic plate

2. Project of Auckland University of Technology

The IVS VLBI2010 Progress Report [3] outlines a number of strategies to improve the long-term accuracy of geodetic VLBI with an eye to achieving 1 mm precision on baselines. Among these strategies are: "to increase the number of antennas and improve their geographic distribution" and "to increase the number of observations per unit of time". These IVS strategies can best be addressed through construction of new small ($\sim$ 12 m), fast-slewing automated antennas in areas that are under-represented (Southern Hemisphere) or lack (e.g., New Zealand) geodetic VLBI stations.

Developing this approach, AUT University has invested US$1m in a geodetic VLBI system, consisting of a fast-slewing automated 12-m antenna, hydrogen maser clock, receiving and digital backend systems, and a 1 Gbps network connectivity.

Like the AuScope antennas, the AUT radio telescope is equipped with the coaxial dual band (S and X) dual polarization (circular left/right) feed horn, which was specifically developed by COBHAM. An S/X receiver has been constructed with the help of Peter McCulloch and the University of Tasmania. A Symmetricom Active Hydrogen Maser MHM-2010 (75001-114) with 5 MHz, 10 MHz, 100 MHz, and 1 pps (pulse per second) outputs and a 1 pps sync facility is installed. A digital base band converter (DBBC) developed at the Italian Institute of Radio Astronomy is expected to be installed in May 2010. The AUT VLBI receiving system uses the Mark 5B+ data recorder developed at MIT Haystack Observatory. Both S and X receivers have been installed and preliminary figures for SEFD are around 4000 Jy, a figure that is higher than expected. Investigations in collaboration with the manufacturer are underway, and several areas have been identified in which improvements can be made. Modifications to the feed design, which will be applied to the AuScope and AUT antennas in 2010, are expected to yield SEFDs of 2900 Jy at S-band and 3500 Jy at X-band.

In November 2008 a new GNSS station (WARK) was built at the AUT radio telescope site. It is a part of the New Zealand GNSS network "PositioNZ". An accurate tie is established between the radio telescope antenna and the GNSS station.

The New Zealand 12-m antenna is scheduled to start participating in regular IVS VLBI sessions from the middle of 2010.

Being a research tool for astronomy and geodesy, the antenna is also used in a new educational program in astronomy started in 2009 at AUT's School of Computing and Mathematical Sciences—an Astronomy Major in the framework of the Bachelor of Mathematical Sciences degree. It is envisaged that both undergraduate and postgraduate students will use the radio telescope in their research projects and as a teaching resource in the courses taught at AUT such as Astrophysics, Radio Astronomy, Practical Astrophysics, Space Geodesy, and others.

References

[1] Deller, A., Tingay, S., Bailes, M., West, C. DiFX: A Software Correlator for Very Long Baseline Interferometry Using Multiprocessor Computing Environments”, PASP, 119, 318, 2007

[2] Ojha, R., Boboltz, D. & Fey, A. 2008, IVS Newsletter, 22, 7

[3] Petrachenko, B. et al., Design Aspects of the VLBI2010 System. Progress Report of the IVS VLBI2010 Committee. NASA/TM-2009-214180, June 2009.

[4] Petrov., L. et al Precise geodesy with the Very Long Baseline Array Journal of Geodesy 83, 859, 2009

[5] Tingay, S., W. Alef, D. Graham, A. Deller Geodetic VLBI Correlation in Software Journal of Geodesy 83, 1061, 2009