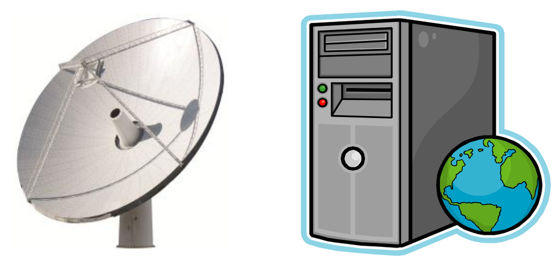
AuScope
AN ORGANISATION FOR A NATIONAL EARTH SCIENCE INFRASTRUCTURE PROGRAM

Continuous monitoring surveys of the AuScope VLBI Array



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Overview

The Australian AuScope VLBI array incorporates three new 12 m radio telescopes at Hobart (Tasmania – Fig 1), Yarragadee (Western Australia) and Katherine (Northern Territory). Following the end of the commissioning phase, the Hobart telescope undertook its first IVS observations in October 2010. An important focus of recent activity has been the design and implementation of a monitoring system to assess the deformation of the telescope invariant point (IVP) at each site in the AuScope array. The primary aim of this study, as described below, is to utilize continuous observations from a Leica TDRA6000 total station to characterize the deformation of the IVP as a function of time, temperature and orientation.

Fig 1: The Hobart 26 m and new 12 m radio telescopes

Fig 2: Target placement on front (left) and back (right) of the Hobart 12m telescope. The red circles are targets used to determine the azimuth axis, and the blue circles are targets used to determine the elevation axis.

Local Tie Surveys

Geoscience Australia (GA) have completed local tie surveys at each of the AuScope VLBI array sites providing the vital connection between space geodetic observing systems at these co-located observatories. As the VLBI telescope IVP is not directly accessible for observation, it is determined using an indirect measurement process. This method involves a rigorous process of three-dimensional circle fitting to the coordinates of targets observed on the structure (Fig 2) during rotational sequences about the azimuth and elevation axes of the telescope. The co-located infrastructure at each site includes:

- Hobart (TAS): 26 m telescope, 12 m telescope, gravity marks, HOB2 GNSS site, associated RMs.
- Yarragadee (WA): 12m telescope, SLR facilities, YARR/YAR2/YAR3 GNSS sites, associated RMs.
- Katherine (NT): 12m telescope, KAT1/KAT2 GNSS sites, associated RMs.

Telescope Deformation

Existing site local tie surveys make the assumption that the telescope IVP is stable as a function of time and temperature throughout the survey. We seek to further understand the contribution of thermally induced antenna deformation to both the local tie and VLBI geodetic analyses of the AuScope array. We are in the process of developing a combined approach involving 1) episodic continuous monitoring using terrestrial surveying/metrology techniques, 2) Finite Element Modeling (FEM) and 3) networks of temperature sensors in and around each telescope. We note each site experiences very different climatic conditions (Fig 3), with sites at Yarragadee and Katherine regularly experiencing strongly diurnal changes in temperature over 20°C. We expect a complex and asymmetric temperature distribution throughout the telescope, with the pedestal primarily constructed from steel, and the dish from aluminum. With funding from the Australian Geodetic Observing System (AGOS), we have acquired a Leica TDRA6000 robotic total station to undertake the monitoring surveys (Fig 4) and associated instrumentation and observe the internal and external temperature variation throughout the telescope. We take delivery of this hardware in March 2012.

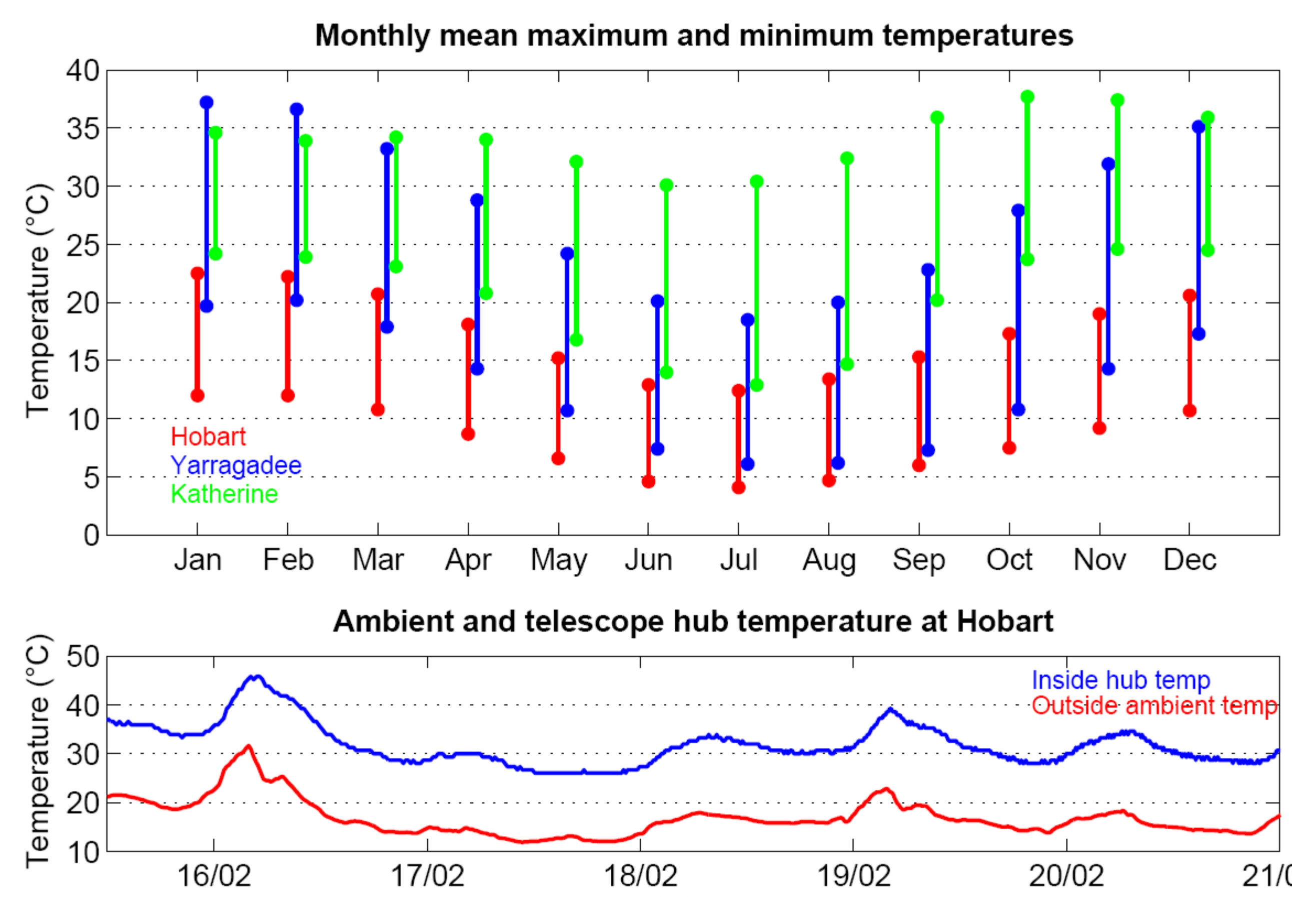

Fig 3: Top panel: monthly mean max and min temperatures for each AuScope telescope location. Bottom panel: example difference between outside ambient temperature and temperature observed inside the antenna hub.

TDRA6000 3D Point Accuracy*:
$U_{XYZ} \leq 30$ m: ± 0.5 mm
$U_{XYZ} > 30$ m: ± 0.3 mm + 13 μm/m
*Maximum Permissible Error (MPE) ~±3σ, Typical accuracies are ½ MPE)

0.5" TBR Targets:
Acceptance angle ± 20°
Magnetic mounts, rotating stands for each TBR (Fig 5).

Fig 4: Robotic total station (Leica TDRA6000) specifications and 0.5" TBR reflector selected for targeting over the telescope.

Methodology

Temperature sensors: The foundation, pedestal and dish structures will be instrumented with temperature sensors enabling continuous monitoring of the thermal response of the structure over time. Separate Campbell Scientific loggers will be used within the dish and in the pedestal.

Finite Element Modeling: FEM of the structure (Fig 6) will be undertaken using the SolidWorks suite yielding a series of expected deformations as a function of temperature.

Direct monitoring of deformation: We plan a series of automated monitoring surveys to quantify the observed motion of the IVP as a function of temperature. A series of targets on the telescope and its surrounds (RMs, foundation, GNSS marks etc) will be sequentially observed using the TDRA6000. Using code adapted from Schmeing et al, we have the ability to control the total station as well as the telescope in real time. Each automated observation set will be repeated continuously over a 48-72 hour period. Of importance here is the minimisation of systematic error caused by the changing incidence angle from the robotic total station to the targets on moveable parts of the telescope. We use Leica 0.5" TBR targets on custom mounts (Fig 4&5) which show negligible degradation in precision with incidence angles of ± 25°. We plan two initial monitoring configurations:

1) Telescope static: fixed azimuth and elevation. This scenario allows direct validation of the FEM derived deformations, as well as initial assessment of our measurement precision.
2) Telescope dynamic: repeated rotations about the azimuth and elevation axes. This scenario replicates the GA IVP determination method, however introduces a time (and hence temperature) dependence to the IVP determination.

We expect to commence the surveys mid 2012, following the installation of the temperature sensors and logging system.

For more information please contact Christopher Watson <cwatson@utas.edu.au>

Fig 5: Custom TBR mounts to be fixed at various mount points over the 12 m telescope.

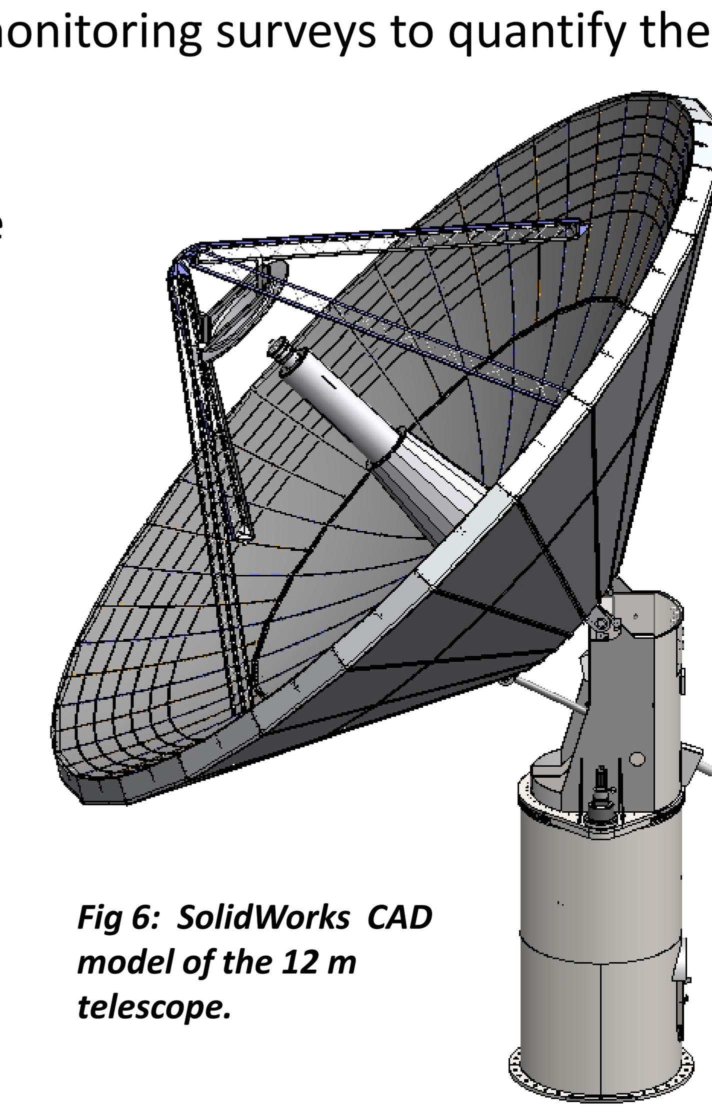

Fig 6: SolidWorks CAD model of the 12 m telescope.

Acknowledgements: We thank Benno Schmeing et al for the provision of their Matlab based monitoring software which has been adapted for this project. COBHAM Satcom, Patriot Products division are also acknowledged for providing the CAD model of the telescope.