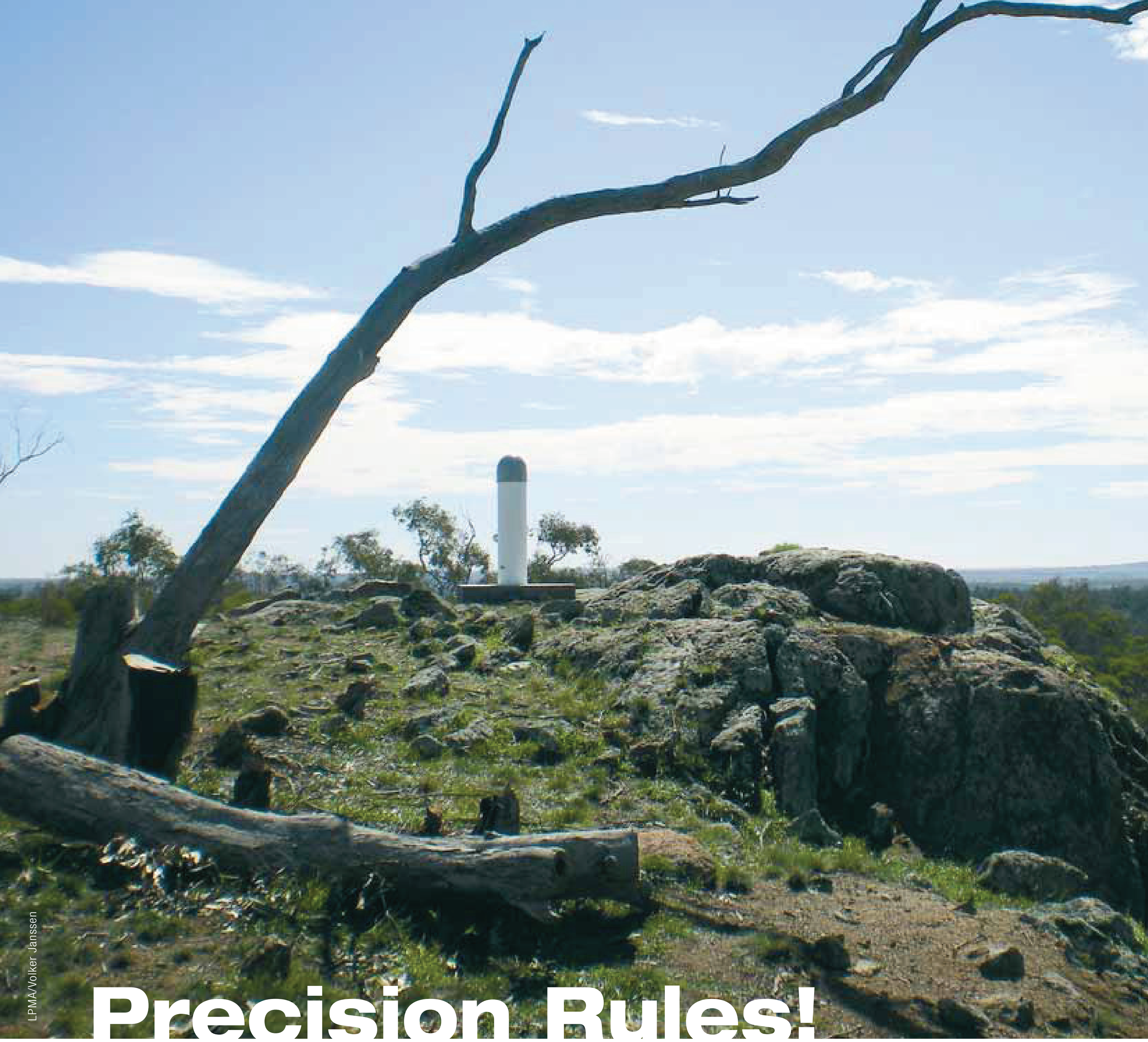

LPMA/Volker Janssen

Precision Rules!

The complete pillar and the first of 70 such monuments that will feed data to both AusCORS and CorsNet NSW

How to establish an AusCORS site

VOLKER JANSSEN

In 2004 the Australian government announced the National Collaborative Research Infrastructure Strategy, aimed at strengthening Australia's research capabilities. As part of this strategy, AuScope was formed in 2007 to facilitate, over five years, the implementation of a world class infrastructure for the Earth and geospatial sciences. This includes a significant increase in the density of the national network of Global Navigation Satellite System (GNSS) Continually Operating Reference Stations (CORS).

This network will be used to monitor slow and rapid movements of the Earth's crust, predict and monitor sea level change, update co-ordinate datums and assist atmospheric modelling.

Many state jurisdictions have committed additional funding to maximise the number of AusCORS stations to be constructed. About 100 stations will be established across the continent. Ten of these will be built in NSW by the Land and Property Management Authority (LPMA), formerly the Department of Lands, in partnership with Geoscience Australia (GA).

The first AusCORS site was established in September 2008 at Spring Bay, Tasmania. In August 2009, NSW's first AusCORS site was installed at West Wyalong.

By the end of this financial year up to five more AusCORS sites will have been built in NSW. These will also contribute to the continuing expansion

of CORSnet-NSW, which consists of 28 stations. This number will climb to 70 CORS by the end of 2013, providing state-wide coverage. CORSnet-NSW will offer network RTK services across large parts of the state, facilitating a significant improvement in the geodetic infrastructure available to the spatial community.

This article describes how the first site was constructed and surveyed to ensure the station would facilitate world class research.

The GNSS antenna had to be mounted on a stable monument so it would move with the Earth's crust. This enabled the detection of crustal motion and contributed to a more accurate geodetic reference frame for Australia.

A concrete pillar measuring about 1.5 metres in height and 40 centimetres across was used. Important factors in the site selection were a clear view of the sky, minimal multipath, accessibility and security. An automatic weather station was also required to collect meteorological data (temperature, atmospheric pressure and humidity) in the vicinity of the GNSS antenna.

After a suitable site was chosen, construction began in April 2009, when the pillar and a concrete pad for the steel cabinet housing the GNSS receiver and auxiliary equipment were built. Foundations for the weather station were also constructed and cables were laid.

A major consideration when choosing the West Wyalong site was the availability of stable bedrock to anchor the pillar.

About 100 stations will be established across the continent...

To achieve the required stability, up to 600 mm of weathered surface rock was removed, providing a clean, strong foundation. Large reinforcing rods were drilled more than half a metre into the undisturbed granite and secured using high-strength construction adhesive. A heavily reinforced base and pillar were then formed around this foundation. A purpose-built tripod was used for holding the PVC formwork upright whilst a survey ensured that the pillar was aligned truly vertically (±1 mm) both during and after the concrete pour. The concrete was then left to settle for at least a month.

Pillar construction was finalised by adding the pillar plate and four reference pins surrounding it, set in concrete. Three reference marks were established in bedrock about 25 metres away, forming a triangular pattern around the monument. The following precision survey of the pillar included precise levelling (using the EDM heighting technique), a horizontal survey and a GNSS baseline observation.

Stability is critical in studying tectonic motion. It is therefore necessary to routinely conduct high-precision surveys to monitor the AusCORS site for local displacement and ensure the structural integrity of the station.

We used a total station with automatic target recognition able to measure directions to 0.5″ and distances to ± (1 mm + 1 ppm, a set of precision prisms (0 mm offset) and a calibrated fixed stainless steel pole and stub combination. A precise optical plummet made it possible to set up over the reference marks to within 0.25 mm. Measurements of temperature, atmospheric pressure and humidity were required throughout the survey.

Levelling connections included the height differences between the pillar plate (i.e. the GNSS antenna reference point) and the pillar benchmark, each of the three reference marks, and the pressure sensor reference mark of the weather station. The latter is necessary to relate the met data to the conditions experienced at the GNSS antenna and only needs to be determined to within one centimetre.

All other levelling observations must meet class L2A specifications, i.e. the misclose of forward and reverse levelling runs must be less than twice the square root of the distance in kilometres between the benchmarks. However, we generally aim for half the error specification.

The height difference between the pillar plate and the pillar benchmark was determined by using the calibrated stub/pole combination and observing five sets of angle and distance measurements with two separate setups of the total station. The calculated misclose was 0.06 mm, well within the error specification of 0.14 mm over this short distance. The height difference is used to monitor the height of the pillar, relative to the surrounding reference marks.

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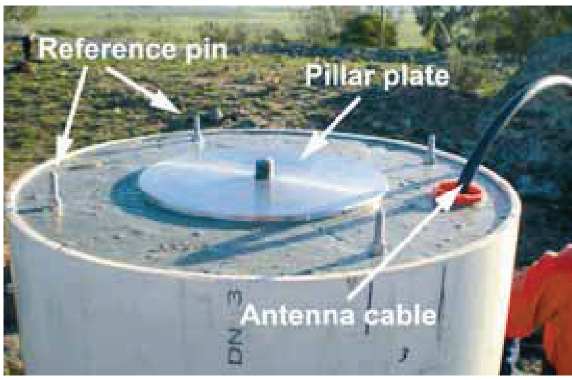
A levelling loop from the pillar benchmark via the three reference marks back to the pillar benchmark was then performed (forward and reverse), observing four sets of angle and distance measurements, in order to connect these marks.



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Pillar plate with reference pins (top) and symmetrically coupled points on the antenna used in the indirect survey (bottom)


LPMA/Volker Janssen

The CORSnet-NSW team (from left): Thomas Grinter, Simon McElroy, Russell Commins, Thomas Yan and the author, Volker Janssen.

The levelling run resulted in an extraordinary misclose of 0.009 mm (9 microns!), made possible because the random errors in the forward and reverse observations nicely cancelled out in this case. When averaging the observations of the loop's forward and reverse runs, the misclose increased to 0.18 mm, which is still well within the error specification of 0.34 mm.

Since the AusCORS site is intended to measure continental plate motion, it needs to be monitored regularly (18-monthly) by precise connection to the three reference marks in order to ensure the monument's integrity. A 'direct' horizontal connection requires the total station to be set up on the pillar and is therefore only performed during the installation of a new site. Once the continuously operating GNSS antenna is installed, it should never be removed. All follow-on surveys will therefore use an 'indirect' technique. During installation both methods are used to provide additional checking.

In the direct survey technique, the total station is set up on the pillar and five sets of observations are made to precision prisms on the three reference marks, as well as to any reference orientation (in this case a nearby trigonometric station), if applicable. Using constrained centring, the procedure is then repeated with the instrument on each reference mark.

After installation of the GNSS antenna on the pillar (oriented to true north to within ±3 degrees), the indirect survey technique is used to again determine the horizontal position of the antenna reference point. This time, three sets of angular direction observations are made from each reference mark to the reference pins surrounding the pillar plate as well as specific (symmetrically coupled) points on the external profile of the antenna. In this way, observations made to either side of the antenna can be intersected to obtain direction observations to the central axis of the antenna (which contains its reference point). The horizontal position of the reference point is then estimated precisely via triangulation of these observations in the adjustment.

The survey network is aligned by obtaining an azimuth via a GNSS baseline observed for at least three hours between the AusCORS pillar and one of the reference marks or an existing mark in the vicinity.

The horizontal survey accuracy requirement is 1 mm. In this case the adjustment of the direct survey delivered standard errors of 0.4-0.6 mm (at 95 per cent confidence interval), while 0.8 mm were achieved in the indirect survey. The co-ordinates derived using both methods agree to within 0.4-0.8 mm, again highlighting the extreme survey quality required for these sites.

During the survey, the cabinet housing the GNSS receiver and other necessary electronic equipment was installed. Due to the remote nature of the location, a solar power system was preferred. It was designed to be capable of powering all of the electrical components with a battery backup of more than two weeks, should the solar input be lost for any reason.

The cabinet itself is a vandal-resistant field enclosure and, in addition to two external vents and a solar shield, the solar panels were mounted above the cabinet to provide protection from the summer heat.

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Communications between the receiver and the Land and Property Management Authority in Bathurst, as well as Geoscience Australia, were established with a wireless modem, using Telstra's Next G mobile network. The purpose of this link is to relay position and weather data. The addition of a solar regulator interface and web controlled relay has also made it possible to remotely check the health of the power supply system, switch equipment on/off and receive alarm notifications for high temperatures and door tampering.

The installation of the GNSS antenna radome (used to protect the antenna from environmental and human interference) concluded the successful establishment of NSW's first AusCORS site. West Wyalong is now streaming data for real time use and post-processing.

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