CORSnet-NSW: Delivering a state-of-the-art CORS network for New South Wales

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ABSTRACT

Following the successful deployment and operation of the SydNET Continuously Operating Reference Station (CORS) network in the Sydney metropolitan region, Land and Property Information (LPI) is committed to expanding the network to cover the entire population of New South Wales. LPI has committed over seven million dollars for capital investment in the Survey Infrastructure Improvement Project – the majority of which will be invested in the CORS network – plus additional funds to operate the network. A strong team of eight technical and customer support staff was formed early this year to handle the development and operation of the network as well as the introduction of user fees. A new network name, CORSnet-NSW, was announced in June 2009 to reflect the new effort. With 28 sites currently operational, the team aims to expand the network to 70 sites within the next four years.

Concluding a competitive and comprehensive tender process, a contract was awarded in June 2009 to deliver LPI with VRS³Net, the latest generation of CORS network management software from Trimble Navigation. The deployment of VRS³Net in CORSnet-NSW will significantly enhance the range and quality of services that LPI can provide to its customers. LPI aims to integrate VRS³Net with its existing accounting and delivery systems, which is a first for this system. Currently, fully-fledged network control centres are being built at the Land and Property Management Authority's (LPMA) data centres in Sydney and Bathurst. Once completed, these control centres will provide a fully redundant network with future-proof capabilities for many years to come.

This new infrastructure will also enable a wide range of research projects in the areas of geodesy, surveying, positioning, navigation and telecommunications. LPI will be involved in research on long-term site monitoring, datum transformation, network-RTK algorithms and GNSS protocols in collaboration with universities and other government agencies.

KEYWORDS: GNSS, CORS network, Network RTK, spatial infrastructure, surveying, geodesy, systems integration.

1. INTRODUCTION

Land and Property Information (LPI), a division of the NSW Land and Property Management Authority (LPMA), is investing in positioning infrastructure for NSW to support industry and provide stimulus for innovative spatial applications and research using positioning technology. Our vision is for a self-sustaining Continuously Operating Reference Station (CORS) network which undergoes a continuous program of renewal to ensure the best possible positioning infrastructure is available to NSW, while maintaining national and international standards and best practice (e.g. ICSM, 2002; 2007; LPMA, 2009b) to accommodate established and developing positioning and navigation applications. With Global Navigation Satellite System (GNSS) technology being intrinsically linked to surveying and geodesy, it is appropriate for LPI to take a leading role and provide guidance for applications of CORS in NSW.

LPI's first CORS was installed in 1992 in Bathurst to support internal survey and aerial photography operations (Kinlyside and Yan, 2005). In 2004 an array of seven CORS was installed in the Sydney metropolitan area and in 2005 this was made available to the public under the name SydNET (Roberts et al., 2007). A renewed effort of expansion to extend the coverage of CORS throughout NSW commenced in 2009 and corresponded with the rebranding of the network as CORSnet-NSW (LPMA, 2009a). This renewed effort will expand the network from its current 28 CORS to 70 by 2013, expand the range of services available and upgrade the service quality in order to provide state-of-the-art positioning infrastructure to NSW.

This paper presents the elements necessary to best deliver CORS to NSW, i.e. building the CORS "dream team", sustainable positioning infrastructure, seamless positioning across NSW, systems integration and research and development.

2. POSITIONING INFRASTRUCTURE FOR NSW

2.1 Building the CORS "Dream Team"

Rolling out a CORS network in NSW requires a team of experts with a range of specialised skills including information technology, project management, geodesy and communications. To accommodate this wide range of skill requirements, LPI has expanded its CORS team to eight dedicated staff who work under a senior governance structure. While all members of the CORS team work closely with one another, the team is split into two primary groups, technical and customer support.

The technical team reports to the Manager of the Survey Infrastructure and Geodesy unit in LPI. The senior surveyor in this team manages four staff and together they handle all technical matters relating to CORS such as the construction, installation, precise survey, communication links, processing and maintenance of the network.

The customer support team reports to the Senior Business Manager for CORS. The team of three is responsible for user management, customer enquiries and support, marketing and communication, licensing, billing and systems integration.

2.2 Sustainable Positioning Infrastructure

LPI has committed $7.25 million in capital investment for the Survey Infrastructure Improvement Program. The majority of this investment will go directly towards the CORS network while other equipment will also be upgraded to support survey functions including CORS. This investment is deemed necessary to avoid future duplication of GNSS reference station equipment and encourage uptake of GNSS positioning in a wide variety of fields. Other benefits of a state-wide CORS include standardised levels of service, connectivity to datum and the ability to provide legal traceability for GNSS positioning. The operating costs for the CORS network are substantial, and in order to ensure a sustainable and permanent CORS network for NSW, fees for user access were introduced on 1 July 2009. The fees aim to cover the operational costs of the network and break-even point is intended to be reached by the conclusion of the rollout in 2013.

The network currently (December 2009) consists of 28 CORS, and the coverage is illustrated in Figure 1.
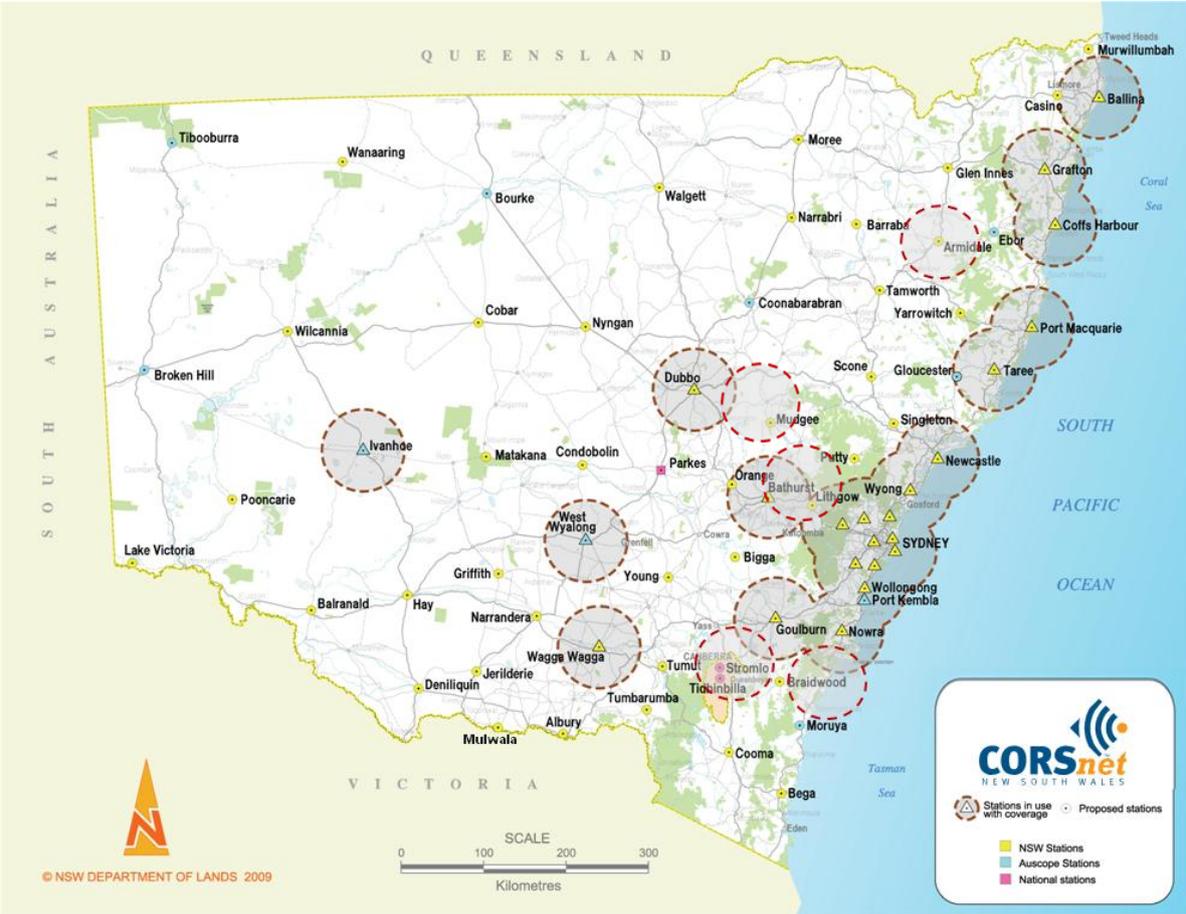

Figure 1. Current coverage of CORSnet-NSW

This coverage is to be expanded to achieve a state-wide network of 70 CORS in 2013 (Figure 2). Station density will be much greater in the east of the state than the west due to application requirements and potential user benefits.

As LPI progresses with the rollout of CORS, more users will have services available to them and the level of service may also improve from its current levels. It is for this reason that LPI

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has also offered new users a free three-month trial in order for them to evaluate whether the service is suitable to their needs.
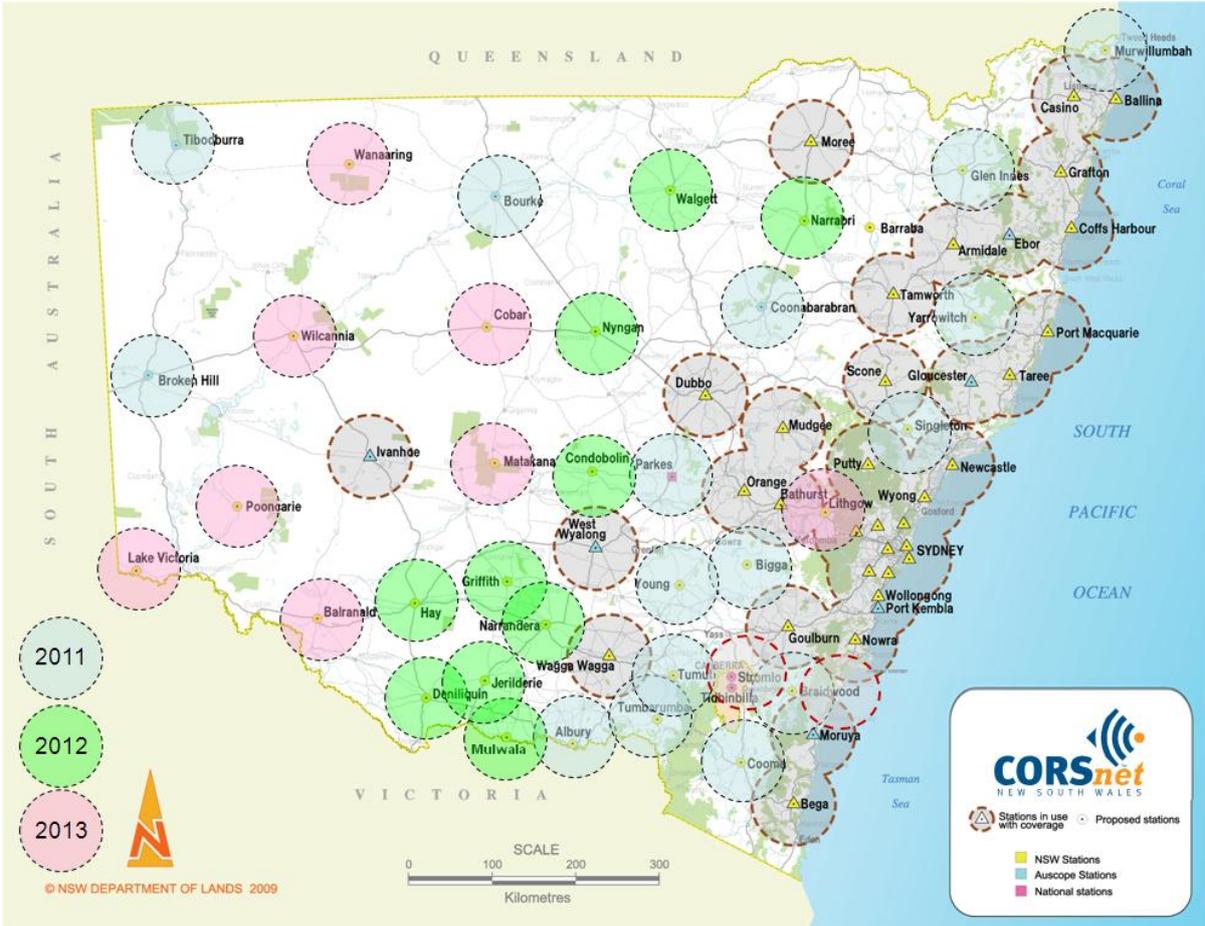

Figure 2. Planned coverage of CORSnet-NSW in 2013

2.3 Seamless Positioning across NSW

While users of CORS in NSW have benefited from high accuracy GNSS positioning for some time, it has been limited to single reference station solutions. These solutions degrade the further away a user is from the base station and high accuracy solutions are generally limited to a distance of 20 km (Zhang et al., 2006). The only area where the current inter-station spacing provides complete coverage, considering this distance restriction, is in Sydney.

To provide high accuracy solutions state-wide using single base solutions would require many hundreds of CORS and this would be extremely costly and not at all sustainable with the existing fee structure. As part of LPI's investment, Trimble Navigation's VRS³Net CORS management software has been purchased to, among other benefits, provide network RTK (NRTK) solutions. These NRTK solutions enable the modelling of atmospheric errors across the network and allow the correction data provided to a user to be optimised based on their location. The NRTK solution is generated using as many as six of the closest CORS with respect to the user and these reference stations can be rolled out at much greater inter-station distances (70-100 km) while maintaining the same level of accuracy. CORSnet-NSW will provide users with NRTK correction data according to both the Virtual Reference Station (VRS) and the Master-Auxiliary Concept (MAC) techniques. A description of these two concepts can be found in Janssen (2009).

Initial tests show that accuracies achieved using NRTK solutions are as good as or better than those achieved from single reference station solutions. Initialisation times were reduced by as much as 50% and, although the sample size is not yet large enough to draw any conclusive results, vertical accuracies appear to improve as well.

VRS3Net includes a range of other advanced features in CORS network management which will further empower LPI in providing a world-class spatial infrastructure for NSW. This includes comprehensive user management and billing system, highly customisable SQL-based reporting functions, alert services, RSS feeds, virtual RINEX and real-time network integrity monitoring.

To provide the highest possible level of service availability, the network is designed with full redundancy by running two independent control centres, one in Sydney and another one in Bathurst. Such system architecture allows for load balancing and backup between the two control centres. Within these control centres, the systems architecture is also designed to mitigate any single points of failure that may exist in the system through the distribution of redundant software modules on multiple servers. Both control centres utilise the latest server virtualisation technology to maximise hardware utilisation and at the same time minimise power consumption, space and carbon footprint. Other forms of redundancy and backup are also being implemented with uninterrupted power supply units being installed at all CORS sites as well as dual communication links at some CORS.

2.4 Systems Integration

As an internationally renowned centre for spatial information in NSW, LPI is well placed to deliver positioning infrastructure services to the state. Systems developed in-house allow for users to easily access a range of products and services efficiently through online interfaces. LPMA's Spatial Information eXchange (SIX) portal (http://six.lands.nsw.gov.au) is an effective and flexible delivery system that LPI uses as an interface between users and a variety of product areas, while e-commerce capabilities allow for online ordering, billing and payment for these products. It is planned to link CORSnet-NSW with SIX to provide consistency with the delivery mechanisms of other LPI products and to achieve a one-stop-shop for all LPI data.

The overarching objective of integrating CORS with other systems is to deliver a quality user experience in a cost effective and timely way. Integration offers the potential to leverage the capabilities in LPMA software, i.e. the accounting/resource management system (SAP), the web portal and e-commerce exchange (SIX) and the new CORS management system (VRS3Net). The aim is for users of the system to benefit from a single familiar point of entry (via SIX), consistent 'look and feel' with single logon and seamless transfer between SIX and VRS3Net, flexibility in payment using the expanding e-commerce services (in SIX) and the ability to buy either longer term subscriptions or small quantities of user specified CORS data. The integration design minimises the need to adapt VRS3Net functionality or data, defines primary data stores and minimises data duplication. Handover points between systems have been minimised by modularising the functions so they could be performed within a single system. Implementing this design will require continuing effective communications between a range of LPMA professional staff, contractors and specialist support from the developers of VRS3Net at Trimble Navigation.

3. RESEARCH AND DEVELOPMENT

LPMA has a long history of engaging with and supporting research in the positioning and navigation field (e.g. Zhang et al., 2006; Roberts et al., 2007; Yan et al., 2009; Janssen et al., 2010). The previous stage of CORS in NSW, SydNET, had a dual role in that it was utilised for research as part of the Cooperative Research Centre for Spatial Information (Kinlyside and Yan, 2005). With the success of the new spatial information bid (CRC-SI2) in the recent National Collaborative Research Infrastructure Strategy funding round, LPMA is looking forward to further enhancing positioning and navigation applications in the future.

4. CONCLUSIONS

This paper has presented the elements necessary to effectively deliver CORS services to NSW, ensuring a sustainable positioning infrastructure, seamless positioning across NSW, systems integration and on-going contributions to research and development. With a strong background in GNSS technology, LPI is well positioned to deliver high-quality CORS services to NSW. The significant efforts being undertaken to roll-out the CORSnet-NSW network and streamline the delivery of data to users will ensure that NSW benefits from state-of-the-art positioning infrastructure. CORSnet-NSW will be sustainable and undergo a continuous program of technological upgrades in order to reduce the duplication of positioning infrastructure across the state.

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