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THE SURVEY MARK INFRASTRUCTURE – IS IT DOING THE JOB?

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ABSTRACT

For many years the coordination of surveys in Australia has been encouraged through the placement and connection to the growing network of survey marks (SMs) in each state. The connection of cadastral surveys to the survey mark infrastructure has facilitated the improvement and maintenance of other spatial databases such as the Digital Cadastral Data Bases (DCDB's). These networks of survey marks are usually managed and maintained by the state surveying and mapping agencies on behalf of the spatial information community. With the downsizing of the government agencies, their ability to coordinate and maintain these marks has come under increasing pressure. Although advances have been made in the connection of the survey mark infrastructure to the cadastre, the actual coordination of survey marks appears to have declined in some states.

This paper will investigate the current status of this survey mark infrastructure across Australia and its impact on the spatial information industry. The changing role of the private sector in the placement, maintenance and coordination of marks will also be examined. The results of a case study in Queensland that investigated the use, access and maintenance of the permanent survey mark infrastructure by the surveying industry will be discussed.

The study found that the permanent survey mark infrastructure in the state is potentially valued in the hundreds of millions of dollars, although this cost does not appear to be fully appreciated by the spatial information community or government. In addition, the effectiveness of the infrastructure appears to be declining due to a range of reasons including the quality of marks, lack of ongoing maintenance, poor access to information and funding. Some possible solutions to these issues are put forward and some examples of recent initiatives across Australia to improve the survey mark infrastructure are examined. The future need for this infrastructure in the context of new positioning technologies will be discussed.

BIOGRAPHY OF KEVIN MCDOUGALL

Kevin McDougall is a senior lecturer in the Faculty of Engineering and Surveying at the University of Southern Queensland and is currently undertaking his PhD in the Department of Geomatics at the University of Melbourne. He holds a BSurv (Hons) and Master of Surveying and Mapping Science from the University of Queensland. From 1995-2002 he was the Head of Department of Surveying and Land Information at USQ and has also served on a number of industry bodies including the Board of Surveyors. Kevin is currently the President of recently formed Australasian Spatial Information Education and Research Association (ASIERA). He has undertaken consulting work both in Australia and overseas in areas such as GIS implementation in local government and implementation of land administration systems. His PhD research lies in the investigation of critical success factors in local-state government SDI partnerships.

INTRODUCTION

The survey mark infrastructure, in the form of ground marking and its associated positional information, is an underpinning component of our spatial information infrastructure (SDI). The physical marks and their co-ordinate information enable the co-ordination of surveys, provide a level of quality assurance and facilitate the establishment of large spatial databases. All states and territories in Australia have some form of survey mark infrastructure and are continuing to develop mechanisms to improve the access to this spatial information. However, the importance of the survey mark infrastructure is often not understood by decision makers and its contribution to supporting the SDI framework appears to be undervalued.

Increasingly, efforts are being directed toward the connection of the survey mark infrastructure to the cadastre, whilst the actual connection of survey marks to the geodetic infrastructure appears to be declining. The resultant framework, although providing additional cadastral connections, contributes little to the incremental improvement in spatial accuracy of the cadastre or to the coordination of isolated surveys. Whilst other types of surveys such as engineering surveys, asset location and topographic surveys continue to increase, little effort has been made to provide the supporting geodetic infrastructure. With the decline in capacity of the government agencies to continue their coordination efforts of the 1970s and 80s, new survey marks (SMs) are increasingly left uncoordinated.

The private sector now plays a crucial role in the placement, maintenance and coordination of marks, so it is essential that information on this infrastructure is readily accessible by the private sector. However, at a time when information and communication technologies (ICT), especially the internet, are impacting on all professions, access and availability to the survey mark infrastructure remains limited in some states and territories. Current access mechanisms in particular, do little to encourage the reporting on mark condition or facilitate the uploading of digital information. There is growing evidence that poor access to information and the lack of current information can result in poor survey practice and decision making.

This paper will firstly examine the status of the survey mark infrastructure in various states across Australia to gain an appreciation of the size and extent of the Australian survey mark infrastructure. A case study of the survey mark infrastructure in Queensland will then be presented and some key findings discussed. Finally some recommendations for the future management and operation of the survey mark infrastructure will be provided.

AN OVERVIEW OF SURVEY MARK INFRASTRUCTURE IN AUSTRALIA

The national coordination of Australia's survey mark infrastructure is undertaken by the Intergovernmental Committee on Surveying and Mapping (ICSM). The ICSM was established by the Prime Minister, State Premiers, and the Chief Minister of the Northern Territory in 1988 to provide leadership and cooperation on surveying and mapping activities in Australia and New Zealand. The surveying and mapping agencies within each Australian state and territory and Geosciences Australia are represented on ICSM. The Australian Defence forces are also represented and have specific national and international defence surveying, mapping and charting responsibilities.

However, it is the State and Territory authorities which maintain the databases of current survey control to support the activities of both government and the private sector. The following is a brief summary of status of each state as obtained from the various states' websites and may, or may not, truly reflect the current situation.

Queensland

In Queensland the custodian of survey marks infrastructure is the Department of Natural Resources and Mines (DNR&M). There are approximately 130,000 survey marks recorded in the Survey Control Data Base (SCDB). The database of coordinate information and metadata is supported by an image library of location sketches. Access to the data has been traditionally via 'over the counter' enquiries at the Department offices. However, part of the database is now available on CD but only at a particular time stamp i.e. start of 2005. To obtain up-to-date information of permanent survey marks, sketches and locality maps, surveyors are still required to attend a Departmental office. Information is provided on a cost per mark basis in hard copy form. Maps showing the locations of marks are provided in hardcopy form and are also charged on a per map basis.

Victoria

The Survey Marks Enquiry Service (SMES) provides interactive, on-line access to and management of the Victoria's survey control mark information. There are currently over 130,000 registered survey marks throughout Victoria.

SMES provides:

- Latest coordinate and height values
- Scanned images of permanent survey mark sketch plans
- Graphical and textual searching tools
- A map base interface
- Printing of coordinates, sketch plans and map base information
- Ability to download SMES information
- Digital lodgement of survey information
- On-line reservation of permanent mark numbers
- On-line updating of database information

SMES supports a wide range of business activities and registered users come from a variety of areas including surveying, mapping, engineering, utility companies and local and state government departments. The on-line service provides users with an efficient means of retrieving, and updating survey records. There are two levels of access to SMES, unregistered or registered users. Both levels of access provide access to the same data, searching methods and printing. Registered users can reserve permanent mark numbers and provide online updates to the database, including new and updated mark information.
(http://services.land.vic.gov.au/landchannel/content/surveymarkintroduction)

ACT

The ACT survey control mark detail database is managed by the ACT Planning and Land Authority (ACTPLA) and is available on-line. The database can be searched by mark type, name or geographic location and access is free.
(http://www.surveymarks.canberra.net.au/)

New South Wales

The NSW Department of Lands Survey Control Information Management System (SCIMS) data-base contains coordinates and related information for survey marks which form the NSW Survey Control Network. "SCIMS Online" allows registered users access to the data-base using various search options. Results of the search can be viewed on the screen, printed or saved to file.

SCIMS Online retrieves GDA94 coordinates and AHD heights where available for all marks in the system including eccentric/witness marks. AGD66 coordinates (ISG/AMG) are also available for some marks. Additional survey information includes accuracy codes, status, combined scale factors, grid convergence and trig station details. To assist with selecting marks, an image can be viewed showing individual marks plotted over the State's cadastre. Detailed locality sketch plans can be ordered through SCIMS Online, they will be returned by fax or email. Survey mark information is charged on a per mark basis.
(http://www.lands.nsw.gov.au/OnlineServices/SCIMS/InformationAndHelp/SCIMSInformation.htm)

South Australia

The Survey Database (SDB) is the major repository for survey mark information within South Australia. The SDB stores coordinates, elevations, accuracy statements and descriptive information about survey marks together with references to connecting plans of survey and visitation information. It comprises approximately 170,000 survey marks, together with 800,000 associated plan references. All permanent survey marks, and generally all non-permanent survey marks that form part of the state’s horizontal and/or vertical control network, are registered in the Survey Database. Access to the public is at a cost per enquiry. Account customers accounts can access the SDB over the Internet. (http://www.denr.sa.gov.au/mapland/pdfs/survey_dbase_factsheet.pdf)

SurveyGEM provides a spatial view of all the survey marks that have been registered in the SDB. It displays their location and identity by overlaying survey mark data from the SDB with cadastral data from the Digital Cadastral Database (DCDB). Clients of the Department of Environment and Heritage may apply for a license to use

SurveyGEM remotely. For this an annual license fee is charged and SurveyGEM is supplied on compact disc. Updates are supplied quarterly. (http://www.denr.sa.gov.au/mapland/pdfs/surveygem_factsheet.pdf)

Western Australia

In Western Australia, the Department of Land Information (DLI) is the custodian of the geodetic database (GESMAR) which stores the details of about 60,000 permanent geodetic survey marks. The data is available in various formats – hardcopy, digital files and online. The information is available on-line via the Landgate Survey Channel Map Viewer and offers access to geodetic mark information via a graphic interface which also displays cadastral data and aerial photography in selected areas. The Map Viewer provides the ability to graphically search for marks either radially from a selected point or by drawing an irregular shaped figure around your points of interest. Textual searches on mark name or stamped name and filtering by status of mark, whether it is spirit levelled or cadastrally connected are also features of this system. Access is charged per enquiry. (https://www.landgate.com.au/foundationr2/)

Tasmania

The Survey Control Marks Database (SurCoM) contains positional, height and other information, relating to Survey Control Marks located at Survey Control Sites in Tasmania. Online access is available to the public and a range of survey reports, pictures and sketches of marks are provided free of charge. Map displays are also available through LISTmap. (http://surcom.dpiwe.tas.gov.au/surcom/jsp/login/index.jsp)

Northern Territory

The Northern Territory Department of Infrastructure, Planning and Environment maintain the integrity of the NT Geodetic Survey System (NTGESS) based on the Geocentric Datum of Australia 94 (GDA94). Online access to the database is currently under development.

As can be seen from the above, many of the states and territories provide online access to their survey mark infrastructure. In some cases the access is free whilst other charge license or access fees. Most now have some form of electronic access and mostly via the internet. A few of the states permit surveyors to upload and update mark information online.

A CASE STUDY OF THE SURVEY MARK INFRASTRUCTURE - QUEENSLAND

A recent study in Queensland investigated the current permanent survey mark (PSM) infrastructure to identify the issues and any possible improvements in regards to the infrastructure. Analysis of the current density, usefulness and suitability of marks, as well an investigation into different methods utilised for updating and accessing PSM information was conducted. The research consisted of a survey of the surveying profession and two case studies. The questionnaire was designed to collect both quantitative and qualitative data and was distributed in electronic format to over 600 surveyors. A total of 161 responses were submitted with 155 valid responses able to be used for the statistical analysis.

The case studies comprised two areas, one urban area in North Brisbane and the other a semi-rural area in Caboolture. Extracts of the Survey Control Database (SCDB) were used in conjunction with a GIS system, Arcview, to conduct spatial analysis on the density of marks and the current status of their attributes.

RESULTS

The research indicates that the overall quality of the PSM infrastructure in Queensland, as measured by access to information, standard of marking and usefulness, is declining. The results demonstrate the intentions and principles behind the requirements for surveyors to connect cadastral surveys to PSMs are generally understood. However, the additional costs incurred to ensure compliance with the current regulations mean that surveyors are adopting the least expensive and easiest options with respect to mark placement and coordination to the detriment of the PSM infrastructure.

Density of PSMs to Meet Requirements

Surveyor's expectations of a suitable urban density for PSMs identified the median for the ideal density range is 200 to 400 metres. The urban case study found the current urban density to be within these limits. The density analysis for case study 1 and case study 2 show the majority of separation distances of PSMs in good condition are in the range of 78 to 164 metres and 108 to 263 metres respectfully. For PSMs that also have heights and co-ordinates, the majority of separation distances were in the range of 79 to 484 metres and 144 to 481 metres for case study 1 and case study 2 respectfully. These results indicate that PSM density is adequate in an urban environment for the case studies investigated.

The Integrity and Usefulness of the PSM Infrastructure

The questionnaire demonstrated heights, co-ordinates and cadastral connections are attributes relied upon by the surveying profession on a regular basis [Scotney, 2003]. Through the analysis of the case studies, it was identified that PSMs are losing their effectiveness through the reduction in positional attributes. This analysis revealed the number of PSMs with height values and observed co-ordinates are decreasing, whilst the number of cadastral connections to PSMs were increasing.

Table 1 illustrates that height information on PSMs in case study 1 have decreased from 81% of marks installed in the period from 1980-1990 to just 7% of marks installed since 2000. Table 2 shows a similar decline in heights for case study 2, where 93% of marks installed in the period from 1980 to 1990 have a height value to just 25% for marks installed since 2000.

Table 1: Case study 1 – Trend of PSM attributes over time

Date Installed	Heights	ObsCoord	Cad Connect
Pre 1960	100%	0%	57%
1960-1970	100%	10%	62%
1970-1980	86%	44%	64%
1980-1990	81%	49%	77%
1990-2000	63%	27%	98%
2000 plus	7%	0%	100%

The situation is similar for PSMs with observed co-ordinates. Table 1 shows that in case study 1 the percentage of PSMs with observed co-ordinates has decreased from 49% of marks installed for the period from 1980 to 1990, to a situation where there are no marks installed since 2000 with observed co-ordinates. Table 2 demonstrates the percentages of co-ordinated marks for case study 2 has also decreased, from 40% to 2% for the same time period. The percentages in the tables show that cadastral connections have increased to almost 100% in both study areas. This high percentage is a result of the regulations.

Table 2: Case study 2 – Trend of PSM attributes over time

Date Installed	Heights	Obs Coord	Cad Connect
Pre 1960	64%	80%	32%
1960-1970	87%	46%	71%
1970-1980	93%	58%	70%
1980-1990	93%	40%	77%
1990-2000	80%	21%	84%
2000 plus	25%	2%	95%

The lack of coordinate information will have the impact of reducing the effectiveness of PSMs as their function will be reduced to the status of a recovery mark for cadastral surveys.

Improvements to Infrastructure Maintenance and Access of Information

The ability to upgrade the information via the web has the potential to improve the reliability and integrity of the Survey Control Database (SCDB), whilst access to the information through this medium would prove beneficial to all users. The current system for updating PSM information involves obtaining a PSM maintenance proforma from a NR&M service centre. These maintenance forms are designed for use in the field and are to be completed and returned to NR&M after a PSM has been visited to update the record of the PSMs condition and location. After the information has been updated in the SCDB it is available to clients searching for survey control information.

The questionnaire found the majority of surveyors are satisfied with the information the SCDB contains on PSMs, however the methods for accessing that information remain unsatisfactory and outdated [Scotney, 2003]. Almost 90% of respondents stated their preference for some form of access via a web portal, as this would be a more convenient option of accessing the information for their firm.

The quality of the infrastructure cannot improve under the current system due to the high percentage of surveyors admitting they do not always notify NR&M of discrepancies. Only 37% of surveyors stated they always notify NR&M of PSM discrepancies under the current system, compared to around 77% of surveyors who are prepared to update PSM information via the web. Infrastructure quality can only be improved by receiving better information from practising surveyors to enable regular updates to the information concerning the status of PSMs.

DISCUSSION

A number of respondents from the survey are worried about the long-term integrity of the SCDB if surveyors were allowed to update the database. Many of these surveyors were from the state government agencies rather than the private sector. Any system employed to update the SCDB over the web would need to have strict guidelines and be fully accountable. Other Australian States have implemented systems which allow access and maintenance via the web.

The research also demonstrates the infrastructure is losing its effectiveness due to the decreasing percentage of PSMs with positional attributes. Of the 131,261 PSMs in the SCDB, 10% have observed co-ordinates, 61% have height values and 65% have a cadastral connection. However, the research suggests the numbers of PSMs that are co-ordinated or assigned height values are decreasing. This will impact on the effectiveness of PSMs, as their function will be reduced to a recovery mark for cadastral surveys and will be of little for engineering surveys and the like.

The questionnaire suggests that the high attrition rate of PSMs could be attributed to the general ignorance of the wider community to the value of the PSM infrastructure. The public needs to be made aware of what PSMs represent so they are readily identifiable as having some importance. By improving access to PSM information and conducting programs to raise the awareness of the importance of the infrastructure, both surveyors and the general public would recognise PSMs as a vital resource and treat them with more care.

In Queensland alone there are over 130,000 permanent survey marks. The cost of placing, connecting, co-ordinating and documenting a mark could range from $300-$750 per mark. The cost for building the survey control database could be of the order of $200 per mark including the data input, checking, scanning and initial adjustments. Ongoing maintenance including updating mark condition, corrections, database management, geodetic network observations and adjustment transformations could easily account for another $50-$100 per mark annually. This would give a re-establishment cost of the infrastructure in the order of $100 million dollars and annual maintenance of approximately $10 million. Extending these figures across Australia, including the commonwealth government's efforts could place the value of the infrastructure in the order of a billion dollars and recurrent costs of $100 million dollars per year. These are only 'back of the envelope' estimates but our understanding of the value of this infrastructure is still very limited.

CONCLUSIONS

It is becoming apparent that the role survey mark infrastructure is generally not well understood by the decision makers and increasingly this is reflected in the poor levels of funding provided by governments. New technology, particularly GPS and its real-time coordination ability, has not yet appeared to have impacted on the co-ordination rates of the survey mark infrastructure. The utilisation of the private sector and the building of partnerships are required to improve the co-ordination efforts and maintenance. Some of the key issues that exist include:

1. **Information Access and Management** – this is considered to be a critical component of the survey mark infrastructure. Improved access to information by those who place and maintain survey marks is fundamental to achieving better decision making and improving the quality of the infrastructure. Linkages to other SDI initiatives should be considered.
2. **Physical Infrastructure Management** – current guidelines for the placement and connection of PSMs have had limited impact on improving the overall quality and usefulness of the survey mark infrastructure. Although most new survey marks are connected to the cadastre, their contribution to wider survey coordination is debateable.

3. **Maintenance** – with limited Departmental capacity the ongoing maintenance of both the physical and information components of the infrastructure needs to be reconsidered. Digital uploading and reporting of data can improve the currency of information, efficiencies in data management and the overall quality of the information. The development of strategies to manage the future maintenance should be considered.
4. **Coordination** – the issue of increased levels of coordination of survey mark infrastructure needs careful consideration in view of the move to a more virtual infrastructure and initiatives such as the Virtual Reference Stations (VRS). Obstacles that are limiting the success of such initiatives should be understood and strategies put in place to operationalise these activities in both the private and public sectors to maximise their benefits.
5. **Institutional/Administrative Arrangements** – limited success has been achieved in recent years in cooperation between other state agencies, local government and the private sector. Establishing partnership arrangements may achieve improved outcomes for the future management of the infrastructure.

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