



# **GEODATA**

## **INFORMATION SYSTEMS**

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## **CADASTRAL MANAGEMENT SOLUTIONS**

### **A STRATEGY FOR A GRADUAL UPGRADE TO A SURVEY ACCURATE GIS CADASTRAL DATABASE**

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## 1.0 Background to GIS, the Cadastral Fabric and the Geodata Cadastral Solution

GIS is now recognized as one of the most important management tools for all levels of government administration and utilities management. With considerable investment in hardware, software and personnel, maximizing the benefits is important. The optimum is that all sections of an organisation contribute to, and utilize the GIS database information that is relevant to historical records, current operations and future planning.

The spatial management of GIS cadastral databases has not kept pace with the improvement in spatial quality provided by GPS, accurate photography and other modern data collection technologies. Upgrading, in the near future, of the **Continuously Operating Reference Stations (CORS)** system will also further increase the accuracy and accessibility of GPS and the demand for its use.

The issue of poor GIS data quality is relevant to most departments in an organization. The outputs, (site plans, zoning plans and aerial photography) given to Architects etc, by the Town Planning and Records sections, may not be of a suitable spatial accuracy for their purposes. Also, the lack of confidence in spatially poor GIS systems reduces the extent that Engineering and Survey departments wish to be involved in population and utilization of the database.

Generally, minimal commercial consideration is given to the economic loss in direct cost or "in-house" allocation of resources to:

- DCDB maintenance when using a 'band-aid' approach
- check and rectify poor spatial quality information prior to releasing internally or to external users.
- rectification of minor or major issues as a result of the supply and use of that data.

The Geodata Cadastral Solution creates a "Survey Accurate Coordinate Database". The coordinate 'model' produced by the input of survey measurements and the adjustment process replicates the accuracy of the survey information entered from the Title Plans of survey. ie, an area of a cadastral model built using Portion plans dated 1900 would not have the same spatial quality of a recent urban area which you would expect a tolerance of 10-20mm

Councils are now aware of the benefits of a survey accurate Digital Cadastral Database (DCDB). Some Authorities who have completed a total rebuild, are able to regularly update the database as data becomes available. This would be an ideal scenario, however it involves:

- considerable 'up front' project costs, internally or for outsourcing.
- GIS system customization.
- Commitment to staff training and development for ongoing database maintenance.

Through Geodata Information Systems, the tools and skills are available to begin and manage the upgrade process 'in-house'. A starting regime using the GeoCadastral™ software would initially allow a Council to update with any plans lodged in the future and resolve other areas as needs and budgets allow. Upgrading of dependant layers in the existing GIS can follow under the direction of Geodata.



The GeoCadastré™/GeoSurvey™ cadastral solution is unique and powerful.

We believe a parallel exists with the repair of a road. When a concrete base is laid, the initial expense is considerable, however future maintenance is minimal. If existing potholes are patched, the process is cost effective in the short term but constant office management and field maintenance resources are required into the future. Economic models show that in both cadastral database maintenance and road repairs, a strong foundation pays significant dividends in the medium to long term.

Other cadastral adjustment engines improve the quality of the existing DCDB with added survey information, but may not provide a dynamic solution that allows efficient upgrading in the future. For the adjustment process, GeoCadastré stores the original survey information, particularly curved boundary parameters (ie, radius & chord), which may not always be recorded in other adjustment processes.

Different levels of development and utilization of a survey accurate coordinated cadastre are outlined in the following Case studies:

- **The Northern Territory** - has nearly completed its coordinated cadastre and has legislation in place to move to Legal Title Coordinates in the future.
- **Australian Capital Territory** – has had a survey accurate Coordinated Cadastre since the 1960's.
- **Hunter Water Corporation** – A survey accurate cadastral database for asset management has been in use for over 10yrs.
- **Gosford City Council** - has commenced a partial upgrade process.
- **Gloucester Shire Council** - has completed a survey accurate cadastre for its rural LGA.

Further details of these projects are included in Appendix A.

The ESRI Corporation will release (ARCGIS 9.2 ) Survey Analyst - Cadastral Editor worldwide in 2007 which adopts the GeoCadastré™ process as the tool to build and maintain a survey accurate cadastral fabric as the base GIS layer within the Geodatabase.

This development has taken several years as ESRI had to incorporate cadastral storage in the geodatabase as defined by points and lines (survey methodology) rather than shape files (GIS methodology). The need to retain the original Title dimensions to describe any legal parcel rather than the dimensions from the adjusted cadastral model was also a move away from traditional GIS methodologies.

The decision to use the GeoCadastré™ methodology was made after reviewing many cadastral solutions from around the world to confirm that the methodology provides the most effective model and management system of the legal cadastre for use in GIS systems.

The benefit of the 'GEODATA' cadastral solution is that it can provide cost effective 'stand alone' platforms to generate the cadastral database with full data interoperability allowing any cadastral datasets to be created, adjusted and then uploaded into the ESRI Geodatabase.



## 2.0 The Geodata strategy for gradual upgrading to a survey accurate cadastral database.

### STAGE 1 - MINIMUM REQUIREMENT

The first stage is to utilize the existing DCDB as a platform for future upgrading with:

- new survey subdivision plans as they are lodged or registered
- other survey control or boundary information beneficial to improving the quality of the cadastral layer.

The program would consist of initial training followed by a period working under direction from Geodata. An understanding of survey control, boundary definition processes, recognition of the plan data quality and the extent of the adjustment computations would considerably shorten the software training process and is advisable to fully realize the software's capability.

The initial process would involve:

#### INPUTS

- Modern electronic survey data is uploaded to upgrade that section of the DCDB to provide survey accuracy.

#### METHODOLOGY

- The existing DCDB is imported into the GeoSurvey™ software where the geometry is inversed to create dimensions to represent the parcel boundaries. These dimensions are theoretical only and are derived from the pictorial representation of the parcel boundaries.
- That cadastral network is then read into the GeoCadastré™ software.
- Data from Survey Subdivision Plans received from surveyors as a condition of the Development Consent is uploaded into GeoCadastré™ replacing the existing cadastre at these locations.
- The network is adjusted using the new survey data and uploaded back to the DCDB.
- Any suitable survey work undertaken by Council or other parties can also be used to upgrade the DCDB as long as the integrity of the survey data has been preserved and the survey has not been adjusted to fit the inaccurate cadastre.
- A survey control network can be introduced and upgraded over time.
- A Condition of Approval for any development would require all plans lodged with Council, to be spatially accurate and a readable format of that data supplied by a Registered Surveyor.

#### Outcomes

- Council moves forward & develops skills in Cadastral database management.
- The process can be managed "in-house" or outsourced partially or wholly as required.
- The GIS cadastral layer in new urban release areas can become survey accurate from the beginning of the urban planning process.
- Plans lodged for any Development Consent would allow a cadastral upgrade for the area and all other plans (building, engineering construction, work as



executed, services etc) would be spatially accurate and easily assimilated into Council's GIS.

- Council builds an asset it owns and which requires no licensing from another source.
- The cadastre thus developed is a valuable asset, which Council can make available on commercial terms to other parties as considered appropriate.
- An accurate cadastre allows for desktop layout design of engineering infrastructure without the need to be visible in the field.

## **STAGE 2**

### **UPGRADE OF AREAS SUBJECT TO NEEDS AND BUDGETS**

Once the system outlined above is implemented, designated areas can then be upgraded by manually entering the relevant historical survey information into GeoCadastre™ from existing plans.

Digital Survey data could also be sourced from the surveyors responsible for lodgment of recent survey plans to upload as described in Stage 1.

Relationships could be developed with those local survey firms involving the outsourcing of data capture or control surveys.

Development Approval for minor or major projects that historically would not involve new boundary definition could require lodgment of a cadastral dataset for the site from a Registered Surveyor. The survey definition would invariably have been done as part of the project, but now, Council would have access to that data. Power-line, cable or pipeline projects would benefit considerably from the upgrade process, however, the spatial connectivity required for these types of projects provide a strong framework which adds considerably to the quality and rigour of the cadastral database along the route and adjacent to it.

Some areas of an LGA would not benefit greatly from a high level of accuracy and there would also be no economic benefit in upgrading some areas. The business cases for these decisions would thus be able to be determined "in-house" and effectively customize the levels of upgrade required, with the commensurate economies.

## **STAGE 3**

### **UPDATING OF DEPENDENT LAYERS IN THE GIS**

Initially, consideration would be given to retaining the upgraded Cadastral layer as a separate layer, subject to the relationship other asset database layers had to the DCDB layer.

The process of realigning existing GIS datasets related to the cadastral layer requires transition vectors to be created in GeoSurvey™ to reflect movements in the cadastre so that dependent layers can be adjusted to the new cadastral fabric.

Dependent layers in the GIS are moved to reflect movements in the new cadastral fabric. This is done in GeoSurvey™ (a specially enabled version) by creating NTV2 transition vectors representing the movement at each point. This is an iterative



process and not wholly automated but allows the dependent GIS layers to be kept up-dated to the cadastral layer in the GIS.

### **3.0 Moving Forward**

GEODATA can:

- Advise on the software and system requirements to set up any level of cadastre upgrade mechanism within a Council.
- Provide software training & backup to resolve technical and data issues.

We believe the purchase of the software without reasonable training and direction within an operation does not achieve an effective outcome for the user or put the software to its most effective use.

The abovementioned processes give a Council the opportunity to be independent in the maintaining of a critical tool in their management and operations.

If you have any further enquiries, please contact Roger Lee or Ian Harper (See Appendix C)

## **APPENDICES**

### **APPENDIX A**

#### **CASE STUDIES**

Administrations with varied levels of a Survey Accurate Coordinated Cadastre utilizing GeoSurvey™ & GeoCadastre™ workflows.

#### **NORTHERN TERRITORY**

A coordinate based cadastre created from existing survey plan measurements is nearing completion.

Why a Coordinated Cadastre? - Coordinate based GPS surveys have replaced conventional measurement survey techniques. A single surveyor with GPS has replaced a field party of 8.

Due to their size, some Pastoral Leases are all ready defined by Latitude and Longitude. i.e. defined spatially by geodetic reference frame.

The NT has enacted legislation to legalize the derived coordinates.

As areas reach a required standard of accuracy they are "proclaimed"

The coordinates then become the primary evidence as to the location of parcel corners.

Local surveyors were involved in the process and supported the Department of Planning and Infrastructure.



The Northern Territory has moved from an 18th Century cadastral system to a New Millennium survey system.

## **The AUSTRALIAN CAPITAL TERRITORY**

The ACT has had a survey accurate Coordinated Cadastre since the 1960's and the current custodian (the ACT Planning and Land Authority) is diligent in maintaining the quality of that database.

Most Survey plans across the ACT are recent (less than 40yrs) and provide accurate survey information and coordination. The resultant spatial quality of the DCDB is high (up to 20mm in most urban areas) all be it, in three different datums or reference systems.

The ACT DCDB is spatially more accurate than any of the other spatial datasets which are likely to be overlaid on it (photography, as constructed, etc). If there is a misalignment between GIS layers the cadastre is the point of truth.

The benefits of the accurate ACT cadastre are difficult to quantify, as the inherent efficiencies result in a system where there are very few problems that are attributable to poor spatial information.

The opportunity does exist (as suggested by the Commissioner for Surveys - Frank Blanchfield) for DCDB coordinates to be considered as one of the survey tools available to surveyors for boundary definition, particularly if stronger evidence (survey reference marks, monuments, etc.) was not definitive. The only impediment is the reluctance of the current generation of surveyors to accept coordinates in the chain of evidence.

The accurate ACT cadastre is also useful for checking the quality of new survey subdivision plans lodged for registration. Most mathematical checks are conducted as part of the process of entering a new subdivision into the DCDB.

Furthermore, a survey accurate coordinated cadastre is considered by the Commissioner to be part of the solution to the projected shortage of Registered Surveyors.

## **HUNTER WATER CORPORATION**

Hunter Water Corporation (HWC) is a water and wastewater Utility on the Central Coast of NSW covering 5 Local Government Areas.

HWC has a long history of the creation and management of survey accurate cadastral networks.

In 1992 the digitized Digital Cadastral DataBase (DCDB) was created by the NSW Lands Dept.

Whilst this was a significant achievement, for HWC it revealed unacceptable spatial accuracy between the surveyed and digitized parcel boundaries so they decided to



create their own coordinated cadastre, based a minimum required accuracy of the width of a backhoe bucket ~ 0.5 m.

Hunter Water then adopted the GeoCadastre™ process for cadastral database mapping.

Important selection criteria were:

- Survey plan information entered into the adjustment was weighted according to accuracy
- When the original field survey locating the pipe network was only related to the cadastre, those survey measurements were retained in the adjustment – i.e. as new accurate survey data is included, updated coordinates for the parcel fabric and the pipe network are produced.

As a condition of final approval for new water & sewer construction, a spatially accurate electronic dataset of the asset and the cadastre must be lodged with HWA by a Registered Surveyor in a specified format to ensure compatibility.

Each day Hunter Water adds data from approximately five new survey plans to the DCDB, equivalent to 3,500 new parcels per year.

Maintenance and updating of the DCDB is achieved with a resource of 0.75 staff.

Field survey recording asset locations is simplified by the need to be only related to the Map Grid of Australia (MGA), so survey boundary definition is not required to determine asset location.

Maintenance crews with field laptops, can view and print the current GIS data set which is upgraded weekly.

Hunter Water now provide on-line:

- 'Dial Before You Dig' – requests for asset location information is returned via an automated email and facsimile system linked to the GIS.
- Property water & sewer connection point plans needed for the transfer of land ownership are sent electronically to solicitors.

An aspect of that management process is that **SURVEYORS CONTROL THE GIS CADASTRAL DATABASE**

Hunter Water's survey accurate cadastre is shared by Energy Australia (Australia's largest energy distributor).

With 20 years experience in cadastral management, HWA now consults to other Councils and Authorities and have undertaken Cadastral upgrade projects across Australia.



## **GOSFORD CITY COUNCIL**

Gosford CC have commenced a program of a gradual upgrade of their GIS Cadastral Layer. Their GIS system is maintained by up to 4 corporate staff.

Gosford is a historically rural area undergoing significant urban, commercial and infrastructure growth as a 'dormitory' suburb to the Sydney urban sprawl.

It has a population of approx 163,000 with 70,000 ( 40,000 urban) land parcels.

The existing DCDB was out by 1 - 5 metres in urban areas and up to 20 metres in rural zones.

In 2005, high resolution Aerial Photography was acquired.

The DCDB was found to be visually and legally unacceptable for Council, particularly when dealing with planning issues relevant to multi-million dollar waterfront development.

In the completed areas Council now have accurately aligned cadastre & photography.

Engineering design layout (roundabouts etc) is being completed in the office and survey information collected by Council surveyors is now being added to the GIS. Previously, they saw no point in populating the GIS with 'work as executed' data due to the poor alignment with the cadastre.

## **GLOUCESTER SHIRE COUNCIL**

Gloucester LGA is a rural Council generally located in hilly & mountainous terrain, which includes part of the Barrington Tops World Heritage Rainforest and Wilderness areas.

The total LGA population is over 4,900 with Gloucester Township containing over half (2600).

Gloucester Council has a total of 20 administration staff - includes 1 GIS operator.

Council was aware of the poor quality of the existing DCDB and there was no indication of improvement of that situation in the near future.

GEODATA completed a contract to capture and convert all historical and current parcels within the Gloucester LGA using GeoCadastre™ software.

Some old Title plans (from late 1800's) were illegible in standard electronic format and there were cost implications to retrieve legible original documents from NSW Government archives. Some plans also had little or no survey information.

Where boundaries were the bank of the creek, many surveys did not measure across the creek – i.e. no connectivity between survey plans which had to be resolved to create a continuous fabric.



4,264 historical & current parcels were captured and converted with discrepancies of up to 200 metres found between the DCDB and the numeric cadastre created.

Plans of any development work now lodged with Council are required to be spatially accurate (endorsed by Registered Surveyor).



## APPENDIX B

### List of Presentations & Reference Documents available on the GEODATA Web site.

| FILE   | DETAILS  |
|--|--|
| GEODATA Status Report<br>Jan 2007  | An brief overview of the technical achievements of the ESRI-GEODATA alliance and an outline of the GEODATA Cadastral Solution with references to Case Studies – 2 pages.   |
| Gradual Upgrade Strategy   | A document outlining strategy options for ranging from a complete cadastral upgrade of a Local Government Area as one project to setting up “in-house” systems to move forward upgrading a cadastral database as new survey plans are lodged. Issues from the case studies - Northern Territory, Hunter Water Corporation and several Councils are outlined in more detail. - 12 pages.  |
| Infrastructure/route<br>Cadastral Modeling   | A review of the technical and economic benefits to major infrastructure projects that have created a survey accurate cadastral database for planning, resumption, engineering and construction purposes. Case studies are referenced. – 3 pages.   |
| Solving the Problem of<br>Associativity  | <b>A paper</b> prepared by Michael Elfick outlining how the ‘GeoSurvey’ software solves the problem of realigning GIS feature datasets that are related to the cadastral layer after the cadastral layer has been adjusted. The process has a ‘Patent Pending”.  |
| Technology Case Study by<br>MJA  | <b>Report</b> prepared by Michael Johnson & Associates – Management Consultants in Technology and Innovation.  |
| <b>POWER POINT<br/>PRESENTATIONS</b>   |  |
| Cadastral Upgrade for<br>Councils  | <b>Power Point Presentation</b> to outline the steps in GeoSurvey and GeoCadastral to upgrade the DCDB.  |
| Introducing GeoCadastral<br>Aug 06   | <b>Power Point Presentation</b> to outline the work flow in GeoCadastral.  |
| Parcel Group Data Entry -<br>DP10443   | Power Point Presentation - A brief introduction to the data entry process in GeoCadastral illustrating the benefits and efficiencies of grouping parcels either by survey plan or some arbitrary selection. Parcels remain grouped and are joined as a group. The example details<br>2 rural survey Subdivision Plan’s of 20 & 28 parcels. The plans are fairly easy to read, well drawn and include roads, creek traverses and a partly digitised creek boundary. Parcel accuracies vary from 1: 17,000 to 1: 73,000. |
| Cadastral Solutions for<br>USA Plats.  | PP Presentation to US surveyors outlining GeoCadastral workflows and ESRI relationship.  |
| Cairns Survey & SSI<br>Conference and ESRI User<br>Conference-San Diego<br>Presentation –Harper &<br>Sandy | Power Point Presentation to the Trans Tasman Survey Conference (Cairns-Sept 2006) & the ESRI User Conference (San Diego-August 2006) - <b>A Background to Survey Accurate Cadastral Databases, Case Studies and the role of the surveyor.</b> – by IAN HARPER & CRAIG SANDY(ESRI).   |



| <b>TECHNICAL PAPERS</b>                                    |  |
|--|--|
| ESRI User Conference – San Diego 2006 - Elfick             | <p><b>CADASTRAL SURVEYORS - TIME TO GO FORWARD DIGITALLY AND COORDINATE ACCURATELY.</b></p> <p>M.H.Elfick.- Geodata Information Systems.</p>   |
| FIG International Conference-Munich 2006 – Elfick & Hodson | <p><b>Managing Cadastral Data in a GIS.</b></p> <p>Michael ELFICK, GEODATA – Australia.<br/>Tim HODSON, ESRI – USA.</p>  |
| ESRI UC Paper 2436 – Ian Harper                            | <p><b>Survey accurate GIS – County and Service Authority Case Studies</b> – Paper given to the ESRI User Conference (San Diego-August 2006) detailing some GIS background and the issues and benefits experienced in the nominated case studies.</p> |

## APPENDIX C

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