COORDINATING A METES AND BOUNDS CADASTRAL SYSTEM

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ABSTRACT

Many cadastral systems are based on the dimensions of each parcel and its location with respect to adjacent parcels. Because of the needs of modern GIS systems and the efficiency of GPS as a positioning tool there is a move to convert these systems to a "coordinate based Cadastre".

This paper discusses techniques to coordinate existing corner positions using limited control and the dimensions from subdivision plans. It also looks at a way of managing this change in an orderly manner at minimum cost by using the surveying resources in both the private and government sectors.

INTRODUCTION

The cadastral system in Australia and New Zealand evolved at a time when it was relatively easy to measure lines but very difficult to find the exact location of a point on the Earth's surface. The accuracy specified in regulations for marking of land and the definition of boundaries is a reflection of the measurement technology at each point in time.

The availability of GPS and the expected technical development of this type of equipment is going to have a considerable impact on all aspects of surveying and in particular the cadastral sector. For the first time it is now simpler to fix a position rather than measure a boundary and we can expect that the cadastral system will be adapted to take advantage of this new technology.

Computer based geographic information systems are "position oriented" and there is a need for the cadastral system to be in a form compatible with all other geographic based data sets.

WHY CHANGE THE CURRENT SYSTEM

The current methods of boundary definition have provided an effective guarantee of title over a long period of time. However, there is no point in debating whether not a change will take place for information systems require coordinated data and the technology is now available to provide it.

The change to a coordinate based cadastre will be at least as significant as the change to Torrens Title in the 1860's. Torrens Title provided a simple system for guarantee of title and with the development of GPS, a coordinate based cadastre can provide a simple system to guarantee boundary location.

On the assumption that change is inevitable, then the main issues are the timetable and the way that the transition is to be implemented. If a profession does not take up new technology and provide a lead then it tends to exclude itself from that area of work. Consequently, if the surveying profession is to continue to be part of the cadastral system then it must show that it has both the technical skills and the capacity to manage the change and make best use of appropriate new technology. As the survey profession has played a major part in the development and management of the current system, they are in a unique position to shape and guide the development of the system to replace it.

WHERE ARE THE BOUNDARIES AT PRESENT

The intention of a subdivider is displayed on the subdivision plan and while a purchaser may buy the land as marked, there is an expectation that the dimensions of the parcel are close to those shown on the plan.

The problem that every surveyor faces when redefining an old boundary is what to adopt as evidence to the original marking. Clearly, the subdivision plans are documentary evidence as to the original intention and survey marks such as old pegs, reference marks etc., give evidence as to the location of specific corners and the quality of the survey work. Other physical objects such as old fences and structures can also be used to provide guidance if the original marking is gone.

As time progresses and evidence of the original subdivision marks are lost, there is a tenancy to favour the adoption of "monuments over measurements" and the original subdivision pattern becomes irregular and disjointed. The aim of each survey is often to find a solution which will minimise the chance of litigation rather than try and define the true location of a boundary. Many of the resurveys are carried out under tight cost constraints and therefore are limited in area and in the amount of detailed investigated.

CONVERSION TO A COORDINATED CADASTRE

There are three main options available for the derivation of coordinates for parcel corners.

(i) Remeasure all parcels.
This could provide a comprehensive solution but it would also be very expensive. It may be a practical solution in some rural areas where the survey data is very old and the fences can be adopted as the boundaries.

(ii) Use coordinates digitised from cadastral maps.
Because of the inaccuracy of this data this approach would require the adoption of "general boundaries" and occupations and other data being used to define the boundary position. Such a solution may provide a quick transition and be attractive to

the legal profession, but the benefits of the precision of GPS technology will be lost, and we will move away from having a clearly defined cadastre.

(iii) Use dimensional data together with selected control points.
This option has the potential to provide accurate coordinates for parcel corners without the cost of complete resurvey and makes good use of data from the current record system.

Computer software designed specially for cadastral data acquisition, parcel joining and cadastral network adjustment is readily available and has been described in previous papers. (Elfick 1991, 1994)

DEFINITION OF CORNERS

If the third option is adopted, then a general strategy will need to be devised to guarantee quality assurance and consistency in the results.

A key issue is the balance which is applied between the adoption of the position of existing survey marks and the adoption of dimensions shown on documents.

At one extreme one could simply adopt all survey marks and distribute excesses and shortages between the marks found. This would result in irregular street frontages and road widths and distortion in parcel dimensions especially in older subdivisions. Taken to the extreme it would simply be the same as the first option.

As an alternative, parcels could be grouped together in areas of say from 100 to 300 parcels and each group adjusted. A selected number of survey marks would be coordinated and these would be used as control to compute geodetic coordinates for the parcel corners. Depending on the weights allocated to the marks found, this process can be used to maintain original dimensions and street widths wherever possible and disregard the exact location of each survey mark. The method is a bit like fixing boundaries by "occupations" where the subdivision pattern is shifted until a "best fit" is achieved with the occupation patten.

The solution adopted will probably lie somewhere between these two extremes and will depend on the guidelines adopted for the transition process. These guidelines in turn will be shaped by the legal definition as to what people own and the weighting placed on the dimensional data.

The process of mathematically joining and adjusting all of the dimensional data for an area is not only a comprehensive way of analysing the documentary evidence, but it also allows the surveyor to analyse the likely quality of marks found as physical evidence of boundary position. Many local anomalies can be only be explained by looking at the complete picture.

WHAT IS THE QUALITY OF DATA FROM SUBDIVISION PLANS

This will vary from place to place and will to a large extent depend on the age of surveys. However, except for some locations, most areas are a mixture of old and new work and by working with blocks of 200 to 300 parcels at a time some definite trends emerge.

The cadastral pattern is often complex with a great deal of "connectivity" between the parcels which creates a very redundant data set. Under these circumstances, errors can be isolated provided that all of the data is used. Perhaps these points can be best illustrated with some examples.

The first example is at Porirua on the outskirts of Wellington NZ. The site is about a kilometre square and is partly rural with urban areas intruding. The topography is quite steep in places (typical of Wellington) and more than half of the surveys predate EDM.

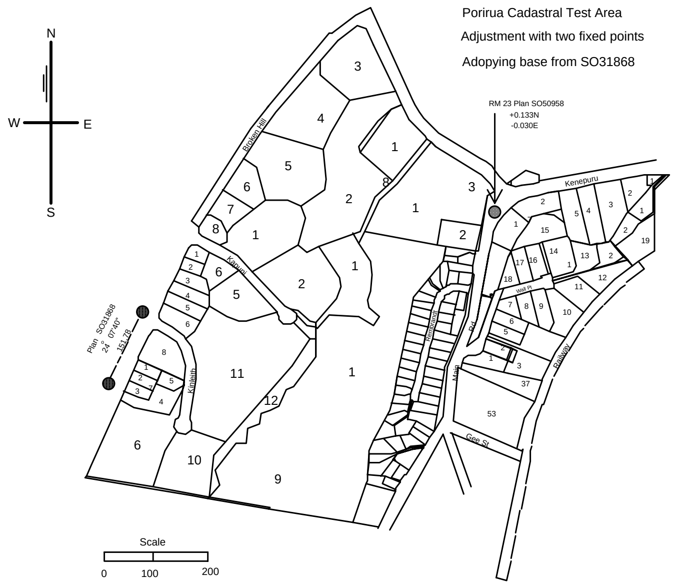

Figure 1

Initially only two control points were used at one edge of the area (see diagram 1). This made the adjustment almost a "free net" since the control could only impose scale and orientation. It determined how the network fitted internally as well as deriving coordinates for all points.

A check was made on a known point on the other side of the area which showed coordinate differences of 133mm in the north and 30mm in the east. These differences represent a scale error of about 1:22000 and an azimuth error of 30 seconds of arc which is approximately 20mm on the baseline.

After adopting this third point and readjusting the network, comparisons were made with ten other points whose coordinates had been provided from other surveys. Those points inside the control had coordinate differences of less than 50mm while some points outside the control along the railway had errors up to 141mm by 92mm. Since the railway survey was very old, these errors could have been greatly reduced if additional control was placed on the eastern side of the area.

Boundary lengths were computed from the adjusted corners and the average difference from plan dimensions was less than 10mm with a few old plans having differences of over 50mm.

Data entry and parcel joining took less than seven minutes per parcel, so if we allow an average of ten minutes per parcel for all processing, then excluding the cost of providing control, the cost per parcel was less than $3 Aus.

The second example is from Alice Springs in Australia. It is an urban area in flat terrain and most of the survey plans are dated between 1945 and 1975. As part of their work towards creating a coordinated cadastre the Department of Lands, Housing and Local Government have coordinated by precise traverse all the remaining old reference marks and have also fixed points by GPS using Leica equipment in "rapid Static" mode.

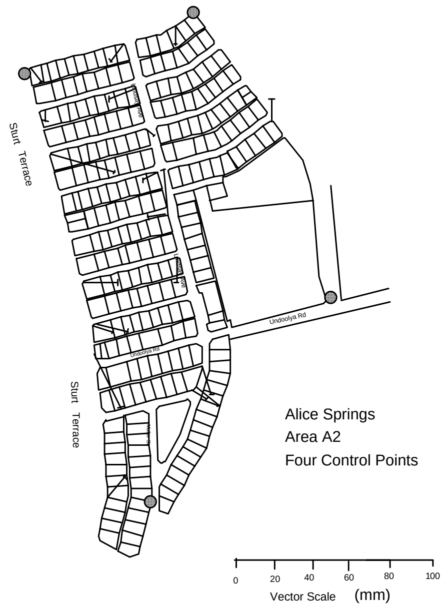

Figure 2

Initially, four GPS points were used as control and these gave differences of less than 100 mm for most points with an obvious trend towards the south end of the area which indicated that one of the old reference marks was unreliable. The area was then readjusted using the traverse values and a more suitable mark used for the most southern point. As shown by figure 2, the residuals on the reference marks were less than 30mm for most points and the difference between plan dimensions and those computed from adjusted coordinates was less than 10 mm. There were three reference marks which exhibited large residuals and it is likely that these were either badly placed originally, or have moved in position due to road works or other disturbance. Effectively the process has determined the most likely position for the parcel corners after considering all the available data and has computed the connections to the actual position of each of the reference marks left by the original survey.

The above two examples show that the cadastral framework can be used to generate a coordinated cadastre with limited control and that the framework itself can be used to select control points which best represent the plan data. The coordinates which are generated can be made to reflect the shape of the original subdivision pattern, or fit closely to later boundary marks depending on the number of control points and the weight allocated to their position. It then becomes a management decision as regards the form that the derived coordinated cadastre will take. To very closely follow the positions of all available survey marks is both costly and may not really reflect the original subdivision boundaries. By accepting the fact that any marks found will have errors in position and will not necessarily be exactly on the boundary, it is possible to closely adhere to the original subdivision geometry in most cases.

IMPLEMENTATION

The cadastral framework is constantly changing as parcels are subdivided and any proposal for change must work with the dynamic nature of the system. Existing metes and bounds systems rely heavily on the skills of the practitioners who use and manage the data and it is advisable to make use of these skills during the transition process.

Many surveying practices have extensive record systems which include original field notes and work sheets going back for many years. Much of this data is unique, for less than a third of all cadastral surveys in NSW result in a plan being lodged in the Land Titles Office (LTO). When a plan is lodged it often does not show all of the current survey information in that area since the surveyor may only include sufficient to justify his boundary definition.

At present, during the subdivision process a surveyor assembles in a computer all the geometry data for the surrounding parcels to help define the boundaries of the subdivision. This information is then discarded, however it could be submitted as part of the subdivision data and in this way the titles office would quickly collect a substantial amount of digital information for existing plans.

As development proceeds, a patchwork of digital data for an area will be built up and when this reaches a reasonable density, the Titles Office can take steps to gather the remaining data and adjust the parcel network. At this stage there is the option to either adopt the adjusted coordinates as the legal definition of the parcel corners or wait until further work has been carried out.

In this way, coordination will proceed according to market forces and those areas where there is a great deal of activity will be "stabilised" first, and those areas where there is little activity will be left to a later date.

To facilitate the coordination process it will be necessary to establish a data bank of cadastral geometry. This will comprise the dimension data from existing survey plans together with information as to the "connectivity" between each parcel. It will be similar to the data in the "Parcels File" described in [7]. Surveyors will extract geometry data from it along with the collection of existing plans as part of the "search process" before carrying out a boundary definition. The plans provide a visual record of previous surveys and the geometry data provides a numerical record of the boundary dimensions.

As digital data becomes available, the checking and charting process for new plans can be modified for instead of simply making comparisons on a line by line basis it will be possible to consider the new survey as a whole and see how it fits to the existing framework and the effect on the framework by the adoption of the new survey dimensions. Examining draftsman will join in the new survey and get a report on how every joined point and line fits with the existing framework. An adjustment of the local area can then be carried out to see how the new dimensions affect the surrounding parcels.

In time, the coordinates for each old area will tend to stabilise and at that stage these values could be proclaimed to uniquely define the parcel corners. Once an area has been proclaimed then all of the old historical plan data becomes redundant and the boundaries are defined by coordinate values for the corners.

Conclusion

It is inevitable that cadastral systems will be coordinate based in the near future and that the transition from the current dimension based system will require careful thought and planning. The existing geometric data can be effectively used to help generate coordinates for existing parcel corners provided that appropriate systems are put in place. The use of all documentary evidence such as plans and written boundary descriptions will facilitate the initial coordinate production and also produce values which are likely to be very close to the intended position of each parcel corner.

The transition process can be achieved over time by small changes in the way that new plans examined in the Titles Office and the rate of change can be determined by the subdivision activity in any area.

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