The Australian Capital Territory
Cadastral Survey and Mapping System
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Abstract
This is the first of two articles examining the Australian Capital Territory (ACT) cadastral and land information system. This article gives a brief account of land administration in the ACT with emphasis on the use made of co-ordinates in the land development process and the ongoing maintenance of the ACT cadastral mapping system. The Subdivision Data Base, a calculated digital model of the planned cadastral development maintained by the Australian Survey Office, is described in some detail. Examples of map products are given to illustrate the flexibility and benefits of this system. Since the ACT is the only jurisdiction in Australia to utilise co-ordinates within an integrated cadastral surveying and mapping system, it could be considered a "cadastral laboratory" for the rest of Australia.

Introduction
This is the first of two articles examining the Australian Capital Territory (ACT) cadastral and land information system. The article gives a brief review of the land administration system and land development process in the ACT. It concentrates on the cadastral surveying and mapping component of the system with particular emphasis on the use made of co-ordinates in the land development process and the ongoing maintenance of the ACT cadastral mapping system. The Subdivision Data Base (SOB), a calculated digital model of the planned cadastral development maintained by the Australian Survey Office, is described in some detail. Examples of map products are given to illustrate the flexibility and benefits of the system.

The second article in the series examines trends in the ACT land administration system and reviews recent initiatives in the LIS area in the ACT.

The review of the ACT cadastral system is justified considering that it incorporates the only co-ordinated cadastral survey system in Australia and that it is the only system which has adopted many fundamental cadastral principles. The experiences of the ACT system should be of interest to other jurisdictions in Australia which are considering the introduction of co-ordinates into their cadastral survey systems. In this sense, the ACT system could be regarded as a model for other States even considering the recent development of the ACT. It is recognised however that for historical, legal, institutional and administrative reasons, each jurisdiction is unique and that procedures or systems workable in one jurisdiction are not always applicable in another.

The review is also timely considering the considerable recent interest in improving the efficiency of the cadastral and land administration systems in Australia. At the core of much of this activity is the growth of the land information system (LIS) concept and the creation of digital cadastral data bases (DCDB). Fundamental to such initiatives is a co-ordinated cadastral survey system being an integral part of the broader cadastral mapping system.

For comparative purposes the major differences between the ACT system and other States which should be recognised are:
I. The ACT has always had relatively good survey control.

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2. Even though co-ordinates were only officially introduced into the ACT cadastral system in 1980, they have been unofficially used since the first days of Canberra.
3. The ACT was developed recently compared to the States and all surveys have been done at a relatively sophisticated level.
4. Most cadastral surveying and cadastral mapping, and all survey examination, is done by one organisation in the ACT.
5. For most applications, ground distances equal projection distances in all the developed areas of the ACT.

Background on ACT Land Administration

The Australian Capital Territory covers an area of 2,358 square kilometres with limits extending approximately 55km east and west and 88km north and south with a border perimeter of 305km. It is located in the southern NSW tableland region and is bounded by the Brindabella Range to the west and the Great Dividing Range in the east. The terrain ranges between 460 and 1900 metres above sea level. The undulating countrysides is traversed by the Murrumbidgee River and some of its tributaries. The site of the National Capital city, Canberra, is dominated by mountains and hills interspersed with broad valleys and two man-made lakes, Burley Griffin and Ginninderra. Serious development of the Capital commenced in the 1920's.

Ninety-nine per cent of the 250,000 people of the Territory live in Canberra within four valleys, each having a satellite town centre surrounded by fully planned urban neighbourhoods. The 'towns' are separated by extensive green belts of open space and are interconnected by arterial road systems.

The policy of not selling land as freehold is a unique feature of the land system of the ACT and stems from the Seat of Government (Administration) Act, 1910. The main form of tenure in the ACT is Crown Leasehold with leases being purchased from the Department of Territories usually at open public auctions. A Torrens system of title registration applies in the Territory with most leases being lodged at the Titles Office. Residential and commercial leases are normally granted for 99 years and rural leases for up to 25 years. Rural leases normally contain withdrawal provisions to facilitate early partial or total resumption when land is required for Commonwealth purposes.

The Department of Territories (DOT) carries responsibility for the ownership and management of all land in the ACT and is involved in all aspects of land administration from land acquisition to the continuing maintenance of the leasehold estate. The Department, under the Districts Ordinance, 1966, directs and co-ordinates the subdivision of land in the ACT into divisions, sections and blocks. The Commonwealth Surveyor-General as head of the Australian Survey Office (ASO), has responsibility for the integrity of the spatial components (boundaries etc) of the parcel base. The Surveyor-General must certify a "Deposited Plan" to the effect that the plan has been prepared in accordance with the Districts Ordinance and that the land is correctly described in terms of division, section and block (the unique identifier adopted for all parcels in the ACT). The Registrar of Titles under the Districts Ordinance and Real Property Ordinance, 1925 has the responsibility for the registration of the spatial data (in the form of a Deposited Plan), and recording the tenure and ownership of the associated parcels.

The Commonwealth Surveyor-General is the Chairman of the Surveyors Board of the Australian Capital Territory as laid down in the Surveyors Ordinance, 1967. The Board maintains reciprocal arrangements with the Surveyors

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Boards of other jurisdictions for the purposes of recognition of a person authorised to practise as a land surveyor. The Board maintains a Register of Surveyors and may give directions as to the practice to be followed by surveyors in making land surveys and preparing plans showing the results of such surveys (Survey Practice Directions, 1980).

Responsibility for the planning and development of the City of Canberra is vested in the National Capital Development Commission (NCDC) by the National Capital Development Commission Act, 1957. It is usual for the approval of the NCDC to be sought for any planning proposal involving the subdivision or use of land within the Territory.

The Land Development Process in the ACT

The Australian Survey Office maintains a network of first order survey control marks and various breakdowns thereof throughout the ACT. Based on this control, the Office produces large scale topographic maps, generally at a scale of 1:500 with 0.5 metre contours, which are used by the NCDC in its town planning processes. Following approval by the Commission, an urban subdivision concept plan at 1:1000 scale is forwarded to the ASO. The ASO calculates the subdivision and updates the Subdivision Data Base (SDB) from which it produces Computation Sheets (refer to following sections for details). All parcels are given unique identifiers in terms of District Name, Division Name, Section Number and Block Number. The Computation Sheets are in effect a series of 1:500 scale set-out plans which portray the "planned parcels" of the ACT.

Copies of the Computation Sheets are sent to the NCDC, DOT, the ACT Electricity Authority (ACTEA), the Department of Housing and Construction (H&C) and the Valuation Branch of the Australian Taxation Office. The ASO updates its 1:500 Topographic Detail and 1:2500 Planed Cadastral Series (a cadastral map series showing "planned" parcels) to reflect the new subdivision. These maps are used by the various authorities to plan the reticulation of water, power and telephone and for the design of sewerage and stormwater drainage systems.

Following completion of the engineering design by the NCDC or its agents, the name of the new Division is gazetted. Before the NCDC commences construction of the new division, the DOT requests the ASO to amend the 1:2500 Actual Cadastral Series (a cadastral map series showing cadastral parcels which are subject to lease or may be available for lease) (see Figure 7) by deleting any existing parcels and adding the planned parcels within the area to be developed. It is this change to the Actual Cadastral Series which upgrades parcels from "planned parcels" to "actual parcels". The DOT, on receiving an update magnetic tape from the ASO, records the street addresses of the parcels in the LANDACT land information system and transfers control of the parcels by instrument to the NCDC. When it has completed construction of the subdivision the NCDC transfers control of the parcels back to the DOT by instrument and advises the Land Sales Office in the DOT that the parcels are ready for disposal.

Prior to the parcels being offered for lease the ASO undertakes the cadastral survey and prepares Sale Plans and X-Plans. An X-Plan is a draft Deposited Plan, the X-Plan number being used to ensure control of the movement of the document until it is registered as a Deposited Plan. The Examination Section in the ASO checks the plan under delegation from the DOT. The plan is certified by the Commonwealth Surveyor-General as having been prepared in accordance with the Districts Ordinance and is lodged with the Registrar of Titles to become a Deposited Plan. Upon registration of a Deposited Plan at the Land Titles Office (LTO) the parcels become "legal parcels".

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Early surveys in the ACT were based on trigonometrical stations established by the New South Wales Department of Lands. During the period 1910-1917, axial lines to control the development of the City of Canberra were surveyed and marked on the ground. All surveys were tied to major control and all marks were given co-ordinates based on an origin at Mount Stromlo Trigonometrical Station. Co-ordinates within the city area were calculated using plane geometry.

As Canberra grew and the satellite towns of Woden, Weston Creek and Belconnen were established, various extensions were made to the early axial control. The 1960's saw the introduction of a Model 4 Geodimeter for distance measurement and the use of the V AR YCORD computer program for network adjustment. Station co-ordinates were initially based on a local Transverse Mercator projection of Clarke's 1858 spheroid. For the V AR YCORD adjustments, the parameters of the Australian National Spheroid were adopted with the semi-major axis increased by 2,000 feet to allow for distances reduced to the "2,000 foot plane".

In 1872, a combined effort of the Survey Branch of the then Department of Services and Property and the Division of National Mapping resulted in the establishment of the ACT Precision Zone of survey control. This extends from the Hume Highway in the north and from Captains Flat in the east, to the southern and western borders of the ACT. This survey has provided the primary control for all new development areas in the ACT since 1972.

The introduction of metric co-ordinates was seen as an opportunity to modernise the map projection. ACT metric co-ordinates are known as ACT Standard Grid Co-ordinates (SCG). They are based on a single zone Transverse Mercator projection of the Australian National Spheroid, with the Central Meridian being that of the Stromlo Trigonometrical Station as fixed by the 1966 National Adjustment (Longitude E 149° 00' 33". 4614).

The central scale factor of 1.000086 is a combination of a 6 metre plane height projection factor of 1.000096 and a negative 1:100000 scale correction to minimise distortion away from the central meridian. For most practical purposes measured ground distances can be directly compared with plane co-ordinate distances. The true origin is the intersection of the central meridian with the equator, with false origin being adopted such that Stromlo Trigonometrical Station has co-ordinates E200,000 N600,000.

It can be seen from the foregoing that the ACT has always had a co-ordinate based approach for surveys. Today the breakdown of control for the purposes of urban development occurs in two distinct phases.

Sectional Control is the first breakdown from the stations of the ACT Precision Zone. It is undertaken as early as possible after an area has been identified for future development. Marks are placed at an average density of one mark per square kilometre. The marks are positioned, taking account of topography and figure geometry, to form a network of braced geometric figures. The physical...
Part of a 1:1000 Reference Mark Plan Showing Neighbourhood Control Marks (NCM's) Figure 1:310 The Australian Surveyor, December, 1986, Vol. 33 No.4
marks consist of a non-corrosive steel rod driven to refusal, capped with a bronze boss. Lengths of galvanized iron water pipe are used to isolate the rod from the upper soil layers to prevent movement with changes in soil moisture. Each mark is surrounded by three concrete posts.

In observing a Sectional Control network, alternate lines of stations and all perimeter stations are occupied. Directions are observed to all adjacent stations using a multi-observer and omni-directional target technique. Angles are read with Wild T3 theodolites at dusk and one set only is observed. All sides are measured using EDM equipment. Levels are established using a mixture of simultaneous reciprocal vertical angles and conventional levelling from existing bench marks. Following the reduction of observations and checking of triangle closures, preliminary co-ordinates are calculated prior to adjustment of the net-work using a "variation of co-ordinates" computer program.

The second phase in the breakdown of control occurs when the road centre-lines have been defined for a new area of subdivision. This phase, known as Neighbourhood Control, involves the co-ordination of a pattern of Neighbourhood Control Marks (NCM) which are used for all later surveys including those for road design and construction, construction of services, preliminary marking of blocks and the final marking prior to the sale of leases.

NCM's consist of a 450mm length of 12mm internal diameter galvanised iron pipe set in a 150mm concrete collar. The top of the pipe protrudes some 10mm above the concrete and is about 150mm below the natural surface. Two red and white painted steel fence posts are driven on either side of the mark to provide additional protection and for ease of location.

NCM's are positioned near road intersections and tangent points at an average spacing of 130 metres. They are placed some 10 to 15 metres behind the front property line, clear of likely disturbance during road construction and away from utility service trenches. The marks are surveyed using forced-centring traverse equipment with single-second theodolites and short-range EDM equipment or total station instruments. Primary traverses follow closely the straight lines joining the previously established Sectional Control marks. Secondary and further traverses are surveyed such that each mark forms part of a closed loop of some five to seven marks. Azimuth is closely controlled by including rays to beaconed trigonometric stations or targeted Sectional Control marks at most reference marks.

Following calculation of loop closures, the traverses are adjusted in sequence commencing with the primary traverses between the Sectional Control. The terminal points are held fixed and a simple swing and proportion adjustment is generally used to determine the final co-ordinates of intermediate stations. At this stage all calculations are made on the 610-metre plane using plane geometry.

The NCM's are added to the Subdivision Data Base which by now also contains a complete mathematical model of the new subdivision. Neighbourhood Control Mark plans showing the control superimposed on the road pattern, are produced automatically from the data base, generally at a scale of 1:1000. These are checked and signed by the Registered Surveyor who carried out the control survey (see Figure 1). Upon completion of the land servicing, final marking is carried out prior to the sale of the leases. The surveyor who carries out the final marking undertakes a set-out task, transferring the co-ordinated mathematical model held in the Subdivision Data Base and portrayed on Computation Sheets onto the ground. This task is greatly facilitated by using the computer to calculate connections between nominated control stations and key points in the subdivision with azimuth rays to nearby trigonometric beacons.
Figure 2:
A Co-ordinated Reference Mark (CRM) set in a concrete kerb.

The surveyor must connect to or place reference marks as specified by the ACT Survey Practice Directions, 1980. Generally, marks are placed near each extremity of the survey, with additional marks at intervals of not more than 200 metres throughout the length of the road frontage. Prior to 1980, the usual forms of reference marks were reinforced concrete blocks, "drill holes and wings" cut into the kerb or galvanised iron pipes placed vertically with the upper surface at least 100mm below the natural surface of the ground. Concrete blocks and galvanised iron pipes were normally placed in the road reserve 1.83m radially from boundary tangent points.

The 1980 revision of the ACT Survey Practice Directions provides for the use of Co-ordinated Reference Marks (CRMs). The usual form of a CRM is a numbered bronze plaque placed in the concrete kerb with the top of the plaque recessed into the kerb to avoid damage by mowers and edging machines (see Figure 2). (Directions 27(e), 28(c) and 28(d)). Pursuant to Direction 3 of the Survey Practice Directions, a "Co-ordinated Reference Mark" (CRM) means a reference mark installed and registered by the Australian Survey Office, connected to a control survey, with the co-ordinates derived from the control survey shown on the plan.

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Cadastral Survey Practice

The ACT Survey Practice Directions, 1980 (Direction 15) state "Where a surveyor makes an urban survey, and the land surveyed abuts or comprises a road or street or other public place:

(i) connect the subject land to each such reference mark by closed traverse which shall include a control mark; and

(ii) record the derived co-ordinate values of such reference mark on the plan of survey.

The surveyor must also make connections to monuments such as the kerb as laid and place additional reference marks at intermediate angles and tangent points. The use of a drill hole and wing cut into the kerb has generally supplanted the placing of concrete blocks and galvanised iron pipes as additional reference marks. Figure 3 is an example of a Deposited Plan showing the placing of reference marks and connections from the Neighbourhood Control Marks to the subject land and the CRMs.

In re-determining boundaries, the boundaries as originally marked on the ground are adopted as the true boundaries (Direction 18). The co-ordinates of CRMs may be used to calculate the bearing of an azimuth datum line, but in other respects CRMs (Direction 9(c) (ii)) are treated similarly to other reference marks and monuments as evidence of the original position of a boundary. Within a "co-ordinated cadastral", the lease-establishment surveyor, having found a CRM and a suitable azimuth mark, is rapidly able to pinpoint where to search for original pegs and reference marks, and to re-establish the corners in the same manner as in other jurisdictions in Australia.

One of the important lessons that other States can learn from the ACT experience is that co-ordinates were officially introduced into the ACT system by the addition of the Directions shown above. Other than these Directions, the Survey Practice Directions, 1980 for the ACT are very similar to the NSW Survey Practice Regulations, 1933 as amended.

Of particular interest are the accuracy criteria. Within the ACT, it has not been deemed necessary to alter the general accuracy criteria adopted in all the other States, in order to accommodate co-ordinates. Distances are all measured to a degree of accuracy ranging from 1:12000 to 1:4500 depending on terrain (Direction 33(a)). Traverse closures range from 1:8000 to 1:3000 depending on terrain (Direction 32). Angular closures are (30 + 20Vn) seconds of arc where "n" is the number of traverse angular stations. However no misclose is to be greater than 3 minutes of arc (Direction 31).

Prior to the introduction of CRM's in 1980 and the requirement to include co-ordinates on Deposited Plans, cadastral survey practice was very similar to the other States. Subdivisions were set-out from control using co-ordinates, but co-ordinates were not shown on the Deposited Plan, nor were connections necessarily shown from the survey to the control. In fact this is very similar to the system today in NSW and other States where often subdivisions or other cadastral surveys (especially road surveys) are undertaken using co-ordinates but co-ordinates are not permitted on the final plan of survey.

Between 1976 and 1980, the ACT system did require surveyors to show connections between the survey and the control network. This was similar to the procedure adopted under the Survey Co-ordination Act, 1949 in NSW. In both cases co-ordinates are not shown on the plans of survey.

Deposited Plan showing Neighbourhood Control Marks and CRMs. (Note that the Reference Marks denoted by GIP are Neighbourhood Control Marks.) Figure 3: 314 The Australian Surveyor, December, 1986, Vol. 33 No.4
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Since 1980, and the requirement to place CRM's and show co-ordinates on Deposited Plans, there has been very little change to survey practice in the ACT. CRM's are used in a similar manner to reference marks in any of the State systems. Co-ordinates don't have any more weight than measurements in the State systems. Redefinition of boundaries is still carried out by adopting established marks and monuments (Directions 18-21).

One of the benefits of using co-ordinates is the ease of establishing an azimuth. In the ACT it is possible to see at least one trigonometric control beacon or monument from the majority of CRM's, thereby making the determination of azimuth a simple calculation. As a check it is usual to be able to sight another CRM in the close vicinity (also see Direction 9(c)).

Even though the Survey Practice Directions in the ACT do not specify in detail the manner of using co-ordinates, guidance is given in the Standards "and Specifications for Deposited Plans prepared by the ACT Board of Surveyors. These standards require a surveyor to use the co-ordinates shown on the control plan prepared by the Australian Survey Office which is applicable to the area.

As in all co-ordinate (and survey) systems, it is possible to find small discrepancies. For example in the ACT it is not uncommon for two surveyors to survey from two different CRM's, co-ordinate the same point and disagree by about ± 0.02 metres. This is not a fault of the system but just highlights normal instrumental and human errors. Such discrepancies are easily accommodated by good survey practice.

Subdivision Data Base and Cadastral Mapping

From the early days of Canberra's development, Federal Capital Layout plans or Computation Sheets have been drawn to portray an accurate mathematical model of the planned development. As mentioned earlier a system of plane co-ordinates was used and co-ordinates of intersection and tangent points on road centrelines were calculated and shown on the Computation Sheets. The road centrelines formed a framework from which the kerb lines and block boundaries were fixed using mathematical traverse closes to determine missing components.

During the 1960's, the necessary calculations were performed on an IBM 1620 computer, one of the first digital computers in the Commonwealth Public Service. Memory capacity on this machine was very limited and input/output was by means of punched paper tape. In 1972 the Survey Branch installed a Honeywell DDP516 computer with disk storage for programs and data files. A Xynetics 1100 flat bed plotter was purchased and the Office set about developing a system to enable the automated plotting of Computation Sheets thus eliminating the tedious and costly manual drafting of these documents. Since 1974 all new subdivisions have been computed using this computer system and a programme of metrication and data-basing of older areas has progressed whenever staff could be made available. Today some 80,000 parcels of an estimated total of 100,000 in the urban area of Canberra are in what has become known as the Subdivision Data Base (SDB).

The SDB is a digital cadastral data base in which the co-ordinates have been fixed by calculation rather than by digitising. Due to earlier limits in disk storage capacity, the base was designed as a series of separate files each covering a geographic area of some five divisions or suburbs. For each geographic area there are three files - a points file, a string file, and a string index file. The total data base is now held permanently on-line on the Prime computer operated by the Survey Office. It occupies about 30 megabytes of disk storage.

All points and circles in a subdivision are given alpha-numeric identifiers. The alpha part, the first lor 2 characters of the identifier, indicates the point...
Figure 4: Part of a 1:500 Identifier Sheet showing point and circle identifiers.
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class for instance R, RX and RT points being used for road centreline chainage, meter-section and tangent points. The points file is a direct access file holding the Easting and Northing co-ordinate pairs for all defined points. For circles the radius and centre point identifier are held. Figure 4, which is part of a point identifier plot, illustrates the labelling of points and circles.

The linking of points to form features such as road centrelines, kerb lines, sections and blocks is defined in the string file. For access purposes strings are arranged in groups related either to sections or roads, with a pointer in the string index file giving the starting location for any particular section or road.

A key factor in the success of the SDB is the effort put into maintaining its completeness, accuracy and integrity. All new broad-acre subdivisions and any amendments to existing data-based areas are added to the data base. The creation, manipulation and use of the data is done with a suite of programs, most of which have "read-only" access to the permanent data files. New points, which are fixed using a series of co-ordinate geometry type commands, are initially stored in temporary work files. Procedural and software checks are used to check the accuracy of points and to prevent the accidental overwriting of points already defined in the points file. Following checking or the preliminary calculations the points file is updated with the work file data and the feature strings are written to the string file.

When an approved Development Plan is received from the NCDC, the road centreline points and strings are fixed first and the road centreline Computation Sheets and Idents Sheets are plotted at I: 1000 scale. The roads, named later by the Canberra National Memorials Committee, are identified by a 3-alpha road code. The Neighbourhood Control Marks are added to the data base which is then used to generate set-out connections and curve lay-out information for pegging of the road centrelines. While the field surveys and engineering design of the roads are in progress, the Subdivision Calculations staff proceed to include the remainder of the subdivision in the SDB. Road widenings, kerb lines and property lines are computed, followed by definition of the individual land parcels. Similar work procedures are followed in the metric conversion and data-basing of the older areas of Canberra covered by earlier imperial computation sheets which were generally drafted at a scale of 40 feet to one inch. The subdivision is re-calculated using work files having units of feet. This enables ready comparison with the previous calculations. On update of the master points file, the feet co-ordinates of points in the work file are automatically converted to the SGC metric co-ordinate system.

The SDB also holds digital representations of the various ACT Districts and Divisions and the ACT-NSW State border.

The flexibility afforded by the SDB is best illustrated by listing some of the ways in which it is used. Outputs from the system are generally of three types - printed reports, digital data for transfer to other systems and plotted outputs.

Printed reports include:

- listings of the metes and bounds defining any particular feature including the identifiers and co-ordinates of all points on the string. Chainages are calculated and output for road centrelines while the area is output for closed figures such as blocks and sections,
- statistical reports giving a count of Blocks by Section, Division, District of the total data base,
- centroid and area for all blocks in a range of Sections,
- set-out information for all circular curves for any road or group of roads, set-out radiations between control reference marks and any point in the subdivision.

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Utility Services plans are composite plots from the Subdiv Data Base and the Utility Services Data Base.

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Digital outputs include:-
.files of statistical information such as block areas and centroids
.character representations of the string features giving sufficient information to enable plotting and analysis at other sites,
.string information in the GENIO format required to input features to the MOSS engineering modelling software,
.log files recording details of all changes to the land parcel base. These are used by the DOT and the NCDC to update their LANDACT and LIMS data bases.

Standard plotted outputs include:-
.I: 1000 Computation Sheets and Point Identifier Sheets showing road centreline information,
.I: 1000 Reference Mark plans showing the Neighbourhood Control Marks over the road network,
.I: 500 Point Identifier Sheets (See Figure 4),
.I: 500 Computation Sheets showing full details of the road centrelines, kerb lines and the parcel boundaries (See Figure 5),
.Cadastral base plans at 1 :500 and 1 :2500 for the ACT Electricity Authority,
.I: 500 cadastral base for the ACT Utility Services Series (See Figure 6), .I: 500 cadastral base for the ACT Topographic and Detail Series,
.I: 2500 cadastral base used for updating the ACT Planned Cadastral Map Series and the ACT Actual Cadastral Map Series (See Figure 7),
direct scribes of the cadastral base for the ACT 1 : 10000 Planning Series, direct scribes of the cadastral base for the NCDC 1: 12500 Town Series Maps (See Figure 8),
direct scribes of the cadastral base for the DOT 1 :7500 Canberra by Suburbs maps,
.road centrelines at 1 :60000 used for updating general charting sheets and map indexes.

The Subdivision Plot software used to produce plotted outputs from the SDB offers the user considerable flexibility and control over the plot content. Following commands that specify the plot window, scale and grid, the specific strings to be plotted are selected. The program provides for the plotting of all or part of strings with options in the choice of linestyles, linewidth with or without annotation, size of annotation, block numbers and areas, road names, point identifiers, etc. User-defined macro commands enable groups of strings related to many roads or sections to be selected and processed with minimal command input. In operation, the program decodes the input data, extracts the required strings from string file and obtains the co-ordinates of points and circle information from the points file. If required, the annotation for strings is generated by calculation for the stored co-ordinate values while the areas and centroids for parcels are calculated. Then follows an analysis phase in which duplicated linework is removed and the positioning of annotation is determined. Annotation is placed using a set of rules designed to keep overplotting to a minimum. Where the space available for annotation of an element is too small, such as the short boundary lines on the Computation Sheet at Figure 5, the missing annotation is listed to the printed report for later manual addition to the plan. The degree of completion of a plan varies with the scale of the plot and the intensity of detail. The plot instructions are written to a multi-layered "pseudo plot file" from where they can be directed to high speed proof plotters, to the Konigshberg high precision plotter for final wet ink plots or scribing, or to the ARC General Drafting System (GDS) graphics stations. By plotting different combinations of layers a variety of products can be produced from the one-plot job.

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Figure 7: Part of a 1:2500 Actual Cadastral Map. *The Australian Surveyor*, December, 1986, Vol. 33 No.4
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Figure 8

Part of a 1:12500 Town Series Map.

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Figure 9

Sale Plan.

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One of the greatest uses of the SDB is in preparing and updating the 1:2500 ACT Cadastral Planned and Actual Map Series (see Figure 7). These are the basic cadastral map series in the Territory. Of interest, the Actual Cadastral Map Series is the spatial component of LANDACT, the DOT's land information system. Any changes to the cadastral framework due to subdivision or consolidation of parcels are immediately reflected in the SDB and the respective cadastral maps.

As well as the standard plot products listed in this paper, the Subdivision Plot software and the SDB can be used to automate or assist the production of various special plots. Figure 9 is a reduced copy of a Sale Plan produced by the ASO for the DOT prior to the sale of leases at auction. For such plans, the cadastral boundaries, kerb lines, block and section numbers, block areas, block dimensions and road names are generated and plotted from the information in the SDB.

Figure 10 shows part of a 1:2500 scale plot produced for the Valuations Branch of the Australian Taxation Office to provide maps for valuers undertaking the 1985 re-determination of lease values for rating purposes. This is a composite of two plots. The cadastral linework, section numbers and road names were generated from the SDB using the Subdivision Plot software. The SDB was also used to generate files of parcel centroids and areas for all parcels in each Division. Using the parcel identifier as a key, the centroids and areas were merged in a relational database with previous unimproved values for rating (UCV) obtained from the Rates Branch of the DOT. The ASO General Purpose Plot system was then used to create plot files in which the block number, UCV and the area were plotted as attributes of the parcel suitably offset from the centroid. Using this procedure, plans of some sixty Divisions covered by the SDB were produced by two people in less than three months.

Conclusion

The ACT land administration system incorporates the only co-ordinated cadastral survey system in Australia. It is the only jurisdiction where co-ordinates appear on a Deposited Plan of survey. In comparison, all other jurisdictions in Australia will generally not register a plan of survey if co-ordinates appear on the face of the plan. As a consequence, the cadastral system in the ACT could be considered a model or "cadastral laboratory" for the rest of Australia.

The cadastral system, and particularly the cadastral survey system in the ACT, is simple, workable and efficient. In general, the system has adopted many fundamental cadastral principles. The survey system is seen as an integral part of the broader cadastral mapping system in the ACT; cadastral surveying is not seen simply as an end in itself. One of the important aspects about the ACT system is that survey control, land development, cadastral surveying, examination of survey plans, cadastral mapping and land registration is basically seen as one process with little duplication. The system is flexible and permits a large variety of map products to be produced for a broad user community.

One of the interesting aspects about the ACT system is its simplicity in the use of co-ordinates as compared with the Integrated Survey Grid proposals for cadastral surveys in NSW in the 1970's. For example, the accuracy criteria for cadastral surveys in the ACT are virtually identical to present State requirements elsewhere. The accuracy standards in the ACT did not change when co-ordinates were introduced. Of interest, the official introduction of co-ordinates came about in 1980 by simply adding or modifying several Directions to the Survey.
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