Cadastral Digital Data Transfer

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ABOUT THE AUTHORS

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More information on the Cadastral Development Unit and its personnel can be found on the Centre's Web Site http:// www.lic.gov.au/cdu.html

Abstract

This paper deals with the methodology of the processes behind the Cadastral Spatial Referencing System (CSRS). The CSRS is the Survey Database currently nearing completion within the Land Information Centre (the Centre) which contains survey accurate cadastral data submitted by the provider surveyor. It contains queriable data on all aspects of information currently appearing on standard Deposited Plans.

The paper moves away from the theories of past papers on this subject, dealing more with the current functionality of the database. Included are the current and pending methodologies for updating, assessing, and storing the data sets. Some of the theory is presented but the emphasis lies in the practical day to day applications. The major purpose of the paper being to show that the Centre's Survey Database is a happening thing.

Introduction

Over the years various papers have been presented at conferences, such as this, on the subject of the Cadastral Spatial Referencing System (CSRS). These papers have concentrated variously on the need for, the impact and uses of, and the implications arising from, a survey database. Other papers have dealt with component problems encountered in the CSRS's development, for example database structure and strategies for the transfer of data into the system. The development of the CSRS has now reached a stage where load testing is taking place.

Load testing of the CSRS has in many instances confirmed the strengths of the original concept and specifications. Certain areas have been reappraised as a result of this testing. The most obvious change being a review of the best format for the transfer of data from the practising surveyor to the database itself. For the cadastral fabric to be modified there needs to be an existing fabric. This is a problem which both the Centre and the Land Titles Office are studying.

Databases, particularly spatial ones, do not exist in isolation - they do not appear one morning when we rock into the office. The Digital Cadastral Database (DCDB) spent many years, and much money, in its development. It is only in the last 12 months or so that it has been effectively introduced as a tool for the dissemination of data to the private surveyor operating in the field. The same will apply to the survey database or CSRS. The job of creating the existing fabric becomes the most urgent of needs, allowing the updating of the fabric on a real time basis.

Background

The New South Wales Central Mapping Authority (CMA) completed its mapping functions in the mid 1980s. Once full coverage of the State had been completed it was expected that the NSW Government would wind down the Authority's functions to that of maintaining the State's map base. However, under the stewardship of the current Surveyor General, the CMA undertook a change in direction, drawing on the combined experience of its 400 employees.

Together with the shifting direction of modern technology, the CMA, renamed the Land Information Centre (the Centre), moved into the area of Land Information Systems (LIS). In 1996 the Centre maintains a growing number of information layers containing digital data relating to the structure of the cadastre and the structure of the land itself (ranging from satellite raster imagery to vector representations of land parcels, topology and so forth).

The Centre is extending its business interests away from core mapping activities into areas such as Australian postcode boundaries and Census district information. Most of the projects that the Centre deal with are based on the base layer of the NSW cadastral fabric. This fabric is represented currently by the Digital Cadastral Database (DCDB). The DCDB has been digitised from a variety of sources, consisting mainly of paper maps held by the Centre, The Water Board and the Land Titles Office (LTO).

At the inception of the Graphic Data Base (GDB), later the DCDB it was going to take 15 years to digitise all cadastral boundaries. To accelerate the digitisation of the NSW cadastre a special grant of around $30 million dollars was provided by the NSW government.

The DCDB is updated by using deposited plans (DPs) which have been lodged with the LTO. These plans are forwarded to the Centre directly from the LTO following registration. The Centre then updates its DCDB using various graphical techniques, including Coordinate Geometry (COGO). COGO essentially uses measurements shown on the Deposited Plan information (mainly bearings and distances) to modify the existing DCDB.

In the late 1980s people such as Mike Elfick from the University of Newcastle argued strongly for the cadastral fabric to be created from survey information rather than through a digitisation process. In fact the COGO updating is very similar to how a survey derived database would be updated if one had been created instead of a digitised database. The Centre decided upon the digitised process due to a series of factors including cost, time, resources and existing technology.

In the early 1990s the Centre began investigating the feasibility of creating a survey based cadastral database. Over the early years of the 1990s the feasibility of such actions, in the long term, was established and a pilot project was commenced. The development phase of the resulting project is now drawing to a close. It is expected that the population of its

databases will commence in the latter part of 1996, when the current load testing is completed.

The CSRS structure

The CSRS is an independent database. It does not rely on any proprietary GIS products for its storage. This offers any users of the database the freedom to choose their own GIS/CAD system for data extraction - nobody is tied to a particular GIS package. Additionally this will allow many different methods of retrieval to become available in the future. Such dreams as full querying capability across the World Wide Web may in the future be a reality.

The storage facility which the CSRS uses is an ORACLE® 7 relational database. If we were designing the system in 1996 we may have opted for an object oriented database structure.

The CSRS model.

The Cadastral Spatial Referencing System (CSRS) has been designed specifically to be accessible by any GIS system through interactive SQL or SQLPlus commands. ORACLE® is a widely used independent relational database. Many of the Centre's datasets, including SCIMS are accessible through the same principle. This enables any new technologies to get the data regardless of format or proprietary design.

The latest technology we will be able to make use of is the Internet's World Wide Web. However, more importantly, it enables cross checking of information to be made available. Survey coordinate information can be compared against SCIMS; parish, county, LGA and suburb can be checked against the DCDB and the Geographic Names Register; Surveyor, registration date etc could be, in a perfect world, compared against the LTO's Business Operating System (BOS). The list is ever expanding.

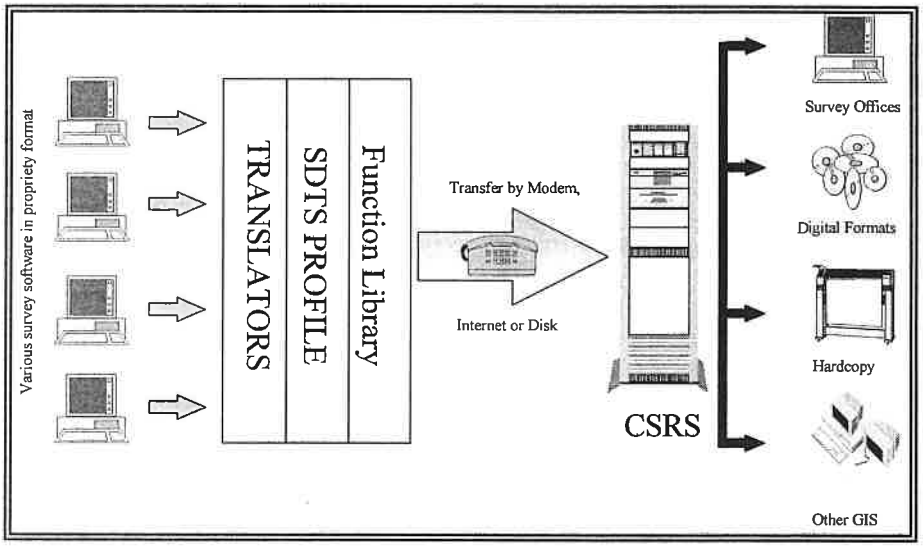

Figure 1 Survey data flow

The model is structured in such a way to allow relationships to be used to interrogate the information. The structure can be detailed in four main subsets. These are:

1. Aspatial Information. This includes all information currently incorporated on the panels in a DP such as surveyors name, survey date, registration date, parish, county, projection zone.
2. Polygons. All lot and easement data is stored including parcel areas, centroids, perimeters etc.
3. Lines. All dimension information appearing on the DP for easements, boundaries connections etc are stored together with the calculated information from coordinates of the same information.
4. Points. The location of monuments, measured corners, resolved corners.

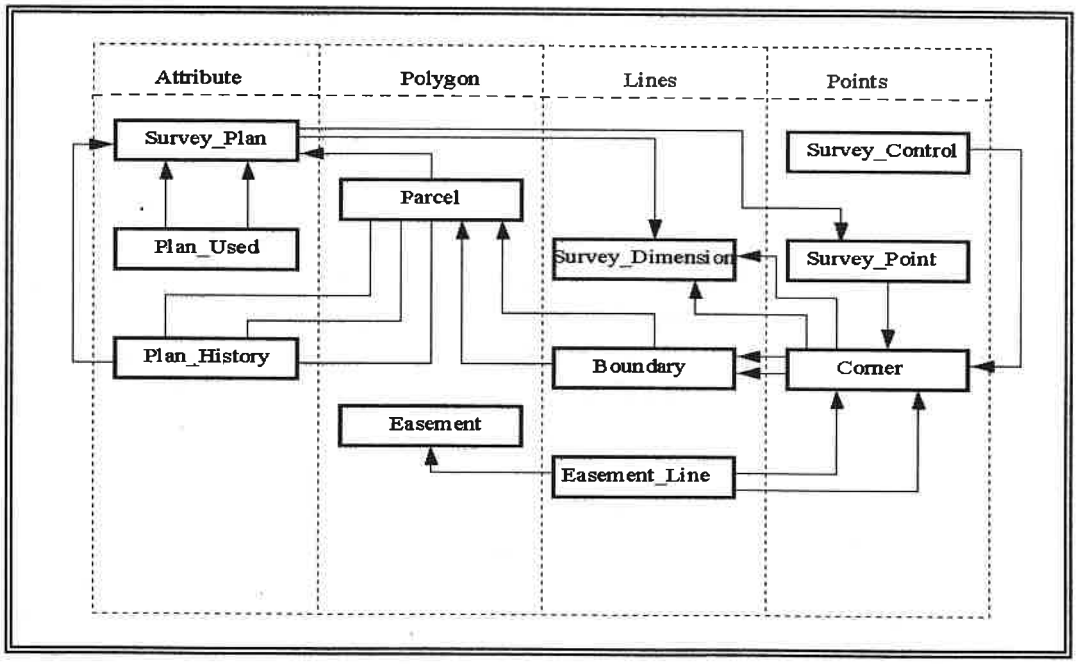

Figure 2 CSRS Entity Relationships

The CSRS contains a range of options to prevent problems occurring in its seamless fabric. These range from corner resolution to coordinate/zone storage and what happens to data in zone overlap areas.

Other areas which are being examined are automated SCIMS updating and least squares adjustments for parcels, DPs and larger areas. In conjunction with similar projects at the Land Titles Office (part of the Calmlink strategy recommended in the *Price Waterhouse Urwick* Report - April 1995) the use of the system to assist the LTO plan examination procedures is being evaluated.

When a surveyor locates a mark on the ground and determines a bearing or a distance to other marks, it is unlikely that all information existing on the plans being worked from will be replicated. This essentially means that if the plans are lodged digitally that there will be discrepancies in the coordinates existing in the fabric and those submitted by the Surveyor. To overcome these perceived inaccuracies the CSRS has multi-representation of each

parcel corner. The database will maintain the correct topology of the entered parcels whilst resolving the graphical corner into the position of most likely occurrence.

The originally stored coordinate information, together with the attribute bearing and distance measurements (as shown on the plan) are retained to maintain integrity and allow later adjustments to be made with the original reduced cadastral data. When each lot is entered the software analyses an area of predetermined radius. Any points which fall within this area are considered to be the same point. Rather than adjusting the points in the incoming file the user is asked to confirm that both points are the same. If so, based on the accuracies of the control used and the standard of the survey (survey_class, survey_order) a resolved point of most likely occurrence is determined. This point is then held until such times as another survey makes use of it.

The coordinates themselves are stored in geographics (AGD66). The beauty of storing the coordinates in this way is that the cadastral fabric is stored directly on the spheroid. The fabric is curved. Then, when the information is required it can be retrieved in the desired format without having to pass through a series of transformations first. If a survey is being undertaken on a zone overlap area then the desired zone can be processed without distorting the original fabric.

In an effort to best position the underlying cadastral fabric a variety of methods are being examined to place surveys in their most likely position. The LTO, using the ACS CAD package is doing this by least squares adjustment, weighting older surveys as being less accurate than modern surveys. Bob Clatworthy has developed a package based on the principle of bundle adjustments which holds road frontages, intended parallel boundaries and coordinate marks fixed whilst allowing large areas to be adjusted simultaneously. Walter Hesse of Melbourne University has developed a product called MAGIC which produces similar results using an object oriented approach.

The Centre is investigating the use of the Clatworthy product upgrading the DCDB. The CSRS stores all the aspatial attribute survey information separately to the data calculated through the GIS. It will then be possible, using this information, to calculate most likely position coordinates. This would be achieved by allowing the cadastre and its source data to act as a network, determining the most likely position of survey points, fine tuning the fabric to most closely resemble the real world position.

The Graphical Interface

The CSRS is populated using a designed utility called Parcel Manager, which sits on top of the Intergraph Corporation's MGE (Modular GIS Environment) package, which in turn relies on the Microstation product. Parcel Manager, organises, cleans and commits the data prior to committing it to the CSRS database. The relationship between the various modules of the MGE suite are shown below.

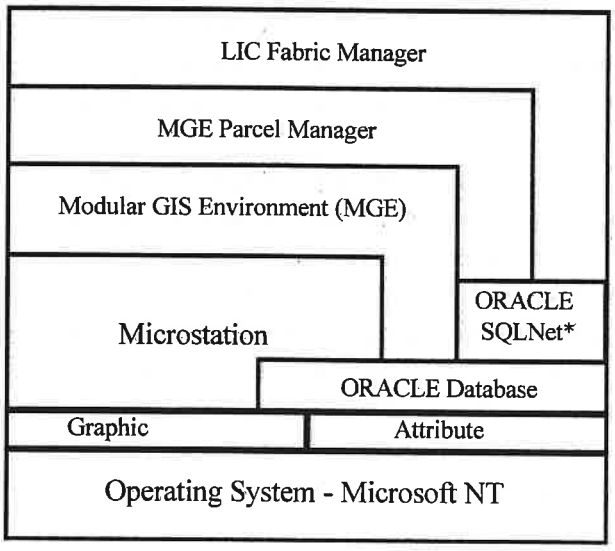

Figure 3 Intergraph software module

The Graphical User Interface (GUI) provided by Intergraph has seven major function points in the processing of data derived in the field. These processes are outlined below in brief, with explanations for their need.

DATA READ IN

Survey plan information is read into the package from the transfer medium. Currently this is through our translator which converts the Neutral Cadastral File format into the Intergraph proprietary product. In the future SDTS will be the format read directly into the package.

When the survey information is read in, it is overlayed onto its correct cadastral context. The raw position coordinate information received in the survey displayed with all adjacent lot and DP information that is read.

TOPOLOGICAL CONVERSION

The raw survey data is analysed for duplicate points, duplicate lines and clean topology. Most survey packages create each lot in isolation, basing their information around the lot rather than the DP. Often survey software will draw most lines twice in exactly the same position. The topographical conversion process breaks all lines where points occur. This enables GIS database analysis. See figure 4.

DATABASE EXTRACTION - POINTS

Once the DP being processed is considered to be internally correct, it can be incorporated into the existing fabric. Each corner of the external boundaries of the DP must fit into the hole that will be created in the existing fabric when the subdivided parcel is removed. Essentially this means that all boundary lines and

corners must correspond with those in the existing fabric.

The Parcel Manager, having extracted the parent parcel identifies all the corners in both the parent parcel and the incoming survey. Having identified these it then searches within predetermined radius to see if these points are in fact the same corner. Corners which are not found within these radii are highlighted and decisions on their acceptability are made by the operator. The decision could be from accepting the points as the same to the other extreme of notifying either the LTO or the Surveyor of discrepancy worthy of requisition.

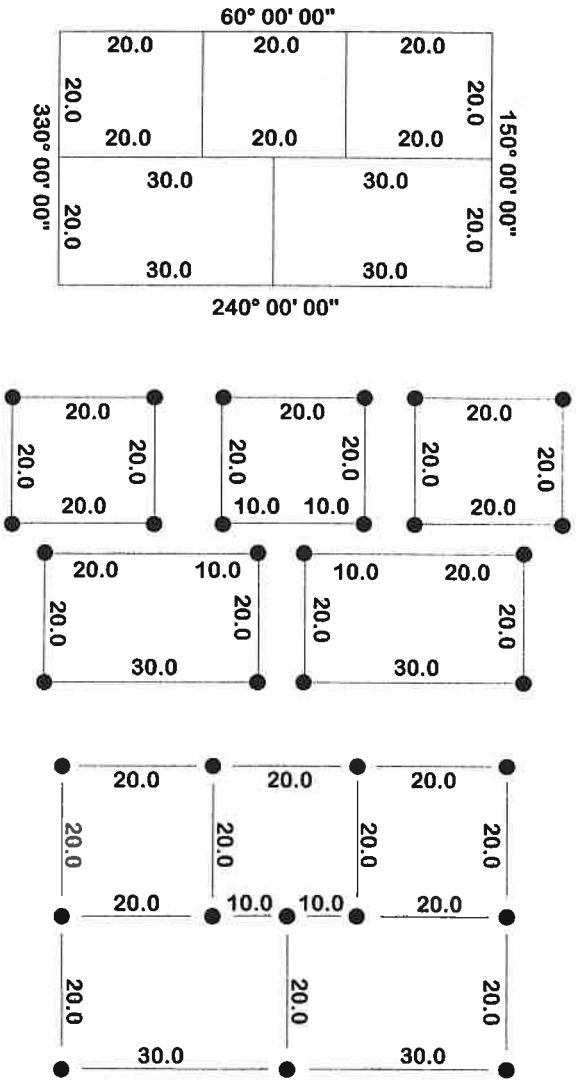

Figure 4 Topological Separation of Survey Data

DATABASE EXTRACTION - SURROUNDING PARCELS

Once the points have been correctly identified the surrounding parcels are extracted automatically. If the graphical representation (or the position of most likely occurence) is identified then the position of boundaries attached to those points in the existing fabric must also be moved. The parcels surrounding the new DP are therefore extracted from the database for processing. The attributes of the information attached to the parcel are not affected in any way at this stage.

DATABASE EXTRACTION - LOCKING

However parcels further out are not affected and therefore can not be allowed to be accidentally shifted. Additionally, as movement is taking place, nobody else can theoretically be able to use the same parcels as the current operator is adjusting. The external boundaries of the surrounding parcels create a large polygon which will be locked out of the database. All records in the database within these areas will not be accessible to any other operators. Data external to these boundaries can not be changed by the current operator.

MERGE

Having locked in the modifiable parcels, lines and points, the Parcel Manager then merges the new parcel into the existing fabric. Modified information superseded existing information. The old data is retained and can be visualised by various commands if so required. Checks are then carried out for duplicate points and boundaries and boundary overlaps. It should also be emphasised that no information is ever removed from the database. This always leaves an audit trail to track changes.

TOPOLOGY CHECK

Once the data has been merged and cleaned the topology of all lots are checked - particularly the existing modified lots, for topological completeness. This is done to maintain the integrity of the database. Each polygon is checked for uniqueness (one centroid), internal consistency and closure.

COMMIT

Once the survey has been incorporated into the existing fabric, information is written from the software and the client computer to the database. All records modified or updated from the pre-existing fabric are flagged with the date and time of their retirement, thus maintaining a temporal record of changes to the cadastre. If at any time in the future it becomes desirable to view the fabric as at a particular date, that fabric can be called up as it was. Once the tables are updated and the flags instituted, the area is unlocked and becomes accessible as new fabric.

Getting the data into the system

One of the advantages of a the digital communications revolution is that most data is stored on computers already. In 1994 it was found that 74% of survey firms used PCs in their offices for survey/planning work. Hence the workflow from 3 in 4 firms was to create the subdivision on computer, plot it onto hardcopy (plan form 2), submit it to the LTO who then forwarded it on to the Centre, who then, through coordinate geometry techniques, put it back on computer. To make use of the digital information already residing in the survey office the Centre proposed to make use of the original computerised data.

In 1991 the Centre developed a file format which would be simple and allow the exchange of information between the proprietary survey software packages available on the market at that time. The Neutral Cadastral File Format, as it became known, was incorporated into the major software packages then being used by the surveying community. These modules were then used extensively in the Collaborative Projects which were established in late 1991, early 1992.

As the collaborative projects progressed it became obvious that there were some

weaknesses within the NCF format. To overcome these problems the Centre re-examined many of the existing standards in an attempt to ameliorate the concerns of the profession. This led to the development of a new format known as SDT, which was presented at the SSA conference last year in Port Macquarie. This design was circulated amongst the profession in 1995 for public comment and only five requests were made for the documentation despite its release in some academic areas and publicity in Azimuth last year. From those people who requested the documentation very little feedback was received.

In light of this feedback the Centre then reassessed the SDT format. Whilst the SDT complied very closely with some work taking place in the International arena, the Centre decided to once again examine the format - taking into account all the research carried out over the previous four years. Examinations had been made by various working parties of the DXF format, formats put in place by other States, the SDTS (AS/NZS 4270) together with the existing NCF and the new simpler ASCII format. The conclusion reached, in line with recommendations of a Price Waterhouse Urwick report (Collection and Processing of Plan Information in Electronic Form - April 1995) was that for the future stability of the software products used to create the transfer mechanisms the direction to be adopted should be that of the new Australian and New Zealand standard. This standard is almost identical to the one adopted by the United States.

What is SDTS?

This section will testify that your average surveyor on the street is going to take one look at SDTS and run in the other direction. It is a general standard and can get simpler not more complicated. The beauty of SDTS is that the average surveyor on the street need not ever know any of this, it's stuff for the boffins in the backroom to deal with. In the same way that the surveyor doesn't need to know what the bits and pieces are in an HPGL plot file. Neither is it necessary to know the contents of how the SDTS holds together. The standard should be "transparent" to the user. However an overview is always nice.

The Spatial Data Transfer Standard (SDTS) was approved in September 1994 as Joint Standard AS/NZS 4270:1995. It was prepared by the Joint Technical Committee IT/4, Geographical Information Systems. It was published on 5 January 1995. It is based on FIPS PUB 173-1992, Spatial Data Transfer Standard (Federal Information Processing Standard Publication issued by the National Institute of Standards and Technology - NIST - in the USA).

SDTS is divided into three main components. These are;

Part 1, Logical Specification;
Part 2, Spatial Features; and
Part 3, ISO 8211 encoding.

Other parts will generally comprise data dictionaries and profiles. These should be considered in conjunction with AS 3654-1989, Information processing - Specification for Data descriptive file for information interchange and AS 2482, Geographic Information

Systems - Geographic data - Interchange of feature coded digital mapping data. The later which will be withdrawn in four years time.

Part 1 of the SDTS is concerned mainly with the introduction of translation procedures, providing the detailed information required specifications for the transfer of data. This is broken into five sections.

Section 1 Being a bit of an overview.

Section 2 Deals with the Conceptual Model of Spatial Data, so the team sending the data and the team receiving it are on the same wavelength regarding what it is they are swapping ie. What spatial phenomena, features, objects etc are going to be exchanged.

Section 3 Deals with Data Quality, this section allows the receivers of data evaluate the suitability of data for their operations.

Sections 4 & 5 Deal with the logical specifications allowing the receiver to actually transfer the data in the requisite modules, telling the receiver what goes where and why.

Part 2 of the SDTS is a rationalisation of around 2,600 definitions of geographic features to 200 defined standard entity types. To quote from the standard itself "thereby facilitating transfer between organisations that might otherwise differ on the nuances of their particular term for, or definition of, essentially the same real world phenomenon."

Part 3 of SDTS deals with the method of encoding, or, how to package your information so that somebody else can read it. This is done using ISO 8211 which is an ANSI standard, ANSI/ISO 8211. This creates the construction, methodology and codes which enable the neutral transfer of data descriptive records to take place.

SDTS is a very broad standard, it is designed to transfer data from simple lines to complex landsat digital imagery. Consequently implementing all of its component parts at any one time is labour intensive and superfluous. To bring the standard down to a manageable size it becomes necessary to create subsets of the standard. These are called profiles. In an effort to create a system which would allow the transfer of geometry and topology the Topological Vector Profile was developed in the United States. This profile received FIPS approval last year and we look forward to its adoption in Australia in the near future.

Simultaneously to awaiting the introduction of a similar standard here in Australia a joint working party was established in South Australia to develop a Cadastral Data Dictionary, which will be adopted under the auspices of Part 2 of the Standard and will allow the exchange of a further subset of data which is applicable to the surveying industry throughout Australia. This will provide a standardised exchange of survey data between many organisations.

Within New South Wales, many utility organisations are also moving towards SDTS which means that in the long term, if we get it right, we will be able to exchange data within a recognised national standard, and hopefully around the world in an International Standard. It will not be necessary to create new modules in programs to cope with new data formats

and any upgrading of procedures will be few and far between, making the rewriting of basic software unnecessary.

The diagram below shows the overall advantage of such an exchange format in the long run. Additionally the Centre is investigating the option of providing surveying software houses with C language program routines which will reduce the cost and duplication of effort to the private marketplace. Currently the Centre is examining a range of pre-written C coding made available through the United States Geological Survey.

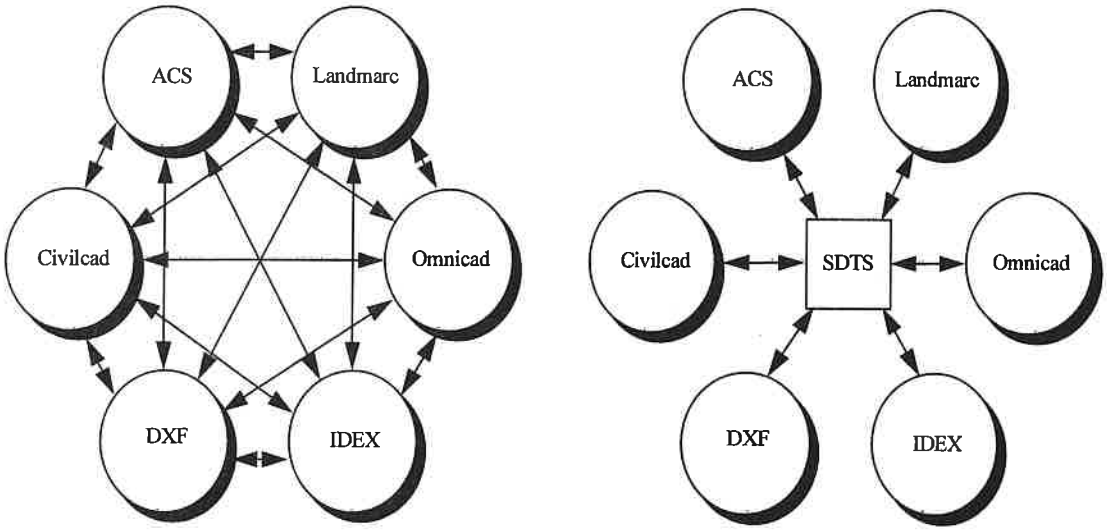

Figure 5 One on One Translation Vs SDTS

Ultimately, using the SDTS approach to information exchange will enable the surveyor to be able to exchange their plan data with an invisible interface to any software compliant with this International Standard. Any Government or semi-autonomous government body or large corporation will be able to receive information directly from the surveyor with any internationally acceptable software product - without waiting for translation modules specific to individual geometry packages. The survey profession will be able to exchange data, receive as well as send, information in relation to environmental impact statements, water board diagrams and a host of other products that they can not yet integrate with their survey software.

Extracting the Data

The survey data is stored in simple ORACLE® tables. The stored information can be extracted by simple SQL commands. The Centre intends this information to be used by as large a group as possible. It will be used by the DCDB, the LTO and surveyors generally.

The Centre is in the process of creating conduits for moving the data from CSRS to the DCDB for automatic updating. Currently the updating of the DCDB is a labour intensive activity. Updating the CSRS is a fairly automatic process which takes from 2 to 5 minutes depending on the size of the subdivision being created. To integrate the two will remove the intensive COGO technique from the updating process reducing turn around time and

costs.

Once the power of a survey accurate database can be examined it will become possible to build new products within the Centre, providing a more reliable and more stable environment for utility organisations to hang their data from. Additionally it will allow other government organisations to make use of its potential for their own products, needing only their own programing and simple queriable interfaces to whatever system they desire.

Interfaces could be as simple as Common Gateway Interface (CGI) scripts on the Internet to access and query the data sets. The Centre is in the process of introducing its own web site which will over time expand to replace its bulletin boards and simplify its communications with sister organisations around the world. (For those interested in accessing the Centres homepage the address will be http://www.lic.gov.au/)

Conclusion

The Centre has developed a highly capable product in the CSRS. It is a dataset which integrates with the rest of the Centre's data sets. It is being developed in consultation with the Land Titles Office to ensure no opportunities are lost to make the flow of survey data more efficient. It is a product which will, over time, provide a state cadastral fabric of great accuracy. The CSRS, in complying with international standards for data transfer, will give the procedures a longevity not currently available in major datasets. Additionally it will provide the survey community with a greater range of searching facilities which should simplify and enable quicker cross checking of survey data.

Making use of the latest of emerging technologies the CSRS will allow the data stored in it to be examinable by the widest range of people and organisations. The ability to cross check their own data sets and survey information, pull in and plot data on their own equipment or query data direct from the database will open a range of many new activities which will be advantageous to their own business interests.

Today's technology introduces new information sources quickly and effectively. The CSRS makes use of these from SDTS, independent databases, powerful graphical interfaces and, in the future the Internet and World Wide Web.

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